Market Concentration in the Nordic Wholesale Electricity Market

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ABSTRACT

The purpose of this thesis was to study and compare the concentration and dominance in the Swedish and Nordic wholesale electricity markets by applying two structural measures to assess the markets; the Herfindahl-Hirschman Index and a measure for dominance. The purpose was, furthermore, to compare the two measures and examine how the measures correspond to changes in markets share distributions. The calculations were performed using data on market shares based on the production of the largest electricity producers in 2007. The result for the Swedish market was a high HHI which indicates a highly concentrated market. According to the measure of dominance, the largest firm could be said to hold a dominant position. The Nordic market was characterized by a low HHI, hence a low market concentration and there was no dominant firm. The measures responded differently to changes in market shares.
SAMMANFATTNING

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Chapter 1
INTRODUCTION

1.1 Background
The Swedish electricity market was reformed in 1996 when electricity trading and production was opened up for competition. The intention was to create a more competitive market structure and hence a more efficient market resulting in lower prices. The other Nordic countries, except Iceland, have also undergone similar market reforms and after the competition reforms an integration of the Nordic markets has taken place (Energy Markets Inspectorate, 2005b).

Since the reform the market concentration in the Swedish electricity production market has, however, increased. Measured in energy produced, the four largest producers in 1996 were Vattenfall, Sydkraft, Stockholm Energi and Gullspång Kraft. Together they produced 85 percent of the total Swedish production. In 2004 the combined market shares of the four largest producers had increased to 88 percent (Energy Markets Inspectorate, 2006a).

According to Tamaschke et al. (2005) most countries that have undergone deregulation and restructured their electricity markets have experienced a development towards a more oligopolistic energy market. This is a situation where the power market is dominated by a few large companies and under such circumstances the energy companies have incentives to employ game strategies that give the possibility to raise price above the marginal cost and thus make greater profits.

The Nordic electricity market is one of the most developed in Europe and trade on the Nordic electricity exchange, Nord Pool, has increased steadily. This is a desirable development since it contributes to effective price formation and transparency on the electricity market. There are however some problems, such as a high degree of concentration among the Swedish and Nordic electricity generators. This is considered problematic since it threatens competition and it is very difficult for new entrants to
establish themselves on the market on a large scale (Energy Markets Inspectorate, 2007b).

Measuring market concentration has traditionally been important in competition policy analysis and the more concentrated the market, the more likely it is that energy companies on the market can exercise market power (Nordic Competition Authorities, 2003). The market concentration depends on the number of firms in a market and their respective market shares. One commonly used concentration measure is the Herfindahl-Hirschman Index (HHI). It is calculated by summing the squared market shares of all firms in the market (U.S. Department of Justice and the Federal Trade Commission, 2007). This measure is however said to have some disadvantages, for example it has limited use for evaluating whether a firm holds a dominant position. Melnik et al. (2008) introduced a new measure for market dominance which is based on the market shares of the two largest firms in an industry and a parameter that includes factors related to potential competition.

What do the Herfindahl-Hirschman Index and the Structural Dominance measure say about the concentration of the Swedish and Nordic energy markets? How will the results from the two measures differ? Furthermore, how is competition affected by changes in market shares according to the two measures?

1.2 Purpose
The purpose of this thesis is to study market concentration and dominance in the Swedish and Nordic electricity markets by applying two measures; the HHI and the Structural Dominance measure. It will study how the two measures differ and how hypothetical changes in market shares affect the HHI and the dominance measure.

1.3 Methodology
The theoretical framework in this thesis is industrial organization theory focusing on market structures. The thesis will apply two different measures to assess the market concentration and market dominance on the Swedish and Nordic wholesale electricity market. Data on the companies’ market shares and information about barriers to entry will be collected and used in the calculations.
1.4 Scope and limitations
The thesis will apply two structural measures and has been limited to a comparison between the HHI of market concentration and the measure for market dominance. No further competition measurement methods will be applied. The market studied will be limited to the Nordic wholesale market for electricity.

1.5 Earlier Studies
Competition in electricity markets has been subject to both governmental investigations and academic research. Borenstein et al. (2000) studied California’s restructured wholesale electricity market. By comparing the market prices with estimates of the prices that would have resulted if owners of instate fossil fuel generating facilities behaved as price takers they found significant exercise of market power.

