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INCENTIVE REGULATION AND NETWORK INNOVATIONS

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Incentive Regulation and Network Innovations

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Abstract

Smart Grids require innovations in the electricity networks, mainly on the level of the distributed system operator (DSO). A main objective is to increase the share of distributed generation (DG) connected to that network level, but also to enable load management on the demand side. This paper analyses network innovations in the context of the regulatory framework, namely incentive regulation.

It is structured as follows: The first section examines how cost-based and price-based regulatory schemes influence RD&D by regulated companies. This is followed by a discussion of various regulatory instruments to stimulate innovation. The third section provides a more general discussion of the pros and cons of promoting network innovations via network regulation.

Keywords

Incentive regulation, price-based regulation, cost-based regulation, RD&D, network innovations

1. The effect of different regulatory mechanisms on innovation

In this section, cost-based and price-based regulation of network tariffs as the two theoretical polar cases are analysed with regard to their effect on network innovations. The main mechanisms through which they affect the innovation activities of DSOs are discussed. The focus of this section is on cost-saving process innovations in order to understand the basic mechanisms.

1.1 Cost-based regulation

One type of regulation is cost-based regulation. The effect of regulation on innovation has traditionally received less attention than the impact of the market structure on innovation in the literature (Mayo, Flynn: footnote 1). In the 1970s and 1980s there were some studies on the effects of regulation on innovation, mainly in the US (Bailey 1974; Müller, Vogelsang 1979; Sweeney 1981; Schoppe, Wass von Czege 1984; Mayo, Flynn 1988); for an overview from an electricity sector perspective, see (Jamasp, Pollitt 2008)). They examined the cost-based regulation that was predominant at the time. The focus of most studies on innovation under regulation has been on vertically-integrated monopolies rather than unbundled networks in liberalised markets.

In its pure (theoretical) form, cost-based regulation constantly monitors a company's costs and revises the tariffs a company can charge accordingly. The effect of this extreme type of cost-based regulation on innovation can be summarised as follows: It would enable companies to conduct RD&D as companies would not bear any cost risk and additional costs would be immediately reflected in higher tariffs. However, it gives them no incentives to do so since any cost savings arising from RD&D would directly lead to lower tariffs. There are no additional profits arising for the company. As a consequence, engineers or managers that are keen to develop innovations and work in an innovative company will find a low-risk environment to try out new things under cost-based regulation. But from a profit point of view there is no reason for the company to make any effort to venture into new technologies or processes. This is in line with the more general point that cost-based regulation does not give the company any incentive to become more efficient.

In contrast to this theoretical extreme, where all costs are accepted and tariffs instantaneously adjusted, cost-based regulation in practice normally means that the regulator does not blindly accept all costs, but will evaluate costs, e.g. based on "used and useful tests" (for the US see Joskow 1989: 161).

More importantly in the context of this discussion, cost-based regulation is normally characterised by a regulatory lag, i.e. adjustments by the regulator of the company's allowed revenue or tariffs due to changes in its cost base lags behind these cost changes. To the extent to which the regulator does not require an ex-post refund at the regulatory review, efficiency gains can therefore be kept by the company for some time, thus providing an incentive for the company to engage in RD&D (Bailey 1974).

This adds an element of price-based regulation. Assuming that RD&D costs have been included in the company's cost base, the regulatory lag allows the company to earn extra profits if its RD&D efforts are successful while there is still no downside risk if an innovation fails.

At the end of the regulatory lag, when the regulator reviews the company's costs, tariffs will be adjusted and cost-savings passed on to consumers so that the rate-of-return a company can earn on its RD&D investments is capped.

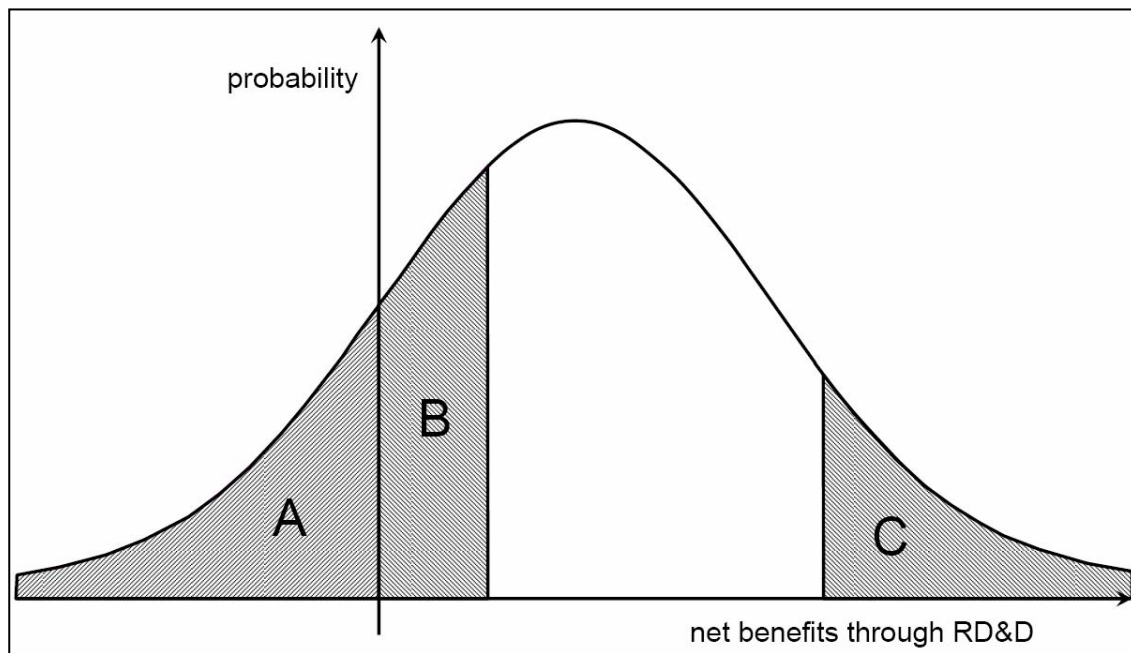
Overall, this version of cost-based regulation provides stronger incentives for a company to carry out research than the pure cost-based approach described above.

The following graph summarises the effects of cost-based regulation (cf. Mayo, Flynn 1988). It assumes that the net cost savings resulting from RD&D, i.e. innovation benefits minus innovation costs, follows a normal distribution. In some cases the net benefits will be negative, with the result that RD&D costs are higher than the savings achieved, partly due to the risky nature of innovation. However, it is assumed that there is a positive outcome overall.

Since costs can be passed on to consumers under cost-based regulation, a company is not exposed to losses, even if innovation costs exceed the benefits of innovation. Area A in Figure 1 is therefore not relevant for the company’s rate-of-return distribution resulting from RD&D. Capping the downside risk for the company will be referred to as lower-end truncation in the following. At the same time, some of the innovation benefits will be passed on to consumers too, with the result that the net benefits are reduced from the company’s point of view. This is represented by area C in Figure 1 and will be referred to as upper-end truncation. Together lower- and upper-end truncation determine the ability as well as the incentive of the regulated company to innovate.

If the regulator capitalises RD&D expenditures, the lower-end truncation would be even stronger as the company could always earn a positive rate-of-return on RD&D. This is shown by the shaded area B in Figure 1 (Mayo, Flynn 1988; see section “2.2.2 Capitalisation of RD&D costs”, page 11). Under pure cost-based regulation, the entire area under the curve would be ‘truncated’ as the company would not be exposed to any risk, neither upside or downside.

