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Empirical Estimation of Electricity Demand Elasticities for Different Customer Groups in Switzerland and Implications for Energy Policies

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Swiss Federal Office of Energy SFOE
XY Research Programme
CH-3003 Bern
www.SFOE.admin.ch

Agent:
Centre for European Economic Research
L 7, 1
68161 Mannheim
Germany
www.zew.de/en

Authors:
Michael Hellwig, ZEW, hellwig@zew.de
Dominik Schober, ZEW, schober@zew.de
Oliver Woll, ZEW, woll@zew.de

SFOE head of domain: Anne-Kathrin Faust; Anne-Kathrin.Faust@bfe.admin.ch
SFOE programme manager: Florian Kämpfer; Florian.Kaempfer@bfe.admin.ch
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Swiss Federal Office of Energy SFOE
Mühlestrasse 4, CH-3063 Ittigen; postal address: CH-3003 Bern
Phone +41 58 462 56 11 · Fax +41 58 463 25 00 · contact@SFOE.admin.ch · www.SFOE.admin.ch

Project goals

The research project investigates price elasticities of electricity demand in Switzerland. Hourly demand elasticities are derived for Switzerland using consumption data at the canton level. Special focus is put on the elasticities of households, industry and services. These elasticities are used to simulate and evaluate (regionally distinguishable) demand reactions to energy policies that influence the price of electricity. The research project also analyzes price elasticities of gas demand in Switzerland on a yearly basis.

Summary

The research project investigates price elasticities of electricity demand in Switzerland. Based on consumption data at the canton level hourly demand elasticities are derived. In addition, we make use of the cantons' different compositions of customer groups enabling us to distinguish among the elasticities of households, industry and services. Different exogenous influences or shocks allow the estimation on a price-per-unit-of-energy basis [kWh]. We further use network-charge changes in order to derive an industry elasticity of demand for power [kW] as well as energy [kWh]. A similar investigation is carried out for price elasticities of gas demand in Switzerland – however given limited data availability, with a focus on yearly elasticities.

The identification of fundamental market data allows investigating several aspects. By means of these elasticities it is possible to evaluate demand reactions to (past) energy policies and to simulate demand reactions to energy policies that influence the price of electricity. These policies can be investigated at a canton or sectoral level so that heterogeneous distributional effects, e.g. of an electricity tax, may be analyzed.

The first months of the project time were dedicated to start building a sound and rich database and to conventionalize the empirical approach. Data being already present at ZEW was validated and updated. Additional data sources have been detected and the respective data retrieved and incorporated into the dataset. Special focus was put on gas data. In a subsequent step, consumption by customer groups will be identified and initial analyses will be carried out.

Work undertaken and findings obtained

The first months of the project time were dedicated to start building a sound and rich database and to conventionalize the empirical approach. As suggested in the kick-off meeting with SFOE we simultaneously start with the investigation of gas price elasticities instead of conducting this analysis after the investigation of electricity price elasticities. We, therefore, extended our data collection process to also already capture gas data. A first assessment of the data reveals a promising foundation for the forthcoming analysis.

National cooperation

None

International cooperation

Aiming for cooperation with Paul Scherrer Institute, Switzerland, and Cambridge Econometrics (SFOE project SWIDEM), England.

Evaluation 2017 and outlook for 2018

2016 was dedicated to gathering data in order to establish a sound and consistent database, which will provide a basis for the empirical analyses and simulations to be conducted in 2018.

