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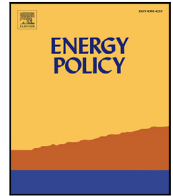
The combined effect of regulators' and retailers' actions to stimulate consumer participation in retail energy markets

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ABSTRACT

Active consumer participation in retail markets is crucial for an affordable and sustainable energy transition. While energy regulators encourage active consumer participation through policies which decrease consumers' switching costs, energy retailers seek to advance customer retention to boost profits. This study investigates how these seemingly opposing goals influence consumer participation in energy retail markets. Using data on the Dutch energy markets, we combine micro-economic and marketing insights through a retailer-aggregated panel vector auto-regression (VAR) model and a market-level VAR to analyse the dynamic interactions. The results indicate that the regulator affects consumer participation both directly and indirectly through energy retailers' actions. We conclude that energy retailers' acquisition and retention actions do not counteract the regulator's efforts to increase active consumer participation. While retention actions lead to decreased switching behaviour, they concurrently decrease perceived switch costs while increasing search behaviour and the consideration to switch. Therefore, retention actions may still improve consumer welfare. Our research reveals mediating relations that require comprehensive examination of the overall impacts of regulatory policies and energy retailer's actions.

1. Introduction

Since the liberalisation of energy markets in the early 2000s, European regulators aim to increase consumer participation in these markets, considering it essential for the European energy transition (ACER and CEER, 2019; Schweiger et al., 2020). Active consumer participation increases in consumer welfare (Amenta et al., 2022), aligns offers which better reflect consumers' preferences, and promotes the availability of green tariffs (MacDonald and Eyre, 2018). However, consumer inertia remains one of the four largest market barriers in European energy markets (European Commission et al., 2021). Imperfect information lies at the root of consumer inertia and requires more than just information provision alone (Gangale et al., 2017; Micklitz et al., 2011). Especially search- and switching costs form major barriers for consumer participation (Ek and Söderholm, 2008; He and Reiner, 2017; Yang, 2014). Search costs concern behavioural costs of acquiring information for optimal decision-making, while switching costs are transactional costs related to the ease and perceived risk of switching contracts. Hence, search- and switching costs form two types of information costs related to acquiring information and processing information, respectively. High search- and switching costs impede the ability to process all available information (Simon, 1959; Wilson and Price, 2010) or the willingness

to exert the necessary effort (Sallee, 2014). Consumers then avoid making a choice and stay with their default supplier (Brennan, 2007). Therefore, regulators aim to decrease these search- and switching costs to foster the energy transition.

Energy regulators aim to reduce search- and switching costs through policies such as standardisation of contracts, availability of comparison websites, or guarantees of origin for renewable energy. They strive to protect consumer welfare, as incumbent energy retailers may find little incentive to improve their offers in markets with inactive, "locked-in" consumers (Farrell and Klemperer, 2007). While regulators aim to encourage active participation, energy retailers are motivated to increase customer retention, which is much more profitable than customer acquisition (Gupta et al., 2004; Natter et al., 2015). Hence, there seems to be a contradiction in objectives regarding active participation between energy regulators and energy retailers.

It is unclear how this contradiction impacts consumers. On one hand, micro-economic theory explains how energy retailers might deliberately increase search- and switching costs to boost customer retention, which negatively affects consumer welfare (Farrell and Klemperer, 2007). On the other hand, marketing literature emphasises the positive effects of retention objectives for consumers, as it may lead to better

offers or increased customer satisfaction by addressing consumers' non-monetary needs, such as convenience, trust, and sustainability (de Haan et al., 2021; Nguyen and Mutum, 2012; Sernhed, 2008), which can further encourage consumers' involvement in energy markets. Hence, the two literature streams offer contrasting perspectives on what is optimal for consumers. To understand how consumer participation is influenced by both the regulator's and energy retailers' actions, we combine insights from micro-economic and marketing literature to answer the research question *what is the combined impact of the regulator's efforts and the energy retailers' actions on consumer participation in energy markets?*

We aim to answer the research question by analysing the mutual effects of the regulator's and energy retailers' actions in dynamic systems models that capture the inter-dependencies between actors and the dynamic nature of the effects. This allows us to empirically examine how regulators and energy retailers affect information costs and consumer participation. Our analysis is based on data from the Dutch retail energy market, which opened up in 2004 and evolved to a mature market where consumers can easily switch suppliers (Mulder and Willems, 2019). The Dutch energy market is appropriate for our analyses, as the market has one of the highest switch rates in Europe and switch rates continue to increase (ACER and CEER, 2019). Our study focuses on household behaviour, and therefore neglects smaller industrial or commercial consumers. The results unveil a complex system of reciprocal effects between different forms of participation and energy retailers' actions. We find that the regulator's policies not only directly affect active consumer participation, but also indirectly through energy retailers' actions, which reduce switching behaviour but encourage other forms of participation.

Our research contributes to the existing literature by integrating insights from micro-economic and marketing literature. Micro-economic studies often analyse consumer behaviour in dynamic models (Labandeira et al., 2017) or as probabilities of behaviours influenced by pricing and search- and switching costs (e.g. Deller et al., 2021; Giulietti et al., 2005; Waddams Price and Zhu, 2016). Marketing literature frequently examines customer switching behaviour in response to energy retailers' actions and consumer preferences using structural (e.g. Apaolaza Ibáñez et al., 2006; Bansal et al., 2005; Hellier et al., 2003) or probability models (e.g. Dolšak et al., 2019; Wieringa and Verhoef, 2007). Our models combine these perspectives through dynamic interactions of both policies and energy retailers' actions on consumer participation. The panel VAR model examines the effects of specific energy retailers and information transparency policies on consumers. The VAR model captures a longer time frame to analyse additional information transparency policies. The results highlight the dynamic and complex nature of these effects, emphasising the importance of considering the interplay between these perspectives.

This research enhances our understanding of how different actors affect consumers within retail energy markets. This helps policymakers and energy retailers to better design and assess the effects of their actions, and underscores the importance to focus on indicators of consumer participation beyond switch rates, which might not reflect true ability to find information and compare different offers. These insights are crucial to design effective policies to counteract consumer inertia to improve consumer welfare and foster the energy transition.

In Section 2, we explain the underlying theory and our conceptual framework. In Section 3, we elaborate on the model estimation and the data gathering process. In Section 4, we provide an overview of the analyses' results which we discuss in Section 5. Finally, in Section 6, we conclude with implications for both future research and policymakers.

2. Background and literature review

Prior research identified search- and switching costs as major barriers for active consumer participation in energy markets. First, we briefly describe the role of search- and switching costs on consumer participation and pricing strategies. Next, we describe the actions of regulators and energy retailers in energy markets, and combine these effects in our conceptual model.

2.1. Search- and switching costs in energy markets

According to micro-economic theory, markets are the most efficient way to coordinate the activities in a supply chain (Mulder, 2023). Micro-economic theory uses the concept of perfect markets as a reference for evaluating real-world markets (Walras, 1926, 1954). These perfect markets are based on a set of assumptions and conditions, often with one or more unmet in real-world markets. According to the modelling properties of perfect markets, maximisation of utility by consumers and maximisation of profits by retailers leads to an equilibrium price which maximises society's total welfare. This requires transparent information for both consumers and retailers. However, high search- and switching costs for consumers can create information asymmetry between retailers and consumers (Mulder, 2023). Moreover, when consumers are unable to assess whether the higher prices are related to higher quality, retailers have little incentive for innovation or quality improvement. This affects the affordability of the energy products and redistributes society's welfare, where the producer welfare increases at the expense of the consumer welfare.

In markets with high search- and switching costs, consumers prefer to encounter these costs once and then remain with their chosen energy retailer (Brennan, 2007). This motivates energy retailers to differentiate pricing between new and established customers, employing "bargain-then-rip-off" pricing schemes (Farrell and Klemperer, 2007, p. 1982). First, energy retailers attract new customers through low "bargain" prices. In subsequent periods, energy retailers increase their price slightly below the consumer's reservation price. Because of the high search- and switching costs, the consumer often continue to pay the "rip-off" price rather than switch to a competitor. Moreover, low "bargain" prices for new customers may lead to market failures due to imperfect information. Aggressive targeting campaigns to attract customers may be associated with high financial risks and even bankruptcies, which are not uncommon in the Dutch retail energy market (van Lieshout, 2021). These "bargain" prices from new, lesser-known energy retailers entail a higher financial risk, even when the regulator guarantees energy supply. In the Netherlands, when a Dutch energy retailer goes bankrupt, the consumer gets assigned to another energy retailer which usually charges higher tariffs (ACM, 2023b). Hence, high search- and switching costs in retail energy markets lead to higher prices for locked-in, established customers, contributing to decreased consumer participation (Ek and Söderholm, 2008; He and Reiner, 2017; Waterson, 2003), and may lead to sub-optimal decisions of active consumers.

The "bargain-then-rip-off" pricing scheme affects consumers differently due to variations in perceived search- and switching costs and individual preferences, resulting in distinct utility-maximising behaviours. Switch behaviour is typically categorised as active or inactive participation, which is a simplified reality which shows much more variation of behaviour. Active consumers perceive lower search- and switching costs than inactive consumers and will use the "bargain-then-rip-off" model to their advantage by regularly switching energy retailers when better offers arise. Inactive consumers perceive too high search- and switching costs to benefit from better offers. A consumer's decision to become an active consumer depends on the transparency of information (Armstrong, 2015), which plays a central role in consumers' individual search- and switching costs. Moreover, when consumers are unable to take their non-monetary preferences into consideration, including preferences for renewable energy sources (Soon and Ahmad, 2015) or pricing schemes (Buryk et al., 2015), this reduces energy retailers' incentive to offer products which match consumers' preferences. By pressuring energy retailers to provide offers which align with preferences, active consumers create positive search externalities for inactive consumers (Armstrong, 2015). Moreover, a larger group of active participants would make the "bargain-then-rip-off" pricing scheme unprofitable. Therefore, a larger number of active participant provides benefits for inactive consumers as well.

2.2. Energy regulators' actions

Energy regulators want to improve consumer welfare and move the market closer to a perfect market by implementing policies that, amongst other things, decrease search- and switching costs for consumers. First, energy regulators aim to make hidden product characteristics, such as the energy source, more transparent to consumers. They achieve this by introducing certificates and warranties that provide consumers with proof of a product's adherence to specific criteria. Second, even when consumers are aware of the product characteristics, they may still face challenges in making utility maximising decisions (Creti and Frontini, 2019). Energy regulators address this by enforcing rules for standardisation of information, such as standardisation of information on the energy bill, which simplifies the comparison of tariffs between energy retailers. Third, energy regulators aim to mitigate 'moral hazard' issues, where one party in a transaction cannot observe the other's actions and is uncertain about meeting agreed conditions (Varian, 2003). Energy regulators tackle this by assessing the financial status of new energy retailers before granting them licenses to enter the market. Additionally, energy regulators may guarantee energy supply to consumers, even in cases of retailer bankruptcy. Through all these actions, regulators in energy markets aim to reduce search- and switching costs and raise the proportion of active consumers in energy retail markets. Therefore, we expect that regulators' information transparency policies boost active consumer participation.

