SLV Assignment1

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1 Introduction

1.1 The Dataset

We explore a dataset from kaggle, which contains information about the housing market in Italy. The data were scraped from one of the most relevant housing sales websites in Italy during the month of *August 2022*. The data consist of more than 223,000 sales posts spread over 7,023 (89% of the total 7,904) Italian municipalities (*comuni*). Some of the entries were removed in dataset construction due to translation limitations (e.g., extended text-based description, specific url of the post).

In order to plot the statistics of interest to maps of Italy, we use the regional and provincial shape files which we obtained from the Italian National Institute of Statistics. These files contain the regional and provincial coding and geographical shape information which can be used cluster the comuni in our data (`location`) into (107) provinces and (20) regions.

For each sale, the dataset contains the following variables:

Table 1: Description of

Variable	Description
id	ID of the sale
timestamp	Timestamp consisting of 10 digits
location	Location on municipality level
title	Short description of property
price	Price in Euros
n_rooms	Number of rooms
floor	Floor
mq	Size in square meters
n_bathrooms	Number of bathrooms
year_of_construction	Year of construction
availability	Availability of property
energy_class	Energy class ranging from a+ to g
status	Status of the property
heating	Type of heating
has_garage	Garage present: yes (1), no (0)
has_terrace	Terrace present: yes (1), no (0)
has_garden	Garden present: yes (1), no (0)
has_balcony	Balcony present: yes (1), no (0)
has_fireplace	Fireplace present: yes (1), no (0)
has_alarm	Alarm present: yes (1), no (0)
has_air_conditioning	Air Conditioning present: yes (1), no (0)
has_pool	Pool present: yes (1), no (0)
has_parking	Parking present: yes (1), no (0)
has_elevator	Elevator present: yes (1), no (0)
is_furnished	Furniture present: yes (1), no (0)

1.2 Exploratory Questions (*EDIT LATER*)

We focus on four exploratory questions concerning housing data set in Italy.

Firstly, we explore if there are any geographical trends in the mean and median housing prices in Italy. (E.g., Is housing more/less expensive in Northern Italy compared to Southern Italy?)

Secondly, we examine if there are differences in mean regional variances of housing prices between the different provinces and regions.

Thirdly, we explore if there is a correlation between the missingness of housing price and other variables.

Fourthly, we identify the most important predictors of housing prices in Italy.

2 Preparation

In order to start our exploratory analysis, we first load relevant packages and import the full data set.

2.1 Load Packages & Import Data

```r
## load packages
library(tidyverse) # for wrangling data
library(magrittr) # for using pipes
library(skimr) # for skimming data
library(sf) # for spatial analysis
library(sp) # for spatial analysis
library(ggplot2) # for plotting
library(fuzzyjoin) # for joining on not-exact matches
library(ggpubr) # for arranging ggplots


## import Italy housing data
housing <- read.csv("data/housing_data_italy_august2022.csv", na.strings=c("","NA"), header = TRUE)

## import Italy shape data
# municipality level
munic_2022 <- st_read("data/italy_shape_2022_files/Com01012022_g")[c("COD_REG","COD_PROV", "COMUNE")]
# province level
prov_2022 <- st_read("data/italy_shape_2022_files/ProvCM01012022_g")
# region level
reg_2022 <- st_read("data/italy_shape_2022_files/Reg01012022_g")
```


3 Preliminary analysis

We skim through our data using the `skimr` package. This summary of the raw data set can be found in the section 6 Appendix. The original data consist of 223,409 rows (sales) and 25 columns (variables). Given our questions, we conclude that `id` (ID of the sale), `timestamp` (timestamp of the sale), and `title` (description of the property) are irrelevant and, hence, we exclude them from the dataset for further analysis. In addition, we remove two columns that have only one unique value (`status`: "other" and `availility`: "not free/other"), as these variables do not provide information specific to certain sales.

Furthermore, we observe that types of some variables are wrongly specified. We convert them to a correct type (e.g., `heating`: character –> factor, `has_xxx`: numeric –> factor, `is_furnished`: numeric –> factor).

We create a new variable `age` which contains the age of the property as of 2022 by subtracting the `year_of_construction` from 2022. In the original dataset, there are some unreasonable years of construction (e.g., 2209). Some properties may be sold before construction is completed, but we deem it unlikely for properties whose `year_of_construction` is more than 4 years later from now. Thus, we exclude the `age` of property lower than −4 (i.e., exclude `year_of_construction` > 2026).

The variable of our main interest `price` has some missing values, and we see that it is highly skewed to the right given that mean is far off to the right of the median (see section 6 Appendix). We look into the distribution

of the `price` further in detail. As shown in Figure 1, there are extreme outliers in `price` that seem unrealistic (e.g., over 2 billion). We decide to filter out the houses whose price is over a million **to prevent severe bias in our subsequent analyses ... KP: NOT SURE IF THIS IS CORRECT TO SAY** (see Figure 2 for the distribution of the price for the filtered houses).

```
## cleaning up the housing data
cleaned_housing <- housing %>%
  # select variables that have more than one unique value
  select(where(~n_distinct(.) > 1)) %>%
  # fix the data type
  mutate(across(c(starts_with("has"), is_furnished, heating, energy_class, n_rooms, n_bathrooms, location)
  # filter out houses whose price is over a million (while keeping NAs)
  filter(price < 1e6 | is.na(price),
  # filter out houses whose construction year is more than 4 years later as of today
         year_of_construction < 2026 |is.na(year_of_construction)) %>%
  # create property age variable
  mutate(property_age = 2022 - as.numeric(year_of_construction)) %>%
            # remove id, timestamp, title and year_of_construction
  select(-c(id, timestamp, title, year_of_construction))
```

```
## boxplot of price
housing %>%
ggplot(aes(x=price)) +
  geom_boxplot() + theme_minimal()
```
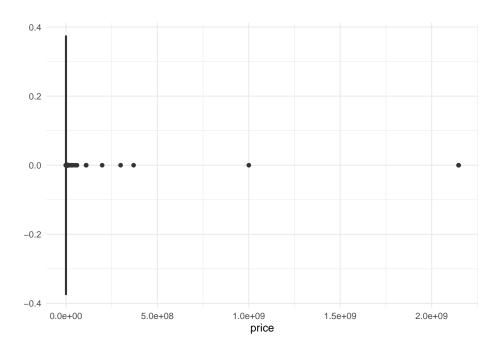

Figure 1: Distribution of housing price

```
## density plot of price (under million)
housing %>%
  # filter out houses whose price is over a million
  filter(price < 1e6) %>%
  ggplot(aes(price)) +
  geom_histogram(aes(y=..density..), color=1, fill="white") +
  geom_density(lwd=0.5, color = 4, fill=4, alpha=0.2) + theme_minimal()
```
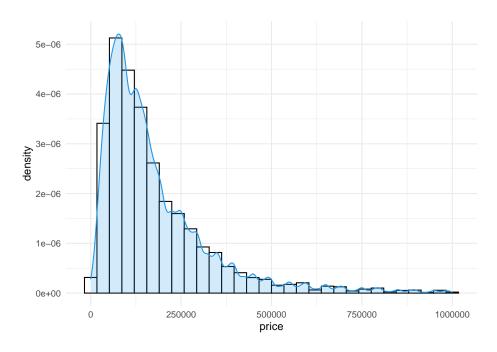
Figure 2: Histogram of housing price (under a million)

3.1 Data summary

After the cleaning up the data, we take a look at the summary statistics for the data set to get a better overview of our data.

```r
# round up by 2 decimal places + disable scientific notation
options(digits = 2, scipen = 999)
# specify skimming function
my_skim <- skim_with(character = sfl(whitespace=NULL, min = NULL, max = NULL),
                     factor = sfl(ordered = NULL),
                     numeric = sfl(p0 = NULL, p25=NULL, p50=NULL, p75=NULL,
                                   p100=NULL, hist=NULL, median = ~median(., na.rm=T),
                                   min = ~min(., na.rm=T), max = ~max(., na.rm=T), n_unique=n_unique))
# summary table
my_skim(cleaned_housing)
```

Table 2: Data summary

Name	cleaned_housing
Number of rows	220607
Number of columns	20
Column type frequency:	
factor	16
numeric	4
Group variables	None

Variable type: factor

skim_variable	n_missing	complete_rate	n_unique	top_counts
location	0	1.00	7023	pis: 192, leg: 190, la : 188, bar: 187
n_rooms	58208	0.74	4	3: 56756, 4: 47126, 5: 30926, 2: 27591
n_bathrooms	12592	0.94	3	1: 107355, 2: 79819, 3: 20841
energy_class	638	1.00	12	g: 115161, f: 25382, e: 17111, a: 15924
heating	0	1.00	2	aut: 197714, oth: 22893
has_garage	0	1.00	2	0: 180548, 1: 40059
has_terrace	0	1.00	2	0: 195984, 1: 24623
has_garden	0	1.00	2	0: 184307, 1: 36300
has_balcony	0	1.00	2	0: 197918, 1: 22689
has_fireplace	0	1.00	2	0: 208689, 1: 11918
has_alarm	0	1.00	2	0: 218611, 1: 1996
has_air_conditioning	0	1.00	2	0: 154964, 1: 65643
has_pool	0	1.00	2	0: 216350, 1: 4257
has_parking	0	1.00	2	0: 217228, 1: 3379
has_elevator	0	1.00	2	0: 207928, 1: 12679
is_furnished	0	1.00	2	0: 203515, 1: 17092

Variable type: numeric

skim_variable	n_missing	complete_rate	mean	sd	median	min	max	n_unique
price	39113	0.82	177146.0	152154.7	130000	1	999999	2554
floor	71354	0.68	1.8	1.1	2	1	52	20
mq	3309	0.99	155.9	124.4	116	1	999	970
property_age	10	1.00	56.1	74.3	42	-3	1022	374

DECRIBE THE SUMMARY TABLE as per changes

From the tables, we can see that there are 12 different energy classes and 7023 different locations. When taking a closer look at the `location` variable, one can see that they are given on a municipality level.

For the numeric variables, we observe that several have lots of missing values (e.g., `price`, `n_rooms`, `floor`, `mq`, `n_bathrooms`). We will discuss how we want to deal with this in section 4.2.

4 Main (exploratory) Analysis

4.1 Question 1: Geographical Differences in the Mean and Median Housing Price

Each sale in our dataset is assigned to one of 7023 municipalities. In order to create plots which visualize the differences in average housing prices across Italy, we assign each municipality (*comune*) to its corresponding province (*provincia*) and region (*regione*). We use the data from the *Italian National Institute of Statistics* (*ISTAT*) to append the province and region information to every observed municipality in our dataset.

4.1.1 Preparation

At the beginning of the assignment, we loaded the *ISTAT* shape files. These files are useful for two reasons. First, they contain the list of all Italian municipalities, their respective provinces and regions. Therefore, we can use this data to append our original dataset with additional location indicators. Second, they contain the shapes of Italy divided into provinces and regions. This is particularly useful for creating map plots using `ggplot2`.

For completeness of our dataset, we append the province and region information. We use fuzzy matching for inexact matches as we found that there were some minor inconsistencies in how the municipalities were named in our dataset as opposed to their names in the ISTAT shape files. The result of the following chunk of code is that all the municipalities are assigned their regions and provinces.

```
cleaned_housing <- stringdist_left_join(cleaned_housing, munic_2022,by = c("location" = "COMUNE"), distance
  group_by(location) %>% slice_min(distance) %>%
  select(-geometry,-distance) %>%
  left_join(., as.data.frame(reg_2022[,c("COD_REG","DEN_REG")])) %>%
  select(-geometry, -COMUNE) %>%
  left_join(., as.data.frame(prov_2022[,c("DEN_UTS", "COD_PROV")], by = "COD_PROV")) %>%
  select(-geometry, -COD_REG, -COD_PROV) %>%
  rename(., "region" = "DEN_REG", "province" = "DEN_UTS") %>%
  relocate(c(region, province), .after=location)
```

To answer the first exploratory question, we aggregate our data on two levels: 1) regional and 2) provincial level by computing two aggregate statistics: 1) the mean housing price and 2) the variance in housing price on the two respective levels. This yields two datasets, one per aggregation level. To each, we attach geometric information needed for plotting and convert it to an `sf` object which is a requirement for plotting maps.

```
price_by_reg <- cleaned_housing %>% group_by(region) %>%
  summarize(mean = mean(price, na.rm=T), median = median(price, na.rm=T), variance = var(price, na.rm=T),
```

```
price_by_prov <- cleaned_housing %>% group_by(province) %>%
  summarize(mean = mean(price, na.rm=T), median = median(price, na.rm=T), variance = var(price, na.rm=T),
```

4.1.2 Plot

As the distribution of `price` is still quite skewed, we inspect the median housing price and the corresponding variance by region.

```
p1 <- ggplot(price_by_reg) +
  geom_sf(aes(fill = median))+
  theme_minimal()

p2 <- ggplot(price_by_reg) +
  geom_sf(aes(fill = variance))+
  theme_minimal()

ggarrange(p1, p2,
          labels = c("median", "variance"),
          legend = "bottom")
```

Price difference between high- and low-median groups We can show facet_wrap...

```
top2_med <- price_by_reg %>% slice_max(median, n = 2) %>% pull(region)
bottom2_med <- price_by_reg %>% slice_min(median, n = 2) %>% pull(region)
groups <- list(top2_med = top2_med, bottom2_med = bottom2_med)

p3 <- cleaned_housing %>%
  filter(region %in% top2_med) %>%
  ggplot(aes(x = price, group = region)) +
  geom_histogram() +
  facet_wrap(~region)

p4 <- cleaned_housing %>%
  filter(region %in% bottom2_med) %>%
  ggplot(aes(x = price, group = region)) +
  geom_histogram() +
```
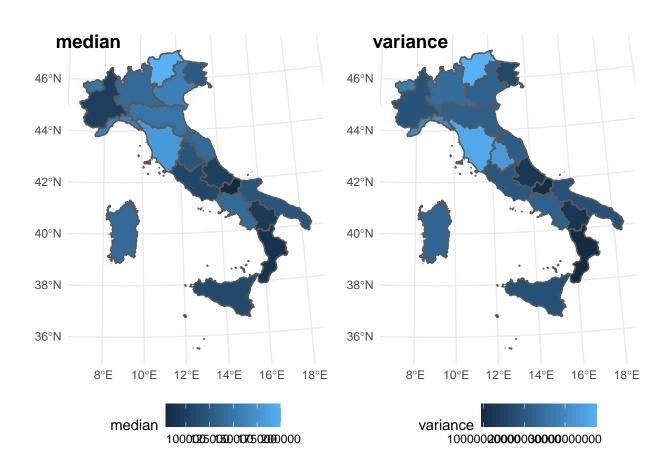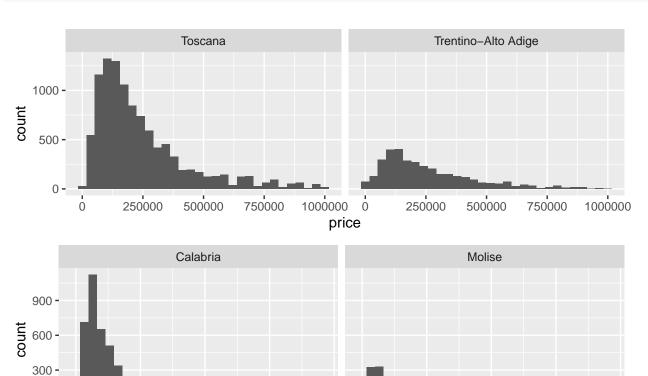
Figure 3: Median and Variance of price per region
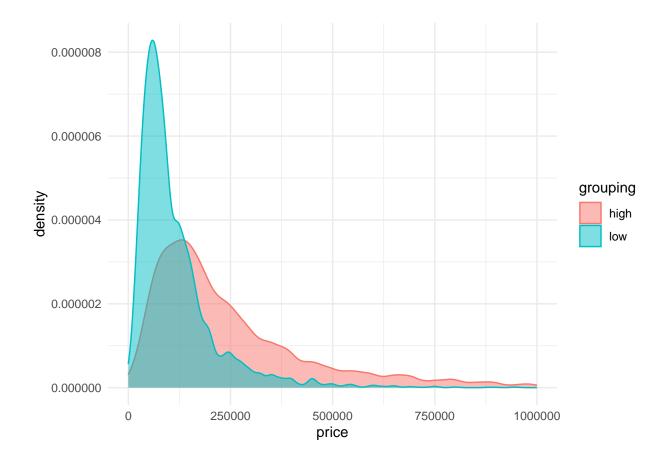
```
    facet_wrap(~region)

ggarrange(p3, p4, nrow=2)
```



```
## OR WE CAN PUT ALL IN ONE PLOT SHOWING THE HIGH MEDIAN GROUP VS LOW MEDIAN GROUP
cleaned_housing %>%
  filter(region %in% c(top2_med, bottom2_med)) %>%
  mutate(grouping = case_when(region %in% top2_med ~ "high", TRUE ~ "low")) %>%
  ggplot(aes(x = price, color = grouping, fill = grouping)) +
  geom_density(alpha=0.5) + theme_minimal()
```

4.1.3 Conclusion

4.2 Question 3: Missingness

For this exploratory research, we are interested which variables can predict house prices. However, from an initial inspection, it became clear that some potential predictors contain missing values. Additionally, the outcome itself includes missing values.

