Competition in the German Market for Retail Electricity: An Agent-based Simulation

Malcolm Yadack
University of Hohenheim
malcolm.yadack@uni-hohenheim.de

Ben Vermeulen
University of Hohenheim
b.vermeulen@uni-hohenheim.de

Andreas Pyka
University of Hohenheim
a.pyka@uni-hohenheim.de

Abstract

Liberalizing retail energy markets has become a tool for policy makers worldwide to introduce competition into a sector historically characterized by regional monopoly. Opening up the products offered by power retailers to free competition, irrespective of region or distribution network, is expected by policy makers to lead to lower markups and thus lower prices for end customers. We observe that this empirically holds true for industrial customers in Germany, but that markups in the price paid by households have not decreased as a result of increased competition. We apply a methodology of combining simulation modeling with insights obtained from survey data to develop an agent-based simulation of the liberalization of a retail electricity market. In the model, firms adjust prices by adjusting their markups to increase profits. Firms also expand by installing and selling capacity in regions outside of their own. Households are heterogeneous in their preferences and in their geographic position in the simulation. We show that for a wide range of realistic parameter settings, firm markups do not converge to zero in the long run, but flatten out to values possibly even higher than the firms' initial markups before liberalization. Markups also initially rise before falling and/or stabilizing. This, and the non-linear path of average markups over time, indicate that liberalized markets need not leave end customers better off. Our results imply, however, also that the stability of markups is largely dependent on households' preferences for their own regional public utility which has implications for new retail business models and investments on the regional level. The results on average markups and household preferences are corroborated by empirical data on the German market.

1 Motivation

The particularly diverse structure of energy markets worldwide leads to much intransparency in the analyses of engineers and economists of the economics of the electricity sector. Although energy use can be objectively evaluated based on absolute levels of generation, mining, use and loss, a deeper understanding of the true driver of growth - innovation - requires country specific analyses which heed and incorporate the institutional and regulatory specifics necessary for drawing meaningful conclusions. An example of two such national energy economies which are not comparable without detailed care in interpreting the contexts in which they are embedded are France and Germany. These two countries opened their electricity markets to competition at different times and followed widely differing strategies for promoting welfare-increasing national energy infrastructures. Germany separated electricity generation and retail from the natural regional monopolies of distribution network operators in 1998. This was followed by a strategy of investment by small and widely distributed landowners and regional firms in renewables such as solar and wind power. France's retail electricity market was opened to competition in the same way a decade later in 2007 but investment strategy was focused instead on and around a portfolio of nuclear generation facilities, owned primarily by one very large publicly owned firm. The results of these differences in policy and investment in the energy portfolios of the two countries are striking. In France, 93% of households purchased their electricity from the same incumbent firm in 2012. There is little regional movement to challenge this overwhelming market power and there is little incentive to invest in regional power generation as the market power of the national provider is strong in both the retail (delivery to households) and wholesale (subsidized generation of large amounts of nuclear power) markets. The liberalization of the German market in 1998 coincided with an increased interest of small actors in investing in distributed generation. Through further regulations incentivizing the investment in decentral renewable and combined-heat-and-power (CHP) power generation, Germany devoted a high proportion of national capital to regionally distributed, and diverse generation plants. According to Trend:research (2011), household owned solar power generation accounted for approximately 40% of the total of all solar power in 2010 with farmers owning another 20%. The market power for the retail sale of electricity of the four largest German firms has also decreased significantly with the increasing investment in regionally distributed generation, nationwide competition in price and service offerings in which smaller firms have also been successful in marketing individual advantages and innovative product offerings. By 2012, for instance, the industry group BDEW reports that 28.8% of all German households had changed their electricity provider at least once (BDEW (2014b)).

The effects of the differing strategies of the policy makers in France and Germany on their respective energy mixes are interesting, but, as the above discussion indicates, only part of the story. More critical, and of more interest from the perspective of the authors, is the effect on firm strategy and innovative activity (and thus on economic growth) that these policies have. In particular, what have the major effects on innovative activity been and how have the policies (and household behaviors) in these wildly different examples of energy economies set the stage for production and efficient innovation in the future? Adam Smith noted that a nation is built upon the interactions of rural (in his case, agricultural) production and urban consumption. Can the preferences of rural households for their local municipal electricity provider distort the gains of competitive price competition for the wider economy? Will these innovative changes in micro-level strategies of regional and national competition happen naturally or will polices and/or other incentives be required to nudge small rural and regional suppliers toward new business models, and/or to shift the economy onto the desired path of development? Will increased household preferences for their local region affect the economy overall? These broader questions lead us to investigate the development of prices in a simulation model of the liberalization of a retail electricity market.

In section 2 we motivate the case for developing our study and simulation framework by reviewing relevant literature and empirical data on household and industrial prices in the German retail electricity market since its liberalization. Section 3 then describes our simulation model in terms of its actors and the dynamics of interaction among them. Section 4 presents the results of Monte Carlo studies of maximum, average and minimum firm markups and their dependance on social and structural assumptions in the model. In Section 5 we conclude and give an outlook on further avenues of research.

