INVESTMENT INCENTIVES IN THE CONTEXT OF REVENUE CAP REGULATION

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ABSTRACT
In this paper an evaluation of investments in the context of revenue cap regulation is presented. The influence of a pure RPI-X regulation on the internal rate of return (IRR) is analysed in a first model. A second approach considers the impact of the behaviour of other market participants by means of game theory. Both methods show several negative effects on the IRR and increasing constraints on investments in case of uncertainty.

INTRODUCTION
While rate of return regulation was criticism as promoting overinvestment and lacking incentives to increase cost efficiency, the risk of underinvestment is a key issue of incentive regulation. It is particularly important for an infrastructure business that increasingly requires replacement investments in many countries, to have a good understanding about how misleading incentives develop and which impact they might have. This paper therefore presents an analysis of investment incentives in the context of a pure RPI-X regulation and highlights some general trends. This provides the basis for a discussion about other instruments such as quality regulation and special investment incentives.

In the first part of this paper the results of a simulation are presented. The deterministic model focuses on the impact of regulation on the IRR and includes a sensitivity analysis. In the second part, it is revealed that the results depend on the behaviour of other market participants as well. The assumption is that investments potentially influence future effects on the IRR and increasing constraints on the third year of each regulatory period. Therefore, an analysis of investment incentives in the context of a pure RPI-X regulation and highlights some general trends. This provides the basis for a discussion about other instruments such as quality regulation and special investment incentives.

IMPACT OF REGULATION ON THE IRR – A DETERMINISTIC APPROACH
The basis for the calculations is the IRR presenting the rate of return, for which the NPV (net present value of the project) is zero. With an investment \( I_0 \) at \( t = 0 \), an expected cash return of \( R_t \), an interest rate \( q \), an asset depreciation range \( N \) and without revenues from liquidation the NPV is given by:

\[
NPV = -I_0 + \sum_{t=0}^{N} R_t (1 + q)^{-t}
\]

The IRR then fulfils the following condition:

\[
-I_0 + \sum_{t=0}^{N} R_t (1 + IRR)^{-t} = 0
\]

It is assumed that companies decide in favour of investments if the IRR is at least as high as the imputed interest, or in other words: as long as costs are at least covered. In the simulation, the IRR that would result for a regulated company does not depend on the actual amount of investment, therefore all results refer to a standardised investment of \( I_0 = 1 \). In the following section the setup of the model and the assumed regulatory framework are presented. The effects of regulation on the IRR are then explained before showing the results and the sensitivity analysis.

Description of the model
The analysis focuses on a pure RPI-X regulation; additional regulatory instruments will be discussed later. Thus costs are decoupled from revenues within the regulatory lag. The revenue cap in the year \( t \) and in the regulation period \( j (R_{j,t}) \) equals the initial revenues \( R_{start,j} \) adjusted according to both the retail price index \( (X) \) reflecting the depreciation of money and to the efficiency requirement \( (X) \). The latter covers the varying potential to increase efficiency which the distribution system operators have compared to the whole economy. It can moreover reflect the lack of efficiency of a specific company compared to the most efficient reference firm of the industry.

\[
R_t = R_{start,j} (1 + t(RPI - X))
\]

In the model the regulation period has a duration of 5 years (in accordance with the German law). As a simplification, the RPI is assumed to be 2% for the full time considered. The efficiency requirement either starts at 3% and then decreases (Scenario 1) or it starts at 1.5%, increases up to 3% and decreases afterwards (Scenario 2). The first Scenario symbolizes the decreasing potential of the company to increase its efficiency further when reaching higher levels of efficiency. The regulator takes this into account and decreases the efficiency requirements. In the second scenario, the regulator was too cautious at first. Therefore the requirement increases in the second regulation period and then starts to decrease. On the whole, the potential of the company to minimize total costs was limited to 50%. This assumption leads to a more conservative calculation as the IRR would be lower without the limit.

