NORTHWESTERN UNIVERSITY

Essays on Spatial Price Dispersion

A DISSERTATION

SUBMITTED TO THE GRADUATE SCHOOL

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

for the degree

DOCTOR OF PHILOSOPHY

Field of Economics

By

Viswanath Pingali

EVANSTON, ILLINOIS

December 2007

ABSTRACT

Essays on Spatial Price Dispersion

Viswanath Pingali

This dissertation explores price differences observed in the market. While some differences are necessitated by market conditions, the others are strategic. I illustrate the former in a study of electricity spot markets in Italy and the latter for the video rental industry.

The first project examines the welfare gains from eliminating price differences in the Italian electricity spot market. The market is divided into two geographic zones – North and South – with limited interzonal transmission capacity that often results in congestion. Congestion leads to different market clearing prices in the two zones, thereby creating potential market imperfections. We employ current market data to characterize the present market structure with limited interzonal transmission. We then simulate a scenario with no transmission congestion and measure the gains from market integration. Our empirical results indicate that easing transmission bottlenecks reduces spot market expenditure

substantially by almost four percent. We further find that that the major firm in the market does not exercise its full market power and benefits from improved transmission.

In the second project, I examine the effect of competition on prices in a market where the product is offered at different quality levels, in the context of the video rental industry. Videos can be classified into DVD and VHS. Firms can also be categorized as branded stores that belong to a major chain and unbranded stores that do not belong to any major national chain. As competition increases, prices of both DVD and VHS should decrease, but from the theory it is not clear which one will decrease more. Moreover, branded and unbranded stores may respond differently to the change in competition. Using a difference-in-difference approach I estimate the effect of competition on the price difference between DVD and VHS. I use an instrumental variables approach to address price-competition endogeneity. My empirical results indicate that the effect of competition on price difference varies according to the type of store and the type of competition faced.

Acknowledgements

I am grateful to Robert Porter for all his guidance and encouragement during my PhD career at Northwestern University. Rob has been a great mentor in the past four years and I learnt a lot about research in economics from several interactions I have had with him during the course of this dissertation. His patience in meeting with me on regular intervals and editing several versions of my papers has been unbounded. I am also thankful to my dissertation committee members: Shane Greenstein, Andrew Sweeting, and Michael Mazzeo. Independent study under Shane during my second year was one of the chief reasons for fostering my interest in empirical industrial organization. I am indebted to Andrew for several insightful discussions on electricity markets. I am also grateful to Jim Dana for several suggestions.

I owe special thanks to several batch mates at Northwestern. Federico Boffa, who worked with me on an empirical project included in this dissertation, introduced me to the economics of electricity markets. Fan Zhang and Dan Liu have come up with invaluable suggestions during our weekly meetings. Michael Coates always came up with appropriate advice whenever I was stuck on a problem. Advice from Maria Salgado and Pablo Guerron are also gratefully acknowledged. Piotr was a great help with all my software needs. Above all, these people remain good friends.

For all their love and inspiration, I am grateful to my parents, Padmavathy and Partha Sarathy. Their support has been invaluable during the course of this PhD. My brother, Bharadwaja (Tammu), has always encouraged me through his personal example. He was always there whenever I needed someone to talk to. I would also like to acknowledge the support from my fiancée, Haritha, during the final stages of this dissertation. They have always believed in me even when things were not going right and provided me with much needed moral support. I am also grateful to Bhagawan Sri Satya Sai Baba for His guidance.

Lot of friends contributed towards making living in Evanston a nice experience. My roommates: Arijit, Ketan, Tapas, and Ankush deserve special thanks for tolerating me at different points over the past six years and making my stay more homely. Their warm personality and culinary skills deserve special mention. It would be a remiss not to thank several other friends in Evanston including Sourav (Goti) and Tumpa for many a gastronomically delightful evenings at their place, my jogging partners: Agila and Monika, Amar and Payal, and Soma. Memories of times I spent with these people would remain with me for a long, long time and ensure that Evanston remains a beautiful chapter in my life.

Counseling and Psychological Services (CAPS) at Northwestern has been instrumental in providing me with invaluable support. Finally, financial support from the Graduate School, Center for the Study of Industrial Organization (CSIO) and the Transportation Center at Northwestern University are gratefully acknowledged.

Table of Contents

List of Tables

List of Figures

CHAPTER 1

Introduction

In this dissertation, I explore various aspects of price differences for identical products across different geographical regions. One can observe such spatial price differences in several industries: airlines,[1] gasoline,[2] fast food chains,[3] etc. In this dissertation, I analyze the spatial price difference observed in the cases of the Italian electricity spot market and the video rental industry in Cook County, IL.

There are several reasons why an identical product is sold at different prices at different places. Some spatial price differences are due to infrastructural shortcomings. These shortcomings, such as a lack of adequate transportation (or transmission) capacity, impede the smooth flow of the product, thereby making it expensive in certain areas. In other cases, *firms strategically segment consumers* (sometimes spatially) *according to their price sensitivity* and charge different prices to increase profits.[4] While the Italian electricity spot market illustrates the former, the video rental industry is an example for the latter type of spatial price difference.

---

[1] Borenstein and Rose (1994)
[2] Shepard (1993)
[3] Thomadsen (2005)
[4] Stole (2007)

1.1 The Italian Electricity Spot Market

This part of the dissertation is based on the joint work with Federico Boffa, a fellow graduate student and currently an associate professor of economics at Free University of Bolzano, Italy. In this project, I am primarily responsible for developing the empirical model and data analysis, while Federico is responsible for data collection and the underlying theoretical framework.

Policy makers have increasingly recognized market integration as a potential source of welfare enhancement. For example, in the Lisbon Agenda in March 2002, the European Union member countries identified interconnection of network utilities – both within and across its member countries – as a necessary condition to improve overall welfare.[5] Market integration in network industries requires interconnecting the physical infrastructure across different markets. Here we quantify the welfare gains that result from interconnection in the context of the Italian electricity spot market.

The main purpose of this project is to empirically analyze the welfare implications of eliminating the spot market price difference of electricity between North and South Italy. This price difference arises due to lack of sufficient infrastructural capacities that link both zones. Specifically, we aim to quantify two aspects of the electricity sector. First, we characterize the objective function of a pivotal electricity generator in a *semi-regulated*

---

[5] The agenda proclaims market integration as a means *"…to make Europe the most competitive and dynamic knowledge driven economy by 2010…"* (*source:* http://www.lisboncouncil.net/)

environment with mixed ownership structure (the Italian treasury and private investors). And second, we estimate the welfare effects resulting from completely eliminating the North-South price difference in Italy via installing sufficient interzonal transmission capacity.

The Italian electricity market is a good example to analyze the consequences of eliminating spatial price differences via market integration. In particular, the market is divided into several zones, with the amount of electricity that can flow across zones being limited (due to insufficient transmission capacity). Generators, with varying degrees of efficiency and capacity, are located in each zone. While a no arbitrage condition ensures that the market clearing price is the same across all zones during low demand periods, prices differ across zones during peak demand periods.[6] One way to eliminate this price difference, or to achieve market integration, is to invest in interzonal transmission capacity.

To highlight the contribution of this work, I present a brief summary of the market structure, empirical methodology employed and key results followed by the literature review. The Italian electricity market is divided into two zones: North and South, with generators located in both zones.[7] The role of the Market Operator (MO) is to coordinate consumption and generation via a spot market. The spot market is organized on an hourly basis. At the beginning of each hour, the MO invites generators to submit a menu of prices and the corresponding quantities which they are willing to supply at those prices (a supply curve).

---

[6] We define low demand periods as the hours where the transmission constraint is not met with equality and high demand periods as the hours where the transfer constraint binds with equality.
[7] See Chapter 2 for a discussion of how the zones are defined.

The MO then forecasts the market demand in each zone.[8] Given the location of each generator and demand in the various zones, the MO solves an optimal dispatch problem subject to the exogenously set interzonal transmission constraint to determine prices and interzonal transmission.[9]

The structure of generation in both zones is similar. In both zones there is a competitive fringe and a major generator, Enel, which acts as a dominant firm (i.e. residual demand monopolist). Specifically, we assume that Enel subtracts the overall fringe supply from the total inelastic demand and calculates residual demand (for which it is a monopolist). While the data suggests that the assumption of Enel being a market leader is reasonable (see Chapter 2, Section 2.2.4), it is not clear that Enel is a profit maximizer. Enel's objective function reflects several concerns. For example, 40% of Enel's shares are owned by the Italian treasury.

Our empirical methodology can be summarized as follows: using current market data (the constrained interconnection regime), we estimate the fringe's supply function. We subtract the fringe supply function from the inelastic total market demand and calculate the residual demand faced by Enel. By utilizing the realized prices and quantities in the spot market, we characterize the objective function of Enel as a weighted average of profit and

---

[8] As the forecast demand is fixed based on the needs of the end users, it is inelastic. See Chapter 2 for further discussion of why the demand is inelastic

[9] The optimal dispatch minimizes the total electricity expenditure of the consumers.

consumer welfare.[10] Under the assumption that the objective function of Enel and the behavior of the fringe do not change, we simulate market-clearing prices and quantities when transmission constraints are eliminated (the unconstrained interconnection regime). We compare consumers' total expenditure on electricity under the constrained and unconstrained regimes to calculate the welfare gain from interconnection.

We find that on average Enel places a weight of 0.64 on its profits and 0.36 on consumer welfare. Under the assumption that the weights in the objective function of Enel do not change due to interconnection, we find that easing bottlenecks would result in a saving of just over six million euros to the end-users of electricity in the month of May 2004, the sample period considered here. These savings account for almost four percent of overall spot market expenditures in the corresponding time period. We also find that Enel's profits increase by a little over one million euros during the sample period. Because we do not have complete data on the cost of providing additional transmission capacity, we characterize the gains alone. Therefore, under the assumption that May is an average month (in terms of electricity consumption patterns), the policy recommendation of our paper is to invest in the interzonal transmission capacity if the annual cost is less than seventy million euros.

In an electricity market, congestion in 'the grid' could potentially lead to two types of inefficiencies. The first inefficiency is productive: cheap (efficient) generators cannot serve

---

[10] Literature on *organizational objectives* suggests that the objective function of a firm can be inferred by looking at one or more of the stretigic variables like employmee compensation (Erus and Weisbrod (2003) and ownership structure (Hollas and Stensell (1988))

geographically distant customers due to insufficient transmission capacity. We find these productive efficiencies reduce Enel's costs in the spot market by a little over five million euros in May 2004. The second is competitive: these bottlenecks also create local monopolies. As the electricity demand is nearly inelastic, the presence of local monopolies leads to market clearing prices and quantities that are significantly different from the *first-best* (where price equals marginal cost).

Note that we assume that the decision of whether or not to build interconnection is binary. That is, we do not consider the question of optimal price dispersion. It is possible that the total welfare gain (net of costs of increasing transfer capacity) might be maximized at a point where prices are not always uniform across zones. Due to the fixed costs involved in increasing transmission capacity, a policy maker is likely to install *sufficient* transmission capacity so that an inadequate interconnection problem does not recur in the near future. We also do not consider the ownership of the transmission network and assume that the entire transmission network is under the control of a public authority (the market operator).[11]

The issue of augmenting interzonal transmission capacity is relevant for several electricity markets. For example, in the Electricity Act of 2003, the Indian government recognized the need to improve transmission capacity to solve rural electricity problems.[12] In

---

[11] Currently, private investment in transmission network is banned in Italy. See Joskow and Tirole (2005a) for arguments against and Harvy Hogan and Pope (1997) for arguments in favor of merchant transmission.

[12] Source: Speech by R.V. Shahi (Secretary Ministry of Energy, India) at World Energy Council, 2004. http://www.worldenergy.org/wec-geis/publications/default/speeches/spc041018rv.asp

2006, the Federal Electricity Regulatory Commission (FERC, the American agency that coordinates interstate electricity transmission) commissioned a study to determine whether competition in the American wholesale electricity market had resulted in prices close to perfectly competitive levels and, if not, what the possible remedies could be. One of the policy recommendations was to improve transmission capacity to ease the entry of new firms and facilitate more efficient use of existing generation.[13] The report further says that improved transmission capacity eases market participation, thereby reducing the chances of market power being concentrated with a few firms – one of the chief reasons for market failure. In this project, we are concerned with cost savings resulting from a more efficient use of existing generation capacity and not with savings from any potential entry.

The industrial organization literature is rich in studies that investigate various nuances of (de)regulation in electricity markets. In terms of the questions addressed, Borenstein, Bushnell and Stoft (2000) and Johnsen, Verma and Wolfram (2004) are similar to our paper, in the sense that they analyze transmission capacity constraints. One unique feature of an electricity market with nodal pricing is that the generator receives the market clearing price of the node at which he produces and not at the selling node. Another feature is that the total amount of transfer between two zones A and B is the absolute value of the transfer from A to B minus the transfer from B to A.

[13] *"…Building appropriate transmission network may* ***encourage entry of new generation or*** **(and)** ***more efficient use of existing generation****…"* Page 4, Staff Report Docket No. AD 05–17–000
http://www.ferc.gov/legal/staff-reports/competition.pdf

In a theoretical study, Borenstein, Bushnell and Stoft (2000) (BBS) link these two features with limited transmission capacity. In particular they show that the equilibrium interzonal transmission is uncorrelated with the nature of competition in the market. They further find that a small investment in transmission capacity can substantially improve welfare. In their analysis of Norwegian electricity markets, Johnsen, Verma and Wolfram (2004) find that when the transmission capacity across zones binds, generators can more readily exercise market power. More precisely, they find that *"…prices in local markets are higher during constrained periods when demand is less elastic."* However, the overall demand in the market they consider is downward sloping, unlike Italy where the demand in the spot market is inelastic. The contribution of our study, in the context of this literature, is to provide a numerical answer to the deadweight loss generated by insufficient transmission capacity.

Market imperfections – in the sense of market price distortion (away from the first best) – are well studied in the literature. The literature suggests that there is no correlation between market concentration and the degree of market power exercised by electricity generators. Wolfram (1999) shows that the mark ups in England and Whales electricity spot market in the early 1990s were lower than those predicted in theoretical studies, even when the market was a duopoly. Sweeting (2006) shows that, in the second half of 1990s, forms in the English electricity market exercised significant market power *"in spite of decreasing market concentration"*. Borenstein, Bushnell and Wolak (2002) estimate the effect of market power exercised by the generators on wholesale electricity prices in California. They find that, in 2002, the presence of market-power doubled the wholesale electricity price. Hortacsu and Puller (2004) show that large generators' bids in the Texas market support the assumption of profit maximization. In this sense, the contribution of this study can be viewed as showing that the firms' objective function need not be profit maximization.

Supply Function Equilibrium (SFE) – where firms choose "supply functions" as their strategy – is examined in many studies.[14] Green and Newberry (1992) (G&N) use SFE to calibrate market prices in the British electricity spot market.[15] Their model predicts that the British electricity market has high mark-ups and substantial deadweight loss, contrary to the general opinion among policy makers. Due to multiple equilibria and cumbersome computations, SFE has not been widely used by empirical economists since G&N.[16] Subsequent empirical studies of the British electricity market also suggest that the mark-ups are not as high as predicted in G&N (Wolfram (1999)).[17]

1.2 The Video Rental Industry

I illustrate a more strategic form of spatial price differentiation (price discrimination) using a data set on prices in video rental stores across Cook County, IL, that I collected.

---

[14] See Klemperer and Meyer (1989) for discussion on the existence of Supply Function Equilibrium

[15] Also see Bolle (1992).

[16] Some recent studies show that the number of equilibria can be reduced under suitable assumptions. For example see Holmberg (2004) and Genc and Reynolds (2005).

[17] SFE also requires the presence of at least two firms with significant market power. As already mentioned this is not the case in Italy.

Typically the Industrial Organization literature interprets second degree price discrimination as *quantity discounts* or *nonlinear pricing mechanisms*. But as Rochet and Stole (2002) point out, even charging different prices for different qualities offered by a firm (not justified by cost concerns alone) constitutes a form of nonlinear pricing, and hence second degree price discrimination.

"…While precisely speaking it is inaccurate to label this variable-quality setting as nonlinear pricing *per se*,… we will use the phrase "nonlinear pricing" through out this paper in the broader sense of variable pricing over the characteristics of final consumption bundle…"[18]

By offering different qualities at different prices, a firm could be trying to screen consumers based on their preference for quality. In such a market, though an increase in competition unambiguously reduces all prices, competition may affect the prices of different qualities differently. It is not clear what the correlation between the quality level and the effect of competition on its price would be. In this paper, I examine this question in the context of the video rental industry. A typical video rental firm offers two kinds of videos: VHS and DVD. While the primary content of both goods is a movie, a DVD is substantially different than VHS and generally lasts longer, enabling a store to circulate it more often.[19]

Video rental stores can also be divided into two categories: (i) branded stores belonging to a major national chain and (ii) unbranded stores that do not belong to any chain. Therefore I can differentiate the competition faced by a firm as well. I use difference-in-

---

[18] Rochet and Stole (2002), page: 278

[19] Extra features like deleted scenes, subtitles, picture clarity, etc undoubtedly make DVD a better alternative

difference methods to see how the *nature of competition* faced by the firm influences price dispersion. It is not only possible that the prices of different products at a given firm react differently to changes in competition, but also that these reactions could differ for different types of firms. For example, the change in the difference between the DVD price and the VHS price change due to changes in competition could depend on the type of the store under consideration (branded or unbranded). Moreover, different types of firms could perceive competition from a given type of firm differently.

This study contributes to the empirical literature on second degree price discrimination in competitive situations. A necessary condition for firms to be able to price discriminate is the presence of market power, though the relationship between price dispersion and competition is ambiguous.[20] Busse and Rysman (2004) study the influence of competition on the menu of prices charged by Yellow Pages. The size of a Yellow Page advertisement and its price are not linearly related. This suggests second-degree price discrimination (quantity discounts). The question addressed in Busse and Rysman (2005) can be summarized as follows: if the competition in a given market increases, would the Yellow Pages publisher reduce the prices of large advertisements more than the prices of small advertisements? They find that as competition increases, purchasers of larger ads pay relatively less compared to the purchasers of smaller ads. Cohen (2004) proposes a test to identify second degree price discrimination (non-linear pricing) with the help of a difference-

[20] See for example: Carbonneau, McAfee, Mialon and Mialon (2004)

in-difference approach. He finds evidence suggesting that paper towel manufacturers price discriminate by offering different package sizes at different unit prices.

Miravete and Roller (2004) develop a structural model to address a similar question in the case of cell phone markets. Cell phone deals offer consumers a list of options to choose from. These options vary from high fixed fees and low per-minute charges to low fixed fees and a high per-minute charge. Firms design a menu of options to screen consumers, suggesting second-degree price discrimination. The market they consider was a monopoly initially, and they see how prices changed as competition was introduced into the market. They concentrate on the welfare effects of two-part tariffs. To address the effect of competition on price dispersion, Ivaldi and Mortimort (1994) exploit multi-principle incentive theory to develop a theoretical model of competition. They fit the model to the French market for energy distribution. Their results indicate that uncertainty regarding consumer preferences plays a crucial role in determining prices.

One crucial aspect that needs to be considered when characterizing the price – competition relationship is the endogeneity of the two variables. Potential problems associated with ignoring endogeneity are well documented in the Industrial Organization literature. For example, see Mazzeo (2002) and Manuszak and Moul (2006). To summarize the main problem: in a market characterized by high entry costs, we may observe high prices and low competition. Hence a typical price-competition regression may *over-state* the effect of competition on prices. Analogously, a region characterized by high demand and low entry costs may witness high competition and high prices. In such case the regression may *under-state* the effect of competition on prices. Such problem arises due to the presence of unobserved (by the econometrician) factors that influence both prices and store location. Unobserved factors that influence both demand and market structure could bias regression coefficients. Moreover, firms set prices not only to respond to current competition, but also to expected competition. Contestability and, in particular, limit pricing arguments are some potential explanations for such a behavior.[21] Hence, in a price – competition regression, the correlation between the error term and competition creates a bias.

I use an instrumental variables approach to address the endogeneity problem. A good instrument should be correlated with competition and not with unobserved determinants of price. I assume that the competition faced by a firm is equal to the distance from the firm to the nearest rival. Under such an assumption, the second nearest rival is a candidate instrumental variable. I discuss this assumption at a greater length in chapter 4. Some studies employ structural methods to address the endogeneity issue. In his analysis of motel industry, Mazzeo (2002) estimates equilibrium market structure and uses the predicted equilibrium market structure in a price – competition regression. Watson (2002), using the entry model developed in Seim (2006), addresses variety – competition endogeneity issue in the eyeglass market. These studies examine several independent markets and exploit cross – market variation. In this paper, I consider a single market that is divided into several sub-markets that are not independent of one another. Another method that has been proposed to address

[21] See Baumol, Panzar and Willig (1988)

endogeneity problem is market-specific fixed effects. For example see the Ashenfelter et al (2004), analysis of the proposed Staples – Office Depot merger.

The video rental industry is the subject of several papers. The welfare effects of the policy shift from fixed fees to revenue sharing between retailers and the studios are explored in Dana and Spier (2001). Their theoretical model shows that revenue sharing contracts encourage stocking up inventories by suppliers. They further show that unlike two-part tariffs, revenue sharing achieves the first best outcome by softening retail-price competition without distorting the retailer inventory decision. Using a proprietary dataset, Mortimer (2003) estimates the effect of revenue-sharing contracts on consumer welfare and firms' profits, relative to linear contracts. Her results indicate that upstream and downstream profits increase and consumers are substantially better off under revenue sharing contracts. Seim (2006) estimates a model of entry of video rental stores. Using a nested fixed-point algorithm, she characterizes the locational choices of video rental firms. Seim assumes that the type of store (branded or unbranded) is immaterial to making entry decisions. This study on video rental stores contends that the type of competition has an influence.

In the next chapter, I describe the Italian electricity market and present the basic model for the fringe electricity firms as well as Enel. I then discuss the dataset used in this study and present some basic summary statistics.

In chapter three I lay out the methodology for evaluating the counterfactual and discuss the primary results of the paper. I also discuss some potential extensions for the project. A technical appendix attached describes the empirical methodology employed in chapters two and three in a greater detail.

In chapter four, I look at the issue of price discrimination and brand effect in the video rental industry. I develop some testable hypotheses based on earlier research and a theoretical example. I then describe the dataset I use, the empirical methodology and the main results of the paper.

CHAPTER 2

Modeling the Current Italian Electricity Spot Market

2.1 The Current Italian Electricity Market Setup

2.1.1 History of Reforms

In 2004, Italian national electricity consumption was around 322 terawatt Hours (TWh), an increase of about 0.4% from the previous year. Hydrocarbons (Coal, oil and natural gas) accounted for around seventy five percent of overall installed generation capacity. Hydroelectric power plants accounted for around twenty five percent and other bio-friendly generation plants (wind, photovoltaic, etc) accounted for less than 0.5% of the total production. Total net installed production capacity (after accounting for self–consumption by the generators themselves) in 2004, was around eighty thousand megawatt hours (one terawatt hour is equal to 1,000,000 megawatt hour), out of which around fifty-two thousand megawatt hours (on an average) are available for generation purposes at any given point in time. These details are presented in the Figure 2-1 and Table 2-1.

Electricity prices are high in Italy relative to the rest of the European Union. In the summer of 2005, prices in Italy were close to 14 eurocents per KWh whereas the corresponding figures in the other European Union nations were between 8 and 12 eurocents per KWh. Unlike France, nuclear energy has been banned in Italy since 1988.[22] This ban, combined with a lack of any substantial competition, is often blamed for Italy's high electricity prices.

From 1963 to 1999, all rungs in the vertical chain of the electricity market were operated by Enel, a state owned monopolist.[23] Enel was also acting as a *de facto* regulator of the electricity market in association with the Ministry of Industry, the Italian Government. Following the European Union directive on the energy sector in 1994, significant changes occurred in the electricity market structure. Starting from March 1999, these changes resulted in Enel being divested and several generating plants previously owned by Enel being auctioned off. The pace of these reforms has been slower than expected and at present, Enel still retains more than 50% of the overall generation capacity. The directive also prescribed a vertical separation of various stages in the supply chain. At the time of our analysis, transmission management was controlled by Independent System Operator (GRTN).[24] Prices have not changed substantially in the aftermath of liberalization. The average realized electricity price was € 56.18 per MWh between April and December 2004. The

---

[22] Roughly 60% of electricity consumption in France is produced by nuclear power plants. *(Source:* Brookings Institution: http://www.brook.edu/fp/cuse/analysis/nuclear.htm)

[23] Various stages in the vertical chain are: generation, transmission, distribution and retail

[24] Currently the institutional controller is Terna.

corresponding regulated price (simulated based on the input-cost algorithm used in the pre-liberalization regime) would have been € 56.00, a negligible 0.3% change.

The Italian Government further provided for a non-mandatory *spot market* to be administered by the *Market Operator* (GME) separately in each hour. The spot market began operation in April 2004, and until the end of 2004 it operated as a monopsonist with an intermediary (a single buyer AU) in charge of buying the total electricity demanded by residential consumers from the spot market. Non-residential consumers operate either through spot market or via bilateral contracts signed with retailers (or generators) directly.