Hjalmarsson (2000) examined market power in the Nordic electricity market with data from the Nord Pool power exchange. He used a dynamic extension of the Bresnahan-Lau model which is based on the assumption that profit-maximising firms set their marginal cost equal to their perceived marginal revenue, $MC=MR_p$. Buyers are assumed to be price-takers. In perfect competition $MR_p=P$, but when market power is present, $MR_p<P$. Vassilopoulos (2003) conducted a similar study. Both rejected an exercise of market power in the Nordic wholesale electricity market during the time periods. They could, however, not say anything about regional market power in the very short run. Bask et al. (2008) used the Bresnahan-Lau model and found that suppliers of electricity had small, but statistically significant, market power. It did however decrease with the expansion of the Nord Pool area.

Bergman (2005) used a simulation model, PoMo, to estimate market power in the Nordic power market. Weekly equilibrium prices were calculated based on the assumption that the relevant market is competitive and that producers are risk neutral. Deviations between PoMo-prices and actual prices reflected shortcomings of the model but also impacts of market power. Bergman came to the conclusion that the Nordic electricity market is competitive and that prices are close to marginal costs.
1.6 Outline
The thesis is divided into five chapters. Chapter 2 provides a background in which the characteristics of electricity markets in general are described, as well as the characteristics and developments in the Swedish and Nordic electricity markets. Chapter 3 describes relevant theory and in chapter 4 the empirical results are presented and analysed. In chapter 5 conclusions are discussed.
2.1 Properties of Electricity Markets

Electricity markets exhibit certain characteristics and properties that differ from other markets. One characteristic of electricity as a commodity is that it has a very low elasticity of demand. The market demand elasticity is typically very low in the short run because of limited information and inflexibility. Most consumers do not have metering that reveals system spot prices or that records their usage in real time so they are often not able to respond to price changes (Bidwell & Henney, 2004).

Supply of electricity is also rather inelastic in the short run, particularly when reaching capacity constraints in production. Electricity is very difficult to store and except for water storage in hydro power systems, storage of electricity is extremely costly. Capacity constraints on production cannot be imposed for longer periods without severe risk of damaging power plants and transmission systems. Electricity production is capital intensive and investments to increase capacity are costly, take time and are irreversible. Because of the properties of electricity transmission, supply and demand have to be balanced at any point in time by a system operator, otherwise the stability of the grid could be threatened and the delivery could be disrupted for all suppliers and consumers (Borenstein, 2002).

2.2 The Deregulation of the Nordic Electricity Market

Since the middle of the 1990’s the electricity markets in the Nordic countries have undergone extensive changes. The national markets have been opened to competition and are now highly integrated with each other (Energy Markets Inspectorate, 2005a). Before the market deregulations the electricity markets were dominated by one state owned utility in each country which was responsible for the transmission grid connecting the country’s regions. In some regions there were also vertically integrated monopolies, producing and distributing electricity in the region. The idea with deregulating the electricity markets was that energy should be competitively supplied.
Following the deregulation the monopoly companies responsible for producing and distributing electricity were eliminated and the transmission and generation were separated. The transmission and distribution remained regulated since it is a natural monopoly, i.e. it would be too costly to expose it to competition. State owned system operators were established in each country to manage the grid and to balance the supply and demand (Fridolfsson & Tangerås, 2008).

Norway was one of the first countries in the world, and the first of the Nordic countries, to deregulate and liberalize its electricity market. Before the deregulation in 1991 there was no direct link between market prices and investment or between market prices and operating cost efficiency. The government was setting the following year’s prices in the electricity market equal to the long run marginal cost and the market was characterized by compensations and subsidies which gave no incentives for utilities to be cost effective (Norwegian Competition Authority, 2006). The fundamental elements of the Norwegian deregulation were that the market should be designed as a regular spot market, incorporating demand. Access to the network should be provided based on transparency and non-discrimination. The dominant state owned company, Statkraft, was divided into two entities; the generating company Statkraft SF and the transmission company Statnett SF. Other vertically integrated companies were divided into generating, trading or network divisions for accounting purposes. Since the transmission network is a natural monopoly the network companies were subject to natural monopoly regulations to achieve economic efficiency in the network operations. The reform was realized without privatizing the power sector (Norwegian Competition Authority, 2006).

The Swedish electricity market was reformed in 1996 and both electricity trading and electricity production was opened to competition. The transmission network remained a regulated monopoly with Svenska Kraftnät as a national transmission system operator. The main objective of the reform was to increase efficiency in production and trading by giving consumers possibility to choose supplier (SOU 2002:7).

