

***Lectures on
Regulatory Problems in Network Industries***

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Lecture No. 1:

***Regulatory Approaches to
Electricity Transmission Services***

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Overview



- **Introduction to Price Regulation**
- **The Bayesian Approach**
- **The non-Bayesian Approach**
- **Regulation of Transmission Pricing**
- **Conclusions and Open Research Questions**

Regulation of Network Industries

Network industries

- Information
- Transportation
- Energy
 - Natural gas
 - Electricity
 - Vertical integration
 - Vertical separation
 - Genco
 - Transco
 - Disco
 - Marco

Issues that require regulation

- Market power
 - Economies of scale and scope
 - Sunk costs
- Externalities

Types of Price Regulation

- **Traditional regulation**
 - **Rate-of-return (= RoR) or cost-plus**
 - **Based on historical cost data**
 - **Can deal with heterogeneous costs of expansion**
 - **Poor efficiency/good equity properties**
- **Performance-based regulation (PBR)**
 - **Delegates pricing to firm (within limits)**
 - **Based on profit motive**
 - **Compatible with competition**
 - **Dominates outside U.S.**
- **Typical example of PBR: Price caps**

The Roots of Incentive Regulation

- Part of the same movement that brought
 - Deregulation of competitive industries in the US
 - Liberalization and privatization around the world
 -
 - Sources:
 - Bad regulation
 - Ideology and political climate
 - Technical, organizational and market changes
- ⇒ Incentive regulation:
- New life for public utility regulation
 - Regulator delegates decisions to the firm
 - Profits depend on performance:
 - Reward outcomes, not behavior
 - Recognize firm's information advantage.

Types of PBR

- **Basis for incentives is asymmetric information.**
- **Non-Bayesian approach:**
 - Resulted from shortcomings of regulation
 - Based on simple principles
 - Directed towards improvement, not optimization
 - Geared for application
- **Bayesian approach:**
 - Resulted from shortcomings of the theoretical optimal pricing literature
 - Uses principal-agent framework
 - Full constrained welfare optimization:
 - No direct applicability
 - Qualitative insights usable for non-Bayesian approach

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The Bayesian Approach

- Regulator maximizes welfare (as the principal), while the Transco maximizes profits (as the agent)
- Regulator induces Transco to set prices (p) in his interest by paying Transco a transfer $T(p)$
 - Transco chooses p or a function $A - t(p)$ out of a menu
- Asymmetric information means that Transco's performance opportunities are described by the subjective type distribution $F(\theta)$ with density $f(\theta)$, where the Transco knows θ , while the regulator only knows $F(\theta)$.
- Regulator maximizes expected welfare under two constraints:
 - Transco will participate only if total expected profits are nonnegative (based on the US Supreme Court's Hope decision).
 - $T(p)$ has to be incentive compatible (induce Transco to reveal its type).

The Bayesian Approach

- The maximization problem for the regulator is to find an incentive scheme $T(p)$ with

$$T(p) = \arg \max_{\theta} \int [V(p(\theta) + \alpha\pi(p(\theta)) + (\alpha - 1)T(p(\theta))] f(\theta) d\theta$$

$$s.t. \quad PC : \Pi(p(\theta), T(p(\theta))) \geq 0 \quad \text{and} \quad ICC : \frac{\partial \Pi}{\partial \theta} = -\psi'(e(\theta))$$

The Bayesian Approach

- **Problems with the Bayesian approach**
 - **Where does $F(\theta)$ come from?**
 - **No discussion of regulatory information gathering**
 - **$F(\theta)$ assumed common knowledge**
 - **Totally unrealistic**
 - **No outside check on regulatory information**
 - **Assumption of transfer $T(p)$ unrealistic in US context**
 - **Can be circumvented through fixed fee of two-part tariffs**

The Bayesian Approach: Main Results

- Full information optimum is not achievable.
- Regulator can generally improve outcome with better information and with additional instruments.
- Superior innate efficiency and effort/lower prices of the Transco need to be rewarded by positive economic profits.
- The more efficient the firm's type the more cost-reducing effort should it be induced to exert. For this purpose the Transco should be offered a choice from a menu of linear transfers $T(p)$.
- For given costs prices should be chosen efficiently (incentive pricing dichotomy).