2.1.2 Zonal Structure

Geographically, the Italian electricity market is divided into several zones. Each zone identifies a geographical area within which the grid is *almost perfect* in the sense that congestion is rarely observed. The regulator defines these zones and makes frequent changes to the geographical boundaries of a zone either by joining two zones or separating an existing zone depending on the amount of observed congestion. In 2004, there were seven zones. Five of these zones are located in Continental Italy (North, Center-North, Center-South, South and Calabria), while the remaining two zones are the islands of Sardinia and Sicily.

In 2004, the most critical bottleneck occurred between North and Center-North (separated 46% of all hours).[25] There was another bottleneck between the zones of South and Calabria with the markets being separated for more than 25% of the times, but for the reasons described in the data section, we ignore this bottleneck. Center-North and Center-South were seldom separated (around 4% of the hours). Center-South and South were never separated in 2004. The map of Italy (Figure 2-2) better illustrates the zonal structure of the market.

2.1.2 Current Market Structure

The spot market is designed to cater to the needs of the residential sector and all industrial customers that do not sign individual contracts. It also acts as a buffer for any unanticipated short-term shocks to the demand. The residential sector operates through a single buyer who operates via the spot market and it accounts for more than 95% of overall spot market quantity. Residential consumers pay a tariff set by the Italian electricity regulator (AEEG), fixed throughout Italy irrespective of zone, and is subject to a quarterly review.[26] Industrial spot market customers pay a weighted average of previous month's spot market clearing prices (weights given by overall spot market quantity consumed). For generators, nodal pricing is in place. That is, generators participating in the spot market receive the

---

[25] This 46% is for the entire year of 2004 and also includes weekends where the markets were seldom separated.

[26] The Electricity price paid by the residential sector and its consumption are a politically sensitive issue. Therefore though in principle it is supposed to be set as a weighted average of all the spot market clearing prices (with weights being quantities consumed), several considerations play a role during the review.

market clearing price in the zone in which they are located. Hence in any given market period the price paid by the consumers that are buying in the spot market does not depend on the price charged by the generators. Therefore the spot market demand can be safely regarded as independent of that day's spot market clearing prices, i.e., inelastic for spot market considerations.

Organization of bilateral contracts is straightforward. Contracting parties negotiate a deal that is mutually agreeable to the parties concerned. These contracts are private information (to the generator) and none of the contracting parties is obliged to divulge any part of the contractual agreement to any third party (including the regulatory authorities). The organization of the spot market is more involved. The market operator (MO) solicits bids from all generators each hour every day. A typical bid submitted by a generator consists of at most fourteen price-quantity combinations.[27] A price-quantity combination is a commitment from the generator of the amount of electricity he is willing to supply at that price.[28] The Transmission System Operator (TSO) announces the maximum amount of electricity that can be transferred across zones, which depends on several criteria such as security of supply and other physical attributes. These transmission lines need to undergo regular maintenance operations. These operations frequently cramp the maximum amount of electricity that can flow across zones. As a result, transmission capacity is subject to wide fluctuations across various hours, even within a single day.

---

[27] The minimum number of combinations is one.
[28] The minimum price that can be bid is zero. Informal discussions with the market experts suggest that if this restriction were not present, bids with negative price and positive quantity are possible.

Given the location of the bidding generators, their supply curves, the transmission constraint set by the TSO and the forecast demand in each zone, the MO solves the *problem of optimal dispatch*. The goal of this optimal dispatch problem is to minimize total expenditure on electricity in the spot market for a given electricity usage. The MO then determines the market clearing price and quantities in each zone. All generators whose submitted bids are below the market clearing price are invited to generate the quantities they committed to in their bids.[29,30]

For the reasons explained in the subsequent parts of this chapter, we concentrate only on the spot market. Therefore in the rest of the analysis, the word market refers to the spot market alone and not to the overall Italian electricity market.

2.2 The Model

2.2.1 Model Description

In this section, we model the Italian electricity spot market. We represent the two zones in the market, the North and the South, by letters *n* and *s* respectively. A *Central Institution* coordinates the actions of the two sectors and, demand and supply conditions in

---

[29] Irrespective of their bid prices
[30] If a generator is small (i.e. strictly price taker), he might have an incentive to bid artificially low prices to ensure that they produce in equilibrium

the overall market.[31] The *Institution* also acts as a link between the generators and the retail market. He buys electricity in the spot market and sells it in the retail sector at a predetermined and exogenous price.[32] At that exogenously determined price, the *Institution* is obliged to supply whatever quantity is demanded in the retail market at that price in both the zones. On the demand side, there is a monopsonist *(the Institution)* buying electricity to supply to the end-users. The monopsonist's demand for electricity in the spot market is equal to the total demand in the retail market at a given retail price. Demand in the spot market is fixed (i.e. inelastic) in both the zones.

On the supply side, the structure is similar in both zones. There is a competitive fringe in each zone, comprising several small firms that supply their entire capacity whenever the market clearing price is above their marginal cost of production. There also exists a big firm, Enel, with substantial market power. We assume that Enel behaves like a dominant firm. On the face of it, this appears to be a rather strong assumption on the market structure; however the fringe's market share and capacity share vis-à-vis Enel's suggests that the assumption is reasonable. (Table 2-3 shows the percentage of fringe production in the spot market. We discuss this assumption more in the subsequent sections of this manuscript).

The assumption on the timing of the game is as follows: every hour, the *Institution* predicts the quantity demanded in the retail market and announces the same in the spot

[31] For the ease of theoretical exposition we combine all the third party entities that play an indirect role in functioning of the spot market under the term *Central Institution.* The Market Operator, the TSO, and the regulator influence spot market at various stages.
[32] We are modeling a static situation and so we consider the retail price to be exogenously given.

market. There is an exogenously set transmission constraint that is known to all suppliers. This constraint defines the maximum amount of electricity that can be transferred across zones in the market.[33] The firms then place their bids consisting of price – quantity combinations. Based on the location of demand, the location of generators, along with the transfer constraint, the regulator computes the most efficient electricity network (that minimizes society's total cost) according to the *optimal dispatch* algorithm explained in the previous section.

Each generator consists of several plants with varying generation efficiencies. We make two assumptions on the cost structure. First, we assume that the marginal cost of any given plant is constant. Next we assume that the cost structure of a generator is known to all the other generators (but not necessarily to the econometrician). We have cost estimates not just for the monopolist, but also for a few fringe firms. As Hortacsu and Puller (2004) point out about marginal costs: *"…if we as economists have been able to gather this information from public sources, firms competing in this market will also have gained this information…"*.[34]

2.2.2 Fringe Supply

---

[33] We assume that the transfer is from North to South only. In the data, electricity never flowed to the North

[34] Hortacsu and Puller (2004), page 14.

Though the overall demand in the market is inelastic, the slope of the demand faced by Enel is strictly negative. The fringe consists of several generators, who in turn have several plants with different constant marginal costs. Moreover, different fringe firms have different commitments in the bilateral contracts market. Multi-plant structure, combined with the bilateral contracts market, ensures that different fringe firms place different threshold prices for spot market participation. Hence as the price increases, more and more fringe firms find it profitable to operate in the spot market. Therefore the residual-demand function is downward sloping. (See Figure 2-3).

As the spot market price increases, more fringe generators find it profitable to employ multiple plants for electricity generation because the price exceeds their marginal cost. Hence the supply curve of the fringe is upward sloping, as represented by the thick dotted line in Figure 2-3. The thin vertical line at Q_{Total} represents the total electricity demanded by the monopsonist (equal to the total demand in the retail market). To obtain the demand function for Enel, we need to subtract this positively sloped fringe supply function from the inelastic demand. The resultant residual demand curve is represented by the thick downward sloping line in the picture.

In order to characterize the supply function of the fringe, we estimate the following equation for every hour for every zone. Quantity supplied in bid *b* at price *p* on day *d* for a given zone at a given hour is given by:

$$q_{bd} = \gamma + \beta p_{bd} + \theta_d + \varepsilon_{bd} \quad (1)$$

θ_d indicates day fixed effects. The parameter we are interested in is beta. The additive inverse of parameter beta is the slope of the residual demand function faced by Enel. We estimate Equation (1) using ordinary least squares, and day fixed effects. There are several factors that could influence the fringe firms' bids on a given day. If there is a scale change in the fringe firms' bids from one day to the other, we would not be able to estimate the slope through OLS without bias.

The functional form chosen for the supply curve is linear. Though it simplifies computations, the assumption of linearity is restrictive. It also guarantees the existence of (a unique) equilibrium. In a nonlinear case, equilibrium need not exist when we analyze both the zonal markets jointly. We have, in fact, tried other functional forms such as constant price elasticity, but the problem of multiple equilibria forces us to revert back to the case of linearity. Perhaps because equilibrium is not guaranteed otherwise, the assumption of linear demand curves is common in the electricity literature.[35]

After estimating β_h each hour, we can characterize the supply function of the fringe for every hour in every zone. The supply function of the total fringe for hour *h* and zone *z* for day *d* is of the following form:

$$Q^f_{h,z,d} = \zeta_{h,z,d} + \beta_{h,z} p_{h,z,d} \qquad (2)$$

---

[35] See Green and Newberry (1992), Bolle (1992), Hogan and Baldick (2003), etc

Here ζ is the sum of the constant term, the day fixed effect and the idiosyncratic error. While the slope of the realized fringe's supply curve (β) is point identified, the intercept (ζ) is not. It is identified up to an error term.

2.2.3 Behavior of Enel

We assume that Enel knows the supply of the fringe up to an error term. After having previously observed the fringe's behavior over several periods, it is not unreasonable to assume that Enel could reasonably estimate (1). Moreover, by assumption, the cost structure of various firms that comprise the fringe is known to Enel. The presence of uncertainty occurs for a couple of reasons. First, the chief source of uncertainty is the presence of the bilateral contracts market coupled with increasing marginal costs. A firm's commitment in the bilateral contract market is private information. As marginal costs are assumed to be weakly increasing (step functions), it is not necessarily clear to Enel as to what the market clearing price ought to be to induce market participation by a given firm. In a typical bilateral contract, the variables that are contracted upon are price(s), and a range of quantities. Second, every firm in the fringe is composed of several small generating plants with varying degrees of efficiency. These plants need to be shut-down occasionally for maintenance reasons from time to time. These maintenance shut-downs are necessitated more by technical reasons. It is not necessary that Enel can guess these shut-downs accurately.

Literature on supply function equilibrium (discussed in section 1) suggests that uncertainty of demand is one of the reasons for the monopolist having a supply function. Figure 2-4 explains the assumption behind Enel's supply curve for three potential realizations of uncertainty. Here we assume that Enel is a profit maximizer and marginal cost is continuous, increasing and linear.

First we characterize the demand faced by Enel when there is limited interconnection between the markets. We call this regime **(C)**. Say the maximum transfer capacity for hour *h* and day *d* is given by $T_{d,h}$. This demand function can be seen clearly in Figures 2-5 (North) and 2-5 (South).

To be precise, the demand under regime **(C)** is given by:

$$Q_{n,h} = \begin{cases} \overline{Q}_{n,h} + T_h \text{ if } p_{h,n} < -\dfrac{\zeta_{h,n}}{\beta_{h,n}} \\ \overline{Q}_{n,h} + T_h - \zeta_{h,n} - \beta_{h,n} p_{h,n} \text{ if } otherwise \end{cases} \tag{3}$$

$$Q_{s,h} = \begin{cases} \overline{Q}_{s,h} - T_h \text{ if } p_{h,s} < -\dfrac{\zeta_{h,s}}{\beta_{h,s}} \\ \overline{Q}_{s,h} + T_h - \zeta_{h,s} - \beta_{h,s} p_{h,s} \text{ if } otherwise \end{cases} \tag{4}$$

$\overline{Q}_{z,h}$ represents the total consumption in zone z for hour h. As we know the slope of the demand curve (from estimating Equation 1) and the realized price and quantity for every hour (a point on the demand curve), we can identify the realized demand for the hour.

As already mentioned, due to a host of reasons, Enel might not be behaving like a profit-maximizing monopolist. Therefore the next task is to characterize the objective function of Enel.

2.2.4 Objective Function of Enel

As Enel's stock is held jointly by the Italian treasury (around 40%) as well as private investors (the remainder), we assume that the objective function of Enel is a convex combination of consumer surplus and profits. As the demand is inelastic, the consumer surplus in theory is infinity. Therefore we measure the change in consumer surplus by the change in the total expenditure on electricity. Let α be the weight given to the profits. Therefore the objective function of Enel for a given hour h can be written as:

$$\max_{P_{n,h},P_{s,h}} \sum_{z=n,s} \alpha_{z,h} \left(P_{z,h}Q_{z,h} - C\left(Q_{z,h}\right)\right) + \left(1-\alpha_{z,h}\right)\left(-P_{z,h}Q_{z,h}^{spot}\right) \qquad \textbf{(*)}$$

Here Q_z^{spot} represents the overall quantity consumed in the spot market in zone z and Q_z is the overall spot market production in zone z. The first part of the objective function, whose weight is α, is a standard profit function, while the second part of the objective function, whose weight is $1-\alpha$, is the objective function of the *optimal-dispatch* algorithm.

We assume α to be different for different periods and different zones. We advance three arguments to justify the assumption on α. The first one is similar to the one made for Ramsey pricing. Ramsey pricing theory says that charging higher prices in situations where the demand is less elastic, when compared to situations where demand is more elastic (subject to a minimum profit constraint), is welfare improving.[36] Therefore a similar argument suggests that Enel varies prices (and hence α) based on the elasticity of demand. Therefore another way to characterize α is $\alpha_{z,h} = \overline{\alpha} + \varepsilon_{z,h}$ where $\varepsilon_{z,h}$ varies every hour based on several criteria, while $\overline{\alpha}$ remains constant. The second argument relates to dynamic considerations. In a dynamic setup, Enel could potentially consider α to be a variable, instead of a parameter. That is, by varying α strategically, one could construct a situation where a better result for the end-users can be achieved, while Enel's profits over the time horizon considered are the same (as in uniform α). The final argument is based on the argument of regulatory retaliation. Huge fluctuations across zones and across hours can be perceived as an undue exploitation of market power that could lead to the market regulator imposing regulatory regime in the market, a scenario not in the best interests of Enel in the long run.

The results presented in the next chapter, show that the computed α does not vary much across hours since the standard deviation is only 0.04. The results also show that the

[36] Notice that though the demand for the market is inelastic, the demand for Enel is, in fact, elastic.

correlation between α and the elasticity of demand faced by Enel is -0.21. That is, as the demand faced by Enel becomes more inelastic, the weight placed by Enel on profits (α) decreases. We provide further details on α in the next chapter.

One assumption is that the electricity flows only in one direction: from North to South. In the entire time period we consider for this study, a net electricity flow from South to North was never recorded. While the consumption in the North is entirely served by the production in the North, consumption in the South is served by both the production in the South as well as the transfer from the North. Notice that there is no transmission constraint because we have calculated Equation 2 under the assumption that the transmission constraints bind with equality. Moreover, we consider only those hours where the prices are different across zones (i.e. the capacity constraint binds with equality).

2.3 Data

2.3.1 Data Sources

The Italian electricity market data are collected from two sources.[37] The primary source of data is the Italian Electricity Market Website.[38] The market operator releases

[37] Unless otherwise specified, the source for all the tables and graphs presented in this section is: http://www.mercatoelettrico.org, the Italian Electricity Board's official website.
[38] http://www.mercatoelettrico.org/GmeWebInglese/Default.aspx

information on all bids submitted on this website one year from the time of market participation for all parties concerned.[39] The information consists of the following items:

1. The price at which the bid is placed (in ascending order of prices)
2. Incremental quantity that the generator commits to at that price
3. The name of the generator and the zone is located in
4. Whether or not the bid is accepted (or partially accepted)
5. Awarded price and quantity allocated to a given firm
6. Status of the bid

The status of the bid indicates whether a bid was replaced, revoked or found incompatible. After the generators submit their bids, they get a chance to either revoke or replace the bids. The Market Operator also reserves the right to cancel some bids on the grounds that they are technically incompatible. These bids are not considered for computation of market structure and therefore we remove these bids from the dataset. From this information, it is straightforward to build the actual bid supply function for the entire fringe for every hour and day by aggregating the total quantity bid by every firm at a given price. This enables us to estimate the supply function of the fringe firms for every hour separately.

The other source of data is the Electricity Dataset (El-Da). This dataset is maintained by *Researches for Economics and Finance* (REF).[40] They compiled this dataset from *Italian*

---

[39] In general it takes more than a year to release information due to several bureaucratic details.

Power Stock Exchange (IPEX). We use this dataset to get information on the demand side. REF also provides estimated marginal costs for all thermo-electric (coal, oil or natural gas based) generating plants.

2.3.2 Aggregation of Zones

The Italian market is divided into six zones: North, Center-North, Center-South, South, Sicily and Sardinia. We ignore the islands of Sicily and Sardinia for the analysis because these islands are cut-off from the main land and often operate separately from the rest of the Italian market. For computational convenience, we further combine the remaining four zones into two zones, *North* and *South*, based on geographical proximity and frequency of bottleneck occurrences.[41] The North zone consists of just the North, while the South zone consists of Center-North, Center-South and South.[42]

2.3.3 Choice of Time Period

Our analysis focuses on the month of May 2004. The choice of the month was made for the following reasons:

---

[40] A consulting firm based in Europe

[41] Geographical proximity and occurrence of bottlenecks were described in previous section (also see Figure 2-2)

[42] There are two more generating points in Italy: Brindisi and Turbigo. These two are not zones per se, but injections of electricity into the South and North zone grids respectively. Therefore any generator located in either of these areas is treated as the one belonging to the corresponding zone (Turbigo to the North zone and Brindisi to the South).

- Italian electricity generation was deregulated at the end of March 2004. A major restriction in the current market is the price cap of 500 euros per Megawatt Hour.[43] Conversations with market experts revealed that April 2004 was a transition period for all market participants, including the generators.

- The MO releases the data on bidding behavior of participating firms one year from the date of participation. At the time of starting the project, we have data available for April and May 2004. For the reasons mentioned above, we decided to eliminate April 2004.

- Climate-wise May is regarded as the month with least amount of uncertainties due to fewer fluctuations in temperatures.

Out of the thirty one days in May 2004, weekends account for ten days. We ignore weekends for the purposes of this paper because the demand across zones over the weekend is generally low. As a result the transmission constraint does not bind and hence the no arbitrage condition ensures that the prices are same across all the zones. Ignoring weekends leaves us with five hundred and four hours (twenty one days). Out of these, the prices across the North and the South zones are different for three hundred and nine hours. This information is summarized in Table 2-2.

---

[43] To our knowledge, this threshold price was never realized (in the rest of 2005 and 2006), in spite of several bids being placed at that price.

Our initial intuition was that we would tend to observe more price parity during the night time than during the day time because electricity demand is typically low. But Figure 2-6 shows that this is not the case. On average the highest price difference occurred in hour 22 (9 P.M. to 10 P.M.) while the least amount of price disparity occurred in hour 5 (4 A.M. to 5 A.M.). The reason for these differences can be two fold: 1) The TSO might be scheduling transmission line maintenance operations at night (for public safety reasons), thereby reducing the amount of electricity that can be transmitted and 2) several industrial costumers realize that it is perhaps less expensive to operate late in the night than during the day. Figures 2-6 and 2-7 provide some summary statistics of price differences as well as prices observed and quantity consumed, respectively, for both zones separately.

2.3.4 Analysis of Bids

To estimate the supply curve of the fringe, we consider all the bids presented by generators other than Enel. Before we present how we analyze the bids, we justify the assumption of Enel acting as a residual demand monopolist. Looking at Table 2-3 and Figures 2-8 to 2-10 it is clear that Enel had (and still has) significant market power in May 2004. In all of Italy, Enel had close to 60% of the capacity. If we ignore the zones of Sicily and Sardinia, the share is much higher. While in the North, Enel has more than around 50% of the overall capacity, in the South it is close to 80%. There is no other generator that even comes close to 15% of overall capacity.

As previously mentioned, generators face a price cap of 500 euros per megawatt hour. The minimum allowed price is zero. During certain hours, generators may have an incentive to bid a price of zero for strictly positive quantities. This zero price bid ensures that the generator would be asked to produce in equilibrium. At the same time, the generator receives market clearing price. By assumption, a fringe generator is not powerful enough to unilaterally influence market clearing prices. Therefore when a generator bids a zero price for a strictly positive quantity, he is merely ensuring spot market participation and actually obtains a strictly positive price. If a generator has substantial commitments in the contract markets for the next hour with none at a given hour, he might find it optimal to ensure spot market participation in that hour. Significant startup costs suggest that switching the plant is not an economically viable option in such circumstances. The case is similar for bids close to the price cap where the prices bid are well above the maximum price ever realized. From some informal discussions with a few fringe generators, it was evident that they have a fairly good idea of the interval in which market clearing price will be realized.

According to the model we proposed in the previous section, this estimated supply function of the fringe reflects Enel's belief about the fringe firms' behavior. Considering such extreme bids biases the estimate of β, the slope of the fringe's supply function. Therefore, to avoid such a situation, we took the maximum and minimum market clearing price for every hour and constructed an interval for every hour separately such that the lower bound of the interval was 25% below the minimum ever realized during for that hour and upper bound, 25% more than the maximum price ever realized (for that hour). If the lower bound is below zero, we artificially set it equal to zero.[44] The maximum and the minimum prices realized every hour (for both the zones) are given below in the Figure 2-11.

Out of the remaining bids, we ignore the bids where the bid price was zero. This was done for the following reason: the supply function of the fringe firms is supposed to represent the belief Enel has about the fringe firms' behavior. As discussed previously, the lowest possible price that one can bid is zero and if the minimum were not zero, it would perhaps have been possible to observe negative price bids as well. Therefore zero is only a lower threshold and any price-quantity combination involving zero-price does not reflect Enel's true belief about the fringe firms' supply at a price of zero. Including these bids overestimates the true β.

2.3.5 Cost Function of Enel

Most electricity generators are multi-plant firms. Based on the location of the plant, its production process and the inputs required for electricity generation, electrical engineers compute the marginal cost of each plant. In such computations, it is assumed that the marginal cost of any given plant is constant. But the marginal cost of a given generator is a step function. That is, various quantity intervals produced by the generator have different marginal costs. REF provides us with engineering estimates of the marginal costs of every

---

[44] This 25% is fixed arbitrarily. Ideally we should consider a weighting scheme such that the farther the bid is from equilibrium, the lesser weight the bid gets. The present approach gives uniform weight to all the observations within the interval and zero weight to all the bids outside the interval.

thermo–electric plant of Enel and a few fringe plants (thermo-electric) in Italy. From this we first eliminate the plants belonging to non-Enel generators and characterize the marginal cost of Enel as a step function shown in the Figure 2-12. Marginal cost is C_1 for quantity level between 0 and K_1 and C_2 for quantity level between K_1 and K_2 and so on. Figures 2-13 (a and b) shows the actual marginal costs of Enel at various quantity levels.

2.3.6 Bilateral Contracts vs. the Spot Market

In this project we only consider the welfare gains in the spot market and not the contracts market. The data on the contracts market are proprietary and difficult to obtain. Even if one were to obtain these contract data, the contracts are numerous and varied that it would probably be computationally intractable to aggregate all the cases. Bilateral contracts form a major portion of electricity consumption in Italy. The term liquidity measures the amount of electricity transacted in the spot market as a fraction of overall consumption. On average, the spot market accounts for around 30% of the overall electricity market. The details on liquidity are presented in Table 2-4 and Figure 2-14.

Wolak (2000), in his analysis of the Australian electricity contracts market, points out that a typical hedge contract looks as follows: *"Hedge contracts are usually signed between a generating company and an electricity retailer. A hedge contract guarantees the price at which a fixed quantity of electricity is sold… If the market price exceeds contract price, then the contract seller pays to the buyer the difference between two prices times the contract* *quantity…"* and vice-versa.[45] The Italian contracts, on the other hand, are mostly bilateral contracts and not just price-insurance mechanisms as practiced in the Australian market. A retailer/generator who signs the contract is expected to physically deliver electricity to the consumer involved in the contract at a pre-determined and mutually agreed price.[46] From the few contracts we have obtained, the price agreed upon is often a weighted average of the previous month's spot market clearing price. But this is by no means a general rule. Currently, the TSO gives preference to the bilateral contract market (over spot markets) for utilizing the existing transmission capacity. Therefore, improving transmission capacity is not likely to effect contracts market substantially. As a result, the welfare gains in the spot market due to market integration can be considered as a good approximation of the overall gains in the electricity market.

However, the contracts market plays a role in determining the '*marginal plant*' Enel uses for production in the spot market. This is an industry characterized by several multi-plant generators, with each plant operating at a different efficiency level. As honoring bilateral contracts is mandatory, while participation in the spot market is not, it is clear that a given generator uses his most efficient plants to supply in the contract market. Therefore it becomes crucial to determine the *marginal plant* where the transition to production in the spot market (from the contract market) takes place. We identify the most efficient plant (belonging to Enel) that participates in the spot market bidding for a given hour as the

[45] Foot note one, pages 1-2
[46] The Italian law forbids generators from signing bilateral contracts directly. These generators operate in long–term contracts market via the retailers (middlemen)

marginal plant for that hour for that zone. To determine the marginal plant in the integrated market we add the capacities of all plants that are designated for contracts market. We then arrange the plants of the integrated market in increasing order of efficiency and determine the marginal plant for the integrated market.

