Mixing regulatory and non-regulatory instruments in sustainability policy: Nudging for reduced energy consumption

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Abstract

Nudging as a policy tool has gained much attention and is thus far treated by governments as a non-regulatory, cost-effective instrument to reach policy goals. It is seen to complement or replace existing tools by altering people's choice architectures towards behaviors that align with government aims, but has fallen short in meeting those targets. One crucial aspect is that governments do not nudge citizens directly, they often need private agents to nudge their consumers. Based on this notion, the paper focuses on the combination of tools that impact behavioral change by looking at the mixture of instruments containing nudges. This is done in the energy policy context where nudging is increasingly incorporated to lower household energy usage through smart meter technology. This technology is being rolled out in almost all European member states as a device to collect the data for information-based nudging. There are differences in how this rollout is regulated at national level and the instrument mixes that follow. The paper compares five cases from the pool of countries with incentive-based systems, three with favorable regulatory and market structures, Austria, Ireland and the UK and two with unfavorable conditions, France and Romania. The findings indicate that contradictory regulatory instruments and the timing of tools limit the effectiveness of green nudges.

Key words: *green nudges, energy policy, policy instruments, regulation*

1. INTRODUCTION

The European Commission is using the Europe-wide implementation of smart meters in households as a way to reduce energy consumption and ultimately carbon emissions. Smart meters are electronic devices in households that have a more sophisticated way of measuring energy consumption compared to conventional meters through transmitting and receiving data and communicating consumption patterns. This is part of a larger trend to utilize so-called 'green nudges' for changing energy consumption behavior of individuals. At the heart of green nudges is the idea that there are ways to use people's inclination to be liked by peers and follow the herd by encouraging consumers to compare their own behavior to others and stimulate social status competition. Nudging has become a prominent area of discussion and is categorized as a non-regulatory, cost-effective instrument to reach policy goals. It is seen to complement or replace existing tools by altering people's choice architectures towards behaviors that align with government aims (Van der Linden et al. 2015; Kunreuther and Weber 2014; Schubert 2017). In recent years, there has been increased attention towards the ability of nudges to promote pro-environmental and sustainable consumption behavior (Sunstein 2015).

However, the impact of green nudges appears to be rather limited and highly context-dependent (Schubert 2017). For the example of smart meters, the influence has so far been disappointing. Those EU Member States with a full-roll out of the meters, Finland, Italy and Sweden, report consumption reduction of around 2 percent, which is far below the previously projected 15 to 20 percent (EC 2012). Preliminary research suggests that energy companies did provide the meters, but only offered limited services that would allow consumers to see their breakdown of energy consumption. Since the smart meters have no nudging capability, the provided services are at the core of the energy reduction strategy. Offering these services however poses a challenge to energy companies, because they carry additional costs linked to the technology and data architecture. In short, the limited success of smart meters for reducing household energy consumption has to do with the regulatory and market context in which private stakeholders carry out the nudging.

To support this argument, the paper draws on policy instrument theory in combination with the behavioral concept of nudging. A large portion of the nudging literature pays limited attention to the potential barriers deriving from the regulatory framework and market dynamics (Southerton et al. 2004; Shove 2010; Mullainathan and Shafir 2013; Weaver 2015). Regulations however provide direction for implementation processes through the selection of implementing institutions and defining legal and financial resources. Potential veto points and incentives for compliance also affect implementation success. For carbon emission reduction linked to smart meters in households, this includes energy, market structures as well as data privacy and emission regulation. Ekhardt and Wieding (2016) in particular urge research into nudges coming from industry and marketing that might contradict the governmental policy goals. In a comparative set-up of EU countries that are implementing smart meters, the analysis focuses on those with incentive-based regulatory frameworks for energy providers and further takes into account the innovation and incentive structures for innovation and consumption data in combination with market characteristics. Following this line of thought, the paper explores the question of *how national instrument mixes affect the implementation of green nudges by private stakeholders*.

The paper is structured as follows. Section 2 gives an overview over the policy instrument literature in combination the idea of nudging. Section 3 looks at the multi-level context and how the theoretical concepts translate into factors in the regulatory and market structure of EU Member States as well as the activities of energy providers. This section further defines these factors and looks at variations of regulatory frameworks, innovation stimuli and the energy market in Europe. The analysis in section 4 looks at five cases from the pool of countries with incentive-based systems, three with favorable regulatory and market structures, Austria, Ireland and the UK and two with unfavorable conditions, France and Romania. The final section 5 concludes the paper.