2.3. Energy retailers' actions

Energy retailers influence active consumer participation through their acquisition and retention efforts to maximise profits. Because of the high search- and switching costs, energy retailers employ "bargain" prices to attract new customers by offering low tariffs, discounts, or free products. Moreover, energy retailers aim to attract customers through product differentiation, such as through renewable energy sources and brand characteristics. Energy retailers offering attractive deals to consumers benefit from transparent information to stand out from competitors. These energy retailers have the incentive to decrease search- and switching costs for customer acquisition, thereby increasing active consumer participation. Therefore, we expect that energy retailers' acquisition efforts contribute to boosting active consumer participation.

Customers who are acquired through high welcome bonuses often become only profitable when they remain a customer in the successive period (Natter et al., 2015). The benefits of customer retention can be up to five times higher than those of customer acquisition in retail energy markets (Gupta et al., 2004). Therefore, energy retailers hope that consumers will remain a customer for the following period and pay the higher "rip-off" tariffs. To retain their customers, energy

retailers often create loyalty programmes to improve customers' satisfaction, strengthen trust in the energy retailer, and increase switching costs (Apaolaza Ibáñez et al., 2006). Energy retailers can increase switching costs by raising the opportunity costs associated with switching, by increasing time and effort involved in the switching process, or by increasing the perceived risks of switching retailers (Hellier et al., 2003). Loyalty programmes often include discounts or credit systems that are forfeited when a customer switches to another energy retailer. The sole existence of sunk costs may as well prevent consumers to switch even when the utility of switching is higher, especially when information is not transparent (Hartmann and Viard, 2008). Energy retailers can increase search- and switching costs through the content and format of information. For example, not providing or concealing the model contract on their website (ACM, 2021). Energy retailers with a loyalty programme attract consumers with "bargain" prices, and subsequently charge "rip-off" prices. However, this the "bargain-then-rip-off" system is hidden by the loyalty discounts, which slightly lower the "rip-off" price, and strongly increase the search- and switching costs. This can further increase the lock-in effect of the pricing scheme. Therefore, we expect retention actions to discourage consumer participation in energy markets.

2.4. Conceptual model

In conclusion, both the regulator and energy retailers dynamically affect active consumer participation. Consumers aim to maximise utility through their search- and switching behaviour. The regulator aims to increase information transparency through policies affecting both energy retailers and consumers. Energy retailers aim to maximise profits through acquisition and retention actions towards consumers. In our research we consider these inter-dependencies to analyse the combined effects of the regulator's efforts and the actions of energy retailers on consumer participation in the energy market. We distinguish four components of consumer behaviour: switch costs, search behaviour, consideration to switch, and switching behaviour. We expect mediation effects from policies and energy retailers' acquisition and retention actions through these four components of consumer participation. This leads to the conceptual model provided in Fig. 1.

3. Methods

The following chapter discusses the methods used in this paper. We provide an overview of the methodology in Section 3.1, an overview of the data and empirical model for the retailer-level model in Section 3.2, and an overview of the data and empirical model for the market-level model in Section 3.3.
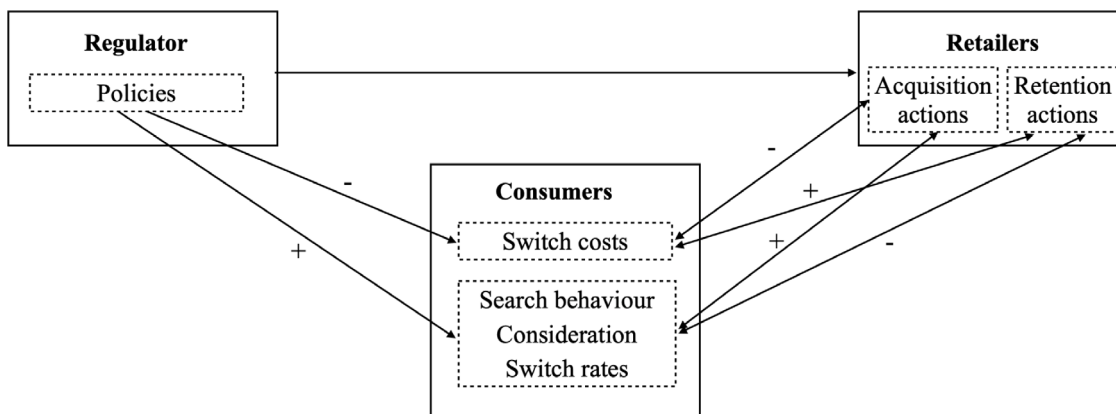

Fig. 1. Conceptual model.

3.1. Overview of the methodology

We estimate dynamic system models to capture the dynamic effects in our conceptual model. These models account for mediating effects between variables, such as the impacts of policies on switching behaviour through switching costs. Moreover, these models correct for endogenous effects which are likely to arise in our analysis through reverse causality (Sims, 1980). For example, energy retailers influence consumer participation, but also respond to behaviour of consumers. Hence, it is important that our model captures these interrelations.

We estimate two models to capture these dynamic effects. The first model uses retailer-level panel data, offering detailed insights into various forms of consumer participation and energy retailers' acquisition and retention actions. However, this data set covers a relatively short period as it relies on quarterly aggregated data. As a result, we complement our analysis with a second model based on market-level time-series data. While this data set provides less granularity, it allows us to examine effects over a more extended time frame, with monthly aggregation levels.

In the retailer-level model, we implement the conceptual model illustrated in Fig. 1 using a dynamic panel model. This model includes seven endogenous variables, with four components of consumer participation (perceived switch costs, search behaviour, consideration, and churn rate indicating switch rate), two components of energy retailers' actions (acquisition actions, retention actions), and the average energy price. Additionally, exogenous variables account for the regulator's policies. In the market-level model, we also implement the conceptual model of Fig. 1, but within a dynamic time-series framework. We capture consumer participation through consumer search behaviour and switch rates in the market, and proxy energy retailers' acquisition actions through energy prices of new contracts and retention actions through the profit margins of energy retailers. These four variables are treated as endogenous variables while the regulator's policies are considered exogenous variables.

To examine the mutual effects between policies, energy retailers' actions, and consumer participation, we first examine whether our variables have a unit root and determine the optimal number of lags. Next, we examine the relationships between our variables through three types of tests. We start with Granger-causality tests to identify short-term temporal precedence between two variables (Granger, 1969). For the panel data set, we account for heterogeneity across energy retailers with the Dumitrescu and Hurlin (2012) panel Granger (non-)causality test, which provides a general statistic representing the average statistic across brands. Second, we estimate our dynamic system models and interpret individual effects through impulse response functions (IRFs). The IRFs indicate responses to non-factorised one standard deviation innovations with confidence intervals estimated using Kilian's unbiased bootstraps (Kilian, 1998). Finally, we analyse the effects of the policies by examining the coefficients of the exogenous variables. The results are presented in Section 4 and discussed in Section 5.

3.2. Retailer-level model

3.2.1. Data gathering and characteristics

The retailer-level model analyses the effects on a retailer-aggregated level in a panel data set containing quarterly aggregated data from Q1 2015 to Q4 2021 of 14 individual energy retailers in the Netherlands, which together comprise over 95% of the total Dutch market, and one cluster combined representing all "other" energy retailers. Not all energy retailers were active during all 28 quarterly observations, which reduces the unbalanced panel data set to 399 observations.

Table 1 provides an overview of the variables used to capture the constructs, along with their definitions and sources. Most of these variables are obtained from the GfK energy monitor surveys (GfK, 2017). Their panel consists of 25,000 Dutch households who report their current energy retailer and whether they switched on a quarterly basis. This provides two groups of respondents, households who switched during the quarter and households who did not switch during the quarter. GfK draws a random sample of approximately 1,500 respondents out

Table 1
Variables of retail-level model.

	Construct	Variable	Description	Source
1	Switch costs	Perceived switch costs	Perceived behavioural costs and financial benefits of switching to another energy retailer by consumers who did not switch on a 5-item Likert scale, where 1 indicates low perceived switch costs and 5 indicates high perceived switch costs.	GfK
2	Search behaviour	Search behaviour	The percentage of an energy retailers' customers who indicated that they acquired the information themselves.	GfK
3	Consideration	Consideration	The percentage of an energy retailers' customers who switched to another energy retailer, or who considered to switch to another energy retailer in a quarter.	GfK
4	Switch rate	Churn rate	The percentage of an energy retailers' customers who switched to another energy retailer in a quarter. This differs from the switch rate, which describes the rate of consumers who switched in a market while the churn rate is retailer specific.	GfK
5	Acquisition actions	Acquisition actions	The percentage of consumers who received information from this energy retailer.	GfK
6	Retention actions	Retention actions	The percentage of switched consumers approached by their previous energy retailer. For the customers who did not switch, the variable indicates the percentage of consumers who wanted to switch but took a counter offer of their current supplier.	GfK
7	Energy price	Energy price	All energy retailers' average quarterly electricity and gas household retail prices converted to euro per KWh, excluding taxes. The prices of electricity and gas are weighted by the ratio of total consumption of the two different products before being converted to KWh per euro.	CBS
8	Policies	Policies	Dummy variables which indicate different information transparency policies of the regulator: Renewed model contract, Disconnection protection, Code decision correction process and Code of conduct IV. The dummies are equal to 1 from the date the regulation was implemented. Appendix A provides an overview of the different policies.	ACM
9	Market share	Market share	Control variable which indicates the market share of the energy retailer.	GfK

Table 2
Descriptive statistics of continuous variables of the retailer-level model.

	Name	N	Mean	St. dev	Median	Min	Max	Unit
1	Perceived switching costs	399	2.869	0.266	2.826	2.138	3.420	1-5 Likert Scale
2	Search behaviour	399	16.711	6.950	16.357	2.560	43.736	Percentage
3	Consideration	399	23.511	8.976	22.991	2.445	52.262	Percentage
4	Churn rate	399	6.867	4.924	5.929	0.000	28.935	Percentage
5	Acquisition activities of retailers	399	0.770	0.624	0.563	0.018	3.520	Percentage
6	Retention activities of retailers	399	4.374	2.895	3.772	0.000	17.903	Percentage
7	Energy price	399	0.042	0.005	0.041	0.0348	0.054	Euro per KWh
8	Market share	399	7.250	7.493	3.677	0.069	24.086	Percentage

of both respondent groups which receive surveys with in-depth questions about their behaviours and perceptions. These in-depth survey responses are used to measure our retailer-specific variables.

The variables *perceived switch costs, search behaviour, consideration, churn rate, acquisition actions, retention actions* and *market share* are all obtained through the GfK energy monitor. Appendix B provides an overview of the used questions how they measure the constructs. The variable *energy price* is obtained through CBS (2023). The variable *policies* is obtained through the ACM, which is the regulator of the Dutch energy market.

We find some outliers in the churn rate variable with unlikely values which we delete from the data and replace by more appropriate values using random forest imputation. This leads to 122 missing values divided over 10 variables in 56 observations in total. We elaborate on our data cleaning and imputation process in the web appendix. The imputed data result in an unbalanced panel data set of 399 observations for all variables. The values in Table 2 provide an overview of the descriptive characteristics of the continuous variables after imputation.