We assume that all plants that are more efficient (than the marginal plant) are utilized to supply in the contracts market, while less efficient plants (including the entire marginal plant) are utilized to supply the spot market. The rationale behind such an assumption is straight forward. While participation of firms in the contract market is mandatory, it is not the case in spot market. So a firm uses the best plants to fulfill its contractual obligations and uses the less efficient ones in the spot market only if the price is greater than the marginal cost. Due to the assumption of constant marginal cost, Enel utilizes a plant only if the next most efficient plant's capacity is entirely utilized. We further assume that all hydroelectric plants and wind and photovoltaic generators (whose marginal cost is close to zero) are also utilized to supply in the contracts along with the imports coming from France.[47]

[47] Electricity is imported into the North zone from France at a pre-determined price.

CHAPTER 3

Simulated Vs Actual Italian Electricity Spot Market

3.1 Evaluating the Counterfactual

To predict the gains from integrating the two markets we first need to simulate the electricity market when there is no transmission constraint. We call this the *unconstrained regime (UC)*.

We make two assumptions while evaluating the counterfactual. First, the behavior of fringe does not change. The rationale behind the assumption is as follows: by assumption fringe is a price taker. That is, the fringe produces whenever the price is greater than the marginal cost. There is no ex-ante reason why the fringe's marginal cost has to change as a result of market integration. They still produce whenever the price in the unconstrained market is greater than their marginal cost. The second assumption concerns the objective function of Enel. We assume that the objective function of Enel does not change as a result of market integration. The rationale behind such an assumption is twofold: one ex-ante and another ex-post. The nature of objective function is partly due to the nature of ownership structure. There is no ex-ante reason why the ownership structure of Enel needs to change as a result of interconnection. Moreover, as talked about in the previous chapter, α does not exhibit great variability, even when we do not impose any restrictions on it. The standard deviation of α across zones and time periods is 0.04, suggesting the lack of variability across several demand conditions.

In the case where the market is unified, denoted by the regime **(UC)**, we assume that Enel is still the residual demand monopolist, albeit now for the combined demand. Also, we have separate fringes participating in the market. Total fringe supply is the summation (across quantities) of both the fringes. Figure 3-1 depicts the summation of the two fringe supplies and Figure 3-2 diagrammatically characterizes the demand function faced by Enel.

Mathematically the demand function faced by Enel takes the following form (using the notation introduced in the previous chapter):

$$Q_h = \begin{cases} \overline{Q} \;\; if \;\; p_h < \min\left(-\dfrac{\zeta_{h,z}}{\beta_{h,z}}\right) \; where \; z = n, s \\ \overline{Q} - \zeta_{h,k} - \beta_{h,k} p_h \;\; if \;\; \min\left(\dfrac{-\zeta_{h,z}}{\beta_{h,z}}\right) < p_h < \max\left(\dfrac{-\zeta_{h,z}}{\beta_{h,z}}\right) \; where \; z = n, s \\ \overline{Q} - \zeta_{h,n} - \zeta_{h,s} - \left(\beta_{h,n} + \beta_{h,s}\right) p_h \;\; if \;\; p_h > \max\left(\dfrac{-\zeta_{h,z}}{\beta_{h,z}}\right) \; where \; z = n, s \end{cases}$$

Here k represents the zone where $\dfrac{-\zeta_{h,z}}{\beta_{h,z}}$ is maximum.

We calculate α for each hour for each zone separately and compute the overall α by taking a weighted average of the zonal α's, where the weights are given by the overall quantity consumed in the spot market. Using the estimated weights for consumer and producer surplus, we simulate the spot-market clearing prices when there are no transmission constraints. This equation highlights the need to assume the fringe's supply function to be linear. Any other functional form might lead to multiple equilibria.

$$\max_{P} \alpha \left[P\left(Q_n(P) + Q_s(P)\right) - C\left(Q_n + Q_s\right)\right] - \left(1-\alpha\right) P\left(Q_n^{spot} + Q_s^{spot}\right) \quad \textbf{(**)}$$

We provide a detailed step-by-step estimation method in the appendix (Appendix A) attached at the end of this thesis.

3.2 Results

The main results that need to be discussed are the results of the fringe regression, followed by the objective function of Enel and finally the characteristics of the simulated market.

3.2.1 Fringe Regression Results

We estimate Equation (1) by OLS and day fixed effects. The results of various estimation methods are presented in Tables 3-1 and 3-2. For the rest of the analysis and simulations, we use the estimates obtained from the fixed effects regression.

The OLS regression results indicate that for the south zone, the slope of the supply curve of the fringe for hour 16 is negative and insignificant. But on any given day, generators bid such that the quantity bid is strictly increasing in price. This highlights the need for day fixed effects. Though on a given day, correlation between price and quantity is positive, it is not so when all the days are considered. Considering day fixed effects also accounts for any idiosyncratic shocks to the overall consumption (for example, previous hour's fringe production). Discussion in the data section indicates that fringe has a larger presence in the North than in the South. Therefore one should find Enel to be more responsive to the price in the North than in the South. The regression results indicate that as expected, the slopes of the supply of the fringe in the North are higher than that of the South for all hours.

To see if slopes, in fact, statistically differ across all hours, we have tested the null-hypothesis of the slope being equal across all the hours. For the North, we are able to reject the null hypothesis at 99% significance. At the same time, we are unable to reject the hypothesis that the slope are the same for any two successive hours. But the difference between the slopes of hours one (1 AM to 2 AM) and twenty-four (11 PM to 12 AM) is statistically different. For the South, we are unable to reject the null-hypothesis that the slopes of various hours are significantly different from each other. The average value of the slope in the South is given by 5.95, significantly different from zero. So for the rest of the analysis, we also check for the case of the slope of the South being constant.

3.2.2 Enel's Objective Function

Before we simulate the market under the alternative market regime of no transmission constraint we characterize the objective function of Enel as described in Chapter 2. Enel places a weight α on profit and $1-\alpha$ on consumer welfare. We compute α for every hour by equating observed prices in both zones with the prices predicted from the first order conditions of the objective function (*) characterized in the previous chapter. We compute the overall α as a weighted average of α_n and α_s, with the weights given by the total quantities consumed in the spot market in the respective zones. On average α takes the value 0.64 with a low standard deviation of 0.04. The median value of α is also 0.64 while the weighted average of α (where weights are given by corresponding quantities consumed that hour) is 0.59.[48] Average value of α, where the slope of South is constant at 5.95 is 0.64. Characteristics of computed α are presented in Table 3-3 and Figure 3-4.

One interesting coincidence deserves to be pointed out. The share of private sector in Enel is about 60% in 2004. Our results indicate that Enel places a weight of 64% on an average on profit function, with low variability. Current research suggests that there is no ex-ante reason why the objective function and of a firm and the ownership structure are correlated with one another. The robustness of this result suggests that some future research is needed to establish a theoretical connection between both the factors.

---

[48] Around 60% of Enel is owned by private investors and around 40% by the Italian treasury.

Casual observation suggests Enel may have, among its objectives, to reduce the price difference between the North and the South. This can result from the fear that a relevant price difference may be perceived as the result of market power exploitation, and thus may foster regulatory retaliation. However, data seem to suggest that, when a homogenous behavior (in terms of markup) between the North and the South entails a large price difference, Enel tends to increase the North profit, in order to align the prices in the prices in the two zones. This speculation is the subject of future research.

3.2.3 Simulations in the Alternative Market

After characterizing the objective function of Enel, we simulate the market under the alternative market structure of no transmission congestion. That is, we solve the problem (**) mentioned in the previous section. For that we make the following assumptions: a) the weight Enel places on profit (α) in (**) is same as the one characterized in (*) and b) the behavior of the fringe does not change as a result of market integration. The motivation behind Enel's objective function is the nature of ownership and other concerns like regulatory retaliation. There is no *a priori* reason why the nature of ownership should change as a result of market integration. The assumption on the fringe firms is that a fringe generator supplies whenever the market price exceeds the marginal cost. Capacity shares of various generators remain the same even after the market integration and hence Enel would still be the residual demand monopolist in the market.

We employ an iterative procedure to obtain equilibrium in the alternative market regime. We order Enel's plants in increasing order of efficiency and calculate objective function–maximizing output for the most efficient plant ignoring the transmission capacity constraint. If that output is feasible (i.e. lower than the capacity) it is the equilibrium quantity. Otherwise, we consider the two most efficient firms and reiterate the process. Figure 3-5 captures this algorithm. For simplicity of exposition, we consider the case of a profit maximizing monopolist with four plants with capacities $K_i - K_{i-1}$ (i = 1…4 and $K_0 = 0$) and marginal costs C_i (i=1 to 4) respectively. q_i represents the profit maximizing quantity when the marginal cost is C_i (ignoring the capacity constraint of the plant).

This procedure is illustrated in Figure 3-5. We start with plant one (whose marginal cost is C_1). As q_1 is less than the plant one's capacity limit, K_1, we know that the monopolist does not stop with utilizing plant 1 alone. When plant two is utilized, the profit maximizing output is q_2. As q_2 does not belong to the interval $[K_1, K_2]$, we know it is not optimal for the monopolist to stop with plant two. Similarly as q_4, the optimal quantity at marginal cost C_4, does not belong to the interval $[K_3, K_4]$, utilizing plant four is not optimal either. The equilibrium quantity q_3 belongs to the interval $[K_2, K_3]$ and hence it is the equilibrium quantity. We present simulated prices and quantities in Figures 3-6 and 3-7 respectively.

Hourly average prices in the integrated market are between the average prices in the north and average prices in the south. It is the same for quantities consumed as well. These graphs illustrate the gains of interconnection clearly. The prices and quantities produced by

Enel in the alternative market structure closely resemble that to the North, that the South. While the prices in the North, only increase marginally, the prices in the South decrease substantially. Therefore one should expect cost reduction as a result of integration.

The simulation results indicate that market integration significantly increases welfare. The overall gains due to interconnection are a little above six million one hundred euros for May 2004. Some hours gain more than other hours. The maximum gain due to interconnection is observed in hour 22 (9 PM to 10 PM) on 17th May 2004. The gain recorded is around one hundred and sixty thousand euros. The maximum loss due to interconnection, little less than fifty thousand euros is recorded for the hour 17 (4 PM to 5 PM) on 7th May 2004. On average, twenty two hours per day recorded a gain due to interconnection. Average hourly gains are presented in Figure 3-8.

We have also checked the gains from interconnection when α (the weight given to profit by Enel) is constant and equal to its median value, $\alpha = 0.64$. In that case we find that the gains from interconnection are a little less than three and a quarter million euros for May 2004. These gains from interconnection did not differ substantially when we set the slope of the South as constant at 5.95. In such case, the gains were little under six million eighty seven thousand euros for the month of May 2004. Gains from interconnection are summarized in Table 3-4.

3.2.4 Effect of Integration on Enel

As discussed earlier, this price reduction in the South (and hence overall cost reduction) could be happening for two reasons. First, in the South, though Enel owns more than 80% of the capacity, in the overall market it only owns around 60%. Therefore this results in the South becoming more competitive. Second, Enel has several more efficient firms in the North that remain idle. Looking at the data tells us there were hours where firms in the North with marginal cost less than twenty seven dollars were idle, while in the South plants with marginal cost more than forty dollars were in operation.

The source of gains becomes clear if we compare the costs incurred by Enel under the two regimes (constrained and unconstrained). Due to the improved transmission network, Enel can reallocate its production strategy in such a way that a plant would be in operation only if every other plant that is more efficient is fully saturated. This reallocation is over entire Italy, as against only within the zone. Our results indicate that by reallocating its production strategy across zones, Enel's total cost in the spot market reduces by little over five million euros. Enel's profits also improve substantially by little over one million euros. Since the market share of Enel only registers marginal improvement (from 0.586 in the constrained regime to 0.589 in unconstrained regime), the role of reallocation becomes more clear. Enel's total variable profit increases by over a million euros. This suggests that Enel also has an incentive to invest in the interzonal transmission.

These results indicate that there are significant gains due to interconnection. If we believe that May represents a typical month over the year, we can expect a total gain of around seventy three million euros for the entire year. In 2004, Terna (the owner of interconnection infrastructure responsible for interconnection) estimated that it would cost around four hundred thousand euros of labor and material cost (e.g. cost of cable) per kilometer of interconnection. Though the actual bottleneck is only for around one hundred kilometers (and hence forty million euros) an improved interzonal transmission network also requires a more efficient intra-zonal transmission mechanism, the cost of which we have no data on. A complete cost analysis should also involve quantifying several other factors. For example, it should include environmental costs and the opportunity cost incurred due to disturbances to the existing transmission network. To our knowledge there is no consensus in the economics and the engineering literatures about how to calculate such costs.

3.3 Conclusion

In this project we have analyzed the benefits associated with eliminating price difference across zones by removing transmission bottlenecks across zones in the Italian electricity spot market. We have also analyzed market power exercised by Enel, the major generator in the market. We found that Enel associates a weight of 64% to the profits and the remaining 36% to the consumer welfare with a standard deviation of 4%.[49] This weighting

[49] Due to the inelastic nature of demand, we measure consumer welfare as the additive inverse of economy's total expenditure on electricity. Therefore maximizing welfare could be viewed as minimizing total expenditure.

function seems reasonable, especially in light of the fact that the Italian treasury held around 40% of the stock in Enel in May 2004. Under the assumption that these weights do not change when transfer constraints were eliminated, we found that the total cost savings to the end-users would be approximately six million euros in the month of May 2004, our sample period. As May is an average month in terms of electricity consumption (due to climatic conditions), the savings in expenditures on electricity for the entire year (from April 2004 to March 2005) would be at least seventy-three million euros. These gains are primarily driven by a major reallocation of production across plants by Enel. This reallocation also results in reducing Enel's costs in the spot market by around five million euros and improves Enel's profits by little over one million euros. This suggests that Enel also might have an incentive to invest in the transmission capacity. Further studies on the costs of interconnection need to be carried out before policy decision on interconnection can be arrived at.

Future work would include a more robust estimation approach for the demand function. Our analysis is based on the assumption of linearity of demand and supply functions. In future we want to consider the step-function approach à la Hortacsu and Puller (2004). Instead of smoothing the supply curve of the fringe (using any functional form), we could consider that the supply function of the fringe consists of a discrete set of points.

There are other ways of achieving price-parity between zones. For example, the Government could encourage private (non Enel) installation of efficient generators in the South by providing appropriate subsidies and scientific know-how. Therefore an immediate extension of the paper is to check the net welfare effects of additional generation capacity in the South vis-à-vis improving the transmission capacity.

Data are also available on all the bids submitted by Enel. However for the empirical strategy developed in this paper, we only utilize the bids submitted by the fringe firms and the final market clearing prices and quantities observed in the market. Therefore our next endeavor would be to use all the information available about Enel to characterize its objective function. Finally, we have ignored the possibility of potential entry that could occur due to easing the bottlenecks. Better infrastructural facilities could, presumably, make electricity generation more profitable and hence we could potentially observe more entry, thus driving down the prices further. In that sense, the gains we have predicted here would be lower bound to the actual potential gains. Therefore another potential extension is to check the effect of entry on the prices in the alternative market scenario.

CHAPTER 4

Brand Effect and Price Discrimination in the Video Rental Industry

4.1 Testable Hypotheses

Several studies have extended the monopoly nonlinear pricing literature to competitive environments. But the effect of competition on second degree price discrimination is ambiguous. To my knowledge, Oren, Smith and Wilson (1983) were the first to establish the feasibility of nonlinear pricing in a competitive environment. In an *n*-firm (symmetric) quantity-setting game (*a la* Cournot) where there are discrete types of consumers, they show that nonlinear pricing is the equilibrium strategy. As the number of firms in the market tends towards infinity, all prices tend towards marginal production cost, but it is not clear from their model as to which prices adjust faster to the competition. Similar results were found in Spulber (1989) in a price-setting game where consumers vary in their preference for a particular brand.

Some studies point out that if quality levels are exogenously fixed, competition has no effect on the difference between the various prices charged. Armstrong and Vickers (2001) show that a standard oligopoly problem can be redefined as one where firms compete on providing utility to consumers. Characterizing competitive outcomes in several dimensions (for example, in multidimensional screening models) can be computationally intensive and is often intractable. They overcome this problem by modeling firms to be supplying utility directly to the consumers. They further show that in an oligopolistic environment (standard Hotelling model) where consumers have private information about their tastes (and differ according to their taste parameters), a *two-part tariff* is the unique equilibrium outcome. Each firm produces *n* different goods with different marginal costs ($c_i, i = 1, 2, \ldots n$). Consumers choose different goods in different quantities, ($q_i, i = 1, 2, \ldots n$) depending on their tastes. They show that the equilibrium tariff for the basket of goods consumed is $T\left(\overline{q}\right) = t + k + \sum_{i=1}^{n} c_i q_i$, where $\overline{q}$ is the basket of goods purchased, *t* is the transportation cost of the consumer per unit distance traveled (the degree of product differentiation), and *k*, any additional cost incurred by the firm for a given buyer.[50] Therefore the price charged to the consumer with unit demand for only one type of good (whose marginal cost is *c*) is $T(q) = t + k + c$. This implies that competition, as represented by *t*, influences prices of all goods in the same manner.

Rochet and Stole (2002) study price discrimination (*two-part tariff case*) in a multi-quality competitive market where consumer participation is *less than perfectly elastic*.[51] That is, they assume that the consumers' outside option is a random variable. For any given price

[50] Proposition 5, page 600 in Armstrong and Vickers (2001)
[51] Page 278, Rochet and Stole (2002)

level, the probability with which a given consumer purchases the good is known. They show that in equilibrium, firms offer contracts such that the price equals the *marginal cost of providing a quality level plus a fixed fee*. Even when firms are identical, it is possible that the fixed fee varies across firms. In this case, the difference between the prices of various quality levels is the difference in their marginal costs. When the quality levels are exogenously fixed, competition faced by the firm has no effect on the difference between prices in that firm. However, since in the video rental industry the competition is both in terms of quantity (renting multiple titles) and quality, analogy with these studies is not straightforward.

Screening of consumers based on quality is also highlighted in the finance literature. Villas-Boas and Schmidt-Mohr (1999) model the banking industry where the firms screen their consumers into high risk and low risk categories by offering different combinations of interest rates and collaterals. They show that, as competition increases, firms compete less aggressively for the most profitable customers. I now construct two examples to derive some testable hypotheses. The first one is straightforward, while the second one is based on the model of Villas-Boas and Schmidt-Mohr (1999).

Consider a linear city of unit length (*a la* Hotelling) with a firm located at each end. Consumers are distributed uniformly on the line. Consumers are of two types: high and low. Each firm sells two types of goods: D and V. Other things being equal, good D is weakly preferred to good V by all consumers. I assume that the high type consumers have high transportation costs and a higher preference for good D (their marginal utility with respect to good D is high), whereas low type consumers have zero transportation costs and are indifferent between the products. That is, low types prefer the cheapest good available and if prices are equal, they select at random. In this situation, Bertrand competition dictates that the price of V be zero, while the standard Hotelling model yields the price of D as t. As t, the degree of competition between the stores, tends towards zero, the price difference between D and V in a given store tends towards zero (i.e., decreases).

The second example differs from the traditional non-linear pricing models. The literature often assumes that the quality levels available to firms are fixed exogenously. In contrast, I allow firms to choose the quality that they offer. In the video rental industry, firms choosing quality can be justified on two grounds. These stores determine: 1) how many times they allow a particular DVD and a VHS to circulate, and 2) the type and amount of inventory they carry (the number of titles in the store and the number of copies of each title).[52] The underlying assumption is that a consumer who visits a particular store ends up renting a video from that store, even if his first choice video is not available. Therefore, the greater the variety and stock of movies, the better the quality the consumer expects to receive *ex ante* (before visiting the store).

Consider a market where firms choose both qualities offered, as well as prices for each quality. The firms are denoted by *Left* (L) and *Right* (R). Firm L is located at point 0,

[52] For example, most of the branded stores like Blockbuster and Hollywood video do not carry movies rated above R. Moreover, branded stores tend to carry multiple copies of a same title to ensure availability to consumers. As most branded stores also specialize in selling used videos, it can be argued that they withdraw a movie from circulation faster than the unbranded stores.

while Firm R is located at 1 on the unit interval. Consumers are distributed uniformly on the line. A consumer's location is denoted by *x*, the distance between the consumer and the firm L. The distance between the consumer located at *x* and firm R is 1-*x*. I denote t_H and t_L to be the cost of traveling a unit distance for high type and low type consumers respectively. Transportation cost $\left(t_i, i \in \{H, L\}\right)$ can be interpreted as the degree of product differentiation. A video rental store differentiates itself from its competitors in two ways: by the location and inventory it carries.

If the transportation cost, *t*, is zero, then spatial competition is irrelevant and the market is perfectly competitive. Price setting (*a la* Bertrand) will then result in price equaling marginal cost for both commodities. I further assume that consumers vary in their preference for quality. Preference for quality is represented by θ. For simplicity, I assume that θ is one of two types: $\theta \in \{\theta_1, \theta_2\}$, such that $\theta_1 > \theta_2$. A fraction α of consumers are of type one whereas the rest are of type two. The location and type of a consumer is private information, while the distribution of consumers' type is common knowledge. I assume that the consumer location and type are independently distributed.

Firms (L and R) sell products at two different quality levels, q_1 and q_2 (to be determined by the firms). The net utility of a consumer of type $\theta > 0$, buying quality *q*, and paying price *p* before the transportation costs is given by the following function,

$$U(\theta, p, q) = \theta q - p + M$$

where *M* is *sufficiently* large.[53]

A consumer's utility strictly increases with the quality of the good purchased. High type consumers (θ_1) value quality more than low type consumers (θ_2). This is the single crossing condition of adverse selection models, i.e. $\frac{\partial^2 U}{\partial q \partial \theta} = 1 > 0$. The utility function is similar to that of Mussa and Rosen (1978), and Rochet and Stole (2002).

Finally, the total utility of a consumer located at *x*, net of costs, is given by $U(\theta, p, q) - d$, where *d* is the transportation cost incurred. The transportation cost, *d*, takes the value $t_i x$ if the consumer buys from firm L, and $t_i(1-x)$ if he buys from firm R instead $\left(i \in \{H, L\}\right)$. The consumer has an outside option that yields a utility of zero.

The incentive compatibility (IC) constraint (that determines a consumer's choice of quality between various products of the same store) does not depend on the consumer's location. *Sufficiently large M* guarantees that the transportation cost plays a role only when choosing a store and not the product. The IC constraint solves the following equation:

$$U(\theta) = U(\theta, p(\theta), q(\theta)) = \max_{\bar{\theta}} U(\theta, p(\bar{\theta}), q(\bar{\theta})) \quad \text{(IC)}$$

Characterizing the individual rationality (IR) or participation constraint is not so straightforward. The participation constraint should satisfy two conditions. The utility that

---

[53] *Sufficiently large M* ensures that, in equilibrium, all potential consumers in the market want the good. Another way to ensure full participation is to assume that the utility associated with no purchase is $-\infty$

the consumer visiting Store *i* receives must exceed his reservation value (assumed to be zero) and the utility obtained from visiting Store *j*, where $j \neq i,$ and $i, j \in \{L, R\}$.

A consumer of type θ located at point *x* consumes from firm *L* if the following condition holds:

$$U(\theta) - tx \geq U^R(\theta) - (1-x)t$$

where $U^R(\theta)$ is the utility promised by firm *R*.

Firm *L* takes the utility provided by firm *R* as fixed. This implies:

$$x \leq \frac{t + U(\theta) - U^R(\theta)}{2t}$$

For the purpose of this illustration, I assume that the cost of producing either quality is zero for both firms. Therefore, firm *L*'s profit from a consumer of type θ, located at *x*, is given by:

$$\pi\left(\theta, p(\theta), q(\theta), x\right) = p(\theta) \text{ if } x \leq \frac{t + U(\theta) - U^R(\theta)}{2t}$$
$$= 0 \text{ otherwise}$$

The problem for firm *L* can be summarized as follows:

$$\max_{p_1, p_2, q_1, q_2} \alpha p_1 x(\theta_1) + (1-\alpha) p_2 x(\theta_2) \quad \textbf{(Max)}$$

subject to the following two incentive compatibility constraints:

$$q_1\theta_1 - p_1 \geq q_2\theta_1 - p_2 \quad \textbf{(IC 1)}$$

and

$$q_2\theta_2 - p_2 \geq q_1\theta_2 - p_1 \quad \textbf{(IC 2)}$$

$$p_1, p_2 \geq 0$$

$$0 \leq \min\{q_1, q_2\} \leq \max\{q_1, q_2\} \leq Q \quad \textbf{(Quality Restrictions)}$$

$x(\theta_1)$ and $x(\theta_2)$ represent the locations of the indifferent consumers of types θ_1 and θ_2 respectively. IC 1 and IC 2 represent the incentive compatibility constraints for consumers of type 1 and type 2 respectively. I also assume that the maximum quality offered by the firm is *Q*. It is costless to provide quality. Since the profit function is increasing in quality, without this restriction, at least one of the qualities would approach infinity.