Figure 1: Truncation effects under cost-based regulation



1.2 Price-based regulation

Against the background of the innovation effects of cost-based regulation, I now turn to price-based regulation, which has become the dominant regulatory regime in the electricity sector and beyond. When price-based regulation as we know it today or ‘incentive regulation’ was first proposed by Littlechild in 1983, the assumption was that it is superior to cost-based regulation both in promoting productive efficiency and innovation (Armstrong et al. 1994: 167; Littlechild 2006: 2). The main argument is that companies benefit from cost reductions they can achieve, including cost reductions from process innovations, and would therefore make an effort to innovate. However, the effects of price-based regulation on innovation are more ambiguous, both theoretically and empirically, than

many promoters of price-based regulation have suggested. This ambiguity can be seen in the literature, but will also be derived from an analysis of the truncation effects of price-based regulation.

1.2.1 Evidence from the literature

Most studies on regulation and innovation are either not related to a specific sector or focus on the telecommunications sector (for an overview see Bourreau, Dogan 2001; Gerpott 2006). Especially price-based regulation in the telecommunications sector has received more attention compared to the electricity sector. It was introduced in this sector before the electricity sector and in fact, price-based or ‘incentive regulation’ in the form of ‘RPI-X’ was first developed to regulate British Telecom after privatisation. More importantly, while in the electricity sector, the network has not changed much since liberalisation and network innovations have not been an issue until very recently, the telecommunications sector has seen a highly dynamic development of its network infrastructure and innovations abound. One of the main rationales of liberalisation in this sector was indeed to foster technical change and network innovations.

The telecommunications sector therefore provides useful material for the analysis of economic regulation and lessons can be drawn for the electricity sector. However, the sector also exhibits a number of peculiarities we need to bear in mind. Most importantly, the majority of telecommunication networks are not natural monopolies anymore and the sector is characterised by (potential) infrastructure competition. The interplay between incentive regulation and competition is likely to lead to innovation dynamics that are different from the ones in the electricity sector, where infrastructure competition is only a fringe issue. In the telecommunications sector, innovation can be a way for companies to gain market shares whereas in the monopolistic electricity network, this will not drive companies to innovate. In the UK, for example, RD&D intensity in all major utilities sector has been falling except in the case of the telecommunications sector (Holt 2005).

The effect of different types of regulation on innovation has not been studied in much detail and the results that are available are ambiguous. Back in 1988, Mayo and Flynn (p. 32) concluded that the innovation effects of cost-based regulation have not received much attention and “*that research to date has shed only limited light on the impact of regulation on the innovative propensities of regulated firms*” (cf. Müller, Vogelsang 1979: 91-92). More than a decade later and after much more research has been carried out on regulation in general, Bourreau and Dogan (2001: 170) still find that “*the literature on regulation, in particular for an oligopolistic setting, is inadequate in presenting general results of the effect of ex ante regulation on the incentives for innovation*”. Regarding the comparison between cost-based and price-based innovation, Jamasb and Pollitt (2008: 1005) conclude that “*the effect of ROR [rate-of-return] versus price cap regulation on the rate of technical change has not been studied in detail*”.

There are arguments that price-based regulation promotes innovation (Magat 1976; Clemenz 1991)¹, but there is also the opposite reasoning (Kahn et al. 1999). Although incentive regulation in principle provides a framework for efficiency improvements including efficiency improvements through technical change, it can undermine the development of innovations at the same time.

In empirical terms, it is clear that the introduction of price-based regulation in the telecommunications sector coincides with a surge of new technologies. However, this has not been the case in the electricity sector; it would therefore be difficult to ascribe the innovation in telecommunications solely to the introduction of price-based regulation. There may be many other factors; as Ai and Sappington (2002: 134) have pointed out in their empirical study of the

¹ Magat analysed price ceilings already in 1976, which was later to become one important element of Littlechild’s ‘incentive regulation’ mechanism.

telecommunications sector, “*the task of isolating the impact of incentive regulation in a dynamic, complex industry like the telecommunications industry is a difficult one*”.

In a detailed overview on studies that have analysed the empirical effects of price-based regulation in the telecommunications sector, Gerpott (2006: 145-148) comes to the conclusion that the introduction of price-based regulation coincides with a significant increase in investments into network modernisation and increasing productive efficiency by incumbents. However, there is no conclusive empirical evidence of the effects of price-based regulation on RD&D and the innovation output by the industry. For the electricity sector, there is some evidence that price-based regulatory regimes have contributed to a decline in RD&D and innovation (Holt 2005; Jamasb, Pollitt 2008).

1.2.2 Main effects of price-based regulation

While the literature on price-based regulation and innovation is not conclusive, it is still possible to summarise the main arguments in this section and identify the main mechanisms through which price-based regulation can affect RD&D and innovation in a regulated industry. I use the discussion above on cost-based regulation as a reference point and once again differentiate between upper-end and lower-end truncation of risk.

Upper-end truncation

In terms of upper-end truncation, price-based regulation generally allows the company to retain a higher share of the innovation gains as compared to cost-based regulation. This is basically the main argument in the literature as to why price-based regulation is more innovation-friendly.

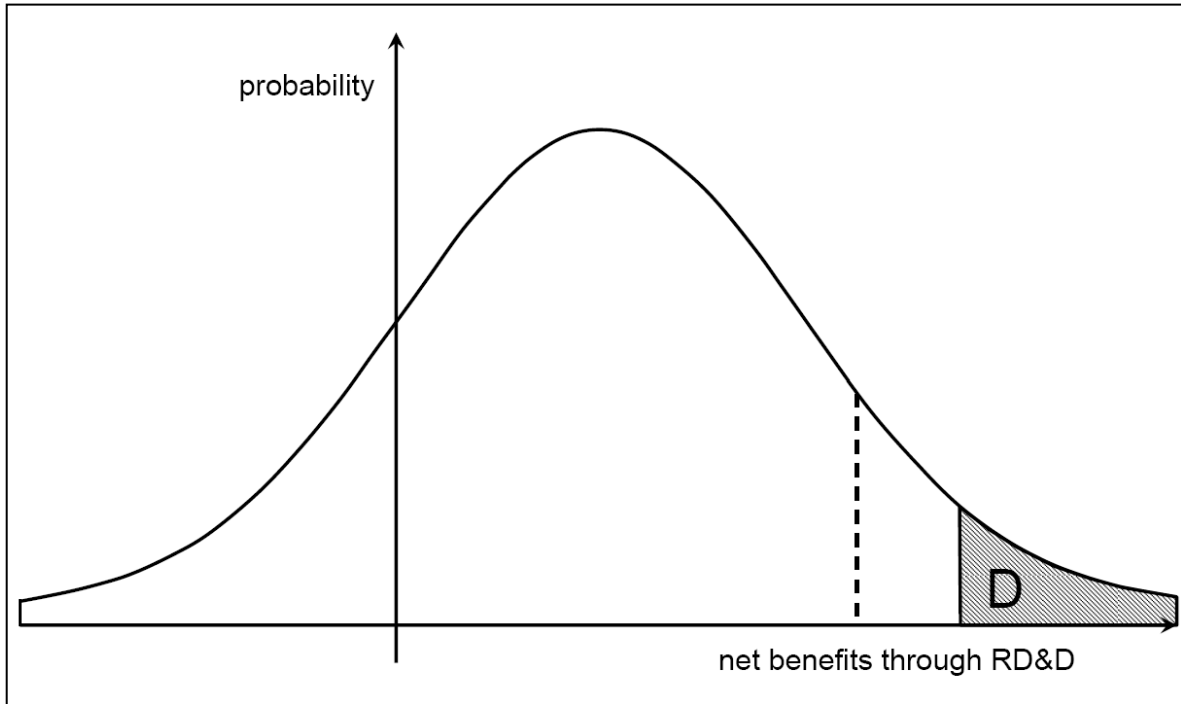
This is certainly true compared to pure cost-based regulation where tariffs are instantaneously adjusted. But also in comparison with ‘regulatory lag’ cost-based regulation described above, price-based regulation tends to leave a higher share of any innovation gains to the company. Area D in

Figure 2 therefore tends to be smaller than area C in Figure 1.