3.2.2. Model specification

We examine whether our variables are stationary through unit root tests assuming cross-sectional independence and through cross-sectionally augmented unit root tests. The results presented in Appendix C indicate that all our variables are stationary and therefore suitable for a panel VAR (PVAR). We estimate our PVAR using a fixed-effects OLS model (Holtz-Eakin et al., 1988). The AIC, HQIC, and SIC suggest a lag structure of 8, 2, and 1 respectively (see Appendix C). Because of the complexity of the model, we choose to go with 1 lag as the SIC penalises model complexity more strongly than the AIC or HQIC. Eq. (1) provides the specification of our within-transformed

fixed-effects model, where $\ddot{x}$ indicates that the corresponding variable is demeaned (retailer i's observation at time t minus retailer i's average value $\bar{x}$: i.e., $\ddot{x}_{it} = x_{it} - \bar{x}_i$). In the model, the vector of endogenous variables includes perceived switch costs ($S\ddot{W}$), consumer search behaviour ($S\ddot{B}$), consideration to switch ($C\ddot{O}$), churn rate ($C\ddot{H}$), acquisition actions of the energy retailer ($A\ddot{C}$), retention actions of the energy retailer ($R\ddot{E}$) and all energy retailers' average energy price ($E\ddot{P}$). Each variable is log-transformed. The vector of exogenous variables includes four policy dummies ($\ddot{P}_1, \ldots, \ddot{P}_4$), a seasonal dummy for the fourth quarter ($\ddot{Q}$) and the energy retailer's market share ($M\ddot{S}$). This results in the following model specification:

$$
\begin{bmatrix} S\ddot{W}_{i,t} \\ S\ddot{B}_{i,t} \\ C\ddot{O}_{i,t} \\ C\ddot{H}_{i,t} \\ A\ddot{C}_{i,t} \\ R\ddot{E}_{i,t} \\ E\ddot{P}_t \end{bmatrix} = \sum_{k=1}^{K} \begin{bmatrix} \beta_{11}^k & \cdots & \beta_{17}^k \\ \vdots & \ddots & \vdots \\ \beta_{71}^k & \cdots & \beta_{77}^k \end{bmatrix} \begin{bmatrix} S\ddot{W}_{i,t-k} \\ S\ddot{B}_{i,t-k} \\ C\ddot{O}_{i,t-k} \\ C\ddot{H}_{i,t-k} \\ A\ddot{C}_{i,t-k} \\ R\ddot{E}_{i,t-k} \\ E\ddot{P}_{t-k} \end{bmatrix} + \begin{bmatrix} \gamma_{P,11} & \cdots & \gamma_{P,14} \\ \vdots & \ddots & \vdots \\ \gamma_{P,71} & \cdots & \gamma_{P,74} \end{bmatrix} \begin{bmatrix} \ddot{P}_{1,t} \\ \vdots \\ \ddot{P}_{4,t} \end{bmatrix}
$$

$$
+ \begin{bmatrix} \gamma_{Q,1} \\ \vdots \\ \gamma_{Q,7} \end{bmatrix} \ddot{Q}_t + \begin{bmatrix} \gamma_{MS,1} \\ \vdots \\ \gamma_{MS,7} \end{bmatrix} M\ddot{S}_{it} + \begin{bmatrix} \epsilon_{1,it} \\ \epsilon_{2,it} \\ \epsilon_{3,it} \\ \epsilon_{4,it} \\ \epsilon_{5,it} \\ \epsilon_{6,it} \\ \epsilon_{7,it} \end{bmatrix}, \tag{1}
$$

where i indexes retailers, t indexes quarters, K the number of lags, β coefficients of the endogenous variables, γ coefficients of the exogenous

Table 3
Variables of market-level model.

	Construct	Variable	Description	Source
1	Search behaviour	Google search behaviour	Google search behaviour of three relevant search terms in the Netherlands for each month. These search terms were added up in one variable which indicates consumers' monthly search behaviour.	Google trends
2	Switch rate	Switch rate	The number of switched households in a month divided by the number of existing household connections in that month ×100%.	ACM
3	Acquisition actions	Energy price	Average monthly electricity and gas household retail prices for new contracts, adjusted for inflation and expressed in Euro 2018 per kWh terms. The prices of electricity and gas are weighted by the total consumption of the two different products.	EC
4	Retention actions	Profit margins	Difference between retail and wholesale electricity and gas prices provides a proxy for energy retailers' profit margins. Larger differences indicate retail prices are less based on wholesale costs.	EC
5	Policies	Policies	Dummy variables which indicate different information transparency policies of the regulator: Code of conduct II, Model contract, Prohibition of automatic contract renewal, Code of conduct III, and Renewed model contract. The dummies are equal to 1 from the date the regulation was implemented. Appendix A provides an overview of the different policies.	ACM
6	Control variable	Temperature	Average monthly temperature in Kelvin at weather station De Bilt, located at the centre of the Netherlands. Control variable for seasonality.	KNMI
7	Control variable	CPI	Consumer price index with base period 2006 = 100. Control variable for general economic conjuncture.	CBS

Table 4

Descriptive statistics of continuous variables of the market-level model.

	Name	N	Mean	St. dev	Median	Min	Max	Unit
1	Google search behaviour	144	88.653	29.528	84.5	29	184	# Google searches
2	Switch rate	144	1.122	0.445	1.534	0.511	3.000	Percentage
3	Energy price	144	0.105	0.006	0.104	0.093	0.118	Euros
4	Profit margins	144	0.078	0.008	0.078	0.061	0.102	Euros
5	Temperature	144	283.810	5.546	283.650	272.050	293.850	Kelvin
6	CPI	144	97.552	5.183	98.700	87.630	107.370	Index

variables and $[\varepsilon_{1,it}, \varepsilon_{2,it}, \varepsilon_{3,it}, \varepsilon_{4,it}, \varepsilon_{5,it}, \varepsilon_{6,it}, \varepsilon_{7,it}]' \sim N(0, \Sigma)$. The equation reads as follows: the seven endogenous variables, indexed by energy retailer i and time period t, on the left-hand side of the equation are explained by their lagged values, the effects of the four exogenous policies $(\ddot{P}_1, \ldots, \ddot{P}_4)$ at time t, an exogenous seasonal dummy for the fourth quarter $(\ddot{Q})$, the exogenous market share $(\dot{MS})$ of energy retailer i at time t. The error terms capture the unexplained variation in the data for the seven different endogenous variables $(\varepsilon_{1,it}, \ldots, \varepsilon_{7,it})$. The estimates of these parameters are provided in Table D.1 in Appendix D.

3.3. Market-level model

3.3.1. Data gathering and characteristics

The market-level model analyses the effects on a market-aggregated level in a time series data set containing monthly aggregated observations from 01-01-2008 up to 01-12-2019, which provides 144 monthly observations. Table 3 provides an overview of the variables used to capture the constructs, including their definitions and the sources. The variables *switch rate* and *policies* are obtained through the ACM, which is the regulator of the Dutch energy market. The *energy price* and *profit margins* are based on data obtained from the European Commission's dashboard for energy prices in the European Union and main trading partners (EC, 2019). *Consumers' search behaviour* is retrieved from Google Trends (2022) using the keywords "energie vergelijken", "energie leverancier", and "energietarieven", which translates into "energy comparing", "energy retailer", and "energy tariffs" respectively. The two control variables *temperature* and *consumer price index (CPI)* are retrieved from KNMI (2022) and CBS (2022) respectively.

The data set contains 14 missing values in 2 variables, which are imputed as described in the web appendix. An overview of the descriptive statistics of all continuous variables is provided in Table 4.

3.3.2. Model specification

Based on the outcomes of the unit root tests presented in Appendix C, we can include Google search behaviour and the switch rate in levels and energy price and profit margins in first differences. We estimate our VAR with an OLS model. Based on the AIC, HQIC and SIC, we estimate the model with 1 lag (see Appendix C). Eq. (2) provides the specification of our model. In the model, the vector of endogenous variables includes Google search behaviour (GS), the consumers' switch rate (SR), first difference of energy price (ΔEP), and the first difference of profit margins (ΔPM). Each variable is log-transformed. The exogenous variables consist of five policy dummies $(P_1, \ldots, P_5)$, the consumer

price index (CPI) and seasonal effects proxied by temperature (T). This results in the following model specification:

$$
\begin{bmatrix} GS_t \\ SR_t \\ \Delta EP_t \\ \Delta PM_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix} + \sum_{k=1}^{K} \begin{bmatrix} \beta_{11}^k & \cdots & \beta_{14}^k \\ \vdots & \ddots & \vdots \\ \beta_{41}^k & \cdots & \beta_{44}^k \end{bmatrix} \begin{bmatrix} GS_{t-k} \\ SR_{t-k} \\ \Delta EP_{t-k} \\ \Delta PM_{t-k} \end{bmatrix}
$$
$$
+ \begin{bmatrix} \gamma_{P,11} & \cdots & \gamma_{P,15} \\ \vdots & \ddots & \vdots \\ \gamma_{P,51} & \cdots & \gamma_{P,45} \end{bmatrix} \begin{bmatrix} P_{1,t} \\ \vdots \\ P_{5,t} \end{bmatrix} + \begin{bmatrix} \gamma_{CPI,1} \\ \gamma_{CPI,2} \\ \gamma_{CPI,3} \\ \gamma_{CPI,4} \end{bmatrix} CPI_t
$$
$$
+ \begin{bmatrix} \gamma_{T,1} \\ \gamma_{T,2} \\ \gamma_{T,3} \\ \gamma_{T,4} \end{bmatrix} T_t + \begin{bmatrix} \tau_1 \\ \tau_2 \\ \tau_3 \\ \tau_4 \end{bmatrix} t + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \varepsilon_{4,t} \end{bmatrix} \quad (2)
$$

where t indexes months, α a constant, K is the number of lags, β coefficients of the endogenous variables, γ coefficients of the exogenous variables, τ the coefficients of time trend t, and $[\varepsilon_{1,t}, \varepsilon_{2,t}, \varepsilon_{3,t}, \varepsilon_{4,t}]' \sim N(0, \Sigma)$. The equation reads as follows: the four endogenous variables, indexed by time period t, on the left-hand side of the equation are explained by a constant α, their own lagged values, the five exogenous policies $(P_1, \ldots, P_5)$ at time t, the exogenous consumer price index (CPI) at time t, the exogenous temperature (T) at time t, time trend t, and the error terms, which capture the unexplained variation in the data for the four different endogenous variables $(\varepsilon_1, \ldots, \varepsilon_4)$ in time period t. The estimates of these parameters are provided in Table E.1 in Appendix E.

4. Results

4.1. Retailer-level model

4.1.1. Granger causality

The Wald statistics and *p*-values of the Dumitrescu & Hurlin panel Granger causality test are provided in Table 5. The results indicate that perceived switch costs temporally precede consumer search behaviour, churn rate, retention actions, and the average energy price. Consideration and churn rates temporally precede the average energy price as well. Moreover, we see that retention actions temporally precede perceived switch costs, churn rate, and acquisition actions, as well

Table 5

Panel Granger causality test.