2 Empirical Background

2.1 Electricity Market Developments in Germany

The liberalization of the German energy market was implemented in 1998 on the assumption that unfettered competition among retail suppliers of electricity would lead to more efficient prices and thus gains for consumers. We note here that this is not what actually came to pass - at least not for all specific customer groups. Although the general expectation was that competition would drive down the markups of retail suppliers of electricity, there is little proof that this has happened in the retail market for household electricity. Figure 1 shows data from BDEW (2014a) on the development of retailers' reported combined costs for generation, transport and sales of electricity (all cost components excluding regulatory fees and taxes).

Figure 1 indicates that the costs of these components initially decreased after the liberalization of the energy market, but that over the course of the years 2002-2008 these prices rebounded to overtake their initial level in 1998. Compare this to the same statistics for industrial electricity customers' retail prices in figure 2.

Figure 2 shows that the sum of costs associated with generation, transport and sales for industrial customers also fell initially after the beginning of liberalization in 1998 and rebounded over the period 2002-2008. Competition, and in particular the increasing tendency of firms to open their electricity contracts

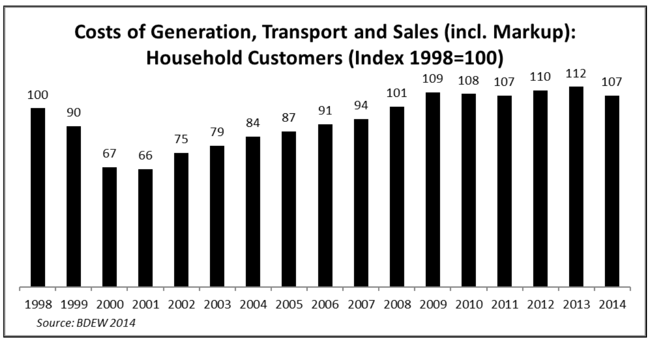


Figure 1: Retail costs of household electricity

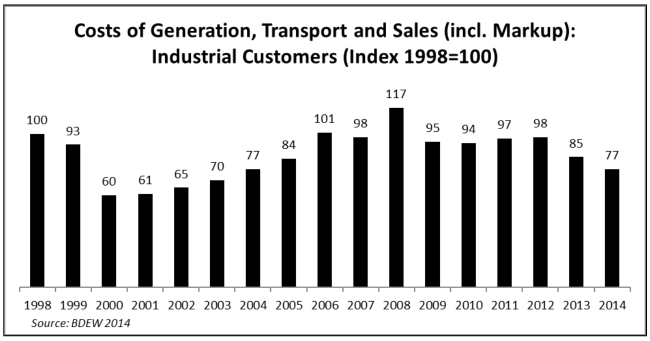


Figure 2: Retail costs of industrial customers' electricity

to open competitive bidding, however, seem clearly to have had a significant effect on these prices since 2008. Industrial firms pay less for their electricity (not including surcharges and taxes), than they did in 1998 – a stark contrast to the situation in figure 1 for household customers. Studies have also directly estimated the costs of sales of electricity retailers to households. The results from Energy Brainpool (2013) and VKU (2013) are depicted in figure 3.

Given that the costs of wholesale power and the costs of distribution have undergone the same developments throughout this time period for both households and industrial customers, figures 1, 2, 3 lead us to conclude that price competition is not as intense in the market for household electricity as it is in the market for industrial users.

Figures 1, 2 and 3 also emphasize a subtle point concerning the increased competition brought about by the new regulations in 1998: namely that liberalization of the retail market coincided with a fundamental change in the way in which households were forced to view electricity - namely as a good offered in different varieties by different firms. Electricity was, in a sense, coerced by the change to the new, open market structure, into being a heterogeneous good, which took on the properties of quality (e.g., in terms of renewable sources) and the attributes of the firm offering the tariff (regional identification, image, etc.), as well as a price component. Consumers discovered at the same time that they were expected to make a choice among a multitude of available electricity tariffs

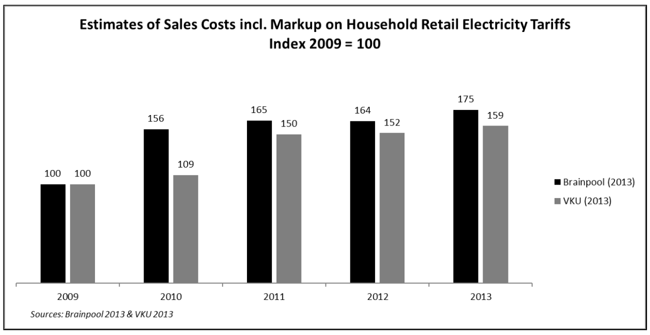


Figure 3: Estimates of retailers' costs of sales (incl. markup) for household tariffs

offered by hundreds of different firms.