2. THEORY

2.1. Policy Instruments

Policy instruments are the means with which decision-makers implement policies. Scholars offer a wide range of schemes to classify these tools. Hood (1986) developed the so-called NATO model, which divides policy instruments into the categories of nodality, authority, treasure and organization. Nodality refers to instruments connected to the central position of government giving access to information. Authority includes command-and-control tools, while treasure is an overarching category for any grants, loans or taxes. Organization refers to the formal organizations providing goods and services (Howlett et al. 2009). Another classification is the three-fold typology of 'sticks, carrots and sermons', which can be translated into regulatory instruments, economic and financial instruments, and soft instruments (Borrás and Edquist 2013). This idea is very similar to the NATO model except that nodality and organization are folded into the soft instruments category. Howlett (2011) groups these tools into substantive and procedural instruments. Substantive policy instruments directly affect the production, distribution and consumption of goods and services, while procedural tools focus on altering behaviour (Ostrom 1986; Howlett 2011). Whereas substantive instruments are directly involved in, for example, regulating the quality of goods and services, procedural tools indirectly affect the behavior of actors involved in implementation.

More recently, alternative models have been developed that take into account both the complexity of the policy problem being addressed, and the ways in which government is challenged to balance governance and government when choosing and applying policy instruments. The emphasis is on the constraints of policy instruments when thinking about different policy-making levels and a variety of policy objectives. Capano et al. (2015) focus on the selection of policy tools and the governmental specification of the goals. They offer four types of governance modes, which include: first, a hierarchical mode, where there is direct government involvement in outputs and outcomes; second, a procedural or regulated market mode with detailed national regulation; third, a steering from the distance; and finally, a self-governance mode. For the latter, government is a shadow stakeholder, involved through participation, persuasion, negotiation and partnership. The 'steering from a distance' or subsidized market model includes priority setting incentives, regulated competition as well as benchmarking and soft regulation (Capano et al. 2015).

In the environmental policy context, regulatory instruments define many aspects of policy implementation. In fact, despite the hype of 'new modes of governance' (Eberlein and Kerwer 2004), regulation remains the most widely used instrument for sustainability goals. This does not exclude the use of other, softer types of instruments, however the legislative framework set by the EU and further refined by Member States remains. This is because regulations support the use of other policy instruments and define the framework in which actions are carried out by both stakeholders, such as companies, as well as individuals. Whereas more flexible instruments, such as market-based tools, address the gaps or emerging issues that are not covered by existing regulation, EU legislation remains the dominant driver of national environmental policy and thus national instrument selection (Jordan et al. 2005).

2.2. Regulatory Instrument Mixes

In the energy policy domain, regulatory instruments largely target energy providers rather than consumers due to the expected time lag in behavioral changes by consumers and the influence of companies on energy usage through, for example, the selling of appliances or the installation of smart meters. In addition, regulations directly aimed at consumers receive less public acceptance and require enforcement and monitoring efforts. Hence, government largely employs indirect measures from a consumer perspective that pre-empt certain behavior and operate on 'one-size-fits-all' basis. Injunction tools are an example of regulatory instruments that target citizens. They are mandatory and require consumers to comply. An example for an injunction is the ban of environmentally harmful products, such as incandescent light bulbs or the prohibition of pouring dangerous liquids into the household waste stream (Sonigo et al. 2012).

Those regulatory instruments targeting private stakeholders can have different characteristics, such as efficiency, flexibility, stringency, differentiation, phasing, enforcement, uncertainty in combination with the market environment (Taylor et al. 2005). Thereby, uncertainty can lead to over-compliance, because the combination of uncertainty and increased threat of punitive measures leads companies to pre-empt government enforcement (Haines and Gurney 2003). However, uncertainty connected to, for example, innovation can also hinder firm compliance in that streamlining of technological elements is unclear and might lead to poor investment decisions (Heiskanen et al. 2015). This is in junction with the market environment that companies experience in particular countries. A company could decide that the potential market benefits in taking a proactive stance outweigh the policy uncertainties (Cashore and Vertinsky 2000). In addition, regulatory instruments use legal elements of social and market interactions to define the frameworks of interactions among actors (Borras and Edquist 2013). Regulatory actions include: 'creating (and destroying) demand for various technologies through regulation; conducting and supporting R&D activities in support of environmental goals; promoting technologies through subsidy; and facilitating knowledge transfer between government, regulated firms, and outside environmental equipment suppliers through everything from the patent system to industry-specific conferences, publications, and collaborations' (Taylor et al. 2005, 348-9).

Those instruments can move along a spectrum of mandatory, command and control type tools to more voluntary or flexible initiatives and a combination of both (Sarkar 2008). At a more general level, there are different accounts regarding which end of the spectrum is more successful. For technological developments, research predominantly cites self-regulation and flexibility in compliance as a driver for innovation (Cashore and Vertinsky 2000). At the same time, the regulation should be stringent and certain, since innovation is connected to investment decisions that rely on the regulatory framework remaining the same or similar over a certain amount of time (Taylor et al. 2005). For environmental regulation, the findings show that policy instruments should mimic the 'free market', since environmental problems are seen as unregulated externalities for which government has to create the missing markets or give an alternative incentive to comply (Reinhardt 1999). Taken together, these different dynamics that play out in both the environmental and the innovation sphere can lead to a policy instrument mix that might be incoherent and prohibit one or the other, or both, resulting in the policy goal not being met.

