Understanding the Co-Evolution of Electricity Markets and Regulation

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Abstract

Electricity markets are complex; they involve long-lead times, include feedbacks that are generally hard to interpret and should consider environmental and policy concerns. In addition to this complexity, after liberalization, the markets moved from monopolies with a single service provider to competitive markets with multiple service providers. Foreseeing the consequences of regulatory decisions is thus becoming increasingly complicated for the regulator. However, understanding these consequences is central to avoid the mismatch between the regulations and the markets since such mismatches can create unanticipated and costly long-term results.

In this paper we aim to provide a behavioural regulatory framework to help understanding how electricity markets and their regulation can successfully coevolution. We first discuss six behavioural elements that play a role in this context. Next we identify five stages of market evolution and discuss the regulatory challenges faced at each stage, linking these to the behavioural elements. We then discuss several examples of regulatory failures in the light of this framework. We conclude with a general discussion of how this framework can contribute to addressing the challenges involved in regulating electricity markets.

Keywords: Electricity markets, deregulation, behaviour

1. Introduction

The move towards a market in electricity over the last thirty years has significantly changed the nature of regulation that is applied in the electricity sector. Where previously regulation was centred on regulating a monopoly, a task that in this context is relatively structured although not always simple, the regulation of markets in electricity is, paradoxically, much more complicated and complex. Whereas the regulation of most other "free" markets requires only occasional intervention, the regulation of electricity markets has needed constant attention of, in most cases, a designated regulator (Hunt, 2002). Rules have been tailored to the national conditions, and have often needed to be amended and in some cases almost completely re-structured. The need for these continuous regulatory changes has been due to the, in some cases relatively fast, development and maturing of electricity markets, imperfect initial designs, changes in technology, as well as behavioural changes by the various stakeholders (consumers, generators, distributors and policy makers).

While some network industries, including electricity, telecom and rail, had an initial private phase (Parker, 1999), they were soon considered and treated as natural monopolies. When they became public-owned or licenced, they were regulated as monopolies. Depending on the stage of development, regulation was focussed on issues such as providing the necessary coverage, ensuring sufficient capacity, affordable prices, etc. (Hunt, 2002). In the seventies and eighties this natural monopoly status started to be questioned. In particular, the issue arose whether at least some of these utilities could operate more efficiently in a market-based setting. This led to the creation of competition in the telecom (e.g., Thatcher, 2004) and electricity sectors. In the electricity sector, the first mover was Chile in the eighties (Watts & Ariztía, 2002), followed by Norway and England and Wales (Bye & Hope, 2005; Green, 1998). Thereafter the situation evolved quickly, with an increasing number of countries moving towards liberalisation, and the EU mandating competition in 2000 (Jamasb & Pollitt,

2005). In what follows we focus on the electricity sector, but many of the arguments apply equally well to other network industries.

The process of deregulation of the electricity industry was initiated for different reasons in different jurisdictions. The main reason in Europe was a belief that the industry could be more efficient; competition should thus lead to lower electricity prices, making Europe more competitive. Another, more political, argument was used in, among others, England and Wales: state-involvement should be as limited as possible. In developing countries, it was often the lack of resources to finance the expansion of the industry that made deregulation necessary (Dyner & Larsen, 2001). Consequently, the initial conditions faced by countries starting the deregulation process varied widely in many respects. Examples include, but are not limited to, coverage (e.g., about 35 percent in Nigeria (Adenikinju, 2005), comparted to close to or 100% in most Western European countries), technology (e.g., Norway has close to 100% hydro ("Energy and manufacturing," 2017) while Denmark has none), and reserve margin (e.g., England and Wales had 24% in 1990 (Bunn & Larsen, 1992), while Colombia had major blackouts before starting to deregulate in 1995 (Larsen et al., 2004).

Due to the large diversity in starting points for deregulation it is impossible to believe that one model could have been ideal across all jurisdictions. However, the purpose of the regulation was similar across all markets: create a sustainable system that guarantees an adequate level of supply to all parts of the nation, at the lowest possible cost, resulting in affordable prices for the end-users. But, as events since the beginning of electricity deregulation tell us, this has far from always been the case. There have been, and still are, many failures, as markets continue to evolve. These market failures, due to regulator problems, deserve attention as they often result in undesirable situations which create embarrassment for the regulatory authorities and policy makers (Larsen et al., 2004) and cannot be resolved overnight; fixing the problems is difficult, costly and takes a long time. Failures in electricity markets can be

critical for the broader economy, since electricity is essential for industrialization: persistent blackouts, rationed electricity and unreliable supply have a direct influence on economic growth. The link between regulation and the market deserves attention to avoid undesirable outcomes and create a forward-looking, proactive regulation rather than a (lagged) reactive response to events.

Our focus here is on the characteristics of a regulatory model that can co-evolve with the market. The maturing of markets is a natural process, which results from interactions between the different market participants; regulation that lacks behind the evolution of the market is likely to create significant challenges for market participants, possibly endangering security of supply at the national level. We refer to this type of regulation as behavioural and will discuss the main components required to develop a forward-looking regulation.

The paper is structured as follows. After the literature review, we present six behavioural elements that affect electricity markets. Next we identify five stages of market evolution and discuss the regulatory challenges faced at each stage, linking these to the behavioural elements we discussed. We then discuss several examples of regulatory failures in the light of this framework. We conclude with a general discussion of how this framework can contribute to addressing the challenges involved in regulating electricity markets.

Next we outline the dimensions of a behavioural approach. We then discuss several examples, from which we derive a set of coherent insights for typical regulatory and market problems that occur at the different stages of the evolution of markets and regulation. Finally, we conclude with a discussion of the guidelines that a more behavioural and forward-looking regulation should follow.

2. Literature Review

Regulation of utilities has been an area of interest for several scholars across different

disciplines, including law (Demsetz, 1968) and economics (Stigler, 1971; Peltzman, 1976; Joskow & Rose, 1987). Researchers have focused on the regulation of monopolies (Posner, 1969), as well as on the liberalisation of utilities such as telecommunication, gas and electricity (Armstrong & Sappington, 2006).

Sectors such as electricity, gas, railways and telecommunications, where demand can be met at the lowest cost by a single firm are considered as natural monopolies (Parker, 1999). In such sectors, under the ideal circumstances where the regulator is fully informed about all the aspects of the market, competition is not expected to improve market effectiveness in terms of price and quality of the service (Armstrong & Sappington, 2006).

However, monopolies are often criticized because of their inefficiency (Demsetz, 1968; Winston, 1998). In the electricity context, Bye and Hope (2005) state that liberalization could address the shortcomings in terms of resource utilization and investment. Joskow (2008) adds that liberalization of electricity markets could provide competition that leads to lower prices and more innovation.

Since deregulation started in the nineties, the deregulation of electricity markets has been studied using a variety of approaches, including economic models (Stoft, 2002), simulation (Teufel et al., 2013), and policy analysis (Bunn & Larsen, 1992; Ochoa, 2007).

In many countries, deregulation of the electricity sector started in the wholesale markets (Woo, Lloyd, & Tishler, 2003). When restructuring their electricity markets, each country has had a different timeline and adopted different types of regulation. In the U.S., electricity industry was regulated under rate of return regulation, where utilities' earnings were regulated by a specified rate of return. This type of regulation is often criticized because it leads to overcapitalization (Knittel, 2002).

