Empirical Analysis of the Spot Market Implications of Price-Elastic Demand

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by

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Outline

- Background and Objective
- Theory of Price-Elastic Demand
- Overview of New York Control Area
- Empirical Methodology and Results
- Conclusions

Background

- Vertical integration: all electricity functions provided by regulated investor-owned utility (IOU)
- Deregulation: introduction of competition into sectors of the electricity industry that are amenable to it
- This has resulted in divestiture of IOUs' generation assets
- In the U.S., deregulation process has separated the sectors with "natural monopoly" characteristics from the competitive ones
- Transmission sector to be controlled by independent system operator (ISO)

Objective

- Most of the effort has been directed towards the supply side with few demand-side initiatives
- Deregulated electricity markets, therefore, differ from others for commodities because end-use consumers are still subject to constant retail rates
- End-users do not perceive real-time fluctuations in the wholesale price
- Consequently, they are unable to adjust their consumption accordingly
- Theoretically, price elasticity is desirable, but how much of an impact would it make?
- Use data from New York market to quantify the benefits of price elasticity from a policymaking perspective

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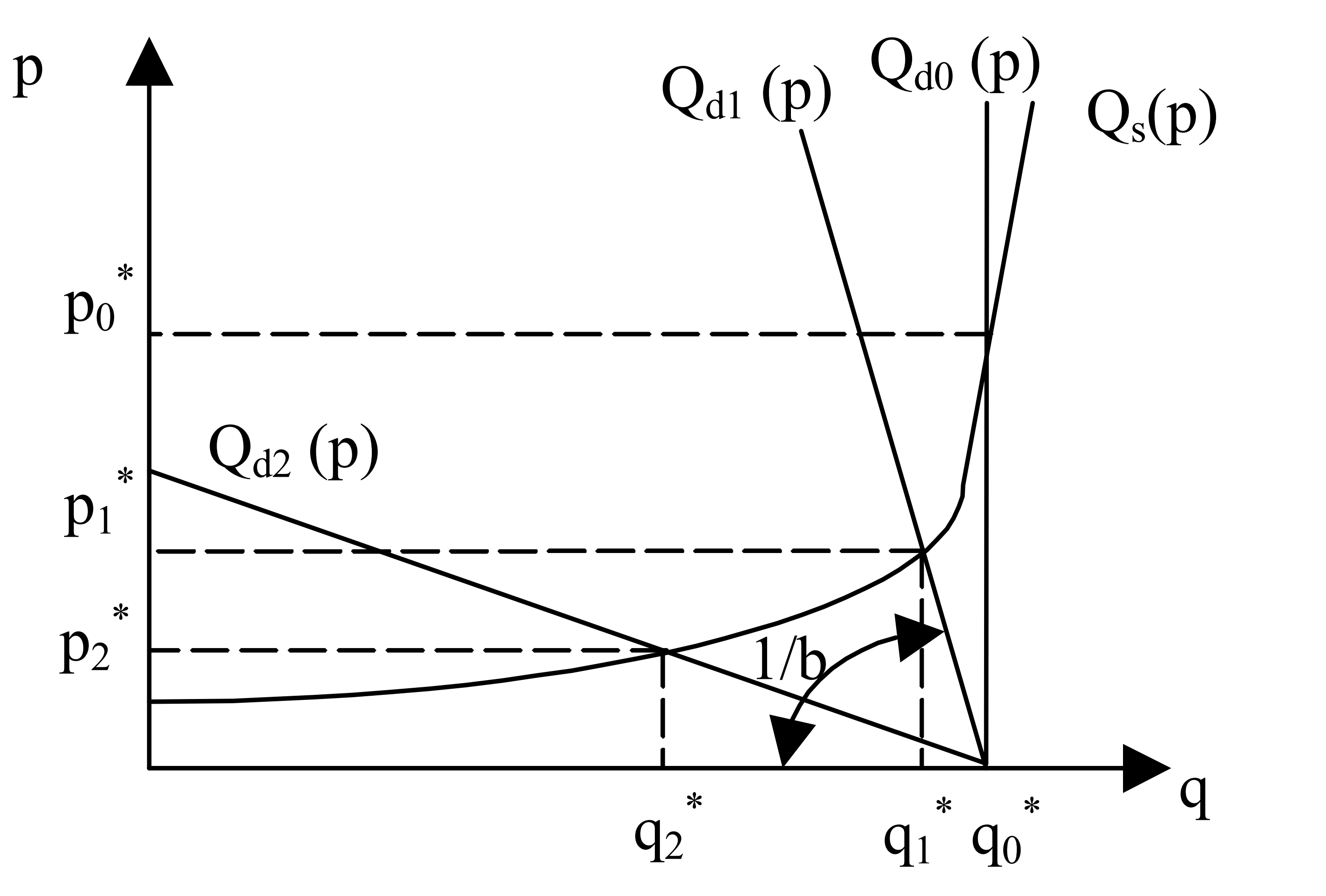
Theory of Price-Elastic Demand