The Bayesian Approach: Main Results

- **The less the regulator can commit to incentives (and the associated profits) the weaker should incentives be.**
- **The ability of regulators to commit (and the set of available instruments) should be constrained if regulatory capture is a possibility.**
- **The best regulatory policy is industry-dependent.**

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The non-Bayesian Approach

- **Dynamic mechanisms that use subsidies or constraints as instruments to induce the regulated firm to improve welfare**
- **Subsidy-based schemes:**
 - **Sappington/Sibley (1988):**
 - $ISS^t = V(p^t) - V(p^{t-1}) - \pi(p^{t-1})$
→ $\Pi^t = \pi(p^t) + ISS^t = \Delta W^t$
 - Induces the firm to choose welfare-optimal prices for every period, in which the mechanism operates
 - Firm may earn rents in first period
 - $V(p)$ generally not observable (except through bids)
 - **Finsinger/Vogelsang (1982):**
 - $SFV^t = (p^{t-1} - p^t)q^{t-1} - \pi(p^{t-1})$
→ $\Pi^t \leq \Delta W^t$
 - Based on observable data
 - Converges to welfare-optimal prices

The non-Bayesian Approach

- **Price cap schemes (Littlechild, 1983):**
 - $p^t q^w / p^{t-1} q^w \leq (1 + i - X)$ with $q^w = q^*$ or $q^w = q^{t-1}$
 - or $(p^{t-1} - p^t) q^{t-1} - p^{t-1} q^{t-1} (X - i) \geq 0$
 - The firm then maximizes the Lagrangean
 $L = \pi(p^t) + \lambda \{(p^{t-1} - p^t) q^{t-1} - p^{t-1} q^{t-1} (X - i)\}$
 - This is closely related to SFV
- **Price caps**
 - Emphasize pricing flexibility
 - Reward cost-reducing effort
 - Need to be reset from time to time
 - There exists no incentive mechanism for resetting of price caps: Revert to rate-of-return regulation with “used and useful” criterion?

Multiproduct Issues

Revenue Requirement = Price Level Regulation
Rate Design = Price Structure Regulation
(Relative Prices)

- **Revenue Requirement Objectives**
 - Rent extraction: Firm vs. customers
 - Incentive for cost reduction
 - Investment: Means and incentive
- **Rate Design Objectives**
 - Wealth distribution between customer groups
 - Short-term efficiency
 - Allocation
 - Capacity utilization
 - Capacity expansion

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Electricity Restructuring

From an Integrated Monopoly to Separation and Competition

- **Two Potentially Competitive Stages**
 - Generation
 - Marketing
- **Two Natural Monopoly Stages**
 - Transmission
 - Key to Competition in Generation
 - Distribution
 - Key to Competition in Marketing

Specific Transmission Issues

- **Nonstorability of electricity, fluctuating demands, stability issues (voltage, frequency), real/reactive power \Rightarrow Real-time coordination of bulk power market required**
- **Transmission output best defined as point-to-point financial transmission rights**
- **Short-term transmission costs (not usually incurred by Transco)**
 - Congestion costs
 - Power losses
 - Costs of ancillary services
- **Long-term transmission costs poorly understood**
 - $MC(FTR)$ = cost of network expansion required to support expansion of that FTR
 - Problem of loop flows and demand fluctuations
- **Transmission demands (for FTRs) derived from generation supplies and load demands**
 - Imperfections in electricity markets affect transmission demands
- **Market power and location decisions of generators hard to counter-act through transmission pricing/expansion**
- **Vertical integration of transmission and generation requires different access pricing than under vertical separation (addressed in Lecture #2)**

Literature on Transmission Pricing

Peak-load pricing

Crew/Fernando/Kleindorfer survey JRE 1995

Priority pricing

Marchand, EER 1974

Chao/Wilson, AER 1987

Wilson, Oxford 1993

Spot pricing/congestion pricing (Nodal pricing)

Vickrey BJ 1971

Schweppe et al. Kluwer 1988

Hogan JRE 1992

Property rights (merchant transmission)

Chao/Peck JRE 1996

Bushnell/Stoft JRE 1996

Joskow/Tirole, 2004

Price Regulation of a Transco

- Objectives
 - Use of Transmission Network
 - Expansion of Transmission Network
 - Cost Reduction
- Problems
 - Economies of Scale and Scope
 - Loop Flow
 - No Storage
 - Fixed Capacity in the Short Run
- Solutions
 - Governance
 - Transco as grid operator
 - Transco and Independent System Operator (ISO)
 - Incentive Regulation (PBR)
 - Rules versus Discretion
 - Price Caps: Cost Reduction and Optimal Pricing

