How does an increase in energy efficiency affect housing prices?

A case study of a renovation

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Abstract

Purpose- The purpose of the paper is to present a case study from Hungary of a renovation, in order to estimate the effect of greater energy efficiency on residential housing prices.

Design/methodology/approach - The paper uses a dataset on real estate transactions. The sample consists of all transactions from 2003 to mid-2012 in a treatment and a control group in Budapest's third district. The paper uses a difference-in-differences framework to test whether prices in a large block of flats - the largest in Hungary - which underwent major energy-efficiency related renovation developed differently following the renovation than prices in comparable, neighbouring blocks.

Findings - Our results show that the renovation resulted in prices 9.42% higher than they would have been absent the renovation, which amounts to over 1 million Hungarian forints on the average flat. This can be contrasted with around 70 thousand forints in yearly energy savings and the 1.3 million forint cost of the renovation per flat. The latter implies that outside funding may also be required to make investment into energy-efficient renovation worthwhile.

Originality/value - The paper is the first empirical investigation into the effect of greater energy efficiency on residential housing prices in Hungary, and fits well with an emerging literature on the subject concerning other countries. It also has relevance in the ongoing debates about the possible need for government funding, and the consequences of making information on energy efficiency more transparent.

Keywords Energy efficiency, Difference-in-differences, Hungary, residential housing prices

1. Introduction

The issue of energy efficiency in residential housing has received increased attention recently. Several countries have implemented "energy certificates" (in accordance with EU policy [1]) which categorise housing units according to their energy efficiency. The expectation is that an energy label will influence the price of a given unit, since energy efficiency not only spares the environment, but also results in lower monthly energy costs for the household in question.

A number of empirical questions naturally arise. How much are buyers really willing to pay for greater energy efficiency? Do they take future savings into account, and if so, do they gauge them correctly, or do they over- or underpay? Who should finance renovations aimed at improving energy efficiency in order to achieve the best outcome, both for residents and the environment?

This paper presents a case study, which can be a first step in answering such questions. The estimation focuses on a specific project in Budapest's third district. A large block of flats (collectively named "Faluház") underwent significant, energy-efficiency related renovation in 2009 (preceded by smaller renovations in 2004-05), while surrounding, otherwise similar blocks did not. We use this natural experiment to find out how transaction prices reacted to such developments. We find a significant positive reaction in prices to the major, 2009 renovation of 9.42%.

Some papers have investigated the relationship between energy efficiency and housing prices in other countries. These papers typically rely on some accepted measure of energy efficiency, some sort of energy certificate [2]. Two notable European examples on the residential real estate market are Brounen et al (2011) (investigating the Netherlands) and Hyland et al (2012) (on Ireland). Using difference-in-differences methodology in gauging the effects of an event on housing prices has a long history, dating back to at least Kiel and McClain (1995).

Section 2 will describe the renovation project, while Section 3 focuses on the dataset and provides descriptive statistics. Section 4 shows the method and the results, and Section 5 will compare results with those found in the literature. Section 6 concludes.