Response to:	SW	SB	CO	CH	AC	RE	EP
Switch costs (SW)	–	2.330**	0.385	3.937***	−0.367	4.704***	2.101**
Search behaviour (SB)	1.174	–	0.137	1.327	−0.743	0.319	1.380
Consideration (CO)	−0.379	−0.311	–	1.224	−0.786	−0.523	2.812**
Churn rate (CH)	−0.327	1.429	−1.338	–	1.031	0.580	2.230**
Acquisition actions (AC)	−1.641	−0.442	−0.932	−0.986	–	−1.211	−0.248
Retention actions (RE)	3.926***	0.635	1.146	16.015***	2.221**	–	0.817
Energy price (EP)	0.798	−0.906	0.193	0.734	1.962*	−1.404	–

Notes: (i) The values indicate test statistics of a Panel Granger test of one lag, with the alternative hypothesis that variables in the left column Granger cause the variables in the top row. *(ii)* * indicates $p < 0.1$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$. *(iii)* All variables are log transformed.
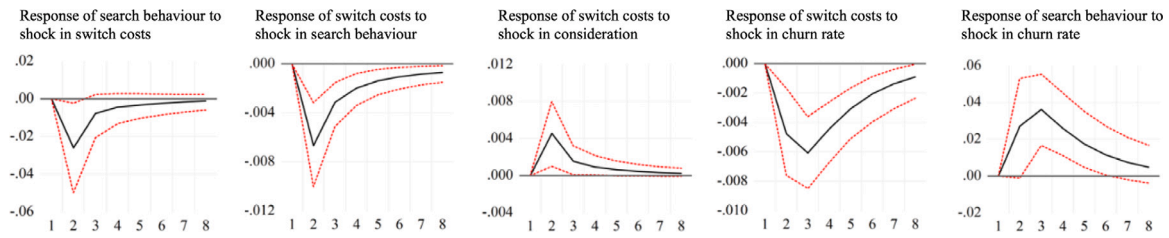
Fig. 2. Impulse Response Functions of different forms of participation.
Notes: the vertical axis represents the change in the response variable after a one standard deviation change in the shock variable, the horizontal axis represents periods (quarters). The black line represents the IRF and the red dotted lines the confidence intervals (95%).

as the average energy price temporally precedes acquisition actions. Hence, the results indicate mutual effects of consumer behaviours and energy retailers' actions, which signifies the interdependence of the endogenous variables. However, the Granger causality is based on the bivariate relationship between the two variables and the size and significance of these effects can better be interpreted by the IRFs presented in Figs. 2 and 3.

4.1.2. Impulse responses

An overview of all IRFs is provided in Fig. D.2 in Appendix D. The IRFs in Fig. 2 illustrate the relations among different forms of active consumer participation. The first two panels in Fig. 2 indicate that perceived switch costs and consumer search behaviour are negatively related to each other. As stated in Table 5, the temporal precedence of these mutual effects starts with the perceived switch costs of consumers. The perceived switch costs may influence whether consumers engage in any form of consumer participation, which then leads to a new perception of the switch costs. The third panel indicates that perceived switch costs are positively related to a shock in consideration. Increased perceived switch costs after considering and comparing different energy contracts may be due to non-transparent information. Moreover, the last two panels in Fig. 2 indicate that perceived switch costs are

negatively related to a shock in churn rates, while consumer search behaviour is positively related to a shock in churn rates. This can indicate learning affects, where prior switching experience encourages future participation.

Next to the direct effects, churn rate is also indirectly related to the perceived switch costs through its effects on consumer search behaviour and consideration to switch. The fifth panel in Fig. 2 shows that churn rate is positively related to consumer search behaviour, which is negatively related to perceived switch costs, as shown in the second panel. Hence, churn rate is indirectly negatively related to the perceived switch costs. Churn rate is also indirectly related to consumer search behaviour through its negative effect on perceived search costs (panel 4). This is an indirect positive relation as search behaviour responds negatively to a shock in perceived switch costs (panel 1).

The results in Appendix D do not indicate any direct effects of energy retailers' acquisition actions on the different forms of consumer participation. The first panel in Fig. 3 shows that a shock in acquisition actions is positively related to churn rates. However, this effect is not consistent, as indicated by the confidence intervals. Hence, there is a positive effect which may vary among different consumer segments. Moreover, the IRFs of Fig. 3 indicate that the perceived switch costs responds negatively to a shock in retention actions (panel 2) while
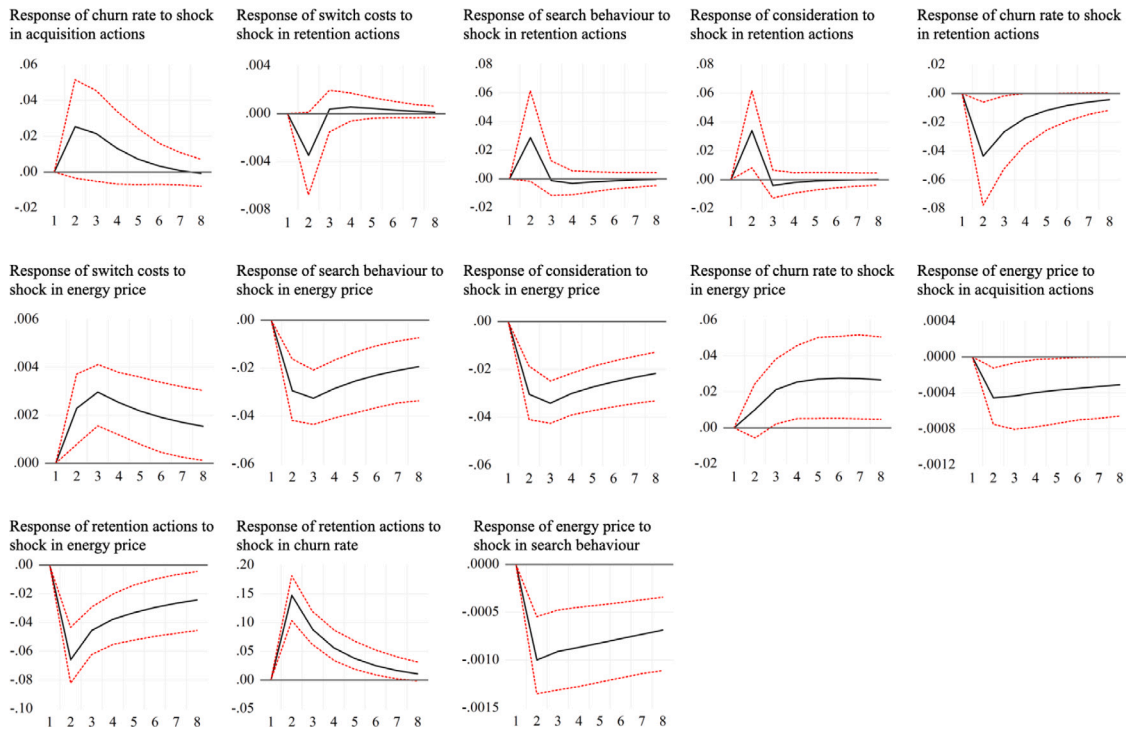

Fig. 3. Impulse Response Functions of different forms of participation.
Notes: the vertical axis represents the change in the response variable after a one standard deviation change in the shock variable, the horizontal axis represents periods (quarters). The black line represents the IRF and the red dotted lines the confidence intervals (95%).

Table 6
Estimates of exogenous policies (standard errors in brackets).

	SW	SB	CO	CH	AC	RE	EP
Renewed model contract	−0.0059	−0.0791	−0.1092**	−0.0027	0.0054	−0.0644	0.0024***
	(−0.0045)	(−0.0406)	(−0.0349)	(−0.0473)	(−0.0191)	(−0.0545)	(−0.0005)
Disconnection protection	−0.0072	0.0538	0.0344	−0.0403	−0.0299	−0.0115	0.0024***
	(−0.0047)	(−0.0423)	(−0.0364)	(−0.0493)	(−0.0200)	(−0.0568)	(−0.0006)
Code decision correction process	−0.0020	0.0144	0.0854*	0.0219	0.0234	0.1427*	−0.0025***
	(−0.0051)	(−0.0458)	(−0.0394)	(−0.0533)	(−0.0216)	(−0.0614)	(−0.0006)
Code of conduct IV	0.0042	−0.1485**	−0.2189***	−0.0614	−0.1316***	−0.2428***	0.0017*
	(−0.0059)	(−0.0534)	(−0.0459)	(−0.0622)	(−0.0252)	(−0.0717)	(−0.0007)

Notes (i) * indicates $p < 0.05$, ** indicates $p < 0.01$, *** indicates $p < 0.001$. *(ii)* SW = perceived switch costs, SB = consumer search behaviour, CO = consideration to switch, CH = churn rate, AC = acquisition actions, RE = retention actions, EP = average energy price.

consumer search behaviour and the consideration to switch respond positively to a shock in retention actions (panel 3 and 4). Retention actions can make information more salient for consumers, decreasing switch costs and increasing search behaviour and consideration to switch. However, this active participation does not lead to an increase in churn rates (panel 5), which may indicate that retention actions are effective for energy retailers to increase customer loyalty. Furthermore, a shock in the average energy price of all energy retailers is positively related to the perceived switch costs (panel 6) and negatively related to consumer search behaviour (panel 7) and the consideration to switch (panel 8). A decrease in the average energy price may lead to a larger difference between consumers' current tariffs and the new energy price. Therefore, the expected benefits of switching may increase when energy prices decrease and encourage active participation of consumers. We find a positive effect of churn rates to the average price of all energy retailers (panel 9), which is only consistent after a few periods. This suggests that in the short term, high energy prices do not necessarily result in increased switching behaviour. However, over the long term, as higher energy tariffs account for a larger portion of consumers' disposable income, they may indeed encourage more switching behaviour.

Within the dynamic systems model, acquisition actions indirectly affect consumer behaviour through its negative relation with the energy price (panel 10). An increase in acquisition actions can lower the market price with "bargain" prices, which can therefore have a positive effect on consumer search behaviour (panel 7) and consideration (panel 8). However, this is expected to be a small effect as the effect size of acquisition actions on the average energy price is not substantial. Furthermore, a shock in the average energy price indirectly affects churn rates through its negative effect on energy retailers' retention actions (panel 11), which is negatively related to the churn rate (panel 4). A shock in the average energy price could therefore indirectly increase the churn rate.

The different forms of consumer participation also affect energy retailers' actions through the dynamic systems model. A shock in churn rates is positively related energy retailers' retention actions (panel 12), with a substantial effect size. Hence, these two variables have an intricate relationship. The Granger causality tests in Table 5 indicate that retention actions temporally precede churn rates. Therefore, there is a feedback loop where first churn rates decrease as a response to retention actions, and then retention actions increase as a response to churn rates. The results identify another intricate relationship between the average energy price of all energy retailers and consumer search behaviour (panel 7 and panel 13), although the effect size of the response of the energy price to a shock in search behaviour is not substantial.

Overall, the results identify many dynamic relations between the endogenous variables. Acquisition actions have a positive but inconsistent effect on churn rates. Retention actions increase search behaviour and the consideration to switch, while decreasing churn rates. Moreover, we identify indirect effects through the different forms of participation, retention actions, and the average energy price of all retailers.

4.1.3. Policy effects

The estimates of the policies are provided in Table 6. An overview of all estimates can be found in Appendix D. The results indicate that the regulator's policies affect both consumer participation and energy retailers' actions. The Renewed model contract, which updated the existing model contract with 14 consideration days, more information on costs and start day, and standardised use of language, negatively affects the consideration to switch. We find that the Disconnection protection of households, which safeguards against disconnection for vulnerable households and prohibits disconnection of households during winter, is not significantly related to active consumer participation or actions of energy retailers. Furthermore, the Code decision correction process provides better protection of consumers' personal information and is positively related to the consideration to switch and retention actions. Finally, the Code of conduct IV, which updated the previous code of conduct for energy retailers with stricter rules regarding acquisition outside the sales area, privacy regulations, collaboration agreements, and a more robust complaint procedure, is negatively related to consumer search behaviour and the consideration to switch. Additionally, it is negatively related to acquisition and retention actions of energy retailers. All policies are significantly correlated with the average energy price. However, this likely due to the fact that both the policy dummies and the average energy price are not retailer specific variables. As the effect sizes are not substantial, we do not interpret these effects.