In the U.K., transmission and distribution of electricity remained regulated, while generation

was deregulated to increase competition and to allow entry into the market (Green & Newbery, 1992). The country introduced price-cap regulation, a new approach at that time (Dnes et al., 1998). This approach was chosen over rate-of-return regulation as it was expected to increase efficiency, as well as regulatory predictability and transparency. However, the price-cap mechanism resulted in incentives to reduce costs, which can lead to lower quality, as observed for instance in the context of telecommunications (Joskow, 1997).

When pursuing regulatory reform in electricity markets, regulators should not only ensure affordability of electricity for the consumers, they should also guarantee security of supply. In competitive electricity markets, underinvestment endangers capacity adequacy, forcing regulatory intervention. In theory, competitive market prices should induce new investments (Wolak, 2000). However, inelasticity of short-term demand, price volatility and unsuitable market rules might prevent prices from sending the right investment signals (Finon & Pignon, 2006). To ensure capacity adequacy, regulators have several policy mechanisms at their disposal, such as capacity payments, capacity obligations and centralised procurement for peak capacity (Finon, 2006). The appropriateness of these mechanisms for a specific market depends on several factors such as market characteristics, timeliness and interconnections. (De Vries, 2007). For instance, De Vries and Heijnen (2008) combine a system dynamics model with Monte-Carlo simulation to compare different mechanisms with respect to the resulting market stability and price volatility when the demand growth rate is uncertain. All the mechanisms they considered achieved a reduction of price volatility and of the risk of blackouts, without leading to higher prices. They also address the role of market power.

New entrants play an important role in the development of competitive electricity market. Long licensing processes (Woo, 2001) and uncertainty due to market reform (Woo et al., 2003) are barriers to entry that should be removed by appropriate policy interventions.

The characteristics of the market, such as technology mix and current market structure, as well as political aims should have a role in the choice of the nature and type of regulation. As markets go through a restructuring process, their policy framework needs to be adjusted (Larsen et al., 2004). In the U.K., major regulatory adjustments took place 10 years after deregulation (Helm, 2003). In Chile, the lack of policy interventions led to blackouts (Fischer & Galetovic, 2000). Therefore, the experience from different countries shows that a regulatory change occurs after a while in electricity markets.

The characteristics of investors are also important when designing policy mechanisms for a market. The investors' perception of political, regulatory, financial and cultural risk is important to secure investments (Komendantova et al., 2012). For example, Neuhoff and De Vries (2004) show that in the presence of risk averse investors, a competitive electricity market without long-term contracts might suffer from lack of investments. In a simulation study, the results suggest that not considering risk aversion of investors might lead to bias policy mechanism and end up with inefficient investments(Roques, Newbery, & Nuttall, 2005).

Experience shows that different countries have experienced different outcomes with their electricity market reforms. Even if certain authors propose a textbook model to be followed when restructuring (Joskow, 2008) and a set of questions to be asked before implementation of the reform (Woo, 2001), each country has its own characteristics that need to be considered when deregulating its electricity market (Larsen & Bunn, 1999). Not taking into account individual characteristics creates a mismatch between the market and the regulation, which leads to failure and need for change. Vogel (1996) refers to this situation as "reregulation"; he argues that in industrial countries, deregulation is a combination of liberalization and reregulation. However with reregulation, markets move away from their initial objective of increased competition.

The mismatch between the regulation and the market is not unique to the electricity sector. Bernstein (1955) states that in regulation there is a natural cycle, which consists of growth, maturity and decline, with the length of the different stages differ depending on the market characteristics. Therefore, in order to enhance the alignment between regulation and market, he suggests that the regulatory frameworks should be designed considering these life cycle elements Bernstein (1955). This view is supported by Fukuyama (2008) who argues that in order not to fail, regulation should evolve with the market, especially in fast-changing markets.

Building on Bernstein's model, Howlett and Newman (2013) state that regulation should follow the development of the market, especially in contexts where scientific and technological innovations pose policy challenges. This is the case in electricity markets, where the introduction of renewable energy resources leads to a need for major policy changes.

3. Elements of a Behavioural View

To understand the difficulties that regulators and policymakers encounter when regulating the electricity sector, we discuss the main behavioural elements that characterize this sector. While our focus is on the electricity sector, a number of these elements are also relevant for other utilities. These elements are not new, but they had little or no impact on the sector before deregulation. They exert a significant influence on the characteristics of the required regulation as well as on the outcome of the regulation, thereby affecting the performance of the sector as a whole. These factors have resulted in regulatory measures leading to unexpected consequences, which came as a surprise to the regulator (Larsen & Bunn, 1999). These unanticipated effects, together with another distinguishing feature of the electricity sector - it is essential for our society – has forced regulators and policy makers to frequently

adjust the regulatory framework in minor or major ways. The consequence of this has been to create a high degree of uncertainty around the long-term profitability and attractiveness of investments in the sector, leading to inadequate levels of new investments. In what follows we discuss six elements that we have consider to be the main areas of concern from a regulatory point of view (Larsen & Bunn, 1999).

Long-term horizon

The assets of the electricity sector are characterised by a long life-span. For instance, power stations are built to last at least of thirty to forty years, grids even longer. While some more recently developed technologies have a shorter life-span (e.g., photo voltaic 25years, Kannan & Turton, 2012), this remains long compared to most other industries. This implies that the consequences of any change will materialise over several decades; it therefore takes a long time for these to become visible to the market participants, regulators and policy makers. The same observation applies to regulatory change: the full effect only becomes visible after many years. However, in the meantime, other regulatory changes are bound to have been initiated, making the identification of the effects of one specific change impossible. These successive changes interact, rendering the consequences for the market totally unpredictable. These long lags can at least partly explain the problems currently encountered by many countries, who are increasingly concerned about the adequacy of supply and the general lack of long-term planning (Larsen et al., 2017).

Dynamics

The market and its regulation evolve over time. While internal and external events affect both the regulation and the market dynamics, the interaction between the regulation and the market creates its own dynamic effects, adding an extra layer of complexity. Considering the market, significant changes to fuel prices, or technological innovation such as windmills, influence the

choice of generation technology, production decisions and the pricing of electricity. The regulatory changes have allowed new market participants with novel business models to enter the market, e.g., intermediaries such as brokers, who neither generate nor distribute electricity. The interaction between regulatory change and the market plays a central role. For instance, environmental regulation coupled with subsidies targeted at renewable energies encourages generators to invest in solar and wind turbines; this results in tight capacity margins at certain times, forcing the regulator to implement subsidies for other technologies. The existence of such dynamics is one of the elements that require regulation to be flexible and forward looking to try to avoid these unanticipated effects and their undesirable consequences. These considerations lead naturally to the next element, which is closely connected to, and partly responsible for, these dynamics: feedback.