The differences in the upper-end truncation are due to the following reasons. Firstly, the regulatory period under price-based regulation tends to be longer than the regulatory lag under cost-based regulation, giving the company more time to appropriate any benefits. Secondly, the regulatory period is fixed ex-ante. This increases the certainty for the company as to how long it can benefit. Fixing the regulatory period ex-ante in a regulatory contract also protects the company against the regulator initiating a regulatory review precisely because the company has become more efficient due to innovations, which could potentially reduce the benefits for the company. In a cost-based regime, the regulator will generally be more inclined to introduce some kind of profit-sharing whereby the rate-of-return is capped and excessive profits have to be refunded to customers.

Overall, upper-end truncation under price-based regulation will be lower than in the case of cost-based regulation, i.e. a company can keep a higher share of the innovation gain it has generated. Nevertheless, companies under price-based regulation still face a truncation of innovation gains. While the rate-of-return is in principle not limited during a regulatory period, the truncation occurs at the next regulatory review. Upper-end truncation after the regulatory period can be especially significant if innovation gains accrue over a long time period. It may then be difficult for a DSO to recover the costs of an innovation within one regulatory period.

Figure 2: Truncation effects under price-based regulation



Lower-end truncation

With price-based regulation, truncation of benefits is generally lower than under cost-based regulation. However, the remaining truncation of benefits can be problematic if it is not matched by a corresponding lower-end truncation, through which the company does not only share innovation benefits, but also costs with its customers. With cost-based regulation, the upper-end truncation is combined with lower-end truncation: companies are not exposed to any significant cost-risk as additional costs will lead to higher tariffs. As a result, companies will not lose out if their RD&D efforts fail. If RD&D costs are treated as capital expenditures there may be even a positive rate-of-return on any R&D costs, irrespective of the innovation outcome.

This lower-end truncation ceases to apply under price-based regulation. Under pure price-based regulation, RD&D costs in principle need to be recovered through resulting efficiency improvements.² As a consequence RD&D efforts that do not generate enough benefits will entail losses for the company as shown in

² In practice, the company may be able to recover some of the costs directly, e.g. if RD&D costs result in the company being classified as inefficient in a comparative efficiency analysis, but needs to reduce this inefficiency only over a certain time period, or if other companies also spend on RD&D, and the related costs therefore do not show up as inefficient when companies are benchmarked against each other.

Figure 2. With price-cap regulation companies thus face the problem that they need to recover RD&D costs through efficiency gains, but those are still shared with customers after the regulatory period.

Overall effect of price-based regulation

Overall, price-based regulation has the following effects: Firstly, it introduces a higher upside and downside risk for companies compared to cost-based regulation. It generally allows a higher rate-of-return, but a company can also lose money. The probability distribution of additional returns that can be earned through RD&D becomes broader under price-based regulation, and the lower end can become negative. While under cost-based regulation, companies can normally earn a reasonable rate of return within a certain range, the rate-of-return can vary more widely with price-based regulation. This feature of price-based regulation becomes particularly relevant in the case of RD&D where the risk distribution is inherently higher.

Secondly, the mean of the rate-of-return distribution can be reduced from a company point of view compared to cost-based regulation. This is the case if price-cap regulation changes the truncation of the upside- and downside risk asymmetrically, i.e. if companies on the one hand bear the entire cost risk of RD&D, but on the other hand still have to share innovation gains with their customers relatively quickly.

In principle this problem applies to all cost-saving efforts undertaken by a company, not just RD&D. However, in the case of 'normal' cost-saving efforts, there is more certainty for the company in terms of the savings that can be achieved. It is also easier to calculate the net present value based on the costs, the savings that can be achieved and the proportion of savings it can retain. The company can counter the regulatory upper-end truncation by not carrying out measures that are not profitable anymore given this upper-end truncation.

In the case of innovation, there is inherently more downside risk as RD&D results are more uncertain. This however is not reflected in the upper-end truncation as the regulator does not normally differentiate between cost savings resulting from 'standard efficiency improvements' and those that have been achieved through riskier RD&D; in both cases savings will be shared with customers according to the same rules.

These arguments show how RD&D becomes riskier under price-based regulation; companies may therefore not spend on RD&D. At the same time, under price-based regulation companies are forced to reduce costs since the regulator generally imposes a revenue path which declines over a regulatory period and is partly based on benchmarking network operators against each other. On top of that, companies can increase their profits in the short term if they manage to outperform this revenue path. This gives companies an incentive to reduce costs in the short term, including RD&D costs. As a result, the static efficiency improvements that can be prompted by incentive regulation may run counter to dynamic efficiency improvements through technical change that can be achieved in the medium to long term, but require short-term expenditures.

Taking away the lower-end truncation and exposing the company to the cost of RD&D means that price-based regulation comes closer to a competitive market where companies also do not have the possibility of passing on any costs of RD&D to consumers. However, in terms of upper-end truncation, a competitive market with protection of property rights through patents can impose a weaker upper-end truncation on companies, with patents protecting innovation benefits for up to 20 years. Under price-based regulation, upper-end truncation is set by the length of the regulatory period, which is geared towards normal efficiency improvements rather than innovations.

1.3 Conclusion

Price-based regulation was thought to overcome the problems of cost-based regulation, not least of all with regard to innovation. However, both theoretically and empirically, there are only ambivalent and

rather tenuous results regarding the effect of regulation on innovation, for cost- as well as price-based approaches. Price-based regulation is not necessarily superior to cost-based regulation. There are a number of arguments and also some empirical evidence that price-based regulation can stifle innovative activities. Also, even if price-based regulation as such provided stronger incentives for regulation than cost-based regulation, it may still not be enough to match the innovation requirements, for example those resulting from the increasing share of DG.

What is certainly positive about price-based regulation is that it shifts the focus from RD&D inputs to innovation outputs, which may lead to more effective and efficient RD&D. However, the other side of the coin is that price-based regulation increases the risk for the regulated company: it exposes the companies to the RD&D costs while still truncating the innovation benefits.

These findings are reminiscent of the general argument made about the standard model of electricity liberalisation, namely that the model may encounter more problems in achieving objectives beyond short-term efficiency, including innovation, than has been previously envisaged.

The arguments made in this paper can be applied to cost-saving process innovations that help DSOs to become more efficient and thus meet or outperform the regulator's efficiency targets. It has become clear that even for these innovations, price-based regulation may weaken the incentives for RD&D; it may be more attractive for DSOs to reduce RD&D expenditures to meet the efficiency targets, rather than trying to reduce its costs through innovations.

The innovation incentives become even more ambiguous once the innovations not only aim at reducing the network costs, but also at enabling other objectives outside the network or at meeting these objectives at lower costs, as in the case of DG-related innovations discussed in this paper. In this case, at least part of the innovation benefits emerge as externalities for the DSOs and the innovations facilitate a development that may increase the overall network costs. It is clear that in a regime in which innovations costs need to be recovered through innovations benefits, the fact that at least some of the benefits are external to the DSOs further reduce the incentive for the DSOs to engage in such innovative activities.