In Finland the deregulation started in 1995 and continued gradually until 1998. In 1997 the company Fingrid was established. It is 12 percent state owned and is responsible for the functioning of the Finnish power system at a national level (Finnish Energy Market Authority, 2005). The electricity market in Denmark has been liberalized gradually
since 1999. In January 2003 all consumers were given the possibility to freely choose electricity supplier. The Danish transmission grid is run by the state owned company, Energinet, which was formed through mergers in 2005 (Danish Energy Regulatory Authority, 2006).

Following the Nordic electricity market reform there is a distinction between electricity as a good and the service of electricity transmission through the power network. An electricity customer’s total cost for electricity consists of three parts; electricity, transmission and electricity tax. The electricity network is a monopoly and it is regulated by laws and the tax amount is regulated by the authorities. The price of electricity is, however, not regulated. It is supposed to be determined through competition and result in lower prices than a regulated market would (Energy Markets Inspectorate, 2006a).

2.3 Actors in the Nordic Electricity Market
Several actors are present in the Nordic electricity market. The electricity producers generate the electricity. The energy from the generating facilities is sold on the power exchange Nord Pool or bilaterally to electricity distributors or directly to users. Many producers are also distributors (Energy Markets Inspectorate, 2006a). Electricity from power stations to consumers is transmitted through a network of power lines. It is essential that the generation and consumption of electricity is in balance at every point in time for the market to function properly. Each of the Nordic countries has a transmission system operator that is responsible for the balance and national grid. The Nordic transmission system operators are cooperating through the organization Nordel (Nordic Competition Authorities, 2003).

Network owners are responsible for the regional networks and for the transportation of electricity to the end-users. The electricity network is a natural monopoly and is therefore regulated by the authorities. Customers pay a network fee for the use of the electricity network (Energy Markets Inspectorate, 2006a). Smaller energy companies buy electricity from Nord Pool or bilaterally from electricity producers and sell to end-users. Contrary to the networks this is a competitive market, since customers are free to choose their supplying energy company. By law there has to be balance between supply of electricity and consumption. A company can choose to either be responsible for the
balance of supply and consumption themselves or buy the service from another company (Energy Markets Inspectorate, 2006a). The end-users are both households and industries. The consumer has contracts with both an energy company for purchase of electricity and the local network owner for transmission of the electricity (Energy Markets Inspectorate, 2006a).

2.4 Electricity Trading

In the Nordic power market electricity is traded competitively either through bilateral agreements or via Nord Pool. On the bilateral market, deals are made directly between actors, usually between large electricity producers and energy intensive industries or smaller energy companies (Energy Markets Inspectorate, 2006a). Nord Pool was the first international power exchange in the world. It was established in Norway in 1991 during the liberalization of the electricity sector and Sweden, Finland and Denmark has gradually joined. The Nord Pool power exchange is owned by the different transmission operators and consists of several markets (Research Institute of Industrial Economics, 2008).

Nord Pool organizes both physical and financial trading of electricity where Nord Pool Spot AS organizes the physical trading and Nord Pool ASA is responsible for the financial market. The physical market involves two different markets; Elspot and Elbas. Elspot is a day-ahead market for short term trading in physical electricity contracts with next day supply. The spot price is determined by the sum of all buying and selling bids one day ahead, for every hour of the day. Elbas is a physical balance adjustment market where trading is available up to one hour before delivery. Today Sweden, Finland and Denmark are trading through Elbas but Norway is said to join shortly. Nord Pool ASA is managing the financial market where actors can speculate in future price changes, guarantee prices and manage risk through derivative contracts. To reduce the financial risk for those with derivative contracts Nord Pool provides a clearing service, where a clearing fee is charged and the companies involved are required to deposit a security to cover the risk taken by Nord Pool Clearing (Energy Markets Inspectorate, 2007a).

In the spot market, the players specify how much electricity they wish to buy or sell at a given price. The following day these bids are aggregated into supply and demand curves for each hour. The supply curve is the players’ aggregated sales bids in terms of prices
and quantity and the demand curve is the players’ aggregated purchase bids. The equilibrium price and quantity is determined by the point where the supply and demand curves intersect. When the electricity production is ranked in order, from the unit of production with the lowest marginal cost to the marginal cost for the last unit of production needed, demand and supply is met at the lowest cost possible at every point in time. This results in a cost-efficient allocation of the production resources in the electric power market (Energy Markets Inspectorate, 2006a).