Feedback

Feedback is a critical element in most social and economic systems, rendering them difficult to manage and control (Morecroft, 2007). It forms the link between delays (the long-term aspects discussed above) and stakeholders: it is their reactions (behaviour) that create the dynamics of the industry. If there were no delays, feedback would be of no consequence, as adjustments could occur instantaneously. Similarly, if the stakeholders behaved strictly rationally (in a neo-classic sense), they would take into account these delays when making their fully informed decision. Unfortunately, none of this happens in real systems, where bounded rationality, delays, and limited information prevent actors from having a general overview (Morecroft, 2007). This combination of feedback and delays affects both the regulators and the market participants. Indeed, the speed and magnitude of the market participants' reaction to regulatory change, e.g., the introduction of subsidies, often exceed the regulators' anticipation, forcing further regulatory change. One example is the large increase of photovoltaic generation in Denmark until 2012, forcing the authorities to abolish the

subsidies much sooner than initially intended (Enkhardt, 2012). Such over-reaction leads to cycles, as has been observed in many industries, including the electricity sector (Bunn & Larsen, 1992; Ford, 1999; Arango & Larsen, 2011). While the actions of all market-participants contribute to the final outcome, a better understanding of the effect of feedback and delays, particularly by regulators and policymakers, can reduce the occurrence of unanticipated undesirable outcomes.

Behaviour

The design of regulatory frameworks often rests on two implicit or explicit assumptions. First, stakeholders will behave in a rational way. But the rational expectation that customers will choose the lowest-cost provider ignores the issues of switching costs and resistance to change: customers will only change supplier if they expect a significant benefit. Similarly, many customers will forego the more energy-efficient appliance which would be the most economical in the long-run, in favour of one with a lower price-tag. Seemingly irrational behaviour can also be the consequence of limited information. For instance, in a study of greenhouse gas emission Lowe (1996) states that consumers cannot be claimed to behave economically rationally as they do not possess the necessary information to make economically rational decisions.

The second assumption is that stakeholders will interpret the legislation as intended by the regulator. But it is in the companies' interest to exploit every possible loophole, pushing the rules to their limits. Recall for instance the large increase of the electricity price that occurred in the early nineties in the England and Wales market.

In electricity markets, the decisions of all stakeholders have an impact on the evolution of the market. Therefore, capturing the self-interest of the stakeholders, political objectives and (over) reactions to incentives is crucial for understanding the effects and long-term

consequence of regulation.

Stakeholders

When electricity was a monopoly business, there were a small number of influential stakeholders, i.e., the regulator, the monopoly firm(s) and possibly the policymakers; consumers only had a limited indirect influence via any pressure they could exert on policy makers. After deregulation this changed drastically: while each jurisdiction still only has one regulator, there are nowadays many competing generation and distribution companies, the financial sector has become a major player with new actors, like brokers, entering the market, and large (if not all) consumers can change provider (Larsen & Bunn, 1999). The interaction between these different stakeholders, whose incentives and motivations are rarely aligned, is a major contributing factor to the evolution of the market and its regulation (Hancher and Moran, 1989). Being able to understand these stakeholders, and their changing motivations and behaviours, has become a prerequisite for understanding the evolution of both the market and its regulation.

Soft drivers

Building on the two previous points, it is important to consider soft drivers to be able to understand how markets and regulation evolve. Soft drivers are the non-economic factors driving individuals' behaviour and the decisions they make. For instance, policymakers may be influenced by their desire to promote their career prospects, leading to decisions such as requiring excess generation capacity to avoid the embarrassment of a blackout or keeping a specific plant in operation to protect local employment, if not outright corruption. Such behaviours can be enhanced in the presence of NIMBY attitudes ("Not In My Back Yard"). A well-known example is the opposition to the North-South high-voltage line in Germany (Steinbach, 2013). Richman and Boerner (2006) argue that this factor poses one of the most

important policy challenges in the United States: regulatory adjustments are required to overcome this effect. While these soft factors are absent in most theoretical models, they affect all actors' decision-making processes, and thus influence the evolution and development of the market, and thereby their regulation.

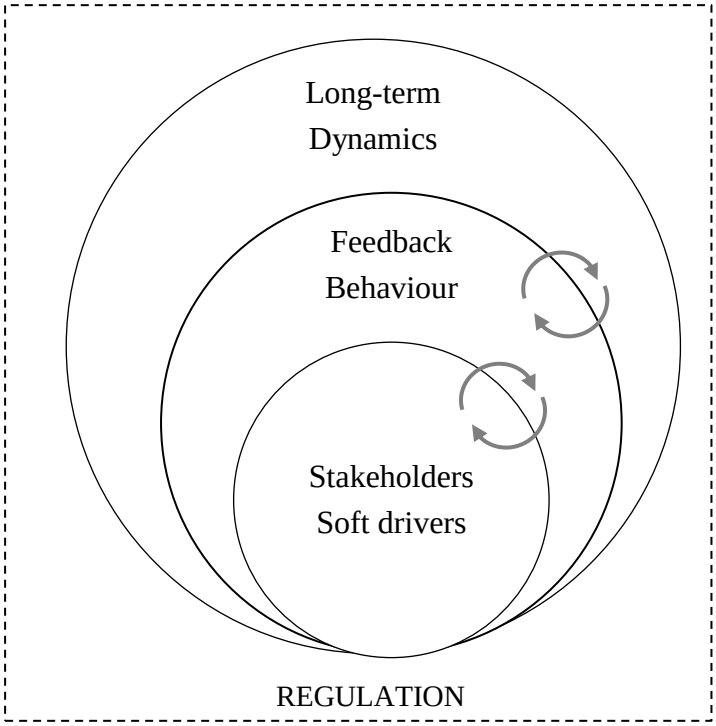


Figure 1 : The conceptual model

Our discussion of these different components can be summarised as shown in Figure 1. This conceptual model consists of different interacting layers. Soft drivers influence stakeholders, whose decisions create market behaviour and feedbacks, which might change the view of the stakeholders. Feedbacks resulting from behavioural factors create the dynamics of the regulation, which affect the long-term performance of the system. For example, people agree to the use of wind power, but do not want to have wind farms nearby (Wolsink, 2000). Consequently, many countries are now opting for off-shore installations. For instance, Denmark has made it increasingly difficult to get permission for on-shore windmills (Gilligan, 2010). But the off-shore solution also encounters opposition, whether from the local

population whose view is affected (Onion, 2016) or from environmental groups if the location interferes with birds' migration path (Morgan, 2016). These behaviours potentially limit investments in wind energy, and delay their implementation, despite most people agreeing that developing this energy source is beneficial.

4. A Conceptual Model of the Evolution of Electricity Markets

In this section new propose a conceptual model of the evolution of deregulated electricity markets. While this arguably could be done in different ways, we identify five stages which we consider to be a generic view of the evolution of electricity markets. This approach allows us to identify particular characteristics and challenges for each of stage of the markets' evolution. The five stages are the following:

- *Monopoly*. The stage before deregulation, characterised by the absence of competition.
- *Wholesale competition*. Often the first stage of deregulation. Large electricity users, mainly distributors and companies in energy-intensive industries can buy electricity directly from the generators, in a spot market or from an electricity broker (Hunt, 2002).
- *Retail competition*. All consumers can choose from whom to buy their electricity, i.e., a free market (Hunt, 2002).
- *Mature market*. When a market matures, dynamics change; this stage is characterised by more stability and increased innovation.
- *Re-regulation*. Markets may reach a point where, due to internal or external factors, things start going wrong and the regulator is forced to intervene to induce or prevent certain behaviours by the market participants.