Households were thus not only confronted with the choice of choosing the cheapest tariff. They were suddenly able to express support for the ongoing energy revolution by purchasing renewable electricity tariffs (Hamburg Institut Consulting (2013)), to expect more service-oriented offerings of their provider (Schmolke (2010)) and to even participate in civic- and stakeholder programs in their regions and cities (Flieger (2011)). Although renewable energies have received much attention in the literature, especially concerning social acceptance in society and markets (see for example, Schubert, Meyer, Selasinsky, Schmidt, Thußand Erdmann (2013) among many others) and in the innovation systems literature (e.g., Jacobsson and Bergek (2011) and references), regionality seems also to have played a very important role in the aftermath of the liberalization of the German market. In the period 1998-2013, out of all German households, 34.3% had changed their electricity provider at least once (BDEW (2014b)). This does indeed represent a large number of households that have made an effort to find a better or cheaper electricity tariff than that provided by their local service provider. However, this also implies that 66.7% of all households either never changed their tariff or changed their tariff to a different offering of their regional electricity firm. The market regulator in Germany, Bundesnetzagentur (2013), reports that 79.9% of all households were supplied by their regional "basic services provider" (ger. "Grundversorger") in 2012. 20.1% of all households were respectively customers of a different electricity retailer than the one closest to them. Combined with the cumulative 34.3% of households that had changed providers at least one since the liberalization, we are led to conclude that there may even be a trend for households to return to their local municipal utility companies after having left them for a few years to try another provider. Figure 4 depicts this turnaround in the movement of households back to choosing their regional electricity utility company.

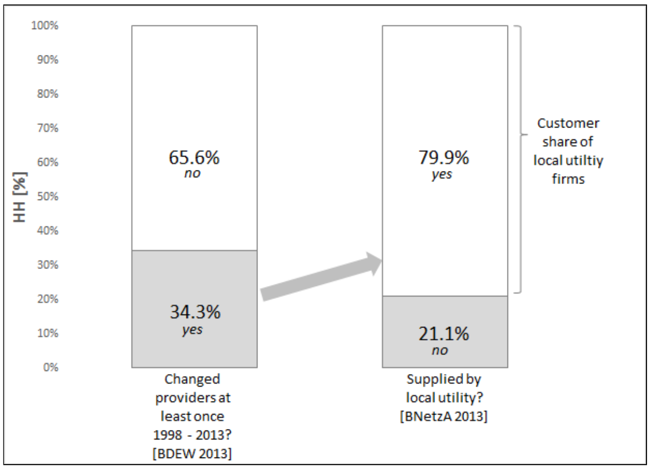


Figure 4: Percentage of German households having changed electricity providers since market liberalization vs. percentage of households choosing the regional utility company for their electricity in 2012. The difference between the size of gray blocks is the implied percentage of households that changed suppliers during liberalization of the market, but decided to change back to their regional supplier at a later time.

These regional dynamics could imply that the liberalization of the retail power market has indeed led to more competition, but that this competition appears not to be for one homogenous good. Utility companies are competing for customers who often exhibit a preference for firms with a vested interest in their region. Many households also prefer renewable energy to conventional energy, all other factors held equal (price, security of supply, etc.). In section 3 we present a simulation framework for analyzing these aspects' effects on electricity firms' behaviors and prices.

2.2 Insights from Micro-level Data

Electrical utility companies are under pressure from regulators in almost every country to move to cleaner sources of energy. In Germany, household preferences for clean sources of energy have combined with regulatory pressure to fundamentally change the business landscape for electricity producers and retailers. In Germany's liberalized market, this has led to intense price competition in renewable and non-renewable electrical power. Faced with such intense price competition, smaller utilities have turned to marketing their strengths as regionally responsible, locally active and trustworthy firms (VKU (2009)). In particular, municipally owned utility companies have proven resilient in the starkly competitive market for electricity, despite small sizes and their inability to take advantage of economies of scale (e.g., in production or IT systems). With nationwide competition in prices on the retail side, these regional firms have been forced to seek innovative strategies in the design and sales of their electricity tariffs. Both the largest of international corporations and the tiniest of local energy cooperatives are subjected to the same regulations and demands of end customers for an identical product in the retail electricity market. In addition to the focus on renewables as a way of differentiating their product (this having been spurred on by feed-in tariffs and embedded in national policy goals), other factors such as regionality, energy efficiency, smart-meter solutions and even social engagement have emerged as factors in retail sales strategies[1].