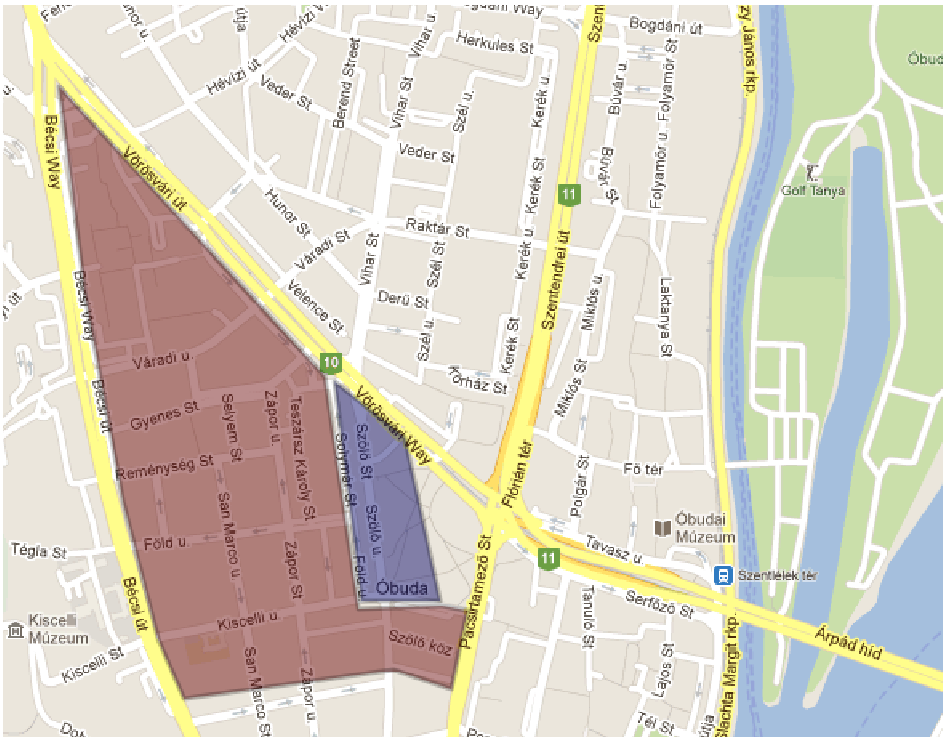
2. Renovation: The "Faluház" project

"Faluház" stands for "Village House", a nickname given to the building in question, since it houses over 3000 people - more than an average Hungarian village. It was built in 1970, has 886 flats in it, and is Hungary's largest apartment building. Faluház suffered from all the problems plaguing the block flats of its era: poor insulation, coupled with massive energy costs. Such blocks were (over) heated centrally, with inhabitants having no control over the temperature. When the temperature was too high, people opened the windows, as this was the only solution available.

During 2004-2005, a minor renovation took place, which enabled inhabitants to adjust the radiators within their apartments. However, energy usage was still not measured on a flat-by-flat basis, and therefore, energy usage did not decrease to the extent expected in advance.

In 2009, however, major renovations took place. Windows were replaced, energy usage (for heating and hot water) became measurable and billable for each flat separately, the building was insulated from the outside, and solar panels were installed on the roof. This major renovation was backed by both government funds and an EU grant, with the inhabitants making a co-payment of around 30% of costs. This co-payment was not a lump sum, rather a commitment to a several-year plan.

Figure 1. A map of the area



This second renovation took many years to plan and implement. What makes it nevertheless a good candidate for analysis is the fact that it was not until the EU funds were actually secured that it was decided (at the municipality level), that Faluház would be the building to receive them. Therefore, it was not apparent to the inhabitants that the renovation could take place until late 2008.

3. The data

Transaction data for residential housing is collected in Hungary for tax purposes, originally by each county, and since 2008 by the central tax authority[3]. This dataset contains a varying amount of information on all transactions in Hungary, notably the price, the location (at street level) and typically the size of the property. Our dataset is comprised of transactions screened from this larger database, firstly, for the treatment group "Faluház", and secondly, for neighbouring, similar blocks of flats, starting in 2000.

The treatment and control groups were assigned through their street addresses and their type (house, flat, block flat), based on multiple visits to the area. We believe our screening method (detailed in the Appendix) is sufficiently accurate in identifying the relevant groups. Both Faluház and the controls are large "block flats", made of prefabricated concrete blocks. The Hungarian housing market differentiates strongly between such block flats and other apartments (typically found in brick buildings), putting a price premium on the latter. Block flats are immediately recognisable and have a characteristic, quite uniform look. Figure 1 shows the location of Faluház, and the control group.

Since there are block flats all over the area, choosing the buildings in the control group was a complex issue. We were looking for block flats, which are similar to Faluház is as many ways as possible (excepting the renovations). While distance is a factor, it is not the only one. Multiple visits to the area helped identify the control group pictured on the map [4].

Table 1. Number of observations by group

	Number of observations	
Time period	**Faluház**	**Control**
2003: Before the first renovation	27	253
2004-2005: During the first renovation	55	29
2006-2008: After the first, before the second renovation	105	407
2009: During the second renovation	22	49
2010-2012: After the second renovation: 2010-2012	80	163
2000-2012	**318**	**1081**

We have 1400 observations after eliminating outliers and incomplete observations [5]. Table 7 in the Appendix shows the number of observations each year by group. There are over twenty observations per year in each group (except for the incomplete year of 2012), and often significantly more. Table 1 shows the number of observations for each relevant time period.