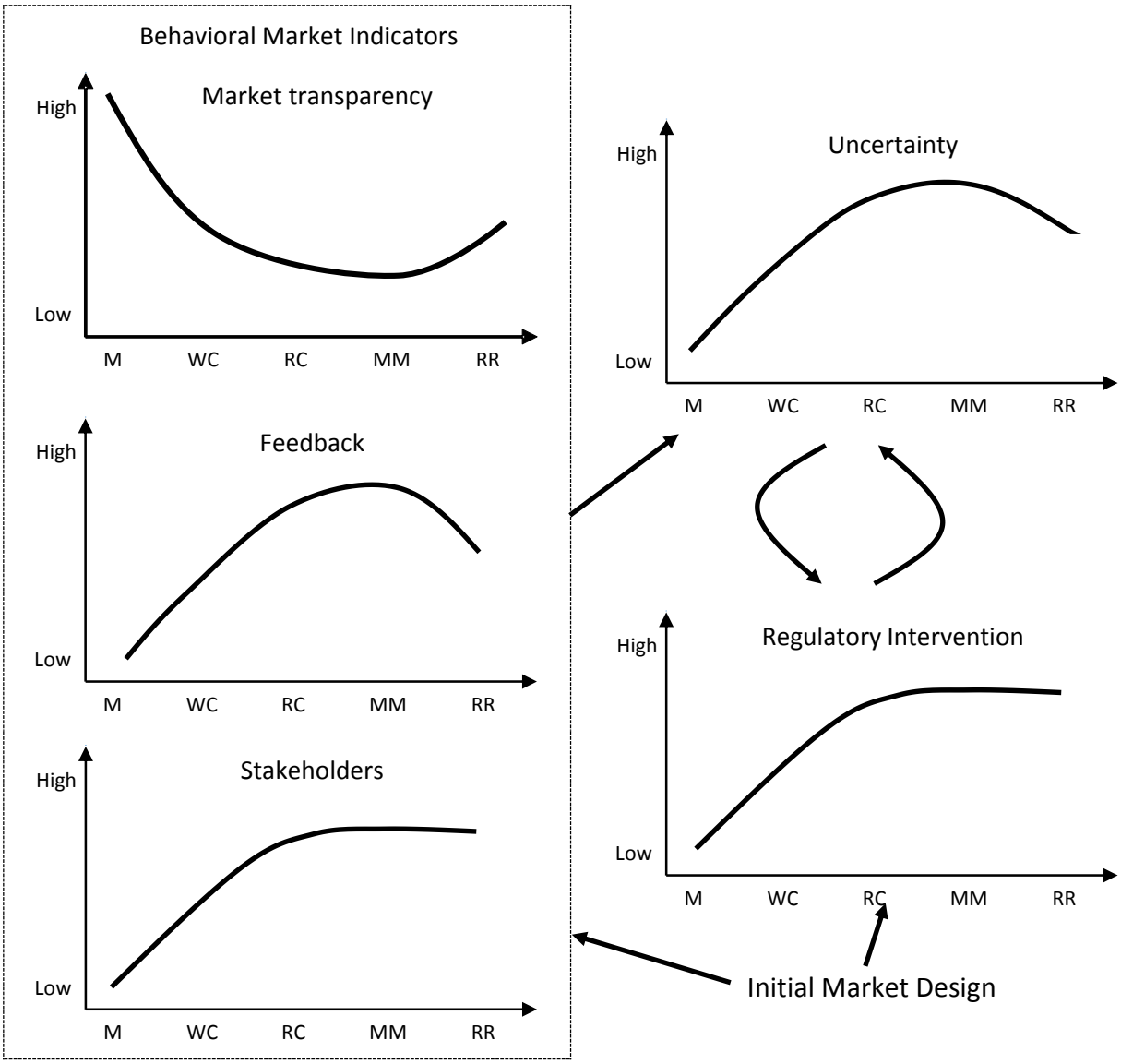
Table 1 outlines the different stages and their characteristics. For each stage we outline the

key market characteristics, the main aim of the regulation and some of the problems that have been observed at that stage of deregulation over the last thirty years. These remarks are general in nature. In the next section we will provide explicit examples that illustrate some of the issues raised in Table 1.

Another way to look at these different stages from a more conceptual point of view is through some of the behavioural aspects discussed in the previous section. The question is: how do they affect the different market stages? Figure 2 provides a stylised view of these interactions. The left panel, labelled shows three factors that affect the market. We start by looking at the evolution of the market transparency, i.e., to what extend is it possible for the stakeholders to achieve an overall view of the industry in terms of current and future investments, intentions of market participants, load factors, etc. In a monopoly there are no reasons to conceal information: there are no competitors and there is nothing to be gained from being secretive about the intentions. As market-deregulation progresses, the available information slowly dries up: competitors might exploit any information to make pre-emptive moves, thereby harming a company's future earnings (Larsen & Bunn, 1999). The regulator is also affected by this lack of transparency, as the market-actors have not incentive to share to inform the regulator of their intentions, unless required to do so. As the market moves through the different stages, the level of transparency decreases, until the stage of re-regulation is reached: here increased regulatory intervention (e.g., capacity auctions), leads to increased transparency (e.g. concerning new capacity investments).

	Monopoly	Wholesale Competition	Retail Competition	Mature Market	Re-regulation
Characteristics	One national or regional supplier No competition Regulated prices Long-term expansion planning	Several suppliers in wholesale market Price is a function of supply and demand for larger buyers Regulated price for small buyers	Competition in all parts of the market except transmission Price is a function of supply and demand for all buyers	Competition in all parts of the market except transmission Price: function of supply and demand for all buyers Increased concentration of generators	Competition in most part of the market – capacity determined by regulator Price is a function of supply and demand for all buyers
Regulation aims	Ensure capacity and cost recovery Access Affordability	Prevent market power and collusion in wholesale market Protect regulated customers Ensure equal access to market Reach environmental targets	Prevent market power and collusion Ensure sufficient investments Reach environmental targets	Prevent market power and collusion Ensure sufficient investments Reach environmental targets	Prevent market power and collusion Subsidies for all generation (Thermal + Renewables)
Typical Problems in the Market	Overcapacity (developed countries) Lack of investments (Developing countries) Relatively high prices	Exploitation of regulated customers Disconnection between regulated price and wholesale price Uncertainty about - long-term development and stability of the market - application and use of the rules	Market power Lack of investments Price volatility	Market power Lack of investments Price volatility National interests	Lack of thermal capacity Increasing prices Increasing volatility Regulator has significant control over the market Public opinion influences the decisions by policy makers

Table 1 : Summary of different market stages



M = Monopoly, WC= Wholesale Competition, RC= Retail Competition, MM= Mature Market, RR= Re-regulation

Figure 2. The development of a subset of the behavioural factors and their influence on the uncertainty in the industry across the different stages

The second factor, feedback, relates to the number of interdependent decisions companies need to make (i.e., the commercial complexity of the operations of the company) and how these decisions affect the other market-participants and their actions. Such decisions include capacity investments, bidding, contract negotiation, etc. As we move through the different stages, the number of decisions to be made increases. The entry of new agents such as electricity brokers increases the available contract strategies, and moving to retail competition requires developing a communication strategy aimed at small customers. When reaching the

re-regulation stage, the regulator takes over certain tasks, such as the planning of new capacity through various capacity mechanisms; this reduces the feedback and complexity.

