Joachim Bertsch and Simeon Hagspiel

Inefficiencies of grid regulation - The case of blackouts in electricity grids

Simeon Hagspiel: Institute of Energy Economics, University of Cologne
Vogelsanger Str. 321, 50823 Cologne, Germany
Phone: + 49 (0) 221 27729 222, Fax: + 49 (0) 221 27729 400
simeon.hagspiel@ewi.uni-koeln.de

Overview

The grid infrastructure of telecommunications, railroads, electricity or gas is considered a natural monopoly for which it is efficient if the provision of the respective goods is concentrated in a single firm. Optimal regulation aims at incentivizing the firm to provide the "right" amount of grid infrastructure at the "right" price. However, demand and costs of grid infrastructures are usually best known to the firm rather than the regulator, leading to an informational advantage for the firm that she can exploit to increase her utility, e.g. by expanding the grid to an inefficiently high level. In the context of electricity grids, the severe consequences of congestion - namely complete system failures and blackouts - further increase the possible range of the demand for grid infrastructure. This may become a particular challenge for systems that are rapidly changing, e.g. due to increased renewable deployment or changes in demand levels, such that true demand levels can hardly be traced and observed by the regulatory agency.

Method

In this paper, we analyze optimal regulation for an electricity grid infrastructure with blackouts as a possible consequence of a congested grid. Our methodology builds on the literature dealing with the theory of incentives in a multiple agent model. In this framework, information asymmetry with respect to demand between a regulator and a firm has first been discussed by Riordan (1984) and Lewis and Sappington (1988a). Lewis and Sappington (1988b) and Armstrong (1998) consider the case of a second information asymmetry regarding the cost function of the firm. Later, additional aspects have been studied, such as shadow costs of public funding (Aguirre and Beitia (2004)) or adverse selection in combination with moral hazard (e.g., Laffont and Martimort (2002)). In our paper, we set up an analytical model to analyze optimal regulation for an electricity grid infrastructure with blackouts as a possible consequence of a congested grid. The general problem structure is similar to Laffont and Rochet (1998), however, we consider adverse selection and moral hazard affecting the demand rather than the cost side. Optimal regulation differs in the timing of learning information and the risk preferences of the firm and the regulator. Moreover, we consider the case of dependent realizations for the demand and blackout levels by introducing a correlation measure.

Results

In the framework previously described, we confirm that for demand uncertainty only, optimal contracting consists of prices equal to marginal costs of the firm. In this case, the first best outcome with respect to social welfare can be achieved by a simple regulatory scheme. The same holds true for the full problem (adverse selection and moral hazard) if the regulatory body has full information and the firm is risk-neutral. However, results are different if the regulator faces an additional uncertainty due to the risk of a blackout. In this case, we find that optimal regulation implies choosing prices lower than marginal costs to prevent the firm from claiming that a high level of grid extension is needed. Here, an informational rent must be left to the firm in order to achieve the second best outcome. We aim at complementing these findings with additional analyses considering different levels for the correlation between the demand and the blackout uncertainty. We will investigate pricing regimes under optimal regulation, revealing whether optimal prices are distorted further away from the previously achieved second best outcome, get closer to the first best result, or do not change at all. Last, we will analyze social surplus and optimal regulation if the firm and the regulator are characterized by different levels of risk aversion with respect to blackouts, expecting that the more the firm is risk averse compared to the regulator, the more she will exploit her informational advantage. Hence, risk aversion would change the level, but not the direction of the previously obtained results.

Conclusions

Regulation of grid infrastructures, such as electricity grids, is a difficult yet important task. Whereas previous studies have focused mainly on informational asymmetries with respect to the costs of the firm, we analyze a regulatory problem characterized by demand uncertainty combined with incomplete information about the blackout probability of the system. Both, the general model as well as the specific results obtained seem particularly relevant for the

regulation of electricity grids. Especially striking is the finding that pricing below marginal costs appears to be beneficial for society as extensive grid extensions above necessary levels can be avoided. For real world environments, our results imply that extensive grid expansion plans suggested by monopolistic firms in the electricity grid sector, e.g. in the context of enhanced renewable energy deployment, should be critically assessed. One approach to potentially decrease the inefficiency found in our paper would be up-to-date assessments of the blackout probability for the system considered.

References

Aguirre, I. and A. Beitia (2004). Regulating a monopolist with unknown demand: Costly public funds and the value of private information. Journal of Public Economic Theory 6(5), 693–706.

Armstrong, M. (1998). Optimal regulation with unknown demand and cost functions. Journal of Economic Theory 84, 196–215.

Laffont, J.-J. and D. Martimort (2002). The theory of incentives - the principal-agent model. Princeton University Press.

Lewis, T. R. and D. E. Sappington (1988a). Regulating a monopolist with unknown demand and cost functions. The RAND Journal of Economics 19(3), 438–457.

Lewis, T. R. and D. E. Sappington (1988b). Regulating a monopolist with unknown demand. The American Economic Review 78(5), 986–998.

Riordan, M. H. (1984). On delegating price authority to a regulated firm. The RAND Journal of Economics 15(1), 108–115.