Theory of Price-Elastic Demand

- Definition of price elasticity: $\eta\left(p^*, q^*\right) \equiv \left| \frac{p^*}{q^*} \frac{\partial Q_d}{\partial p} \right|$
- Linear inverse-demand specification: $Q_d\left(p\right) = a - bp$, where *a>0* and *b>0*, then $\eta\left(p, q\right) = \frac{p}{q} b$
- If both demand and supply are linear, then what are the comparative statics resulting from changes in *b*?
- Both the equilibrium price and quantity decrease, but at a diminishing rate: $\frac{\partial p}{\partial b} < 0 \quad \frac{\partial^2 p}{\partial b^2} > 0 \quad \frac{\partial q}{\partial b} < 0 \quad \frac{\partial^2 q}{\partial b^2} > 0$
- Implication: do not need much elasticity in order to have an effect
- Try to quantify this feature for the New York industry

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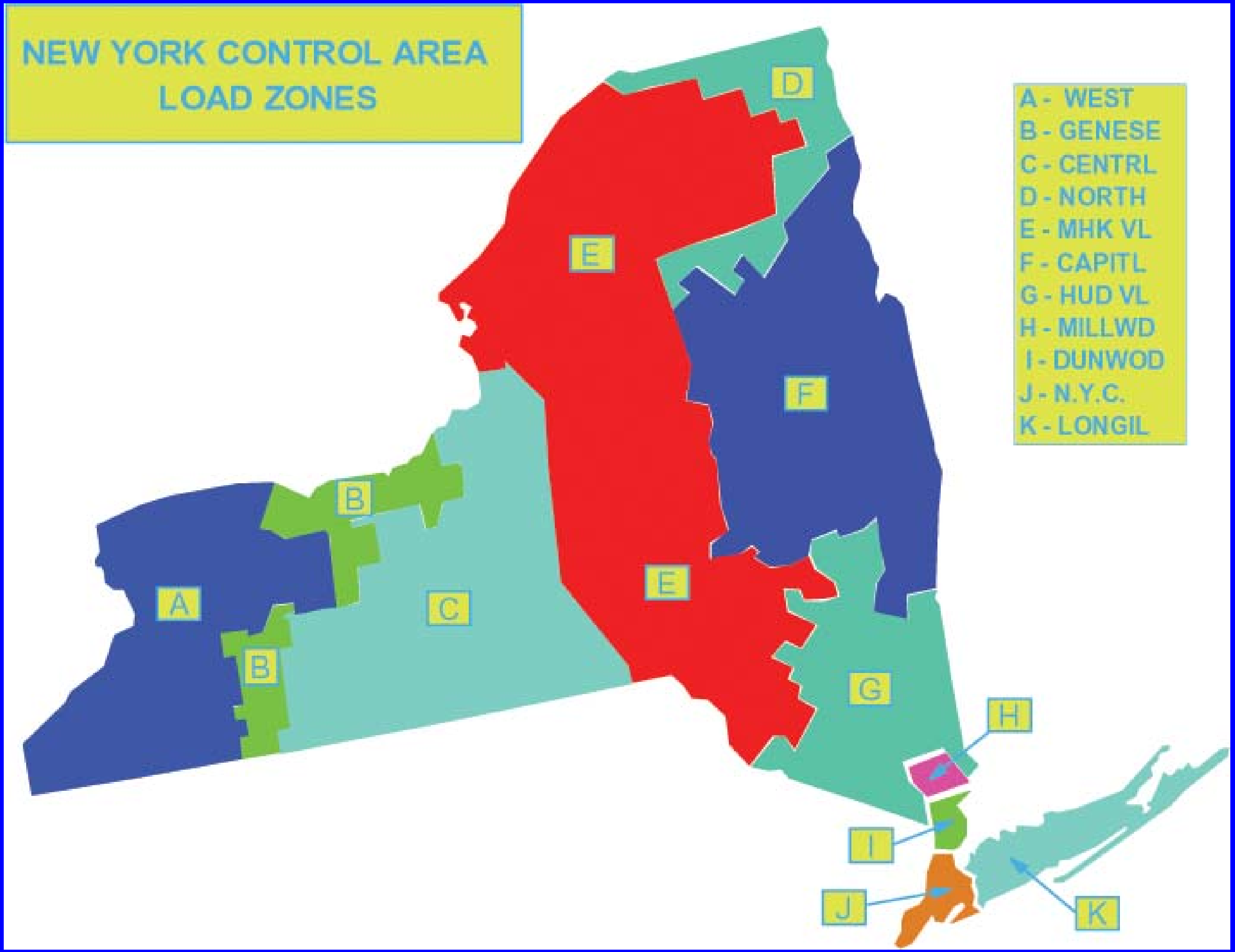
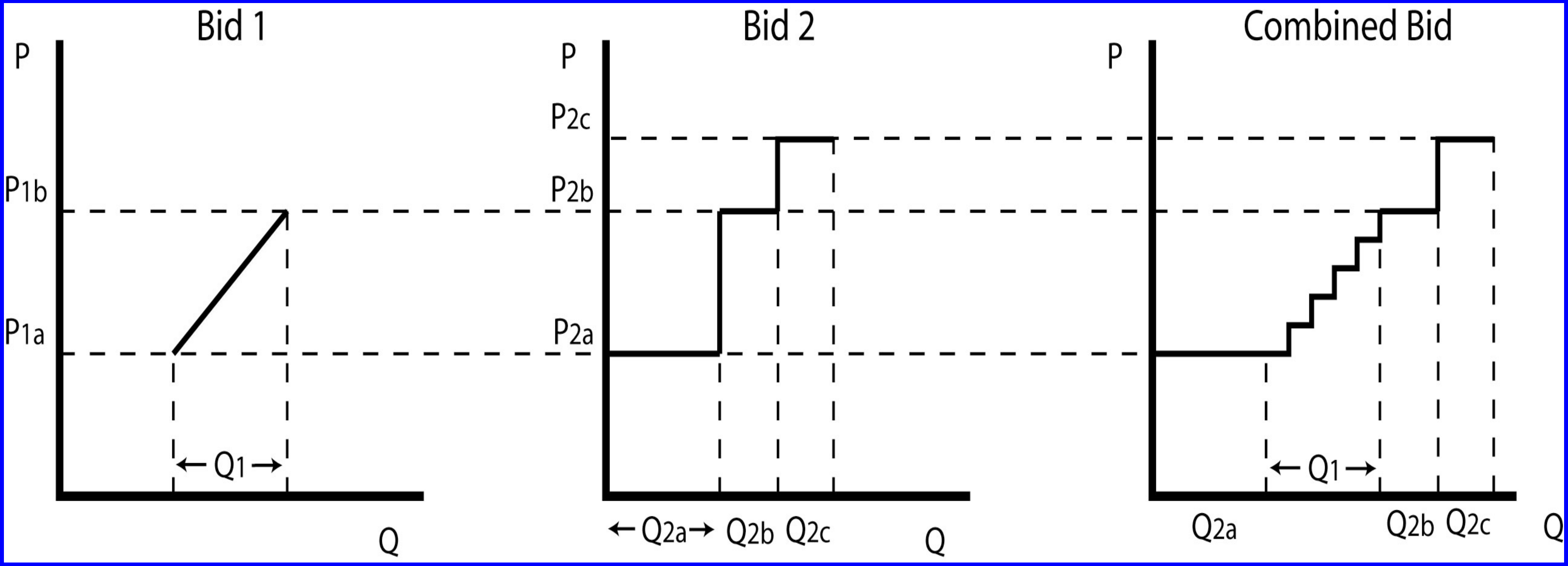
New York Control Area



New York Control Area

- New York ISO (NYISO) manages the entire grid in the state and operates markets that provide half of the electricity
- State is divided up into eleven congestion zones, each of which consists of many generation buses
- Locational-based marginal price (LBMP) is calculated for each zone and bus
- LBMP depends on intersection of supply offer and demand bid stacks
- We construct generator offer stacks by adding individual ones horizontally
- Assume no congestion or demand-side response