Within the dynamic systems model, the policies also have indirect effects on other forms of participation. The Renewed model contract is negatively related to consumers' consideration to switch, which is positively related to consumers' perceived switch costs (Fig. 2, panel 3). Hence, the Renewed model contract indirectly decreases consumers' perceived switch costs, which may even increase consumers search behaviour (Fig. 2, panel 1). The Code decision correction process is positively related to consumers' consideration to switch, which is positively related to the perceived switch costs (Fig. 2, panel 3). Moreover, the Code decision correction process positively affects the retention actions of energy retailers, which negatively affects perceived switch costs and churn rates (Fig. 3, panel 2 and 5), and positively affects consumer search behaviour and consideration to switch (Fig. 3, panel 3 and 4). The Code of conduct IV negatively affects consumer search behaviour and the consideration to switch, which have opposite effects on the perceived switch costs (Fig. 2, panel 2 and 3). Through the negative relation with retention actions of energy retailers, the policy may decrease consumer search behaviour and the consideration to switch (Fig. 3, panel 3 and 4), and increase perceived switch costs and churn rates (Fig. 3, panel 2 and 5).

Concluding, we find that the policies affect both consumer participation and energy retailers' actions. It is important to consider the many indirect relations in the dynamic systems model when assessing the full effects of these policies. Some policies are directly negatively related to active consumer participation, but these effects may be neutralised or reversed through the many indirect relations between the endogenous variables.
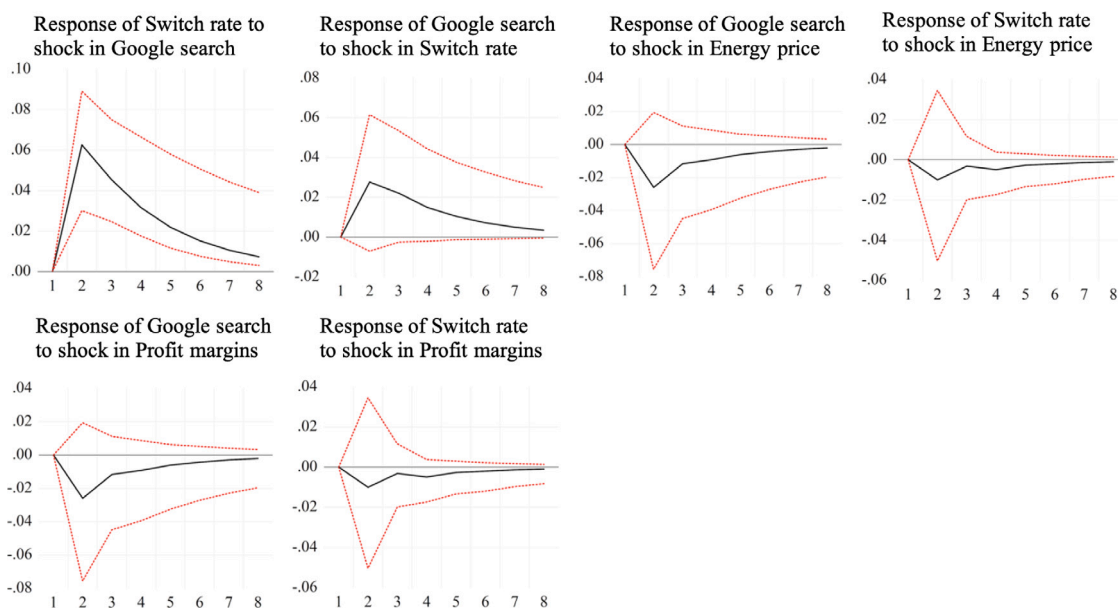
Fig. 4. Impulse response functions of market-level VAR model.
Notes: the vertical axis represents the change in the response variable after a one standard deviation change in the shock variable, the horizontal axis represents periods (months). The black line represents the IRF and the red dotted lines the confidence intervals (95%).

4.2. Market-level model results

4.2.1. Granger causality

The Wald statistics and p-values of the Granger causality test are provided in Table 7. The results indicate that Google search behaviour temporally precedes the market's overall switch rate. We do not find any other temporally preceding effects between two variables.

Table 7
Granger causality test.

Response to	GS	SR	Δ EP	Δ PM
Google search behaviour (GS)	–	15.148***	0.001	1.367
Switch rates (SR)	2.415	–	1.048	0.289
First difference of energy price (Δ EP)	0.941	0.086	–	0.785
First difference of profit margins (Δ PM)	0.348	0.934	0.543	–

Notes (i) Table indicates χ^2 statistics of Granger test of one lag, with the alternative hypothesis that variables in the left column Granger cause the variables in the top row. *(ii)* * indicates $p < 0.10$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$. *(iii)* All variables are log transformed.

4.2.2. Impulse responses

We use IRFs to illustrate the effects of active consumer participation. An overview of all IRFs is provided in Fig. E.2 in Appendix E. The first panel of in Fig. 4 indicates that a shock in consumers' Google search behaviour results in an increase in switch rates in the energy market. This might imply that more search behaviour makes information more salient to consumers and therefore decreases switching costs and increases switch rates in the market. We do not find a significant effect from switch rate on Google search behaviour, as shown in the second panel. We do not find any significant effects from energy retailers' actions towards consumer participation, as the confidence intervals of the third, fourth, fifth, and sixth panel of Fig. 4 all include zero.

4.2.3. Policy effects

The estimates of the policies are provided in Table 8. An overview of all estimates can be found in Appendix E. The results indicate that most policies have no significant direct effect on the different forms of active participation. The results indicate that the Code of conduct II, which is an update of the prior Code of conduct with agreements on information transparency and fairness of the acquisition of customers, New market model, which makes energy retailers the single point

of contact for consumers, and Capacity tariff for distribution, which creates a fixed tariff of distribution costs for all Dutch households, are combined negatively related to the energy price. The effects of the three policies are combined as the policies were all installed at the same date. The Model contract, which is the obligation for energy retailers to offer a standardised product that is identical across energy retailers on all aspects except price, is positively related to the switch rate. The Prohibition automatic renewal, which gives consumers the right to cancel the contract every month after termination of a fixed contract, is negatively related to the energy price. Moreover, the model identifies no effects of the Code of conduct III, which is an update of the Code of conduct II including the provision that consumers need to be precisely informed about the total annual costs of a specific offer. Finally, we find no significant effect of the Renewed model contract, which updates the Model contract with the obligation of 14 consideration days for consumers and precise information of the total annual costs of the offer.

The effects of the policies on the endogenous variables have no indirect effects on other endogenous variables in the system, as the switch rate and the energy price are not related to the other endogenous variables. Hence, the results indicate that two policies negatively affect the energy price and one policy positively affects the switch rate in the market.

Table 8
Estimates of exogenous policies (standard errors in brackets).

	GS	SR	ΔEP	ΔPM
Code of conduct II	−0.0756	−0.1325	−0.0207*	−0.0291
	(−0.1013)	(−0.0883)	(−0.0094)	(−0.0207)
Model contract	0.0786	0.1954*	0.0021	−0.0076
	(−0.1106)	(−0.0964)	(−0.0103)	(−0.0226)
Prohibition automatic renewal	−0.1865	0.0476	−0.0196*	−0.0095
	(−0.1055)	(−0.0920)	(−0.0098)	(−0.0216)
Code of conduct III	−0.1999	0.0479	0.0016	0.0088
	(−0.1077)	(−0.0939)	(−0.0100)	(−0.0220)
Renewed model contract	−0.0437	0.0162	0.0023	0.0071
	(−0.0936)	(−0.0816)	(−0.0087)	(−0.0191)

Notes (i) * indicates $p < 0.05$, ** indicates $p < 0.01$, *** indicates $p < 0.001$. *(ii)* GS = Google search behaviour, SR = switch rate, ΔEP = first difference of energy price, ΔPM = first difference of profit margins.

5. Discussion

This research analyses the dynamic effects of the regulator's and energy retailers' actions on consumer participation in the Dutch retail energy market to see whether the actors enforce or counteract each other's efforts. In this section, we discuss the results of the two dynamic system models to answer the research questions.

The policies of the regulator have mixed effects on the different forms of active consumer participation. Stricter rules for acquisition are negative related with many forms of active consumer participation, while stronger rules for unjustified switches increase the consideration to switch. We find negative effects of simplification of information on consideration to switch in the retailer-level model, but a positive effect of such policies on switch rates in the market-level model. The different effects on the various forms of participation validate prior research which found that different mechanisms affect search- and switching behaviour (Buso and Hey, 2021; Flores and Price, 2018; Giulietti et al., 2005; Wilson, 2012) and internal and external switching behaviour (Ek and Söderholm, 2008; Schleich et al., 2019). This emphasises the need for policy makers to not only focus on switch rate, but also consider consumers' ability to compare and assess different offers in the market. Furthermore, it is important to not only consider the direct effects of these policies, but also the indirect effects through the different forms of participation and energy retailers' retention actions, which may counteract some negative direct effects on consumer participation.

Our models only identify a positive, but inconsistent, effect of acquisition actions on churn rates, and not on other forms of active consumer participation. However, this does not imply that energy retailers' acquisition actions are not effective. Firstly, due to the small sample size, the insignificant result might the result of power issues. The IRFs in Appendix E indicate effect sizes different from zero for search behaviour, consideration, and churn rate, however with large confidence intervals. The aggregate nature of the data does not allow to distinguish different consumer segments, which are found to behave differently in energy markets (Yang et al., 2015). Moreover, consumers who respond to acquisition actions in the same quarter are not captured by the model, due to the monthly aggregation level. We find that energy retailers' retention actions are negatively related to switch costs and churn rate, while positively related to the consideration to switch. This implies that retention actions increase active consumer participation, yet it does not result in more switch behaviour. This may indicate barriers between intentions and switch behaviour which are not explained by the perceived switch costs, as found in Sheeran and Abraham (2003) and Arkesteijn and Oerlemans (2005). However, it might as well indicate that energy retailers provide competitive retention offers for their customers and active consumers' best decision is not to switch. In this case, retention actions still lead to an increase in consumer welfare. The contrasting effects of acquisition and retention action are consistent with previous research, which indicates that energy retailers often prioritise retention over acquisition when allocating resources due to the higher profitability associated with retention actions compared to acquisition actions (Gupta et al., 2004; Natter et al., 2015; Berger and Bechwati, 2001).