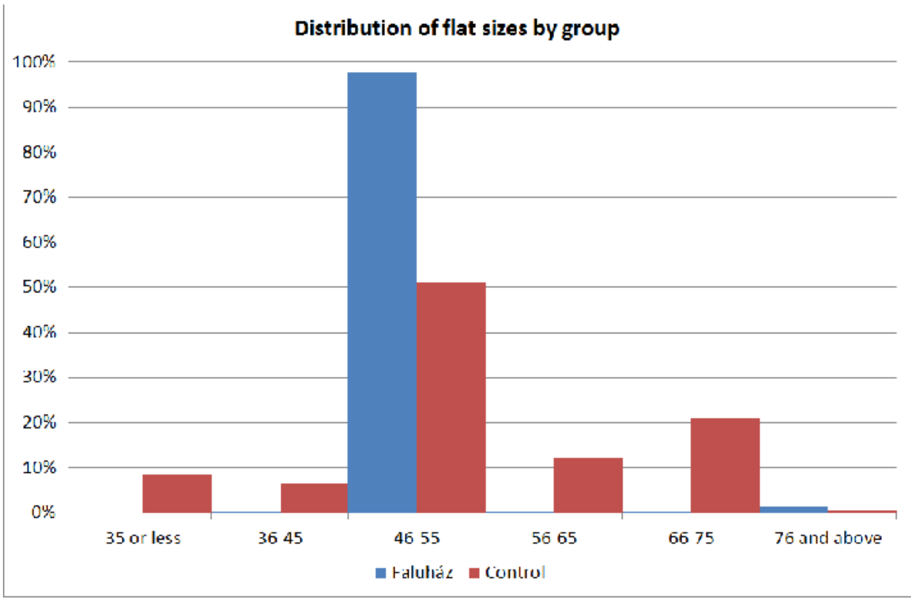
Table 2. Variables in the dataset

Variable Name	Description
Price	The transaction price of the property in Hungarian Forints (HUF)
Size	The size of the property in square metres
Year	The year of the transaction, between 2003 and 2012
Faluház	Equals one if the transaction took place in the treatment group
Control (large)	Equals one if the transaction belongs to the larger control group only
Housing Price Index	A housing price index for ats in Budapest's third district. Base index, with 2011 (the last complete year) as its base.

Table 2 describes the variables available for each transaction in the dataset. We will now present descriptive statistics, first focusing on size. Figure 2 shows the distribution of the size of the properties sold over the entire period, for each group.

A few conclusions can be drawn from this figure. Firstly, there is little variation in the size of flats in the Faluház block. This is not surprising, since blocks of flats are built with a limited number of available layouts. Most flats are therefore 48, 49 or 52 square metres in size. There is greater variability in the control groups, since they contain multiple blocks with differing layouts. Here, too, however, there are pile-ups at 32, 48-52 and 66 square metres: these are typical flat sizes. Table 8 in the Appendix shows the average, median, minimum, maximum and standard deviation of flat size in each group.

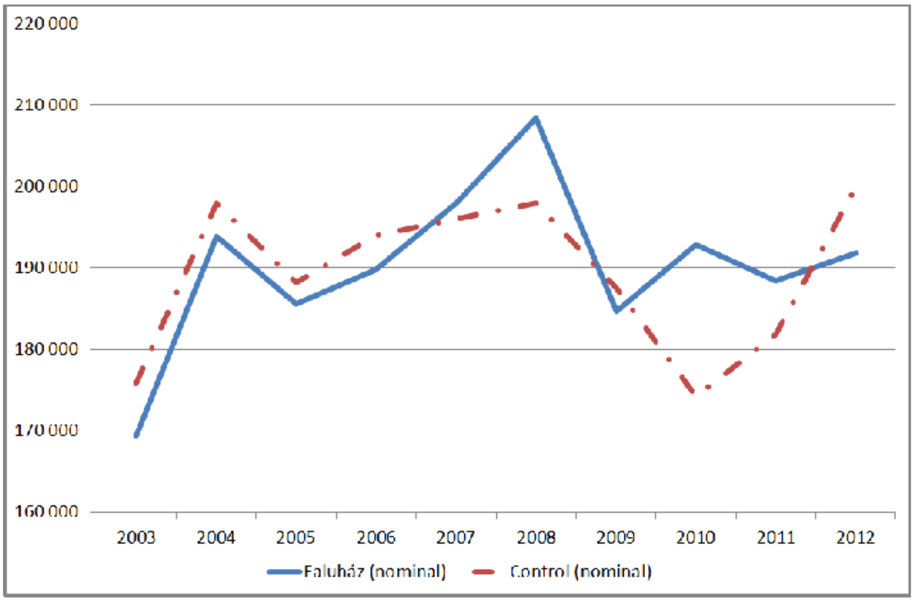
Figure 2. Distribution of flat sizes (in square metres) by group



