Thermal insulation in apartment buildings: decision making proces and effect on energy savings

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Motivation

- Topic of revitalization of old block of flats has become largely discussed topic recently mainly because of EU requirements for energy efficiency of buildings
- The subsidy programmes such as Panel, Green for Savings and others have been launched in the Czech Republic
- How much people finally save after thermal insulation measures were implemented in the multi-family buildings, considering the invested money into these measures

Research question

- How successful and effective the government funding of multi-family building renovations was in the Czech Republic
- How large was the effect of investment in thermal insulation in terms of energy consumption

Data collection

- **Survey:** Face to face interviews with heads of SVJ (Association of Dwelling Units Owners) and facility management companies
- **Target group:** Multi-family houses insulated in past 10 years with data on energy consumption 3 years before & 3 years after the insulation was made
- **Sampling:** survey was conducted in Prague and Pilsen (easily accessible areas)
  - Meetings with heads of SVJ arranged by phone calls.
    - Phone numbers were collected by browsing of given member of SVJ (ARES) obtained from facility management companies.
  - Communication with facility management companies that provided the necessary information on selected buildings
- **When:** Survey was accomplished during January and February 2016
- **Sample size:** Data for 45 insulated apartment buildings over 6 year period (3 years before and 3 years after)

Data description 1/2

- **Energy consumption for heating** – annual energy consumption on heating (in GJ) available from collected data (AECH)
- **Normalization of AECH by heating degree days (HDD) and floor area** (NAECH) – normalized annual energy consumption on heating (in GJ)
    - $(AECH \times \frac{HDD_N}{HDD_A})$ / (floor are related to heating)
- **Determinant of energy consumption used in the models** – specific energy consumption per year (SECA)
    - $SECA = \frac{NAECH}{Floor\ area\ related\ to\ heating}$
- **Project –** dummy variable equals to 1 when insulation has been implemented and 0 otherwise
- **Investment –** financial means used for insulation (in models the variable *Inv6* is given in millions CZK)
- **SubsidyD** – dummy variable equals to 1 when subsidy provided and 0 otherwise

Data description 2/2

Variable	Obs	Mean	Std. Dev.	Min	Max
SECA (HDD normalized GJ by per m2)	270	**0.309**	0.131	.0810	.669
Investment in insulation (Inv6, million CZK)	45	**8.188**	6.067	.339	25
Subsidy (if received=1, dummy)	45	**0.578**	0.500	0	1
Subsidy (million CZK)	45	**2.876**	2.871	.306	11
NumberFloors	45	**8.11**	2.26	4	12
NumberFlats	45	**58.02**	39.21	9	180
FloorArea (m2)	45	**3,627.71**	2,611.85	550	11,498

Econometric model (1/2)

- 45 different apartment buildings *(cross-sectional elements)* + 6-year time period *(time dimension)* => *panel data*
  - (allows exploring the effect of treatment – implementation of new energy saving technology – insulation in this case, controlling for the effect of other explanatory variables on energy consumption at the same time thanks to the consecutive observations for each individual unit)
- *Unobserved effects* (a_i) => factors that could be correlated with explanatory variables in the model but we do not observe them
  - Controling for these effects => random effects (RE) or fixed effects (FE)

Econometric model (2/2)

$$y_{it} = \alpha_1 + \beta_1 x_{it1} + \beta_2 x_{it2} + \cdots + \beta_k x_{itk} + a_i + u_{it};$$

$$t = 1, 2 \ldots t; i = 1, 2 \ldots n; t = 6; n = 45$$

- We use FE since we suppose there are some time invariant factors included in a_i that are possibly correlated with explanatory variables (assumption for using RE model as a suitable estimator are not satisfied => RE model is not consistent)
- FE refers to the population – average – it holds constant average effect of each building
  - By FE we are controlling for average differences across buildings in any observables or unobservables (e.g. quality of insulation…)
- The coefficient on each explanatory variable represents the average effect of the given explanatory variable

Models 1/4

$$SECA_{it} = \alpha_1 + \beta_1 PROJECT_{it} + a_i + u_{it}$$

where $SECA_{it}$ is normalized annual energy consumtpion in GJ per, and the subscripts t and i are the year (1,..,6) and multi-family building (1,..,45).