The company has the choice either to invest or not. In case it decides to invest, the investment \( I \) is depreciated linearly over 40 years \((N) \). According to German law, the allowed rate of return \( (r^*) \) is 5.66% assuming that the project is financed with 40% equity and 60% debt and without consideration of taxes (A sensitivity analysis will show the results for other values of \( r^* \)). The cost review takes place in the third year of each regulatory period. Therefore an investment within years 1 to 3 of the first regulation period...
leads to a higher revenue cap in the second period; investments in years 4 and 5 are considered in the third period. Such a time lag is a characteristic of RPI-X regulations. To increase the general validity of the model, the construction time is set to zero and taxes are not included. The taxes depend on the legal framework of the considered country and the construction time depends on the characteristics of the project. Both issues would lead to a lower IRR. Ballwieser (2008) [1] e.g. specifies the effects for Germany. Summarizing, the results of this simulation present the maximal IRR that can be achieved due to revenue cap regulation in general for a given r*, X, RPI and a taking certain time lag into account.

The development of the revenue cap, which would ceteris paribus occur without any investments, provides the reference values: The differences between the reference revenues and the development of the allowed revenues when investing are interpreted as the monetary impact of the investment leading to the IRR. So the calculations refer to the amount of revenues a company is allowed to earn additionally due to the investment. The ceteris paribus observation allows the clear evaluation of a (marginal) investment on a project level. Because the real WACC (weighted average cost of capital) of the distribution system operators is unobserved, r* will be the reference deciding on the profitability. This assumption for example includes that the amortization period of the debt equals the depreciation period specified by the regulatory decree (40 years).

**Effects of regulation on the IRR**

The central questions the analysis was based on were:

- What are the effects of revenue cap regulation on the profitability of investments?
- How strong is each effect?
- When is it rational to invest?

In the context of revenue cap regulation, the cash flow related to an investment results from the increase of the cap due to capital expenditure. The increment depends of course on the regulatory rules concerning the depreciation period and method and on the allowed rate of return (r*). But in contrast to ROR regulation the resulting IRR will not equal r*. This section focuses on the first two questions and gives differentiated explanations of the occurring effects causing this deviation of the IRR. As the time lag between the point of investment and the adjustment of revenues has by far the greatest impact, this will be explained first. Then, the impact of the X-factor and of the RPI will be explained.

**Influence of the time lag**

Since the revenues do not depend on the actual cost within the regulatory lag, capital expenditures will be relevant for the revenue cap with delay. Even if the investment is capitalized exactly in the relevant year for the cost review, there would be a delay of 3 years in Germany (2 years are common in the international regulatory practice). From a microeconomic point of view, two negative effects follow from that.

The first is maybe more obvious and relates to the delayed cash return and to the relevant book value. Depending on the year of investment, the cash return would start 3-7 years after the capitalization. As the investment has to be depreciated on a linear basis, the amortized cost decreases over time and therefore the book value decreases as well. If the capitalization did not take place in the year of the cost review, a lower book value than the initial value would become relevant for the increase of the cap. Therefore, some of the lowered investment costs reduce the resulting IRR.

The second effect relates to the opportunity costs when investing. The general idea of incentive regulation is to create incentives for cost reductions allowing companies to keep profits within the regulatory lag. This concept also includes the possibility of losses. Therefore the company either has to take losses into account or it forgoes extra profits when investing. These opportunity costs occur until the investment costs are revealed within a regulatory review and the revenue cap is adjusted due to the investment. Increases of the whole asset base may lead to losses. They are likely to happen, when companies face a growing need for replacement investments and / or if the asset base is relatively old. The latter refers to the operational life span of the assets that often exceeds the amortization period. Therefore the book values of some assets equals zero before the point of replacement investment. If the regulatory authority underestimated the potential to increase cost efficiency or if the asset base decreased without the investment, the company would forgo extra profits when investing.

Summarizing, the decoupling of revenues from actual costs leads to sunk costs and in the short term to losses or to missed extra profits. The time lag until the adjustment of revenues takes place has therefore by far the greatest negative impact on the IRR. Still, there can also be a positive effect resulting from the cost decoupling: In the model, the company would not fall below the allowed revenues. Hence, the decreasing book values offer additional financial scope which is evaluated beneficially. In practice this benefit probably will be reduced by other regulatory rules. Nevertheless, all effects have fully been considered and the highest theoretically possible IRR is calculated.