Borras and Equist (2013) further distinguish between direct and indirect regulatory instruments, whereas a direct relationship refers to regulations which are designed with the explicit purpose of positively affecting innovative activities. Indirect regulatory instruments restrict certain activities to ultimately foster innovation. Along the same lines, Bergek and Berggren (2014) argue that there are technology-specific and more general instruments. The distinction between the two lies in the advancement of the technology:

> General policy instruments mainly benefit already commercially available technologies, whereas technology-specific policies, such as R&D, demonstration, niche market creation, network support and standard setting, are needed to stimulate the various product and process innovations that eventually can make immature technologies available for selection within the frame of more general policy instruments. (Bergek and Berggren 2014, 114)

While these instruments can be chosen individually, they often are combined in mixes, which raises questions of synergetic or contrasting effects of instruments among each other (Flanagan et al. 2011). In addition to the complexity arising from the interaction of different policy instruments among each other and regulatory instruments affecting the market, research also finds that they are chosen on an ad-hoc basis. This implies that the underlying problem might have not been properly identified and the interaction among instruments has not been fully explored (Borras and Edquist 2013).

Due to the complexity and uncertainty of environmental issues, conventional policy instruments are part of a much richer mixed strategy. In the set of 'new' instruments policymakers can use to facilitate implementation of policies, 'nudging' is one. It is largely seen as an alternative to 'command and control' type regulation and a categorized as a 'soft' policy tool targeting consumers directly (Oliver 2013; Baldwin 2014). Policymakers are using this soft policy instrument to avoid some of the gridlock of more traditional instruments. The idea is to bypass some of the hurdles posed by existing structures and regulations. In addition, the argument is that command-and-control type instruments demand uniform behavior of those being targeted by the policy and that nudging offers more flexibility in tailoring the approach towards individual behavior. As the following section will show, this is a very simplified notion of nudging, as nudging itself comprises different tools and interacts with existing policy instruments in various ways. More recent research identifies nudges as a complement to traditional policy instruments rather than a substitute or alternative for regulatory tools (Lehner et al. 2016).

2.3. Nudging as a policy tool

Nudging is based on the basic premise of voluntary changing individual behavior by targeting citizens' perceptions, preferences and abilities (Abrahamse et al. 2005). A nudge is

> any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not mandates. Putting the fruit at eye level counts as a nudge. Banning junk food does not. (Thaler and Sunstein 2008, 6)

Aiming to change citizen behavior stems from developments in behavioral economics and psychology (Titmuss 1971; Frey 1997; Le Grand 2006). By introducing incentives, the goal is to change individual behavior to be more altruistic (Thaler and Sunstein 2008). The research linked to nudging focuses on questions, such as how people make decisions and under which circumstances they deviate from this behavior. 'These deviations are behavioral economic phenomena, and can be considered as a box of tools for policymakers to use on a case by case basis to attempt to improve the effectiveness of their policy interventions' (Oliver 2015, 700).

Nudging comprises four different types of tools: 1) simplification and framing of information; 2) changes to the physical environment; 3) changes to the default policy; and 4) the use of social norms (Mont et al. 2014).

Information provision is a prominent tool in promoting sustainable consumption. In the wake of bounded rationality and the finding that people are subject to behavioral biases, more targeted information tools developed, such as the distinction between feedback and information (Lehner et al. 2016). Information can be defined as more generally increasing knowledge and awareness. Feedback on the other hand, is a measure after certain behavior has taken place. 'The idea is that through feedback, occupants learn to connect their actions/ behavior with the resulting energy consumption, put what they learn into practice and eventually develop a routine that leads to lower energy use' (Chiang et al. 2012, 472). More practically speaking, this entails, for example, informative energy bills, metering and displays.

Changes to the physical environment, the second nudge tool, include designing people's environment with intent, such as homes or appliances. Research suggests that 'especially in low involvement decision-making situations individuals are likely to allow the physical environment to influence their choices, as for example in the retail store where people make daily purchases' (Mont et al. 2014, 25).

Third, defaults refer to the results that occur when no action is taken. A widely cited example in this context is that of organ donation and the difference between opting in and opting out of such a program. Participation is much higher in countries where citizens have to actively opt out of the program rather than opt in (Johnson and Goldstein 2003). Similar results apply to pension plans (Cronqvist and Thaler 2004). This is also a popular option for private stakeholders where individuals are signed up for, for example, subscription models. Thaler and Sunstein (2008) argue that for this variation of nudging specifically, government needs to carefully design default options before companies do (Mont et al. 2014).

Finally, the use of social norms is another tool grouped under the idea of nudging. There is a distinction between descriptive norms, which are norms that we observe others adhering to, and injunctive norms that are moral implications for behavior. 'In any given choice situation whatever norm is most present in the individual's mind (i.e. most salient), will have the greatest impact on the behavioral outcomes' (Mont et al. 2014, 28).