It is customary to use price per square metre as a dependent variable in the real estate market. It is important to note, however, that while size is a defining factor in house prices, the relationship between price per square metre and size is not necessarily linear. In our case, the relationship appeared to be quadratic, implying that both very small and very large housing units may enjoy a premium in price per square metre, instead of just very small units. There are a few possible of reasons for this, which it may be interesting to examine in detail in a more general case. We mention only one, a supply-side effect: there may be a shortage of large flats, since these were often divided up into smaller units in the past. In the case of Faluház, the quadratic form of the size was invariably highly significant.

Figure 3 shows median price per square metre over time, for each group[6]. The graph shows that in the first half of the decade, the control group had a fairly stable price premium over Faluház, which changed around 2008.

Figure 3. Median nominal HUF price per square metre over time



Our dependent variable of choice will be (the logarithm of) price per square metre in 2011 forints, that is, deflated by the local Housing Price Index [7]. There are a few other observations we can make based on the deflated time series. Firstly, that block flats have been losing their value throughout the entire period. This is a country-wide phenomenon, and the area under investigation is no exception. In Faluház, however, flats have been more successful in retaining their value over the past few years. These trends are even more apparent in median values, see Figure 6 in the Appendix. Second, it is worth noting that deflating by the local Housing Price Index should partial out the effects of the economic crisis, a defining characteristic of the real estate market since 2008.

4. Method and results

We estimate the following difference-in-differences model, where size and year-dummies may appear as controls:

$$log\left(\frac{price/size}{index/100}\right) = \beta_0 + \beta_1 \cdot after + \beta_2 \cdot faluhaz + \beta_3 \cdot after \cdot faluhaz + controls. \quad (1)$$

The parameter of interest is β_3, which shows the difference in the dependent variable between the treatment and the control group, after and before the renovation, where y indicates the dependent variable:

$$\hat{\beta}_3 = \left(\bar{y}_{after,faluhaz} - \bar{y}_{after,control}\right) - \left(\bar{y}_{before,faluhaz} - \bar{y}_{before,control}\right) \quad (2)$$

The difference-in-differences approach is essentially a fixed effects technique: it eliminates unobserved heterogeneity that changes over time but is the same across (treatment and control) groups. Nevertheless, it would still be worthwhile to control for other housing characteristics, not only in order to decrease the error variance, but because flats selling before 2009 may have been systematically different from those selling after 2009. It is not unlikely that this is the case, taking into account that the period in question coincides with a worldwide economic crisis. Currently, we can control for the size of the unit only.

Dividing by the index removes the local (district-wide) trend in sales prices over the period. This enables us to put transactions from 13 years (where inflation, the economy and the real estate cycle all caused sales prices to change) into two categories: "before" and "after" the renovation, and to interpret results in 2011 forints. However, we can also include year-dummies as controls - these will pick up any residual time trend left in the data.

The issue of timing is crucial. We are looking for the effects of a renovation on housing prices, so the question naturally arises: when would we expect such effects to materialize? Housing prices may conceivably react to the first rumours of a renovation. Another point of interest is when the rumour becomes fact, that is, when it is established that the renovation *will* take place. However, co-payments are usually required, and housing prices may not react until after these payments have been made. Payments may, however, continue for several years, while saving resulting from the renovation begin immediately after it is completed. All in all, we expect the adjustment of housing prices to be gradual, and therefore, we chose to omit the "murky" years from the estimation. The effect of the first renovation was therefore measured by comparing 2003 to 2006-2008, while the effect of the second, major renovation was estimated by comparing 2006-2008 to 2010-2012.

Results can be seen in *Tables 3* and *4*. We use robust standard errors as there was evidence of heteroskedasticity.