The practical effects of the regulatory regimes under discussion and the actual lower- and upper-end truncation will depend on a number of parameters that need to be set by the regulator (e.g. which costs are accepted, what the short-term efficiency improvements demanded by the regulator are). How the different mechanisms I have identified interact in a real-life regulatory setting, is an empirical question. Overall, it is more useful in this context to move beyond comparisons of cost-based and price-based regulatory regimes and examine how these regimes can be designed in practice to promote innovation.

2. Regulatory approaches to innovation

Having looked at the way standard regulatory approaches affect innovation, I now turn to specific mechanisms to make network regulation more innovation-friendly. This is not a question of comparing both and choosing between cost-based or price-based regimes for the regulation of network tariffs, but of adapting these regimes to the requirements of RD&D and innovation by introducing specific instruments to promote RD&D and mixing cost- and price-based elements for that purpose. However, as regulatory regimes are generally price-based nowadays, the focus is on how various innovation-specific mechanisms, partly cost-based and partly price-based, can be added to this regime.

The literature on this issue is even more incomplete than the above-mentioned literature on the innovation effects of regulation. In terms of practical regulation, there are hardly any examples of regulators that have addressed this issue. The only major exception is the UK. The section attempts to structure different proposals that have been made and discusses the pros and cons.

When discussing instruments to promote innovation activities, one should bear in mind that there can also be too much innovation efforts and that RD&D can be inefficient from the point of view of social welfare. For example, capitalising RD&D costs as discussed below can lead to ‘gold-plating’ RD&D projects, i.e. spending too much on such projects to benefit from the guaranteed rate-of-return. RD&D should not be an end in itself and innovations should not just increase efficiency or yield new products or services, but rather they should do this in an efficient way. Although it will be impossible in this context to determine the right level of RD&D and the necessary costs in practical terms, efficiency should nevertheless inform the debate on regulation and should be used as a guideline when designing regulatory instruments.

There are a number of approaches to regulating RD&D and innovation in networks. In the following, I present them and distinguish between cost-based or input-based approaches on the one hand and price-based or output-based approaches on the other hand. Before discussing these approaches, the next section briefly discusses the issue of innovation externalities and additional objectives.

2.1 Removing innovation externalities for the DSO

In the previous section it was argued that price-based regulation can provide insufficient incentives for DSOs to invest in innovation, even if the innovation increases network efficiency and thus contributes to meeting the efficiency objective imposed on the company by the regulator. If the innovation contributes to meeting other objectives, the innovation benefits can appear as externalities for the regulated company, which further reduces the incentive to pursue these innovations. If DSOs do not have the objective to connect DG, they do not have an incentive to connect them in an innovative way, either.

This is why incentivising DG connections is an important prerequisite for promoting innovative DG connections. However, if companies do have an incentive to connect DG, they still face the general innovation problems described above that can result from regulation in general and price-based regulation in particular. It is therefore not sufficient to rely on DG objectives and incentives to promote DG-related network innovations, just as it is not sufficient to rely on the efficiency objective prescribed by incentive regulation to promote innovations that make the network more efficient.

It is therefore not convincing when Abildgaard et al. (2003: 4) propose that in order “*to prompt active networks and innovation, the revenue should become more dependent on network performance/output*”. The argument is that this approach would not prescribe the company what to do to meet these performance targets. The regulator would not need to judge whether innovations are necessary, but can observe how its performance criteria affect RD&D.

This would clearly simplify the regulatory process, but faces the same problems as incentive regulation in general. Under standard incentive regulation the performance criterion is based on efficiency and the regulated company can in principle choose how to meet this criterion. However, the asymmetric truncation of costs and benefits can lead to a bias towards short-term measures. The same would happen with additional performance criteria, unless they are set at such a high level that innovations are the only possible way to meet them.

What is positive about performance criteria in terms of innovation is that they could be one element of a long-term framework spanning several regulatory periods, as DSOs would know they will need to improve their performance along the lines of these output criteria beyond the next regulatory period, provided the regulator can credibly commit to retaining the performance criteria beyond one regulatory period.

Since removing externalities by adding new performance criteria is not enough, the following sections explore additional mechanisms to promote innovations.

2.2 Input-based mechanisms

Input-based or cost-based approaches target the costs of RD&D and explicitly include them in the regulatory scheme. It needs to be stressed that such cost-based approaches to innovation can be implemented well within a regulatory environment that is generally price-based. In this case, cost-based regulation of RD&D costs exempts these costs from the price-based regime.

First of all, a cost-based approach requires that the regulator recognises these costs when it determines a company's cost base. This in itself would send a signal to companies that the regulator sees innovation as an important issue and expects network operators to participate in development and demonstration projects. Alternatively, the regulator could argue that network operators should not spend money on developing innovations themselves, that these costs unnecessarily increase network tariffs and are therefore not included in the accepted cost base. Clearly, this exacerbates the disincentives against innovation compared to the analysis in section 0, as there is no truncation of costs whatsoever. If the regulator accepts the RD&D costs, then this would make the DSO less efficient in a comparative efficiency analysis with other network operators, but the less efficient DSOs may still be able to recover some of these "inefficient" costs. If the regulator does not accept any RD&D costs, then none of these costs can be recovered.

Most regulators have not explicitly addressed this issue yet (for the EU-15 see Skytte, Ropenus 2005), which in many cases means that companies will find it difficult to get RD&D costs accepted in a regulatory review. In the case of Australia, the former regulator for New South Wales, IPART, has explicitly decided not to allow the recovery of costs associated with learning by doing in the case of network-related demand-management projects (IPART 2004).

If the regulator accepts RD&D costs in principle, the next question is whether RD&D costs are accepted, but treated as any other costs, or whether the regulator acknowledges that RD&D is not sufficiently incentivised under normal price-based regulation and requires special treatment. In the latter case, two approaches can be distinguished: firstly, there can be a direct pass-through of costs to customers, secondly, research costs can be capitalised and treated as investment. They are not entirely separate, but as I discuss below, may be combined in different ways, depending on the overall regulatory regime.

Any separate treatment of RD&D related costs with cost pass-through or capitalisation is faced with the problem of how these costs can be clearly separated from other costs and poses the risk that DSOs will seek to shift costs that are not related to innovation into this special regime. It is therefore recommendable for the costs that can be passed through or capitalised to be capped.

2.2.1 Pass-through of RD&D costs

The first cost-based approach is a cost pass-through mechanism. This approach can be applied to pass the costs of RD&D to customers. Cost pass-throughs are often used for costs which a company has no control over by directly including these costs into network tariffs. In the case of passing through RD&D costs, the instrument is used to shield DSOs from the uncertainty of RD&D. The costs are not subject to any benchmarking, nor is the ability of the company to recover these costs capped by a price-based mechanism, even if the overall regulatory regime is price-based. In terms of the truncation effects discussed above, the approach introduces the lower-end truncation that is typical for cost-based regulation in a price-based regime.

Cost pass-throughs as specific instruments will typically be employed in a price-based environment, because with cost-based regulation all costs are passed through anyway. In a price-based environment, however, it represents a special treatment of the respective costs.

If RD&D costs are completely included in the pass-through mechanism in a price-based environment, RD&D essentially does not increase the company costs it has to recover via efficiency

improvement. At the same time, the innovation can help the company to become more efficient, thereby benefiting from the increased gap between price-cap and costs during a regulatory period. In other words, network customers pay for the RD&D efforts which then benefit the company, at least partially.

This combination of ring-fencing costs from the price-cap mechanism on the one hand and on the other hand allowing the company to keep, at least temporarily, the resulting benefits under that same price-cap mechanism should give the company an incentive to spend on RD&D and try and develop useful innovations. The approach can thus remedy the potentially weak innovation incentive in a price-based regime.