Table 1 summarizes these four nudging tools together with regulatory and fiscal measures. One distinction relevant for the case of smart meters is that of the provision of information and the simplification and/or framing of information. This touches upon the difference between information and feedback earlier, since information alone is not enough to change behaviors.

Regulation of the individual	**Fiscal measures directed at the individual**		**Non-regulatory and non-fiscal measures with relation to the individual**				
Eliminate and restrict choice	*Guide and enable choice*						
	Incentives and information			Nudging			
Laws and regulations	Fiscal incentives	Non-fiscal incentives	Provision of information	Simplification and framing of information	Changes to physical environment	Changes to the default policy	Use of social norms

Table 1. Policy tools to influence individual behavior (based on House of Lords 2011).

Recent research raises more critical aspects of nudging. Critics point towards the limited long-term effect of behavioral changes and environmental factors that impact the choices individuals make (Hallsworth and Sanders 2016), as well as the lack of discussion around the political context in which claims about behavioral techniques are made (Shove 2010; Southerton et al. 2004; Lehner et al. 2016). In addition, the assumption underlying the nudge idea is rather simple, but the implementation of nudges requires attention to detail. For example, several evaluating studies find that feedback linked to energy consumption in households is most effective when it is frequent, involves interaction and choice as well as includes a breakdown of consumption by appliances (Delmas et al. 2013). Ekhardt and Wieding (2016) urge to look at nudges coming from industry and how they potentially counteract governmental goals in the environmental policy domain. These so-called 'counternudges', can 'persuade people to choose in a way that confounds the efforts of choice architects' (Sunstein 2016, 1). In some cases, government relies on private stakeholders to deliver the nudge tools, which creates a complex situation in which government needs to incentivize companies to nudge citizens.

Oliver (2013) calls this 'budging', where the idea of nudging is combined with the tools of regulation by counteracting efforts of private sector manipulation (Oliver 2013; 2015). Private entities might have weak incentives to carry out the nudge and are further restricted by systemic and organizational constraints (Weaver 2015). The nuance between nudging and budging is relevant to policy implementation, because the nudge premise makes assumptions about individual behavior that are based on government nudges – without the intervention and potential disruption by implementers. In short, nudging looks at the direct link between government and the individual, the reality however shows that there are implementing agents that also impact the choice architecture (Baldwin 2014). Focusing on private entities, companies compensate for nudges that might potentially harm their economic interests and might thus move individuals in their preferred direction, rather than the policy goal (Sunstein 2016).

For nudging to reach sustainable policy goals, there is a nested set-up of mechanisms that government relies on to reach sustainability goals. First, for citizens to change their behavior, they require information that would lead to such as change. This feedback mechanism however only works if the companies provide the services with built-in feedback mechanisms. The company behavior is, in a second step, influenced by the regulatory and market mechanisms. The regulatory framework thus indirectly affects the effectiveness of the nudge by involving numerous stakeholders, potentially with veto powers, and offering incentives for type and speed of implementation (Sibony and Alemanno 2015; Abdukadirov 2016).

2.4. Summary

The literature shows that policy mixes in the environmental policy domain are dominated by regulatory tools targeting companies; they do however increasingly include nudging as an opportunity to shape individual behavior. For nudges to reach consumers, government needs a facilitating regulatory and market environment in order for companies to support energy reduction goals. This two-step process of 'budging' and 'nudging' is currently underdeveloped and draws attention to the combination of regulatory and non-regulatory policy instruments. Based on this, the following propositions apply:

- The mix of regulatory government instruments affects company behavior in the context of green nudging;
- Companies are able to weaken or undo nudging effects if their economic interests run counter to the policy goal.

The question that follows from this is: *How do national instrument mixes affect the implementation of green nudges by private stakeholders?*

3. DATA AND METHOD

This research question is explored based on the example of European smart meter implementation. European and national regulation and market characteristics have proven to be driving factors in smart grid investments and updating consumer technology. Whereas the European regulatory framework remains the same for all Member State, national regulation varies on these important dimensions:

- Regulatory instruments for DSOs (incentive-based/cost-based/hybrid)
- Incentive structure for showing actual consumption (yes/no)
- Energy market structure (distribution sector concentration)

These indicators are hypothesized to shape the investment and service provision by energy companies within member states:

- Investment level into smart grid/ smart meter development
- Service provision levels (number of smart meter functionalities)

For the analysis of smart meter nudging efforts, positive cases were selected in which smart meters are being implemented. This means from the total number of 27 EU member states, 15 fall into this category. The analysis only includes those countries with incentive-based regulatory frameworks for DSO, as this a major factor in having smart meter technology and smart meter services in the first place (Cambini et al. 2016). In this pool of cases (11), the existence of innovation and smart meter incentives is identified. For the behavior of DSOs, the level of investment according to the country's GDP and the number of smart meter functionalities is included. Finally, the DSO behavior presumably leads to varying levels of household consumption and, over time, to a reduction of electricity consumption at household level (Eurostat 2013). Testing this relationship however goes beyond the scope of this paper.