Therefore, in equilibrium, the high type's quality is fixed at *Q*, the highest possible level. Given that the high type's quality level is fixed at *Q*, the incentive compatibility constraint of the high type binds. Otherwise, the firm can increase q_2 (IC 2 still binds) and obtain higher profits. Therefore, the quality level of the low type, as a function of p_1 and p_2, is given by:

$$q_2 = Q - \frac{p_1 - p_2}{\theta_1} \quad (1)$$

From equation (1), it is straightforward to check that the incentive compatibility of low type is satisfied as long as $\theta_1 > \theta_2$.

I further assume the following condition that ensures a separating equilibrium:

$$1 > \alpha > \frac{\theta_2 t_H}{\theta_1 \left(t_H - t_L\right)} \quad \textbf{(T1)}$$

Condition **(T1)** is guaranteed only if the following condition is true:

$$\frac{t_L}{t_H} < \frac{\theta_1 - \theta_2}{\theta_1} \quad \textbf{(T2)}$$

First order conditions for the profit maximization routine are given by:

$$p_1 = t_H \left[1 - \frac{1-\alpha}{\alpha}\frac{\theta_2}{\theta_1}\frac{p_2}{t_L}\right] \qquad \text{(FOC w.r.t. } p_1\text{)}$$

$$p_2 = \frac{t_L \theta_1}{\left(\theta_1 - \theta_2\right)} \qquad \text{(FOC w.r.t. } p_2\text{)}$$

Condition **T1**, and a *sufficiently large* ***Q***, along with the first order conditions, yield the following equilibrium price – quality combinations:

$$p_1 = t_H \left[\frac{\alpha\theta_1 - \theta_2}{\alpha\left(\theta_1 - \theta_2\right)} \right] \qquad p_2 = \frac{t_L \theta_1}{\left(\theta_1 - \theta_2\right)}$$

$$q_1 = Q \qquad q_2 = Q - \frac{p_1 - p_2}{\theta_1}$$

The regularity condition **T1**, ensures that the price of the high type good (p_1) is not only positive, but also higher than the low type good's price (p_2). If these conditions are not satisfied, the separating equilibrium does not exist.

Competition changes with a change in either t_H or t_L. To separate these three cases, I assume $t_H = t.H$ and $t_L = t.L$ where $H > L$. The price difference is given by:

$$p_1 - p_2 = t\left[\frac{\alpha\theta_1(H - L) - \theta_2 H}{\alpha(\theta_1 - \theta_2)} \right] \qquad \textbf{(2)}$$

From equation (2), it is straightforward to verify that (given the regularity condition) the price difference increases as *t* increases. If *H* increases, i.e., if competition for the high type good decreases, price difference increases. On the other hand, if *L* increases, i.e. competition for the low type good decreases, the price difference decreases.

Therefore, under the assumption that a typical branded store concentrates on DVDs and a typical unbranded store on VHS, we should observe the following effects. An increase in competition from the unbranded store is equivalent to t_L (or L) decreasing. In such a case, the price difference between DVD and VHS at both the branded and the unbranded store should decrease. Similarly, an increase in competition from the branded store is equivalent to t_H (or H) decreasing. In such a case, the price difference at both the branded and unbranded store increases.

4.2 Industry Structure and Data

The video rental industry is well suited to answer the question posed in Chapter 1 for several reasons. There are two distinct varieties of products available: DVD and VHS. Again, each product is classified into new release and old release (called library collection). Prices vary significantly across these products both within a single store as well as across stores. Prices also differ among stores that belong to the same brand (Blockbuster, Hollywood etc). Stores can also be divided into two distinct types: branded and unbranded stores.

I use an original dataset to analyze the effect of competition on the DVD/VHS price difference. The unit of observation is the price of a good in the store. The market I consider for the analysis is Cook County, IL. The choice of the market is geographical proximity, which enables me to cross check at least a sample of stores. Discussions with market experts suggest that, in this industry, the firms' decisions are similar across geographical areas.

I obtain a list of video rental stores from Yahoo! Yellow Pages. Yahoo! Yellow Pages, a part of Yahoo! Inc. is a reliable online local telephone directory. For the purposes of this project, I consider the list of stores provided by Yahoo! Yellow Pages as the population (of stores) present in Cook County, IL. Yahoo! provides the exact location and telephone numbers of all the video rental stores in every city in the county. These stores are generally secretive about the data they provide. For that reason, quantity data (data on number of videos rented) is hard to obtain.[54] On the other hand, pricing data is relatively easy to get as an econometrician can pose as a consumer and enquire after the prices.

Using the phone numbers provided in Yahoo! Yellow Pages, I called each store and posed as a potential consumer and enquired about the prices of various categories of videos available in the store. Questions asked at each store included the following: 1) the prices of new and old DVDs and VHS, 2) if the store carried video games and if it did, what the prices were, 3) the number of days the store lent the video without incurring late fees,[55] 4) whether the prices reported were the final prices or if there were additional sales taxes, and finally, 5) if the store also rented ethnic movie titles and if it did, which ethnic movie titles it carried. If a particular store did not respond, I called the store a couple of more times on different days before eliminating the store from the dataset.

I classify any store that belongs to a major national chain as a branded store. The list includes three types of stores: Blockbuster Video, Family Video and Hollywood Video. I

---

[54] Conversations with Blockbuster employees confirmed that these quality data are proprietary and one has to go through substantial legal proceedings to obtain such data.
[55] In January 2005, Blockbuster introduced a controversial "No Late Fees" policy, according to which consumers do not pay late fees subject to certain conditions. The data for this paper, however, were collected in October 2004 itself.

consider all non-chain stores as unbranded. Table 4-1 gives the details of the various types of stores. Not surprisingly, Chicago, the major city in Cook County, has substantially more video rental stores than any other city in the county. Chicago accounts for around forty percent of branded stores, and fifty seven percent of unbranded stores. The break-up across various cities is in Table 4-5. Among the branded stores, Blockbuster has more stores than the other brands do. This is not surprising given that Blockbuster Video has higher market share (for the entire country) than the second biggest player in the market, Hollywood Video. Table 4-2 presents market shares of the major players in the country. In USA, Blockbuster Video enjoys a substantially higher market share (around 40%) than Hollywood Video (the second biggest player in the market with around 11% market share).

I present the details of price differences across various types of firms in Tables 4-3 and 4-4.[56] Graphs 4-1 and 4-2 present the histogram of various prices in branded and unbranded stores. Table 4-3 shows that a new DVD is the most expensive product available at a store whereas an old VHS is the least expensive. The price of a new DVD has the least standard deviation while that of an old DVD has the highest standard deviation. Table 4-4 shows that the major stores charge different prices for old DVDs and VHS, whereas they do not differentiate (in terms of prices) between new DVDs and VHS. Though the rental fee for old and new DVDs is the same in major stores, the duration of the rental differs. Blockbuster typically lends a new release for two days whereas it lends an old release for a week.

---

[56] Prices reported (and used in subsequent analyses) are the prices charged by the store directly. Sales taxes, if any, are additional.

I identify the census tract that each store belongs to from the census website by using the exact location of each store provided in the Yellow Pages.[57, 58] This helps me identify the local demographics of each store. Each county is divided into several census tracts for easing the collection of data. *Census tracts are small, relatively permanent geographical entities within the counties…When first established, census tracts are to be as homogenous as possible with respect to population characteristics, economic status and living conditions… When delineating the census tracts, the Census Bureau requires that the average population of all the tracts in the country be four thousand people (fifteen hundred housing units) with individual census tracts ranging from two thousand five hundred to eight thousand inhabitants.*[59]

The total population of Cook County is slightly below five and a half million people. The county is divided into one thousand three hundred and forty three census tracts with an average population size of around four thousand per tract. The average annual household income in the county is a little under fifty four thousand dollars. The details about census tracts are presented in Table 4-6. Out of these counties, three hundred tracts have at least one video rental store. Details on number of tracts containing various combinations of branded and unbranded stores are in Table 4-7.

---

57 Literature varies in this regard. While some studies suggest the use of census block (e.g. Thomadsen (2003)), some other studies suggest tracts (e.g. Seim (2003)). Several studies use zip codes as well (e.g. Mortimer (2003)).

58 http://factfinder.census.gov/servlet/AGSGeoAddressServlet?_lang=en&_programYear=50&_treeId=420&_sse=on

59 *Source:* http://www.**census**.gov/geo/www/GARM/Ch10GARM.pdf

From the Census web pages, I collect the demographic information for each store. As Table 4-7 points out, there are several tracts without any store. Therefore the market of a store extends well beyond the tract it is located in. Given the size of each tract, demographics of the tract in which a store is located could be a good indicator of the overall demographic characteristics of the market the store targets, i.e. the demographics of the tract are used as a proxy for the surrounding tracts as well. Conversations with industry experts reveal that the industry is very local in nature, with an average consumer willing to commute no more than three miles (round trip) for renting a video.[60] This is the average figure for all of America and it could be lower in urban areas. This suggests that one measure of competition faced by the store is the distance from the nearest neighbor.

Stores differentiate themselves from their rivals on several counts. For example, their locations and the amount of inventory they carry are strategic decisions of the firms. Branded stores manage better deals with the studios; so, one can assume that they maintain better inventory than the unbranded ones. For this project, I assume that (everything else remaining constant) a consumer is indifferent between any two branded stores. I have data on prices charged by the firms for all their products. To isolate the effect of the brand of competition on price variation, I estimate how price dispersion changes as a result of both the branded and unbranded competition.

---

[60] Seim (2003)

Each store has at least two products: VHS and DVD. Many stores also carry video games. Between the DVD and VHS, many stores differentiate across new and old releases. All branded stores charge the same price for all new releases, irrespective of them being a DVDs or VHS. More than a third of the stores in my dataset do not carry video games. For that reason, I do not consider prices of video games in the analysis. Not all households in a tract have the hardware to play a VHS or DVD. Tract level information on the number of households having DVD and VHS players is not available. This information is not available to the stores either. A household's decision to purchase durable goods depends on the household's characteristics.[61] As long as I control for demographics, the lack of information on DVD and VHS players should not bias the influence of competition on the prices.

The next issue is to define competition faced by a store. As mentioned earlier, I consider distance from the nearest store as the measure of competition. For a similar market, Seim (2003), proposes another measure of competition by drawing the distance bands across each store and counting the number of stores in each band. While such a measure of competition might be appropriate when analyzing the entry decisions of firms, it is not the case while analyzing the pricing decisions (especially when the firms are price setters). The argument becomes clear if we consider the following two scenarios. In the first case, there are two firms in the same geographical location (for example, two very close stores in a shopping complex) while there is no other firm in a mile's radius from that spot. The

[61] Though it is not their main focus, Gowrisankaran and Rysman (2005) characterize the effect of household demographics on purchase decisions in durable consumer goods market, suggesting that accounting for demographics takes care of lack of information on VHS and DVD players.

distance to the nearest neighbor is almost close to zero. In the second case, consider a firm that has n firms in a mile's radius, n>1, but the nearest neighbor is half a mile away. In the first case, Bertrand competition forces the firms to charge price equal to the marginal cost, whereas in the second case, the firm under consideration enjoys some market power. If we consider the number of firms as a measure of competition, we find that the firm in the second case faces more competition than the first one. Any analysis with such a measure of competition, as in Seim, could be biased.

To calculate the distance between any two stores in the dataset, I first determine the latitude and longitude of those stores.[62] Once the geographical coordinates are known, the 'crow fly' distance or 'great circular distance'[63] between any two points on earth can be calculated using the following formula:

$$Dist = 1.1575 * 60 * \arccos\left[\left(\sin(l1) * \sin(l2)\right) + \left(\cos(l1) * \cos(l2) * \cos(DG)\right)\right]$$

Here, l_1 is the latitude of point 1, l_2 is the latitude of point 2 and DG is the difference in the longitudes of points 1 and 2. While angles are measured in degrees, the distance is measured in miles. Summary statistics of the competition faced by both the branded and unbranded stores are in Table 4-8.

---

[62] http://www.geocoder.us
[63] Great circular distance is the shortest distance between two points on a sphere

Another important issue to be addressed here is the case of franchisee stores. A nation wide chain might franchise some of its stores. In such a case, these franchisee stores may act in a substantially different way when compared to the non-franchised stores. Hollywood Video does not franchise its stores. The presence of other branded store, Family Video, in the market under consideration, is negligible. There are six Family Video stores in Cook County whereas the total number of stores is well over four hundred (Table 4-1). This franchising issue is a concern with regards to Blockbuster Video. Blockbuster's corporate website claims that the interest in franchising is increasing.[64]

To further understand the issue of franchising, I, as a potential franchisee, contacted Blockbuster and Hollywood Video. Two principle requirements for franchising a Blockbuster store are that the franchisee: a) should have a net-worth of at least four hundred thousand dollars, and b) needs to find a location that does not have any Blockbuster store within ten miles' radius. Blockbuster refused to reveal any further information on negotiability of the terms of franchising contracts. In my dataset, there is no Blockbuster store that does not contain another Blockbuster store within ten miles' radius. Therefore, I assume all Blockbuster video stores in my dataset to be corporate-owned stores. Hollywood Video informed me that it does not encourage any franchising. I attach the mails from both Blockbuster Video and Hollywood Video in Appendix B.

---

64 http://www.blockbuster.com/corporate/displayAboutBlockbusterDetails.action?articleId=1082957&cctr=AboutBlockbusterLeftNav

One final issue that needs to be addressed is Netflix. Netflix had around 2.5% of market share in this industry in 2004. Their customer base increased by about 60% in 2005. With more than fifty five thousand titles and five million subscribers in 2005, Netflix is fast turning out to be one of the biggest players in the video rental market.[65] As Netflix delivers its products through the United States Postal Service, it can be considered 'omnipresent' affecting the demand for all the stores.[66] So, the demand faced by non-Netflix firms can be considered as the residual demand for movie rentals, after accounting for Netflix. The underlying assumption is that it affects all stores in a similar way. This might not be a realistic assumption. According to some industry studies, the chief goal of Netflix is "(to) *edge out traditional rental brands, and Blockbuster in particular*."[67] However, lack of data on Netflix necessitates this assumption. This would imply that I would be over-measuring the competition faced by a branded store vis-à-vis an unbranded store.4.3 Empirical Specification and Results

4.3.1 Empirical Specification

To analyze the effect of competition on the DVD/VHS price difference, I propose the following empirical specification. The price of a product $g, g \in \{D, V\}$, in store *s*, located at point *t*, is given by the following equation:

---

[65] Source: Netflix Fact sheet of 2005

[66] There are other online movie websites as well, like www.cinemanow.com etc. Also, Pay-Per-View cinema via cable TV is also another major competitor to video rental firms. But the argument of *'omnipresence'* applicable to Netflix is applicable to these cases as well.

[67] "Netflix analyzed via Value Framework": Levy and Cormia (2002)

$$\begin{aligned} P_{gst} &= X_t\beta + \mu time_g + \delta_1 D_g + \delta_2 New_g + \delta_3 B_s + \gamma_1 Cbr_s \\ &+ \gamma_2 Cubr_s + \theta_1 D_g * B_s + \theta_2 D_g * Cbr_s + \theta_3 D_g * Cubr_s \\ &+ \lambda_1 Cbr_s * D_g * B_s + \lambda_2 Cubr_s * D_g * B_s + error_{gst} \end{aligned} \qquad \textbf{(*)}$$

The explanation of the variables is given below:

X- A vector of characteristics of location t

Time- Rental Period

D- Takes value 1 if the product considered is DVD

NEW- Takes value 1 if it is a new release

B- Takes value 1 for Branded store

Cbr- Competition from a branded store, measured as either driving distance or driving time from the nearest branded rival

Cubr- Competition from an unbranded store, measured as either driving distance or driving time from the nearest unbranded rival

The demographics I control for are:

Population: Number of people (in thousands) in the census tract the store is located in

Income: Median annual household income (in thousands of dollars)) of all the households in the tract

Rent: Median rent (in hundreds of dollars)

Child: The Number of children in the tract (in hundreds)

Retd: The Number of retired people in the tract (in hundreds)

Firms: The Number of firms in the zip code

Labor: The number of people working in the zip code

Chicago: Takes value 1 if the tract belongs to Chicago

From the above equation we can derive:

$$\Delta P_B = \delta_1 + \theta_1 + (\theta_2 + \lambda_1)Cbr_s + (\theta_3 + \lambda_2)Cubr_s \qquad \text{(A)}$$

$$\Delta P_U = \delta_1 + \theta_2 Cbr_s + \theta_3 Cubr_s \qquad \text{(B)}$$

$$\Delta P_B - \Delta P_U = \theta_1 + \lambda_1 Cbr_s + \lambda_2 Cubr_s \qquad \text{(C)}$$

where ΔP_b represents the price difference in the store of type $b \in \{B, U\}$.

When the competition from a branded store changes, the price difference in a branded store changes by $\theta_2 + \lambda_1$, whereas it changes by θ_2 in an unbranded store. Similarly, when the competition from an unbranded store changes, the price difference changes by $\theta_3 + \lambda_2$ in a branded store and by θ_3 in an unbranded store.

I estimate equation (*) by OLS, Feasible Generalized Least Squares (FGLS) and IV. (For FGLS I assume that the variance of the error term depends not only on the store, but also on the product. This is a restrictive assumption. I have tried alternative forms of heteroscedasticity. For example, variance of the error term could be the same for all DVD products. Alternatively, variance of the error term could be similar for all the products in a branded store. The results I have obtained for these alternative specifications have not deviated substantially from the ones with the most general form of heteroscedasticity.)

The Industrial Organization literature suggests the use of location-specific fixed effects (Ashenfelter *et al* (2004)) or Generalized Least Squares with market specific error structure (Busse and Rysman (2004)) to control for price-competition endogeneity. One chief difference between these studies and my paper is the presence of several independent markets. In the case of several independent markets, the use of market specific fixed effects controls for the unobserved variables that influence both the market structure and prices. Here, I consider a single market comprising several loosely connected (and not necessarily independent) sub-markets.

In addition to the above-mentioned specification, I also run separate specifications for each of the products (DVD and VHS in branded and unbranded stores). Moreover, consumers' sensitivity to the distance to a store need not be the same across all geographical areas. In urban areas, where commuting/driving is difficult, consumers are more sensitive to the distance to the store. To account for this distance sensitiveness, I run separate regressions for Chicago and overall Cook County.[68]

Instruments:

---

[68] OLS regression results using driving distances (instead of *crow-fly* distances) as a measure of competition do not show any significant difference from the results obtained from using driving times as a measure of competition.

I address the issue of price-competition endogeneity with the instrumental variables method. Ideal instruments are the ones correlated with the unobservable variables influencing competition, but not the unobservable determinants of prices. Economic theory suggests that fixed costs are a barrier to entry; hence, they would determine the competition faced by a store, while they do not have any direct effect on the prices charged by the store. Rent paid (foregone rent where the store is owned by the party that owns the property as well) is a fixed cost. Higher rents imply lower profit margins for the stores and hence lower entry potential. If I assume that the stores are located at a given locality for a "sufficiently long time", then marginal rent for an additional movie sold is negligible. Therefore, rents do not affect prices. Another candidate for an instrument could be the property value of the store. The Cook County Assessor's Office keeps a record of property values. But such values are available for the entire property and not for individual units.

The instrument I primarily use in this analysis is the location of the second nearest store.[69] This concept is illustrated in Figure 4-3. By assumption, the prices in a given store are only influenced by the proximity to the nearest rival. Therefore, prices in store A are influenced by the distance between A and B, but not by the distance between A and C. However, the location of B (and hence the distance between A and B) is influenced by the location of store C. Therefore, I instrument the distance between A and B with the distance between A and C, i.e. the instrument is the distance to the next nearest rival. Table 4-11

[69] The distance to the second nearest store from a given store *in the direction of* the nearest store can also be used as an instrument for the competition faced by the store.

presents the details of correlation between both types of competition and their respective instruments. A correlation of above 0.8 suggests that the location of the major rival and the second nearest rival are highly correlated.[70]

4.3.2 Results

I estimate (*) using several methods, for both Chicago and overall Cook County separately. These results are presented in Tables 4-9 (OLS Regression), 4-10 (FGLS Regression), and 4-11 (Instrumental Variable Regression). I also run a separate instrumental variable regression for each of these products. These results are reported in Tables 4-12 (DVD in branded stores), 4-13 (VHS in branded stores), 4-14 (DVD in unbranded stores), and 4-15 (VHS in unbranded stores). Since the issue of endogeneity between market structure and price is an empirical issue in a specification like this, I concentrate on Instrumental Variable regression (Tables 4-11 to 4-15) for the rest of the analysis. Competition faced by a store is divided into two types: branded competition (defined as the distance to the nearest branded store) and unbranded competition (defined as the distance to the nearest unbranded store). I instrument for these measures of competition by the distance to the second nearest branded and unbranded stores respectively. First stage regression for the IV regression are presented in Tables 4-17 (a and b).

---

[70] Interaction terms are instrumented with instruments multiplied by dummy variables. (For example, the variable Cbr*DVD is instrumented with instrument_major* DVD, where instrument_major represents the distance to the second nearest branded store).

As the duration of the rental increases by a day (number of days consumers are allowed to keep the video without incurring late fees), the price of the video rented decreases significantly by three to ten cents. This is because videos with high demand (and hence higher price) are lent out for shorter periods. Following Blockbuster Video, almost all major video rental stores have implemented the controversial *'no-late fees'* policy starting from January 2005. But, the number of days a video is lent out is still valid in this analysis because the data were collected in October 2004. Prior to this policy, a typical Blockbuster Video or a Hollywood Video lent new releases for two days and old releases for a week. As expected, new releases are more expensive than old ones since they are in higher demand. Typically, a new release costs half a dollar more than an old one, but the difference is higher in the case of VHS tapes in a branded store. Generally, most branded stores mark old VHS tapes as library items and rent them out at lower prices. A DVD costs eighteen to twenty cents more than a VHS. Moreover, on an average, it is significantly more expensive to rent a movie in Chicago as against in Cook County overall. A store in Chicago has to account for greater overhead costs (higher rent, security considerations etc) while determining its prices.

As explained earlier, I proxy for the demographic characteristics of the market the store considers with the characteristics of the census tract the store is located in. For an increase of a thousand people in the census tract, the price in an unbranded store goes up significantly by about five to seven cents. On the other hand, in a branded store, the effect of population is insignificant. As expected, an increase in the tract's average income significantly increases prices. Typically, a thousand dollar increase in the average income of the residents of the tract increases the price of the rental significantly by one cent. Industry sources reveal that children and retired people are some of the major sources of demand for the video rental stores. Therefore, in theory, one should expect that as the number of children and retired people in a tract increases, the prices should go up. But the evidence from the results is mixed. The price of a rental in a branded store increases significantly with the increase in number of retired people (by two to three cents per thousand). However, it has no effect on the prices at unbranded stores. The number of children does not seem to statistically influence the prices across all specifications. One possible explanation could be that these groups (children and retired) are also the ones with lesser disposable income. The number of jobs available in the tract increases the prices significantly. Given that the consumers are averse to traveling long distances to rent a movie (and that the video tapes and discs are easy to transport), stores close to work are more attractive to them. The evidence suggests that an increase of a thousand jobs in the zip code increases the price by about two cents.

As expected, a decrease in competition from a branded store reduces the prices of both the VHS and DVD significantly. When the distance to the nearest branded store increases by one mile (i.e., competition from a branded store decreases), the price of DVDs increases by about seven cents in a branded store and by about seventeen cents in an unbranded store, whereas the price of VHS tapes in a branded store goes up by about ten cents and by about fourteen cents in an unbranded store. However, when the distance to the nearest unbranded store increases, prices do not increase unambiguously. Competition from an unbranded store does not influence the prices significantly.

Tables 4-16 (a and b) show the influence of competition on the price difference between DVD and VHS. In a branded store, as the competition from a branded store changes, the price difference changes by $(\theta_2 + \lambda_1)$ and when the competition from an unbranded store changes, the price difference changes by $(\theta_3 + \lambda_2)$. The point estimates indicate that as the competition faced by a branded store increases, the price of DVD adjusts slower than the price of VHS, suggesting that the price difference increases. When the distance to the nearest branded store reduces by a mile, the price difference in a branded store increases by about two to three cents. When the distance to the nearest unbranded store reduces by a mile, the price difference in a branded store increases by around one to six cents. Though the sign of the effect of competition on the price difference is the same across all specifications, it is not statistically significant.

Similarly, in an unbranded store, when the competition from a branded store changes, the price difference changes by θ_2 and when the competition from an unbranded store changes, the price difference changes by θ_3. The point estimates indicate that the effect of competition on the price difference is ambiguous. When the distance to the nearest branded store reduces by a mile, the price difference in an unbranded store reduces by around three to five cents. On the other hand, when the distance to the nearest unbranded store reduces by a mile, the price difference decreases by about five to fifteen cents. Just as in the previous case, though the sign of the effect of competition on the price difference is the same across different specifications, it is not statistically significant.

In summary, these results seem to suggest that for a branded store, an increase in the competition increases the DVD/VHS price difference, but not significantly. The price difference in an unbranded store decreases when the competition from a branded store increases and increases when the competition from an unbranded store increases, but not significantly. In comparison, Busse and Rysman (2005) find that as the competition changes in the Yellow Pages market, the price of larger advertisements is affected more than that of smaller ones. In this analysis, I account for two distinct types of stores and analyze the effect of various types of competition.