**Influence of the X-factor and the RPI**

As the efficiency requirement refers to total costs, it has a smaller but still relevant impact on the internal rate of return. The X-factor proportionally reduces the cash flow of new capital expenditures as it is a part of total costs – also in case the investment was efficient. Since the investment costs are ex post not influenceable, this part of the costs are
sunk costs. Nevertheless, the interest and other expenses have to be paid and the company has to compensate this effect by reducing cost somewhere else. Thus, the efficiency requirement leads to stranded costs and to opportunity costs, both of the same amount.

Furthermore the cash return and the whole revenue cap decrease in real terms even if the efficiency requirement is zero. This effect always occurs if the compensation for the change of the RPI during the regulatory lag is calculated on the basis of the initially allowed revenues $R_{\text{start}}$. If the RPI refers to the revenue cap of the previous year this effect does not occur.

**Results and sensitivity analysis**

This section focuses on the third question: When is it rational to invest? Table 1 shows the IRR resulting from the simulation for an investment in year 1-5 of the regulation period: With $r^* = 5.66\%$ as a reference value, a rational investor would not invest.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>$t = 1$</th>
<th>$t = 2$</th>
<th>$t = 3$</th>
<th>$t = 4$</th>
<th>$t = 5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>3.63%</td>
<td>4.33%</td>
<td>5.06%</td>
<td>2.84%</td>
<td>3.32%</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>3.38%</td>
<td>4.03%</td>
<td>4.77%</td>
<td>2.69%</td>
<td>3.18%</td>
</tr>
</tbody>
</table>

Table 1: Resulting IRR

These results are particularly alarming because the calculations contain some conservative assumptions. The simulation contains a limitation for the cumulative efficiency requirements of 50\%, a complete use of strategic advantages due to decreasing book values and a construction time of zero. Besides, taxes are not included.

![Additional Revenues, Comparison Scenario 1 and 2](image1)

**Figure 1: Comparison of scenario 1 and 2**

The comparison of the both scenarios reveals a strong influence of the development of the efficiency requirement over time (figure 2). The higher the X-factor is after the revenue cap is adjusted, the stronger its negative impact becomes: It is rational to postpone the investment, in case the investor expects a high efficiency requirement in the next regulation period. As not only the allowed revenues ($r^*$) but several other factors influence the IRR, the impact of $r^*$ is relevant but the change is not proportionate. The sensitivity analysis shows that the effect of the IRR on $r^*$ is less than 1:1 and decreases with increasing $r^*$. Taking scenario 1 and the first year of the regulation period as an example, the variables change close to the starting point of 5.66\%, in the proportion 1:0.47, so that a 0.1\% increase of $r^*$ leads to a 0.047\% increase of the IRR. A change of $r^*$ from 8.1\% to 8.2\% would cause a change of the IRR from 4.68\% to 4.71\%. This trend is the same for all years and for both scenarios; only the level of the IRR differs.

The efficiency requirement has a greater impact on the IRR than the allowed return on capital ($r^*$). Figure 2 illustrates the impact of the efficiency requirement regarding an investment in the first year and for the first scenario. Because the model assumes that the X-factor decreases over time a concave curve results. As the cumulative efficiency requirement in the considered time period is limited to 50\%, the IRR reaches a minimum which is here about 3.44\%. Without these assumptions and with a constant efficiency requirement over time, the proportion would be exactly 1:1 and no minimum would be reached. Here again the trend is the same for all years; only the level of the IRR differs. Scenario 2 shows the same tendencies, but modifications of the efficiency requirement in the second regulation period are of high relevance for the IRR.

The impact of the efficiency requirement on the IRR substantially increases the risk and therewith the constraints for investments. Panteghini and Scarpa [3] show for example, that there is an incentive to postpone investments unless the uncertainty is not compensated by changes of the direct profitability of the investment using real options theory.