3.1. European and Member State Instruments

At European level, Directive 2009/28/EC on renewables and Directive 2003/87/EC on the EU Emissions Trading System (ETS) establish the framework for the energy market and energy reduction goals. In this framework, smart meter technology in households is seen as one solution to addressing high energy use (EC 2012). A 'smart metering system' or 'intelligent metering system' is defined by the EU Directive 2012/27 as 'an electronic system that can measure energy consumption, providing more information than a conventional meter, and can transmit and receive data using a form of electronic communication' (EU 2012, 11). By showing the consumer real-time consumption and pricing information in combination with variations in feedback delivery and device design, the expectation is that more efficient devices are bought, used less and during off-peak times (Torriti 2012). The smart meters pose a crucial step towards the implementation of Smart Grids (SG) and are often funded and handled within the larger goal of digitizing the grid. Households are thereby an important target group, because they make up a considerable share of national GHG emissions (Abrahamse et al. 2005; Michalek et al. 2016).

Since the smart meter technology needs to be developed and implemented by Distribution System Operators (DSOs) and energy providers, this goal is coupled with policy instruments, like financial incentives at member state level. DSOs are regulated entities that carry the costs of this development through regulated revenues and are expected to balance the benefits from SG investments with their capital costs (Cambini et al. 2016). DSO are also expected to have a reduction of operational costs once meter readings, power theft, remote detection of power outages and the like have been eliminated based on smart grid and smart meter technology. DSOs and energy providers are the link between the energy consumption reduction and the consumer by developing the commercial solutions. This has led to some national legislation becoming more innovation-friendly, but, according to DSOs, not friendly enough as many smart grid demonstration and R&D projects are treated as any other costs and not incentivized sufficiently (Cambini et al. 2016). The regulatory set-up in which DSOs and energy providers operate can be categorized into three models: First, incentive-based models, where pricing decisions are made at firm level and profit comes from cost reduction (Vogelsang 2002). This includes regulatory models, such as revenue caps or profit sharing. This type of regulation is widely used by EU member states. Second, cost-based models, where prices are kept close to realized costs and therefore provide a weak incentive for investments (Cambini et al. 2016). Third, a hybrid of both types, which often is a cost-based approach in principle while also offering incentive-based measures in connection to operating expenditures.

Each member state also has different energy market conditions. While generally speaking, the EU energy market unbundling regime has increased competition in markets, market structures per country differ depending on the market share of the largest electricity generator and the number of electricity providers active in the retail electricity market (ACER 2014). Studies find that the more the market is penetrated, the higher the urge to make the energy network 'smart', leading to higher investments (Lopes Ferreira et al. 2011; Cambini et al. 2016). Also relevant, according to Ruester et al. (2014) is the size of DSOs. The smaller they are, the easier it is for them to jointly invest into a technical infrastructure. Cambini et al. (2016) also emphasize that markets low in concentration generally invest more than the ones with medium or highly concentrated ones.

3.2. National Instrument Mixes

The regulatory factors include the regulatory mechanism for DSOS, so whether there is an incentive-, cost-based or hybrid regulatory model. Cambini et al. (2016) find that incentive-based regulation promotes SG investments more effectively than cost-based regulation or a hybrid of both. Another factor is whether there is an innovation-stimulus mechanism. EU countries have implemented different models, such as a regulatory weighted average cost of capital (WACC), which offers a higher rate of returns for providers or the adjustment of revenues by providing extra allowance. In addition, there are dedicated mechanisms for supporting innovation within energy distribution systems targeting smart grid technology. Through an incentive structure for showing actual consumption, for example, governments can facilitate a more detailed level of granularity in data collection. This can ultimately be translated into showing real-time consumption to consumers. A number of countries promote such a regulation, for example Denmark, Finland, Ireland, Italy, the Netherlands as well as Sweden and the UK.

The market conditions further determine some of the financial decisions that DSOs make and could support smart meter development down the line. For this aspect, it is relevant how big the market is and what share individual companies have as to assess the competition and the pressure to innovate. For example, the French power markets is highly concentrated and dominated by EDF, the incumbent utility. Even though market liberalization began in 1999, EDF is still the main player. Reliance on this dominant player for implementing smart grid and smart meter technology might slow down the process, as there is limited competition to facilitate the process. In comparison, countries like Denmark or Italy record a lower market share for the largest electricity generator, which means the number of providers goes up and increases competition. Cambini et al. (2016) predict that less concentrated markets lead to investment-incentives for the implementation of smart grid (pilots). Thereby 'high'concentration is defined as one distribution system or DSO having all the distributed power. Those countries with 'medium' concentration have one dominant DSO serving about 80 percent of the market or the three largest DSOs serve more than 60 percent. Those categorized as 'low', are those countries where the largest DSOs deliver about 50 percent of the power.