4.4 Conclusion

In this project, using the video rental industry as an illustration, I have demonstrated how price differentials in a multi-product industry are affected as the level of competition varies. Classifying the video rental stores into two types, branded and unbranded, allows me to differentiate between the kinds of competition faced by a given firm. Videos can also be classified into two products: DVD and VHS. The issue analyzed here is how the price difference between DVD and VHS is affected when the competition faced by a store increases. The point estimates suggest that when the competition increases for a branded store, the price difference increases, implying that DVDs are less susceptible to competition. On the other hand, the effect of competition on the price difference in an unbranded store depends on the type of competition faced by the store. Though these results are similar across the various specifications, they are not statistically significant. Hence, competition might be influencing the prices of DVD and VHS in a similar fashion. The type of competition faced by a store plays a role in explaining the price differential.

I conclude the analysis by discussing a few ideas for future research. The first one is to control for the location of the firm. Endogeneity problems between the competition faced by the firm and the prices charged is an issue that has been well explored in the industrial organization literature. A more structural model that accounts for the prices as a function of competition faced might explain the effect of competition on the price differences better (Mazzeo (2002), Manuszak and Moul (2006), etc). Quantity data in the video rental industry are proprietary and hence, difficult to obtain. Moreover, I consider a single market with several sub-markets which are not independent of each other. Thomadsen (2005) faces a similar problem in his analysis of fast food industry in California. One potential extension of this paper is to check how the structural model developed in Thomadsen (2005) extends to the case analyzed here. Finally, a better theoretical model is necessary to explain the effect of competition on price differences.

Tables

Table 2-1: Generation Capacity

	Gross			Net			available
	Producers	Autoproducers	Total	Producers	Autoproducers	Total	peak capacity
MW							**2004**
hydroelectric	20,862.1	210.5	21,072.6	20,538.6	205.6	20,744.1	13,550[1]
thermal	57,352.5	4,859.9	62,212.5	54,981.3	4,651.1	59,632.4	38,950[2]
conventional	*56,671.5*	*4,859.9*	*61,531.5*	*54,339.3*	*4,651.1*	*58,990.4*	*38,400*
geothermal	*681.0*	*0.0*	*681.0*	*642.0*	*0.0*	*642.0*	*550*
wind & photovoltaic	1,137.1	1.5	1,138.6	1,133.5	1.5	1,135.0	250[3]
total	**79,351.7**	**5,072.0**	**84,423.7**	**76,653.3**	**4,858.2**	**81,511.5**	**52,750**

1 The unavailability from hydro power plants is to be chiefly ascribed to hydrological causes (systematically occurring in the Winter period), as well as to faults and external causes. The net maximum capacity is the maximum value that is reached under conditions of maximum water flows. Since water supply is scarce in Winter with respect to other periods of the year, in-service hydro plants deliver a net capacity that is much lower than the maximum capacity.

2 The unavailability from thermal power plants is to be mainly attributed to:
- unplanned average unavailability of plants used for electricity production only;
- long outages, repowering projects, lack of authorisations for plants used for electricity generation only and for co-generation plants (the latter value also includes seasonal co-generation plants, such as sugar factories that typically operate in late Spring).

3 The production of these plants depends on a primary source whose availability is highly discontinuous. Consequently, available peak-load capacity is usually taken to be equal to 25% of installed capacity.

Table 2-2: Sample Characteristics

Sample Characteristics	
Total Days	31
Weekend Days	10
Weekdays*	21
Total Hours Considered	504
Hours where Prices are same	195
Hours where Prices differ	309

* No other holidays in this month

Table 2-3: Fringe's Production

	Fringe's Production Share
Max	0.58
Min	0.05
Median	0.31
First Quartile	0.22
Third Quartile	0.39
#of firms in fringe	13

Table 2-4: Liquidity Statistics

Liquidity	
Maximum	40.01
Minimum	9.89
Average	0.3
SD	7.05

Table 3-1: OLS Regression Results for Fringe's Supply Function

OLS Regression (Fringe's supply curve, equation (1))						
	North			**South**		
Hour	Slope ^	N	R Sq	Slope	N	R Sq
1	11.51	392	0.52	5.24**	103	0.20
2	14.63	486	0.56	6.06**	110	0.18
3	13.18	470	0.55	5.33**	113	0.14
4	12.80	416	0.58	4.06	94	0.14
5	11.78	348	0.68	4.99	45	0.20
6	7.22	323	0.55	3.32	50	0.21
7	13.99	358	0.59	5.46	94	0.1
8	16.36	676	0.80	5.03***	160	0.43
9	19.03	913	0.86	5.42***	160	0.50
10	22.51	922	0.86	4.08**	117	0.65
11	22.33	933	0.83	3.45**	113	0.63
12	24.59	957	0.87	5.68***	143	0.62
13	22.36	1022	0.88	4.64**	132	0.62
14	23.49	1050	0.89	5.08***	137	0.60
15	24.91	1003	0.86	5.76***	146	0.63
16	25.06	991	0.86	-1.23	78	0.75
17	25.81	970	0.90	5.69***	131	0.06
18	25.03	1012	0.86	5.87***	185	0.66
19	24.84	982	0.87	5.6***	185	0.69
20	23.57	980	0.90	5.4***	179	0.72
21	22.90	970	0.89	5.23***	182	0.75
22	27.76	1273	0.83	5.49***	180	0.07
23	28.92	896	0.63	3.71***	187	0.49
24	31.43	865	0.67	3.72	171	0.61
Dependent Variable				Quantity bid		
Slope is the coefficient of price						

^ All coefficients are significant at 99% for North

*** significant at 99%, **significant at 95%

*significant at 90%

Table 3-2: Fixed Effects Regression – Fringe's Supply Function

FE Regression (Fringe's supply curve, Equation (1))						
	North			**South**		
Hour	Slope	N	R Sq	Slope	N	R Sq
1	12.17	392	0.71	8.71	103	0.6
2	14.84	486	0.65	7.9	110	0.59
3	13.63	470	0.64	7.55	113	0.58
4	13.53	416	0.68	7.89	94	0.53
5	13.16	348	0.79	8.08	45	0.87
6	10.56	323	0.74	7.88	50	0.86
7	11.38	358	0.78	5.85	94	0.74
8	15.88	676	0.81	6.45	160	0.59
9	19.59	913	0.76	6.45	160	0.54
10	22.96	922	0.77	5.22	117	0.39
11	23.82	933	0.78	5.32	113	0.38
12	24.92	957	0.79	5.6	143	0.46
13	23.27	1022	0.82	5.48	132	0.43
14	23.59	1050	0.82	5.58	137	0.45
15	25.88	1003	0.81	5.53	146	0.45
16	25.76	991	0.80	4.24	78	0.32
17	25.58	970	0.80	5.09	131	0.4
18	25.78	1012	0.80	6.63	185	0.59
19	25.58	982	0.79	6.64	185	0.59
20	25.79	980	0.82	6.63	179	0.58
21	23.32	970	0.82	6.6	182	0.59
22	26.78	1273	0.83	5.66	180	0.5
23	27.57	896	0.85	3.9	187	0.51
24	31.03	865	0.85	3.58	171	0.5

Dependent Variable Quantity Bid

Slope is the coefficient of price

All coefficients significant at 95%

Table 3-3: Characteristics of Alpha

Characteristics of Alpha	
Maximum	0.756
Minimum	0.509
Mean	0.647
Median	0.646
Weighted Average^	0.589
Standard Deviation	0.04
First Quartile	0.615
Third Quartile	0.679

^ Weights given by spot market consumption for the hour

Table 3-4: Gains from Interconnection

Gains from Interconnection		
	Hour	**Gain**
Maximum Gain	Hour 22: 17^{th} May	€ 159,599
Maximum Loss	Hour 17: 7^{th} May	€ 49,598
Overall Welfare Gain	Month of May 2004	€ 6,148,771
Welfare Gain (alpha = 0.64)	Month of May 2004	€ 3,219,849

Table 4-1: Division of Stores

Division of Stores		
Total Stores		366
Number of Branded Stores		173
Blockbuster	119	
Hollywood Video	48	
Family Video	6	
Number of Unbranded stores		193

Source: Personal Dataset, for Cook County Il

Table 4-2: Market Shares of Major Players

Market Shares of Major Players	
Total Revenue	$20.4 Billion
Blockbuster Video	39.40%
Hollywood Video	11%
Movie Gallery	5.40%
Netflix	2.50%
Family Video	1.70%

Source: Rentrak Corporation for the entire year of 2002

Table 4-3: Average Prices of Various Products

Average Prices of Various Products		
Product	**Average Price**	**St Dev**
Old VHS	**2.43**	**0.77**
Major	2.44	0.68
Minor	2.41	0.85
New VHS	**3.36**	**0.73**
Major	3.86	0.41
Minor	2.93	0.67
Old DVD	**3.25**	**0.87**
Major	3.82	0.56
Minor	2.75	0.78
New DVD	**3.43**	**0.68**
Major	3.86	0.40
Minor	3.05	0.65

Table 4-4: Price Differentials for Different Store Types

Price Differentials for Different Types of Stores		
Differential	**Mean**	**SD**
D Old (Old DVD-Old VHS)	**0.82**	**0.75**
Major	1.38	0.5
Minor	0.33	0.56
D New (New DVD-New VHS)	**0.06**	**0.25**
Major	0.008	0.08
Minor	0.11	0.33
D VHS (New VHS-Old VHS)	**0.94**	**0.75**
Major	1.41	0.45
Minor	0.52	0.70
D DVD (New DVD-Old DVD)	**0.18**	**0.47**
Major	0.05	0.26
Minor	0.29	0.57

Table 4-5: Break-up of Stores across Cities

Break-up of Stores Across Cities

City	# Major	# Minor	# Stores
Alsip	1	1	2
Arlington Heights	4	2	6
Bellwood	1	0	1
Berkeley	0	1	1
Berwyn	4	4	8
Blue Isalnd	1	2	3
Bridge View	2	1	3
Broadview	0	1	1
Brookfield	0	1	1
Burbank	2	1	3
Calumet City	1	2	3
Chicago	70	111	181
Chicago Heights	2	1	3
Chicago Ridge	1	0	1
Cicero	3	5	8
Countryside	1	0	1
County Club Hills	0	1	1
Crestwood	1	0	1
Des Plaines	1	2	3
Dolton	0	1	1
Elk Grove Village	1	1	2
Elmwood Park	2	2	4
Evanston	2	3	5
Evergreen Park	2	0	2
Forest Park	1	2	3

Franklin Park	1	1	2
Glencoe	1	0	1
Glenview	2	2	4
Hanover Park	1	1	2
Harvey	1	0	1
Harwood Heights	1	1	2
Hazel Crest	1	0	1
Hickory Hills	1	0	1
Hoffman Estates	3	1	4
Homewood	2	1	3
Justice	1	0	1
La Grange	1	0	1
La Grange Park	1	0	1
Lansing	2	2	4
Lincolnwood	1	1	2
Markham	1	0	1
Maywood	0	1	1
Melrose Park	1	1	2
Morton Grove	1	1	2
Mount Prospect	1	3	4
Niles	4	1	5
Norridge	1	2	3
Northbrook	1	1	2
Northlake	1	0	1
Oak Forest	2	0	2
Oak Lawn	5	0	5
Oak Park	2	1	3
Olympia Fields	1	0	1
Orland Park	3	4	7
Palatine	4	2	6
Palos Heights	1	0	1
Palos Hills	0	2	2
Park Forest	0	1	1
Park Ridge	2	1	3

Prospect Heights	0	2	2
Richton Park	0	1	1
River Grove	1	1	2
Riverdale	0	1	1
Riverside	1	1	2
Rolling Meadows	1	1	2
Sauk Village	1	0	1
Schaumburg	4	1	5
Schiller Park	0	1	1
Skokie	2	2	4
South Holland	0	1	1
Steger	0	1	1
Streamwood	2	0	2
Thornton	0	1	1
Tinley Park	3	2	5
Western Springs	1	0	1
Wheeling	2	1	3
Wilmette	1	0	1
	173	193	366

Table 4-6: Income and Population of Census Tract

Income and Population of Census Tracts

	Mean	Max	Min	St. Dev
Population	4003.5	18290	0	2520.7
Households	1470	6946	0	1009
Income*	$53,855	$200,001	0	$28,713

*Mean household income

Table 4-7: Distribution of Stores in Various Tracts

Combination of Stores	
Combination (major, minor)	# of Stores
(0,0)	1044
(0,1)	127
(1,0)	118
(1,1)	17
(2,0)	14
(0,2)	17
(1,2)	3
(2,1)	2
(1,3)	1
(1,4)	1
Total Tracts	1344

Table 4-8: Details of Competition Faced by Stores

Summary Statistics of Competition

	Competition From	
Store Type	**Branded Store***	**Unbranded Store***
Branded Stores		
Average	1.086	1.158
Standard Deviation	0.873	0.957
Unbranded Stores		
Average	0.932	0.875
Standard Deviation	1.003	0.818
	Branded Store**	**Unbranded Store****
Branded Stores		
Average	0.836	0.856
Standard Deviation	0.538	0.755
Unbranded Stores		
Average	0.879	0.522
Standard Deviation	1.195	0.49

*Distance in miles for Cook County

** Distance in miles for Chicago

Table 4-9: OLS Regression Results

OLS Regression Results (Dependent Variable: Price)

Variable		(1)*	(SE)	(2)**	(SE)
Time	μ	-0.032	(0.01)	-0.091	(0.015)
Population ('000)	β_1	-0.033	(0.022)	0.010	(0.027)
Income ('000 $)	β_2	0.008	(0.001)	0.006	(0.002)
Retired ('000)	β_3	0.129	(0.073)	-0.073	(0.119)
Children ('000)	β_4	0.030	(0.072)	-0.070	(0.084)
# firms (zip code)	β_5	-0.018	(0.007)	-0.013	((0.008)
Labor ('000 zip code)	β_6	0.018	(0.003)	0.018	(0.003)
Chicago	β_7	0.195	(0.046)	-	-
DVD	δ_1	0.184	(0.07)	0.239	(0.008)
New	δ_2	0.491	(0.043)	0.263	(0.054)
Brand	δ_3	0.517	(0.057)	0.651	(0.081)
Cbr (in miles)	γ_1	0.122	(0.027)	0.129	(0.034)
Cubr (in miles)	γ_2	0.015	(0.03)	0.053	(0.057)
DVD*B	θ_1	0.548	(0.099)	0.491	(0.147)
DVD*Cbr	θ_2	0.033	(0.043)	0.026	(0.048)
DVD*Cubr	θ_3	0.017	(0.051)	-0.056	(0.102)
DVD*Cbr*B	λ_1	-0.071	0.056	-0.055	(0.107)
DVD*Cubr*B	λ_2	-0.024	(0.059)	0.075	(0.112)
R-Squared		0.45		0.47	

* For Cook County **For Chicago

Table 4-10: GLS Regression Results

GLS Regression Results (Dependent Variable: Price)

Variable		(1)*	(SE)	(2)**	(SE)
Time	μ	-0.052	(0.009)	-0.059	(0.013)
Population (‘000)	β_1	-0.07	(0.02)	-0.006	(0.02)
Income (‘000 $)	β_2	0.006	(0.001)	0.006	(0.002)
Retired (‘000)	β_3	0.305	(0.066)	-0.014	(0.103)
Children (‘000)	β_4	0.098	(0.067)	-0.015	(0.073)
# firms (’00 zip code)	β_5	-0.019	(0.006)	-0.013	(0.007)
Labor (‘000 zip code)	β_6	0.014	(0.003)	0.014	(0.003)
Chicago	β_7	0.163	(0.043)	-	-
DVD	δ_1	0.059	(0.068)	0.222	(0.086)
New	δ_2	0.352	(0.039)	0.166	(0.051)
Brand	δ_3	0.636	(0.055)	0.686	(0.081)
Cbr (in miles)	γ_1	0.095	(0.025)	0.137	(0.015)
Cubr (in miles)	γ_2	0.015	(0.031)	0.038	(0.053)
DVD*B	θ_1	0.560	(0.087)	0.50	(0.118)
DVD*Cbr	θ_2	0.082	(0.043)	0.006	(0.030)
DVD*Cubr	θ_3	0.034	(0.050)	-0.015	(0.094)
DVD*Cbr*B	λ_1	-0.15	(0.044)	-0.14	(0.06)
DVD*Cubr*B	λ_2	-0.037	(0.05)	-0.017	(0.089)
R-Squared		0.51		0.55	
		*For Cook County		** For Chicago	

Table 4-11: IV Regression Results

IV Regression Results* (Dependent Variable: Price)

Variable		(1)**	(SE)	(2)***	(SE)
Time	μ	-0.031	(0.011)	-0.093	(0.015)
Population (‘000)	β_1	-0.03	(0.022)	0.011	(0.028)
Income (‘000 $)	β_2	0.008	(0.001)	0.007	(0.002)
Retired (‘000)	β_3	0.113	(0.074)	-0.078	(0.12)
Children (‘000)	β_4	0.022	(0.072)	-0.069	(0.084)
# firms (zip code)	β_5	-0.019	(0.007)	-0.011	(0.009)
Labor (‘000 zip code)	β_6	0.018	(0.003)	0.017	(0.004)
Chicago	β_7	0.171	(0.048)	-	-
DVD	δ_1	0.178	(0.078)	0.256	(0.10)
New	δ_2	0.491	(0.043)	0.261	(0.054)
Brand	δ_3	0.520	(0.057)	0.648	(0.083)
Cbr (in miles)	γ_1	0.112	(0.033)	0.141	(0.036)
Cubr (in miles)	γ_2	-0.015	(0.039)	0.074	(0.072)
DVD*B	θ_1	0.611	(0.108)	0.482	(0.172)
DVD*Cbr	θ_2	0.055	(0.050)	0.032	(0.050)
DVD*Cubr	θ_3	-0.001	(0.066)	-0.098	(0.138)
DVD*Cbr*B	λ_1	-0.087	(0.073)	-0.060	(0.147)
DVD*Cubr*B	λ_2	-0.062	(0.076)	0.106	(0.146)
R-Squared		0.45		0.47	

* Second nearest stores is the instrument for distance to the nearest store

For Cook Count * For Chicago

Table 4-12: IV Regression – DVD Prices in Branded Stores

IV Regression Results (Dependent Variable: Price)

Variable	(1)*	(SE)	(2)**	(SE)
Time	0.097	(0.02)	-0.017	(0.017)
Population (‘000)	-0.010	(0.028)	0.013	(0.022)
Income (‘000 $)	0.001	(0.001)	0.001	(0.001)
Retired (‘000)	0.233	(0.1)	0.084	(0.115)
Children (‘000)	-0.084	(0.097)	-0.078	(0.07)
# firms (zip code)	-0.006	(0.01)	-0.004	(0.008)
Labor (‘000 zip code)	0.006	(0.004)	0.005	(0.003)
Chicago	0.203	(0.07)	-	-
New	0.398	(0.088)	-0.051	(0.076)
Cbr	0.072	(0.044)	0.014	(0.07)
CuBr	-0.08	(0.036)	-0.031	(0.035)
R-Squared	0.16		0.13	

*Entire Cook County ** Chicago Alone

Table 4-13: IV Regression – VHS Prices Branded Stores

IV Regression Results (Dependent Variable: Price)

Variable	(1)*	(SE)	(2)**	(SE)
Time	0.1	0.02	0.028	(0.036)
Population (‘000)	-0.013	(0.031)	0.004	(0.044)
Income (‘000 $)	0.003	0.002	-0.001	(0.002)
Retired (‘000)	0.306	(0.112)	0.201	(0.228)
Children (‘000)	-0.082	(0.108)	-0.108	(0.139)
# firms (zip code)	-0.011	(0.011)	-0.007	(0.017)
Labor (‘000 zip code)	0.011	(0.005)	0.009	(0.007)
Chicago	0.197	(0.077)	-	-
New	1.78	(0.099)	1.567	(0.151)
Cbr	0.094	(0.05)	0.018	(0.138)
CuBr	-0.076	(0.04)	-0.070	(0.069)
R-Squared	0.69		0.72	

*Entire Cook County ** Chicago Alone

Table 4-14: IV Regression – DVD Prices Unbranded Stores

IV Regression Results (Dependent Variable: Price)

Variable	(1)*	(SE)	(2)**	(SE)
Time	-0.04	(0.021)	-0.084	(0.028)
Population (‘000)	0.054	(0.036)	0.065	(0.046)
Income (‘000 $)	0.01	(0.003)	0.013	(0.005)
Retired (‘000)	-0.227	(0.127)	-0.311	(0.208)
Children (‘000)	-0.162	(0.104)	-0.175	(0.125)
# firms (’00 zip code)	-0.027	(0.013)	-0.024	(0.016)
Labor (‘000 zip code)	0.028	(0.006)	0.026	(0.007)
Chicago	0.171	(0.101)	-	-
New	0.246	(0.072)	0.101	(0.089
Cbr	0.17	(0.04)	0.177	(0.041)
CuBr	-0.041	(0.073)	-0.044	(0.142)
R-Squared	0.25		0.30	

**Entire Cook County ** Chicago Alone

Table 4-15: IV Regression – VHS Prices Unbranded Stores

IV Regression Results (Dependent Variable: Price)

Variable	(1)*	(SE)	(2)**	(SE)
Time	-0.096	(0.022)	-0.122	(0.029)
Population (‘000)	0.071	(0.038)	0.093	(0.047)
Income (‘000 $)	0.01	(0.003)	0.011	(0.005)
Retired (‘000)	-0.233	(0.134)	-0.379	(0.212)
Children (‘000)	-0.284	(0.11)	-0.319	(0.127)
# firms (zip code)	-0.014	(0.014)	-0.001	(0.002)
Labor (‘000 zip code)	0.021	(0.006)	0.018	(0.007)
Chicago	0.124	(0.107)	-	-
New	0.402	(0.076)	0.219	(0.091)
Cbr	0.137	(0.042)	0.172	(0.041)
CuBr	0.012	(0.076)	0.141	(0.142)
R-Squared	0.31		0.33	

* Entire Cook County ** Chicago Alone

Table 4-16 (a): Influence of Competition on Price Differences

Effect of Competition on Price Difference

Specification	OLS		GLS		IV	
	(a)	(b)	(a)	(b)	(a)	(b)
Competition from branded store on:						
Branded Store $(\theta_2 + \lambda_1)$	-0.038	0.03	-0.068*	-0.134**	-0.032	-0.028
Unbranded Store (θ_2)	0.033	0.026	0.082**	0.006	0.055	0.032
Competition from unbranded store on:						
Branded Store $(\theta_3 + \lambda_2)$	-0.007	-0.021	-0.003	-0.032	-0.063	0.008
Unbranded Store (θ_3)	0.017	-0.056	0.034	-0.015	-0.001	-0.098

(a) For entire Cook County

(b) For Chicago alone

* Significant at 90%, ** Significant at 95%

Table 4-16 (b): Influence of Competition on Price Differences[71]

Effect of Competition on Price Difference

Specification	IV (a)	IV (b)
Competition from branded store on:		
Branded Store $(\theta_2 + \lambda_1)$	-0.022 (0.067)	-0.004 (0.155)
Unbranded Store (θ_2)	0.033 (0.058)	-0.039 (0.077)
Competition from unbranded store on:		
Branded Store $(\theta_3 + \lambda_2)$	-0.004 (0.054)	0.005 (0.141)
Unbranded Store (θ_3)	-0.053 (0.105)	-0.185 (0.142)

(a) For entire Cook County

(b) For Chicago alone

(Standard errors)

[71] For the case of separate regressions for each product

Table 4-17 (a): First Stage Regressions

First Stage Regression

Dependent Variable	**C Br**	
Variable	Coeff	(SE)
Inc	0.004	0.001
Retd	0.166	0.054
Child	0.052	0.054
Popl	-0.032	0.017
Firms	-0.007	0.005
Labor	-0.0001	0.002
Chicago	0.178	0.037
rent_time	0.013	0.008
Dvd	-0.033	0.059
New	0.031	0.032
Majorstore	-0.058	0.042
DVD*Majorstore	0.091	0.084
DVD*Inst_major	0.023	0.032
DVD*Inst_minor	0.0002	0.032
DVD*Majorstore*Inst_major	-0.067	0.044
DVD*Majorstore*Inst_minor	0.011	0.040
Instrument_Major	**0.840**	**0.020**
Instrument_Minor	-0.097	0.021

Table 4-17 (b): First Stage Regressions

First Stage Regression

Dependent Variable	**C Br**	
Variable	Coeff	(SE)
Inc	-0.0001	0.001
Retd	-0.041	0.056
Child	-0.001	0.055
Popl	0.007	0.017
Firms	0.010	0.005
Labor	-0.003	0.002
Chicago	0.124	0.038
rent_time	0.017	0.009
Dvd	0.138	0.061
New	0.030	0.033
Majorstore	0.065	0.044
DVD*Majorstore	-0.335	0.086
DVD*Inst_major	-0.028	0.033
DVD*Inst_minor	-0.069	0.033
DVD*Majorstore*Inst_major	0.068	0.045
DVD*Majorstore*Inst_minor	0.143	0.042
Instrument_Major	0.017	0.021
Instrument_Minor	**0.688**	**0.021**