Therefore, we are interesting to explore if the missingness of the predictors and the outcome variable: house prices are related. First, we investigated the correlation between the missingness indicator for price and the predictors. Second, we visually examined the relationship between the predictors' missingness indicators and the price densities. Lastly, we visually inspected the percentage of missingness per region. These results could provide us some indication of the missing data mechanism. Specifically, if missing completely at random (MCAR) is plausible to assume or not.

```r
# barplot to show the missingness per variable
cleaned_housing %>%
    is.na() %>% colMeans() %>% stack() %>%
    ggplot(aes(x = reorder(ind, values), y=values)) +
    geom_bar(stat="identity", width = .2, fill = "black") +
    geom_point() +
    theme_minimal() +
    coord_flip() +
    labs(x = "Variable", y = "Missingness (%)")
```
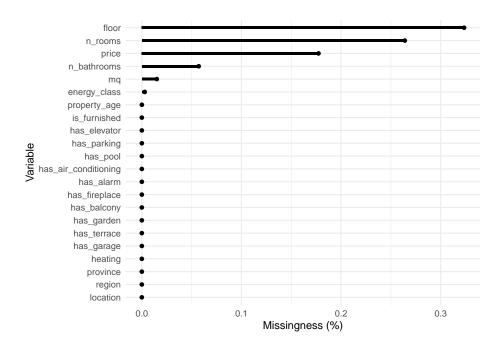
Figure 4: Distribution of housing price

4.2.1 Results

```r
# missingness correlation between price and predictors
cleaned_housing %>%
   mutate(missing = ifelse(is.na(price), 1, 0)) %>%
   ungroup() %>%
   summarize(across(n_rooms:property_age, ~cor(as.numeric(.x), missing,
      use = "pairwise.complete.obs"))) %>% t(.) %>% .[order(abs(.)),] %>%
   round(2)
```
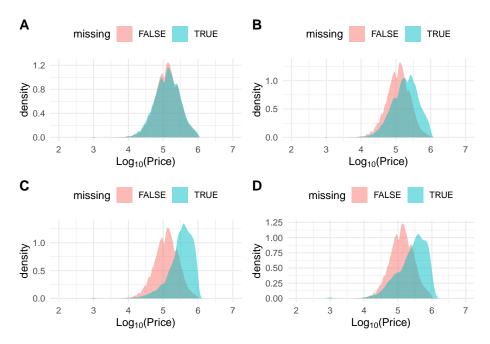
is_furnished	has_pool	floor
0.01	-0.01	0.01
n_bathrooms	property_age	has_alarm
0.02	-0.02	-0.03
mq	has_parking	has_balcony
0.03	-0.04	-0.06
n_rooms	has_elevator	has_terrace
0.06	-0.08	-0.08
has_air_conditioning	has_fireplace	has_garage
-0.09	-0.09	-0.10
heating	has_garden	energy_class
0.11	-0.11	-0.27

The missingness of price appears to be moderately correlation with the energy class. Further, the missingness of price seems to be weakly correlated to having a garden and heating, and the type of home heating system.

```r
# function to create a density plot of price with missing indicator
missing_plots <- function(x) {
   plot <- cleaned_housing %>% ungroup() %>%
      mutate(missing = is.na(.[,x])) %>%
      ggplot(aes(x = log10(price), fill = missing)) +
```

```
        geom_density(alpha = 0.5, color = NA) +
        theme_minimal() +
        theme(legend.position = "top") +
        labs(x = expression(paste(Log["10"],"(Price)"), y = "Density")) +
        scale_x_continuous(limits = c(2, 7))
    return(plot)
}

# multiple plots for floor, no. of rooms, no. of bathrooms, and meters squared
ggarrange(missing_plots("floor"),
          missing_plots("n_rooms"),
          missing_plots("n_bathrooms"),
          missing_plots("mq"),
          labels = c("A", "B", "C", "D"),
          ncol = 2, nrow = 2)
```


The missingness of number of floors (@ref(fig:missingness_density) A) and number of rooms (@ref(fig:missingness_density) B) does not seem to be dependent on the observed price information. Whereas for the number of bathrooms (@ref(fig:missingness_density) C) and the meters squared (@ref(fig:missingness_density) D) missingness shows a different result, namely missingness tends to occur at higher house prices.

```
## check missingness w.r.t regions
cleaned_housing %>%
    mutate(na_ind = ifelse(is.na(price), 1, 0)) %>%
    group_by(region) %>%
    summarize(total_missing = sum(na_ind) / n()) %>%
    left_join(.,reg_2022, by = c("region" = "DEN_REG")) %>%
    st_as_sf() %>%
    ggplot() +
        geom_sf(fill=NA) +
        geom_point(color = "coral1",
        aes(size = total_missing, geometry = geometry),
        stat = "sf_coordinates") +
        theme_void() +
        theme(legend.position = "bottom")
```

total_missing   ●   0.1   ●   0.2   ●   0.3

Figure 5: Missingness of Price per Region

Finally, figure @ref(fig:missing_reg) shows that the proportion of missing data is not equal for each region.
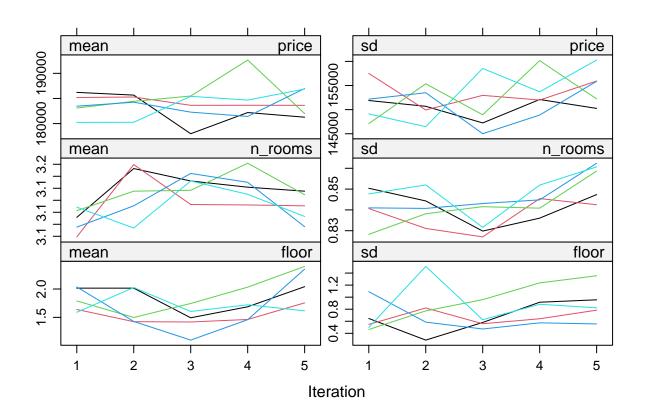
4.2.2 Conclusion

We explored if the missingness of the predictors and the outcome variable: house prices are related. From our results it appears that it does. Hence, it is unlikely that the missingness mechanism is MCAR. Therefore, we include an multiple imputation procedure before the creation of the prediction model in the next section.

4.3 Question 4: Relevant Predictors for Housing Price

As mentioned in the previous section, we will handle the missing data using a multiple imputation procedure. Subsequently, we are interested to find out which variables can predict house prices. For this purpose, we used two step-wise modeling strategies. The first strategy consists of a backward selection method based on the pooled estimates. The second strategy is a forward selection method applied to each imputed data set ($m = 5$) and variables are selected in the final that appear the majority of the models. The models will be compared based on their included predictors, pooled coefficient of determination, and Bayesian information criterion (BIC).

4.3.1 Preparation

```r
# fix seed for reproducibility
set.seed(1)

# reduced data set
housing_sampled <- cleaned_housing %>%
    # ungroup on location
    ungroup() %>%
    # sample 10000 records
    sample_n(10000) %>%
    # ignore location, and province information
    select(-location, -province)

# convergence of the algorithm
plot(imp)
```

```r
# plausibility of the imputed data
densityplot(imp, ~n_rooms + mq + floor + n_bathrooms + price, lwd = 2)
```

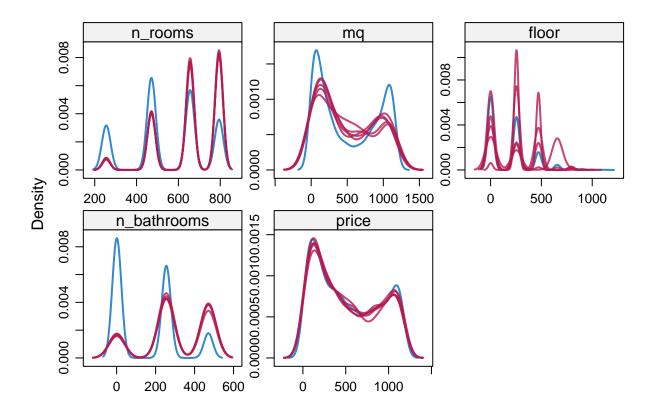To reduce the computation time of the imputation model, we sampled 10000 records from the initial data set. Further, for the scope of this exploratory research, we limited ourselves to simple random sampling and disregarding location and province as predictors. Furthermore, we limited the diagnostics for the imputation procedure to the convergence of the algorithm and plausibility of the imputed data. There appeared to be no convergence issues and the imputed data appeared to be plausible with respect to the observed data.

4.3.2 Analysis

The model based on backward selection method based on the pooled estimates contains 10 predictors: region, number of rooms, squared meters, number of bathrooms, energy class, type of home heating system, and the home including a terrace, alarm, pool, or elevator. The predictors in the model explain 40 percent of the variability observed in the house price.

```r
# define the scope of which predictors
scope <- list(upper = ~ region + n_rooms + floor + mq + n_bathrooms +
    energy_class + heating + has_garage + has_terrace + has_garden + has_balcony +
    has_fireplace + has_alarm + has_air_conditioning + has_pool + has_parking +
    has_elevator + is_furnished + property_age,
            lower = ~ 1)

# apply a forward selection method to each imputed data set
expr <- expression(f1 <- lm(price ~ 1),
                   f2 <- step(f1, scope = scope))
fit <- with(imp, expr)
```

```
Start:  AIC=238221
price ~ 1
```

	Df	Sum of Sq	RSS	AIC
+ n_bathrooms	2	54336502897827	167341038907972	235413
+ mq	1	50889310539286	170788231266514	235615
+ n_rooms	3	19431643153023	202245898652776	237310
+ has_pool	1	8774521787041	212903020018758	237819
+ region	19	6938088405072	214739453400727	237941
+ energy_class	11	6176473905456	215501067900343	237960
+ has_garden	1	2944709296933	218732832508867	238089
+ has_alarm	1	881756990898	220795784814901	238183
+ has_balcony	1	750446457390	220927095348409	238189
+ has_garage	1	319769708067	221357772097733	238209
+ has_terrace	1	287748875944	221389792929855	238210
+ has_air_conditioning	1	253559902276	221423981903524	238212
+ has_elevator	1	235059759974	221442482045825	238212
+ has_fireplace	1	166372771384	221511169034415	238216
+ is_furnished	1	151484247480	221526057558320	238216
+ heating	1	108665111335	221568876694464	238218
+ floor	1	58795129717	221618746676082	238220
<none>			221677541805799	238221
+ property_age	1	11474672209	221666067133590	238223
+ has_parking	1	517681	221677541288118	238223

Step: AIC=235413
price ~ n_bathrooms

	Df	Sum of Sq	RSS	AIC
+ mq	1	17410044009023	149930994898949	234317
+ region	19	7264378108319	160076660799654	235007
+ has_pool	1	5020658093888	162320380814084	235111
+ energy_class	11	3792919678881	163548119229092	235206
+ n_rooms	3	2153800911569	165187237996403	235290
+ has_garden	1	584694205114	166756344702859	235380
+ has_alarm	1	310988843260	167030050064713	235397
+ heating	1	194446548025	167146592359947	235404
+ has_air_conditioning	1	128084924620	167212953983352	235407
+ has_garage	1	124142204999	167216896702974	235408
+ has_terrace	1	110433206873	167230605701099	235409
+ is_furnished	1	106396135598	167234642772374	235409
+ has_balcony	1	84248116062	167256790791910	235410
<none>			167341038907972	235413
+ has_parking	1	18192656408	167322846251565	235414
+ has_elevator	1	11856544839	167329182363134	235414
+ property_age	1	3207306079	167337831601894	235415
+ has_fireplace	1	2069443647	167338969464325	235415
+ floor	1	1888258410	167339150649562	235415
- n_bathrooms	2	54336502897827	221677541805799	238221