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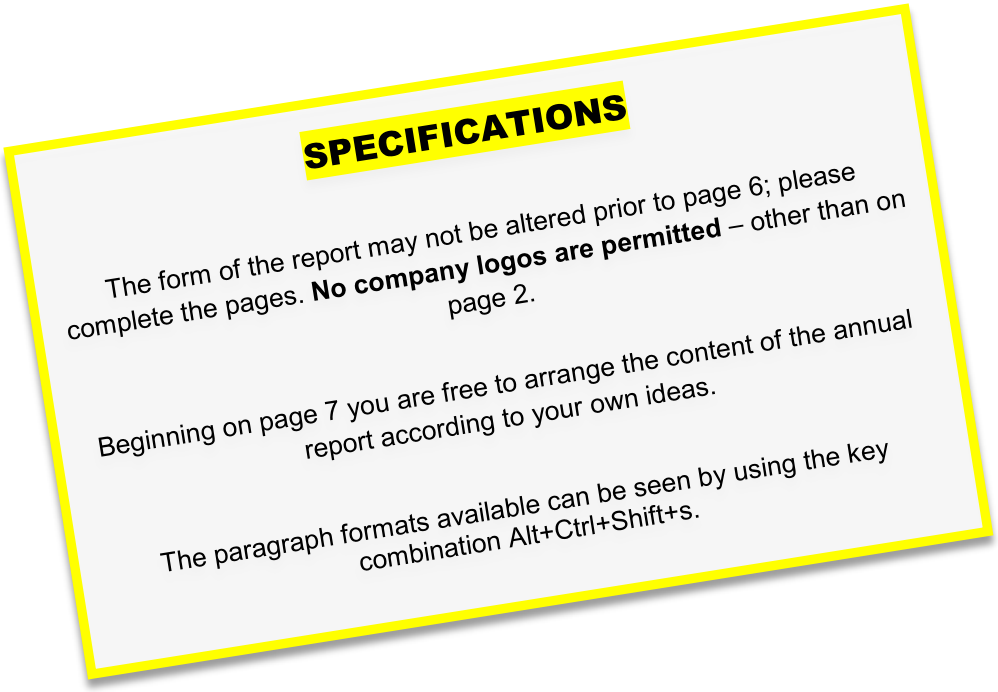
Appendix

Appendix



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List of abbreviations

2SLS	Two-stage least squares
CO2	Carbon dioxide
GMM	Generalized method of moments
IV	Instrumental variable
kW	Kilowatt
kWh	Kilowatt hour
MW	Megawatt
NOGA	Nomenclature Générale des Activités économiques
TSO	Transmission system operator

1. Main Idea

The research project investigates price elasticities of electricity demand in Switzerland. Based on consumption data at the canton level hourly demand elasticities are derived. In addition, we make use of the cantons' different compositions of customer groups enabling us to distinguish among the elasticities of households, industry and services. Different exogenous influences or shocks allow the estimation on a price-per-unit-of-energy basis [kWh]. We further use network-charge changes in order to derive an industry elasticity of demand for power [kW] as well as energy [kWh]. A similar investigation is carried out for price elasticities of gas demand in Switzerland – however given limited data availability, with a focus on yearly elasticities.

The identification of fundamental market data allows investigating several aspects. By means of these elasticities it is possible to evaluate demand reactions to (past) energy policies and to simulate demand reactions to energy policies that influence the price of electricity. These policies may – in accordance with SFOE – be investigated at a canton or sectoral level so that heterogeneous distributional effects, e.g. of an electricity tax, may be analyzed.

Thus, the main contribution is twofold. First, as a practical, political contribution, we determine hourly demand elasticities in a representative way for whole Switzerland (this contributes to the existing literature). We use these estimated parameters as well as market fundamentals – i.e. estimated demand and costs – to analyze future demand reactions. Thereby we can analyze welfare optimality of different energy policies. Second, as a more scientific contribution, we use hourly data on demand in the different cantons as well as the aggregated yearly demand of the cantons' customer groups as weights in estimation restrictions to finally derive hourly individual customer group elasticities. More specifically, we estimate weights for household, industry and services in each hour and each canton under the restriction that each of these groups meets its yearly demand value reported from other statistical sources.

2. Policy Relevance

There is always the challenge to choose the right policy instruments for reaching a certain policy goal or target. Effectiveness and efficiency of many energy policy instruments depend on customers' reactions to these policies. It is thus of high relevance to analyze demand elasticities and to estimate the effects of a certain policy instrument. The results of the proposed research project will give a better understanding of the behavior of Swiss electricity customers. In addition, distributional effects across cantons can be identified and the efficiency and effectiveness of different policy instruments in Switzerland can be evaluated.

Especially the welfare effects of the introduction of an environmentally motivated electricity tax might be of high value for policy makers. Losses in partial electricity market welfare from charging too high prices to elastic customers might outweigh the positive effects of saving CO_2-emissions. The same applies to the optimal dynamic taxation, i.e. the question how to determine optimal time-varying taxes, e.g. on an hourly basis. Investigating the trade-off between efficient taxation to obtain state-revenue at minimum cost inducing least possible quantity and welfare distortions on the one hand, and achieving environmental targets on the other hand is of great policy value.