In observing how electricity companies, and municipal utility companies in particular, have fared during the liberalization of the German energy market (and the introduction of the feed-in tariff system alongside an EU-wide carbon cap-and-trade scheme), we also observe the diversity of demands by household customers. Households are affine to different "qualities" of clean energy (disapproval of RECS certificates, emergence of specialized green energy retailers, etc.). Some consumers also prefer their local municipal utility simply based on a sense of local engagement and loyalty. We confirm these trends in proprietary surveys of utility firms' management and customers in Germany[2]. Estimates of customer behavior of the firm involved indicated that customers in the own region were approximately 43% more likely to choose a regional supplier that offered higher prices than a non-regional electricity firm.

These heterogeneous aspects of supply and demand in the electricity sector lead us to ask, "what roles do firm size and regionality play in the transition to a cleaner energy economy?" The implications of national energy policy for the municipalities with stakes in local generation are also too little understood. The role these regional actors can play (both on the supply and demand sides) in achieving policy goals has not yet been sufficiently examined. Answering these questions will lead us to highlight the developments in strategies followed by firms in the electricity sector, and how these are influenced by competitive, regional, stakeholder and political factors.

One of the most distinctive features of electricity markets is the degree to which they are heavily regulated. Monopolies of power-line network operators are naturally occurring in electricity markets, and their market power can be limited by employing various regulations (see section 1). The regulatory structure which implements this in Germany is a nationwide "unbundling" of network operators from energy retailers and a "common carry" rule, requiring that network operators charge uniform network fees to all retailers delivering electrical power through their distribution networks. These complex regulations are implicit in our assumption here that households have free choice among all retail firms' offerings. The common carry framework has, however, regional consequences: for example, network fees increase with the number of volatile generation facilities in the network. We abstract from the issue of network fees and physical limits on the flow of electricity in order to focus on the effects of retail competition.

In order to begin shedding light on these issues, and to study the effect that policy can have on the various market actors (and on the economy as a whole) we define a simplified model of retail competition in the electricity market.

[1] One example of a new business model based on a case study of a small municipal utility company is given by Graebig, Erdmann and Röder (2014).

[2] Updated results and reports concerning this proprietary survey data will be available at `www.sw-agent.de`. Further details of the surveys are available on request.

3 Model Dynamics

3.1 Agent Behavior

Consider N firms selling goods to M households. Households are free to choose from which firm they purchase a product, but their demand for the product is inelastic - they must buy from one firm - and constant over time (one unit per period). Firms sell two products that are exact physical substitutes: a lower value product 1 (representing the standard mix of conventional electricity) and a higher valued product 2 (representing purely renewably generated power). Households weigh the choice of purchasing product 1 or product 2 against other aspects of their preferences in deciding for a firm to be their supplier.

Let all N firms and all M households be distributed on a 2 dimensional plane. Firms and households do not change their position throughout the simulation. Each firm i sells only one type of product (τ_i = gray or green) in each period and does not change products throughout the simulation. We refer to firms selling gray electricity as gray firms and to firms selling green electricity as green firms. Households that are densely placed on the map are explicitly labeled as either belonging to a given regional cluster or not. Household j has a preference for the green electricity product defined by the parameter g_j $(0 \leq g_j)$ which weights a household's utility of consuming renewable electricity instead of the standard mix.

Each household j also considers regionality to be a factor in choosing a supplier. This is reflected in their preferences by the factor ϕ_j which weights physical distance from the household to the supplier. Household j's utility is thus a function of price (p_i), the type of product (gray or green) and the distance to the selling firm (d_{ij}). Households' utilities take the following functional form:

$$U = U_0 - p + g\,\mathbb{1}(\tau_{\text{eco}} = 1) - \phi d \tag{1}$$

where p is the price paid for power, d is the distance to the selling firm, ϕ is a parameter weighting distance in the household's decision, and U_0 is the intercept of the utility function. τ_{eco} is equal to one if the firm sells renewable power, and is equal to zero otherwise. i indexes firms and j indexes households.

Households thus choose the firm i from which they purchase according to:

$$\arg\min_i \; U_j(p_i, \tau_i, d_{ij}) \tag{2}$$

Firms set prices equal to their costs plus a markup:

$$p_i = c_i + \eta_i \tag{3}$$

where c_i denotes the wholesale costs of supplying the product. c_i is given by exogenously set, constant wholesale prices for the two types of power. These prices are equally available to all firms on an open wholesale exchange (see figure 5).

Letting x_i denote the total demand of household customers of firm i, we model the price setting decision of the firm such that firm i adjusts its markup up or down by a fixed incremental amount such that the firm's expected profit increases the most. There are three possible outcomes for each firm: 1) raise markup, 2) keep markup constant, or 3) lower markup. If the firm adjusts price

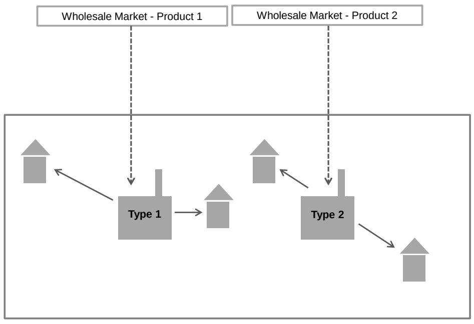


Figure 5: Wholesale and retail market structure (conventional mix and RES electricity)

downward, and expects (ceteris paribus) to capture no household demand in the next period, then it continues to adjust its markup downward until some household customers are expected to be acquired. Firms assume in forecasting next period sales that the prices of all other firms remain unchanged. Furthermore, we assume that households' preferences are known to the firms for the purposes of forecasting sales.