Graphs and Figures

Figure 2-1: Generation Capacities by Generation Types

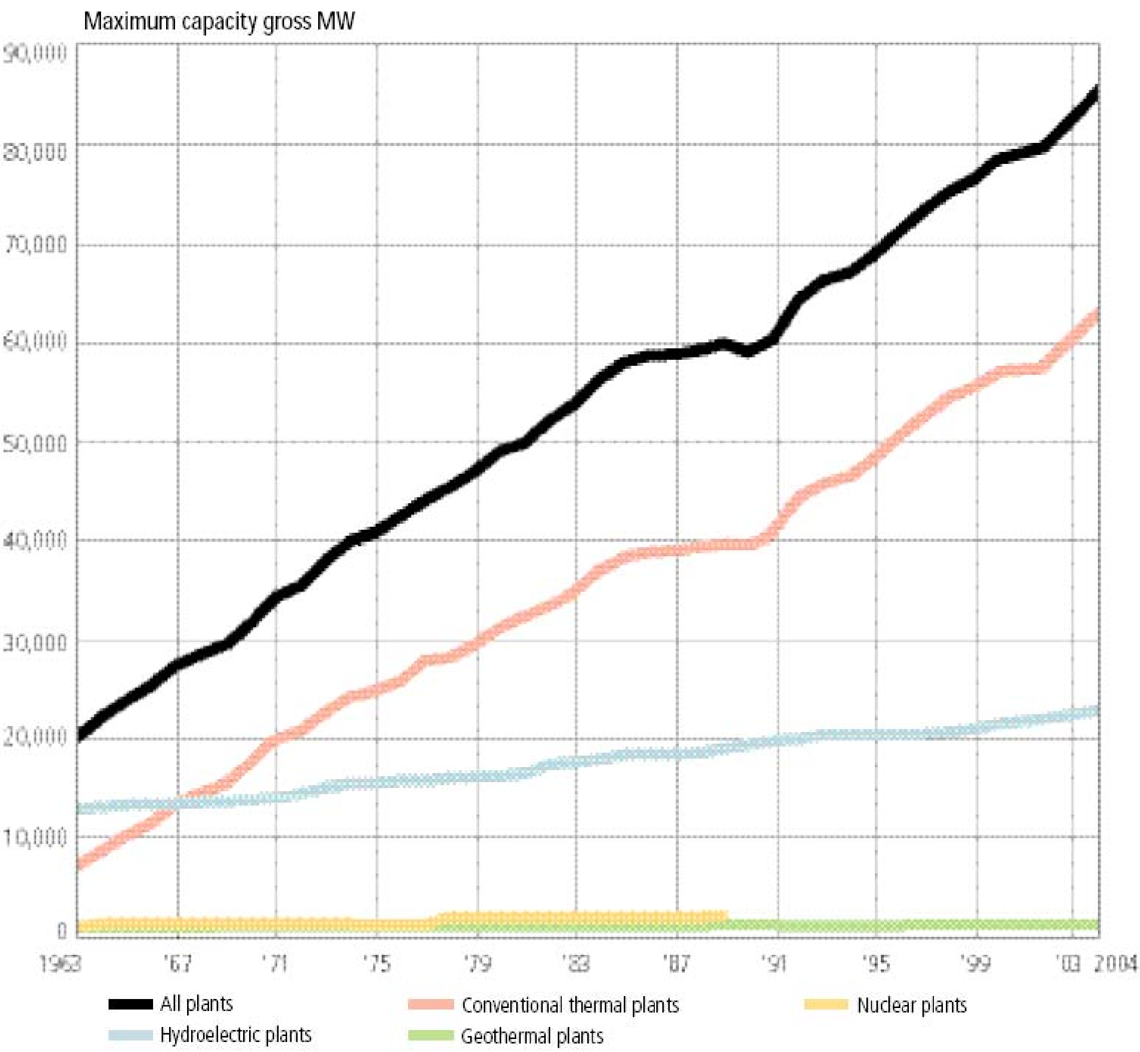
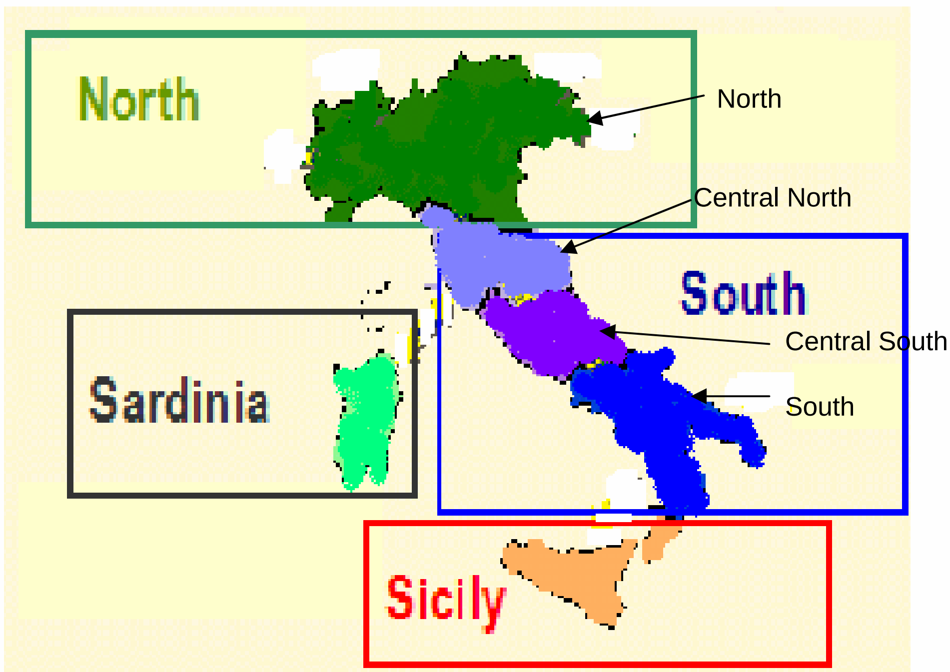


Figure 2-2: Zonal Structure



Source: (edited from) www.mercatoelettrico.org

Figure 2-3: Illustration of Residual Demand Function for Enel

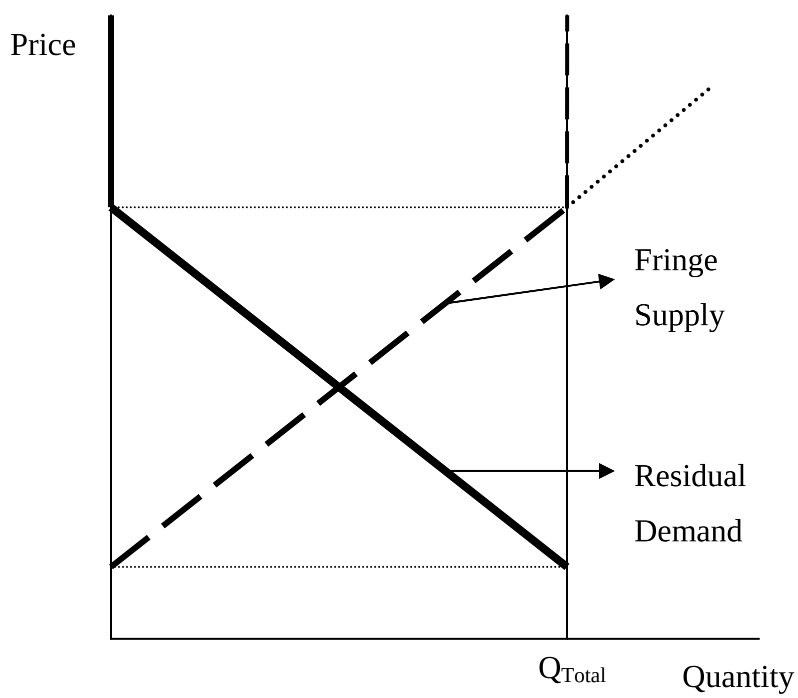


Figure 2-4: Supply Function Equilibrium in a Monopoly

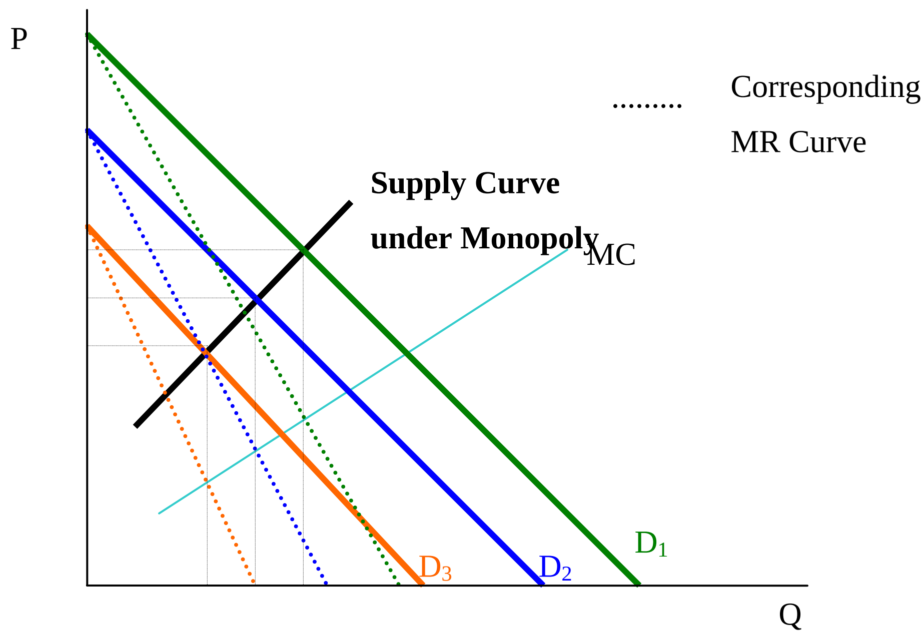
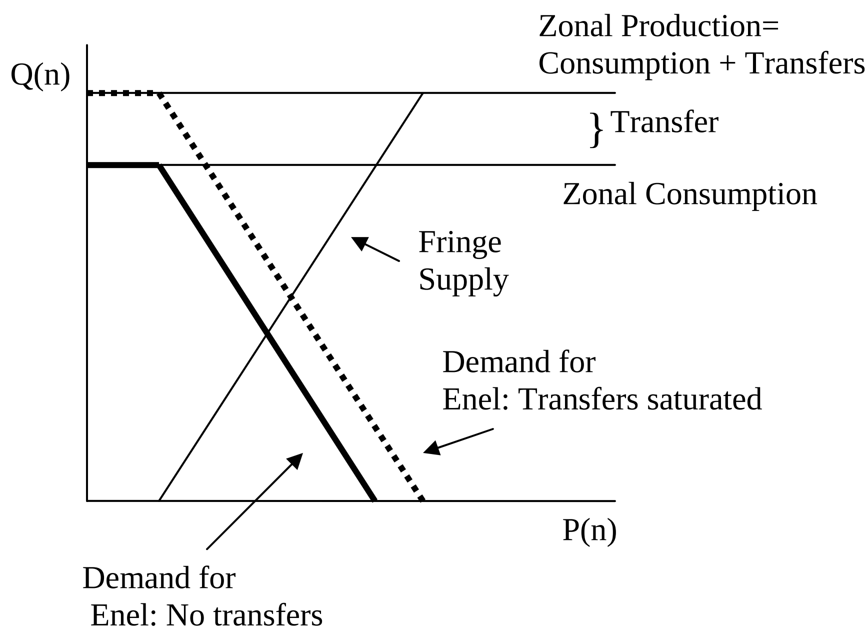
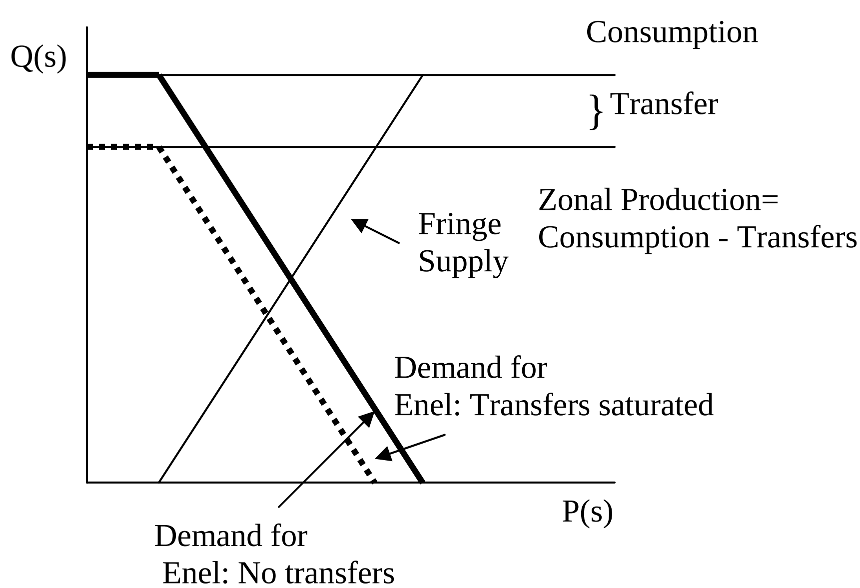


Figure 2-5: Enel's Demand with Transfers



(North)



(South)

Figure 2-6: Hourly Price Difference

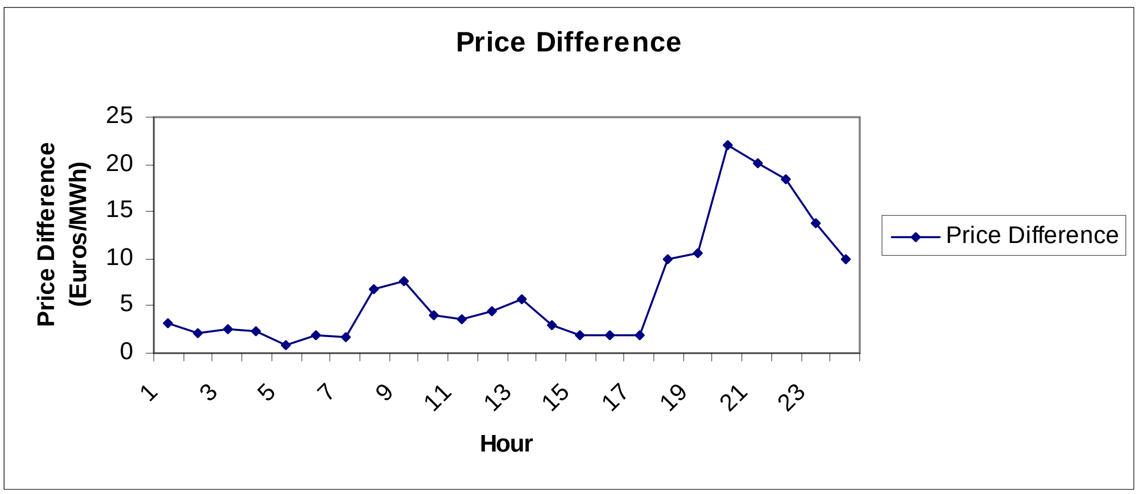
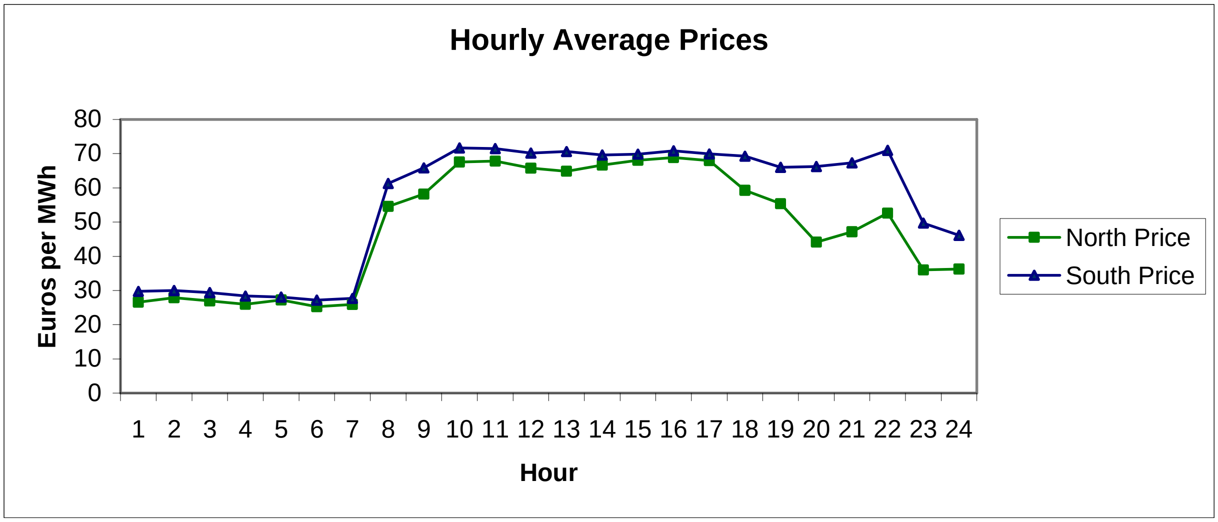
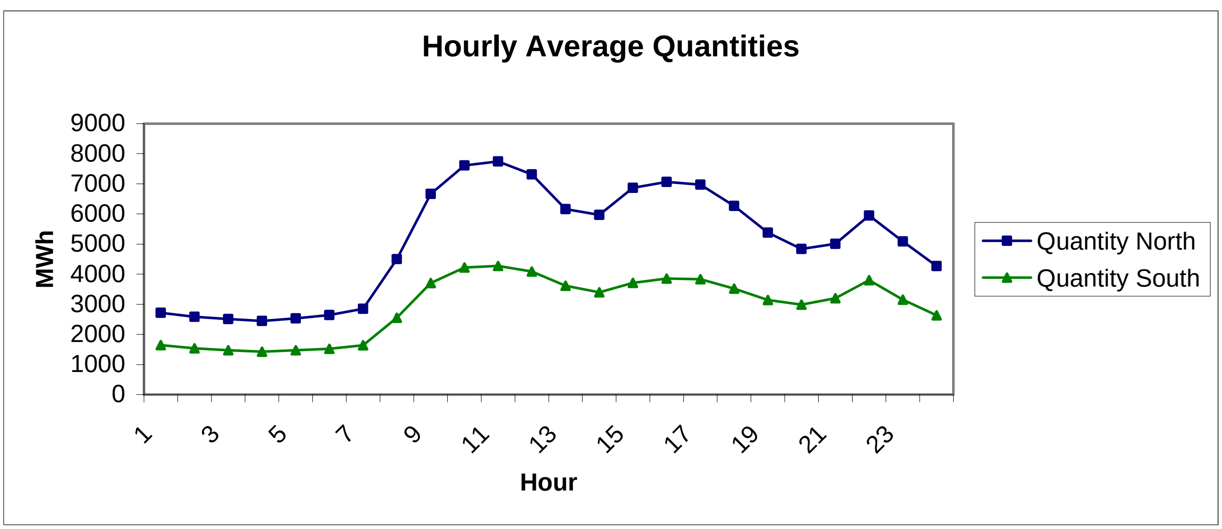


Figure 2-7: Hourly Average Prices and Quantities



(a)

(Note: Average prices for 21 days considered in May 2004)



(b)

(Note: Calculated for 21 days in May 2004)