At the same time, however, the approach exhibits at least two potential short-comings: Firstly the risk distribution between the network company and its customers is uneven. The downside risk if RD&D does not generate any results lies completely with network customers, whereas the upside risk of useful innovations is shared between them and the network company. Secondly, and as a result of the first point, network companies have incentives for useful RD&D, but are not incentivised to be efficient – unless the amount of costs that can be passed through is capped.

2.2.2 Capitalisation of RD&D costs

Under the cost pass-through approach presented in the previous section, a large part of RD&D costs will be treated as operational expenditure. Alternatively RD&D costs can be categorised as an investment, i.e. RD&D costs are regarded not just as operational expenditure, but are capitalised, included in the regulatory asset base (RAB) and depreciated. As a result, the regulated companies can earn a rate-of-return on RD&D expenditures and these costs will therefore lead to a minimum rate-of-return, irrespective of any efficiency or quality improvements resulting from the innovation.

While a cost pass-through is not an option for promoting innovation in a cost-based environment (where costs are passed through anyway), capitalisation of costs (that are passed-through, but normally treated as OPEX) may be applied both in a price-based and a cost-based environment to promote innovations. A number of studies have analysed RD&D capitalisation in the context of ‘traditional’ cost-based regulation in the US (e.g. Mayo, Flynn 1988).

In a price-based environment, there are two options. Firstly, if price-based regulation applies to OPEX only, with investment still mainly cost-based, capitalisation would have a double effect: RD&D costs are both taken out of the price-based regime and the company can earn a rate-of-return on these costs. If price-regulation applies to total expenditures, capitalisation would only imply a rate-of-return on costs that were previously OPEX, but no cost pass-through. In this case, capitalisation would not be a cost-based mechanism anymore.

The capitalisation approach raises two questions: Firstly, how can it be justified that costs that are normally operational costs in accounting terms, are classified as investment by the regulator (except that this may serve the objective to promote innovation). The second question is whether the capitalisation approach actually promotes innovation?

Regarding the first question, Holt (2005: 3) has pointed out that, “*the economic rationale for capitalising the value of RD&D is that it is likely to generate benefits beyond the year in which these expenditures are made. In this respect such expenditure is like investment in any physical, tangible asset and could be capitalised into the RAB*”. In a similar vein Damodaran (no date) argues that RD&D expenses should not be treated as operating expenses, because they are not incurred to generate income in the current period, but to provide benefits over multiple periods. There are examples that such costs have been capitalised in other sectors (Competition Commission 2002).

The second question is whether the capitalisation approach actually promotes innovation. Based on an analysis of empirical data, Mayo and Flynn (1988) find that capitalising RD&D expenditures into

the rate base significantly increases the amount of money spent on RD&D by the regulated company. This supports the theoretical argument that this approach takes away the downside risk from companies and insures that regardless of whether RD&D expenditures lead to innovations and cost reductions sufficient to justify the costs of RD&D they will in any case generate the allowed rate-of-return (lower-end truncation).

Already we arrive at the first problem: Capitalising RD&D expenditure may increase the amount of money spent on RD&D, but it should not be equated with an increase in useful innovations. In other words, companies have an interest in RD&D, but not necessarily an interest in the productive outcome of innovations. Increasing RD&D expenditure, however, is not an end in itself, and does not necessarily translate into innovations. With this approach, there is a danger that capitalising RD&D expenditures can lead to an inefficient over-investment in RD&D or ‘gold-plating’ of RD&D projects, similar to the more general problem that rate-of-return regulation can lead to excessive capital expenditure (Averch-Johnson effect).

A further problem of capitalising RD&D expenditures can be that it gives companies an incentive to declare as many costs as possible as RD&D costs. Since DSOs will not get involved in basic research in most cases, but will test how an innovation can be implemented in its network in, for example, demonstration projects, most innovation costs will not be incurred in a specialised RD&D centre, but will more likely be linked to ‘normal business’. In practice it will therefore be difficult to assign costs to the RD&D budget that is to be capitalised.

Under price-based regulation, the positive effect of the capitalisation approach on RD&D should be even stronger in principle, because the upper-end truncation is generally weaker. As opposed to cost-based regulation, this gives companies some incentive to aim for useful innovations.

Finally, if capitalisation increases the amount of money spent on RD&D, it may reflect an inefficient RoR set by the regulator. As Holt (2005: 4) has pointed out, “*capitalising or expensing expenditures should not have any present-value effect for the firm if the allowed rate of return is set at the level of the cost of capital (determined by the regulator). Therefore, any additional R&D spending could reflect a generous cost of capital, and it would be difficult to determine whether these additional expenditures were ‘efficient’.*”

2.3 Output-based mechanisms

While the approaches discussed in the previous section tackle the input side of RD&D, I now turn to mechanisms that are based on RD&D outputs, i.e. actual innovations. While input-based approaches basically take away the cost risk from companies (introducing lower-end truncation), output-based approaches make the innovation outputs more attractive for them (relaxing the upper-end truncation). Under these approaches, companies can only benefit from successful innovations. I present the following output-based approaches:

- including innovation outputs in price-based regulation through additional revenue allowances, raising the cap imposed by the regulator;
- extending the regulatory period;
- regulatory holidays, effectively removing the cap on the regulated company for a limited period of time.

One general problem of output-based approaches is that innovation outputs are even more difficult for the regulator to define and identify than innovation inputs.

2.3.1 Raising the cap based on output criteria

In a price-based-environment, companies can generally not directly recover the costs of RD&D, but have to recover them through the cost-savings relative to the revenue cap imposed by the regulator. If a company develops and introduces an innovation, the regulator can raise this cap, thereby allowing the company to recover some of the RD&D costs through the resulting higher revenue. As opposed to cost-based approaches, under a price-based mechanism this additional revenue allowance is not directly linked to the underlying costs a company has incurred, but is a function of the actual innovation, thus assuming an average cost value. The effect for the company would be that it still carries the downside risk of RD&D, but due to a higher cap the upside truncation is less severe and there is a higher potential for the company to benefit from successful innovations, at least as long as the costs of developing these innovations are matched by the higher cap.

While input-based approaches have to be based on a sound definition of RD&D costs, the main challenge with this approach is to define what exactly should drive the cap, or in other words how innovations can be defined. Two approaches to define revenue drivers can be differentiated: Firstly, it has been proposed that general innovation-related output criteria such as patents be used (Holt 2005: 4). While this indicator is relatively easy to measure, the question is whether it can adequately reflect RD&D efforts by regulated network operators, especially as they will mainly be involved in demonstrating and implementing innovations. Also if the patent is held by a manufacturer outside the regulated industry, but the DSO still plays an important role in the innovation process, it would not be covered by this indicator.

Secondly, the regulator can define ex-ante what counts as innovation or rewards innovations in a specific area, e.g. innovative connections of DG. This is the approach that has been applied by Ofgem in the UK under the Registered Power Zone scheme (Ofgem 2004). While this approach can be more targeted, there is also a significant danger of the regulator micro-managing RD&D.

2.3.2 Extending regulatory periods

During regulatory periods, efficiency gains that exceed the efficiency gains foreseen by the regulator at the beginning of the regulatory period lead to higher profits. During these periods, companies can appropriate the benefits of innovation. At the beginning of the next regulatory period of an incentive scheme, efficiency gains are shifted to consumers. Under rate-of-return regulation, the regulatory lag has the same effect in principle.

While the previous approach “Raising the cap” relaxes the upper-end truncation by allowing the company to increase its revenue and make a higher profit during a regulatory period, the approach discussed in this section leaves the revenue cap untouched, but gives the company more time to benefit from reducing its costs below this cap.