The third factor characterizing the industry is the number of stakeholders, which increases through across the different stages as more and more actors can directly participate in the market. While in a monopoly there are relatively few direct participants, this changes with the introduction of wholesale competition: there are more generator and distributors involved, as well as the larger customers. The number of participants reaches its maximum with retail competition, where small consumers enter the market. After this point there is no further change in the number of stakeholders.

To summarize, as the industry moves away from a monopoly situation, the number of stakeholders increases, it becomes increasingly difficult for them to have a global view of what is going on in the industry, and they are required to take an increasing number of more complex, interrelated decisions. Consequently, the uncertainty in the industry as a whole increases significantly, as illustrated in the top-right panel of figure 2. This holds for the companies and the consumers, as well as for the regulator. This increased uncertainty makes investment decisions particularly challenging for generators: competition renders their demand less predictable, subsidies for certain technologies affect prices and supply, and regulatory changes become increasingly difficult to predict.

This uncertainty also affects the regulator, who is forced take decisions under increasingly incomplete information. This increases the probably that specific measures don't achieve their intended objective, compelling the regulator to intervene more frequently, fuelling a spiral of uncertainty for all actors. The increased level of regulatory intervention moves the market towards the reregulation stage. In the following section will we link specific cases to the Table 1 and the discussion of Figure 2.

5. Regulation, Markets and Their Interaction: Examples

In this section we use the framework developed above to analyse and learn from a number of instances where regulation and markets have not worked optimally together. These cases were selected to illustrate different ways in which this malfunctioning can occur, at different stages of maturity of the deregulated market. We start with the well-known problems linked to monopoly markets, discussing three issues observed in a number of different markets, which have been motivating factors for the move to liberalisation.

Monopoly

In a monopoly, severe disruptions of the electricity system, leading to blackouts, are a major embarrassment for any government. In the absence of tight budgets regulators can easily reduce this risk to close to zero by building significant levels of excess generation capacity and redundancy in the grid. This strategy seems to have been followed in Western Europe: at the time of deregulation, most countries had significant overcapacity, e.g., more than 30% in the England and Wales market (Roques et al., 2005). In a world with captive customers and no competition there was little or no awareness of the price-impact of this excess-capacity: the lights stayed on and few complained.

Developing countries faced a very different situation: population growth and an increase in per capita electricity consumption created a need for major investments. But the combination of political pressures to keep tariffs affordable and the difficulties in reducing the unpaid share of electricity consumption (euphemistically referred to as "non-technical losses"), which could exceed 25 percent of the consumption, deprived the electricity companies of the resources required for capacity expansion. The resulting electricity shortages led to repeated, occasionally major, blackouts (e.g., in Colombia (Larsen et al., 2004)), or worse, to extremely frequent blackouts (e.g., Nigeria (Amobi, 2007)).

These contrasting situations in Western Europe and some developing countries illustrate the influence of political sensitivity on regulation: avoiding disruptions at any cost (Western Europe) versus keeping prices artificially low out of fear of political unrest, leading to capacity shortages (developing countries).

The third example for monopoly relates to the USA, where the standard price regulation was based on a guaranteed rate-of-return on actual investments (Gilbert & Kahn, 1996). This created unanticipated incentive problems, as cost-overruns led to higher profits. This is illustrated for instance by the case of several of nuclear plants in the USA, where actual construction costs exceeded budgeted by a factor of five or more. For instance, the Clinton plant, budgeted at USD 534 million ended up costing 3.13 billion (McCallion, 1995).

This example illustrates a behavioural aspect of a regulatory system: the exploitation of a system intended to provide a fair profit to the company, leading to excessively expensive electricity for the consumer.

Wholesale Competition

The period following deregulation is a time of major uncertainty for all the stakeholders. Regulators are discovering whether or not the newly designed regulatory framework achieves its objectives, companies are unsure as to what is actually allowed under this new regulation and the customers who have access to this new "free" market are inexperienced in dealing with its inherent uncertainty and the resulting risks (Larsen & Bunn, 1999). At this early stage usually only a wholesale market is established. This implies that, at least in principle, all market participants are well-informed professionals: generators, distribution companies and large consumers. Still, over the years problems have occurred even in these early stages of liberalisation.

Shortly after deregulation in 1992, London Electricity (LE) established a retail chain selling

all types of electrical appliances. But, being unfamiliar with the retail sector, they failed to control their costs. For instance, selecting prime locations for shops resulted in high rent. The situation was made worse by disappointing sales levels. LE incurred a UKP 10 million loss in 1993, the year before the retail chain was sold. Other UK regional electricity companies set up similar operations, with similarly disappointing results (The Independent 1995). These initiatives also faced complaints from other retailers, who claimed that the electricity companies subsidised their retail chains by up to UKP 250 million a year, implying that it is most likely the captive consumers most footed the bill for these adventures (Independent 1995). In retrospect, this failure is not a surprise as these companies, coming from a monopoly situation, had neither the capabilities nor the experience to enter the retail market. These failures illustrate the lack of understanding previous monopolies had of their capabilities and resources, as well as of competitive markets in general.

Another well-known example is the crisis in California in 2000-2001. The combination of a number of independent factors led to an electricity shortage and blackouts; prices rose from $36/MWh in 1999 to $166/MWh in 2000 (Harvey & Hogan, 2000). These factors included natural events (weather patterns in the northwest of the USA), regulatory issues (slow approval of new generation projects), and behavioural aspects (possible manipulation of the system by Enron, rapidly growing demand in California). A monopolist or a fully deregulated market might have coped with this situation, but at that time only the wholesale market was deregulated in California. While the generating companies benefitted from the high prices, distributors were caught in the middle, buying electricity at high prices in the deregulated wholesale market, and selling at low, regulated prices in the retail market (Borenstein, 2002). This led to a financial crisis; one of the largest distributors failed and the government had to step in and subsidise the industry. It is estimated that the share of the cost of this crisis, borne by the taxpayer, is in the 40 to 45 billion USD range (Weare, 2003).

This example illustrates how essential it that the regulator and the market participants understand the underlying market structure, and the consequences of this structure on market behaviour, particularly during a transition: rectifying a failed design can be extremely costly.

In the England and Wales market there were strong indications that the two main electricity companies started to test the boundaries of what it was possible to "get away with" in the second and third year after deregulation. Electricity prices increased significantly over that period, and there were suspicions, but no proof, that this resulted from the two main companies successfully signalling to each other through their bids to the pool. After the regulator threatened to change the bidding process prices fell; it is generally assumed that this (credible) threat was sufficient to eliminate this form of collusion (Independent, 1992).

This example illustrates a behavioural aspect: participants will be tempted to test the boundaries in a newly deregulated market, forcing the regulator to step. Similar behaviours are observed in most utilities; in more mature industries such unauthorised cooperation often takes the form of illegal cartels.