- The main reason to study the effect of *PROJECT* on *SECA* is to find the impact of introducing the insulation on energy savings that is given by coefficient $\hat{\beta}1$.
- The coefficient$\hat{}$1 shows an average *SECA* without project including the average effect of individual-specific intercepts (unobserved effects) on *SECA* (Wooldridge, 2012).
- Coefficient $\hat{\beta}1$ is statistically significant at 1% significance level. *PROJECT* is reducing *SECA by* approximately **0.135 GJ/m2** per year when the insulation is performed after controlling for other factors.

Models 2/4

$$SECAind_{it} = \alpha_1 + \beta_1 PROJECT_{it} + a_i + u_{it}$$

$$SECAind_k = \frac{SECA_k}{SECA_1}; \qquad k = \{1, \dots, 45\}$$

- In this model we are mainly focused on estimation of the percentage effect of project on energy consumption given by the coefficient^1.
- The project of insulation leads to almost **36 % decrease in energy consumption** after controlling for other factors. Independent variables are both significant at 5% significance level

Models 3/4

$$SECA_{it} = \alpha_1 + \beta_1 Inv6_{it} + a_i + u_{it}$$

- The coefficient^1 is considered as an approximate change in *SECA* as a consequence of one million CZK invested in insulation after controlling for other factors
- Each one million of CZK invested into thermal insulation of a building resulted in *SECA* that is about **10 MJ/m2 per year lower**.
- The coefficient on *Inv6* is highly significant and it is reasonable to keep this variable in the model.

Models 3/4

- Considering the average heated floor area that is 3,628 m2 we get average **energy savings of 36.28 GJ per year** as the effect of **each invested million** in the insulation project in multi-family apartment buildings.
- The average value of investment in the insulation project in our sample is equal to amount of 8,188,175 CZK (303,041.266 EUR) that implies the average effect of about **297 GJ per year per project**.
- An alternative interpretation, when assuming the average cost of energy use for heating (593.6 CZK per GJ), then each insulation project led on average to **financial savings of about 176,299 CZK per year**.
- In other words, each million CZK invested in the thermal insulation led to **21,500 CZK of financial savings** that implies around **46 years of payoff period.**

Models 4/4

$$SECA_{it} = \alpha_1 + \beta_1 Inv6_{it} + \beta_1 SubsidyD_{it} + a_i + u_{it}$$

- We hypothesize that providing subsidy will …
  - either make the effect of investment weaker (due to **sub-optimal behaviour**), or
  - make larger and hence **more effective projects** feasible (the economy of scale effect)
- The model (4) introduces both of these variables to analyze the effect of investment (-) on SECA while controlling the effect of subsidy provision (+/-).
- We found that both coefficients are NEGATIVE and highly significant (with p-value<.01) and so it is reasonable to have them in model.
- The coefficient^1 indicates approximately **0.55 MJ/m2 per year reduction** in *SECA due to* investment of one million CZK into insulation and^2 is equal to **-9.55 GJ/m2 per year**, indicating additional reduction in SECA.
- Overall effect of the projects that received public subsidy on SECA is approx. **11 GJ/m2 of savings per year**.

Models 4/4

- Multi-family buildings using the subsidy as a part of their funding, they saved about **40 GJ/m2 per year per each invested million CZK** that is about **20 GJ/m2 more than those without the subsidy**.
- Hence, the average value of investment in insulation project given as 8,188,175 CZK led to energy savings of about **327.5 GJ/m2 per year**.
- Using average energy cost in Czech Republic of 593.6 CZK per GJ the **financial savings correspond to 194,420 CZK per year**.
- In other words, a million CZK of invested money into the insulation project led to 23,700 CZK of financial savings.


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