Figure 2.1 The Principle for Price Formulation on the Nordic Spot Market
Source: Energy Markets Inspectorate (2006b)

The Nord Pool system price is the valid price in the entire spot market if there are no bottlenecks. There are, however, physical limitations in all electricity grids, therefore situations arise where transmission capacity is insufficient, so that electricity cannot be traded to the desired extent between different areas. This means that price signals from one area can not affect supply and demand in other areas. To manage these bottlenecks, the Nord Pool spot market is divided into different Elspot pricing areas. Whenever the transmission capacity is insufficient for a single price in the entire Nord Pool area, separate spot area prices are calculated. This means that several Elspot pricing areas can form a common price area but can also be separate ones (Svensk Energi, 2008).
2.5 Market Structure in the Nordic Electricity Market

The introduction of market liberalization in the Nordic countries has resulted in a process of structural changes in the electricity sector. The transmission of electricity has been separated from generation and supply and there has been a legal separation between distribution and retail activities. There are still relatively many suppliers in each country but the market shares of the largest suppliers have increased. Typical for the Nordic markets are high local market shares held by local incumbent suppliers. The electricity market liberalization has not necessarily implied fundamental changes in ownership as in some other liberalising countries but there have however been some acquisitions and mergers resulting in ownership changes in Finland, Sweden and Denmark, while Norway has had only minor changes (Nordic Energy Regulators, 2006).

The production of electricity in the Nordic market is concentrated to a few companies. The five largest companies account for more than 50 percent of the electricity generation in the Nordic market. Vattenfall is the largest producer which in 2007 produced 19 percent of the Nordic production. Three of the five largest producers are fully or partly owned by the government. Vattenfall is completely owned by the Swedish government and Statkraft is owned by the Norwegian government. Fortum is 60 percent owned by the Finnish government while E.ON is private owned where German interests are dominating. TVO is a private owned Finnish company (Energy Markets Inspectorate, 2008).
Table 2.1 Market shares of the largest Nordic electricity producers in 2007

<table>
<thead>
<tr>
<th>Producer</th>
<th>Market share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vattenfall</td>
<td>19 %</td>
</tr>
<tr>
<td>Fortum</td>
<td>13 %</td>
</tr>
<tr>
<td>Statkraft</td>
<td>9 %</td>
</tr>
<tr>
<td>E.ON</td>
<td>8 %</td>
</tr>
<tr>
<td>TVO</td>
<td>4 %</td>
</tr>
</tbody>
</table>


2.6 The Swedish Electricity Market

The objective of the Swedish Government’s electricity market policy is to achieve an efficient and competitive energy market that generates a secure supply of electricity at internationally competitive prices. The policy focuses on a further development of the common Nordic electricity market with few borders between the countries and a well functioning and effective trading. The Swedish electricity market is being gradually more integrated with both the Nordic region and the European Union. Today there is a common Nordic wholesale market for electricity via Nord Pool. The Nordic region is however subject to constraints in transmission capacity so that there are periods when the capacity cannot meet transmission needs. Nord Pool has therefore split the Nordic electricity market into different spot price areas. This means that the price area Sweden often appears in different combinations with other price areas but at some times constitutes a separate price area. In 2007 there was a common price for the entire Nordic region for 28 percent of the time. Sweden’s electricity production is dominated by a few companies (Energy Markets Inspectorate, 2008). Since the market reform in 1996 the market concentration, measured in electric power produced, among the Swedish electricity producers has increased. The four largest producers in 1996 accounted for 85 percent of the Swedish production. The corresponding market share for the four largest producers in 2004 was 88 percent and 87 percent in 2007. In 2007 the three largest companies accounted for 85 percent of all electricity generated in Sweden (Energy Markets Inspectorate, 2008).
Table 2.2 Market shares of the largest Swedish electricity producers in 2007

<table>
<thead>
<tr>
<th>Producer</th>
<th>Market share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vattenfall</td>
<td>45 %</td>
</tr>
<tr>
<td>E.ON</td>
<td>22 %</td>
</tr>
<tr>
<td>Fortum</td>
<td>18 %</td>
</tr>
<tr>
<td>Skellefteå Kraft</td>
<td>2 %</td>
</tr>
<tr>
<td>Statkraft</td>
<td>1 %</td>
</tr>
</tbody>
</table>