3.2 Generation Capacity

Each period, one randomly selected firm is permitted to expand its activities into a new region. This is modeled as the installation of new capacity to be marketed directly to households in the new region. Costs of the investment are assumed to be equivalent to long-term revenue which allows for abstracting from the discussion of financial factors of the investment decision. Focusing instead on the prominent social factors associated with power generation and sales, we assume that firms choose to locate their new generation and sales activities in regions where households are relatively unsatisfied with their current suppliers. Local, regional marketing by the firm aims to provide a more attractive electricity product for households in the area in question. Specifically firms locate new capacity according to the following:

1. A firm i is chosen at random
2. Firm i identifies clusters of relatively dissatisfied households - specifically those clusters with average utility below a given threshold U_0
3. Of the identified clusters, firm j chooses to install capacity in the cluster with the lowest average utility.
4. Consumers can then choose to purchase directly from the new regional generation plant (at retail prices equal to that of the stakeholder firm).

Pop. in region	Freq. of occurrence	Terrian Type
0 - 0	15	Water
1 - 19	10	Nature
20 - 499	30	Rural
1500 - 1999	5	Town
3000 - 6499	3	City

Table 1: Simulated population density distribution. Areas are allotted uniform random distributions of households whereby the number of households in each square is drawn from the distribution shown here. The total number of households is, however, scaled such that the entire simulation environment contains approximately 250 households.

5. If no clusters have average utility below the value U_0, then firm i can expand capacity at an existing plant by 5 units. Capacity is expanded if more households are being serviced directly by the regional plant, than the plant has capacity to directly deliver to.

Firms manage their generation portfolio such that extra generation in one region is applied to deliver to households in other regions. Generation in excess of firm i's customers' total demand is sold on the wholesale market at an exogenously given price $p_{overcap}$. Any additional monetary penalties are ignored. Putting this another way, the price at which the over generation is sold by firm i at the last minute is assumed to incorporate the penalties or advantages of trading on spot and short-term markets[3].

3.3 Geography

A predetermined number of firms are randomly placed on the square, non-wrapping simulation landscape. We generate landscapes for the model from a user input distribution of region types (city, town, rural, nature and water) and respective population densities. Values for the simulations in this paper were taken from the distribution shown in table 1.

An example of a generated map is depicted and described in figures 6, 7 and 8.

This flexibly specified tessellation of populated geographic regions lends itself well to the further study of a variety of spatial models and related research questions. In this first study with the model, we generate many such graphs and test the robustness to geographic variations of firms' markups over time.

[3]Short-term trading on spot, intraday and balancing markets actually pose significant financial risks to electricity providers. These have trading time horizons in Germany of 1 day ahead, 4 hours ahead, and real time on intervals of 15mins, respectively. We abstract from these details of the energy market here, in order to focus on more general developments in competition in retail markets and, in particular, on the social aspects of behavior in electricity markets.

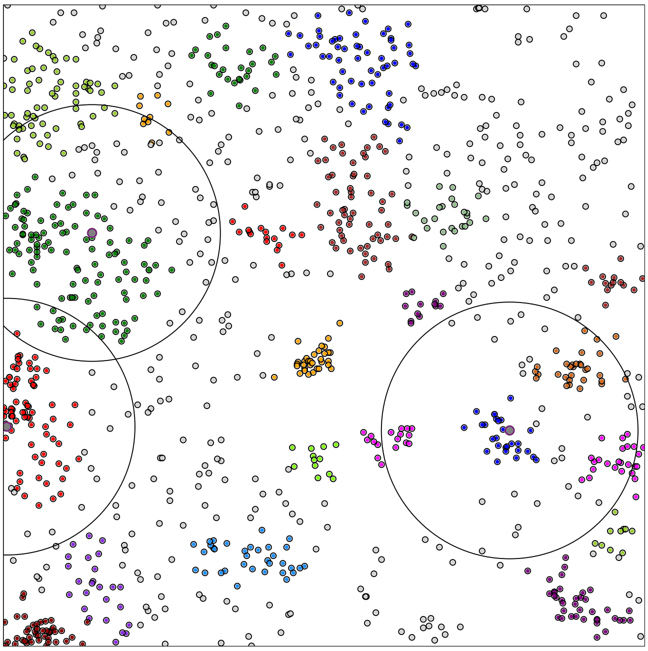


Figure 6: An example of a randomly generated set of firms (dark grey circles) and households (smaller circles of varying shades). Households are grouped into clusters in which firms consider investing in regional generation facilities. Circles around firms are iso-utility curves (U=0), the radius of which is affected by the firm's price and households' weighting of distance in their preferences.