Figure 2-8: Firm's Capacity in Entire Italy

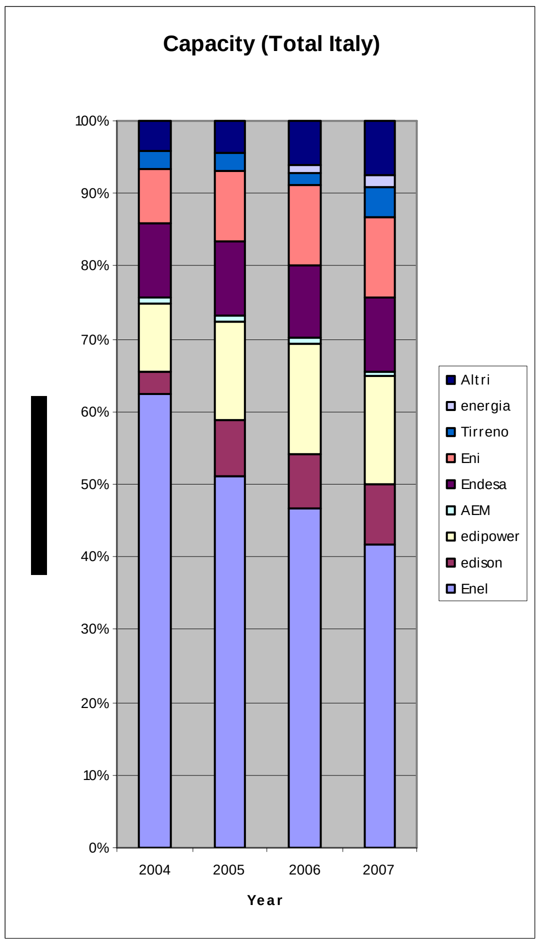


Figure 2-9: Firms' Capacity in North Italy

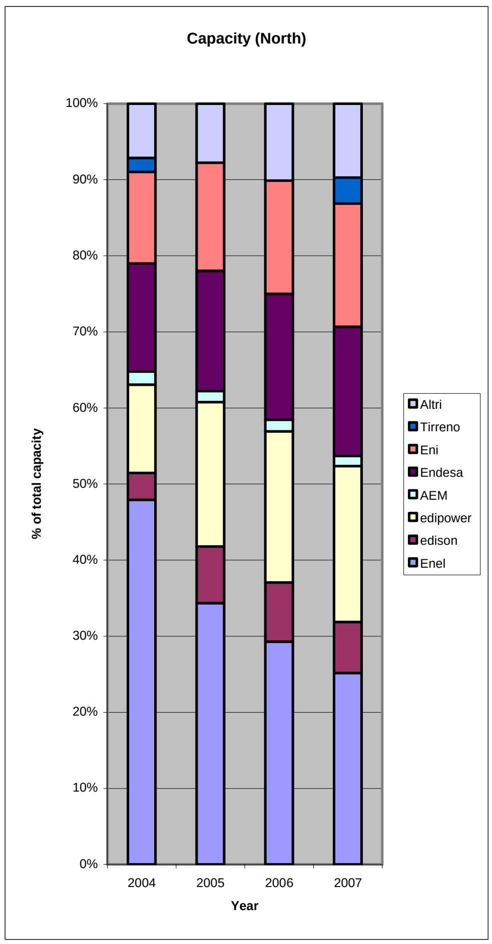


Figure 2-10: Firms' Capacity in South Italy

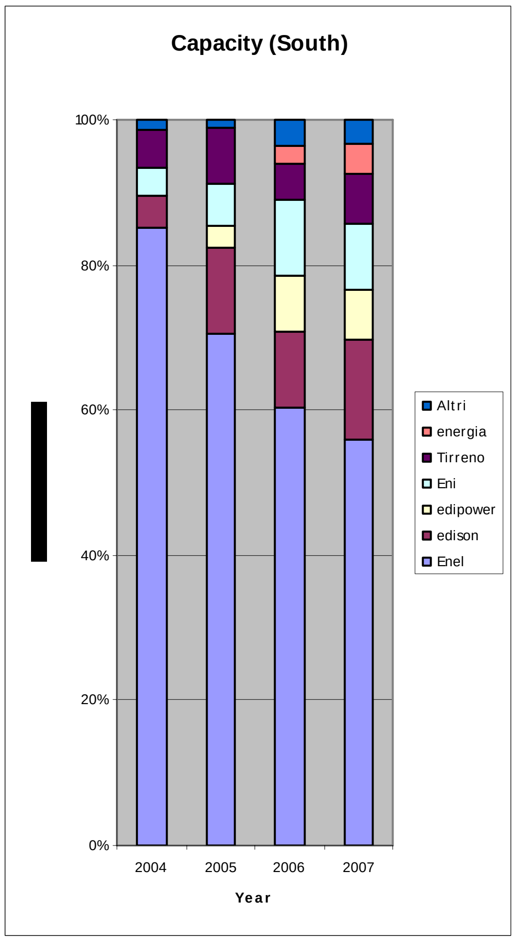


Figure 2-11: Maximum and Minimum Realized Prices

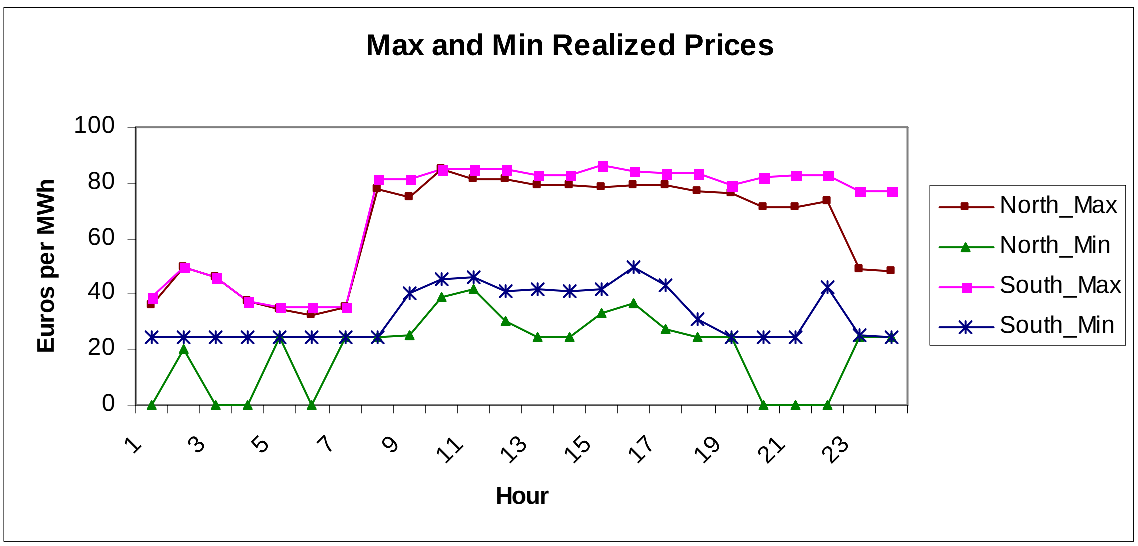


Figure 2-12: Marginal Cost as a Step Function

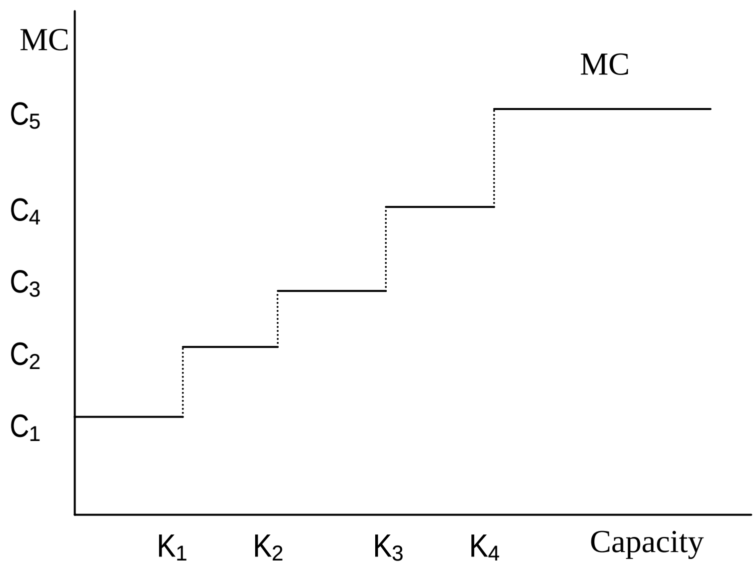
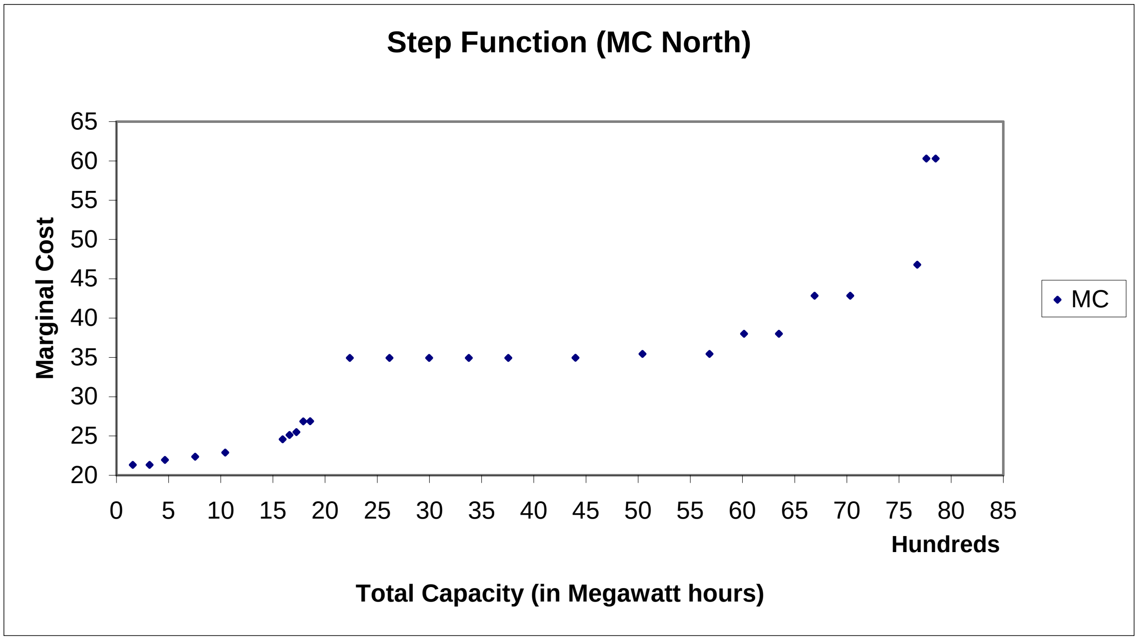
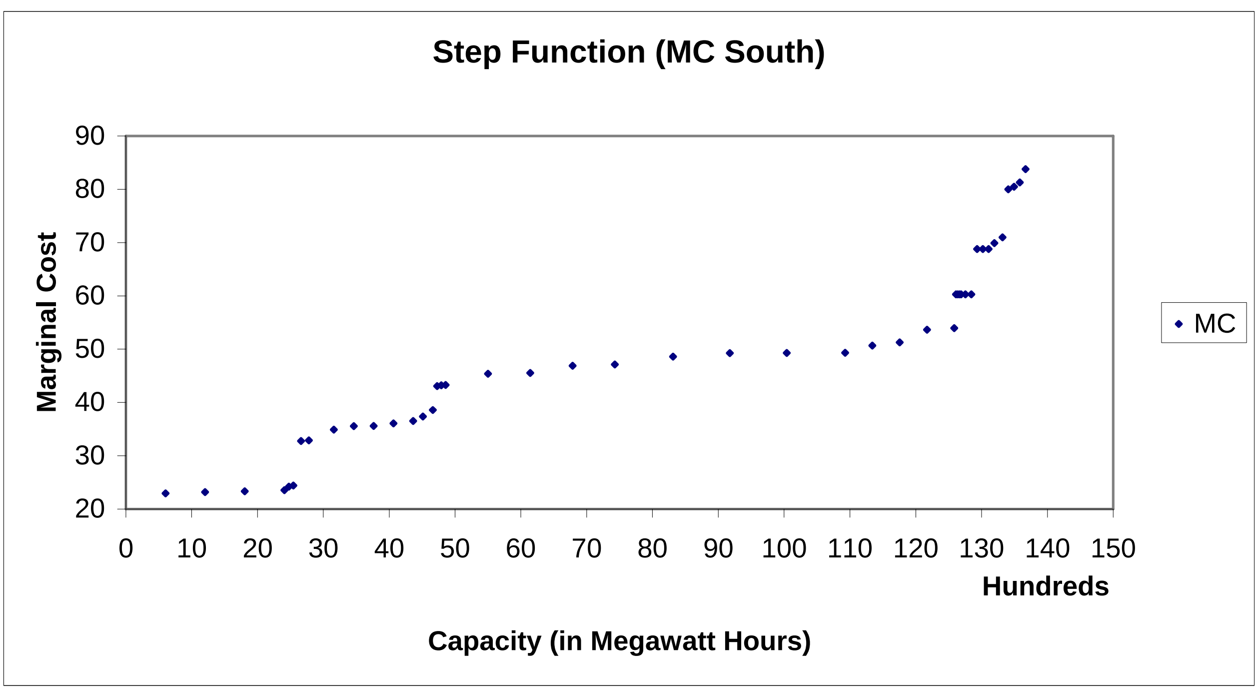


Figure 2-13: Observed Marginal Cost



(a)



(b)

Figure 2-14: Hourly Liquidity

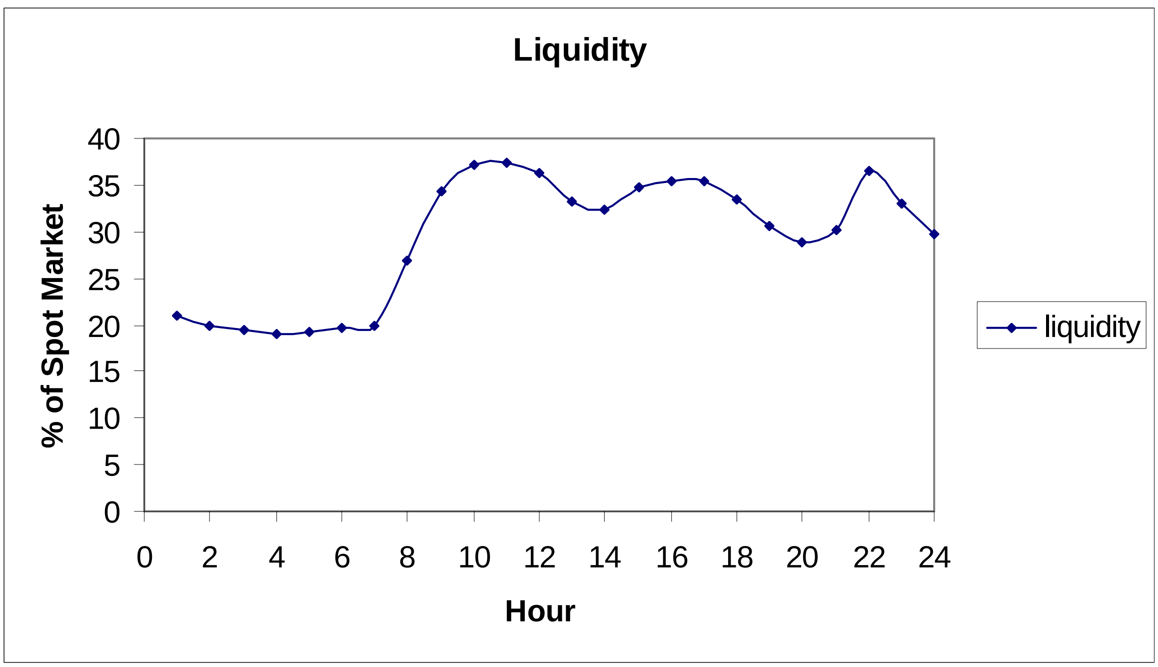


Figure 3-1: Calculating Fringe Supply Function in the Integrated Market

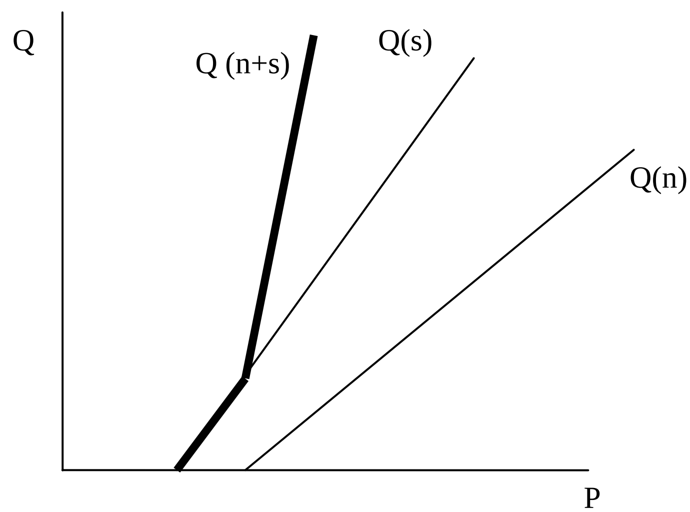


Figure 3-2: Enel's Demand Function in the Integrated Market

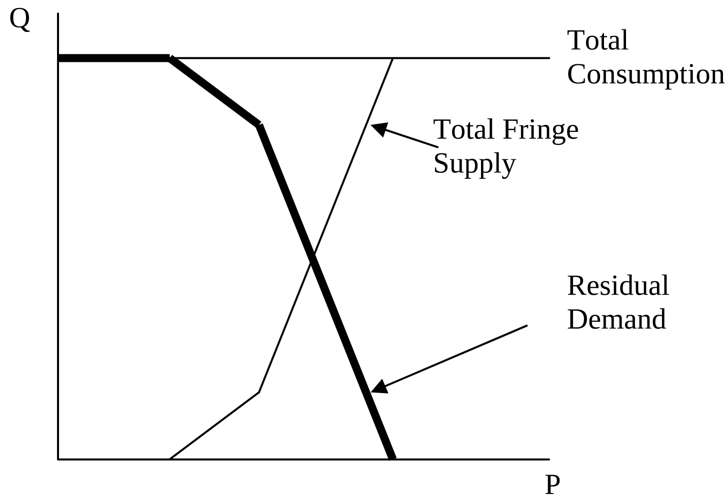


Figure 3-3: Regression Results

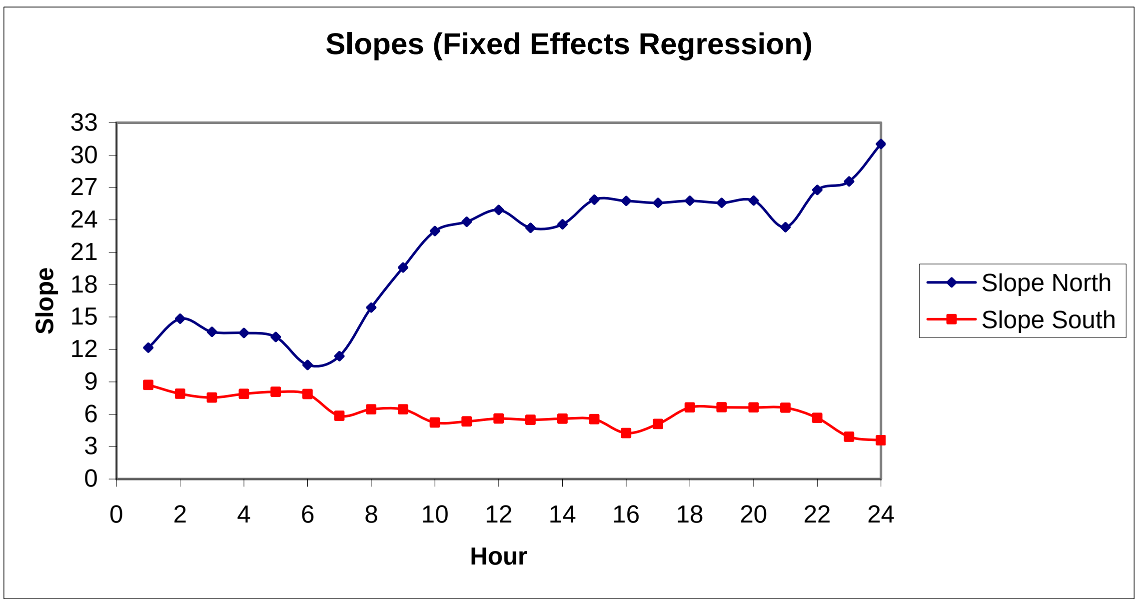


Figure 3-4: Hourly Average Alpha

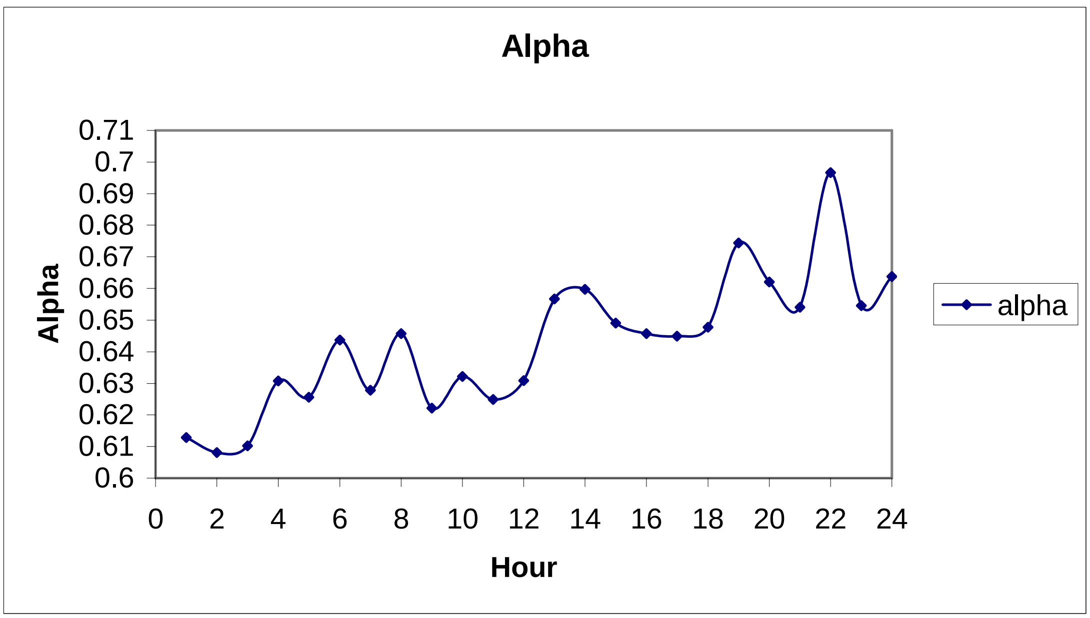


Figure 3-5: Illustrating the Iterative Procedure

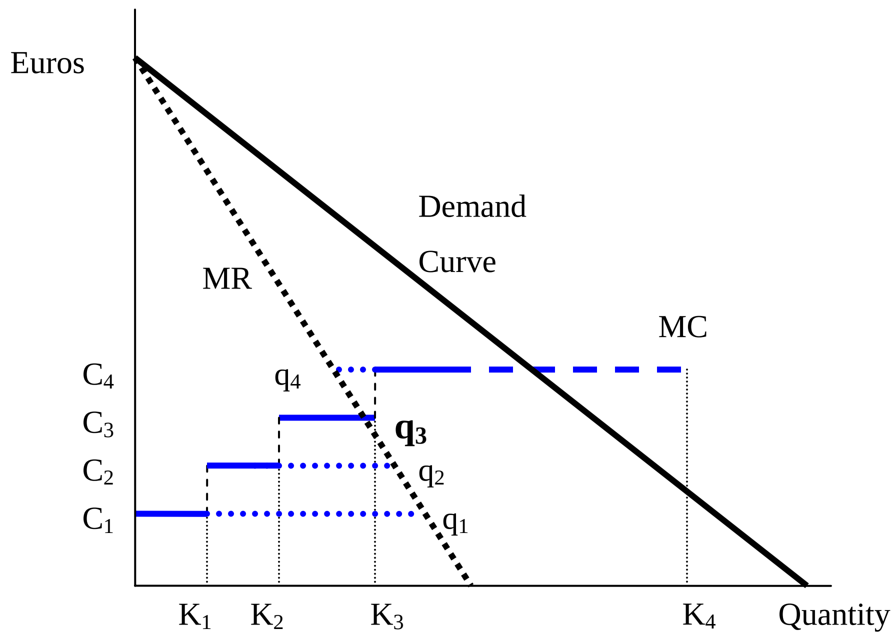


Figure 3-6: Simulated Vs. Actual Prices

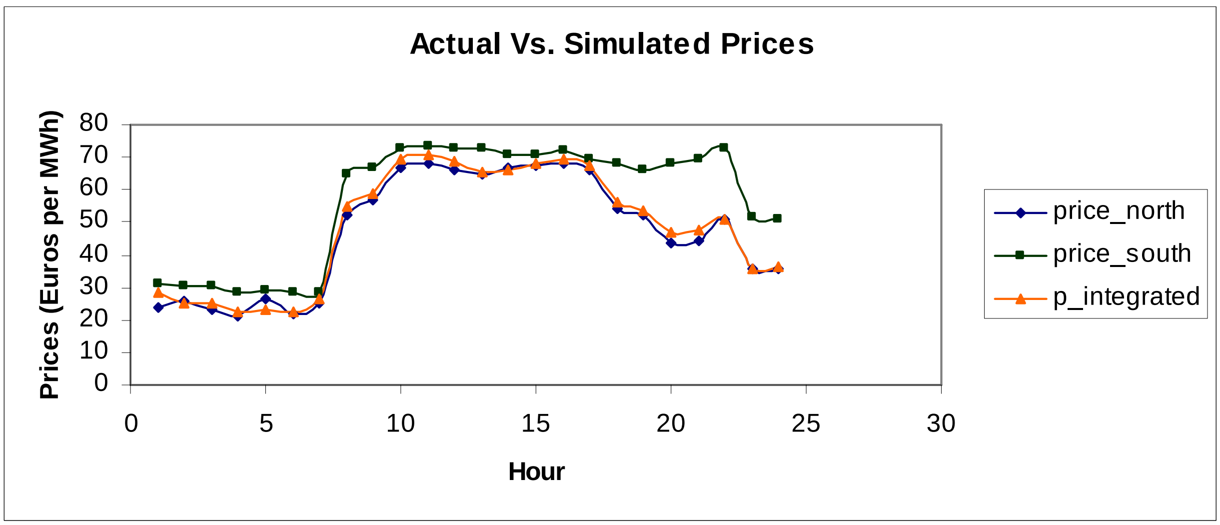


Figure 3-7: Simulated Vs. Actual Quantities

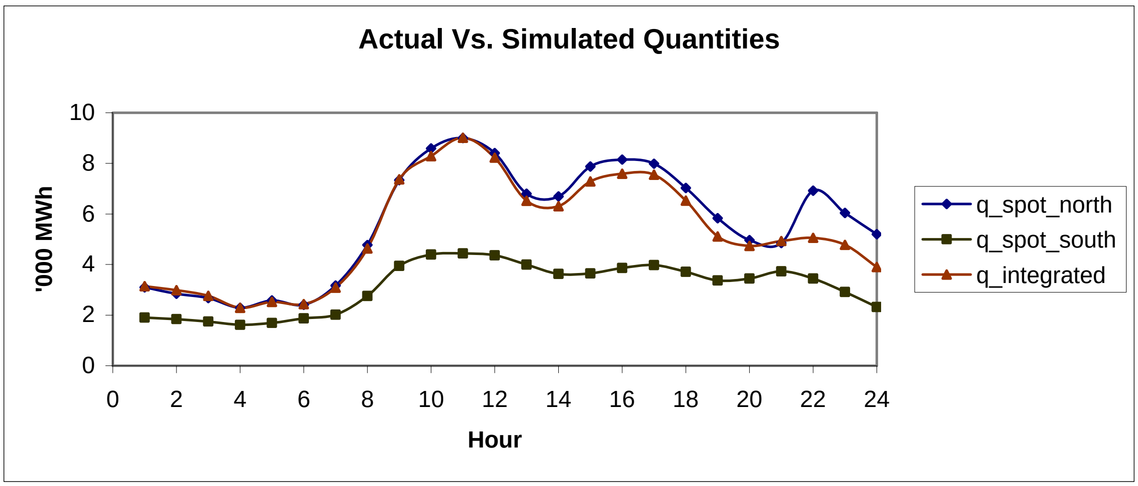


Figure 3-8: Average Hourly Gains

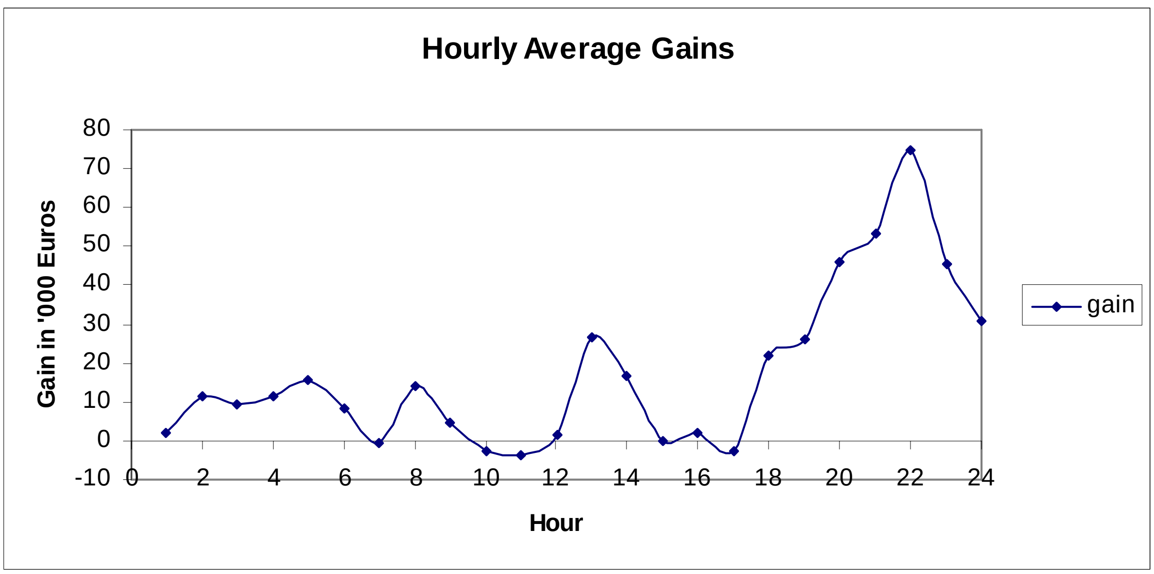
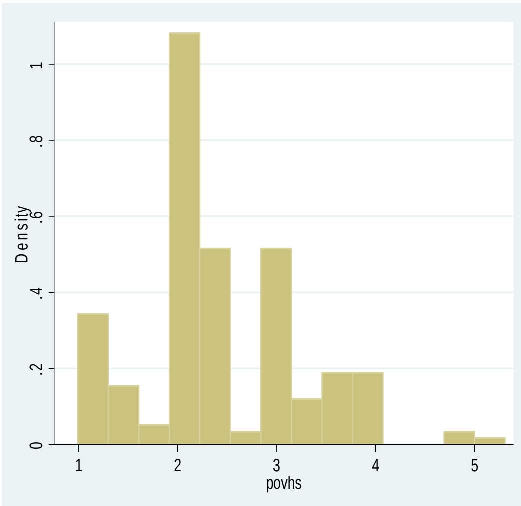
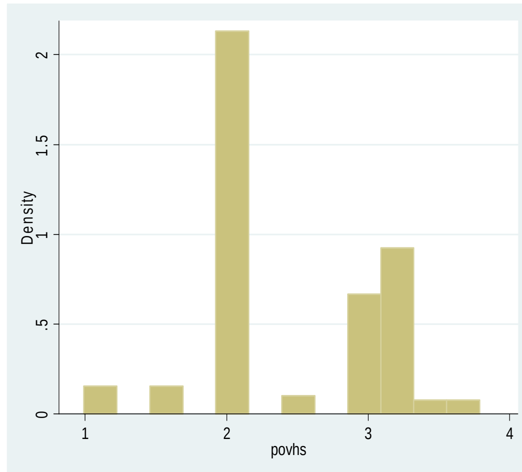