In contrast to the wholesale market, the retail market is national. Electricity consumers in Sweden can only buy electricity from retailers located in Sweden. Swedish electricity consumers have two different contracts for their electricity supply; one with the retailer who they buy the electricity from, and one with the network company that owns the local power lines. The customers can choose which retailer they wish to buy the electricity from but not the network company, since network operations are run as a monopoly. In 2007 there were 115 electricity retailers in Sweden. The three largest electricity generators, Vattenfall, E.ON and Fortum, also act as retail companies themselves and in 2007 about 20 of the 115 retail companies were totally independent from these large energy groups (Energy Markets Inspectorate, 2008).
Chapter 3
THEORY

This chapter will describe the economic theory of market structure and competition and apply it on the wholesale electricity market. Furthermore, concepts of market power and market dominance will be described as well as structural market analysis. Lastly, the structural measures applied in this thesis are presented; the Herfindahl-Hirschman Index and the Threshold Measure of Dominance.

3.1 Market Structures
In economic theory market structure describes the market with respect to the competitive situation and market structure can be said to describe the firms’ behaviour in an industry or market. There are a number of factors affecting the market structure and firms’ behaviour. A firm is affected by the choices available to it. For example it can choose to set prices, decide what quantity to produce, set production capacity or choose location. Another important factor is the number of firms in the industry and whether there are high or low barriers for new firms to enter. Firms’ expectations about how other firms are able to act and how other firms will respond to changes are significant. The behaviour of firms is also influenced by firms’ expectation about the number of firms in the market and the potential of new entry (Shy, 1995).

Market structures are usually classified into two categories; competitive and imperfectly competitive. In a perfectly competitive market each firm takes price as given and chooses its production quantity. The market price is determined by the intersection of the market demand curve and the industry’s aggregate supply curve and there are no entry barriers. There are several categories of imperfectly competitive market structures and among those monopoly is the most extreme. There is only one seller who can choose any combination of price and quantity along the consumers’ aggregate demand curve. Between these two market structures are the imperfectly competitive market structures duopoly (with only two sellers), oligopoly (with more than two sellers) and monopolistic competition (where there are many sellers producing differentiated goods).
These can either be classified as cooperative or non-cooperative. When cooperating, firms collude by agreeing to either produce the total monopoly profit-maximizing quantity or to charge the monopoly price. Non-cooperative behaviour is when firms choose their quantities or prices at the same time or set their strategic variables (quantity or price) sequentially. When the firms’ strategic decisions are quantities there is a Cournot market structure and when the strategic variable is price the market structure is referred to as Bertrand (Shy, 1995).

3.2 The Cournot and Bertrand Competition Models

There is no consensus about which oligopoly model that best describes the competition and strategic options for firms in electric power markets. The discussion has focused on whether a Cournot or Bertrand model of competition should be applied (Hope, 2005). When firms are using the Bertrand model framework they must consider how their choice of price will affect the quantity they are able to sell. In a situation where firms do not have any capacity constraints the products of the firms on the market must be at least slightly differentiated in quality, function or brand in order for firms to exercise market power. If the products are completely homogenous consumers will shift their consumption to the rival charging the lowest price, hence market price would equal marginal cost. Electric power is very difficult to differentiate but producers are restrained by the capacity of their production facilities. In this situation the firm with the lowest price may not be able to serve the entire market and it will then be possible for other firms to use their capacity constraints strategically in order to gain market power (Danish Energy Research Program, 2003).

With Cournot competition it is, unlike Bertrand, not necessary for the product to be differentiated in order for the firm to hold market power. In this situation market power comes from the unwillingness of rivals to accommodate all the consumers that want to shift away from a particular firm. In the Nash equilibrium, where all firms have decided how much to produce, the equilibrium price is the price where all consumers will buy all the output of all firms (Danish Energy Research Program, 2003).

It has been argued that since electricity is a non storable commodity, the Bertrand model reflects the conditions on the electricity market and the strategic behaviour of firms better than the Cournot model. In contrast, when firms are facing capacity constraints
and especially in periods with high demand, the Cournot model appears to be more appropriate. In the Bertrand model a firm can capture the entire market by setting the price lower than its competitors, but with increasing marginal cost and limited installed capacity which is typical for electricity markets, the Cournot assumption seems more realistic. However, in many markets organized as power exchanges producers do not compete by setting a fixed price or quantity but rather compete in supply functions (Hope, 2005).