3.3. DSO and Energy provider behavior

The behavior of DSOs and energy providers can be portrayed as the level of investment into the smart grid and the functionalities provided by the smart meter. Because smart meters are both the first step in building the smart grid and a cornerstone in developing it further, the investment into the larger idea of smart grids directly benefits and starts with smart meters (Erlinghagen et al. 2015; Zhou and Brown 2017). For the investment, Table 2 shows normalized data based on the amount of investment in relation to GDP. The numbers are based on Cambini et al. (2016) who normalized country investment data by dividing them by the respective GDP. This accounts for socioeconomic inequalities among countries. The numbers thereby account for a time span of 5 years (2008-2013). Generally, the transformation of the energy system towards a smart grid requires significant investment and is also a hurdle towards implementing smart meters on a large scale.

The functionalities are based on the European Commission recommendation to:

- Provide readings directly to the customer and any third party designated by the consumer;
- Update the readings…frequently enough to allow the information to be used to achieve energy savings;
- Allow remote reading of meters by the operator;
- Provide two-way communication between the smart metering system and external networks for maintenance and control of the metering system;
- Allow readings to be taken frequently enough for the information to be used for network planning. (EC Directive 2012/148/EU)

For smart meters to be effective in changing consumer behavior, the smart meter technology has to be connected to a standardized interface to enable timely and accurate energy consumption patterns to be relayed to the consumer (EC 2012). These recommendations translate into the following functionalities:

- An alarm alerting the customer of exceptional energy use;
- An open gateway through which the customer can access and control their consumption;
- A remote upgrade capability
- The capability to measure injected as well as consumed energy;
- The capability to receive immediate information on non-notified energy interruptions at the connection point.

These elements link up to the European recommendations by emphasizing specific functions. For example, the alarm for alerting consumers of exceptional energy use is meant to reduce energy consumption during peak times of the day or year. The open gateway is a way for the consumer to access and control the data showing consumption with again the goal of reducing consumption by raising awareness. The remote upgrade capability is relevant for both consumers and providers as this allows energy companies to update, for example the software from a remote location and with that provide more detailed energy consumption analytics. The last two functionalities have to do with the data collection and connected to that the ability to visualize consumed energy and react to energy interruptions.

Table 2 summarizes these varying factors for those Member States with incentive-based regulatory mechanisms.

EU Member States *(with incentive-based regulatory mechanism)*	**Innovation-stimulus Mechanism** *(Cambini et al. 2016)*	**Incentive Structure for showing actual consumption** *(CEERE 2013)*	**Distribution-sector concentration** *(Cambini et al. 2016)*	**DSO Investment into the smart grid** (Investment Euro/of GDP) *(Cambini et al. 2016)*	**Smart meter functionality** *(CEERE 2013)*
Austria	Adj. Rev.	no	low	193.80	2/5
Germany	none	yes	low	109.19	1/5
France	none	no	medium	191.15	3/5
Ireland	Adj. Rev.	yes	high	88.99	3/5
Luxembourg	none	no	medium	68.33	3/5
Netherlands	none	yes	medium	155.37	5/5
Romania	none	no	medium	27.55	0/5
Spain	none	no	low	N/A	2/5
Slovakia	none	N/A	medium	68.75	N/A
Sweden	none	yes	low	234.89	0/5
United Kingdom[1]	Adj. Rev.	yes	medium	203.18	5/5

Table 2. Factors of smart meter and smart grid implementation and DSO investment and service provision.

4. DISCUSSION

4.1. Austria, Ireland and the UK

Looking at the EU Member States that have an innovation stimulus, Austria, Ireland and the UK stand out. The three countries have revenue adjustment as innovation stimulus, which provides additional allowances to energy providers. Both Ireland and the UK furthermore have an incentive structure for showing actual energy consumption. The distribution in the energy sector varies, whereas Austria and the UK have low and a medium level respectively, Ireland has a high concentration. For the DSO investment, UK and

[1] In a 2016 referendum, the UK decided to leave the European Union and the process was started in March 2017. The exact conditions are currently being negotiated and the effects on energy regulation are pending.

Austria have some of the highest investment levels, along with Sweden, France and the Netherlands. Ireland on the other hand, has quite low investment levels.