![Sensitivity Concerning the Efficiency Requirement (X) Scenario 1, Year 1](image2)

**Figure 2: Sensitivity concerning the X-factor**

In the deterministic analysis the interdependencies with other market participants and the impact of investments on future efficiency requirements were ignored. These interdependencies are to be discussed in the next section.
CONSIDERING THE IMPACT ON FUTURE EFFICIENCY REQUIREMENTS

In electricity distribution efficiency usually means to succeed in producing a given output at a minimum cost – provided that inputs and outputs are correctly measured. If the efficiency benchmarking is based on total costs and on book values, replacement investments potentially influence future efficiency requirements, as the efficiency requirement of company A depends on its own input/output coefficient in relation to the best efficiency achieved by a comparable company B. Therefore A has to anticipate how the other market participants will behave in order to decide whether to increase the value of the asset base or to postpone some investments. As postponing investments would lead to higher costs in the future and also entails the risk of decreasing quality of supply, A generally prefers to invest. Still, if B would not increase its asset base at least by the same amount, A would ceteris paribus appear less efficient in the next benchmarking. The increase of the efficiency requirement would then erode the depreciation and the rate of return and the costs would be sunk.

The situation can be modelled as a two-player, two strategy game with two Nash equilibriums (table 2). If both companies invest they will be allowed to earn back the investment costs including a rate of return according to the requirements. The role of the regulatory commitment could provide sufficient investment incentives. The same is true enough to avoid underinvestment, particularly, if there is a reasonable level, but as the resulting IRR is further influenced, this is maybe not sufficient to promote a sustainable level of investment.

Therefore, quality regulation could be kind of a “control mechanism” partially compensating the market forces that would influence the offered quality in case of competition. But unless the return on capital is not reasonable, it does not provide sufficient investment incentives. The same is true for the allowed rate of return. It is very important to set it at a reasonable level, but as the resulting IRR is further influenced, this is maybe not sufficient to promote a sustainable level of investment.

Concluding, the results highlight the necessity of additional investment incentives that efficiently compensate for the time lag. It is very likely that quality regulation alone is not enough to avoid underinvestment, particularly, if there is a growing need for replacement investments. Besides this, regulation brings about relevant risk factors - due to the impact of the efficiency requirements on investments and through the impact of investments on future efficiency requirements. The role of the regulatory commitment could be discussed additionally. The impact of uncertainty is worth further analysis; in any case it underlines the need for investment incentives.

REFERENCES


Figure 2: Possible Strategies

<table>
<thead>
<tr>
<th></th>
<th>Invest</th>
<th>Don’t Invest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invest</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Don’t Invest</td>
<td>-20</td>
<td>0</td>
</tr>
</tbody>
</table>

In theory, Harsanyi and Selten [3] for example state that rational players come to the payoff dominant strategy which means here that the companies would invest. In contrast, evolutionary models show that the risk dominant strategy is more likely to occur. In any case, a benchmarking based on total costs induces some additional risk for underinvestment that should be taken into account.

CONCLUSIONS AND DISCUSSION

The deterministic analysis proves strong distortions of the IRR caused by regulation, so that the resulting rate of return would not equal the allowed rate of return \( r^* \). So even if \( r^* \) matches the real imputed interest of the company, it would not be achieved in the context of a pure revenue cap regulation. Furthermore, the sensitivity analysis shows a relevant influence of the efficiency requirement on the IRR which increases the risk substantially. Considering the potential impact of today’s investments on future efficiency requirements, the regulatory risk even increases. On the whole, there are strong incentives for postponing investments.

Of course, there is no “pure” RPI-X regulation in practice. So the first question that would occur is, whether quality regulation is practicable and sufficient to avoid underinvestment. Though quality regulation is a useful and on the whole necessary instrument, the answer seems to be no. Due to quality regulation, bad quality is penalised and good quality is rewarded for example by changes of the revenue cap. If the return on investments is sufficient to cover the costs, companies would probably decide in favour of investments instead of decreasing costs by means of not investing. Still, investments influence quality of supply with a relevant delay (hysteresis). Furthermore quality regulation does not touch the distortions of the IRR that result mainly from the time lag until the revenue cap is adjusted.

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