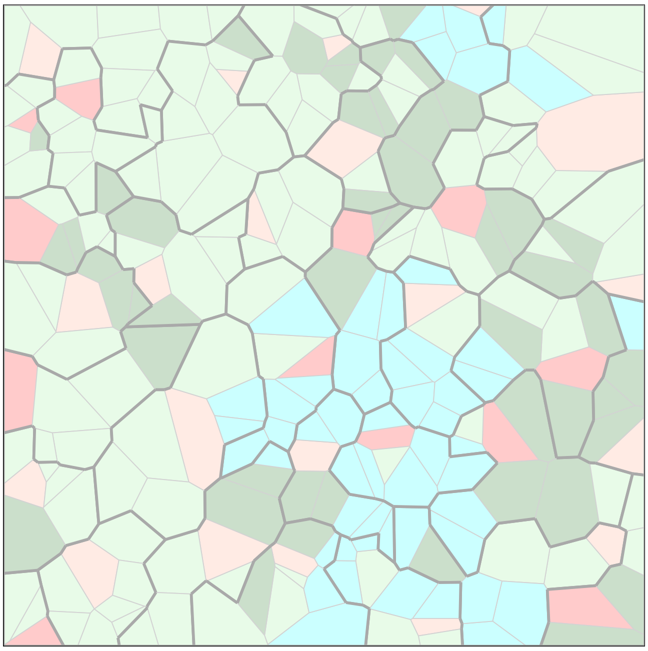


Figure 7: An example of a randomly generated map. Five types of cells are generated on a Voronoi landscape according to a user input distribution. The types of cells are differentiated by shade and are city, town, rural, nature and water areas. The generated cells are populated with households also according to a user input population density for each region type.

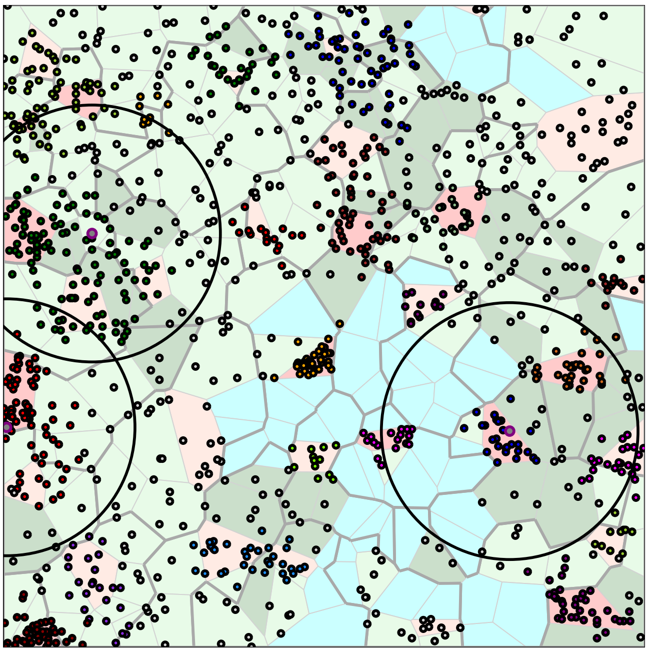


Figure 8: The world map overlaid with households and firms in our simulation of the liberalization of a retail energy market.

4 Results

In this section we present a Monte Carlo study using the model described in section 3. In this first study we assume that all firms sell conventional electricity. That is, renewable energy plays no role. The focus of this study is, instead, the specific nature of the competition that these firms are subjected to in the described model. In particular, we ask, "how do firms' markups develop over time?" and "how do the model dynamics relate to the observations of the electricity market liberalization in Germany?"

In analyzing the model, we focus on the changes in firms' markups over time, as the initial state of the simulated economy is opened up to liberalized competition. We assume a uniform preference for distance to the supplier (ϕ) for all households in the model environment. This also implies that in the first period of any model simulation that we carry out, firms start with regional monopolies (each serving all the households closest to them). In each subsequent period, households react in the environment given their freedom to choose the provider they most prefer. We analyze the evolution of markups and their sensitivity to the various input parameters of the model in this setup. The parameters across which model runs vary are described in table 2.

For each combination of parameter settings, we generate 30 random graphs and analyze simulation runs of 300 time steps. All combinations of the parameter values are shown in table 3.

The results of Monte Carlo simulations shed light on the both the functioning of the model and on the structure of competition in the liberalized energy market. Consider the development of firms' markups over time. An illustrative case is the set of parameters shown in table 4 being held fixed with the value of the parameter *phi* varying from 0.1 to 0.7.