Step: AIC=234317
price ~ n_bathrooms + mq

	Df	Sum of Sq	RSS	AIC
+ region	19	8023589005658	141907405893291	233805
+ energy_class	11	4620272521502	145310722377447	234026
+ has_pool	1	4152885276017	145778109622932	234038
+ heating	1	539541691034	149391453207915	234283
+ n_rooms	3	593154581373	149337840317576	234283

```
+ has_alarm              1     382716093411 149548278805538 234293
+ has_garden             1     269392773370 149661602125579 234301
+ has_terrace            1     209541658918 149721453240031 234305
+ has_garage             1     177723987371 149753270911578 234307
+ has_elevator           1     175113863340 149755881035609 234307
+ property_age           1     152641116702 149778353782247 234308
+ has_air_conditioning   1     111854692998 149819140205951 234311
<none>                                       149930994898949 234317
+ is_furnished           1      19302911311 149911691987638 234317
+ has_parking            1      13047557443 149917947341506 234318
+ floor                  1       4713659703 149926281239246 234318
+ has_fireplace          1        442199401 149930552699548 234319
+ has_balcony            1         27795610 149930967103339 234319
- mq                     1   17410044009023 167341038907972 235413
- n_bathrooms            2   20857236367565 170788231266514 235615

Step:  AIC=233805
price ~ n_bathrooms + mq + region

                        Df      Sum of Sq             RSS    AIC
+ energy_class          11  4860276170297 137047129722993 233478
+ has_pool               1  3663112684884 138244293208406 233545
+ n_rooms                3   607540237683 141299865655608 233768
+ heating                1   415902225470 141491503667821 233777
+ has_alarm              1   373367856349 141534038036942 233780
+ property_age           1   334643762946 141572762130344 233783
+ has_garden             1   240364432177 141667041461114 233790
+ has_elevator           1   206651903798 141700753989492 233792
+ has_terrace            1   191255145226 141716150748065 233793
+ has_garage             1   157528170023 141749877723267 233795
+ has_air_conditioning   1    93534212287 141813871681003 233800
<none>                                     141907405893291 233805
+ floor                  1    20731452092 141886674441198 233805
+ is_furnished           1     9071712319 141898334180971 233806
+ has_parking            1       29243607 141907376649684 233807
+ has_balcony            1        4498019 141907401395271 233807
+ has_fireplace          1        3115196 141907402778095 233807
- region                19  8023589005658 149930994898949 234317
- mq                     1 18169254906363 160076660799654 235007
- n_bathrooms            2 20951998359152 162859404252442 235178

Step:  AIC=233478
price ~ n_bathrooms + mq + region + energy_class

                        Df      Sum of Sq             RSS    AIC
+ has_pool               1  3480817875692 133566311847302 233223
+ n_rooms                3   577505904936 136469623818057 233442
+ heating                1   440011752537 136607117970456 233448
+ has_alarm              1   268737241556 136778392481438 233460
+ has_garden             1   195178006240 136851951716753 233466
+ has_elevator           1   154920879158 136892208843835 233469
+ has_terrace            1   125522114773 136921607608220 233471
+ has_air_conditioning   1    94752206037 136952377516956 233473
+ has_garage             1    93068449687 136954061273307 233473
+ property_age           1    88598625284 136958531097710 233474
+ floor                  1    31963414578 137015166308415 233478
```

```
<none>                             137047129722993 233478
+ is_furnished          1     13417360398 137033712362595 233479
+ has_fireplace         1      9508516056 137037621206937 233479
+ has_balcony           1       975128994 137046154593999 233480
+ has_parking           1       349746345 137046779976648 233480
- energy_class         11   4860276170297 141907405893291 233805
- region               19   8263592654454 145310722377447 234026
- n_bathrooms           2  18803827191218 155850956914211 234760
- mq                    1  19367401337231 156414531060224 234798
```

Step: AIC=233223
price ~ n_bathrooms + mq + region + energy_class + has_pool

```
                       Df      Sum of Sq             RSS    AIC
+ n_rooms              3   573634238948 132992677608354 233186
+ heating              1   472202192146 133094109655156 233189
+ has_alarm            1   206832014796 133359479832506 233209
+ has_elevator         1   151029005594 133415282841708 233213
+ property_age         1    72652673164 133493659174137 233219
+ has_terrace          1    63989269140 133502322578162 233220
+ has_garden           1    59393677424 133506918169878 233220
+ has_garage           1    49148361032 133517163486269 233221
+ has_air_conditioning 1    41985059548 133524326787753 233222
+ floor                1    37979561225 133528332286077 233222
<none>                             133566311847302 233223
+ is_furnished         1     6968733536 133559343113766 233224
+ has_fireplace        1     4718071557 133561593775744 233224
+ has_balcony          1     1807850141 133564503997161 233225
+ has_parking          1     1799719874 133564512127428 233225
- has_pool             1   3480817875691 137047129722993 233478
- energy_class        11   4677981361104 138244293208406 233545
- region              19   7689206690012 141255518537314 233745
- n_bathrooms          2  17722303889331 151288615736633 234465
- mq                   1  18451389648549 152017701495851 234515
```

Step: AIC=233186
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    n_rooms

```
                       Df      Sum of Sq             RSS    AIC
+ heating              1   494073069815 132498604538539 233151
+ has_alarm            1   197321213835 132795356394519 233173
+ has_elevator         1   144618048186 132848059560168 233177
+ property_age         1    72400274945 132920277333409 233182
+ has_terrace          1    64536266721 132928141341633 233183
+ has_garden           1    48957564971 132943720043383 233184
+ has_air_conditioning 1    39851547519 132952826060835 233185
+ has_garage           1    36464459313 132956213149041 233185
+ floor                1    34037187631 132958640420723 233185
<none>                             132992677608354 233186
+ is_furnished         1     8232116247 132984445492107 233187
+ has_fireplace        1     4553909926 132988123698428 233187
+ has_parking          1     2509150507 132990168457847 233188
+ has_balcony          1      715398434 132991962209920 233188
- n_rooms              3   573634238948 133566311847302 233223
- has_pool             1   3476946209703 136469623818057 233442
```

```
- energy_class          11   4647573287062 137640250895416 233507
- region                19   7715560869437 140708238477792 233712
- n_bathrooms            2  15586705271215 148579382879569 234290
- mq                     1  16631746933302 149624424541656 234362

Step:  AIC=233151
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    n_rooms + heating

                          Df      Sum of Sq             RSS    AIC
+ has_alarm               1    204843507561 132293761030978 233137
+ has_elevator            1     98411243159 132400193295380 233145
+ has_garden              1     72242786132 132426361752407 233147
+ has_terrace             1     67576558277 132431027980262 233147
+ property_age            1     62338362949 132436266175591 233148
+ has_air_conditioning    1     39911967233 132458692571306 233150
+ has_garage              1     31451446180 132467153092359 233150
<none>                                      132498604538539 233151
+ floor                   1      9332033562 132489272504977 233152
+ is_furnished            1      7026620411 132491577918128 233152
+ has_fireplace           1      2080968383 132496523570157 233152
+ has_parking             1      1394710193 132497209828346 233152
+ has_balcony             1         3105452 132498601433087 233153
- heating                 1    494073069815 132992677608354 233186
- n_rooms                 3    595505116617 133094109655156 233189
- has_pool                1   3510673281402 136009277819941 233410
- energy_class           11   4672897327945 137171501866484 233475
- region                 19   7616475535962 140115080074502 233671
- n_bathrooms             2  15776748010528 148275352549067 234272
- mq                      1  16928449047062 149427053585601 234351

Step:  AIC=233137
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    n_rooms + heating + has_alarm

                          Df      Sum of Sq             RSS    AIC
+ has_elevator            1     95314455613 132198446575365 233132
+ has_terrace             1     60780903001 132232980127977 233134
+ property_age            1     57063047698 132236697983281 233135
+ has_garden              1     52466302435 132241294728543 233135
<none>                                      132293761030978 233137
+ has_air_conditioning    1     25292870698 132268468160280 233137
+ has_garage              1     17232110863 132276528920116 233138
+ floor                   1      9827090257 132283933940722 233138
+ is_furnished            1      5618761773 132288142269205 233139
+ has_fireplace           1      5018488883 132288742542095 233139
+ has_parking             1      1734315344 132292026715634 233139
+ has_balcony             1       261904493 132293499126485 233139
- has_alarm               1    204843507561 132498604538539 233151
- heating                 1    501595363541 132795356394519 233173
- n_rooms                 3    585842297252 132879603328230 233175
- has_pool                1   3449114985392 135742876016371 233392
- energy_class           11   4586379352841 136880140383819 233456
- region                 19   7620653890046 139914414921024 233659
- n_bathrooms             2  15597938323944 147891699354923 234248
- mq                      1  16982975237389 149276736268367 234343
```

```
Step:  AIC=233132
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    n_rooms + heating + has_alarm + has_elevator

                        Df      Sum of Sq              RSS    AIC
+ has_garden             1     61159148117  132137287427248  233129
+ property_age           1     54445740063  132144000835302  233130
+ has_terrace            1     51902218547  132146544356818  233130
<none>                                      132198446575365  233132
+ has_air_conditioning   1     16249326429  132182197248936  233133
+ has_garage             1      9421525948  132189025049417  233133
+ floor                  1      5355425136  132193091150229  233133
+ has_fireplace          1      4836223957  132193610351408  233133
+ is_furnished           1      4014132029  132194432443336  233134
+ has_balcony            1      3945344067  132194501231298  233134
+ has_parking            1      3056677261  132195389898105  233134
- has_elevator           1     95314455613  132293761030978  233137
- has_alarm              1    201746720015  132400193295380  233145
- heating                1    455580369762  132654026945128  233164
- n_rooms                3    579676525022  132778123100387  233170
- has_pool               1   3445143311113  135643589886478  233387
- energy_class          11   4547727289616  136746173864981  233448
- region                19   7640781006174  139839227581539  233656
- n_bathrooms            2  15658500788593  147856947363958  234247
- mq                     1  17075103321421  149273549896786  234345

Step:  AIC=233129
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    n_rooms + heating + has_alarm + has_elevator + has_garden

                        Df      Sum of Sq              RSS    AIC
+ property_age           1     50541863348  132086745563900  233127
+ has_terrace            1     42267654699  132095019772549  233128
<none>                                      132137287427248  233129
+ has_fireplace          1     10356669792  132126930757456  233130
+ has_air_conditioning   1      8459032832  132128828394416  233131
+ floor                  1      6360867435  132130926559813  233131
+ has_balcony            1      5365990505  132131921436744  233131
+ has_parking            1      4476246517  132132811180732  233131
+ is_furnished           1      2876818714  132134410608534  233131
+ has_garage             1      2441621608  132134845805640  233131
- has_garden             1     61159148117  132198446575365  233132
- has_elevator           1    104007301295  132241294728543  233135
- has_alarm              1    180550093526  132317837520774  233141
- heating                1    474203658450  132611491085698  233163
- n_rooms                3    568535243653  132705822670902  233166
- has_pool               1   3313268205837  135450555633085  233375
- energy_class          11   4529960529561  136667247956809  233444
- region                19   7640720222268  139778007649516  233653
- n_bathrooms            2  15454489282464  147591776709712  234231
- mq                     1  16988907775051  149126195202299  234337

Step:  AIC=233127
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    n_rooms + heating + has_alarm + has_elevator + has_garden +
```

```
      property_age

                         Df        Sum of Sq              RSS     AIC
+ has_terrace             1        40966203128  132045779360772  233126
<none>                                          132086745563900  233127
+ has_fireplace           1        10149888787  132076595675113  233129
+ has_air_conditioning    1         8861596288  132077883967612  233129
+ floor                   1         6505764824  132080239799076  233129
+ has_balcony             1         6190334826  132080555229074  233129
+ has_parking             1         4221677144  132082523886756  233129
+ is_furnished            1         2821165542  132083924398357  233129
- property_age            1        50541863348  132137287427248  233129
+ has_garage              1         1582501606  132085163062294  233129
- has_garden              1        57255271402  132144000835302  233130
- has_elevator            1       101074575946  132187820139846  233133
- has_alarm               1       176568314083  132263313877983  233139
- heating                 1       465132493162  132551878057062  233161
- n_rooms                 3       568995401445  132655740965345  233164
- has_pool                1      3304490097943  135391235661843  233372
- energy_class           11      4340507785764  136427253349664  233429
- region                 19      7690265127321  139777010691221  233655
- n_bathrooms             2     15370944013976  147457689577876  234224
- mq                      1     17030709774998  149117455338898  234338

Step:  AIC=233126
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    n_rooms + heating + has_alarm + has_elevator + has_garden +
    property_age + has_terrace

                         Df        Sum of Sq              RSS     AIC
<none>                                          132045779360772  233126
+ has_fireplace           1        14919973103  132030859387669  233127
- has_terrace             1        40966203128  132086745563900  233127
+ has_balcony             1         8921712424  132036857648348  233128
+ floor                   1         6374898958  132039404461814  233128
+ has_parking             1         5403389335  132040375971437  233128
- has_garden              1        48146187939  132093925548711  233128
- property_age            1        49240411777  132095019772549  233128
+ has_air_conditioning    1         3330173048  132042449187724  233128
+ is_furnished            1         2391329915  132043388030857  233128
+ has_garage              1           16401897  132045762958875  233128
- has_elevator            1        92158271849  132137937632621  233131
- has_alarm               1       173030550983  132218809911755  233137
- heating                 1       467539374870  132513318735641  233160
- n_rooms                 3       570786122994  132616565483766  233163
- has_pool                1      3266672536707  135312451897478  233369
- energy_class           11      4313238661697  136359018022469  233426
- region                 19      7680353416340  139726132777112  233654
- n_bathrooms             2     15319005444085  147364784804857  234220
- mq                      1     17063860089851  149109639450623  234340
Start:  AIC=238364
price ~ 1

                         Df        Sum of Sq              RSS     AIC
+ n_bathrooms             2     55797405750737  169061397861259  235515
+ mq                      1     53531930281789  171326873330207  235647
```

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+ n_rooms               3 19675066210920 205183737401076 237454
+ has_pool              1  9215271803956 215643531808040 237947
+ energy_class         11  6499048268387 218359755343609 238092
+ region               19  6564944794857 218293858817139 238105
+ has_garden            1  2681816135799 222176987476197 238246
+ has_balcony           1  1034719585301 223824084026695 238319
+ has_alarm             1   834117900908 224024685711088 238328
+ has_terrace           1   301169606944 224557634005052 238352
+ has_air_conditioning  1   237929526960 224620874085036 238355
+ has_garage            1   230011340285 224628792271712 238355
+ has_elevator          1   204447197869 224654356414127 238356
+ has_fireplace         1   150649919457 224708153692539 238359
+ heating               1   128177106483 224730626505513 238360
+ is_furnished          1    62490486124 224796313125872 238363
<none>                                    224858803611996 238364
+ property_age          1    33023437820 224825780174176 238364
+ floor                 1    26290180445 224832513431551 238364
+ has_parking           1        25703    224858803586293 238366

Step:  AIC=235515
price ~ n_bathrooms

                       Df      Sum of Sq             RSS    AIC
+ mq                    1 18374058455989 150687339405270 234367
+ region               19  6783376412852 162278021448407 235144
+ has_pool              1  5317937130060 163743460731199 235198
+ energy_class         11  4061793658768 164999604202491 235294
+ n_rooms               3  2191219626729 166870178234530 235391
+ has_garden            1   463047731070 168598350130189 235490
+ has_alarm             1   292931275274 168768466585985 235500
+ has_balcony           1   178093927216 168883303934043 235507
+ heating               1   148285772237 168913112089022 235509
+ has_air_conditioning  1   135896223485 168925501637774 235509
+ has_terrace           1    93332711808 168968065149450 235512
+ has_garage            1    72408067346 168988989793913 235513
+ is_furnished          1    37577003517 169023820857742 235515
+ floor                 1    36541636063 169024856225196 235515
<none>                                    169061397861259 235515
+ has_elevator          1    25598147053 169035799714205 235516
+ property_age          1    16685863484 169044711997775 235516
+ has_parking           1    15891082871 169045506778388 235516
+ has_fireplace         1      441003430 169060956857829 235517
- n_bathrooms           2 55797405750737 224858803611996 238364

Step:  AIC=234367
price ~ n_bathrooms + mq

                       Df      Sum of Sq             RSS    AIC
+ region               19  7593880644200 143093458761070 233888
+ energy_class         11  5063186058622 145624153346647 234047
+ has_pool              1  4312366711708 146374972693562 234079
+ heating               1   494923636334 150192415768935 234336
+ n_rooms               3   414181000988 150273158404281 234345
+ has_alarm             1   351322788579 150336016616691 234346
+ has_elevator          1   226535076668 150460804328601 234354
+ has_terrace           1   202203326640 150485136078629 234355
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+ has_garden              1    191986317473 150495353087797 234356
+ property_age            1    122790503163 150564548902107 234361
+ has_air_conditioning    1    117900812583 150569438592687 234361
+ has_garage              1    117824665706 150569514739564 234361
+ floor                   1     76807553995 150610531851275 234364
<none>                                      150687339405270 234367
+ has_balcony             1     14340128188 150672999277082 234368
+ has_parking             1     13712111648 150673627293622 234368
+ has_fireplace           1      2866697971 150684472707298 234369
+ is_furnished            1        51584072 150687287821197 234369
- mq                      1  18374058455989 169061397861259 235515
- n_bathrooms             2  20639533924937 171326873330207 235647