Table 3. Results: first renovation, 2004-2005

VARIABLES	(1) Log price per square metre (2011 forints)	(2) Price per square metre (2011 forints)	(3) Price (2011 forints)
After	-0.0556*** (0.0198)	-10,538*** (3930)	-456,795** (207,806)
Faluház	-0.0968** (0.0379)	-18,565*** (5628)	-802,899*** (278,719)
After × Faluház	0.0558 (0.0428)	7,305 (6607)	317.928 (330,651)
Size, size squared	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Observations	822	822	822
R-squared	0.133	0.160	0.281

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The results for the first renovation show no significant effect, that is, the interaction term is insignificant. As expected, the "after" variable, along with the year dummies, is significant, indicating simply that even deflated prices change over time. The "Faluház" variable is also significant, and shows the price premium of non-Faluház blocks.

Table 4. Results: second renovation, 2009

VARIABLES	(1) Log price per square metre (2011 forints)	(2) Price per square metre (2011 forints)	(3) Price (2011 forints)
After	-0.0800*** (0.0232)	-17,623*** (4967)	-1,041,000** (273,207)
Faluház	-0.0435** (0.0198)	-11,709*** (3608)	-506,442 (181,691)
After × Faluház	0.0942*** (0.0288)	19,107*** (5568)	1,052,000*** (289,679)
Size, size squared	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Observations	755	755	755
R-squared	0.139	0.140	0.306

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In the case of the second, major renovation of 20009, all variables of interest are strongly significant (including size and its square). Year-dummies are also often highly significant typically individually are always jointly.

The relationship between the dependent variable and size displays the conjectured U-shape. The minimum is at 73 square metres, a typical mid-sized flat. The gradual decrease in the relative value of block flats is apparent from sign of the coefficient on "After", as well as the year dummies, which, when significant, are always negative.

In the first specification, the coefficient on Faluház shows that before the renovation, Faluház flats were relatively cheaper than control flats (by around 4.4%), that is, the relationship seen in Figure 4 holds even when controlling for size and year. After the renovation, this relationship changed: the sum of the coefficient on Faluház and the coefficient on After ×Faluház is positive at around 3.7%. The difference-in-difference estimator is the coefficient on the interaction term. This shows a positive, significant effect of the renovation of 9.42% - enough to reverse the relationship between Faluház and control group flats.

The second specification shows a difference of around 11 700 forints per square metre between Faluház and control flats before the renovation (Faluház being cheaper), which changes to around 7400 forints after the renovation, with Faluház the more expensive option. The difference-in-differences estimator shows an effect of over 19 000 forint per square metre. The third specification is run with the total price as the dependent variable (deflated, of course). In this case, the difference-in-differences estimator shows an effect of over 1 million forints per flat.

In order to place these results in context, it is worth making some back-of-the-envelope calculations.

First, we'd like to know whether the increase in price is on par with the savings in energy costs. We know that energy costs per flat dropped by approximately 50 000 forints between 2008 and 2011 (in 2011 forints)[8]. Our results show an increase in the price of an average Faluház flat of around 1 052 000 forints (also in 2011 forints). We will look at the situation of a buyer deciding between getting an energy efficient flat similar to Faluház currently and getting a less energy efficient flat similar to Faluház before the renovation (for about a million forints less). The buyer is indifferent between the two options if the present value of the savings in energy costs are also around one million forints. The present value, in turn, depends on the expected interest rates, and the number of time periods. If we treat the yearly savings as an annuity, then indifference occurs at an interest rate of 4.75%. However, at a rate of 50 000 a year it would take over 21 years to get a present value of 1 052 000 forints, even if interest rates were close to zero. This implies that the increase in price reflects more than the energy savings only. The effects of a renovation can affect the price through several channels - for example, the fact that the building managed to attract such large investment in itself may signal desirability. A more likely scenario is that there is an expectation that energy costs will continue to increase. Since 2007, gas prices have increased by over 10% each year. If people expect this trend to continue, then assuming a 4% risk-free interest rate, a price-difference is equal to about 15 years of savings - a realistic result.

Second, it is also worth comparing the results with the costs of the renovation. The average cost per flat for the 2009 renovation was around 1 300 000 forints (in 2008 forints), which is higher than the one million gained in the value of the flat (or the savings that accrue over the years, with realistic interest rates). This shows that such renovations are unlikely to take place without some sort of outside funding. Such funding is therefore necessary in order for the state's goals regarding energy efficiency to be realized.