Over each of the 300 time steps of a Monte Carlo study, figure 9 plots the averages of maximum markups, average markups and minimum markups. The maximum of the maximum markups and the minimums of the minimum markups are additionally included as dotted lines in the graph in order to show the robustness of the simulation results.

The curves depicted in figure 9 are representative of a wide range of parameter values, and two aspects of the markup graphs are particularly noteworthy. First, the period of increasing and then decreasing markups after the initial liberalization of the market is counter-intuitive. Free competition should, intuitively, lead to downwards pressure on markups. This initial increase can be explained by the geographic dimension inherent in our model. At the beginning

Parameter	Description
c	Wholesale cost of conventional electricity
$P_{overcap}$	Wholesale price received for sale of overcapacity
ϕ	Weight of distance in household preferences
U_0	Utility threshold for household dissatisfaction
N_f	Number of firms
η_0	Initial markup of all firms

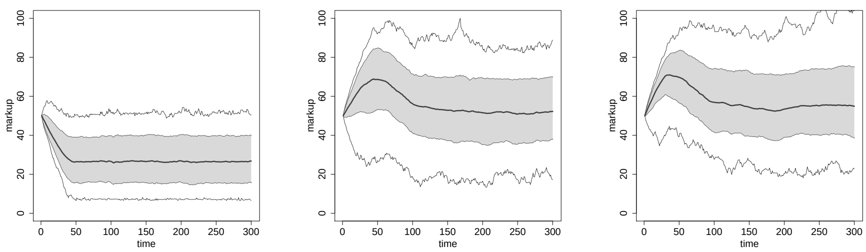
Table 2: Model parameters: The simulation results vary across on the values of these model parameters.

Parameter	Description
c	40, 50
$P_{overcap}$	45
ϕ	0.1, 0.4, 0.7
U_0	100, 150
N_f	5
η_0	50

Table 3: Parameter values in the Monte Carlo simulations: The average path of firm markups was analyzed in simulations of the economy for all possible combinations of these parameter values.

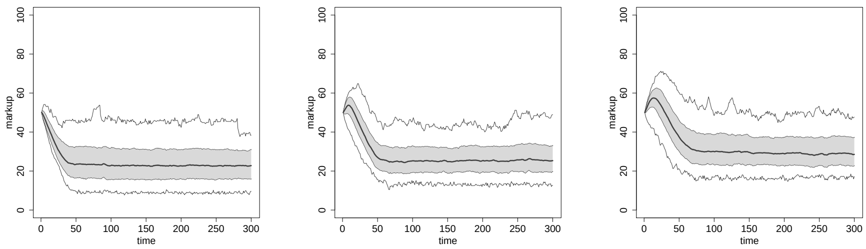
Parameter	Value
c	40
$P_{overcap}$	45
U_0	150
N_f	5
η_0	50

Table 4: Model parameters for the Monte Carlo results reported in figure 9.



(a) $c = 40$, $P_{overcap} = 45$, $\phi = 0.1$, $U_0 = 150$, $N_f = 5$ (b) $c = 40$, $P_{overcap} = 45$, $\phi = 0.4$, $U_0 = 150$, $N_f = 5$ (c) $c = 40$, $P_{overcap} = 45$, $\phi = 0.7$, $U_0 = 150$, $N_f = 5$

Figure 9: Monte Carlo simulations for differing weights of distances in household preferences: Average maximum, average mean and average minimum markups over time across all 50 Monte Carlo simulation runs. The small dashed lines show the maximum markup and the minimum markup among all the simulation runs at the respective simulation time step.



(a) $c = 40$, $P_{overcap} = 45$, $\phi = 0.1$, $U_0 = 100$, $N_f = 5$

(b) $c = 40$, $P_{overcap} = 45$, $\phi = 0.4$, $U_0 = 100$, $N_f = 5$

(c) $c = 40$, $P_{overcap} = 45$, $\phi = 0.7$, $U_0 = 100$, $N_f = 5$

Figure 10: Monte Carlo simulations for differing weights of distances in household preferences. These results are for a lower threshold of household dissatisfaction ($U_0 = 100$). As before, average maximum, average mean and average minimum markups over time across all 50 Monte Carlo simulation runs are plotted. The small dashed lines show the maximum markup and the minimum markup among all the simulation runs at the respective simulation time step.

of liberalization, however, many households are customers of a firm that is their closest alternative, but that is nonetheless geographically relatively far away. These customers would be willing to except slightly higher prices in return for having a provider in their immediate vicinity and it exactly this which firms in our model take advantage of initially in their price-setting and investment decisions. Firms locate new facilities near the households with the lowest levels of utility. This, combined with a lack of intense competition from other suppliers in the region, leads to a situation in which the firm can raise prices without losing significant sales to regional households. This explains the initial rise in markups visible in figures 9b and 9c. After the “clusters” of relatively unsatisfied households are covered by the services of the firms, markups begin to sink as price competition intensifies. Depending on the specific geographic constellation and placement of firms and households, firms’ markups sink until regional markets stabilize, resulting in multiple regional monopolies of the retailers. This regionality inherent in the long-run steady state of these model runs ensures that markups do not decrease to zero. They stabilize at levels significantly above zero. That markups do not decrease to zero for household electricity customers is exactly what we empirically observe in the case of Germany (whereas markups are approximately zero for industrial customers).