While competitive electricity markets are designed to remedy inefficiencies in monopolies, they often create their own inefficiencies. In Switzerland, where only the wholesale market is deregulated, some distributors have a large captive market of small domestic customers. The regulated price paid by captive customers being significantly higher than the market price, these distributors can cross-subsidise between large and small consumers ("Les sept erreurs qui ont coulé la fée hydroélectricité," 2017). Such a market distortion can only occur in the presence of wholesale competition without retail competition, i.e., when small customers cannot change supplier. This is a clear example of regulatory failure since one of the objectives of the regulation in competitive markets is to protect the weaker captive customers (Borenstein et al., 1999).

Towards Fully Competitive Markets

As deregulated wholesale markets mature and the retail market is added, concerns evolve. While in the initial stages the focus was on "will the system work?", i.e., can shortages and blackouts be avoided, attention turns to identifying what adjustments are required to improve market functioning. In this stage the focus is on the behaviour and the dynamics of the market. Market power becomes a central issue: how can the regulator prevent companies from manipulating the market? Companies will always look for ways to legally exploit the market structure to their advantage.

There are many indications of market-participants having successfully exerted market power in this stages in different parts of the world, but hard proofs are rare. For instance, there have been signs of market power and strategic behaviour during peak hours in the German market (Müsgens, 2006). The absence of excess generation capacity in India's deregulated market also point to companies having market power (Shukla & Thampy, 2011). The limited number of generators seems to have led to market power problems in the England and Wales market during the initial liberalization stages (Wolfram, 1999) and in California during the electricity crisis in 2000 (Wolak, 2003).

Regulators were aware of the dangers of excessive market power when developing the initial regulations, and devoted significant efforts to limit this risk. Still, the large number of instances where market power has been suspected indicates they have failed on many occasions. While different contextual factors can explain part of these market power problems, a common contributing factor is the discrepancy between the assumed rational behaviour (the homo economicus hypothesis) and on the other hand the actual behaviour of market participants.

The initial England and Wales regulation (1990) did not allow for vertical integration between

a generator and a distributor. The objective was to insure a sufficient level of competition: distribution companies were forced to buy all their electricity either through contracts or on the spot market. However, the regulator soon realised that with only three main generating companies the level of competition was insufficient in this segment (Joskow, 2009). 1999 saw a major regulatory changed: National Power was allowed to acquire a distribution company on the condition that it reduced its share of generation (Codognet et al., 2003).

This example illustrates a situation where the regulator realised that the initial design would not create a sufficient level of competition in the market, exacerbating the risk of companies being able to exert market power. Rectifying this step required a major change of the initially planned market structure: the ban on vertical integration was lifted.

As a comparison, Colombia allowed vertical integration from the start, and created a competitive market by mandating that distribution companies buy at least 40% of the electricity they sold from another generator (Olaya et al., 2016). But the newly liberalised market ran into trouble in 1999 as a major economic crisis led to lower electricity demand: the resulting overcapacity resulted in lower prices, creating serious financial problems for several companies (Larsen et al., 2004). The Colombian regulator successfully managed this changing situation by repeatedly adapting the capacity mechanism (Olaya et al., 2016).

These last two examples illustrate that a given design (in this case, allowing for vertical integration to increase competition) can be appropriate in one context, but fail to work in another one; this highlights how sensitive regulation can be to the context. These two examples also show that it can take quite a long time to understand whether or not an initial design works and, if not, to reach agreement on the necessary adjustments, as it is most likely that any change will make some stakeholders worse off.

Mature Deregulated Markets

As the market continues to mature, the different stakeholders learn to deal with the regulatory context; the initial problems have been sorted out, and the market has demonstrated its ability to deliver electricity. The mature market functions well until changes in the environment create a need for further adaptation. For instance, in Western Europe markets matured in a context of overcapacity; consequently, there was no need to incentivise investments in generation capacity. But today security of supply and, in particular, capacity adequacy, has become major concerns. One of the causes lies in the move towards green energy which has led to a marked policy change: governments started to support investment in renewable generation. This has led to a situation combining on the one hand overcapacity (leading to a collapse in prices) and on the other hand an inappropriate capacity mix (lack of investment in and premature closing of unprofitable thermal peak generators). The uncertainty resulting from the frequent, difficult to predict, policy changes has reduced investments in non-renewables, resulting in a need for capacity mechanisms. This has been argued by, among others, the regulator of the England and Wales market believes that there is insufficient investments due to uncertainties about future policies and prices (OFGEM, 2013). This concern is shared by the regulators of a large number of countries, including Sweden, Germany, and New Zealand, all of which have introduced capacity payments in recent years, often in the form of capacity auctions (Finon & Pignon, 2008; EC, 2016). The fundamental problem is: how can one balance a market where one part (renewables) is (heavily) subsidised, while another part (among others, thermal peak-units) is expected to be competitive without subsidies – it turns out this may simply be impossible, which would explain why we increasingly observe subsidies being extend to other technologies.

This is another example of problems that have taken a long time to develop and even longer to be recognized. And they will take a long time to fix. Most importantly, if the regulator is not extremely careful in defining and implementation corrective measures, these may lead to

other, equally problematic, issues in the future.

It should be noted that the number of companies varies significantly across jurisdictions, from a handful in England and Wales or France (too few to create a competitive market (Helm, 2003)) to hundreds in Denmark and Germany (Eurostat, 2017). Economics and strategy textbooks would predict that in electricity, which is essentially a commodity business, deregulation should lead to concentration over time, i.e., a smaller number of larger companies. However, there is evidence that this is far from being the case in general; both the initial conditions and the evolution differ significantly across countries, in certain instances in the opposite direction of that predicted by economic theory. For instance, in Germany the number of companies did not decline after deregulation, it actually increased slightly, with the small companies surviving, the large national actors expanding, and the regional companies declining (Liu & Wezel, 2015).

Denmark has seen a very different evolution, with a high degree of consolidation, and a state-owned company becoming the major player. The EU and the OECD have actually expressed concerns over this development (*OECD Annual Report*, 2005) and there have been cases of market abuse (Energy Denmark, 2007).

These examples illustrate that, when designing markets, regulators have in many instances (i) not been able to understand ex-ante link between market concentration and competition, (ii) failed to foresee how concentration would evolve in the liberalized market and (iii) been unable to design regulation that achieves the desired level of concentration, in particular preventing a national player from dominating the market.

So far we have focused on single jurisdictions. A complicating factor is the existence of cross-border trade between neighbouring markets with different, possibly incompatible, regulations. The design of these cross-border markets is the outcome of inter-governmental negotiations.

However, as few, if any, countries would consider handing over control of something as essential as electricity, there is no supra-national regulator; this is a source of conflict and problems. For instance, regulators are tempted to put the blame for major blackouts on their neighbouring countries; this was indeed initially the case for the 2003 blackout in Italy ("Huge blackout cripples Italy," 2003), although it was later acknowledged the true cause was a combination of the weather and human error (*UCTE*, 2004). Tensions also arise when countries accuse each other of unfair trading practices, including subsidies. For instance, Germany is periodically flooding the central European market with electricity, putting pressure on neighbouring countries' electricity prices and the profitability of their generators, with the German consumers subsidise consumers in these neighbouring countries (Reuters, 2015a).

This example illustrates that when markets expand beyond their national boundaries, problems become even more complex; developing a comprehensive and fair regulation is essential to ensure that this evolution is beneficial, in particular for the small consumer.