It can be argued that the regulatory lag or regulatory period has a similar effect on the incentive to innovate as patents, in that it protects the gains made through innovations (Schoppe, Wass von Czege 1984: 147; Bailey 1974). While patents protect the innovation from being imitated by competitors for a certain period of time, the regulatory period protects the benefits of innovations from being passed on to consumers.

In a theoretical study, Bailey (1974: 295) has shown for rate-of-return regulation that extending the regulatory lag does have a positive effect on RD&D activities: *“If regulatory lag is short, the firm will adopt a lower level of innovative activity. If the lag is longer, then the firm innovates more but society does not obtain as quickly the benefit in the form of lower prices”*.

Based on these arguments, Fuckso et al (2004: 38) have proposed for network regulation in Hungary to extend the regulatory period from four to five years. The period between regulatory reviews would thus be deliberately used by the regulator to influence the innovation propensity of

regulated companies. Under price-based regulation with its regulatory periods that are determined ex ante, this is in principle an option that is available to the regulator. Under cost-based regulation it may be more difficult for the regulator to commit ex-ante to an extension of the lag.

While it is plausible that the length of the regulatory period influences a company's propensity to innovate, simply extending the regulatory period to provide innovation incentives does not seem to be a solution for at least three reasons. Firstly, the innovation incentive is not unambiguous. In another theoretical study of cost-based regulation, Sweeney (1981) has come to the conclusion that while the regulatory lag does play an important role for the incentive to innovate, companies may also have an incentive to delay the adoption of innovations due to the lag, as such a delay would also postpone the price reduction imposed by the regulator.

Secondly, as has already been indicated by the citation from Bailey, there is also a trade-off between innovation incentives and shifting innovation benefits to consumers. In fact, there is a more general trade-off between efficiency incentives for the company and allocative efficiency that needs to be taken into account when discussing an extension of the regulatory period. In other words, an extension cannot solely be judged from an innovation perspective. The longer the regulatory period, the more a company can benefit from improved efficiency, yet the more the prices deviate from the costs. Also, a new regulatory period gives regulators the opportunity to fine-tune and adapt regulatory mechanisms based on the experiences made. As a consequence, the regulatory period should not be too long.

The question arises if given this constraint the regulatory period can be long enough to stimulate innovations. Regulatory periods normally are between three and five years; Fucsko et al. (2004: 38), when putting forward their proposal to extend the regulatory period to promote innovations, concede that a one-year extension does not do much to promote innovation. Yet a longer extension does not seem to be feasible, given other regulatory objectives and constraints.

Finally, there is an important difference between patents and regulatory periods. While patents protect one specific innovation, extending the regulatory period would not just affect innovations developed by a company, but would be valid for the business as a whole.

In order to differentiate between innovation effects and the rest of the business, Holt (2005) has proposed to "*allow companies to retain the benefits of efficiency savings derived as a result of undertaking RD&D for longer than the current five-year period for 'conventional' efficiency savings*". However, it is doubtful whether this approach is feasible in practice. It would require a detailed analysis by the regulator as to which efficiency savings can be traced back to a company's RD&D efforts. The fact that some in-house RD&D can lead to efficiency savings by enabling a company to appropriate external RD&D results would make this process even more complicated.

In summary, extending the regulatory period to stimulate RD&D and innovation cannot provide strong enough incentives, especially given the constraints of the overall regulatory process.

2.3.3 Removing the cap: Regulatory holidays

Another approach that has been discussed mainly in the telecommunications sector are so-called access or regulatory holidays (Gans, King 2004a; Gans, King 2004b). Under this approach, the cap is not just raised, but a certain part of the network is temporarily exempted from regulation, i.e. the cap is lifted altogether and the network company can in principle charge monopoly prices. Again, this is similar to patents in some ways.

This mechanism seems quite radical compared with the previous mechanisms that seek to amend tariff regulation, rather than to intermit it. So why have regulatory holidays been proposed? The reason is related to the truncation problem I have discussed earlier.

An RD&D project (or an investment in general) has a rate-of-return probability distribution, i.e. the project can fail or be successful in various degrees. Now assume an RD&D project is highly successful and generates a high RoR. In their analysis focusing on the telecommunications sector, Gans and King argue that the regulator may consider this too high and intervene to reduce it to a 'reasonable' level, e.g. to avoid any 'fat cat' claims of excessive profits from the political side or network customers.

Ex-post – i.e. once the project has turned out to be successful – the reduced rate of return may still be sufficient for the company, and leads to lower network tariffs that enable efficient use to be made of the network including the innovative facility. However, from an ex-ante point-of-view, this additional upper-end truncation of the probability distribution would have reduced the average rate of return, and may have made the project with this adjusted risk profile unprofitable. In other words, if the company expects in advance that the upper end will be truncated, it would not have invested in the first place as the regulatory risk further truncates the potential profit. The problem is, as argued by Gans and King, that the regulator cannot credibly commit ex-ante that it will not exploit the company's sunk costs ex-post. From this perspective, the only way around this problem is to introduce regulatory holidays, i.e. the regulator does not commit to adhere to a certain overall rate of return, but commits to discontinuing regulation for a certain period of time, allowing the company to fully exploit its investment.

The analysis that leads to the regulatory holiday proposal is similar to the analysis of price-based regulation I have presented in section 0. The underlying problem is the asymmetric truncation of cost and benefits: If the project fails, the company is stuck with the costs; if the project is successful, part of the benefits is passed on to consumers without taking into account the risk associated with achieving these benefits. In the analysis provided by Gans and King the asymmetry results from the fact that the regulator cannot credibly commit to not truncating the upper-end ex-post. In the analysis provided in section 0, the asymmetric truncation is due to the fact that the regulator cannot distinguish between benefits that result from normal efficiency improvements on the one hand and innovative efforts with a higher risk on the other hand. As a result, the regulator applies the truncation that is appropriate for normal business to the riskier investments, too.

In the telecommunications sector with potential infrastructure competition, the regulatory holiday approach may be applied to entirely new networks, like a cable network for pay TV, which is the example used by Gans and King, or a VDSL (Very-High-Data-Rate Digital Subscriber Line) network, which was proposed by the German government. But even in the telecommunications sector, the approach is highly controversial, both politically (the German proposal was rejected by the European Commission) and theoretically (Blankart et al. 2006).

In the electricity sector, the approach is even more problematic. Firstly, as there is no potential for infrastructure competition, it cannot be argued that network users that face monopoly prices during a regulatory holiday can switch to or build up an alternative network. Also, as innovations in this sector are typically more embedded in the existing network, it would be difficult to identify which part of the network should be exempted. Exemption of the whole network in which an innovative company operates could not be justified. I could not find any practical examples where electricity regulators have applied this approach.

2.4 Conclusion

The discussion in this section has shown that there are mechanisms available within the incentive regulation framework to counter the weak innovation incentives of the standard model and promote innovation. Price-based regulation as such can reduce incentives for innovation as compared to cost-based regulation. However, as an additional innovation-oriented mechanism both price-based and cost-based approaches can be designed to promote innovations. The general advantages of incentive

regulation – that it can help the regulator deal with information asymmetries and can trigger efficiency gains – are relevant to the promotion of innovations, too.

In terms of the individual mechanisms discussed, both the extension of regulatory periods and regulatory holidays have been found to be inappropriate for the promotion of innovations, at least in the electricity sector. For the other mechanisms, specific incentive properties and regulatory issues have been identified. For the design of these innovation mechanisms it is important whether the objective is to trigger efficiency gains or to support additional objectives.

