A Dissertation
Presented to the Faculty of the Graduate School
of Cornell University
in Partial Fulfillment of the Requirements for the Degree of
Doctor of Philosophy

by
Hyungna Oh
January 2003
# Table of Contents

**Biographical Sketch** iii

**Acknowledgements** v

**Table of Contents** vii

**List of Tables** xiii

**List of Figures** xiv

## Chapter One: Introduction 1

Offer behavior in the literature 1

Objectives 6

Research procedures 6

Data 10

References 12

## Chapter Two: Classifying Offer Behavior of Individual Firms 16

I. Introduction 16

II. Competitive and Monopolistic Offer Behavior 16

  Competitive offer behavior 16

  Monopolistic offer behavior 18

  Classifying offer behavior of individual firms 19

III. Firm Structure in the 1999 PJM Spot Market 20

  Classification results of supply firms in PJM 23

IV. Conclusion 26

References 27
CHAPTER THREE: MODELING OFFER BEHAVIOR BY INDIVIDUAL FIRMS

I. Introduction 28
II. Offer Pricing Behavior of Individual Firms 29
III. General Model for the Offer Curve of a Firm 31
   The model of a daily offer curve by an individual firm 32
IV. Estimation Results 36
V. Conclusion 43
References 45

CHAPTER FOUR: MODELING WITHHOLDING BEHAVIOR BY FIRMS

I. Introduction 46
II. Observed Withholding Behavior by Firms 46
III. A Model of Withholding by Firms 52
   Withholding model 53
IV. Estimation Results 55
V. Conclusion 59

CHAPTER FIVE: SIMULATING PRICE BEHAVIOR IN THE PJM MARKET

I. Introduction 62
II. Simulation Process 63
   Offer curve model 64
   Capacity withholding model 65
III. Simulation Results for Actual Offer Behavior
IV. The Effects of Changes in Offer Behavior
V. The Effects of Changing Load
VI. Conclusion

CHAPTER SIX: A DYNAMIC MODEL FOR THE RESIDUAL DEMAND CURVE

I. Introduction
II. A Dynamic Approach to the Offer Behavior of Firms
III. Residual Demand Curve
   Total supply function
   Residual demand function
IV. A State-Space Model for the Residual Demand Curve
   Measurement equation
   Transition equation
   The updating process
   Kalman updating
   Kalman smoothing
   Setting the initial values
V. Assumptions
VI. Data
VII. Relation of the Parameter Estimates to the Residual Demand Curve
VIII. Estimation Results
   Part 1- estimated parameters
   Part 2- estimated residual demand curves
CHAPTER SEVEN: OPTIMIZING THE OFFER CURVE WHEN LOAD IS UNCERTAIN

I. Introduction

II. Assumptions

- Management goal of firms
- Vertical integration and financial position
- Capacity composition and cost structure
- Withholding penalty
- Risk attitude
- Number of offers by block
- The order of the optimization

III. Stochastic Optimization

- Case 1 - fully dispatched
- Case 2 - partially dispatched
- Case 3 - not dispatched
- Expected net profit of an offer
- Withholding decision

IV. Data

V. Optimization Results

VI. The Impacts of Demand and Price Shocks on the Optimum Offer Behavior

- Non-peak load without a price spike
- Demand shock
- Combination of a demand and a price shock
II. Five Simulation Scenarios
   Scenario 1- purely competitive agent
   Scenario 2- base
   Scenario 3- price responsive load
   Scenario 4- 6 big
   Scenario 5- 30 small

III. Simulation Results
   Market price
   Offer curves of two different firm sizes
   The optimum offer by block

IV. Conclusion

References

CHAPTER TEN: SUMMARY AND CONCLUSIONS
Classifying offer behavior observed in the PJM market
Market simulation using an offer curve and a capacity withholding model
A dynamic model for the offer behavior of individual firms
A multi-agent simulation of the wholesale electricity market