New York Control Area



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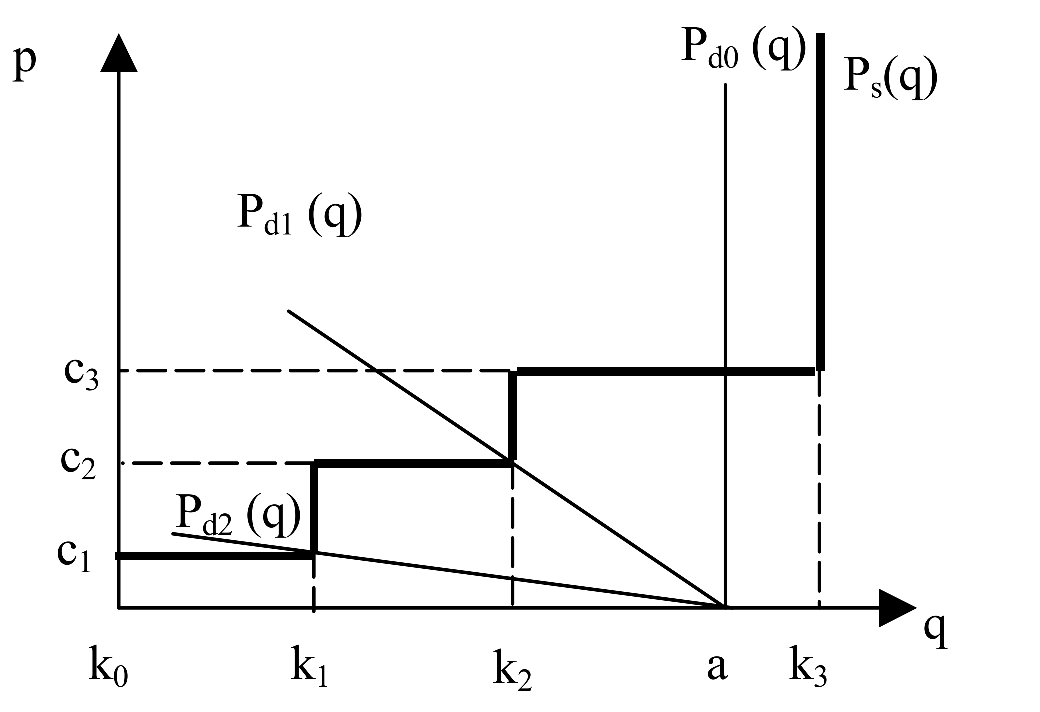
Methodology

- Objective: use NYISO data for year 2002 to construct hourly supply stacks and determine the potential impact of real-time pricing
- In effect, calculate $\frac{\partial p}{\partial b}$, $\frac{\partial^2 p}{\partial b^2}$, $\frac{\partial q}{\partial b}$, and $\frac{\partial^2 q}{\partial b^2}$



Methodology

- By how much to increase the slope at each increment?

$$0 = b_0 < b_1 < \cdots < b_i < \cdots < b_{n-1} = \min\left\{ b \,\middle|\, a - bp = \min_p Q_s(p) \right\}$$