Cost- and price-based approaches are theoretical extremes cases that can be mixed in different ways. This is not only because in the course of practical implementation the boundaries get blurred, but also because elements of both approaches are intentionally mixed to give companies certain incentives and achieve certain results. Such hybrid mechanisms have already been discussed for the promotion of DG more generally (Bauknecht, Brunekreeft 2008). Similarly, the input- and output-based mechanisms discussed in this section can be combined to promote RD&D and innovation.

3. Beyond the incentive regulation mechanism

The previous sections have shown that the standard model can provide insufficient incentives for innovation, but the very mechanisms of the standard model can be adapted to promote innovation. The last section on innovation specific mechanisms was mainly concerned with amending the incentive regulation mechanism itself. This final section of this paper broadens the perspective beyond the “incentive regulation formula” in two ways: firstly, it discusses whether incentive regulation is the right place to promote network innovations; secondly, it discusses the policy-regulation interface and how it is affected by innovation mechanisms.

3.1 Is economic regulation the right place to foster innovations?

3.1.1 Critique from the perspective within regulatory economics

Innovation mechanisms have not been a major issue in the standard model literature, but proponents of the standard model generally tend to be reluctant to include new mechanisms in this model to pursue new objectives. This is the case although these can be based on the very mechanisms of the standard model. There are several reasons for this reluctance:

Firstly, when the standard model was introduced, it was claimed that it improves the conditions for innovations in electricity networks. It is clear that based on this claim, additional mechanisms seem unnecessary.

Secondly, there is the argument that regulatory interventions are unlikely to have the desired effect on the innovation outcomes (e.g. Gerpott 2006: 148 on the telecommunication sector).

Thirdly, additional mechanisms are assumed to weaken the core efficiency incentives of the standard model and lead to negative side effects. For example, Brunekreeft and Ehlers (2006: 82-83; cf. Pollitt 2008: xxx) are concerned about the consistency of the overall regulatory framework and potential contradictions between different elements if new mechanisms to pursue additional objectives are added.

While this is certainly a serious issue, it is largely a matter of properly designing mechanisms, but not a fundamental argument against such additional incentives. We also need to bear in mind that additional mechanisms are not necessarily added to a hitherto consistent framework. Although economic regulation itself may be consistent, there can be significant inconsistencies between ‘pure’ incentive regulation incentivising DSOs against RD&D (as shown in section 0), on the one hand and policies outside network regulation that require and/or promote innovations on the other hand.

A more serious argument against regulatory innovation mechanisms is the fact that additional mechanisms within incentive regulation are to be paid by network customers. Shifting the innovation costs to customers of individual networks can be problematic especially if the innovations not only benefit network customers in one network area, but also help support national policy objectives. In this case, it is clear that these objectives should be pursued through innovation instruments outside economic regulation.

For example, in Australia the former regulator for New South Wales, IPART, decided in 2004 to set up a programme to facilitate “demand-side management”, including “embedded generators”. In this context, the regulator decided not to include costs associated with ‘learning by doing’, arguing that it is “*inappropriate for customers to bear the costs of knowledge-building or experimental demand management activities – rather, this is a role for government or the distribution network services providers themselves*” (IPART 2004: 94).

If innovations are to be financed via network charges, an alternative to economic incentives for individual companies are public service obligation funded by all customers. For example, this approach has been applied in Italy and Denmark (Bauknecht et al. 2007).

However, even if one argues that economic regulation is not the best place to support innovations and that RD&D should be mainly supported outside regulation, e.g. through public funding, the economic incentives of network companies are still largely influenced by economic regulation. Regulation should therefore at least point into the same direction as other instruments outside regulation. This can be achieved by applying the mechanisms discussed earlier. The practical design of the instruments should take into account any support outside regulation, e.g. when determining the relevant parameters.

For example, if network companies receive part-funding for RD&D projects through research programmes outside regulation this represents a form of lower-end truncation. However, economic regulation still needs to take into account the company’s own contribution to the projects funded under this programme and generally support the innovation objectives pursued by the research programme. In summary, economic regulation should not be the main instrument for providing RD&D funding. Yet if ‘pure’ incentive regulation is applied with the innovation incentives analysed earlier, it is likely to be inconsistent with innovation instruments outside regulation. Innovation mechanisms within economic regulation are therefore still necessary and need to be consistent with innovation instruments outside regulation.

3.1.2 Critique from the perspective outside regulatory economics: Are revenue incentives sufficient?

Also from outside the regulatory economics perspective and based on the innovation perspective put forward for example by evolutionary economics, a number of short-comings of the above discussion on amending the standard model become visible. Most importantly, the mechanisms discussed tend to assume that innovation is an optimisation process performed by individual companies. This means that the company compares known RD&D inputs with known RD&D outputs and decides to spend on RD&D projects in order to maximise its RD&D benefits. From this perspective, innovation is analysed like an investment made by the network company. With the mechanisms presented above, the regulator changes the economic parameters of this optimisation process in order to influence the innovations outputs or the efficiency of RD&D.

In contrast to this view, the evolutionary economics literature argues that innovation is not a rational optimisation with perfect foresight, but is characterised by bounded rationality and imperfect information as well as institutional factors that influence a company’s decision-making. In other words, innovation is no longer regarded as an input-output relation, with RD&D spending as the most relevant input factor and with upper- and lower-end truncation from the company’s perspective.

Rather, innovation processes are put into a wider context that constrains and directs the innovation process. In the case of network innovations this can include, for example:

- the RD&D capacity of regulated companies that is a prerequisite to react to external price signals,
- the RD&D culture and routines within companies that guide the search for new solutions,
- innovation networks, e.g. the link between regulated companies and equipment suppliers which is necessary for the regulated companies to introduce innovations in their network,
- general visions and expectations of future network developments, e.g. in the sector itself or in the political realm that guide innovation processes within individual companies beyond a mere input-output optimisation.

In this perspective the regulated companies can hardly be characterised as rational, optimising actors that adapt their RD&D and innovation strategy more or less instantaneously to changes in the economic incentives given by regulation. Nevertheless, economic regulation does represent a key factor influencing the decision-making processes of regulated companies, including decisions to build up internal RD&D capacities and establish links into an innovation network. Applying the terminology of the evolutionary perspective on innovations, economic regulation is an important element of the *selection environment* in which innovations develop.

Therefore, even if amending revenue incentives is not sufficient, it is still necessary – not least of all in order to ensure that economic regulation is consistent with other approaches that are based on evolutionary thinking on innovation. The conclusion from this discussion is thus in line with the outcome of the previous section. Incentive regulation is not a neutral instrument, where one can decide whether or not to use it to incentivise innovations. Rather, even in its ‘pure’ form it provides innovation-related incentives that need to be altered in line with innovation objective and instruments outside regulation.

3.2 Policy-Regulation Interface

The previous section has already highlighted that the discussion on promoting innovations via economic regulation cannot be limited to the incentive regulation mechanism itself. Rather, it needs to be seen in broader energy and innovation policy context. This is necessary for two reasons: firstly, economic regulation needs to be coordinated with other innovation instruments as discussed before; secondly, even if network innovations were only facilitated through network regulation, this has a political dimension, too. This is the case irrespective of whether innovations increase efficiency or support other objectives.

If the objective of innovation mechanisms is ‘merely’ to promote innovations to further increase network efficiency, the design of innovation mechanisms could be left to the regulator, provided that innovation was a well-understood optimisation process. In this case, the innovation mechanisms could be designed so that their additional costs for network customers are justified by the expected innovation benefits. The regulator could deal with this additional efficiency potential within its efficiency remit.