Re-regulation

The evolution over the last decade can best be described as a kind of re-regulation, where the control of the industry is slowly reverting back to the regulator. In some cases the deregulation process has been temporarily halted, e.g., after the Californian crisis in 2001 and more recently in 2013 in Arizona (O'Donnell, 2013), and an increasing number of jurisdictions are repealing certain aspects of deregulation.

The main driving force behind this form of reregulation is the pressure to achieve environmental commitments at the national, regional and/or planetary level. Examples of such commitments include the European Union's "20-20-20" climate and energy targets, reducing greenhouse gas emissions by 20% compared to 1990 levels by 2020, (Commission of the

European Communities, 2008) or UN agreements like the COP 21 Paris Agreement (United Nations, 2016).

One of the external factors that have been forcing the hand of regulators and policy makers is technological development. The implementation of deregulation was facilitated to some degree by the arrival of a disruptive technology, CCGT, in the eighties. The possibility of building comparatively small generation units reduced the required investment to enter the market, thereby removing one of the major entry-barriers (Olaya et al., 2016). But the rising share of renewables has created new challenges for regulation. The wide-spread incentives to invest in renewable technologies, such as wind and photovoltaics, and their fast technological development have resulted in a previously unseen growth rate. In some countries, e.g., Germany, wind and solar energy at certain times accounts for half of the total generation (Fraunhofer, 2014). Their introduction forces a rethinking of the concept of capacity adequacy. These technologies are disruptive due to their intermittent nature and close to zero marginal costs, which create financial pressure for the existing generators. When PV and wind generation peak, they displace peak units, in particular thermal and hydro plants, and prices drop significantly (Traber & Kemfert, 2011). This leads to lower revenues and possibly losses. To insure sufficient generating capacity when renewables are not available (e.g., winter evenings), regulators are forced to introduce incentives for thermal capacity, known as capacity payments.

This shows that the policy objective of green energy is gradually transforming what was originally intended to be a free market, in a highly regulated and subsidised market. Technological innovations can change the evolution of the market and set the regulatory system under pressure in ways which could not be anticipated when the regulation was initially designed. This highlights the fact that regulatory regimes designed for a specific context are likely to fail when this context changes; for instance, regulatory design developed

for a generation mix consisting mainly of thermal and nuclear plants is unlikely to perform well when renewables represent a significant share of the installed capacity. The impact of renewables far exceeds that of the introduction of CCGT, whose generation characteristics were similar to those of existing plants (non-intermittent, fossil-fuel based variable costs).

The rush towards renewals has been driven by increasing environmental concerns. Coal plants in particular are being heavily criticised (Nace, 2011). Certain developing countries, for which coal has long been one of the main sources of fuel (e.g., China), face unsustainable levels of air pollution in their major cities (Huang et al., 2014). This has led to the regulator being forced to step in to limit or stop the construction of coal fired plants, despite these being the most attractive from an economic point of view. Other countries, however, are still planning major investment in coal-fired generation, e.g., Malaysia (Power Engineering International, 2014). The problem is not limited to developing countries: coal fired plants are a favourite target of activists and regulators in many countries, including Germany (Teffer, 2016).

Nuclear power plants have long been a source of safety concerns. The Fukushima accident has increased opposition to this source of generation. These pressures have led policymakers to decide on the closedown of nuclear power plants (e.g. Germany, (Reuters, 2015b)) or a moratorium on the construction of new plants (e.g., in Switzerland, (Federal Administration, 2016). This illustrates another of the dimensions discussed in the previous section, i.e., how public opinion, in this case environmental concerns and safety of the general public, can influence regulatory and policy choices, i.e., environmental and safety concerns can outweigh economic interests.

Our focus on examples of regulatory failure might lead to the incorrect impression that deregulation is bound to fail. This is not the case. Deregulation of electricity markets has worked well for several countries. The Nordic electricity market (Nordpool), which is an

integrated market of Denmark, Finland, Norway and Sweden, is an example of a successfully deregulated electricity market (Amundsen & Bergman, 2006). Another example is Texas, whose electricity market is referred to as a "robust competitive market" (Sioshansi & Pfaffenberger, 2004, p.383). The markets of Chile and Argentina are other successful examples (Joskow, 2008).

Implications

Table 2 elaborates on the role behavioural aspects play in the examples discussed above. Our aim is to show how the behavioural elements we identified contribute to the issues raised in these examples, without claiming to be exhaustive; we could have listed many more problems relating to deregulation and the ensuing evolution of these newly created markets. But the selected examples do illustrate how a static, purely economic approach to regulation fails to capture important elements necessary to understand the functioning and the evolution of deregulated markets. We argue that when regulatory frameworks are designed and implemented, special attention must be paid to these behavioural aspects.

As can be seen from the analysis in Table 2, behavioural elements help explain issues arising in the different phases: they already played a role before deregulation, explaining some of the problems that contributed to the decision to deregulating the electricity sector. These include, on the one hand, the issue of overcapacity in developed countries, where companies were allowed (if not encouraged) to invest in excess capacity; this led to unnecessarily high electricity prices, a cost not directly "visible" to most consumers. On the other hand, developing countries suffered from under-capacity, as the problem of consumers not paying for the electricity consumed limited investments. In both instances economic growth was affected, respectively by the high cost or the insufficient availability of electricity, leading to the logical conclusion that the system needed to change. However, the option selected by

policy makers, to deregulate the industry and to create competition, was one of the most drastic changes observed in any industry in over fifty years (Dyner & Larsen, 2001); not surprisingly it resulted in a whole new set of problems.

The process of deregulation and the creation of wholesale competition was initially subject to a high degree of inertia: companies continued to behave as if they were still monopolies, adapting slowly to the new environment. This is not a surprise; from an organizational perspective this is the stage of exploitation (March, 1991), i.e., relying on what one already knows. However, companies gradually switched to an exploration mode, taking advantage of the newly granted freedom and discovering the opportunities created by deregulation. Eventually they even went too far, forcing the regulator to intervene. For instance, as discussed above, unacceptable practices such as implicit collusion in the England and Wales market or overcharging captive customers to be more competitive in the wholesale market were observed. The question arose whether such a partly deregulated market could in the long-term be truly competitive, i.e., without being heavily regulated. California is the clearest example of how things can go wrong when price increases cannot be passed on to the stakeholders responsible for the capacity shortage by their opposition to new plants; in the end the market breaks down. When problems surfaced, a significant amount of time elapsed between the moment the regulator, realising the need to intervene, started the discussion process, and the actual implementation of the changes. This was particularly the case for major overhauls, as in the England and Wales market, leading to long periods of significant uncertainty for all stakeholders.

When, at the next stage, retail competition is introduced, one would expect electricity markets to function like any other market: with sufficient competitors, market prices should provide adequate investment signals: when capacity is tight, market prices should enable the recovery of both variable costs and CapEx. However, there are few, if any, examples where this has

indeed been the case. While the reasons for these failures are manifold, an important factor has been the political desire to keep at least some control over the choice of generation technology, mainly due to environmental concerns. This has led to a number of different incentive schemes for renewable energy, primarily wind and photovoltaic. These incentives increased the level of uncertainty in the market, making the major players reluctant to commit to new capacity. This happened at a time when companies were reaching the end of the rationalisation process launched during the initial stage of deregulation. Financial markets' pressure for further increases in profitability led to a movement of consolidation, a phenomenon commonly observed in industries characterised by economies of scale. This led to international tensions, e.g., between Germany and Spain (when Eon tried to take over Endesa) and between France and Italy (with ENEL trying to take over Suez) (Durand, 2006), making it clear that what was supposed to be a “free” well-functioning market was far from this ideal picture.