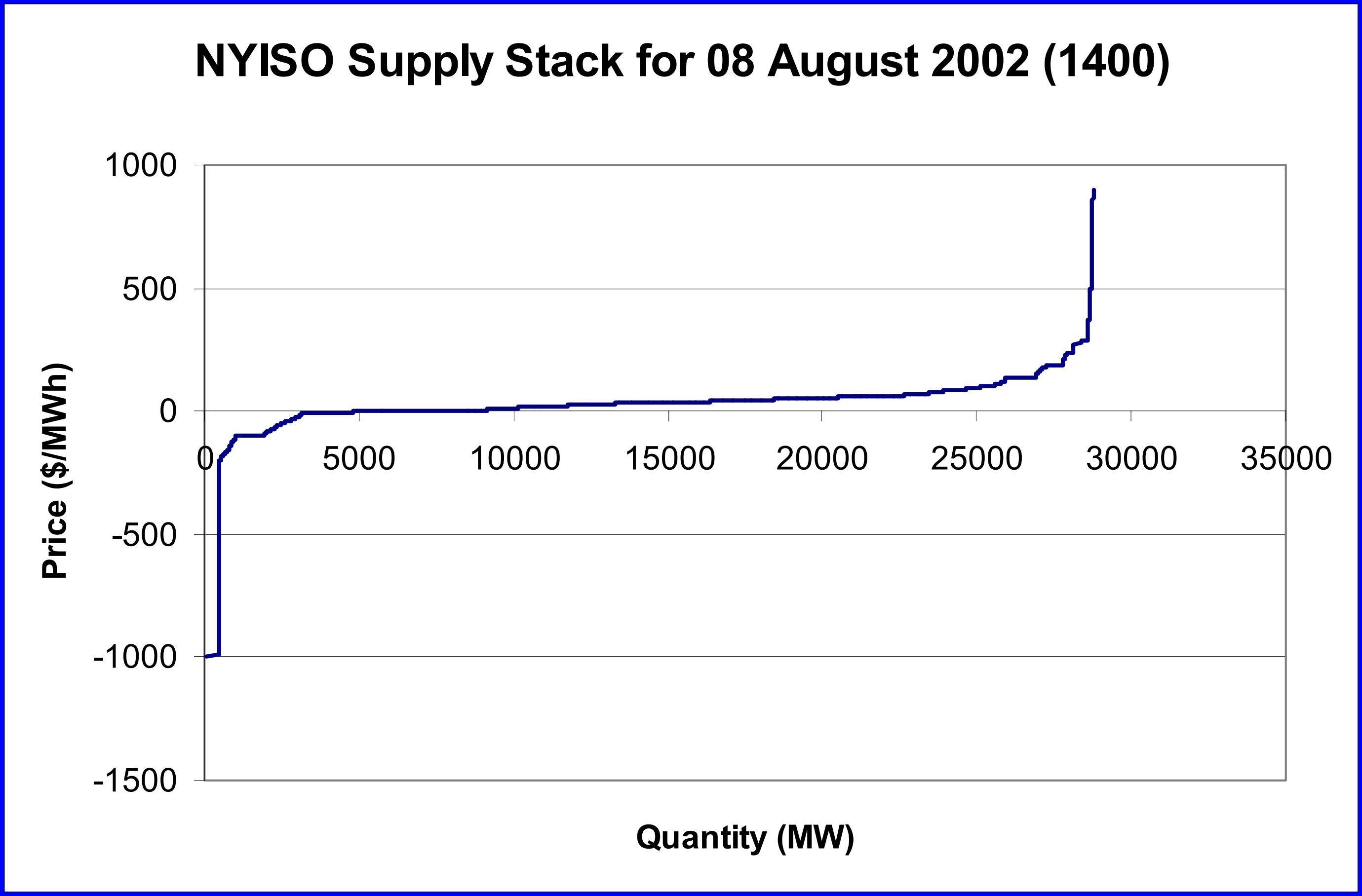
$$b_j = \min\left\{ b \,\middle|\, \frac{a - k_{n-j}}{b} = c_{n-j} \right\} \Rightarrow b_j = \frac{a - k_{n-j}}{c_{n-j}}, 1 \le j \le n-1$$

- If the supply stack's step sizes are small enough, then the increments to the slope are also small
- Allows approximate calculation of the slopes $\frac{\partial p}{\partial b}$ and $\frac{\partial q}{\partial b}$:

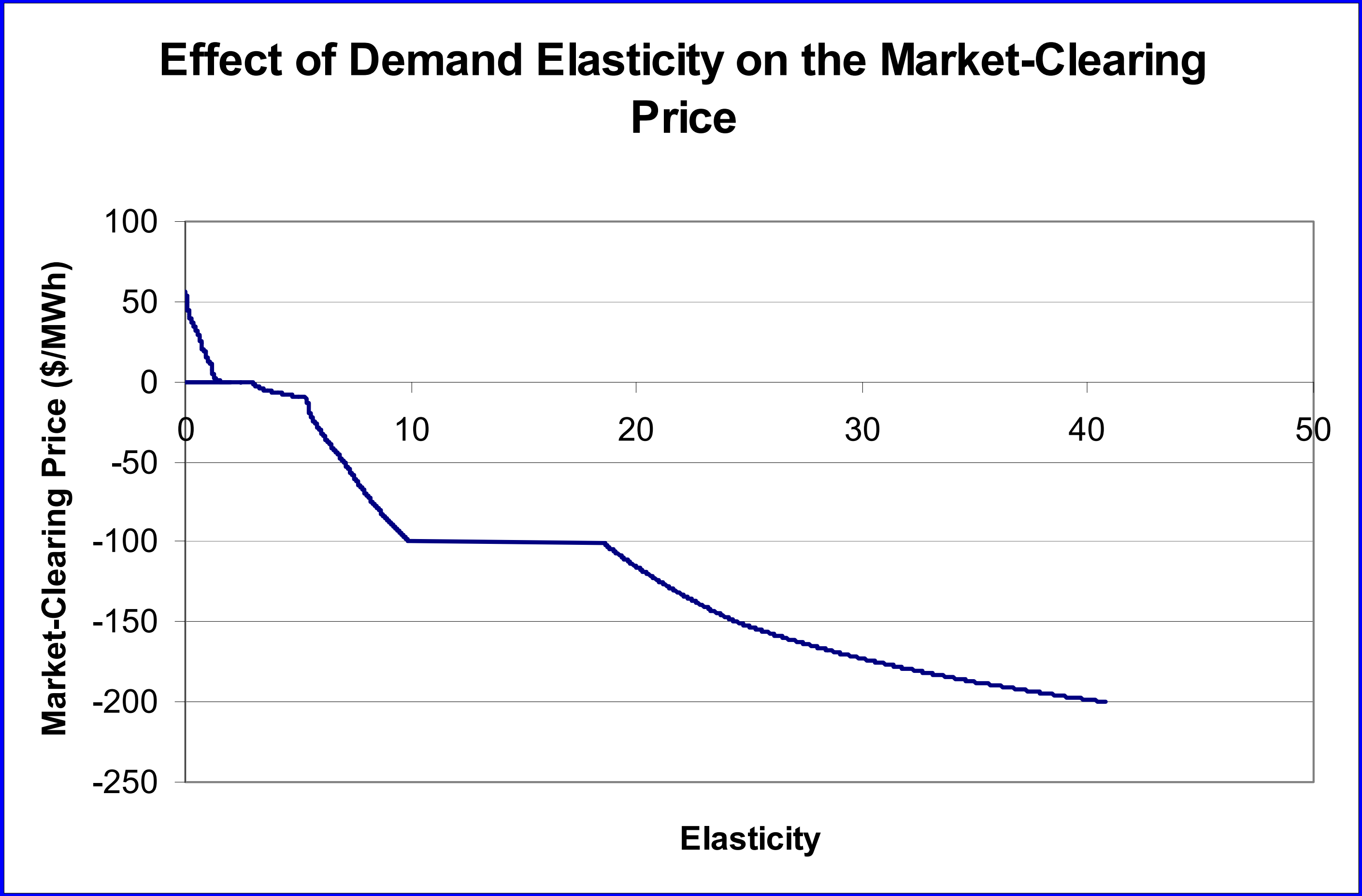
$$\left.\frac{\partial p}{\partial b}\right|_{(p_i^*, q_i^*)} = \lim_{\Delta b_i \to 0} \frac{\Delta p_i^*}{\Delta b_i} \approx \frac{p_i^* - p_{i-1}^*}{b_i - b_{i-1}}, i = 0, \ldots, n-1$$

$$\left.\frac{\partial q}{\partial b}\right|_{(p_i^*, q_i^*)} = \lim_{\Delta b_i \to 0} \frac{\Delta q_i^*}{\Delta b_i} \approx \frac{q_i^* - q_{i-1}^*}{b_i - b_{i-1}}, i = 0, \ldots, n-1$$