Our retailer-level model identified that energy retailers' pricing strategies influence different forms of consumer participation with direct effects and indirect effects through its effect on retention actions, which is in line with prior research (Armstrong, 2015; Mulder, 2023). However, we found no direct effect on churn rate, which might be because price incentives can be insufficient to encourage consumer participation (Annala et al., 2013; Deller et al., 2021; Wilson and Price, 2010). However, we do find long term positive effects on churn rates, which may be attributed to the fact that higher energy tariffs over time can lead to increased energy expenditures, potentially reducing consumers' disposable income. Consequently, energy contracts become more important for consumers. We encourage future research to identify the mechanisms behind the effects of energy prices on switch rates. The insignificant effects of energy price in the market-

level model can be explained by the fact that consumers often have long-term contracts and might have to pay a fine when they break these contracts. Moreover, as the prices in these contracts are fixed for a longer period, they are less aware and responsive to monthly price changes, as consumers typically only check offers at the end of their contract period. Therefore, the decision to switch might be motivated by their ability and awareness to switch rather than a change of market prices.

We find mediating relations between the different forms of consumer participation, which indicate that effects of policies and energy retailers' actions can be equivocal. This highlights the importance of capturing not only active participation as switch behaviour, but also other forms of participation. The effects of churn rates on other forms of participation are in accordance with the literature (He and Reiner, 2017; Waddams Price and Zhu, 2016), and indicate learning effects, where prior experience in switching between energy retailers encourages future participation. Moreover, the results indicates mutual influence between energy retailers' actions and consumer participation. High churn rates can motivate energy retailers to increase efforts to retain their customers. However, in our data, consumers only receive a retention offer when they are about to switch, which can create a selection of customers who are more prone to switching.

Though we were able to use unique data for our analyses, a limitation of our data is that some important characteristics of the customers' current and old offers are not included. For the retailer-level model, the tariff of their old and new contracts, the energy sources of the old and new contracts, and the type of contracts would help to understand how energy retailers influence participation with their pricing strategies and their product mix. For the market-level model, inclusion of price differences in the market, the ratio of grey and green source contracts in the market, and the ratio of variable and fixed contracts in the market would also help to explain the interrelation between policies and energy retailers' actions on consumer participation. A second limitation of the data is that the data are aggregated on a retailer- and a market-level. Aggregation on a household would allow to distinguish the effects on different consumer segments, as identified by Yang et al. (2015). This includes distinguishing customers on a fixed tariff, who are more likely to be active consumers, and consumers on a variable tariff, who are more likely to be inactive consumers. We recommend future research to include this in their analysis. Furthermore, during the observation period in this research, the costs of early breach of an energy contract for consumers was rather low. However, the Dutch regulator changed these termination fees from June 2023 (ACM, 2023a), which will lead to larger costs of early termination fees for many consumers. Therefore, we recommend future research to take these early termination fees into consideration, as they can significantly affect consumer switching costs and hence, switching behaviour. Finally, while our dynamic system model is very flexible by construction, it does not account for potential shifts in consumer preferences over time. We advise future research to give due consideration to this aspect, particularly when the observation period encompasses events such as the Ukraine war and the subsequent increases in European gas prices.

6. Conclusions and policy implications

In this article, we explore the factors that influence active consumer participation in retail energy markets, which is an important requirement for the energy transition. After all, the more residential consumers respond to market signals, the more they will be able to provide flexibility in consumption, mitigating the impact of renewable energy on energy systems. Using dynamic system models, we examined the combined effect of policies of the regulator and energy retailers' actions on consumer participation. The purpose of this research is to examine whether energy retailers' actions complement or counteract the regulator's efforts to boost consumer participation in retail energy

markets. To answer our research question, we analysed consumer participation on a retailer level and on a market level in the Dutch retail energy market over the period 2009 to 2021.

Our findings reveal that the policies implemented by regulators have distinct effects on the different forms of active consumer participation. The regulator affects consumer participation either directly or indirectly through energy retailers' actions. We conclude that retailers' acquisition and retention actions do not counteract the regulator's efforts to increase active consumer participation. While retention actions lead to decreased switching behaviour, they concurrently decrease perceived switch costs while increasing search behaviour and the consideration to switch. This underscores the importance of considering a broader range of active participation forms beyond just switch rates. Regulators aim to enhance consumers' ability to actively participate in retail energy markets, which may as well result in staying with the same energy retailer or changing contracts within their current energy retailer.

This research offers a contribution to established research by uniting the perspectives of both regulators and energy retailers. Using dynamic system models, this research reveals how the regulator, energy retailers, and consumers mutually influence each other. This approach reveals mediating effects that enable comprehensive examination of the full impact of regulatory policies and energy retailer's actions. The results validate these dynamic interactions and pave the way for future research to further analyse dynamic effects between the different actors in retail energy markets. Another contribution of our research is that we examine different forms of active participation. Since different forms of active participation entail distinct behavioural costs, the effects of the regulator's policies and energy retailers' actions varies across these forms. The results indicate dependencies between these different forms of participation and underscore learning effects from experience. Active participation expands beyond the confines of switching behaviour, and we advise future research to consider different forms of participation.

This research bears important implications for energy regulators. Our research indicates that policies can exert both direct and indirect influences on consumers' participation through actions of energy retailers. Our findings reveal that policies influence energy retailers' acquisition and retention activities, which subsequently affect active consumer participation. Particularly retention activities are found to be influential on different forms of active participation. This aligns with the call of Gamble et al. (2009) for more stringent regulation on loyalty programmes and facilitating measures to negotiate contracts. The inclusion of these indirect effects can improve the design and assessment of regulatory policies. Another implication for policymakers is to focus on indicators for active participation beyond switch rates. Active participation can result in the decision to remain with the same energy retailer. Policies can best focus on enhancing consumers' ability to access information and compare options in the market.

An implication of our research for energy retailers is that we find that consumers mainly respond to retention activities. Therefore, energy retailers can best influence their customers' behaviours through these activities, for example through customer satisfaction and customer loyalty. Energy retailers can exploit the many indirect effects of their actions on consumer behaviours, such as influencing the churn rate through the relation between energy prices and perceived switch costs. Energy retailers can also use this influence to encourage other forms of active participation of consumers, such as response to dynamic tariffs or the adoption of solar panels.

Concluding, this research finds that the regulator affects consumer participation both directly and indirectly through energy retailers' actions. Energy retailers affect consumer participation through acquisition and retention actions. Though energy retailers' retention actions decrease switch behaviour, they increase other forms of active participation. Therefore, energy retailers might still improve consumer participation and, hence, consumer welfare through these actions and

do not hamper the efforts of the regulator. Through our holistic approach, our results highlight the dynamic nature of the market and the importance to analyse effects on different forms of active participation. The results provide implications for policymakers and energy retailers on the direct and indirect effects of their actions on future active consumer participation. Policymakers and energy retailers both dynamically influence these forms of consumer participation and, as a result, understanding consumers' search- and switching behaviour is a crucial step to enable these forms of consumer participation. Future research can build on these findings by examining the mechanisms how regulators and energy retailers influence consumer participation, examining how different consumer segments are affected by these actions or comparing the effects of policies in different countries.

CRediT authorship contribution statement

Hester M. Huisman: Conceptualization, Methodology, Software, Formal analysis, Writing – original draft, Visualization. **Evert de Haan:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Machiel Mulder:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Jaap E. Wieringa:** Conceptualization, Methodology, Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Large part of the data is proprietary and the data provider does not allow publishing the data.

Acknowledgements

Appendix A. Policies

The regulator's policies are retrieved from the public online database of the ACM, which is the Dutch energy regulator. We selected policies which affect the information transparency or the perceived risk for consumers, as these are aimed at decreasing switching barriers and improving consumer welfare. An overview of the selected policies which fall within our observation period is provided in Table A.1.

Appendix B. Variables from survey questions

Table B.1 provides an overview of the used questions for each construct. We use factor analyses to assess whether different questions for switch costs measure the same construct. First, the internal consistency of the constructs is assessed through the variable's Cronbach's alpha, according to the value interpretations of Taber (2018). Second, the unidimensionality of the construct is assessed with through an Explorative Factor Analysis by examining the variable's eigenvalues. Finally, we examine the degree to which an item contributes to a dimension through a Principal Component Analysis as we examine the factor loadings. Below, we provide an overview of the used survey questions and how they are used in the analysis.

Table A.1
Overview of regulations.

	Date	Name	Description	Market model	Retail model
1	01/01/2009	Code of conduct retailers II	Update of first code of conduct for energy retailers with agreements on information transparency and fairness of the acquisition of customers.	✔	
2	01/01/2009	New market model	All communication of consumers has to go through retailers as single point of contact.	✔	
3	01/01/2009	Capacity tariff for distribution	Fixed tariff of distribution costs for households.	✔	
4	03/04/2012	Obligation to offer a model contract	Each energy retailer should offer a standardised product that is identical across retailers on all aspects except price.	✔	
5	04/12/2012	Prohibition for automatic renewal of contracts	After termination of a fixed contract, a consumer has the opportunity cancel the contract every month.	✔	
6	01/01/2015	Code of conduct retailers III	Includes the provision that consumers need to be precisely informed about the total annual costs of a specific offer.	✔	
7	14/11/2016	Renewed model contract	Obliged 14 consideration days, more information included, more comprehensible use of language.	✔	✔
8	01/05/2018	Disconnection protection of households	Additional safeguards against disconnection for vulnerable households, and prohibition of disconnection of all households during the winter (October 1–April 1).		✔
9	11/09/2019	Code decision correction processes	Retailers have to respond to unjustified switches within a specified time period. Changed characteristics can be put back to original value. Obligated settlement process for involved parties. Link		✔
10	01/01/2021	Code of conduct retailers IV	Includes GDPR, stricter rules for acquisition of customers outside the sales area, agreements between suppliers, intermediaries and distribution platforms, sharpening of the complaint procedure, and the scope of the code of conduct is clarified.		✔

The construct *Consideration* (CO) is captured by question 1 and the churn rate, as for each retailer i at time t the percentage of consumers who answer the question with "Yes" is added to the churn rate:

$$CO_{it} = Churnrate_{it} + Consider_{it} \times (1 - Churnrate_{it})$$

The construct *switch costs* captured by questions 2, 3, 4, and 5 yields a Cronbach's alpha of 0.66, which Taber (2018) interprets as a slightly low Cronbach's alpha, which is accepted due to the similarity of the questions. The eigenvalues indicate unidimensionality, with only the first eigenvector larger than 1. A principal component analysis shows that all absolute factor loadings are larger than 0.4, and therefore all sufficiently contribute to the construct. The scale of question 5 is reversed and a new switch costs variable is created as the mean value of the four questions per retailer per quarter.

For the construct *search behaviour*, the percentage of consumers who answer question 6 with "I searched myself" is taken as a measure for both switched and non-switched consumers. For consumers who switched, answers are aggregated for consumers' new retailer and for not switched consumers for their current retailer. The percentages are weighted according to the churn rate for retailer i at time t to provide the search behaviour (SB) variable:

$$SB_{it} = Churnrate_{it} \times SBswitch_{it} + (1 - Churnrate_{it}) \times SBnotswitch_{it}$$

Table B.1
Questions per construct.