5. Related literature

In this section we briefly present how our results fit in with those in the related literature. As mentioned in Section 1, there are at least two notable, recent European examples of investigations into the effect of energy efficiency on residential housing prices: Brounen et al (2011) (investigating the Netherlands) and Hyland et al (2012) (on Ireland). Both these papers measure energy efficiency through energy performance certificates (also called energy labels), and both find significant effects. The expectation that a favourable energy label will increase prices is shown to be true. Table 5 shows price premiums compared to a "D" label in the two papers [9].

Table 5. Price premium compared to a "D" label

	Price Premium	
Label	**Holland**	**Ireland**
A	10.2%	11%
B	5.6%	5.8%
C	2.2%	0.7%
D	0%	0%
E	-0.5%	1.7%
F	-2.5%	-5.6%

In Hungary, energy labels are still a novelty and during most the period under investigation are not yet present on the market. The increase in price that we measure, however, is similar in magnitude to an improvement from a D to an A label, that is, quite large. We believe that effects may become even more pronounced once energy labels become widely used and can act as a reliable indicator of energy efficiency levels.

Both papers also compare their results on prices with the energy-related savings due to a better energy label. Hyland et at (2012) treat the savings as an annuity, and use a 5% discount rate. The difference in price in such a case does not completely account for the savings. Brounen et al (2011) on the other hand assume 12 years of ownership (the average in Holland) and a 4% discount rate. In their case, conversely, the price premium exceeds the expected savings. The chosen parameters, as we have seen in the Hungarian case, matter greatly, and further work will attempt to identify the most plausible values.

6. Conclusion and further work

This paper presented a case study from Hungary on the effect of greater energy efficiency on residential housing prices, using a dataset on real estate transactions. Our data show that the second, major renovation of Faluház had a significant effect on apartment prices in the Faluház building. Prices after the renovation are over one million forints higher then they would have been absent the renovation, a change of over 9%.

In further work we plan to analyse the various channels that led to this shift in prices. We plan on collecting advertising data to see how the renovation(s) were presented. Another avenue of investigation is the generalisability of our results. When energy certificated become widely used, it will become possible to conduct analyses on a wider scale.

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Notes

[1] Directive 2002/91/EC makes energy performance disclosure mandatory for all member states. It was recast in 2009, and implementation is still ongoing.

[2] A few papers relating to the residential housing market are Australian Bureau of Statistics (2008), Zheng et al (2012), Amecke (2012) and Yoshida and Suguira (2010).

[3] NAV: Nemzeti Adó- és Vámhivatal.

[4] Block flats are either 10 or 4 stories high, and the latter are viewed more favourably by the market. In a future extension, data permitting, we plan to focus only on 10-story blocks.

[5] A detailed description of the screening process for eliminating outliers and incomplete observations can be found in the Appendix.

[6] The median is the preferred measure of central tendency when looking at time trends in real estate prices. Averages are shown in the Appendix.

[7] The exact values of the Housing Price Index, and figures showing the mean nominal prices and median price per square metre can be found in the Appendix.

[8] Calculation of energy costs made by the Energiaklub Climate Policy Institute, http://energiaklub.hu/en.

[9] The results come from different models in different countries and are thus not immediately comparable. However, it is noteworthy that they still show a remarkable similarity. All results are statistically significant, excepting Ireland's "C".

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A. Appendix

The Appendix contains additional information on how our sample was obtained, and provides more detailed tables and further figures.

A.1 Acquiring and screening the data

The original source of the real estate transaction data used in this paper is the Land Registry Office. All real estate transactions are obligatorily registered at the Office, and several descriptors of each transaction are archived there. The database includes the year of the transaction, the contract price, the address, the size and the type (detached house / condominium / prefabricated block flat) of the real estate. In around 10% of cases, the Office also conducts a site visit to verify submitted data. In these cases around 30 further features of are registered, including, for example, the building materials used for the walls and roof, and the type of heating installed. We acquired the first part of the dataset (up to the end of 2007) from the FHB Mortgage Bank, and the second part (from 2008) from the Hungarian Statistical Office (KSH).