3. Methodology

We will estimate structural single-equation and system-equation models in order to determine price elasticities of demand in a static partial equilibrium model. Thereby, we model demand as a function of price, network charges, business cycle, income, temperature, sunshine hours and time amongst others, and supply as a function of input prices, availability generation capacities and (cross-border-exchange-adjusted) generation from volatile renewables amongst others. We use state-of-the-art parametric and semiparametric two-stage models. This encompasses strategic models such as Cournot competition estimated in a conjectural variation framework.

By controlling for simultaneous supply and demand shocks (through instrumental variable (IV) techniques such as two-stage least squares (2SLS) as well as (system) IV-GMM methods) we are able to disentangle their impact. Accounting for the simultaneity of supply and demand is crucial when estimating demand elasticities which otherwise would not be identifiable due to endogeneity. Furthermore, we are able to identify the detailed structure at different times of the day and along different residual load levels by the inclusion of several exogenous (hour and month dummies) and endogenous (non-linear demand functions like bins and splines) interaction terms with the treatments. Only by conditioning on demand function shifters and pivoting factors, it is possible to identify different supply situations, which in turn allows identifying demand elasticities.

We use these fundamental market characteristics for simulation studies. Given a certain Swiss policy option, we will calculate the corresponding demand reactions (which can be distinguished by customer group and hour of the day). Our methodological framework allows us to draw conclusions about future consumer and producer surplus impacts of different policy options for Switzerland – differentiated by canton or customer group. Shifts in taxes simply act as marginal cost add-on variations. Depending on demand and supply elasticities, a tax increase will lead to a reduction in market equilibrium quantities and a corresponding welfare loss. This additional information about allocative inefficiency in addition to production inefficiency is a major advantage over traditional system cost-minimizing models.

4. Data

We will build up on both Swissgrid data for canton-level electricity demand and production, and on an existing rich and unique database on European electricity markets at ZEW, which we will extend. The data set contains information on electricity wholesale and commodity (coal, gas, oil) prices, consumption, import and export data received from auction offices and TSOs and detailed information on wind and solar generation forecasts as well as the installed capacity by fuel type in most European countries and especially Swiss neighboring countries. We further use weather condition data (such as temperature) as exogenous market equilibrium shifters. These data are also used with respect to neighboring countries to include their influence on Swiss market equilibria. This data is available on a consistent and hourly basis since January 2015.

Customer groups are identified building on previous work by Eymann et al. (2014). They describe a procedure to approximate the shares of household, industrial and services sectors on canton-level energy demand using publicly available data. Specifically, they employ shares of single-/multi-family houses and their respective type of heating to identify the cantons' household demand. Information on nationwide demand by industry and on their respective size (number of firms and employees) in each canton is used to derive the demand of the cantons' industrial and services sectors. The selection of sectors is based on the SFOE publication "Energieverbrauch in der Industrie und im Dienstleistungssektor" comprising 19 manufacturing and services branches that translate to 85 NOGA branches. Eymann et al. (2014) estimate yearly demand values for 2011. We will validate this procedure and update it to the most recent data.

5. Gas

With regard to gas, data availability is more limited. In contrast to electricity, canton-level data on gas consumption is not available on a more disaggregated resolution than on year-basis. Still, it is possible to derive yearly values for gas demand by customer group and canton. Consumption data availability allows constructing a comprehensive dataset dating back to 2011. For single earlier years a substantial share of data is available. In the course of this project the reliability of this data will be examined.

The analysis will yield at least yearly demand elasticities by canton and customer group. Similarly to the electricity case above, subsequent simulation studies can be conducted to assess demand reactions to energy policies. Since the electricity data also allows conducting yearly analyses for the same years, we are additionally able to evaluate the welfare optimality with respect to affected cantons and type of energy. This includes the balancing of taxes between the two different sectors. In particular, the investigation of tax policies addressing CO_2-emissions' damage internalization with respect to partial welfare optimal tax policies appears fruitful. This analysis will be conducted in accordance with SFOE.