The surge in environmental concerns did not facilitate the regulators' job. The introduction of incentives for renewables, while a reasonable response, created major problems in many developed countries. Europe in particular moved within a decade from a context of excess capacity to a situation of tight margins, as the surge of renewables made thermal generation plants unprofitable: investment plans were cancelled, and existing plants mothballed. These events took the evolution of the deregulated markets to a new stage where, to ensure sufficient capacity at times where renewables cannot deliver enough electricity, the regulator had to step in and subsidise traditional generators. In other words, the sector is moving to a point where most generators are subsidies in one way or another – raising the question as to what actually happened to the market. With the introduction of capacity mechanisms the regulator to a large extend took back control over investments in new generation capacity – a situation not unlike the one we started from – a monopoly – just significantly more complicated and less effective.

To summarise, we have outlined the role behavioural factors have played in the evolution of electricity markets throughout the different stages of deregulation, ending up in a stage having a surprising number of similarities with the situation the industry started from – a monopoly.

Examples	Behavioral elements	
	Monopoly	
Overcapacity in Europe	Soft drivers Dynamics Behavior	*- Avoiding blackouts is the top priority* *- Guaranteed cost recovery* *- Ability to invest more than economically optimal*
Insufficient investments in developing countries	Behavior Feedback Long-term / Dynamics	*- High non-technical losses* *- Loss of revenue and uncertainty about return on investments* *- Lack of resources to invest*
Rate of return regulation in the USA	Behavior Feedback	*- Moral hazard as companies are rewarded for cost overruns* *- Captive consumers have limited influence leading to an absence of feedback*
	Wholesale Competition	
Unsuccessful diversification	Dynamics Stakeholders	*- Insufficient understanding of the markets* *- No loyalty from retail customers*
(Illegal) collusion	Behaviour Soft driver Dynamics	*- Testing the limits of the regulatory framework to enhance profitability* *- Believe regulator will not discover the collusion* *- Resulting prices and bidding pattern point to the collusive behaviour*
Overcharging captive customers	Dynamics Stakeholders Behavior	*- Competition drives down wholesale prices* *- Powerless captive customers vs large consumers* *- Cross-subsidisation : low prices in the competitive market, high prices for captive customers*
	Towards Fully Competitive Markets	
Market power	Behaviour Long-term	*- Price increases, conviction of invulnerability* *- No short term consequences for the company*
Market redesign in the UK	Long-term	*- It took the regulator 10 years to decide and implement a change in market design*
Economic crisis in Colombia	Long term	*- It took an economic crisis 5 years of the creation of the market to understand that its design was unsustainable*
	Mature Deregulated Markets	
Managing technological transitions	Dynamics Behavior Long-term	*- The change in technology from thermal to renewable* *- The effectiveness of incentives for renewables* *- The need to ensure an appropriate mix of technologies*
Consolidation	Long-term Dynamics	*- Pressure to consolidate, leading to market power* *- Evolution of the number of market participants*
International expansion	Stakeholders Soft drivers Dynamics	*- Each jurisdictions has its own regulation* *- Refusal to delegate authority* *- Uncoordinated jurisdictions*
Capacity shortage in Europe	Long-term	*- It took over a decade to realize that the market designs might not deliver enough capacity*
	Re-regulation	
Technological innovation	Long-term	*- the regulatory framework did not evolve fast enough to accommodate the technological changes*
Environmental issues	Stakeholders Behaviour / Feedback Dynamics	*- Pressure from a variety of stakeholders concerned about the environment* *- Environmentally driven regulatory change, e.g., capacity incentives for renewable energy* *- Support for renewables endangers the economic viability of other technologies*

Public opinion	Soft drivers	- *e.g. the attitude towards nuclear power, particular after a major incident, driven by perceptions rather than facts*

Table 2. Overview of the examples and the role of behavioural elements

Conclusion

When, from the late 1980s onwards, many electricity markets went through a liberalization process, the aims varied widely across countries, ranging from increasing efficiency through the creation of a free competitive market with lower prices, to ensuring the necessary investment in generation (Sioshansi, 2006). However, as discussed in the previous section, the implementation process and the ensuing evolution were in many, if not most cases, far from smooth. Regulators and market participants alike realised that markets neither performed nor behaved as predicted by theory. Regulatory adjustments, and even full overhauls, were implemented to correct emerging market imperfections or to drive the industry into a particular direction, e.g., increasing the share of renewables. However, unanticipated side-effects created new market imperfections, needing further corrections, resulting in a self-sustaining cycle of continuous change.

We can think of a successful regulatory process as one that manages to dampen this cycle, i.e., a negative feedback process that brings stability by creating over time a better fit between the market and its regulation. In other words, a successful regulator should learn faster than the market and be able to anticipate and mitigate future imperfections, thereby minimising unanticipated side-effects. On the opposite, an unsuccessful regulator's failure to manage this cycle could unleash an escalation of ever more frequent regulatory changes, leading to increasing levels of uncertainty in the market.

Given the difficulties of designing a deregulated market that will evolve towards and remain in equilibrium, it is necessary to understand the behavioural factors that affect the coevolution

of markets and their regulation. Markets have often been designed based on relatively rational economic assumptions. But, as has been increasingly acknowledged over the last decades, among others in the literature on behavioural and experimental economics (e.g., Parisi & Smith, 2005), economic decisions are often irrational. We believe that to create a sound regulatory framework it is not only necessary to look at economics, but also at the more behavioural factors we discussed.

Today's regulatory systems generally have a relatively narrow focus; most of the effort is devoted to ensuring competition and capacity adequacy in the liberalised industry. After the initial design stage, regulators have tended to be reactive, while facing innovative and proactive market participants; this has resulted in many cases in a regulatory framework lagging behind the realities of the industry. Such a situation creates a need for further regulatory interventions, leading to increased uncertainty and market malfunctioning, which in turn requires further interventions, a never ending story.

It is thus necessary to focus on what a forward-looking, adaptive, regulatory system would look like: only such a system has the potential to create increased competition among market participants, while achieving an acceptable level of stability. There is a need for a comprehensive framework for behavioural regulation in the electricity sector, but which respects the idiosyncrasies of the different countries.

This paper takes a first step in this direction, by identifying some of the aspects that must be considered in a behavioural regulatory framework, what we have labelled the behavioural factors: a long-term perspective, dynamics, feedback, behaviour, stakeholders and soft drivers. We have illustrated how each of these factors has played a role, sometimes a major role, in the challenges encountered when deregulating the electricity sector. Taking these factors into account when designing regulatory frameworks will we enable us to create a more

agile, forward looking regulation, requiring less frequent major changes. This will reduce uncertainty in the industry, resulting in more desirable outcomes for companies and consumers alike. The next step in this work will be to develop a conceptual model that can incorporate these elements.

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