Step:  AIC=233888
price ~ n_bathrooms + mq + region

                         Df     Sum of Sq             RSS    AIC
+ energy_class           11 5435819485465 137657639275605 233523
+ has_pool                1 3820331279848 139273127481222 233619
+ heating                 1  401067838511 142692390922559 233862
+ n_rooms                 3  420184850615 142673273910455 233864
+ has_alarm               1  342080507586 142751378253484 233866
+ property_age            1  293931174539 142799527586531 233869
+ has_elevator            1  266038635305 142827420125764 233871
+ has_terrace             1  182778385524 142910680375546 233877
+ has_garden              1  174420137627 142919038623443 233878
+ floor                   1  131508671841 142961950089229 233881
+ has_garage              1  109894621014 142983564140056 233882
+ has_air_conditioning    1  104136738139 142989322022931 233883
<none>                                     143093458761070 233888
+ has_balcony             1   11785365561 143081673395509 233889
+ has_fireplace           1    1863138341 143091595622728 233890
+ is_furnished            1    1235765765 143092222995305 233890
+ has_parking             1      74905196 143093383855874 233890
- region                 19 7593880644200 150687339405270 234367
- mq                      1 19184562687337 162278021448407 235144
- n_bathrooms             2 20623637806856 163717096567926 235230

Step:  AIC=233522
price ~ n_bathrooms + mq + region + energy_class

                         Df     Sum of Sq             RSS    AIC
+ has_pool                1 3624547199899 134033092075706 233258
+ heating                 1  412577292261 137245061983344 233494
+ n_rooms                 3  410644187146 137246995088459 233499
+ has_alarm               1  236214321583 137421424954022 233507
+ has_elevator            1  214718230221 137442921045384 233509
+ floor                   1  154336407900 137503302867705 233513
+ has_garden              1  140546840128 137517092435477 233514
+ has_terrace             1  119995996889 137537643278716 233516
+ has_air_conditioning    1  112183985338 137545455290267 233516
+ property_age            1   60649311160 137596989964445 233520
+ has_garage              1   58292950600 137599346325005 233520
<none>                                     137657639275605 233523
+ has_fireplace           1    5093283980 137652545991624 233524
+ has_balcony             1    4187511092 137653451764513 233524
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+ has_parking            1       610144400 137657029131205 233524
+ is_furnished           1        69261895 137657570013710 233524
- energy_class          11   5435819485465 143093458761070 233888
- region                19   7966514071042 145624153346647 234047
- n_bathrooms            2  18377522136314 156035161411919 234772
- mq                     1  20589416184431 158247055460036 234914

Step:  AIC=233258
price ~ n_bathrooms + mq + region + energy_class + has_pool

                         Df      Sum of Sq             RSS    AIC
+ heating                1    444571773388 133588520302318 233226
+ n_rooms                3    412206710568 133620885365138 233233
+ has_elevator           1    209256014980 133823836060726 233244
+ has_alarm              1    176883832775 133856208242931 233246
+ floor                  1    155324250693 133877767825013 233248
+ has_terrace            1     59223472174 133973868603532 233255
+ has_air_conditioning   1     52326579850 133980765495856 233256
+ property_age           1     46539595030 133986552480676 233256
+ has_garden             1     29616981412 134003475094294 233257
<none>                                      134033092075706 233258
+ has_garage             1     24268965662 134008823110044 233258
+ has_fireplace          1      9732038350 134023360037356 233259
+ has_balcony            1      2884970298 134030207105408 233259
+ is_furnished           1      1707900559 134031384175147 233260
+ has_parking            1      1406308671 134031685767035 233260
- has_pool               1   3624547199899 137657639275605 233523
- energy_class          11   5240035405516 139273127481222 233619
- region                19   7378732452516 141411824528222 233756
- n_bathrooms            2  17350860331330 151383952407036 234471
- mq                     1  19531338672552 153564430748258 234616

Step:  AIC=233226
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating

                         Df      Sum of Sq             RSS    AIC
+ n_rooms                3    428610556668 133159909745650 233200
+ has_alarm              1    183875417362 133404644884956 233215
+ has_elevator           1    155873197800 133432647104519 233217
+ has_terrace            1     61935692513 133526584609805 233224
+ floor                  1     61472040978 133527048261340 233224
+ has_air_conditioning   1     52512995655 133536007306663 233225
+ has_garden             1     47591072323 133540929229996 233225
+ property_age           1     38784643625 133549735658694 233226
<none>                                      133588520302318 233226
+ has_garage             1     20707058922 133567813243397 233227
+ has_fireplace          1      6030781877 133582489520441 233228
+ has_balcony            1      6001086290 133582519216029 233228
+ is_furnished           1      2325118531 133586195183788 233228
+ has_parking            1       659804581 133587860497737 233228
- heating                1    444571773388 134033092075706 233258
- has_pool               1   3656541681026 137245061983344 233494
- energy_class          11   5248041686506 138836561988825 233590
- region                19   7311766356532 140900286658850 233721
- n_bathrooms            2  17560893594621 151149413896939 234457
```

```
- mq                        1 19870087590510 153458607892828 234611


Step:  AIC=233200
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms

                        Df      Sum of Sq            RSS    AIC
+ has_alarm             1    177843632381 132982066113269 233189
+ has_elevator          1    148792307638 133011117438012 233191
+ has_terrace           1     61733773854 133098175971797 233198
+ floor                 1     57487497171 133102422248480 233198
+ has_air_conditioning  1     52022532522 133107887213128 233198
+ has_garden            1     41337450111 133118572295539 233199
+ property_age          1     36875302194 133123034443456 233200
<none>                                     133159909745650 233200
+ has_garage            1     12814792829 133147094952821 233201
+ has_balcony           1      7776041836 133152133703814 233202
+ has_fireplace         1      5808657836 133154101087814 233202
+ is_furnished          1      1756961041 133158152784610 233202
+ has_parking           1       479305781 133159430439869 233202
- n_rooms               3    428610556668 133588520302318 233226
- heating               1    460975619488 133620885365138 233233
- has_pool              1   3659764466893 136819674212544 233469
- energy_class         11   5237725864761 138397635610411 233564
- region               19   7321555497094 140481465242744 233698
- n_bathrooms           2  15527385124774 148687294870425 234299
- mq                    1  17790384747017 150950294492667 234452


Step:  AIC=233189
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm

                        Df      Sum of Sq            RSS    AIC
+ has_elevator          1    145163081189 132836903032079 233180
+ floor                 1     58049388431 132924016724838 233187
+ has_terrace           1     55672589496 132926393523773 233187
+ has_air_conditioning  1     36167512434 132945898600835 233188
+ property_age          1     33065484908 132949000628361 233188
+ has_garden            1     27600296919 132954465816349 233189
<none>                                     132982066113269 233189
+ has_balcony           1     11054220525 132971011892744 233190
+ has_fireplace         1      9948036259 132972118077010 233190
+ has_garage            1      4889694993 132977176418276 233191
+ is_furnished          1      2519156786 132979546956483 233191
+ has_parking           1       674983010 132981391130259 233191
- has_alarm             1    177843632381 133159909745650 233200
- n_rooms               3    422578771688 133404644884957 233215
- heating               1    467773749856 133449839863125 233222
- has_pool              1   3600049479762 136582115593031 233454
- energy_class         11   5149882552774 138131948666043 233547
- region               19   7325599682368 140307665795636 233687
- n_bathrooms           2  15378618824211 148360684937480 234279
- mq                    1  17842124430283 150824190543552 234446


Step:  AIC=233180
price ~ n_bathrooms + mq + region + energy_class + has_pool +
```

```
        heating + n_rooms + has_alarm + has_elevator

                            Df        Sum of Sq                  RSS      AIC
+ has_terrace                1      45238334438   132791664697642   233179
+ floor                      1      38387274599   132798515757480   233179
+ has_garden                 1      35478637002   132801424395078   233179
+ property_age               1      30667983251   132806235048828   233180
+ has_balcony                1      26762045091   132810140986988   233180
<none>                                            132836903032079   233180
+ has_air_conditioning       1      22916282169   132813986749910   233180
+ has_fireplace              1       9643941706   132827259090373   233181
+ is_furnished               1       4168553897   132832734478182   233182
+ has_parking                1       1829882296   132835073149783   233182
+ has_garage                 1        735759578   132836167272501   233182
- has_elevator               1     145163081190   132982066113269   233189
- has_alarm                  1     174214405933   133011117438012   233191
- n_rooms                    3     415632548225   133252535580305   233205
- heating                    1     414534669097   133251437701176   233209
- has_pool                   1    3594482837782   136431385869861   233445
- energy_class              11    5110999223822   137947902255901   233536
- region                    19    7350295688757   140187198720837   233681
- n_bathrooms                2   15460006850230   148296909882310   234277
- mq                         1   17971873962660   150808776994739   234447

Step:  AIC=233179
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_elevator + has_terrace

                            Df        Sum of Sq                  RSS      AIC
+ floor                      1      38272129836   132753392567806   233178
+ has_balcony                1      32851657530   132758813040112   233178
+ property_age               1      29433439357   132762231258285   233178
+ has_garden                 1      28646012841   132763018684801   233178
<none>                                            132791664697642   233179
+ has_fireplace              1      15135096448   132776529601194   233179
+ has_air_conditioning       1      12537053747   132779127643895   233180
- has_terrace                1      45238334438   132836903032079   233180
+ is_furnished               1       4878384628   132786786313014   233180
+ has_parking                1       2759357989   132788905339653   233180
+ has_garage                 1        190534031   132791474163611   233181
- has_elevator               1     134728826132   132926393523773   233187
- has_alarm                  1     168908168140   132960572865782   233189
- n_rooms                    3     415805313774   133207470011415   233204
- heating                    1     418372064259   133210036761901   233208
- has_pool                   1    3542078564527   136333743262169   233440
- energy_class              11    5078139703594   137869804401235   233532
- region                    19    7340093173067   140131757870708   233679
- n_bathrooms                2   15366813343961   148158478041603   234270
- mq                         1   18008693782532   150800358480173   234448

Step:  AIC=233178
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_elevator + has_terrace +
    floor

                            Df        Sum of Sq                  RSS      AIC
```

```
+ has_balcony            1      31952917903 132721439649903 233177
+ has_garden             1      30951401032 132722441166774 233177
+ property_age           1      29291536014 132724101031792 233178
<none>                                      132753392567806 233178
- floor                  1      38272129836 132791664697642 233179
+ has_fireplace          1      14487132019 132738905435787 233179
+ has_air_conditioning   1      12498033459 132740894534347 233179
- has_terrace            1      45123189674 132798515757480 233179
+ is_furnished           1       4607087490 132748785480315 233179
+ has_parking            1       2528917209 132750863650597 233180
+ has_garage             1         59607467 132753332960338 233180
- has_elevator           1     115959824149 132869352391955 233184
- has_alarm              1     169583674102 132922976241908 233189
- heating                1     346275496641 133099668064447 233202
- n_rooms                3     413030457201 133166423025007 233203
- has_pool               1    3540809796850 136294202364656 233439
- energy_class          11    5089557493767 137842950061573 233532
- region                19    7364199969632 140117592537438 233680
- n_bathrooms            2   15383130971435 148136523539240 234270
- mq                     1   17993212225369 150746604793174 234447

Step:  AIC=233177
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_elevator + has_terrace +
    floor + has_balcony

                        Df     Sum of Sq             RSS    AIC
+ has_garden             1      33230203651 132688209446252 233177
+ property_age           1      30783759602 132690655890301 233177
<none>                                      132721439649903 233177
- has_balcony            1      31952917903 132753392567806 233178
+ has_air_conditioning   1      20054149704 132701385500199 233178
- floor                  1      37373390209 132758813040112 233178
+ has_fireplace          1      11177642598 132710262007305 233178
+ is_furnished           1       3463228132 132717976421771 233179
+ has_parking            1       2116328768 132719323321135 233179
- has_terrace            1      51116789028 132772556438931 233179
+ has_garage             1        523930225 132720915719678 233179
- has_elevator           1     131609948818 132853049598721 233185
- has_alarm              1     174766211714 132896205861617 233188
- heating                1     351336895081 133072776544984 233202
- n_rooms                3     416172977825 133137612627728 233203
- has_pool               1    3532312464299 136253752114202 233438
- energy_class          11    5062872168793 137784311818696 233530
- region                19    7363797653921 140085237303824 233679
- n_bathrooms            2   15342960650111 148064400300014 234267
- mq                     1   17883584274665 150605023924568 234439

Step:  AIC=233177
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_elevator + has_terrace +
    floor + has_balcony + has_garden

                        Df     Sum of Sq             RSS    AIC
+ property_age           1      28704126187 132659505320065 233177
<none>                                      132688209446252 233177
```

```
- has_garden             1    33230203651 132721439649903 233177
- has_balcony            1    34231720522 132722441166774 233177
+ has_fireplace          1    16230579704 132671978866548 233178
+ has_air_conditioning   1    14154481848 132674054964404 233178
- floor                  1    39707540694 132727916986946 233178
- has_terrace            1    43550944197 132731760390448 233178
+ is_furnished           1     4277097472 132683932348780 233179
+ has_parking            1     2889191145 132685320255107 233179
+ has_garage             1       98045851 132688111400400 233179
- has_elevator           1   139581171880 132827790618132 233185
- has_alarm              1   160514742987 132848724189239 233187
- n_rooms                3   410566376358 133098775822609 233202
- heating                1   361628709447 133049838155698 233202
- has_pool               1  3428184997165 136116394443417 233430
- energy_class          11  5054333565666 137742543011918 233529
- region                19  7367947067865 140056156514117 233679
- n_bathrooms            2 15200801245337 147889010691589 234257
- mq                     1 17823257391931 150511466838183 234435

Step:  AIC=233177
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_elevator + has_terrace +
    floor + has_balcony + has_garden + property_age

                         Df     Sum of Sq             RSS    AIC
<none>                                    132659505320065 233177
- property_age           1    28704126187 132688209446252 233177
- has_garden             1    31150570236 132690655890301 233177
- has_balcony            1    35647334340 132695152654404 233177
+ has_fireplace          1    15930930318 132643574389747 233177
+ has_air_conditioning   1    14858303871 132644647016194 233178
- floor                  1    39468318252 132698973638317 233178
- has_terrace            1    42714361054 132702219681119 233178
+ is_furnished           1     4302607237 132655202712827 233178
+ has_parking            1     2709906554 132656795413511 233178
+ has_garage             1      263992444 132659241327621 233179
- has_elevator           1   137690249378 132797195569443 233185
- has_alarm              1   157784760580 132817290080645 233187
- n_rooms                3   409239896898 133068745216963 233201
- heating                1   356142892943 133015648213007 233201
- has_pool               1  3421073303550 136080578623614 233429
- energy_class          11  4880034018467 137539539338532 233516
- region                19  7395973171859 140055478491924 233681
- n_bathrooms            2 15126828896284 147786334216348 234252
- mq                     1 17825382578640 150484887898705 234435
Start:  AIC=238270
price ~ 1

