Comments on: "Regulated expansion of transmission networks" by W.-P. Schill, J. Rosellon, and J. Egerer

Thomas-Olivier Léautier

Toulouse School of Economics

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The problem

- Transmission grid expansion an important issue. Until recently, cross border expansion main focus in Europe. Massive investment in renewable generation, mostly off shore wind mills, brings designing regulatory contracts to induce grid expansion to the forefront of policy issues
- Three families of approaches:
  1. Develop optimal expansion plan, and include it in the regulatory contract (Regional Planning Process, USA)
  2. Make the grid owner pay for the cost of congestion (Transmission Services Scheme, Britain)
  3. Use price cap to induce optimal expansion

Price cap induces optimal production (1/2)

- Finsinger and Vogelsang, 1979
- Multiproduct monopolist. q^n production of good $n = 1, ..., N$, $\mathbf{Q} \in \mathbb{R}^N$ vector of production of N goods, $P^n(\mathbf{Q})$ inverse demand for good n, $C(\mathbf{Q})$ cost of production. Inverse elasticity rule:

$$P^n\left(\hat{\mathbf{Q}}\right) - \frac{\partial C\left(\hat{\mathbf{Q}}\right)}{\partial q^n} = \frac{\partial P^n\left(\hat{\mathbf{Q}}\right)}{\partial q^n}(-\hat{q}^n) > 0$$

- Include a revenue cap: $\sum_m w^m P^m(\mathbf{Q}) \leq R$. $\mathcal{L}$ the Lagragian, λ shadow cost of the constraint:

$$\frac{\partial \mathcal{L}}{\partial q^n} = P^n(\mathbf{Q}) - \frac{\partial C(\mathbf{Q})}{\partial q^n} - \frac{\partial P^n(\mathbf{Q})}{\partial q^n}(\lambda w^n - q^n)$$

Price cap induces optimal production (2/2)

- If (i) the program is concave, and (ii) revenue cap is

$$\sum_m q^{m*} P^m(\mathbf{Q}) \leq \sum_m q^{m*} \frac{\partial C^n(\mathbf{Q}^*)}{\partial q^n}$$

where q^{n*} is socially optimal output $\left(P^n(\mathbf{Q}^*) = \frac{\partial C^n(\mathbf{Q}^*)}{\partial q^n} \; \forall n\right)$, then

$$\hat{q}^n = q^{n*}$$

- Dynamic (stationary) setting: $w_n(t) = q_n(t-1)$ yields convergence towards q_n^*
- Can add a two-part tarif (or a minimum revenue constraint) to cover the fixed costs
- Complete contract: dynamic two part tarif price cap

Output choice

1. *Natural choice*: $q_n = K_l$ capacity on a transmission line (corridor). Problem mathematically well defined:
   - "Demand" for transmission capacity globally concave (duality property)
   - Costs are non-decreasing and convex (at least, reasonable approximation)
2. *Market choice*. Hogan, Rosellon, and Vogelsang (HRV, 2010): $q_n = q_{ij}$ Financial Transmission Right between nodes i and j
   - Objective: align long-term incentives with short-term market instruments
   - Drawback: program may not be "well behaved". HRV obtains conditional results using an illustrative grid: "in a neighborhood of a specific point, where the program is concave, then ...."

This article's contribution: solve HRV numerically for a realistic representation of the European power grid

Main results

- Compare numerically outcome from "optimal" expansion, HRV regulation, and (i) cost plus regulation, and (ii) no investment incentives, for different scenarii, including random wind generation
- Numerical analysis confirms theoretical prediction: HRV converges towards "optimal expansion": under most scenarii, more than 80% of "optimal" social welfare is generated

Comments/observations

- Important contribution: until then, HRV "theoretical construct". Numerical "proof of concept" adds reality to the proposal
- Comparison with other "efficient" approaches
- Robustness of the results to richer/more realistic assumptions (higher wind penetration)
- Dynamic properties, in a highly uncertain environment
- Practical implementation with multiple transmission asset owners