From the Land Registry Database, we needed to identify block flats in the treatment and control areas. While the database contains a variable describing the real estate's type, this variable - not a key variable for the purposes of the Lard Registry Office - is often imprecise: specifically, not all block flats are identified as such. This is because block flats form a subset of flats (apartments, condominiums), and many are simply noted (technically, miscategorised) as condominiums. The opposite type of miscategorisation, that a flat would be marked as a special type when it in fact isn't, is far less likely (and based on cases we could verify, did not occur at all).

Due to a change in data protection legislation, the data available in the database changes at the beginning of 2008. Until the end of 2007, the exact address of the flats was included in the database. Since 2008, however, the house numbers are no longer available. This means that we had to follow slightly different processes for selecting the transactions relevant to this paper (either as treatment or control observations) in the two periods. In the following paragraphs, we describe how selection took place.

We took several field visits to the neighbourhood, and compiled a detailed list of the exact street addresses (and based on these, the postal codes) of the relevant real estate (block flats) in the area. Prior to 2008, therefore, the records needed for the paper could be exactly identified in the transaction database.

Beginning in 2008, the lack of the street address made it somewhat more complicated to exactly identify our target groups. Some streets in the neighbourhood (Ágoston utca and Szőlő köz) contain only block flats, and we therefore included all observations from these streets in our selection. In those cases where the records specifically stated that the real estate in question was a block flat, we accepted this identification (for the reasons outlined above). Some observations could be identified as block flats based on their other features (eg. concrete walls and roofs).

Table 6. Screening the data: number of observations

Screen	Number of observations
Original dataset (2003-2012)	1,588
No size	3
No price	0
Result	1,585
Size under 30 or over 120 square metres	177
Price too high	0
Price too low	5
Price per square metre too high	0
Price per square metre too low	3
Final result	**1,400**

In all other cases, we identified block flats using the typical block flat unit sizes in each street. Prefabricated blocks have a limited number of unit sizes, and flats on each floor resemble each other closely. We used the database from before 2008 to see the typical block flat unit sizes in each street, and calculated the ratio of block and non-block flats for each unit size. We then decided on some (arbitrary) thresholds for inclusion: if the ratio of block flat to non-block flat transactions for a given size in a given street before 2008 was at least 80% (4:1), and this ratio was calculated from at least 20 transactions, then we categorized all flats of that size in the given street as block flats from 2008 onwards. In the case of the treatment group Faluház's street (Szőlő utca), we also took into account that the street spans two postal codes. The postal code containing Faluház itself has a few other, non-block houses in it, however, between 2000 and 2007 there were no non-block flat transactions at all. Identifying the treatment group from among the block flats was therefore relatively simple. There are in fact two other block buildings in Faluház's street, but they have a different postal code.

This method of identifying block flats does, of course, introduce the possibility of bias. If we are including some observations that didn't, in fact, relate to block flats, then this may increase average prices (since non-block flats are typically more expensive than block flats). However, this should not severely influence the difference-in-differences estimator.

The resulting database was purged of outliers and incomplete observations. Table 6 demonstrates the results of the screening process. From the original 1588 observations 3 were dropped as they lacked data either on size or on price. The resulting dataset of 1585 observation was then screened for outliers. In fact, there were very few observations that needed to be excluded, and all together only 185 were. These included transactions where sizes were implausibly large or small (sometimes 1 square metre, indicating a mistake made during data entry), prices that were too unlikely (a maximum price of 30 million HUF and a minimum price of 2 million HUF were specified for 2011, and then deflated by the Consumer Price Index to form maximum and minimum prices for each year), and prices per square metre which were too unlikely (the maximum in the case of prices per square metre was 500 thousand HUF, and the minimum, 50 thousand).