                         Df     Sum of Sq             RSS    AIC
+ n_bathrooms            2 53782230389404 168981418584563 235511
+ mq                     1 53730360295692 169033288678274 235512
+ n_rooms                3 20046648231173 202717000742794 237333
+ has_pool               1  7929109944155 214834539029811 237909
+ region                19  6617877940370 216145771033597 238006
+ energy_class          11  5724680949685 217038968024282 238032
+ has_garden             1  3263653319723 219499995654244 238124
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+ has_balcony              1      887627519705  221876021454262  238232
+ has_alarm                1      845212927343  221918436046624  238234
+ has_terrace              1      333589217169  222430059756798  238257
+ has_garage               1      314395330244  222449253643722  238258
+ has_air_conditioning     1      272281716971  222491367256996  238260
+ has_elevator             1      207205729318  222556443244649  238263
+ has_fireplace            1      166634855844  222597014118122  238264
+ is_furnished             1      166617816547  222597031157420  238264
+ heating                  1      158355774296  222605293199671  238265
<none>                                          222763648973967  238270
+ property_age             1       12566180762  222751082793205  238271
+ floor                    1        1563158911  222762085815056  238272
+ has_parking              1          38228692  222763610745274  238272

Step:  AIC=235511
price ~ n_bathrooms

                          Df       Sum of Sq             RSS     AIC
+ mq                       1  19230163850360  149751254734203  234305
+ region                  19   6823074188625  162158344395938  235137
+ has_pool                 1   4219894100767  164761524483796  235260
+ energy_class            11   3385920923034  165595497661529  235330
+ n_rooms                  3   2279582568544  166701836016018  235381
+ has_garden               1     769966971065  168211451613498  235467
+ has_alarm                1     319857727219  168661560857344  235494
+ has_air_conditioning     1     147617468636  168833801115927  235504
+ has_balcony              1     129353350338  168852065234225  235505
+ heating                  1     114887382441  168866531202122  235506
+ is_furnished             1     113953774998  168867464809565  235506
+ has_terrace              1     113209493496  168868209091067  235506
+ has_garage               1     101365408703  168880053175860  235507
<none>                                         168981418584563  235511
+ floor                    1      22339722365  168959078862198  235511
+ has_parking              1      16864410998  168964554173565  235512
+ has_elevator             1      15645650207  168965772934356  235512
+ property_age             1      12081841793  168969336742770  235512
+ has_fireplace            1       2357047359  168979061537204  235513
- n_bathrooms              2  53782230389404  222763648973967  238270

Step:  AIC=234305
price ~ n_bathrooms + mq

                          Df       Sum of Sq             RSS     AIC
+ region                  19   7514718447699  142236536286504  233828
+ energy_class            11   4332117355177  145419137379026  234033
+ has_pool                 1   3440301619041  146310953115162  234074
+ heating                  1     431285403882  149319969330321  234278
+ has_garden               1     387328434580  149363926299623  234281
+ has_alarm                1     360374840685  149390879893518  234282
+ n_rooms                  3     387232876016  149364021858187  234285
+ has_terrace              1     237366472418  149513888261785  234291
+ has_elevator             1     206474235566  149544780498637  234293
+ has_garage               1     161583433025  149589671301178  234296
+ property_age             1     139586941745  149611667792458  234297
+ has_air_conditioning     1     126479998872  149624774735331  234298
<none>                                         149751254734203  234305
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```
+ floor                    1      28369685534 149722885048670 234305
+ is_furnished             1      25874771955 149725379962248 234305
+ has_parking              1      12915081472 149738339652731 234306
+ has_balcony              1       2218988353 149749035745850 234306
+ has_fireplace            1        247635370 149751007098833 234307
- mq                       1 19230163850360 168981418584563 235511
- n_bathrooms              2 19282033944071 169033288678274 235512

Step:  AIC=233828
price ~ n_bathrooms + mq + region

                          Df      Sum of Sq             RSS     AIC
+ energy_class            11   4634572564828 137601963721677 233518
+ has_pool                 1   3018539430067 139217996856438 233615
+ has_garden               1    362702204751 141873834081754 233804
+ has_alarm                1    352076326253 141884459960251 233805
+ n_rooms                  3    405202038632 141831334247873 233805
+ heating                  1    344803702948 141891732583556 233805
+ property_age             1    296498320237 141940037966268 233809
+ has_elevator             1    238235498754 141998300787751 233813
+ has_terrace              1    219806525758 142016729760747 233814
+ has_garage               1    145513789108 142091022497397 233819
+ has_air_conditioning     1    109104067344 142127432219161 233822
+ floor                    1     42737385724 142193798900780 233827
<none>                                       142236536286504 233828
+ is_furnished             1     13127230067 142223409056437 233829
+ has_balcony              1      2147400870 142234388885634 233830
+ has_parking              1         2859868 142236533426636 233830
+ has_fireplace            1         1135689 142236535150815 233830
- region                  19   7514718447699 149751254734203 234305
- n_bathrooms              2  19362083402647 161598619689151 235100
- mq                       1  19921808109433 162158344395938 235137

Step:  AIC=233518
price ~ n_bathrooms + mq + region + energy_class

                          Df      Sum of Sq             RSS     AIC
+ has_pool                 1   2845001265524 134756962456153 233312
+ heating                  1    350950650459 137251013071218 233495
+ n_rooms                  3    392408971324 137209554750353 233496
+ has_garden               1    312415645187 137289548076490 233498
+ has_alarm                1    247469992866 137354493728811 233502
+ has_elevator             1    184388429661 137417575292016 233507
+ has_terrace              1    152928509196 137449035212481 233509
+ has_air_conditioning     1    112742063722 137489221657955 233512
+ has_garage               1     84022963219 137517940758458 233514
+ property_age             1     73208297668 137528755424009 233515
+ floor                    1     72630563375 137529333158302 233515
<none>                                       137601963721677 233518
+ is_furnished             1     20206404167 137581757317510 233519
+ has_fireplace            1     10320254711 137591643466965 233520
+ has_parking              1       652296678 137601311424999 233520
+ has_balcony              1        70996720 137601892724957 233520
- energy_class            11   4634572564828 142236536286504 233828
- region                  19   7817173657349 145419137379026 234033
- n_bathrooms              2  17230201863132 154832165584809 234694
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- mq                      1 21249724793543 158851688515220 234953


Step:  AIC=233312
price ~ n_bathrooms + mq + region + energy_class + has_pool

                          Df       Sum of Sq             RSS    AIC
+ heating                  1   378115694937  134378846761216 233285
+ n_rooms                  3   398172557215  134358789898938 233288
+ has_alarm                1   193341245522  134563621210632 233299
+ has_elevator             1   180106152360  134576856303793 233300
+ has_garden               1   145547401783  134611415054370 233303
+ has_terrace              1    89671199693  134667291256460 233307
+ floor                    1    73293150348  134683669305805 233308
+ property_age             1    60644848439  134696317607714 233309
+ has_air_conditioning     1    58495875145  134698466581009 233309
+ has_garage               1    46175593824  134710786862329 233310
<none>                                       134756962456153 233312
+ is_furnished             1    12553459110  134744408997044 233313
+ has_fireplace            1     2373986230  134754588469924 233313
+ has_parking              1      860337930  134756102118224 233313
+ has_balcony              1        2815988  134756959640166 233314
- has_pool                 1  2845001265524  137601963721677 233518
- energy_class            11  4461034400284  139217996856438 233615
- region                  19  7317447537757  142074409993910 233802
- n_bathrooms              2 16214632399483  150971594855636 234444
- mq                       1 20435633987323  155192596443477 234721


Step:  AIC=233285
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating

                          Df       Sum of Sq             RSS    AIC
+ n_rooms                  3   412857737259  133965989023957 233261
+ has_alarm                1   199931861912  134178914899304 233273
+ has_garden               1   180233030037  134198613731180 233274
+ has_elevator             1   134355052435  134244491708781 233277
+ has_terrace              1    92669655617  134286177105600 233281
+ has_air_conditioning     1    58583971906  134320262789310 233283
+ property_age             1    52221138098  134326625623118 233284
+ floor                    1    51178208889  134327668552327 233284
+ has_garage               1    41498035065  134337348726151 233284
<none>                                       134378846761216 233285
+ is_furnished             1    11175426615  134367671334602 233287
+ has_fireplace            1      852335618  134377994425599 233287
+ has_balcony              1      406334914  134378440426302 233287
+ has_parking              1      336655880  134378510105337 233287
- heating                  1   378115694937  134756962456153 233312
- has_pool                 1  2872166310002  137251013071218 233495
- energy_class            11  4464143473638  138842990234855 233590
- region                  19  7258150958423  141636997719639 233773
- n_bathrooms              2 16406925192713  150785771953929 234433
- mq                       1 20741309731720  155120156492937 234719


Step:  AIC=233261
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms
```

```
                            Df      Sum of Sq              RSS     AIC
+ has_alarm                  1     191510060581  133774478963376  233248
+ has_garden                 1     168052180722  133797936843236  233250
+ has_elevator               1     128533059060  133837455964897  233253
+ has_terrace                1      94492053817  133871496970141  233256
+ has_air_conditioning       1      58265997793  133907723026164  233258
+ property_age               1      51037525154  133914951498803  233259
+ floor                      1      50352563559  133915636460399  233259
+ has_garage                 1      30558936164  133933430087794  233260
<none>                                           133965989023957  233261
+ is_furnished               1      12091863904  133953897160053  233262
+ has_balcony                1        889996285  133965099027673  233263
+ has_fireplace              1        867017756  133965122006201  233263
+ has_parking                1        603475648  133965385548309  233263
- n_rooms                    3     412857737259  134378846761216  233285
- heating                    1     392800874981  134358789898938  233288
- has_pool                   1    2879403132105  136845392156062  233471
- energy_class              11    4450516514683  138416505538640  233565
- region                    19    7275505429857  141241494453814  233752
- n_bathrooms                2   14210505598176  148176494622133  234265
- mq                         1   18541640373044  152507629397001  234555

Step:  AIC=233248
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm

                            Df      Sum of Sq              RSS     AIC
+ has_garden                 1     138401482535  133636077480841  233240
+ has_elevator               1     125121330673  133649357632703  233241
+ has_terrace                1      86707442683  133687771520694  233244
+ floor                      1      48930577642  133725548385734  233247
+ property_age               1      46424518678  133728054444698  233247
+ has_air_conditioning       1      40874156886  133733604806490  233247
<none>                                           133774478963376  233248
+ has_garage                 1      16998216494  133757480746882  233249
+ is_furnished               1      10329071605  133764149891771  233250
+ has_fireplace              1       2904418405  133771574544971  233250
+ has_balcony                1       2238493422  133772240469954  233250
+ has_parking                1        822395550  133773656567826  233250
- has_alarm                  1     191510060581  133965989023957  233261
- n_rooms                    3     404435935928  134178914899304  233273
- heating                    1     399276393307  134173755356684  233276
- has_pool                   1    2825480195584  136599959158960  233455
- energy_class              11    4362235243785  138136714207161  233547
- region                    19    7280355430643  141054834394020  233740
- n_bathrooms                2   14072240498555  147846719461931  234245
- mq                         1   18573291699096  152347770662473  234546