3.3 Market Power and Market Dominance

Market power is normally defined as the ability of a firm to raise its product price above a competitive level, the benchmark price, in a profitable way. The lowest possible price a firm can profitably charge is the price that equals the marginal cost of production; therefore market power is normally defined as the difference between price charged by a firm and its marginal cost of production. There are two problems with the benchmarking approach from a competition policy point of view. The marginal cost can be quite difficult to define and measure accurately in practice. The benchmark is based on the market structure and market conditions of an idealized model of perfect competition. These characteristics are usually not the case in reality so if market power is defined as the ability to raise price above marginal cost, then almost all firms would have at least some degree of market power. This makes the definition less useful for practical competition policy application (Hope, 2005).

According to industrial organization theory the less competition a firm faces, the greater is its market power hence the higher is the firms’ ability to set prices profitably above the marginal cost (Carlton & Perloff, 2005). Bishop and Walker (2002) define market power as the ability of a firm or group of firms to raise price, through the restriction of output, above the level that would prevail under competitive conditions and thereby to enjoy increased profits from the action. The Nordic Competition Authorities (2003) assert that a company has significant market power if it can profitably maintain prices that are considerably higher than the lowest possible marginal production cost. In the absence of market power, price will equal marginal cost under efficient production and perfect competition. Companies with market power will take into account that a higher production will lead to lower prices and will thereby restrict volumes of production. The exertion of market power is nevertheless a fundamental part of a well functioning
competitive market. Companies try to attain market power to maximize profits and this can be reached by simply supplying superior products or using superior technologies. However, if market power is possessed by a dominant firm, the company can profitably raise prices without being superior.

A dominant market position is defined by the European Court as “a position of economic strength enjoyed by an undertaking which enables it to prevent effective competition being maintained on the relevant market by giving it the power to behave to an appreciable extent independently of its competitors, customers and ultimately of its own consumers.” The European Court (1978) further states that “in general a dominant position derives from a combination of several factors which, taken separately, are not necessarily determinative”. The abuse of a dominant position is prohibited both in the Nordic countries and within the European Union and according to European antitrust policy “any abuse by one or more undertakings of a dominant position within the common market or in a substantial part of it shall be prohibited as incompatible with the common market insofar as it may affect trade between Member States” (European Court Treaty, Article 82). It is not a dominant position in itself, or the establishment of a dominant position that is forbidden according to Article 82, but an actual abuse of a dominant position. According to EU competition law, competition authorities must first ensure that the company really has a dominant position and then determine whether the firm has abused its dominant position in an antitrust case (Hope, 2005).

3.4 Structural Market Analysis
When assessing a firm’s ability to raise price above the competitive price, a main approach is to focus on the visible dimensions of the market structure. Economic theory suggests that the strength of competition is related positively to the number of firms in the industry. Competition is also affected by the concentration of the firms in the relevant industry. In an industry with 100 sellers it is not the same if each firm controls one percent of the market or if four firms control 80 percent together and the remaining 96 firms control 20 percent combined. Concentration measures are often used as an indication of potential market power. The first indicator of the competitiveness in an industry is market share. The market share is the percentage of sales that a firm controls in a relevant market. The n-firm concentration ratios, CRn, is equal to the sum of the market shares of the n largest firms. When attempting to measure and estimate the
potential for market power the first step is to clearly define the market and identify the geographic area and the products included (Vassilopoulus, 2003).

The U.S. Department of Justice and the Federal Trade Commission start their evaluations by defining the product or product group. The U.S. Department of Justice asks what would happen if a hypothetical monopolist would increase the price significantly and non-transitory. If, in response to the price increase, the reduction in sales of the product would be large enough, so that a hypothetical monopolist would not find it profitable to impose such an increase in price, then the next-best substitute for the product will be added to the product group. Subsequently the geographic area is defined. If a price increase by a monopolist would cause people to buy the product from outside the defined area, leading to a reduction in sales large enough that the price increase would not prove profitable, then the cautiously identified geographic area would prove to be too narrow. After that, the relevant firms in the market are identified. These are all firms that currently produce or sell in the relevant market. In addition, uncommitted entrants will be identified. These are firms not currently producing or selling the relevant product in the relevant area but they are however identified as participating in the relevant market if their inclusion would more accurately reflect probable supply responses (U.S. Department of Justice and the Federal Trade Commission, 1997). In markets where there are substitutable goods and where the same good can be bought at other locations, market power is generally more likely to be low and vice versa. In electricity markets the transmission system and its capacity determines the geographic area (Vassilopoulus, 2003).