	Question	Answers	Sample	Construct
1	Did you consider to switch to another retailer?	MC: "Yes", "No" or "I don't know"	Not switched	Consideration
2	It requires much effort/time to arrange a switch to another retailer.	5 point scale from "completely disagree" to "completely agree"	Not switched	Switch costs
3	It is difficult to find trustworthy information about energy retailers which you can best switch to.	5 point scale from "completely disagree" to "completely agree"	Not switched	Switch costs
4	You can save a lot of money by switching retailer.	5 point scale from "completely disagree" to "completely agree"	Not switched	Switch costs
5	I am not motivated to delve in finding another energy retailer.	5 point scale from "completely disagree" to "completely agree"	Not switched	Switch costs
6	How did you acquire information about switching to another retailer?	MC: "I searched myself", "I got it from one or more retailers", or "I don't know"	Switched and not Switched	Search behaviour
7	How did you acquire information about switching to another retailer?	MC: "I searched myself", "I got it from one or more retailers", or "I don't know"	Switched and not switched	Acquisition activities of retailers
8	Did your previous retailer reach out after the switch?	MC: "Yes", "No" or "I don't know"	Switched	Retention activities of retailers
9	Did you want to switch retailers but did your current supplier provide a better counter offer?	MC: "Yes", "No" or "I don't know"	Not switched	Retention activities of retailers

Notes: MC = Multiple choice.

For the construct *acquisition* of retailers (AC), the percentage of consumers who answer question 7 with "I got it from one or more retailers" is taken as a measure for both switched and non-switched consumers. For both switched and not switched respondents, the answers are aggregated by retailer(s) of who they received information. The percentages are weighted according to the churn rate for retailer i at time t to provide the acquisition (AC) variable:

$$AC_{it} = Churnrate_{it} \times ACswitch_{it} + (1 - Churnrate_{it}) \times ACnotswitch_{it}$$

For the construct *retention activity* of retailers, the percentage of respondents who answer question 8 with "Yes" is taken as a measure for switched respondents, and the percentage of respondents who answer question 9 with "Yes" is taken as a measure for not switched respondents. For switched respondents, the answers are aggregated by their previous retailer and for not switched respondents, the answers are aggregated by their current retailer. The percentages are weighted according to the churn rate for retailer i at time t to provide the retention actions (RE) variable:

$$RE_{it} = Churnrate_{it} \times REswitch_{it} + (1 - Churnrate_{it}) \times REnotswitch_{it}$$

Appendix C. Unit root test and lag selection

C.1. Retailer-level data

We examine whether our variables have a unit root through first generation unit root tests, which assume cross-sectional independence. These tests are similar to time-series ADF test, as they are multiple-series unit root tests applied to panel data structures. We execute four Fisher-ADF panel tests which combine p-values from ADF regressions per retailer, as these tests are compatible with unbalanced panel data. Second, we examine stationarity through a second generation unit root test, which relaxes the assumption of cross-sectional independence. Table C.1 provides an overview of the test outcomes for our demeaned endogenous variables perceived switching costs ($S\ddot{W}$), search behaviour ($S\ddot{B}$), consideration ($C\ddot{O}$), churn rate ($C\ddot{H}$), acquisition activities ($A\ddot{C}$), retention activities ($R\ddot{E}$) and energy price ($E\ddot{P}$). The results in Table C.1 indicate that the variables in levels are all stationary. Hence, we can continue to estimate a PVAR model in levels.

Table C.2 provides an overview of the lag selection criteria.

C.2. Market-level data

For the market-level timeseries model, we examine whether our variables are stationary using the Augmented Dickey Fuller test (Dickey and Fuller, 1979) and the KPSS test (Kwiatkowski et al., 1992). Following Enders (2014), we take a general to specific approach in selecting specification with a drift or trend. Table C.3 provides an overview of the results.

The first three columns of Table C.3 indicate the stationarity of variables in levels and the last three columns indicate the stationarity of variables in first differences. The results indicate that the ADF test finds a unit root ($p < 0.05$) for Google search behaviour (GS), switch rates (SR) when a trend is included, but does not find a unit root ($p > 0.05$) for energy prices (EP) and profit margins (PM) in levels. The KPSS test with one lag shows similar results as it rejects the null hypothesis of level or trend stationary ($p < 0.05$) for the energy price (EP), profit margins (PM). The results of both the ADF test as the KPSS test indicate that all variables are stationary with a trend and/or drift in first differences. We test for cointegration among the endogenous variables with Johansen's Full Information Maximum Likelihood (FIML) test (Enders, 2014; Johansen, 1988), which indicates that there is no cointegration between the variables. Therefore, we can estimate a VAR model.

Table C.4 provides an overview of the lag selection criteria.

Table C.1
Results of panel unit root tests.

	First generation panel unit root tests								Second generation	
	Inverse test		*p-test*		Inverse normal test		Logit test		CIPS	
	No trend	Trend	No trend	Trend	No trend	Trend	No trend	Trend	No trend	Trend
$S\ddot{W}$	252.92**	206.8**	28.78**	22.83**	−13.33**	−11.6**	−18.22**	−14.89**	−2.65**	−3.26**
$S\ddot{B}$	349.73**	227.57**	41.28**	25.51**	−15.62**	−10.22**	−25.08**	−14.92**	−3.58**	−3.53**
$C\ddot{O}$	375.25**	285.34**	44.57**	32.96**	−16.59**	−12.74**	−26.95**	−18.75**	−3.62**	−3.96**
$C\ddot{H}$	173.09**	129.72**	18.47**	12.87**	−9.91**	−7.10**	−12.38**	−8.66**	−2.49**	−2.94*
$A\ddot{C}$	256.57**	161.39**	29.25**	16.96**	−13.2**	−9.23**	−18.47**	−11.48**	−3.05**	−3.19**
$R\ddot{E}$	224.49**	154.98**	25.11**	16.13**	−11.54**	−7.74**	−16.06**	−10.04**	−2.55**	−2.85*
$E\ddot{P}$	140.84**	92.8	14.31**	8.11**	−9.10**	−4.28**	−18.22**	−14.89**	−4.32**	−4.41**

Notes: (i) First generation tests include Inverse χ^2 test (Maddala and Wu, 1999) also known as p-test by Choi (2001), the modified p-test for large N (Choi, 2001), the inverse normal test (Choi, 2001) and finally the logit test (Choi, 2001). The alternative hypothesis for all these tests is stationarity. The tests are executed without a trend (No trend) and with a trend (Trend) variable. The number of lags are automatically selected using the Schwarz information criteria (SIC). (ii) The second generation tests comprises the cross-sectionally augmented IPS test (CIPS) with a lag of 1, which solves the cross-dependence problem through cross-sectional averages of lagged levels and first differences of the variables (Pesaran, 2007). The alternative hypothesis for the CIPS test is stationarity. (iii) * indicates $p < 0.05$, ** indicates $p < 0.01$. (iv) All variables are log transformed.

Table C.2
Lag selection criteria PVAR.

Lag	AIC	SIC	HQIC
0	−13.146	−12.600	−12.927
1	−14.424	**−13.240**	−13.949
2	−15.033	−13.211	**−14.302**
3	−15.190	−12.730	−14.204
4	−15.294	−12.196	−14.051
5	−15.393	−11.657	−13.894
6	−15.634	−11.261	−13.880
7	−16.001	−10.100	−13.999
8	**−16.077**	−10.428	−13.811

Table C.3
Tests of unit roots hypothesis.

| | Levels | | | | | | First differences | | | | | |
| | ADF(1) | | KPSS(1) | | KPSS(4) | | ADF(1) | | KPSS(1) | | KPSS(4) | |
	ϕ_1 drift	ϕ_1 trend	η_μ	η_τ	η_μ	η_τ	ϕ_1 drift	ϕ_1 trend	η_μ	η_τ	η_μ	η_τ
GS	−4.77**	−4.82**	0.34	0.22**	0.19	0.12	−10.11**	−10.08**	0.02	0.02	0.04	0.03
SR	−3.99**	−6.90**	4.58**	0.08	2.32**	0.06	−13.14**	−13.09**	0.01	0.01	0.02	0.02
EP	−2.08	−2.03	0.44*	0.39**	0.20	0.17*	−8.16**	−8.15**	0.10	0.07	0.09	0.06
PM	−2.60	−2.79	0.78**	0.19*	0.36	0.09	−8.95**	−8.92**	0.06	0.05	0.06	0.05

Notes: (i) the alternative hypothesis of the Augmented Dicky Fuller (ADF) test is stationarity and the alternative hypothesis of the KPSS test is non-stationarity. The number of lags for the ADF test is based on AIC and BIC, which both select a variable length of 1 for each variable. For the KPSS test, we use two types of lag structures, the same number of lags as for the ADF tests and a lag structure based on $(4 \times (N/100))^{1/4}$, which provides lag length of 4 for $N = 144$. *(ii)* * indicates $p < 0.05$, ** indicates $p < 0.01$. *(iii)* All variables are log transformed.

Table C.4
Lag selection criteria VAR.

Lag	AIC	SIC	HQIC
0	−8.476	−7.701	−8.161
1	−9.055	**−7.936**	**−8.600**
2	−9.028	−7.564	−8.433
3	−8.964	−7.157	−8.230
4	−9.121	−6.969	−8.247
5	−9.081	−6.584	−8.066
6	**−9.319**	−6.478	−8.164
7	−9.269	−6.084	−7.975
8	−9.235	−5.705	−7.800

Appendix D. Results retailer-level PVAR model

Table D.1
PVAR FE OLS parameters (standard errors in brackets).

	SW	SB	CO	CH	AC	RE	EP
Switch costs$_{t-1}$ (SW)	0.1810***	−0.9464*	−0.6050	−0.8189	−0.3225	−0.3849	−0.0048
	(−0.0502)	(−0.4523)	(−0.3895)	(−0.5274)	(−0.2135)	(−0.6074)	(−0.0061)
Search behaviour$_{t-1}$	−0.0270***	0.1273*	0.0442	0.0771	−0.0350	0.0958	−0.0040***
	(−0.0072)	(−0.0645)	(−0.0556)	(−0.0752)	(−0.0305)	(−0.0867)	(−0.0009)
Consideration$_{t-1}$ (CO)	0.0215**	−0.0445	−0.0657	−0.1386	−0.0157	−0.1092	0.0003
	(−0.0081)	(−0.073)	(−0.0629)	(−0.0851)	(−0.0345)	(−0.098)	(−0.0010)
Churn rate$_{t-1}$ (CH)	−0.0166**	0.0943	0.0380	0.7104***	0.0228	0.5113***	0.0009
	(−0.0060)	(−0.0539)	(−0.0464)	(−0.0628)	(−0.0254)	(−0.0723)	(−0.0007)
Acquisition actions$_{t-1}$ (AC)	0.0071	−0.1609	0.0459	0.2172	0.2945***	−0.0229	−0.0039*
	(−0.013)	(−0.1169)	(−0.1007)	(−0.1363)	(−0.0552)	(−0.1570)	(−0.0016)
Retention actions$_{t-1}$ (RE)	−0.0105	0.0870	0.1026*	−0.1312*	−0.0062	−0.0988	0.0000
	(−0.006)	(−0.0539)	(−0.0464)	(−0.0628)	(−0.0254)	(−0.0724)	(−0.0007)
Energy price$_{t-1}$ (EP)	0.6921	−8.8967	−9.1656*	3.0307	−4.5672	−19.8374**	0.8691***
	(−0.5758)	(−5.1868)	(−4.4661)	(−6.0476)	(−2.4485)	(−6.9657)	(−0.0696)
Renewed model contract	0.0059	−0.0791	−0.1092**	−0.0027	0.0054	−0.0644	0.0024***
	(−0.0045)	(−0.0406)	(−0.0349)	(−0.0473)	(−0.0191)	(−0.0545)	(−0.0545)
Disconnection protection	−0.0072	0.0538	0.0344	−0.0403	−0.0299	−0.0115	0.0024***
	(−0.0047)	(−0.0423)	(−0.0364)	(−0.0493)	(−0.0200)	(−0.0568)	(−0.0006)
Code decision correction process	−0.0020	0.0144	0.0854*	0.0219	0.0234	0.1427*	−0.0025***
	(−0.0051)	(−0.0458)	(−0.0394)	(−0.0533)	(−0.0216)	(−0.0614)	(−0.0006)
Code of conduct IV	0.0042	−0.1485**	−0.2189***	−0.0614	−0.1316***	−0.2428***	0.0017*
	(−0.0059)	(−0.0534)	(−0.0459)	(−0.0252)	(−0.0622)	(−0.0717)	(−0.0007)
Quarter 4 dummy	−0.0064	0.2732***	0.2445***	0.0934	0.0965***	0.1699*	−0.0112***
	(−0.0056)	(−0.0503)	(−0.0433)	(−0.0586)	(−0.0237)	(−0.0675)	(−0.0007)
Market share	0.0167	0.2870**	0.2552**	−0.0116	0.1651***	−0.0709	−0.0003
	(−0.0103)	(−0.0925)	(−0.0796)	(−0.1078)	(−0.0436)	(−0.1242)	(−0.0012)
F-test (13, 371)	8.765***	8.531***	8.973***	22.181***	13.460***	10.325***	46.368***
R^2	0.221	0.219	0.225	0.418	0.303	0.250	0.600
Adjusted R^2	0.196	0.194	0.200	0.399	0.281	0.226	0.587