Step:  AIC=233240
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_garden

                            Df      Sum of Sq              RSS     AIC
+ has_elevator               1     141294467695  133494783013147  233231
+ has_terrace                1      68766299947  133567311180895  233237
```

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+ floor                    1     52979638622 133583097842219 233238
+ property_age             1     41213323215 133594864157627 233239
<none>                                       133636077480841 233240
+ has_air_conditioning  1     22882734999 133613194745843 233240
+ has_fireplace            1     10375330936 133625702149906 233241
+ is_furnished             1      7711223183 133628366257658 233241
+ has_garage               1      3769163958 133632308316884 233242
+ has_balcony              1      3557458259 133632520022582 233242
+ has_parking              1      2041800891 133634035679950 233242
- has_garden               1    138401482535 133774478963376 233248
- has_alarm                1    161859362394 133797936843236 233250
- n_rooms                  3    394044866116 134030122346957 233263
- heating                  1    429406214654 134065483695495 233270
- has_pool                 1   2667899761875 136303977242717 233436
- energy_class            11   4340994457125 137977071937966 233538
- region                  19   7286255080584 140922332561425 233733
- n_bathrooms              2  13832250536693 147468328017534 234221
- mq                       1  18446622989714 152082700470556 234531

Step:  AIC=233231
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_garden + has_elevator

                          Df      Sum of Sq             RSS    AIC
+ has_terrace             1     56319843000 133438463170146 233229
+ floor                   1     47395198064 133447387815083 233230
+ property_age            1     38175609405 133456607403742 233231
<none>                                       133494783013147 233231
+ has_balcony             1     13870156401 133480912856746 233232
+ has_air_conditioning  1     11923771710 133482859241437 233233
+ has_fireplace           1     10605254885 133484177758261 233233
+ is_furnished            1      5327419682 133489455593464 233233
+ has_parking             1      3947696187 133490835316960 233233
+ has_garage              1       197933351 133494585079796 233233
- has_elevator            1    141294467695 133636077480842 233240
- has_garden              1    154574619556 133649357632703 233241
- has_alarm               1    156957295059 133651740308206 233241
- n_rooms                 3    387545107924 133882328121071 233254
- heating                 1    381230909810 133876013922956 233258
- has_pool                1   2655934202431 136150717215578 233426
- energy_class           11   4296528775195 137791311788342 233526
- region                 19   7307218406210 140802001419357 233726
- n_bathrooms             2  13897098848812 147391881861959 234218
- mq                      1  18574644796874 152069427810021 234532

Step:  AIC=233229
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_garden + has_elevator +
    has_terrace

                          Df      Sum of Sq             RSS    AIC
+ floor                   1     48052474148 133390410695998 233228
+ property_age            1     36916088478 133401547081669 233228
<none>                                       133438463170146 233229
+ has_balcony             1     18612338982 133419850831164 233230
+ has_fireplace           1     16376591299 133422086578847 233230
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+ has_parking             1     5302005818 133433161164328 233231
+ is_furnished            1     4632556054 133433830614093 233231
+ has_air_conditioning  1     4426371525 133434036798622 233231
+ has_garage              1      809693567 133437653476580 233231
- has_terrace             1    56319843000 133494783013147 233231
- has_elevator            1   128848010748 133567311180895 233237
- has_garden              1   136366369507 133574829539654 233237
- has_alarm               1   153019014984 133591482185131 233239
- n_rooms                 3   389892246628 133828355416774 233252
- heating                 1   383690473950 133822153644097 233256
- has_pool                1  2617691219674 136056154389821 233421
- energy_class           11  4264551420363 137703014590509 233522
- region                 19  7298021266646 140736484436792 233724
- n_bathrooms             2 13817099624455 147255562794601 234211
- mq                      1 18620870439116 152059333609262 234534

Step:  AIC=233228
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_garden + has_elevator +
    has_terrace + floor

                         Df      Sum of Sq             RSS    AIC
+ property_age            1    36925044112 133353485651886 233227
<none>                                      133390410695998 233228
+ has_balcony             1    17533093948 133372877602050 233228
+ has_fireplace           1    16166376653 133374244319345 233228
- floor                   1    48052474148 133438463170146 233229
+ has_parking             1     5202008427 133385208687571 233229
+ is_furnished            1     4989801624 133385420894374 233229
+ has_air_conditioning  1     4314400296 133386096295702 233229
+ has_garage              1      456952354 133389953743644 233230
- has_terrace             1    56977119085 133447387815083 233230
- has_elevator            1   123431913066 133513842609064 233235
- has_garden              1   139771529234 133530182225232 233236
- has_alarm               1   151462614648 133541873310646 233237
- n_rooms                 3   389174384312 133779585080310 233251
- heating                 1   363710617792 133754121313790 233253
- has_pool                1  2616168708679 136006579404677 233420
- energy_class           11  4287703282441 137678113978439 233522
- region                 19  7310061120929 140700471816927 233723
- n_bathrooms             2 13826366783953 147216777479951 234210
- mq                      1 18606154186503 151996564882501 234531

Step:  AIC=233227
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_garden + has_elevator +
    has_terrace + floor + property_age

                         Df      Sum of Sq             RSS    AIC
<none>                                      133353485651886 233227
+ has_balcony             1    18748431537 133334737220349 233227
- property_age            1    36925044112 133390410695998 233228
+ has_fireplace           1    15914189310 133337571462577 233228
- floor                   1    48061429783 133401547081669 233228
+ is_furnished            1     4951001026 133348534650861 233228
+ has_parking             1     4939774600 133348545877287 233228
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+ has_air_conditioning  1     4641643792 133348844008094 233228
+ has_garage            1      855150134 133352630501753 233229
- has_terrace           1    55710102489 133409195754375 233229
- has_elevator          1   120779314171 133474264966058 233234
- has_garden            1   134849869836 133488335521722 233235
- has_alarm             1   148382724646 133501868376532 233236
- n_rooms               3   388563380088 133742049031974 233250
- heating               1   356873902624 133710359554510 233252
- has_pool              1  2610511828557 135963997480443 233419
- energy_class         11  4122193989215 137475679641102 233509
- region               19  7346572379724 140700058031611 233725
- n_bathrooms           2 13737730244205 147091215896091 234203
- mq                    1 18624623839666 151978109491552 234532
Start:  AIC=238366
price ~ 1


                          Df       Sum of Sq              RSS    AIC
+ n_bathrooms             2 54331391807869 170587682559785 235605
+ mq                      1 52840610663533 172078463704121 235690
+ n_rooms                 3 21880386504878 203038687862775 237349
+ has_pool                1  8280509779581 216638564588073 237993
+ energy_class           11  6183006511165 218736067856488 238109
+ region                 19  6302684935712 218616389431941 238120
+ has_garden              1  2900574826863 222018499540791 238238
+ has_balcony             1   988526356760 223930548010894 238324
+ has_alarm               1   830844000263 224088230367391 238331
+ has_terrace             1   342312474223 224576761893431 238353
+ has_elevator            1   249503961215 224669570406438 238357
+ has_air_conditioning    1   225683795169 224693390572485 238358
+ has_fireplace           1   173527549907 224745546817747 238360
+ has_garage              1   163415939151 224755658428503 238361
+ heating                 1   147480757176 224771593610478 238362
+ is_furnished            1   134475423422 224784598944232 238362
<none>                                      224919074367654 238366
+ property_age            1    16045562375 224903028805279 238368
+ floor                   1    13690114667 224905384252987 238368
+ has_parking             1      124434109 224918949933545 238368

Step:  AIC=235605
price ~ n_bathrooms


                          Df       Sum of Sq              RSS    AIC
+ mq                      1 19037868233574 151549814326211 234424
+ region                 19  6738962316534 163848720243250 235240
+ has_pool                1  4675740623660 165911941936125 235329
+ energy_class           11  3645125278618 166942557281167 235411
+ n_rooms                 3  2850366402335 167737316157450 235443
+ has_garden              1   583499578252 170004182981533 235573
+ has_alarm               1   287869268570 170299813291215 235590
+ has_balcony             1   159307282809 170428375276975 235598
+ heating                 1   133537756196 170454144803589 235599
+ has_air_conditioning    1   121546899222 170466135660562 235600
+ is_furnished            1   109459233418 170478223326367 235601
+ has_terrace             1   105205166804 170482477392981 235601
+ has_garage              1    42314445455 170545368114330 235605
<none>                                      170587682559785 235605
```

```
+ has_parking              1     15818783507 170571863776278 235606
+ property_age             1     13491883827 170574190675958 235607
+ floor                    1     11365448329 170576317111456 235607
+ has_elevator             1      6078457230 170581604102555 235607
+ has_fireplace            1      3216333622 170584466226163 235607
- n_bathrooms              2 54331391807869 224919074367654 238366

Step:  AIC=234424
price ~ n_bathrooms + mq

                          Df     Sum of Sq             RSS    AIC
+ region                  19 7534393920250 144015420405961 233952
+ energy_class            11 4603353233232 146946461092979 234137
+ has_pool                 1 3770940211063 147778874115148 234174
+ heating                  1  467024026362 151082790299849 234395
+ has_alarm                1  359568217202 151190246109008 234402
+ n_rooms                  3  363228313898 151186586012312 234406
+ has_garden               1  258029613845 151291784712366 234409
+ has_terrace              1  226324375940 151323489950271 234411
+ has_elevator             1  169830402379 151379983923832 234415
+ property_age             1  132406641344 151417407684867 234417
+ has_air_conditioning     1  112354895230 151437459430981 234419
+ has_garage               1   75642455087 151474171871124 234421
<none>                                      151549814326211 234424
+ is_furnished             1   22463799565 151527350526646 234424
+ floor                    1   15857920002 151533956406208 234425
+ has_parking              1   13273811984 151536540514227 234425
+ has_balcony              1    8524272515 151541290053696 234425
+ has_fireplace            1     225927504 151549588398706 234426
- mq                       1 19037868233574 170587682559785 235605
- n_bathrooms              2 20528649377910 172078463704121 235690

Step:  AIC=233952
price ~ n_bathrooms + mq + region

                          Df     Sum of Sq             RSS    AIC
+ energy_class            11 4843499680517 139171920725444 233632
+ has_pool                 1 3339560855810 140675859550151 233719
+ heating                  1  362430766312 143652989639649 233929
+ has_alarm                1  345120247835 143670300158126 233930
+ n_rooms                  3  401796960706 143613623445255 233930
+ property_age             1  264661676096 143750758729865 233936
+ has_garden               1  248111014038 143767309391923 233937
+ has_terrace              1  210298778072 143805121627889 233939
+ has_elevator             1  207717313538 143807703092423 233940
+ has_air_conditioning     1  101110987556 143914309418405 233947
+ has_garage               1   71545480259 143943874925702 233949
+ floor                    1   37865032156 143977555373805 233951
<none>                                      144015420405961 233952
+ is_furnished             1   10875337361 144004545068600 233953
+ has_balcony              1    7391205463 144008029200498 233953
+ has_fireplace            1     221647262 144015198758699 233954
+ has_parking              1       6091202 144015414314759 233954
- region                  19 7534393920250 151549814326211 234424
- mq                       1 19833299837289 163848720243250 235240
- n_bathrooms              2 20671633731459 164687054137420 235289
```

```
Step:  AIC=233632
price ~ n_bathrooms + mq + region + energy_class

                        Df     Sum of Sq             RSS    AIC
+ has_pool               1  3177625449342  135994295276102  233403
+ heating                1   370261739467  138801658985977  233607
+ n_rooms                3   423784031825  138748136693618  233607
+ has_alarm              1   243003296857  138928917428586  233616
+ has_garden             1   207497575392  138964423150052  233619
+ has_elevator           1   163458825979  139008461899464  233622
+ has_terrace            1   142074575233  139029846150211  233624
+ has_air_conditioning   1   105561812308  139066358913135  233626
+ floor                  1    59759408397  139112161317047  233630
+ property_age           1    55422180001  139116498545443  233630
+ has_garage             1    33007923998  139138912801445  233632
<none>                                     139171920725444  233632
+ is_furnished           1    17223510293  139154697215151  233633
+ has_fireplace          1    14452498008  139157468227436  233633
+ has_balcony            1     2108725496  139169811999948  233634
+ has_parking            1     1071684461  139170849040982  233634
- energy_class          11  4843499680517  144015420405961  233952
- region                19  7774540367535  146946461092979  234137
- n_bathrooms            2 18446097032830  157618017758274  234873
- mq                     1 21160725385248  160332646110691  235045

Step:  AIC=233403
price ~ n_bathrooms + mq + region + energy_class + has_pool

                        Df     Sum of Sq             RSS    AIC
+ heating                1   399492284591  135594802991510  233376
+ n_rooms                3   432558396458  135561736879644  233377
+ has_alarm              1   186166234973  135808129041129  233391
+ has_elevator           1   159515295463  135834779980639  233393
+ has_terrace            1    78829548116  135915465727986  233399
+ has_garden             1    70623508732  135923671767369  233400
+ floor                  1    59533727923  135934761548179  233401
+ has_air_conditioning   1    50731384052  135943563892050  233401
+ property_age           1    43595017650  135950700258452  233402
<none>                                     135994295276102  233403
+ has_garage             1    10077896900  135984217379201  233404
+ is_furnished           1     9738516225  135984556759877  233404
+ has_fireplace          1     1518613222  135992776662880  233405
+ has_balcony            1     1249632328  135993045643774  233405
+ has_parking            1      612112485  135993683163617  233405
- has_pool               1  3177625449342  139171920725444  233632
- energy_class          11  4681564274050  140675859550151  233719
- region                19  7260001524768  143254296800869  233885
- n_bathrooms            2 17435580728524  153429876004626  234605
- mq                     1 20209505952792  156203801228894  234786

Step:  AIC=233376
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating

                        Df     Sum of Sq             RSS    AIC
```

```
+ n_rooms               3   449608644591 135145194346920 233348
+ has_alarm             1   193063264419 135401739727092 233363
+ has_elevator          1   115536007576 135479266983934 233369
+ has_garden            1    95835637684 135498967353826 233370
+ has_terrace           1    81740985634 135513062005876 233371
+ has_air_conditioning  1    50980473065 135543822518446 233374
+ floor                 1    46500953267 135548302038244 233374
+ property_age          1    36391091498 135558411900012 233375
<none>                                   135594802991510 233376
+ is_furnished          1     8510161791 135586292829719 233377
+ has_garage            1     7941345398 135586861646112 233377
+ has_balcony           1     3328207695 135591474783815 233377
+ has_fireplace         1      363187965 135594439803545 233377
+ has_parking           1      184355826 135594618635684 233378
- heating               1   399492284591 135994295276102 233403
- has_pool              1  3206855994467 138801658985977 233607
- energy_class         11  4686461467284 140281264458794 233693
- region               19  7179415583543 142774218575053 233853
- n_bathrooms           2 17642989368485 153237792359996 234595
- mq                    1 20528257559435 156123060550945 234783

Step:  AIC=233348
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms

                       Df    Sum of Sq             RSS    AIC
+ has_alarm             1   185052149118 134960142197802 233337
+ has_elevator          1   110692595450 135034501751469 233342
+ has_terrace           1    86277927915 135058916419004 233344
+ has_garden            1    83252403647 135061941943272 233344
+ has_air_conditioning  1    51768097171 135093426249749 233346
+ floor                 1    47427952228 135097766394691 233347
+ property_age          1    41126126524 135104068220396 233347
<none>                                   135145194346920 233348
+ is_furnished          1     9739711223 135135454635697 233350
+ has_balcony           1     4159820526 135141034526394 233350
+ has_garage            1     3224785827 135141969561093 233350
+ has_fireplace         1      762320916 135144432026004 233350
+ has_parking           1       70260861 135145124086059 233350
- n_rooms               3   449608644590 135594802991510 233376
- heating               1   416542532724 135561736879644 233377
- has_pool              1  3216614289749 138361808636669 233582
- energy_class         11  4707672432016 139852866778935 233669
- region               19  7211357837595 142356552184515 233830
- n_bathrooms           2 14841737554434 149986931901354 234386
- mq                    1 17693151148729 152838345495649 234577

Step:  AIC=233337
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm

                       Df    Sum of Sq             RSS    AIC
+ has_elevator          1   107617838869 134852524358933 233331
+ has_terrace           1    79033806820 134881108390982 233333
+ has_garden            1    62908790928 134897233406874 233334
+ floor                 1    47341506284 134912800691518 233335
```

```
+ property_age             1     37127208224 134923014989579 233336
+ has_air_conditioning  1     35714394108 134924427803694 233336
<none>                                    134960142197802 233337
+ is_furnished            1      8155560337 134951986637465 233338
+ has_balcony             1      6656837214 134953485360588 233338
+ has_fireplace           1      2654847637 134957487350165 233338
+ has_garage              1       155707376 134959986490426 233339
+ has_parking             1       154606614 134959987591188 233339
- has_alarm               1     185052149118 135145194346920 233348
- n_rooms                 3     441597529290 135401739727092 233363
- heating                 1     423298972373 135383441170175 233366
- has_pool                1    3159947529232 138120089727034 233566
- energy_class           11    4621799556181 139581941753984 233651
- region                 19    7211559858079 142171702055881 233819
- n_bathrooms             2   14685606844996 149645749042798 234366
- mq                      1   17747359241685 152707501439487 234570

Step:  AIC=233331
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_elevator

                        Df      Sum of Sq             RSS    AIC
+ has_garden             1     73022936941 134779501421992 233327
+ has_terrace            1     68229865076 134784294493857 233328
+ floor                  1     36419999888 134816104359045 233330
+ property_age           1     34863337268 134817661021666 233330
<none>                                    134852524358933 233331
+ has_air_conditioning  1     24235944463 134828288414470 233331
+ has_balcony            1     17380300213 134835144058721 233331
+ is_furnished           1      6099313204 134846425045729 233332
+ has_fireplace          1      2505497689 134850018861244 233332
+ has_parking            1       730029224 134851794329709 233333
+ has_garage             1       607464188 134851916894745 233333
- has_elevator           1     107617838869 134960142197802 233337
- has_alarm              1     181977392536 135034501751469 233342
- heating                1     379168653725 135231693012658 233357
- n_rooms                3     436930164818 135289454523751 233357
- has_pool               1    3155732721588 138008257080521 233560
- energy_class          11    4587893370898 139440417729831 233643
- region                19    7237027917889 142089552276823 233815
- n_bathrooms            2   14749901040746 149602425399679 234365
- mq                     1   17852040169472 152704564528406 234572

Step:  AIC=233327
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_elevator + has_garden

                        Df      Sum of Sq             RSS    AIC
+ has_terrace            1     56177669499 134723323752494 233325
+ floor                  1     37513746938 134741987675055 233326
+ property_age           1     31445647633 134748055774359 233327
<none>                                    134779501421992 233327
+ has_balcony            1     20587091996 134758914329997 233328
+ has_air_conditioning  1     13653314336 134765848107656 233328
+ has_fireplace          1      7221654103 134772279767889 233329
+ has_garage             1      6309819594 134773191602398 233329
```