PBR Proposals for Transmission Pricing

- **Merchant transmission investments**
 - Substitutes or complements for PBR
 - Joskow/Tirole (2004) critique
- **Léautier (2000)**
 - Menu of revenue-sharing rules from Bayesian approach
 - Make Transco “responsible for the full cost of the [operational] out-turn, plus the transmission losses, valued at the System Marginal Price”
- **Gans/King (1999)**
 - Application of ISS
 - $\Delta V(p)$ derived from bidding curves of generators and LSEs

PBR Proposals for Transmission Pricing

- **Vogelsang (2001)**
 - Price caps with two-part tariffs
 - $(p^{t-1} - p^t)q^w + (F^{t-1} - F^t)N^w \geq 0$ (or $\geq i - X$)
 - Reductions in congestion are rewarded by increased fixed fees. Rewards increase in point-to-point flows.
 - Compatible with real-time nodal pricing (through ISO)
 - Converges to optimal capacities (depending on choice of q^w)

PBR Proposals for Transmission Pricing

- Average of Laspeyres and Paasche price-cap index
 - $F^t N \leq F^{t-1} N + \frac{1}{2}(p^{t-1} - p^t)(q^t + q^{t-1})$ implies F.O.C.:
 - $-(\partial q^t / \partial p^t)(p^t - \partial C / \partial q^t) = q^t - q^{t-1} + (\partial q^t / \partial p^t)(p^{t-1} - \partial C / \partial q^t)$ or
 - $L^t = -[1 - q^{t-1}/q^t]/\varepsilon^t - (p^{t-1} - \partial C / \partial q^t)/p^t$
 - $\Rightarrow p^t = \partial C / \partial q^t$ for linear demand

PBR Proposals for Transmission Pricing

- **Efficient Capacity Utilization \Rightarrow Spot Pricing \Rightarrow Average Revenue Constraint**
 - Variable prices set by TRANSCO
 - Inefficiently high spot prices (off-peak)
 - **Solution: Competitive market rule and peak quantity weights**
 - First order conditions:
 - Off-peak prices: $p_j^t = 0$
 - Peak prices: $\sum_k p_k^t - \partial C / \partial K^t = (q_k^w - q_k^t) \sum_k (\partial p_k^t / \partial q_k^t)$

A synthesis approach based on a three-period framework

- **The ultra-short period**
 - Real-time pricing or peak-load pricing
 - Only allocative efficiency matters: No possibility for reducing operational or investment costs of Transco
 - Full regulatory commitment
 - Steep incentives to reach allocative efficiency feasible
- **The short period**
 - Pricing of fixed fees and (RPI-X)-type adjustments or profit sharing
 - Transco decisions on operations, repairs and maintenance costs
 - Full regulatory commitment
 - Steep incentives for cost reductions feasible
- **The long period**
 - Revisions of (RPI-X)-adjustments and of PBR mechanisms at the end of each long period
 - Transmission expansion investments go beyond several long periods
 - Only very basic regulatory commitment beyond a long period
 - No cost-reducing incentives feasible beyond a long period

A synthesis approach based on a three-period framework

- **Consequences of the three-period framework:**
 - **Implement real-time pricing through ISO**
 - **Achieve revenue smoothing and penalty for high congestion prices through adjustment of fixed fees**
 - **Combine profit sharing with RPI-X adjustment for short periods**
 - **Long-term adjustments and adjustments for expansion investments via rate-of-return and “used and useful” criteria**
- **This combination can be interpreted as ISS with two-part tariffs and a long-term profit adjustment (while the ISS has a profit adjustment in every period)**

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Conclusions

- **Efficient day-to-day operation of the bulk power market feasible**
- **Efficient investment in the transmission system likely**
- **(Historic) cost recovery of transmission assets feasible through choice of starting price level and subsequent adjustments**
- **Simplicity and transparency as far as possible**

Open Research Questions

- **How to infer investment information from short-run congestion and bidding behavior**
- **How to determine the half-life of information gained by the regulator about the ability of the regulated firm**
- **How to signal locational advantages for generation and distribution investments through transmission pricing**
- **How to reduce market power in generation through PBR for transmission**
- **How to determine fixed fees with good allocative and fairness properties**
- **How to improve quality of transmission services, in particular, reliability through pricing or other instruments**
- **The feasibility of merchant transmission as complement or substitute for Transco investments**