Notes: * indicates $p < 0.05$, ** indicates $p < 0.01$, *** indicates $p < 0.001$.
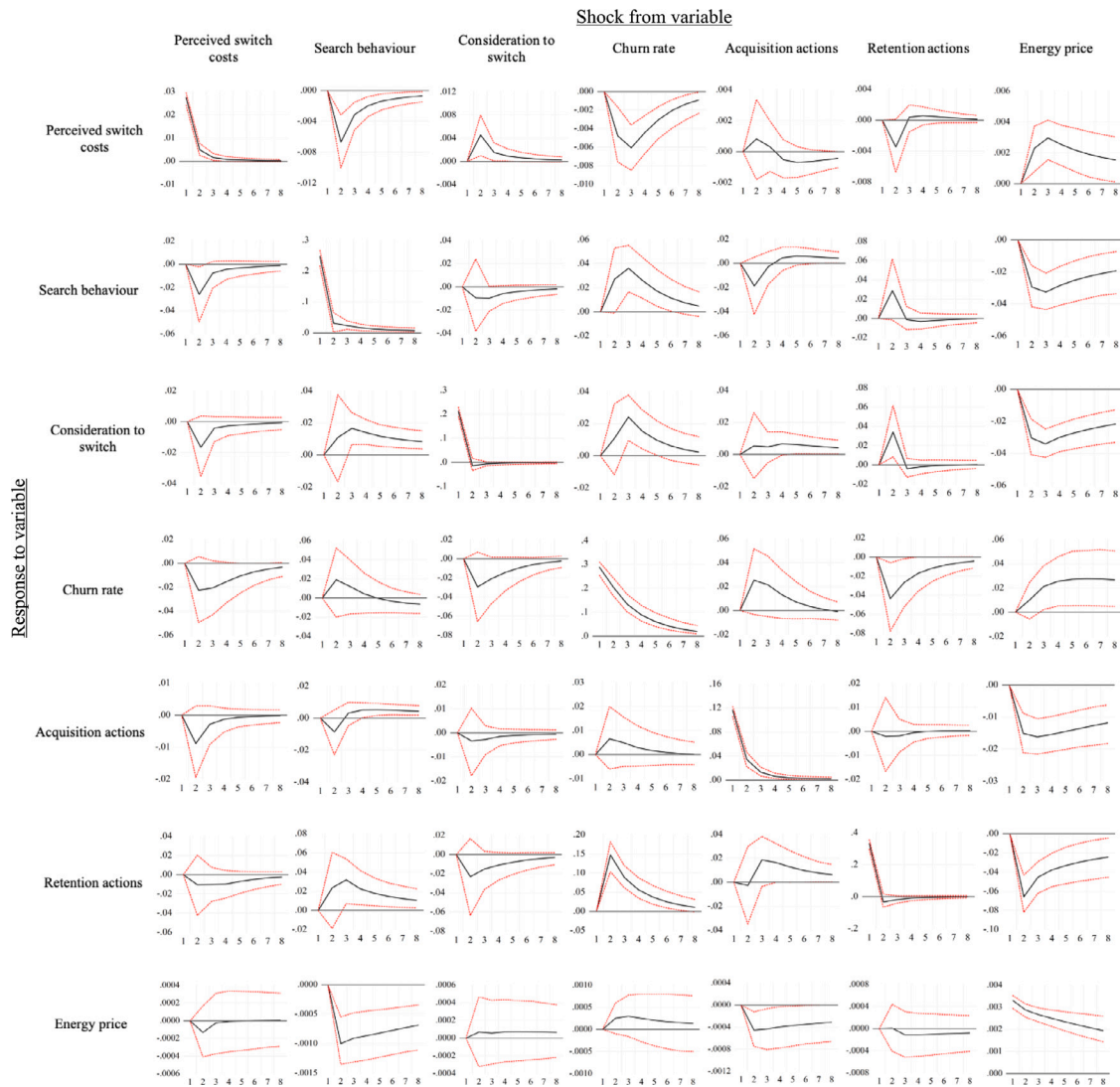
Fig. D.2. Impulse response functions of retailer-level PVAR model.

Notes: the vertical axis represents the change in the response variable after a one standard deviation change in the shock variable, the horizontal axis represents periods (quarters). The black line represents the IRF and the red dotted lines the confidence intervals.

Appendix E. Results market-level VAR

Table E.1
VAR parameter estimates (standard errors in parentheses).

	GS	SR	ΔEP	ΔPM
Google search$_{t-1}$(GS)	0.6174***	0.2672***	−0.0002	0.0156
	(−0.0721)	(−0.0629)	(−0.0067)	(−0.0147)
Switch rate$_{t-1}$(SR)	0.1355	0.0728	−0.0081	0.0137
	(−0.0971)	(−0.0846)	(−0.009)	(−0.0198)
ΔEnergy price$_{t-1}$(EP)	−1.1926	−0.4587	−0.1506	0.2259
	(−1.1892)	(−1.0365)	(−0.1105)	(−0.2428)
ΔProfit margin$_{t-1}$(PM)	0.3652	0.6182	0.0339	−0.1259
	(−0.5508)	(−0.4800)	(−0.0512)	(−0.1125)
Code of conduct II	−0.0756	−0.1325	−0.0207*	−0.0291
	(−0.1013)	(−0.0883)	(−0.0094)	(−0.0207)
Model contract	0.0786	0.1954*	0.0021	−0.0076
	(−0.1106)	(−0.0964)	(−0.0103)	(−0.0226)
Prohibition automatic renewal	−0.1865	0.0476	−0.0196*	−0.0095
	(−0.1055)	(−0.0920)	(−0.0098)	(−0.0216)
Code of conduct III	−0.1999	0.0479	0.0016	0.0088
	(−0.1077)	(−0.0939)	(−0.0100)	(−0.0220)
Renewed model contract	−0.0437	0.0162	0.0023	0.0071
	(−0.0936)	(−0.0816)	(−0.0087)	(−0.0191)
CPI	−0.5936	−5.909*	0.4311	0.7089
	(−3.1014)	(−2.7031)	(−0.2882)	(−0.6333)
December Dummy	0.1454	0.2084**	0.0033	0.0076
	(−0.0797)	(−0.0695)	(−0.0074)	(−0.0163)
Temperature	1.3218	−2.7443*	0.1795	0.4024
	(−1.2465)	(−1.0864)	(−0.1158)	(−0.2545)
Time trend τ	0.0032	0.0111*	−0.0003	−0.0008
	(−0.0049)	(−0.0043)	(−0.0005)	(−0.0010)
Constant	−3.0773	40.5448***	−2.9394*	−5.4937
	(−13.9293)	(−12.1406)	(−1.2942)	(−2.8443)
F-test (14, 128)	12.403***	26.198***	1.778*	0.843
R^2	0.557	0.727	0.153	0.079
Adjusted R^2	0.513	0.699	0.067	−0.015

Notes: * indicates $p < 0.05$, ** indicates $p < 0.01$, *** indicates $p < 0.001$.
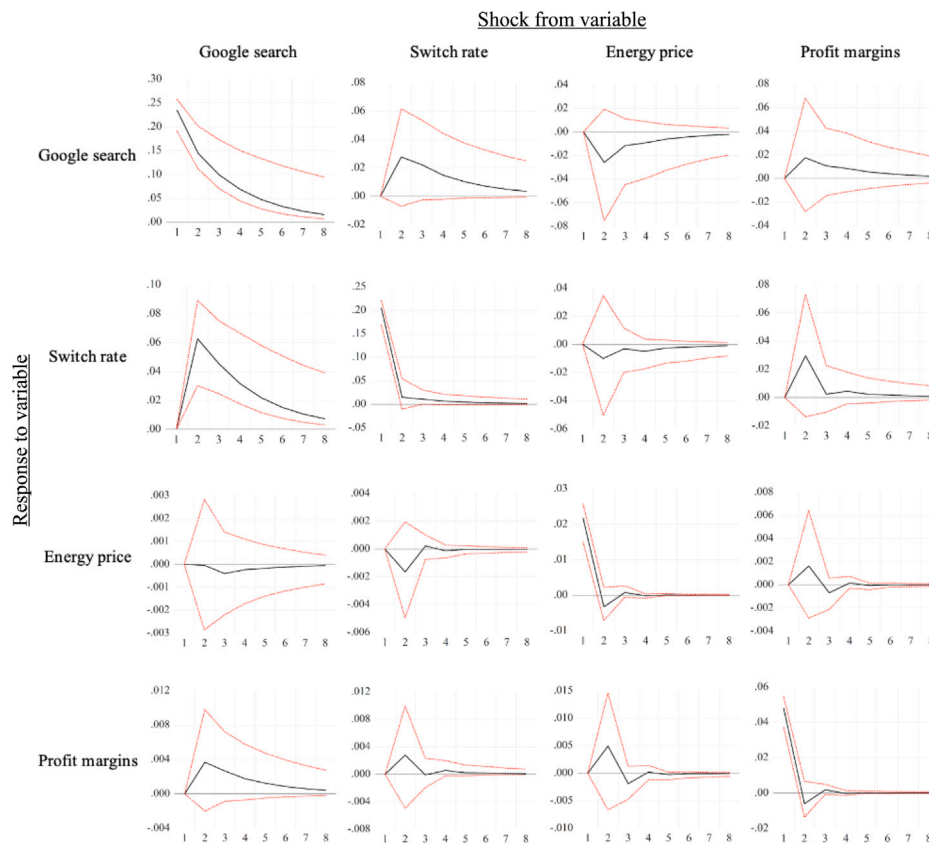

Fig. E.2. Impulse response functions of market-level VAR model.
Notes: the vertical axis represents the change in the response variable after a one standard deviation change in the shock variable, the horizontal axis represents periods (months). The black line represents the IRF and the red dotted lines the confidence intervals.

Appendix F. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.enpol.2023.113890.

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