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+ is_furnished            1      4541995641 134774959426351 233329
+ has_parking             1      1580128309 134777921293683 233329
- has_garden              1     73022936941 134852524358933 233331
- has_elevator            1    117731984882 134897233406874 233334
- has_alarm               1    160227517791 134939728939784 233337
- n_rooms                 3    425389709040 135204891131032 233353
- heating                 1    398265687852 135177767109844 233355
- has_pool                1   3021970325807 137801471747799 233547
- energy_class           11   4570623823234 139350125245227 233639
- region                 19   7245661316034 142025162738026 233813
- n_bathrooms             2  14561149295788 149340650717780 234349
- mq                      1  17773670483701 152553171905693 234564
```

Step: AIC=233325
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_elevator + has_garden +
    has_terrace

```
                         Df     Sum of Sq             RSS    AIC
+ floor                   1     37171157783 134686152594711 233324
+ property_age            1     30340456031 134692983296463 233325
<none>                                      134723323752494 233325
+ has_balcony             1     26294316063 134697029436430 233325
+ has_garage              1     15229635853 134708094116641 233326
+ has_fireplace           1     12055343502 134711268408992 233326
+ has_air_conditioning    1      5544510865 134717779241628 233327
+ is_furnished            1      3900034627 134719423717867 233327
+ has_parking             1      2463287798 134720860464696 233327
- has_terrace             1     56177669499 134779501421992 233327
- has_garden              1     60970741364 134784294493857 233328
- has_elevator            1    106442750211 134829766502705 233331
- has_alarm               1    156302752583 134879626505076 233335
- n_rooms                 3    430196837334 135153520589827 233351
- heating                 1    400771083042 135124094835535 233353
- has_pool                1   2981298541547 137704622294040 233542
- energy_class           11   4535900871044 139259224623538 233634
- region                 19   7236661375236 141959985127729 233810
- n_bathrooms             2  14470731666698 149194055419191 234341
- mq                      1  17816774262190 152540098014684 234565
```

Step: AIC=233324
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_elevator + has_garden +
    has_terrace + floor

```
                         Df     Sum of Sq             RSS    AIC
+ property_age            1     30952691792 134655199902919 233324
<none>                                      134686152594711 233324
+ has_balcony             1     25158642458 134660993952252 233324
- floor                   1     37171157783 134723323752494 233325
+ has_garage              1     13850160404 134672302434307 233325
+ has_fireplace           1     11809655042 134674342939669 233325
+ has_air_conditioning    1      5230239306 134680922355405 233326
+ is_furnished            1      4040658462 134682111936249 233326
+ has_parking             1      2382979465 134683769615246 233326
- has_terrace             1     55835080344 134741987675055 233326
```

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- has_garden              1     61995295959 134748147890670 233327
- has_elevator            1     95645077233 134781797671943 233329
- has_alarm               1    156237177522 134842389772233 233334
- n_rooms                 3    431175258808 135117327853519 233350
- heating                 1    391456242872 135077608837583 233351
- has_pool                1   2980420518547 137666573113258 233541
- energy_class           11   4553378785886 139239531380596 233635
- region                 19   7254076909150 141940229503861 233811
- n_bathrooms             2  14485591220708 149171743815419 234342
- mq                      1  17802004461405 152488157056115 234564

Step:  AIC=233324
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_elevator + has_garden +
    has_terrace + floor + property_age

                         Df      Sum of Sq             RSS    AIC
<none>                                      134655199902919 233324
+ has_balcony             1     26461562750 134628738340169 233324
- property_age            1     30952691792 134686152594711 233324
- floor                   1     37783393544 134692983296463 233325
+ has_garage              1     15608865331 134639591037588 233325
+ has_fireplace           1     11571231778 134643628671141 233325
+ has_air_conditioning    1      5581747509 134649618155410 233326
+ is_furnished            1      3997879667 134651202023252 233326
+ has_parking             1      2228167104 134652971735815 233326
- has_terrace             1     54719532417 134709919435335 233326
- has_garden              1     59013131579 134714213034498 233326
- has_elevator            1     93440276314 134748640179233 233329
- has_alarm               1    153421750921 134808621653840 233333
- n_rooms                 3    435664960325 135090864863244 233350
- heating                 1    384770126744 135039970029663 233351
- has_pool                1   2974351154697 137629551057616 233540
- energy_class           11   4391276198136 139046476101055 233623
- region                 19   7284480764850 141939680667769 233813
- n_bathrooms             2  14408888655016 149064088557935 234337
- mq                      1  17810396036214 152465595939133 234564
Start:  AIC=238477
price ~ 1

                         Df      Sum of Sq             RSS    AIC
+ n_bathrooms             2  54912671786631 172516729975884 235718
+ mq                      1  53814233390660 173615168371855 235779
+ n_rooms                 3  20758941326844 206670460435671 237526
+ has_pool                1   8024828213392 219404573549124 238120
+ region                 19   6586530845980 220842870916536 238221
+ energy_class           11   5781117273068 221648284489447 238242
+ has_garden              1   2850526659610 224578875102905 238353
+ has_balcony             1    878047307979 226551354454536 238441
+ has_alarm               1    813245825914 226616155936601 238443
+ has_terrace             1    389502386388 227039899376127 238462
+ has_elevator            1    260563952267 227168837810248 238468
+ has_air_conditioning    1    255730374167 227173671388348 238468
+ has_garage              1    238730281660 227190671480855 238469
+ is_furnished            1    121095137425 227308306625090 238474
+ has_fireplace           1    104377236015 227325024526500 238475
```

```
<none>                                  227429401762515 238477
+ heating               1      42679873802 227386721888714 238477
+ floor                 1      29236040425 227400165722090 238478
+ property_age          1      12378923127 227417022839388 238479
+ has_parking           1        105161245 227429296601270 238479

Step:  AIC=235718
price ~ n_bathrooms

                        Df      Sum of Sq            RSS    AIC
+ mq                     1 19078164784300 153438565191584 234548
+ region                19  6783049908194 165733680067690 235355
+ has_pool               1  4475096211809 168041633764075 235457
+ energy_class          11  3398692241063 169118037734821 235541
+ n_rooms                3  2444735298625 170071994677259 235581
+ has_garden             1   552090552820 171964639423064 235688
+ has_alarm              1   299887148560 172216842827324 235702
+ heating                1   298077152770 172218652823114 235702
+ has_terrace            1   149961937706 172366768038178 235711
+ has_air_conditioning   1   143965739844 172372764236040 235711
+ has_balcony            1   116650512675 172400079463209 235713
+ has_garage             1    81429384762 172435300591122 235715
+ is_furnished           1    80021545524 172436708430360 235715
<none>                                    172516729975884 235718
+ floor                  1    18623251191 172498106724693 235719
+ has_parking            1    13392319996 172503337655888 235719
+ has_elevator           1     9947383705 172506782592179 235719
+ property_age           1     3823327260 172512906648624 235720
+ has_fireplace          1      862675417 172515867300467 235720
- n_bathrooms            2 54912671786631 227429401762515 238477

Step:  AIC=234548
price ~ n_bathrooms + mq

                        Df      Sum of Sq            RSS    AIC
+ region                19  7628804040775 145809761150809 234076
+ energy_class          11  4318628085206 149119937106377 234284
+ has_pool               1  3595656195202 149842908996381 234313
+ heating                1   747846155388 152690719036196 234501
+ n_rooms                3   446324430932 152992240760652 234525
+ has_alarm              1   368589831952 153069975359632 234526
+ has_terrace            1   284591791342 153153973400241 234531
+ has_garden             1   239628637640 153198936553944 234534
+ has_elevator           1   176069734885 153262495456698 234538
+ property_age           1   171654325811 153266910865773 234539
+ has_garage             1   129887670567 153308677521017 234541
+ has_air_conditioning   1   127868577957 153310696613626 234541
+ floor                  1    45975671766 153392589519818 234547
<none>                                    153438565191584 234548
+ has_parking            1    12117673545 153426447518039 234549
+ is_furnished           1    11504404397 153427060787187 234549
+ has_fireplace          1     8774388731 153429790802853 234549
+ has_balcony            1     1341305281 153437223886303 234550
- mq                     1 19078164784300 172516729975884 235718
- n_bathrooms            2 20176603180272 173615168371855 235779
```

```
Step:  AIC=234076
price ~ n_bathrooms + mq + region

                        Df      Sum of Sq             RSS     AIC
+ energy_class          11   4474612154286  141335148996523  233786
+ has_pool               1   3184920301935  142624840848874  233857
+ heating                1    622378018557  145187383132252  234035
+ n_rooms                3    460866275026  145348894875783  234050
+ has_alarm              1    355378750528  145454382400280  234053
+ property_age           1    320596669603  145489164481206  234056
+ has_terrace            1    263789100788  145545972050021  234060
+ has_garden             1    214630334367  145595130816442  234063
+ has_elevator           1    206280861105  145603480289704  234064
+ has_air_conditioning   1    109868679270  145699892471538  234070
+ has_garage             1    105943727406  145703817423403  234071
+ floor                  1     94682138615  145715079012193  234071
<none>                                      145809761150809  234076
+ has_fireplace          1      4510768427  145805250382382  234078
+ is_furnished           1      4099666959  145805661483850  234078
+ has_balcony            1      1642373300  145808118777508  234078
+ has_parking            1         7881659  145809753269150  234078
- region                19   7628804040775  153438565191584  234548
- mq                     1  19923918916881  165733680067690  235355
- n_bathrooms            2  20183426440377  165993187591185  235368

Step:  AIC=233786
price ~ n_bathrooms + mq + region + energy_class

                        Df      Sum of Sq             RSS     AIC
+ has_pool               1   3024776462040  138310372534483  233572
+ heating                1    654589754726  140680559241796  233742
+ n_rooms                3    453124207479  140882024789044  233760
+ has_alarm              1    251270394392  141083878602131  233770
+ has_terrace            1    189110193194  141146038803328  233775
+ has_garden             1    171862534562  141163286461961  233776
+ has_elevator           1    161685511499  141173463485024  233777
+ has_air_conditioning   1    114732468502  141220416528020  233780
+ floor                  1    109790324795  141225358671728  233780
+ property_age           1     92223565814  141242925430708  233782
+ has_garage             1     57189201980  141277959794543  233784
<none>                                      141335148996523  233786
+ is_furnished           1      7917205753  141327231790770  233788
+ has_parking            1       864362487  141334284634035  233788
+ has_fireplace          1       789409164  141334359587359  233788
+ has_balcony            1         7443360  141335141553163  233788
- energy_class          11   4474612154286  145809761150809  234076
- region                19   7784788109855  149119937106377  234284
- n_bathrooms            2  18066266687983  159401415684506  234985
- mq                     1  21197582555028  162532731551550  235182

Step:  AIC=233572
price ~ n_bathrooms + mq + region + energy_class + has_pool

                        Df      Sum of Sq             RSS     AIC
+ heating                1    691849781744  137618522752739  233524
+ n_rooms                3    473715243398  137836657291085  233544
```

```
+ has_alarm              1   194187521318 138116185013165 233560
+ has_elevator           1   157629793136 138152742741347 233562
+ has_terrace            1   116061555066 138194310979417 233565
+ floor                  1   114623868011 138195748666472 233566
+ property_age           1    76417987159 138233954547324 233568
+ has_air_conditioning   1    58509557347 138251862977136 233570
+ has_garden             1    52606423279 138257766111204 233570
<none>                                    138310372534483 233572
+ has_garage             1    25844656897 138284527877586 233572
+ has_fireplace          1    16291475318 138294081059165 233573
+ is_furnished           1     3413710780 138306958823703 233574
+ has_parking            1      708075309 138309664459174 233574
+ has_balcony            1       56697505 138310315836978 233574
- has_pool               1   3024776462040 141335148996523 233786
- energy_class          11   4314468314391 142624840848874 233857
- region                19   7301218706695 145611591241178 234048
- n_bathrooms            2  17107291064188 155417663598671 234734
- mq                     1  20274734246038 158585106780521 234938

Step:  AIC=233524
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating

                        Df      Sum of Sq             RSS    AIC
+ n_rooms                3   505666326654 137112856426085 233493
+ has_alarm              1   203416836572 137415105916167 233511
+ has_terrace            1   120718447082 137497804305658 233517
+ has_elevator           1   101256170154 137517266582585 233518
+ has_garden             1    82135771865 137536386980874 233520
+ floor                  1    65754990748 137552767761992 233521
+ property_age           1    63897289737 137554625463002 233521
+ has_air_conditioning   1    58801228877 137559721523862 233521
<none>                                    137618522752739 233524
+ has_garage             1    21311133677 137597211619062 233524
+ has_fireplace          1    10241637945 137608281114794 233525
+ is_furnished           1     2504886439 137616017866300 233525
+ has_balcony            1      479102999 137618043649740 233526
+ has_parking            1      142055813 137618380696926 233526
- heating                1   691849781744 138310372534483 233572
- has_pool               1   3062036489057 140680559241796 233742
- energy_class          11   4343325187773 141961847940512 233812
- region                19   7205907176429 144824429929168 233996
- n_bathrooms            2  17395751564964 155014274317703 234710
- mq                     1  20728276115956 158346798868695 234925

Step:  AIC=233493
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms

                        Df      Sum of Sq             RSS    AIC
+ has_alarm              1   191643131792 136921213294293 233481
+ has_terrace            1   121564812693 136991291613392 233486
+ has_elevator           1    97288186043 137015568240043 233488
+ has_garden             1    70382116044 137042474310041 233490
+ property_age           1    65761885712 137047094540374 233490
+ floor                  1    64043283160 137048813142926 233490
```

```
+ has_air_conditioning  1      56376018013 137056480408072 233491
<none>                                     137112856426085 233493
+ has_garage            1      13619664361 137099236761725 233494
+ has_fireplace         1      10338654948 137102517771137 233494
+ is_furnished          1       3017326851 137109839099234 233495
+ has_balcony           1       1014470176 137111841955910 233495
+ has_parking           1        150167307 137112706258779 233495
- n_rooms               3     505666326654 137618522752739 233524
- heating               1     723800865000 137836657291085 233544
- has_pool              1    3083941024597 140196797450682 233713
- energy_class         11    4331850768116 141444707194202 233782
- region               19    7211957351735 144324813777820 233967
- n_bathrooms           2   14982253430573 152095109856659 234526
- mq                    1   18435035613330 155547892039415 234752

Step:  AIC=233481
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm

                       Df      Sum of Sq             RSS    AIC
+ has_terrace           1     112800527501 136808412766793 233475
+ has_elevator          1      94345251681 136826868042613 233476
+ floor                 1      66382656493 136854830637800 233478
+ property_age          1      60603523675 136860609770618 233478
+ has_garden            1      51416293605 136869797000689 233479
+ has_air_conditioning  1      39314162812 136881899131482 233480
<none>                                     136921213294293 233481
+ has_fireplace         1      15948630796 136905264663497 233482
+ has_garage            1       5165842337 136916047451956 233482
+ has_balcony           1       2419580589 136918793713705 233483
+ is_furnished          1       2159295452 136919053998841 233483
+ has_parking           1        266292519 136920947001775 233483
- has_alarm             1     191643131792 137112856426085 233493
- n_rooms               3     493892621874 137415105916167 233511
- heating               1     732703638120 137653916932414 233532
- has_pool              1    3026277137607 139947490431900 233697
- energy_class         11    4244888171025 141166101465318 233764
- region               19    7214190724044 144135404018338 233956
- n_bathrooms           2   14830011259511 151751224553804 234505
- mq                    1   18486145828558 155407359122852 234745

Step:  AIC=233475
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_terrace

                       Df      Sum of Sq             RSS    AIC
+ has_elevator          1      82212071754 136726200695039 233471
+ floor                 1      65191483117 136743221283675 233472
+ property_age          1      57613325566 136750799441226 233472
+ has_garden            1      39041305602 136769371461190 233474
<none>                                     136808412766793 233475
+ has_fireplace         1      27236551408 136781176215385 233475
+ has_air_conditioning  1      17848816025 136790563950768 233475
+ has_balcony           1       6293085103 136802119681689 233476
+ is_furnished          1       1404315161 136807008451631 233477
+ has_parking           1       1062878545 136807349888247 233477
```

```
+ has_garage              1        33921198 136808378845595 233477
- has_terrace             1     112800527501 136921213294293 233481
- has_alarm               1     182878846600 136991291613392 233486
- n_rooms                 3     494982411865 137303395178658 233505
- heating                 1     737236777067 137545649543859 233526
- has_pool                1    2955781741475 139764194508268 233686
- energy_class           11    4193598727681 141002011494474 233755
- region                 19    7201852556084 144010265322876 233950
- n_bathrooms             2   14718464299106 151526877065899 234492
- mq                      1   18563212290981 155371625057774 234745

Step:  AIC=233471
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_terrace + has_elevator

                          Df      Sum of Sq            RSS     AIC
+ property_age            1     55290439690 136670910255348 233469
+ floor                   1     48994778887 136677205916152 233469
+ has_garden              1     46772648532 136679428046507 233469
<none>                                      136726200695039 233471
+ has_fireplace           1     26150319155 136700050375884 233471
+ has_balcony             1     14872581523 136711328113516 233472
+ has_air_conditioning    1     11475621345 136714725073694 233472
+ has_parking             1      1980057973 136724220637066 233472
+ is_furnished            1       739040916 136725461654122 233473
+ has_garage              1       565684786 136725635010253 233473
- has_elevator            1     82212071754 136808412766793 233475
- has_terrace             1     100667347574 136826868042613 233476
- has_alarm               1     180647584520 136906848279559 233482
- n_rooms                 3     491361798977 137217562494016 233500
- heating                 1     683196524903 137409397219941 233518
- has_pool                1    2955472922536 139681673617575 233682
- energy_class           11    4165655877552 140891856572590 233749
- region                 19    7220572057964 143946772753003 233947
- n_bathrooms             2   14779302777062 151505503472100 234493
- mq                      1   18644620642787 155370821337825 234747

Step:  AIC=233469
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_terrace + has_elevator +
    property_age

                          Df      Sum of Sq            RSS     AIC
+ floor                   1     48953102629 136621957152720 233467
+ has_garden              1     43445102651 136627465152697 233467
<none>                                      136670910255348 233469
+ has_fireplace           1     25971556290 136644938699059 233469
+ has_balcony             1     16306742721 136654603512627 233469
+ has_air_conditioning    1     11928698856 136658981556493 233470
+ has_parking             1      1815657966 136669094597383 233470
+ has_garage              1      1204139582 136669706115766 233470
+ is_furnished            1       704598072 136670205657276 233471
- property_age            1     55290439690 136726200695039 233471
- has_elevator            1     79889185878 136750799441226 233472
- has_terrace             1     98068764927 136768979020275 233474
- has_alarm               1     176006601103 136846916856451 233479
```

```
- n_rooms              3   493395117505 137164305372854 233499
- heating              1   672503762241 137343414017589 233516
- has_pool             1  2943289650733 139614199906081 233680
- energy_class        11  3987079843485 140657990098834 233734
- region              19  7269618765172 143940529020520 233949
- n_bathrooms          2 14685744677471 151356654932820 234485
- mq                   1 18691246225561 155362156480910 234748

Step:  AIC=233467
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_terrace + has_elevator +
    property_age + floor

                       Df     Sum of Sq             RSS    AIC
+ has_garden            1   46405806597 136575551346123 233466
<none>                                  136621957152720 233467
+ has_fireplace         1   25072045125 136596885107595 233467
+ has_balcony           1   16139983558 136605817169162 233468
+ has_air_conditioning  1   11710498987 136610246653733 233468
- floor                 1   48953102629 136670910255349 233469
+ has_parking           1    1729358903 136620227793817 233469
+ has_garage            1     902710041 136621054442679 233469
+ is_furnished          1     858497151 136621098655569 233469
- property_age          1   55248763432 136677205916152 233469
- has_elevator          1   63960771408 136685917924128 233470
- has_terrace           1   98190218395 136720147371115 233472
- has_alarm             1  178190055237 136800147207957 233478
- n_rooms               3  492219548761 137114176701481 233497
- heating               1  635645082909 137257602235629 233511
- has_pool              1 2945528941883 139567486094603 233678
- energy_class         11 3996538342957 140618495495677 233733
- region               19 7298122347110 143920079499830 233949
- n_bathrooms           2 14707103959190 151329061111910 234485
- mq                    1 18695618175822 155317575328542 234748

Step:  AIC=233466
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_terrace + has_elevator +
    property_age + floor + has_garden

                       Df     Sum of Sq             RSS    AIC
+ has_fireplace         1   34228090414 136541323255709 233465
<none>                                  136575551346123 233466
+ has_balcony           1   18087529735 136557463816388 233466
- has_garden            1   46405806597 136621957152720 233467
+ has_air_conditioning  1    6420362172 136569130983951 233467
+ has_garage            1    4937823873 136570613522250 233467
- property_age          1   51811956259 136627363302382 233467
- floor                 1   51913806574 136627465152697 233467
+ has_parking           1    2587841100 136572963505024 233467
+ is_furnished          1     454530751 136575096815372 233468
- has_elevator          1   70414058261 136645965404384 233469
- has_terrace           1   85299315350 136660850661473 233470
- has_alarm             1  161321386676 136736872732799 233475
- n_rooms               3  482661862870 137058213208994 233495
- heating               1  653359306409 137228910652532 233511
```

```
- has_pool                  1  2843762129084 139419313475207 233670
- energy_class             11  3988273486524 140563824832647 233731
- region                   19  7299488025710 143875039371834 233948
- n_bathrooms               2 14559339112078 151134890458201 234475
- mq                        1 18606397747434 155181949093557 234741


Step:  AIC=233465
price ~ n_bathrooms + mq + region + energy_class + has_pool +
    heating + n_rooms + has_alarm + has_terrace + has_elevator +
    property_age + floor + has_garden + has_fireplace

                           Df      Sum of Sq             RSS    AIC
<none>                                      136541323255709 233465
- has_fireplace             1    34228090414 136575551346123 233466
+ has_balcony               1    14416090318 136526907165391 233466
+ has_air_conditioning      1    10696224984 136530627030725 233466
- floor                     1    51138606357 136592461862066 233467
- property_age              1    51273628413 136592596884122 233467
+ has_garage                1     2887528552 136538435727157 233467
+ has_parking               1     1531632462 136539791623247 233467
+ is_furnished              1      622710224 136540700545485 233467
- has_garden                1    55561851886 136596885107595 233467
- has_elevator              1    70133504286 136611456759995 233468
- has_terrace               1    95761367559 136637084623268 233470
- has_alarm                 1   167413201576 136708736457285 233475
- n_rooms                   3   481803196890 137023126452599 233494
- heating                   1   646779747331 137188103003040 233510
- has_pool                  1  2873536399618 139414859655327 233671
- energy_class             11  3935377855671 140476701111379 233727
- region                   19  7295197683252 143836520938961 233948
- n_bathrooms               2 14575333157309 151116656413018 234475
- mq                        1 18612876104431 155154199360140 234741
```

```r
# majority vote which predictors to include
formulas <- lapply(fit$analyses, formula)
terms <- lapply(formulas, terms)
votes <- unlist(lapply(terms, labels))
table(votes)
```

```
votes
 energy_class          floor      has_alarm    has_balcony  has_elevator
            5              4              5              1              5
has_fireplace     has_garden       has_pool    has_terrace        heating
            1              5              5              5              5
           mq    n_bathrooms        n_rooms   property_age         region
            5              5              5              5              5
```

```r
# model based on forward selection method applied to each imputed data set
model_2 <- with(imp, lm(price ~ energy_class + floor + has_alarm + has_elevator +
    has_garden + has_pool + has_terrace + heating + mq + n_bathrooms +
    n_rooms + property_age + region))

# pooled effect estimates
summary(pool(model_2))
```

```
                      term estimate std.error statistic    df
```