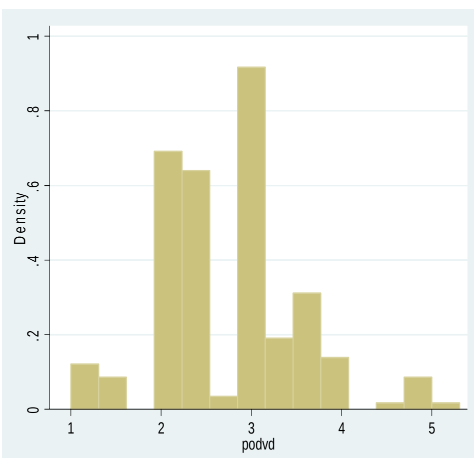
Figure 4-1: Histogram of Prices: Old DVD and Old VHS



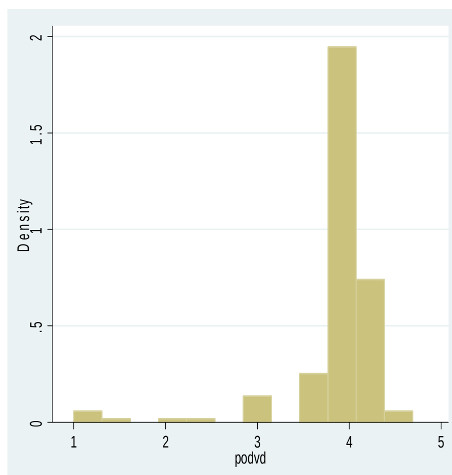
(a) Price of Old VHS, Unbranded store



(b) Price of Old VHS, Branded store

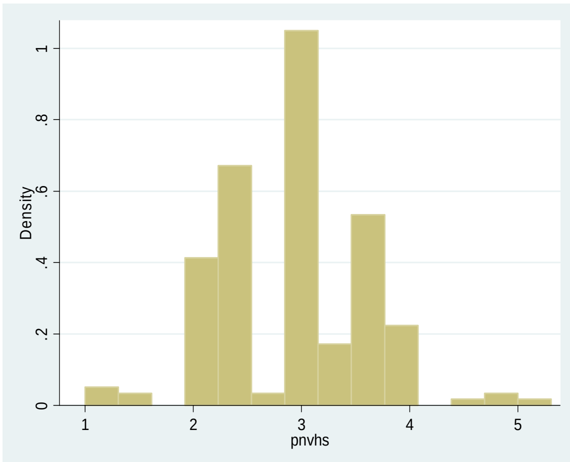


(c) Price of Old DVD, Unbranded store

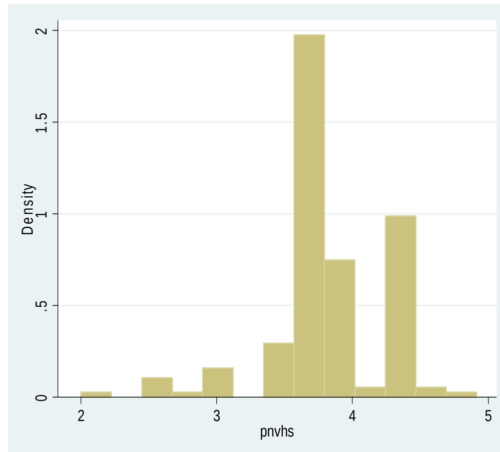


(d) Price of Old DVD, Branded store

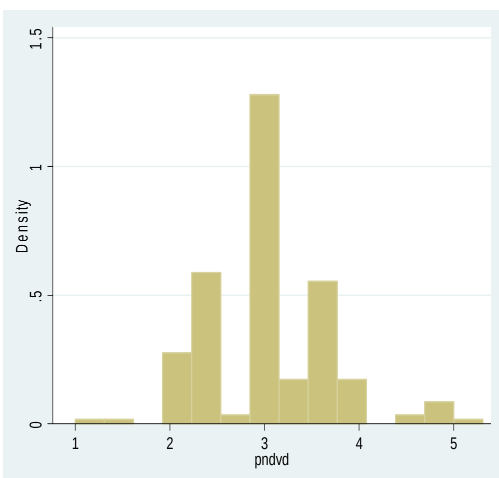
Figure 4-2: Histogram of Prices: New DVD and New VHS



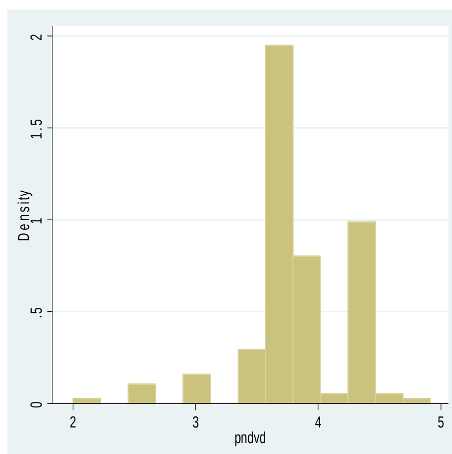
(a) Price of New VHS, Unbranded Store



(b) Price of New VHS, Branded store

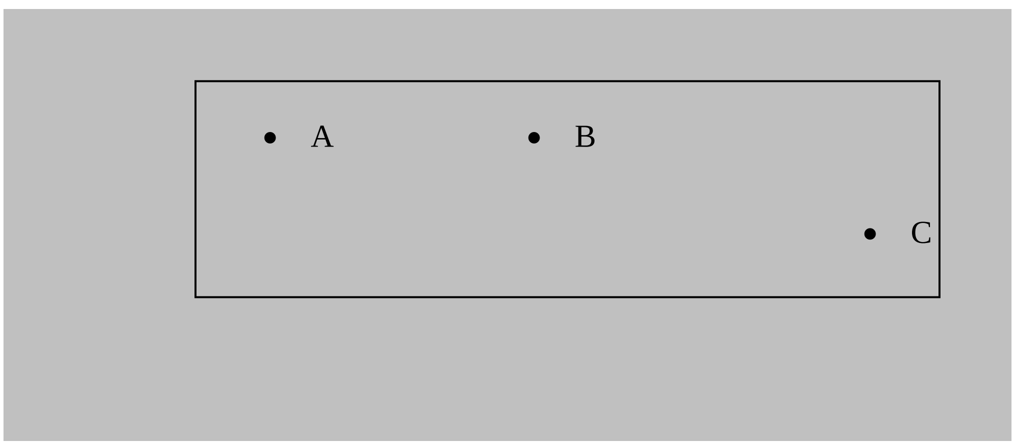


(c) Price of new DVD, Unbranded stores



(d) Price of new DVD, Branded stores

Figure 4-3: Illustration of Instrumental Variables



References

Anderson, E. and J. Dana (2005), "When is Price Discrimination Profitable?" *Working Paper, Northwestern University*

Armstrong, M. (2005), "Recent Developments in the Economics of Price Discrimination." *Working paper, University College London*

Armstrong, M. and J. Vickers (1993), "Price Discrimination, Competition and Regulation." *The Journal of Industrial Economics* 41(4): 335-359

Armstrong, M. and J. Vickers (2001), "Competitive Price and Discrimination." *Rand Journal of Economics* 32(4): 579-605

Ashenfelter, O, et al (2004), "Econometric Methods in Staples." *Princeton Law and Public affairs paper No. 04-007*

Baldick, R. and W. Hogan (2003), "Capacity Constrained Supply Function Equilibrium Models of Electricity Markets: Stability, Non-decreasing Constraints and Function Space Iterations." *Working Paper 89, POWER*

Ballou, J. (2002), "The Relationship between Pricing Behavior and Ownership Type in the Wisconsin Nursing Home Industry, 1984-1995." *Working Paper 02-25, Institute or Policy Research, Northwestern University*

Baumol, W., J. Panzar and R. WIllig (1982), "Contestable Markets and the Theory of Industry Structure", *New York: Harcourt Brace*

Bolle, F. (1992), "Supply Function Equilibria and the Danger of Tacit Collusion." *Energy Economics* 14(2): 94-102

Borenstein, S., J. Bushnell and S. Stoft (2000), "The Competitive Effects of Transmission Capacity in a Deregulated Electricity Industry." *The Rand Journal of Economics* 31(Summer): 294-325

Borenstein, S., and N. Rose (1994), "Competition and Price Discrimination in the U.S. Airline Industry." *The Journal of Political Economy* 102(4): 653-683

Busse, M. and M. Rysman (2004), "Competition and Price Discrimination in Yellow Pages Advertising." *Rand Journal of Economics* 36(2): 378-390

Carbonneau, S., P. McAfee, H. Mialon and S. Mialon (2004), "Price Discrimination and Market Power" *Working Paper, University of Emory*

Cohen, A. (2004), "Identifying Price Discrimination when Product Menus are Endognous." *Dissertation Thesis, Northwestern University*

Crawford, G. and M. Shum (2004), "Monopoly Quality Degradation and Regulation in Cable Television." *Working Paper, University of Arizona*

Dana, J. and K. Spier (2001), "Revenue Sharing and Vertical Control in the Video Rental Industry." *Journal of Industrial Economics* 49(3):

Deneckere, R. and P. McAfee (1996), "Damaged Goods", *Journal of Economics and Management Strategy"* 5(2): 149-174

Erus, B. and B. Weisbord (2003), "Objective Functions and Compensation Structures in Nonprofit and For-Profit Organizations: Evidence from the "Mixed" Hospital Industry." *The Governance of Not-for-Profit Firms*, ed. Edward Glaeser, University of Chicago Press, June 2003

Genc, T. and S. Reynolds (2005), "Supply Function Equilibria with Pivotal Electricity Suppliers." *Working Paper, University of Arizona*

Gowrisankaran, G and M. Rysman (2006), "Dynamics of Consumer Demand for New Durable goods", *Working Paper,* Washington University at St. Louis

Green, R. and D. Newberry (1992), "Competition in the British Electricity Spot Market." *The Journal of Political Economy* 100(5): 929-953

Harvey, S, W. Hogan and S. Pope (1997), "Transmission Capacity Reservations and Transmission Congestion Contracts." *Mimeo, Kennedy School of Public Policy, Harvard University*

Holmberg, P. (2004), "Unique Supply Function Equilibrium with Capacity Constraints." *Working Paper 2004:20, Uppsala Universitet*

Hollas, R. and S. Stansell (1988), "An Examination of the Effect of Ownership Form on Price Efficiency: Proprietary, Cooperative and Municipal Electric Utilities." *Southern Economic Journal* 55(2): 336-350

Hortacsu, A. and S. Puller (2004), “Testing Strategic Models of Firm Behavior in Restructured Electricity Markets: A Case Study of ERCOT.” *Working Paper, University of Chicago*

Ivaldi, M. and D. Mortimort (1994), “Competition Under Nonlinear Pricing.” *Annales D’Economie Et De Statistique* Pages: 71-114

Johnsen, A., S. Verma and C. Wolfra (2004), “Zonal Pricing and Demand-Side Responsiveness in the Norwegian Electricity Market.” *Working Paper 063, POWER*

Johnson, J. P. and D. Myatt (2003), “Multiproduct Quality Competition: Fighting Brands and Product Line Pruning.” *American Economic Review* 93(3): 748-774

___________ and __________(2006), “Multiproduct Cournot Oligopoly.” Forthcoming: *Rand Journal of Economics*

Joskow, P. and J. Tirole (2000), “Transmission Righrs and Market Power on Electric Power Networks.” *Rand Journal of Economics* 31(Autumn): 450-487

________ and ________ (2005a), “Merchant Transmission Investment.” *Journal of Industrial Economics* 53(2): 233-264

________ and ________ (2005b), “Reliability and Competitive Electricity Markets.” *IDEI Working Paper 0405*

Klemperer, P. and M. Meyer (1989), “Supply Function Equilibrium in Oligopoly under Uncertainty.” *Econometrica* 57(6): 1243-1277

Levy, M. and B. Cormia (2002), “Netflix Analyzed via the Value Framework.” Available at http://www.valueframeworkinstitute.org/May2002/feature.article.htm

Manuszak, M and C. Moul (2006), “Prices and Endogenous Market Structure in Office Supply Superstores.” *Working Paper, Washington University*

Maskin, E. and J. Riley (1984), “Monopoly with Incomplete Information.” *Rand Journal of Economics* 15:171-196

Mazzeo, M. (2002), “Competitive Outcomes in Product-Differentiated Oligopoly.” *Review of Economics and Statistics* 2002 (November):

Miravete, E and L-H. Roller (2004), "Competitive Nonlinear Pricing in Duopoly Equilibrium: The Early U.S. Cellular Telephone Technology." *Working Paper, University of Pennsylvania*

Mortimer, J. (2003), "The Effects of Revenue Sharing Contracts on Welfare in Vertically-Separated Markets: Evidence from the Video Rental Industry." *Working Paper, Harvard University*

Mussa, M and S. Rosen (1978), "Monopoly and Product Quality." *Journal or Economic theory* 18: 301-317

Oren, S., S. Smith and R. Wilson (1983), "Competitive Nonlinear Tariffs." *Journal of Economic Theory* 29: 49-71

Porter, R. and D. Zona (1999), "Ohio School Milk Markets: An Analysis of Bidding." *Rand Journal of Economics* 30(2): 263:288

Puller, S. (2004), "Pricing and Firm Conduct in California's Deregulated Electricity Market." Forthcoming, *Review of Economics and Statistics*

Rochet, J-C and L. Stole (2002), "Nonlinear Pricing with Random Participation Constraint." *Review of Economic Studies* 69: 277-311

Salop, S. (1979), "Monopolistic Competition with Outside Good."*Bell Journal of Economics* 10: 141-156

Stahl, K (1982a), "Location and Spatial Pricing Theory with Nonconvex Transportation Cost Schedules." *Bell Journal of Economics* 13(2): 575-582

Stahl, K (1982b), "Differentiated Products, Consumer Search and Locational Oligopoly." *Journal of Industrial Economics* 31(1/2): 97-113

Seim, K (2006), "An Empirical Model of Firm Entry with Endogenous Product Choices." *Forthcoming: Rand Journal of Economics*

Spulbre, D (1989), "Product Variety and Competitive Discount." *Journal of Economic Theory* 48: 510-525

Stole, R. (1996), "Nonlinear Pricing and Oligopoly." *Journal of Economics and Management Strategy* 4(4): 529-562

Thomadsen, R. (2005), "The Effect of Ownership Structure in Geographically Different industries." *Rand Journal of Economics* 36(4): 908-929

Watson, R (2002), "Product Variety and Competition in the Retail Market for Eyeglasses." *Ph. D Dissertation, Northwestern University*

Wolak, F. (2000), "An Empirical Analysis of the Impact of Hedge Contracts on Bidding Behavior in a Competitive Electricity Market." *International Economic Review* 14(2): 1-39

Wolfram, C. (1999), "Measuring Duopoly Power in the British Electricity Spot Market.", *American Economic Review* 89(4): 805-826

Electric Energy Market Competition Task Force (2006), "Report to Congress on Competition in the Wholesale and Retail Markets for Electric Energy."

APPENDIX A

Details of the Empirical Strategy

This section provides the details of empirical strategy for modeling and evaluating the counter factual in the Italian electricity spot market.

Step 1: Supply Function of the Fringe

We estimate the supply curve of the fringe separately for all twenty four hours, i.e., we estimate twenty four supply curves. For every hour, all participating plants submit various prices and the incremental quantity (from the previous price) they are willing to supply at that price. The data on the bids placed by all generators are provided by the Italian electricity market operator. Before we estimate the supply curve of the fringe we perform the following steps:

- We first eliminate all the bids placed by plants owned by Enel.
- Also, from all the fringe bids, we remove the bids that are replaced, revoked or found incompatible.

- Then, we arrange all the bids of the fringe in the increasing order of prices and add the incremental quantities to compute the quantity the fringe is willing to supply at that price for that hour (separately for every day).
- From these bids, we eliminate all the bids that have extreme prices

We then estimate the supply function of the fringe by estimating the linear regression that includes *day fixed effects*, Equation (1).

Step 2: Demand Function of Enel

The key parameter is β, the slope of the supply curve of the fringe. By assumption, $-\beta$ is the slope of the residual demand curve faced by Enel. As uncertainty is present in the fringe's supply function, the intercept of the realized demand for Enel is not identified. After identifying β, we identify the realized demand curve faced by Enel as follows:

- For every hour we know the quantity supplied by Enel and the market clearing price, i.e., a point on the realized demand curve.
- Once the slope and the point on the demand curve are known, it is straightforward to compute the demand function realized by Enel for that particular hour.[72]

[72] We assume that Enel's bid supply curve is Enel's optimal response to all potentially realized uncertainties. (Please see Chapter 2 for discussion on Enel's behavior.)

Step 3: Identifying Enel's Objective Function

Since the North fringe is more efficient than the South, we assume that the transmission constraint is always binding with equality.[73] That is, we assume that the total demand faced by the generators in the North is equal to the total inelastic demand by the end-users in the North plus the total allowed interzonal transmission capacity. By the same argument, the demand faced by the generators in the South is equal to the total demand by the end-users in the South minus the transmission capacity. Before estimating the counter factual, we also need to identify the marginal plant, where the transition from the contracts market to the spot market takes place. We identify the marginal plant as the most efficient plant that participates in the spot market. All plants more efficient participate in contracts market and all plants less efficient, including the marginal plant, participate in the spot market.

Since the goal of our paper is to check how overall expenditure changes when interzonal price dispersion is eliminated, we omit all hours where the prices are same.[74] We calculate α separately for each zone for every hour. α_n and α_s are computed by equating the predicted prices from the first order conditions of equation **(*)** with the observed prices. Specifically, for every hour we have:

---

[73] Also, currently, less expensive imports from France, Slovenia, etc, are only possible in the North.

[74] If the price difference is less than five cents, we consider the prices in the North and the South to be same (to consider any accounting or rounding up errors).

$$\alpha_z = \frac{Q_z^{spot}}{Q_z^{spot} + p_z \frac{\partial Q_z}{\partial p_z} + Q_z - C'(Q_z)\frac{\partial Q_z}{\partial p_z}} \qquad z \in \{N, S\}$$

Here Q_z^{spot} and Q_z represent total spot market consumption and total production of Enel in zone *z* respectively.

Step 4: Evaluating the Counterfactual

To evaluate counterfactual we make the following assumptions. As a result of interconnection:

- The slope of the fringe's supply curve does not change
- Objective function of Enel does not change

We compute the overall α as a weighted average of α_n and α_s. The weights are given by the total spot market quantities consumed in respective zones. That is,

$$\alpha = \frac{\alpha_n \overline{Q}_n + \alpha_s \overline{Q}_s}{\overline{Q}_n + \overline{Q}_s}$$

Prices in the alternative market structure are determined from the first order condition of the equation **(**)** (section 3.4). Specifically, the prices are determined by solving the following equation:

$$p = \frac{\left(1-\alpha\right)Q^{spot} + \alpha\left(C'(Q)\dfrac{\partial Q}{\partial p} - Q\right)}{\alpha\left(\dfrac{\partial Q}{\partial p}\right)}$$

where $Q = Q_n + Q_s$ and $Q^{spot} = Q_n^{spot} + Q_s^{spot}$

Total contracts in the alternative market are equal to the sum of zonal contracts. To identify the marginal plant, we arrange the plants in increasing order of efficiency for overall Italy and allocate the most efficient plants to the contract market.

APPENDIX B

Mails from Blockbuster Video and Hollywood Video

E-mail from Hollywood Video:[75, 76]

Thank you for writing to us regarding franchise information.

Hollywood Video is dedicated to providing exceptional guest experiences delivered with genuine warmth and friendliness.

Hollywood Video stores are company owned and managed, not franchised.

We appreciate your membership and if there is anything else we can do for you, please do not hesitate to email us at: E-Mail-Us@hlyw.com or call our Guest Relations department, toll free at 1-877-325-8687. We look forward to serving you again.

Sincerely,

xxxxx

Guest Relations Agent

Hollywood Entertainment

---

[75] Dated 19th June 2005

[76] This letter's format has been edited.

E-mail from Blockbuster Video:[77, 78]

Thank you for your interest in Blockbuster Franchising. We do not have an information packet that we send out at this time. We do have a financial requirement of a $400,000 net worth, of which $100,000 is liquid. If you meet this criterion, the next step would be to review the market you are interested in operating. We do not maintain a list of areas specifically open for franchise opportunities. We review them on a case-by-case basis.

You would need to find a location that does not currently have a store in it, with the closest Blockbuster being approx. 10 miles away.

You can use our store locator tool at www.blockbuster.com to assist you in finding where our existing stores are located (essentially, it would be a reverse search tool for you).

Please visit our website at www.blockbuster.com and follow the link at the bottom of the page to Franchise Opportunities. There you will find more information about becoming a Blockbuster franchisee as well as a Request for Consideration form you can download and fill out. I can be reached at 214-854-3431, should you have further questions.

Regards,

xxxx

Blockbuster Franchise Development

---

[77] Dated 6th May 2004

[78] This mail's format has been edited

APPENDIX C

CURRICULUM VITA

Viswanath Pingali

Cornerstone Research | 699 Boylston St
Boston, MA 02116 | (773) 225 9906
v-pingali@northwestern.edu

PERSONAL INFORMATION

Age: 27
Marital status: Single
Citizenship: Indian

FIELDS OF SPECIALIZATION

Primary: Industrial Organization
Secondary: Applied Econometrics, Competitive Strategy

DOCTORAL STUDIES

Ph.D., Economics, Northwestern University, Evanston, IL
Dissertation: Essays in Price Dispersion
Committee Chairperson: Professor Robert Porter
Date of Completion: July 2007 (expected)

PREDOCTORAL STUDIES

B.Sc.: Economics (Honors), Sri Satya Sai Institute of Higher Learning, India, 1999
M.S.: Quantitative Economics, Indian Statistical Institute, India, 2001
M.A.: Economics, Northwestern University, 2002

TEACHING EXPERIENCE

Teaching Assistant, Department of Economics, Northwestern University, 2002-2006
Introduction to Microeconomics, Econometrics, Intermediate Microeconomics, Transportation Economics and Policy, Comparative Economic Systems, African American Economic History

Teaching Assistant, Kellogg School of Management, Northwestern University, 2003-2006
Turbo Finance *(Summer 2003)*, Statistical Methods for Managerial Decisions *(Summer 2005)*, Mathematical Methods for Managerial Decisions *(Winter 2005)*

Lecturer, Northwestern University, Summer and Fall 2006
Transportation Economics and Policy

FELLOWSHIPS AND AWARDS

Center for the Studies of Industrial Organization Fellowship, Northwestern University, Winter 2007
Transportation Center Dissertation Year Fellowship, Northwestern University, 2006-07
Outstanding Teaching Assistant Award, Northwestern University, 2005-2006
Northwestern University Conference Grant, Summer 2006
Government of India Fellowship and Annual Contingency Grant, awarded to eight students across India, Indian Statistical Institute, July 1999 – May 2001
Kanika Pandit Gold Medal awarded to the student with best Cumulative GPA in B.Sc. (Economics) at Sri Satya Sai Institute of Higher Learning, November 1999

RESEARCH EXPERIENCE (Northwestern University)

Research Assistant to Professor Robert Porter, Summer 2003 and Summer 2006
Research Assistant to Professor Albert Yoon, Northwestern School of Law, 2005

WORK EXPERIENCE

Associate Analyst (Summer Internship) at NERA, White Plains, NY, Summer 2004

CONFERENCE AND WORKSHOP PRESENTATIONS

"Zonal Pricing in the Italian Electricity Spot Market" (with Federico Boffa), European Association for Research in Industrial Economics (EARIE) Annual Conference, Amsterdam, the Netherlands, August 2006
Applied Microeconomics Seminar, Northwestern University, October 2006
Transportation Center Seminar Series, Northwestern University, October 2006

WORK IN PROGRESS

"Efficiency Gains and Market Integration in the Italian Electricity Spot Market" with Federico Boffa, (*Under Review*) 2007
"Brand Effect and Price Discrimination in the Video Rental Industry", 2006

OTHER SKILLS

Fluent in English and the Indian languages of Telugu, Bengali and Hindi

REFERENCES

Available upon request