Energy Efficiency of Residential Buildings in the European Union – An Exploratory Analysis of Cross-Country Consumption Patterns

Petrik Runst, Institute for Small Business Economics at the University of Göttingen, +49 551 3917 4885, petrik.runst@wiwi.uni-goettingen.de
Anita Thonipara, Institute for Small Business Economics at the University of Göttingen, +49 551 3917 4888, anita.thonipara@wiwi.uni-goettingen.de
Kilian Bizer, Chair of Economic Policy and SME Research, +49 551 39 4602, bizer@wiwi.uni-goettingen.de
Christian Ochsner, University of Göttingen, +49 551 3917 4891, christian.ochsner@stud.uni-goettingen.de

Overview

Despite a common EU directive on energy efficiency in residential buildings, levels of energy efficiency differ vastly across European countries. This article analyzes these differences and investigates the effectiveness of different energy efficiency policies in place in those countries. We firstly use panel data to explain average yearly energy consumption per dwelling and country by observable characteristics such as climatic conditions, energy prices, income, and floor area. We then use the unexplained variation by sorting between-country-differences as well as plotting within-country changes over time to identify better performing countries. These countries are analyzed qualitatively in a second step. We conduct expert interviews and examine the legal rules regarding building energy efficiency. Our analysis shows that carbon taxation is highly effective in lowering energy consumption. In line with previous results, we also show that regulatory measures can be effective in the long run.

Methods

We employ a mixed-methods approach. Our quantitative analysis serves the purpose of explaining energy consumption by country and year by observable characteristics. We pay close attention to individual country fixed effects as they can indicate a higher (or lower) level of energy consumption than what we would expect from the vector of observable characteristics. We also plot the country specific residuals over time. Systematic changes over time indicate improvements or decline in energy efficiency. We then build upon these quantitative insights by qualitatively investigating certain countries, which stand out due to their better-than-expected energy conservation, in detail. These case studies identify likely (policy) causes for their high levels of energy conservation.

Having data of the 28 countries of the European Union and Norway for the years from 2000 – 2015, we use panel data methods. The mean energy use per dwelling by country i and year t (as tons of oil equivalent) represents the dependent variable in our empirical model which takes the following form:

$$Energy_{it} = \beta_0 + \beta_1 \bar{X}_{it} + \beta_2 \widehat{Wapitax}_{it} + \beta_3 longitude_i + \beta_4 latitude_i + \beta_5 country_i + \beta_6 year_t + \varepsilon_{it}$$

Where:

$$\widehat{Wapitax}_{it} = \gamma_0 + \gamma_1 Wapitax_{it-1} + \gamma_2 exogenous\ regressors_{i(t)} + \varepsilon_{it}$$

Where:

$$\gamma_2 = 0$$

In order to capture the country-specific effects a Least Squares (Country) Dummy Model will be run. Therefore, a country dummy variable $country_i$ is included in the model controlling for time-invariant country-fixed effects. These country dummies show whether a country consumed more or less energy than others after having controlled for country-specific conditions. We expect that the country fixed effects mainly capture public policy differences across countries. The vector $\bar{X}$ is composed of the following time-variant explanatory variables:, mean floor area, GDP per capita, share of homes that are owned (as opposed to being rented), share of apartments (as

opposed to free standing houses), the share of newly constructed residential buildings each year. We further include HDD (heating degree days), longitude and latitude to control for climatic differencese and a weighted average price index which calculates the energy price according to the country's specific energy mix and prices. Regression residuals ε_{it} can also be plotted and represent a measure of changing efficiency levels within countries over time. We conduct tests on and take care of heteroscedasticity, endogeneity and autocorrelation which is why we have two model specifications.
As a result of our quantitative analysis, we obtain information about a country's average energy consumption and its consumption changes over time. In a subsequent qualitative analysis, we investigate the energy efficiency policies (with respect to buildings) in selected countries by examining official policy documents and by conducting interviews with experts in these countries.

Results

The countries which display the lowest energy demand and are jointly significant in all specifications are Sweden, Bulgaria, Finland and Hungary. The two countries which display the highest energy requirements are Ireland and Luxembourg. A negative time trend is observable, which can be explained by technological progress as well as increasingly stringent European energy efficiency policies. Furthermore, the quantitative analysis showed that the greatest improvements in energy efficiency over time were found in France, Hungary, Latvia as well as Luxembourg. All these and the above mentioned countries are analysed in the qualitative part of this paper.

We find that building regulations are an effective policy instrument for reducing the consumption of energy in residential buildings. However, the impact of regulatory standards becomes only visible over time. Sweden and Finland exhibit stringent regulatory demands that have existed for more than 40 years and have been further adjusted over time. In the case of Ireland, where a third of the buildings have been constructed during the last 15 years, regulation has also markedly contributed to the reduction of overall energy consumption in a comparatively short amount of time. Sweden and Finland are interesting cases since they display low energy requirements (contingent on observable characteristics). Being geographic neighbors, they are also situated in a similar climatic and cultural zone and are thus, ideally suited for a direct policy comparison. However, as regulatory standards as well as other factors (such as shares of district heating) are almost identical in the case of Sweden and Finland, another explanation is required in order to understand the advantage of Sweden relative to Finland when it comes to energy consumption. We assert that this crucial difference can be found in the high CO2-taxation rates that have existed in Sweden since the year 1990. The decline in the energy consumption pattern over time is consistent with such an explanation as the increases in taxation coincide with the decline.

Conclusions

In line with previous findings by O'Broin et al (2015) and Filippini et al (2014), we present evidence on the effectiveness of regulatory (building efficiency) standards. The evidence further suggests additional factors to be at work. In particular, we conclude that energy taxes and CO2 taxation represent effective means of energy efficiency. We also show that the level of CO2-taxation plays a critical role for its effectiveness.

References

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