In the traditional regulatory economics literature innovation tends to be portrayed as an optimisation process that allows the regulated company to maximise its profits. For example, Bailey has modelled regulation based on the firm’s objective “*to select that level of innovative activity which, for any stated value of the regulatory lag T , maximizes its discounted stream of net profits*” (Bailey 1974: 286). More recent insights into the innovation process like those presented in the evolutionary economics literature (e.g. Dosi et al. 1988) undermine the notion that the company is able to determine an optimal level of innovation effort.

What is more, modern regulatory economics stresses the information asymmetry between the company and the regulator. As a consequence, any knowledge about the right level of RD&D the company may have is not easily accessible to the regulator. Incentive regulation aims at overcoming this information asymmetry. However, while benchmarking procedures may give the regulator an idea about efficient network provision, the benefits of RD&D are much more difficult to assess. It is therefore hardly possible for the regulator to gain an insight into the right level of RD&D, at least not in the sense that this could justify innovation specific mechanisms in the first place.

The decision to set up regulatory mechanisms for innovations will therefore not be based on a computer model or the like that identifies innovations as a way to increase efficiency. Rather, it represents a more fundamental decision to shift the regulatory agenda based on an overall judgement of the sector and its development potential: from short-term efficiency gains to long-term network development and the implementation of innovative network concepts at short-term costs. As the benefits of this shift are uncertain, it basically becomes a decision whether to err on the side of over- or under-inclusiveness (Baldwin, Cave 1999: 104). In the context of this discussion, this refers to the risk of spending too much or too little on innovation. This is ultimately a political decision.

If innovations are to support objectives beyond efficiency the political dimension becomes even more apparent. In this case, the decision to be made is not just about the *level* of innovation, but the additional objectives also determine the *direction* of innovation, which even more strongly calls for a political decision and needs to be coordinated with overall energy policy objectives. If there is a political decision to support DG and related network innovations, this can be the basis for the regulator to support these innovations and to err on the side of over-inclusiveness.

References

- Abildgaard, J., Hindsberger, M. and Lilledahl, E.B. (2003), *Regulatory Road Map For Denmark*, Sustelnet project report.
- Ai, C. and Sappington, D. (2002), 'The Impact of State Incentive Regulation on the U.S. Telecommunications Industry', *Journal of Regulatory Economics*, 22 (2), 133-160.
- Armstrong, C.M., Cowan, S., Vickers, J. (1994), *Regulatory Reform, Economic Analysis and British Experience*, Cambridge, MA: MIT Press.
- Bailey, E.E. (1974), 'Innovation and Regulation', *Journal of Public Economics*, 3 (3), 285-295.
- Baldwin, R., Cave, M. (1999), *Understanding Regulation - Theory, Strategy and Practice*, Oxford: Oxford University Press.
- Bauknecht, D., Brunekreeft, G. (2008), 'Distributed Generation and Network Regulation', in Sioshansi, F.P. (ed), *Competitive Electricity Markets: Design, implementation and performance*, Oxford: Elsevier, pp. 469-497.
- Bauknecht, D., Leprich, U., Späth, P., Skytte, K. and Esnault, B. (2007), *Regulating Innovation and Innovating Regulation*, DG-GRID project report.
- Blankart, C.B., Knieps, G. and Zenhäusern, P. (2006), *Regulation of New Markets in Telecommunications? - Market dynamics and shrinking monopolistic bottlenecks*, Institut für Verkehrswissenschaft und Regionalpolitik, Discussion Paper, Freiburg.
- Bourreau, M. and Dogan, P. (2001), 'Regulation and innovation in the telecommunications industry', *Telecommunications Policy*, 25 (3), 167-184.
- Brunekreeft, G. and Ehlers, E. (2006), 'Ownership unbundling of electricity distribution networks and distributed generation', *Competition and Regulation in Network Industries*, 1 (1), 63-86.
- Clemenz, G. (1991), 'Optimal price-cap regulation', *The Journal of Industrial Economics*, 39 (4), 391-408.
- Competition Commission (ed) (2002), *The supply of banking services by clearing banks to small and medium-sized enterprises*, London.
- Damodaran, A., *Research and Development Expenses: Implications for Profitability Measurement and Valuation*, Stern School of Business, New York.
- Dosi, G., Freeman, C., Nelson, R.R., Silverberg, G. and Soete, L. (eds) (1988), *Technical Change and Economic Theory*, London: Pinter.
- Fucsko, J., Kis, A. and Bartus, G. (2004), *Regulatory road map for Hungary - Road Map for Transition of the Regulatory Framework of the Hungarian Electricity Supply System*, MAKK, Sustelnet project report.
- Gans, J.S. and King, S. (2004a), 'Access Holidays: The Panacea for Network Infrastructure Investment?', *Utilities Policy*.
- Gans, J.S. and King, S.P. (2004b), 'Access Holidays and the Timing of Infrastructure Investment', *The Economic Record*.
- Gerpott, T.J. (2006), 'Innovation und Regulierung in der Telekommunikationswirtschaft', *Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung* (Special issue 54), 133-153.
- Holt, D. (2005), *Where has the innovation gone? R&D in UK utility regulation*, Oxera, Agenda November 2005.

- IPART (Independent Pricing and Regulatory Tribunal of New South Wales) (ed) (2004), *NSW Electricity Distribution Pricing 2004/05 to 2008/09, Final Report*.
- Jamasb, T. and Pollitt, M. (2008), 'Liberalisation and R&D in network industries: The case of the electricity industry', *Research Policy*, 37 (6-7), 995-1008.
- Joskow, P.L. (1989), 'Regulatory Failure, Regulatory Reform, and Structural Change in the Electrical Power Industry', *Brookings Papers on Economic Activity*, 1989, 125-208.
- Kahn, A.E., Tardiff, T.J. and Weisman, D.L. (1999), 'The Telecommunications Act at three years: an economic evaluation of its implementation by the Federal Communications Commission', *Information Economics and Policy*.
- Littlechild, S. (2006), *Beyond Regulation*, CWPE 0616; EPRG 0516.
- Magat, W.A. (1976), 'Regulation and the rate and direction of induced technical change', *The Bell Journal of Economics*, 7 (2), 478-496.
- Mayo, J.W. and Flynn, J.E. (1988), 'The effects of regulation on research and development: theory and evidence', *Journal of Business*, 61 (3), 321-336.
- Müller, J., Vogelsang, I. (1979), *Staatliche Regulierung - Regulated Industries in den USA und Gemeinwohlbindung in wettbewerblichen Ausnahmehereichen in der Bundesrepublik Deutschland*, Baden-Baden: Nomos.
- Ofgem (Office of Gas and Electricity Markets) (ed) (2004), *Electricity Distribution Price Control Review - Regulatory Impact Assessment for Registered Power Zones and the Innovation Funding Incentives*, London.
- Pollitt, M. (2008), 'Foreword: Liberalization and Regulation in Electricity Systems - How can We get the Balance Right?', in , *Competitive Electricity Markets: Design, Implementation, and Performance*: Elsevier.
- Schoppe, S.G., Wass von Czege, A. (1984), 'Alternative Theorien über innovative Auswirkungen von Preisregulierungen', in Boettcher, E., Herder-Dorneich, P. and Schenk, K. (eds), *Jahrbuch für Neue Politische Ökonomie*, Tübingen: J.C.B. Mohr, pp. 142-156.
- Skytte, K. and Ropenus, S. (2005), *Regulatory Review and International Comparison of EU-15 Member States*, DG-GRID project report D1.
- Sweeney, G. (1981), 'Adoption of cost-saving innovations by a regulated firm', *The American Economic Review*, 71 (3), 437-447.

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