A.2 Further tables and figures

Table 7. Number of observations by year and by group

	Number of observations	
Year	**Faluház**	**Control**
2003	57	253
2004	19	78
2005	36	131
2006	38	202
2007	36	130
2008	31	75
2009	22	49
2010	34	59
2011	29	66
2012	17	38
Sum	**319**	**1081**

Table 8. Flat size: descriptive statistics by group

Statistic	Faluház	Control
Mean	49.37	52.88
Standard deviation	3.95	10.56
Minimum	42	31
25th percentile	48	48
Median	49	50
75th percentile	49	65
Maximum	82	82

Table 9. Values of the Housing Price Index for the 3rd district in Budapest and the Consumer Price Index, 2011=100

Year	Housing Price Index	Consumer Price Index
2003	85.2	66.8
2004	98.2	71.4
2005	95.2	74
2006	99.7	76.8
2007	100	83
2008	106.1	88
2009	101.5	91.7
2010	95.9	96.2
2011	100	100
2012	95.8	105.6

Figure 4. Mean price per square metre over time (nominal)

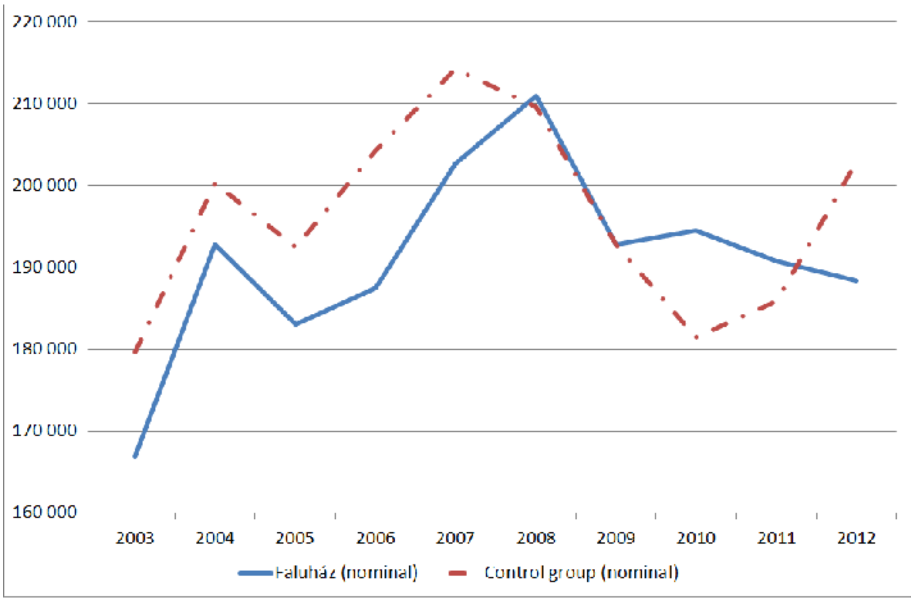

Figure 5. Mean price per square metre over time (deflated)

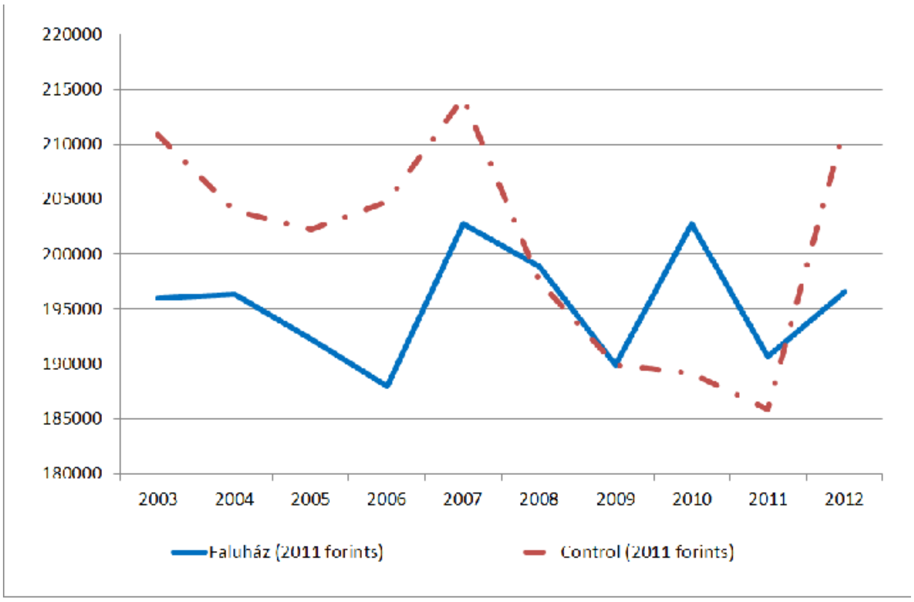

Figure 6. Price per square metre over time (median, deflated by a Housing Price Index)