In April 2012, the Austrian Federal Ministry of Economics, Health and Youth decided that DSOs have to implement smart meters gradually from 10 percent in 2015 up to 95 percent in 2020. A more recent assessment however shows that this goal will not be reached and the estimate of smart meter implementation is at around 70 percent for that timeframe. Currently, around 456.000 smart meters are installed (USmart Consumer 2016). In addition, the Austrian energy regulator published a decree on data format and the form of consumption information, which includes that the 'system operator has to provide customers equipped with smart meter access to an internet portal which, among others, displays their actual and historic electricity consumption data and load patterns' (E-control 2012; Schleich et al. 2013, 1098). The portal also has to show information on electricity savings measures and energy providers are tasked with offering monthly information on customers' electricity consumption and costs. However, utilities had to postpone their installation awaiting more detailed federal regulation (Schleich et al. 2013). To stimulate smart meter development and implementation, the Austrian energy regulator (E-control) introduced a cost-based element in the incentive-based system (Cambini et al. 2016). Energy providers further point towards the importance of application-oriented R&D funding as an important source for boosting competition (USmart Consumer 2016). Another relevant factor is the introduction of an 'opt in' system by government. This means that customers have the possibility to opt out, which requires the smart meter to have different functionalities. Such additions can delay service provision, because this kind of flexibility can slow down technology deployment (Zhou and Brown 2017).

Ireland is in phase three of smart meter implementation. This means that analysis, engagement and consultation processes have been concluded and the Commission for Energy Regulation (CER) has made decisions on data storage and minimum functionalities. In 2011, the Commission for Energy Regulation (CER) put in place an extra-allowance mechanism for incentivizing DSOs to undertake research and development activities (Cambini et al. 2016). The functionalities of smart meters include that data will be stored with the supplier and real time consumption data is available to consumers. In addition, 'minimum information requirements for customers will be provided through three channels: mandatory In Home Displays (IHD) for real time consumption data, smart bill and 'harmonized downloadable file' with historic information which the consumer can analyze or share' (USmart Consumer 2016, 20). To attract more customers, energy providers offer a 'smart pay-as-you-go' system, which allows citizens to pay electricity bills through the smart meter. In January 2017 however, the Irish Commission for Energy Regulation delayed implementation to late 2018, due to procurement issues with utility firms. Specifically, Irish utilities were delayed in issuing tenders for smart meter development, because interoperability of meters with the country's smart meter standards were unresolved (Edwards 2017). This also means that there have not been major investments by DSOs towards the smart grid and service provision connected to it fulfils minimal requirements only where pilots have happened.

In the UK, suppliers installed more than 540,000 meters. This adds up to 2.75m smart meters installed in British homes (5.8 percent of all domestic meters) operated by large energy suppliers (Farrell 2016; DECC 2016). The roll-out is supplier-led where the suppliers are free to plan their own installation strategy (DECC 2016). The government put in place requirements for those meters to qualify as 'smart'. Companies have to comply with this Smart Meter Equipment Technical Specification (SMETS), which requires smart meters to have the ability to transmit readings to energy suppliers and receive data remotely. However, due to the roll out being led by energy companies, some have rolled out smart-type meters early without complying with the SMETS standard (DECC 2016). This means that some customers will have to replace their meters in the coming four years. For the most recent plan, this issue has been addressed and there is one operating system for all smart meter technology (Palmer 2015). Both, the meters without the correct smart technology and the discrepancies in software led however to additional reluctance among companies to offer smart meters and for citizens to adopt the technology. In short, a supplier-financed competitive roll-out model led to companies having to potentially pay for the installation and distribution of meters twice. The services connected to the rollout include In Home Displays that communicate with smart meter hubs for real time and historic consumption data. The output from this data differs depending on the energy provider (USmart Consumer 2016). The required updating of smart meters and the financial burden being placed with the energy providers explains the high levels of investments by DSOs. The competitive nature of the implementation facilitates the service provision, where the functionality of the meter is used to advertise to consumers. Additionally, competition between metering service providers can potentially reduce metering costs and in turn facilitate both deployment and service provision (Zhou and Brown 2017).

4.2. France and Romania

Looking at a case where the regulatory and investment structure is set-up in an unfavorable way, such as France, there is no innovation stimulus or incentive structure for showing actual consumption and the distribution sector concentration is medium. However, the investments by DSOs are high and three out of five smart meter functionalities are provided. These largely include consumer information provision and feedback, such as online consumption historic data comparison, thresholds, and SMS notifications on consumption. These services pertain to a pilot done in 300.000 rural and urban households in order to have a full roll-out by 2018. The smart meters and the attached costs were provided by Enedis (previously ERDF), an energy provider who is tasked with smart meter implementation by French regulators together with major international providers. The pilot also gave suppliers the opportunity to test production, warehousing, distribution and installation logistics as well as data collection and collating. Hence, costs can be predicted better and a favorable cost-benefit analysis based on this pilot further facilitates smart meter roll-out. The National Energy Agency indicates that 4,5 -11 percent in energy savings can be reached if specific information based on real-time consumption is provided to consumers (USmart Consumer 2016).

