Generation Investment and Access Regulation in the Electricity Market

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Motivation

- Large scale introduction of **green energy** such as wind energy, **creates congestion** on the electricity network
- Green producers have a lower MC than the brown producers
- Competitive allocation of network capacity in spot market: **Green producers outbid brown producers**
- Brown producers expected to obtain network access for life time of power plant
- Hold-up problem between the network operator and brown producers? (No long term contract between network operator and producers)
- Should brown producers be compensated? Entry of green energy be taxed? Should long-term contracts be introduced?

What we do

- Develop 2-period stochastic model
  - Two firms: Brown and green producer
  - Each period: investment and production decisions
  - Green producer is only present in 2nd period
  - Investment cost of the green is random
- Introduce 3 types of market mechanisms
  - Nodal Pricing
  - Nodal Pricing with Financial Transmission Rights
  - Physical Transmission Rights

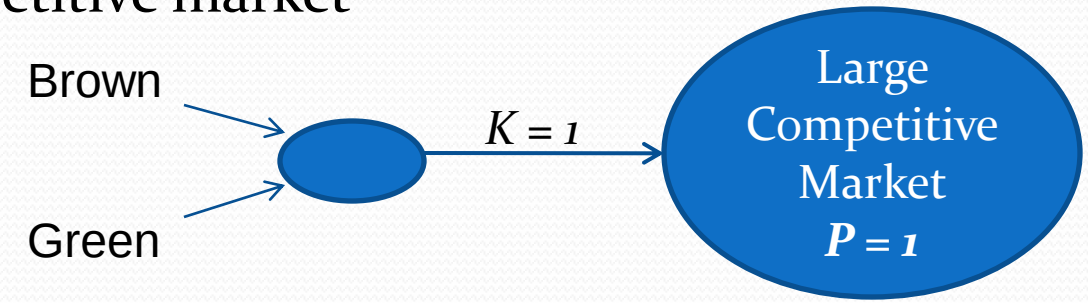
- MODEL
- ANALYSIS
- ALTERNATIVE MARKET MECHANISMS
- CONCLUSION

Model: Timing

- **Period 1**
  - Incumbent decides whether to invest or wait
  - Operation of power market (duration T_1)
- **Period 2**
  - If incumbent invested in period 1
    - Entrant decides about investment
  - If incumbent did not invest in period 1
    - Entrant & Incumbent decide about investments
  - Operation of power market (duration $T_2=1$)

Model: Spot Market

- **Transmission line** connects investment location with large competitive market



- Marginal cost of entrant ***g*** < Marginal cost incumbent ***c***
- **If 1 firm is active**: No congestion
  - Firm receives market price of downstream market (**1**)
- **If 2 firms are active** : Congestion
  - Only green firm produces
  - Bertrand competition reduces the net price it receives to the marginal cost of the incumbent (***c***)

Model: Investment

- Incumbent's investment cost F cannot be recovered by producing only in period 1
- Incumbent's total cost: c+F<1
- Entrant's investment cost G is stochastic, revealed to all players between period 1 and 2
  - Prob $(1-\lambda)$: G^L
    - Total cost entrant $G^L + d$ < Marginal cost incumbent c
  - Prob λ: G^H
    - Total cost entrant $G^L + d$ < Total cost incumbent $F + c$
    - Total cost entrant $G^L + d$ > Marginal cost incumbent c

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Analysis: Period 2

- If the incumbent entered in period 1
  - Entrant will enter as long as $G + d < c$
- If the incumbent did not yet enter
  - Simultaneous entry game
  - Multiple Nash eq. → Select eq. with lowest cost

- Investment by green producer is efficient conditional on 1st period decision of incumbent

Analysis: Period 1

- The incumbent invests as long as fixed cost F is lower than profit it collects in both periods
  - $F < T_1 (1-c) + \lambda (1-c)$
- For the social planner, investment in the first period has a lower value
  - $F < T_1 (1-c) + \lambda (d + G^H - c)$
- Hence, the incumbent will overinvest
  - First mover effect is larger than the real option value

- Introduce entry tax on incumbent = profit loss of entrant $t = \lambda (1 - d - G^H)$
- Alternative: commitment to a subsidy to the entrant before period 1

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Financial Transmission rights (FTR)

- FTR = financial instrument which gives the owner a share of the congestion rent
- Long Term FTR + nodal spot pricing
  - Nodal spot prices = lead to efficient real time use of network
  - LT-FTR allow firms to hedge against uncertain congestion charges and to coordinate investment decisions
- **In our model**
  - Introduction of FTRs aggravates the problem of over-investment
  - Reason: the incumbent is hedged against entry by the green producer
  - Only solution: (Higher) Tax on Entry

Physical Transmission Rights

- PTR = Full ownership right on the transmission line
- The owner of the right has the option "not to use" a transmission line, *i.e.* withhold capacity from the market
- Leads to market power abuse in the spot market
- **In our model**
  - The incumbent can resell the PTR in period 2 to the entrant. The resale value increases if he does not invest in period 1.
  - Introduction of PTRs restores efficiency

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Conclusions

- In a nodal spot market
  - Investment of brown producer is inefficient
    - Brown producer tries to exploit first mover advantage and builds too much
  - Investment of green producer is efficient (conditional on the investment of the brown producer)
    - It reduces the profit of the brown producer, but this is normal market interaction
- Financial Transmission rights make the situation worse

- Market efficiency can be restored by
  - Introduction of physical transmission rights
  - Taxing *investment* of brown producer

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