1	(Intercept)	12720	11010	1.1554	56
2	energy_classa+	49899	13360	3.7349	39
3	energy_classa1	8571	12250	0.6997	10
4	energy_classa2	65052	15445	4.2117	522
5	energy_classa3	77395	19808	3.9072	23
6	energy_classa4	68859	9816	7.0148	429
7	energy_classb	16751	9106	1.8395	89
8	energy_classc	25115	10022	2.5059	19
9	energy_classd	-45	8353	-0.0053	30
10	energy_classe	-6542	7742	-0.8451	27
11	energy_classf	-4547	6926	-0.6565	32
12	energy_classg	-24316	7592	-3.2030	10
13	floor	1830	1335	1.3707	63
14	has_alarm1	46587	13690	3.4029	6907
15	has_elevator1	13687	5352	2.5573	395
16	has_garden1	6906	4014	1.7202	37
17	has_pool1	130325	11637	11.1994	20
18	has_terrace1	7557	4035	1.8728	274
19	heatingother	22650	5190	4.3641	24
20	mq	399	14	29.0791	29
21	n_bathrooms2	60585	2863	21.1647	769
22	n_bathrooms3	138742	5964	23.2645	19
23	n_rooms3	16942	4220	4.0150	184
24	n_rooms4	22808	4439	5.1380	193
25	n_rooms5	16422	6304	2.6049	17
26	property_age	-28	17	-1.6408	895
27	regionBasilicata	-4372	19279	-0.2268	7312
28	regionCalabria	12821	11529	1.1120	95
29	regionCampania	50746	8977	5.6529	3090
30	regionEmilia-Romagna	48004	9259	5.1845	176
31	regionFriuli Venezia Giulia	11776	10609	1.1100	6882
32	regionLazio	45226	8917	5.0721	2086
33	regionLiguria	96738	9699	9.9741	2522
34	regionLombardia	53843	8006	6.7254	706
35	regionMarche	32288	9688	3.3326	7423
36	regionMolise	-18090	18729	-0.9659	92
37	regionPiemonte	13252	8126	1.6308	2703
38	regionPuglia	36731	10205	3.5991	180
39	regionSardegna	62249	11772	5.2880	159
40	regionSicilia	25039	9298	2.6931	3002
41	regionToscana	106770	9406	11.3512	269
42	regionTrentino-Alto Adige	113228	12863	8.8026	188
43	regionUmbria	28011	11970	2.3400	467
44	regionValle d'Aosta	97099	16549	5.8673	1906
45	regionVeneto	33615	8534	3.9389	1761

	p.value
1	0.25287826826479698
2	0.00060354684675890
3	0.49958616455213889
4	0.00002985774702813
5	0.00072421194210248
6	0.0000000000902789
7	0.06918449285035333
8	0.02136013492641586
9	0.99576752819520209
10	0.40558654802391181

```
11 0.51622270228130773
12 0.00898845007849691
13 0.17531958282284776
14 0.00067054062705507
15 0.01092124116542736
16 0.09377117778800570
17 0.00000000034822678
18 0.06215781888758709
19 0.00020917407152732
20 0.0000000000000000
21 0.0000000000000000
22 0.00000000000000222
23 0.00008645298932164
24 0.00000067790979452
25 0.01847751696153033
26 0.10118520285568477
27 0.82062013649058585
28 0.26894561126574867
29 0.00000001721118226
30 0.00000058964178251
31 0.26705138915737758
32 0.00000042819012602
33 0.00000000000000000
34 0.00000000003619660
35 0.00086446656782524
36 0.33664917683696416
37 0.10303865280988367
38 0.00041249970953716
39 0.00000040229541032
40 0.00711835033761621
41 0.00000000000000000
42 0.00000000000000089
43 0.01970438384324402
44 0.00000000521219512
45 0.00008503236718815
```

```
# pooled r-squared estimate
pool.r.squared(model_2, adjusted = TRUE)
```

```
        est lo 95 hi 95  fmi
adj R^2 0.4  0.38  0.42 0.28
```

The model based on backward selection method based on the pooled estimates contains 13 predictors: region, number of rooms, number of floor, squared meters, number of bathrooms, energy class, type of home heating system, property age and the home including a elevator, alarm, garden, pool, or terrace. The predictors in the model explain 40 percent of the variability observed in the house price. The code for the second model is reused from Gerko Vinks' mice vignettes, which are publicly available.

```
# derive the BIC value for each model
model_1_bic <- model_1$analyses %>% sapply(BIC)
model_2_bic <- model_2$analyses %>% sapply(BIC)

# compare the BIC value
sum(model_1_bic < model_2_bic)
```

```
[1] 5
```

```
model_2_bic - model_1_bic
```

```
[1] 20 20 11 18 17
```

To compare the models we used the BIC for each imputed data set. For all imputed data sets, the BIC favors model 1 over model 2. For all comparisons, the absolute difference in BIC score is at least 10 points. So, according to the BIC model 1 is preferred. This is congruent with the coefficient of determination results, considering adding three predictors: floor, property age, garden, did not yield a higher r-squared value.

4.3.3 Conclusion

5 Overall Conclusion

6 Appendix

Summary of the raw data using the my_skim function.

```
my_skim(housing)
```

Table 5: Data summary

Name	housing
Number of rows	223409
Number of columns	25
Column type frequency:	
character	6
numeric	19
Group variables	None

Variable type: character

skim_variable	n_missing	complete_rate	empty	n_unique
location	0	1	0	7023
title	0	1	0	199305
availability	0	1	0	1
energy_class	679	1	0	12
status	0	1	0	1
heating	0	1	0	2

Variable type: numeric

skim_variable	n_missing	complete_rate	mean	sd	median	min	max	n_unique
id	0	1.00	111705.00	64492.77	111705	1	223409	223409
timestamp	0	1.00	1661135705.37	12645.42	1661135577	1661114079	1661158618	42238
price	39116	0.82	239938.98	7562062.01	135000	1	2147483647	2852
n_rooms	60323	0.73	3.50	0.99	3	2	5	4
floor	72365	0.68	1.82	1.13	2	1	52	22

skim_variable	n_missing	complete_rate	mean	sd	median	min	max	n_unique
mq	4034	0.98	158.63	128.68	117	1	999	976
n_bathrooms	14397	0.94	1.59	0.67	1	1	3	3
year_of_construction	10	1.00	1965.13	76.75	1980	1000	2209	389
has_garage	0	1.00	0.18	0.38	0	0	1	2
has_terrace	0	1.00	0.11	0.32	0	0	1	2
has_garden	0	1.00	0.17	0.37	0	0	1	2
has_balcony	0	1.00	0.10	0.30	0	0	1	2
has_fireplace	0	1.00	0.05	0.23	0	0	1	2
has_alarm	0	1.00	0.01	0.10	0	0	1	2
has_air_conditioning	0	1.00	0.30	0.46	0	0	1	2
has_pool	0	1.00	0.02	0.15	0	0	1	2
has_parking	0	1.00	0.02	0.12	0	0	1	2
has_elevator	0	1.00	0.06	0.23	0	0	1	2
is_furnished	0	1.00	0.08	0.27	0	0	1	2