Figure 10 shows the results for the same values of varying ϕ for the case in which households are more easily considered to be dissatisfied with their current provider. Instead of the previously applied value of $U_0 = 150$, we analyze the case for $U_0 = 100$.

The results for $U_0 = 100$ exhibit a similar structure to those for $U_0 = 150$. As the markup curves turn downward, we see that competition at the regional level does intensify as firms spread out with their investments in new capacity across the map. In this case, however, the “price competition phase” sets in earlier, as firms are less able to exploit households’ dissatisfaction with their initial regional providers. Firms competition for local customers with lower markups embody the downward sloping portion of the curves in figure 10. The simulation results indicate robustly that, dependent on the value that households place on the product in general (the intercept of their utility function, U_0), firms are exposed to more or less price pressure through regional competition. A similar effect occurs for variation in the weight that households place directly on regionality in their decisions.

5 Conclusion

This paper is a report on first steps and first results from the application of a new agent-based simulation model to understand the dynamics of liberalized electricity markets. The model incorporates both geographic and sociological components of free competition for customers among electricity retailers. We reviewed the historical development of markups in the prices of electricity firms in Germany since market liberalization in 1998, and showed that lower markups have been passed on to industrial customers while household electricity customers have not seen the same decrease in prices (despite identical wholesale costs for both customers groups). We showed in a series of Monte Carlo studies that the dynamics in the level of markups set by the simulated electricity retailers varied over time and that, depending on customer preferences for regionality, markups could 1) increase despite intensified competition and 2) that they converge, in the long term, to a lower bound significantly greater than zero.

Due to world-wide moves to liberalize electricity markets (including China and other emerging economies) it is critical that the social effects on the nature of liberalized competition be thoroughly analyzed. In further work, we will investigate the effect of further heterogeneity in the regional preferences of households on the development of economic indicators and the effect that renewable energies (and renewable energy policies) have on the model outcomes. Energy policy also creates challenges at the municipal level, and we therefore also expect insights from the analysis of different types of electricity firms' behaviors in this agent-based framework (e.g., public vs. private, regional vs. aregional, etc.) to prove valuable to policy makers and stakeholders at both national, international and regional levels.

References

BDEW, "BDEW-Strompreisanalyse Juni 2014: Haushalte und Industrie," Technical Report, BDEW, Berlin 2014.

——, "Wechselverhalten im Energiemarkt 2014," Technical Report April, BDEW 2014.

Bundesnetzagentur, "Monitoringbericht 2013," Technical Report, Bundesnetzagentur, Bonn 2013.

Energy Brainpool, "Zusammenhang von Strombörsenpreisen und Endkundenpreisen," Technical Report, Agora Energiewende, Berlin 2013.

Flieger, Burghard, "Lokale Wertschöpfung durch Bürgerbeteiligung," *Fachzeitschrift für Verbands- und Nonprofit-Management*, 2011, *37* (1), 50–57.

Graebig, Markus, Georg Erdmann, and Stefan Röder, "Assessment of residential battery systems (RBS): profitability, perceived value proposition, and potential business models," in "37th IAEE International Conference," Vol. 25 2014.

Hamburg Institut Consulting, "Entwicklungsstand und Perspektiven des freiwilligen Ökostrommarktes," Technical Report, EnergieVision e.V., Freiburg 2013.

Jacobsson, Staffan and Anna Bergek, "Innovation system analyses and sustainability transitions: Contributions and suggestions for research," *Environmental Innovation and Societal Transitions*, June 2011, *1* (1), 41–57.

Schmolke, Heiko, *Erfolg von Marketingstrategien bei homogenen Produkten: Eine Fallstudie in Bezug auf den deutschen Strommarkt*, Norderstedt: GRIN Verlag, 2010.

Schubert, Daniel K J, Thomas Meyer, Alexander Von Selasinsky, Adriane Schmidt, Sebastian Thuß, and Niels Erdmann, "Der Stromausfall in München - Einfluss auf Zahlungsbereitschaften für Versorgungssicherheit und auf die Akzeptanz Erneuerbarer Energien," Technical Report, Technical University of Dresden 2013.

Trend:research, "Marktakteure Erneuerbare-Energien-Anlagen In der Stromerzeugung," Technical Report 2011.

VKU, "Emnid-Umfrage: Kommunale Unternehmen sind Spitzenreiter in Sachen Vertrauen," 2009.

___ , "Grafiken zur Entwicklung des Strompreises und seiner Bestandteile für Haushaltskunden," Technical Report, Verband kommunaler Unternehmen e.V. 2013.