Another country with an unfavorable set-up is Romania, where, similar to France, no incentive structure exists and the distribution sector concentration is also medium. In this Member State, investments by energy companies are low and there are no smart meter services offered at the moment. This can be linked to the limited legal and regulatory framework, which leads to delayed implementation by DSOs (USmart Consumer 2016). There are currently no minimum functionalities defined in the legal framework. For the implementation, Romania is using the expertise of the Italian smart meter instalments. In 2016, the Italian National Regulatory Authority for Energy (ANRE) gave permission for the energy provider Enel to install 110,000 smart meters in Romania as part of a pilot project. Enel controls 1/3 of the distribution market and has the grid capacity to scale this up to potentially 2.7 million meters (BR 2016). Due to the limited involvement of Romanian providers and the early stages of the implementation, there are no significant investments or services.

4.3. Summary

Taken together, there are some common elements emerging from these cases. Most countries have specific regulatory instruments for smart meters, both for the minimal functionalities as well as their implementation. However, more detailed, legal elements often intervene with full service provision linked to such as rollout. First, without detailed definition of standards and technical details, DSOs may use different communication solutions and protocols, which might lock them into suboptimal technologies and limit economies of scale. Energy providers might also postpone investments to fund the smart meter technology at a later point in time when it is further developed. Especially the definition of standards is important, because it allows providers in a monopoly market to aim for advance metering before other companies move in (Zhou and Brown 2017). These technical requirements in combination with market structure are something that both Ireland and the UK have been struggling with. Second, most countries start out with a pilot or test period before a full rollout. This has been confirmed as a facilitating factor in other studies, because technology and data communication structures can be tested, as was done in France. However, the size of the pilot matters, because if it is too small compared to a full rollout, the scaling of the meters and the software might not be feasible, while test sites that are too large require too much upfront investment from which other providers might benefit in the long run or some aspects need to be outsourced, which delays service provision (Erlinghagen et al. 2015).

Considerably, these aspects relate directly to the fit between regulatory, market and incentive structures. Hereby, the service dimension of smart meters is key to delivering effective nudges, it is however treated as an addition and thus not targeted through public incentives. The provider actions are largely driven by market and cost structures, which can be influenced by government through defining mandates for DOS and providing incentives based on ownership. Some countries are now in the process of defining these aspects. For the mix of regulatory and non-regulatory instruments, there are two opposing dynamics that stand out. First, European governments have regulatory instruments in order to urge companies to nudge citizens through energy consumption feedback, however to collect the information necessary to generate feedback, privacy laws and data storage regulations have to be aligned with green nudging. This is something that not only takes time, but one might also undermine the other. If smart meters with certain data architectures are offered and government regulation is changed, private stakeholders might be unwilling to advance their services due to retrofitting. Privacy regulations limit certain smart meter functionalities from the get-go due to partial storage and analysis of consumption data. In the same line of thought, the timing of combining these instruments plays a role. If the combination of regulatory tools is not fully developed for the smart meter context, it might restrict the effects of nudging.

5. CONCLUDING REMARKS

Addressing the recent rise and ineffectiveness of 'green nudges', the paper focuses on the role of implementation agents that carry out the nudges. The case of European smart meter implementation is an example for nudging expectations not being met and the challenges connected to regulatory and market conditions within Member States that in turn shape the behavior of energy providers even before individual consumption behavior can be altered through the smart meter services. Based on policy instrument theory in combination with the underlying behavioral concepts of nudging and budging, the paper asks how national instrument mixes affect the implementation of green nudges by private stakeholders? Dimensions that are relevant to this exploratory question include the regulatory framework more generally, such as incentive-based, cost-based or a hybrid of both, whether the country has an innovation stimulus for developing smart meter technology and the energy market structure linked to high, medium or low market distribution concentration. For energy provider behavior, the investment into the smart grid and thereby smart meter development is relevant paired with the number of smart meter functionalities that are offered based on European Commission recommendations.

Identifying these factors for EU Member States that are implementing smart meters and have an incentive-based structure, the analysis looks at five cases from the pool of countries with incentive-based systems, three with favorable regulatory and market structures, Austria, Ireland and the UK and two with unfavorable conditions, France and Romania. Through the lens of policy instrument mixes, basic regulatory structures are in place for smart meters, but the sensitivity towards the interplay of technical development, both R&D and innovation, consumer rights and privacy as well as market dynamics is not fully reflected in the different government strategies. In other words, the behavior by companies based on the regulation and market structures is not fully integrated into the initial green nudging plans. This applies specifically to the relationship between regulation and market and/or technology. Several of the cases point towards delayed implementation and limited functionalities of smart meters due to uncertain rules or standards.

To conclude, the analysis here gives a prominent role to mix of regulatory instruments with green nudges. This is merely a starting point for linking the idea of green nudges to reducing the environmental impact of human behavior and the regulations set by government. More detailed research is needed to further define the characteristics of regulatory set-ups that promote energy provider behavior in line with the policy goal of reducing energy consumption. The paper makes the argument of including the behavior of implementing agents and with that implementation barriers and facilitators into the research on nudging to contribute to the question of why they fail and which regulatory conditions might enhance them.

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