Methodology

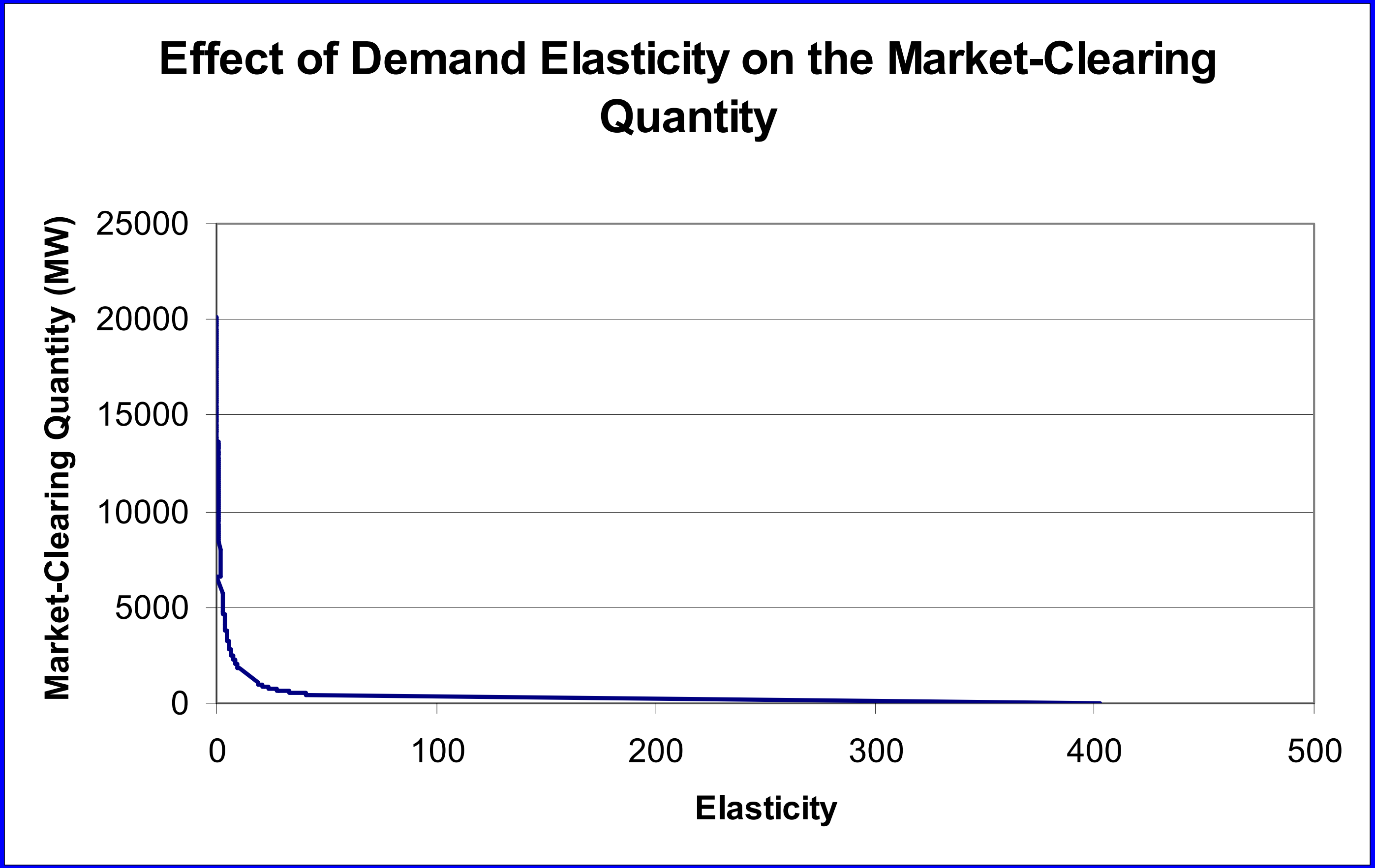


Results



Effect of Demand Elasticity on the Market-Clearing Price
Market-Clearing Price ($/MWh)
100
50
0
-50
-100
-150
-200
-250
0
10
20
30
40
50
Elasticity

Results



Effect of Demand Elasticity on the Market-Clearing Quantity
Market-Clearing Quantity (MW)
25000
20000
15000
10000
5000
0
0
100
200
300
400
500
Elasticity

Results

Scenario	Average Elasticity Required	Standard Deviation of Required Elasticity	Corresponding Average Demand (MW)	Average Percentage Decrease in Demand
25% Decrease in Price	0.23	0.12	13004	18%
50% Decrease in Price	0.53	0.19	10411	34%
75% Decrease in Price	0.87	0.31	8483	46%

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Conclusions

- Deregulated electricity industries suffer from a lack of demand-side response
- Attempt to quantify the effect of real-time pricing on the equilibrium prices and quantities in the NYISO control area for year 2002
- Results confirm the diminishing marginal returns of elasticity
- Most of the feasible potential reductions in the price can be achieved at levels of elasticity that are exhibited by large consumers
- Directions for future research: non-linear demand curves, supply shocks, forward market implications of real-time pricing