3.5 The Herfindahl-Hirschman Index

The Herfindahl-Hirschman Index (HHI) is the most commonly used measure of market concentration both in research focusing on the relationship between market structure and firm performance and when assessing the competitive impacts of proposed mergers. Since 1982 it has played a central role in the U.S. Department of Justice and the Federal Trade Commission’s merger guidelines (Hannan, 2004). Market concentration is a function of the number of firms in a market and their respective market shares. The HHI is calculated by summing the squares of the individual market shares of all firms in the market. The HHI reflects the entire composition of the market and gives proportionally greater weight to the market shares of larger firms. The HHI is given by the formula:
where $s_i$ is the market share of the $i^{th}$ firm (U.S. Department of Justice and the Federal Trade Commission, 1997).

The HHI ranges from one or 10 000 in the case of a pure monopoly and a number approaching zero in the case of a perfectly competitive market. In a market with ten equal sized competitors each firm would control 10 percent of the market and the HHI would be $10^2 \cdot 10 = 1 000$. With five equal sized firms the HHI would be $20^2 \cdot 5 = 2 000$. Two large companies with 40 percent each and ten firms with 2 percent each would result in a HHI at $(40^2 \cdot 2) + (2^2 \cdot 10) = 3 240$. Although it is desirable to include all firms when calculating the HHI lack of information about small firms is not critical because these firms do not affect the HHI significantly. The U.S. Department of Justice has divided the measure of HHI into three categories. A HHI below 1000 is considered un-concentrated, a HHI between 1000 and 1800 characterizes a moderately concentrated market and a HHI above 1800 is a highly concentrated market (U.S. Department of Justice and the Federal Trade Commission, 1997).

### 3.6 The Threshold Measure of Dominance

The HHI includes the entire distribution of firms in a market and because of this it cannot be used as a measure of market dominance by one firm. Instead market concentration ratios in terms of market shares of individual firms are often used. According to the EC Commission a firm that has a market share of 40-45 percent can generally be said to possibly have a dominant position. However, market shares between 20-40 percent cannot be ruled out since dominance could be the case depending on certain circumstances with regard to the market structure and competition in the specific case (Hope, 2005).

Melnik et al. (2008) propose a measure of dominance for assessing whether a firm holds a dominant market position. They suggest that competition might be high even if there are only two firms in an industry. An example could be a Bertrand model, where the
price ends up equal to the marginal cost of the firms, even if there are only two firms. The measure is a threshold for dominance which is based on the observed market shares of only the two largest firms in the industry. The measure also includes a parameter so that competition authorities can decide how factors related to potential competition should be weighted. The parameter could either be interpreted as an industry-specific assessment of the entry barriers for the industry, or as a more general policy instrument characterizing the relative importance of potential competition compared with existing competition.

The market shares are treated as fractions, \( 0 \leq s_i \leq 1 \), and not in percentage terms. Further, the firms are assumed to be indexed in an order satisfying \( s_1 \geq s_2 \geq \cdots \geq s_N \).

The threshold market share beyond which firm one is said to have a dominant position in a market with a total of \( N \) active firms is denoted by \( s^D \). This threshold is defined by

\[
s^D = g(s_1, s_2, \ldots, s_N) = \frac{1}{2} \left[ 1 - \gamma(s_1 - s_2) \left( 1 - \sum_{i=3}^{N} s_i \right) \right]
\]  

(3.2)

In a market with \( N \geq 2 \) active firms, firm one is said to be dominant if its market share satisfies \( s_1 > s^D \). Firm two has a larger market share than all the rest of firms one’s rivals and therefore poses the most significant obstacle for firm one to be dominant. As a result, the dominance threshold, \( s^D \), decreases proportionally with the difference \( s_1 - s_2 \). This captures the idea that the criterion under which firm one qualifies for dominance is stricter the larger its market share advantage relative to its largest competitor is. The measure weighs the difference between the two largest firms, \( s_1 - s_2 \), by the combined market share of these two largest firms, \( 1 - \sum_{i=3}^{N} s_i \) which is equal to \( s_1 + s_2 \). This captures the idea that the dominance threshold is lower and stricter the higher the joint markets share is. This is because when the joint market share of the two largest firms is high, all other firms represent less competition. \( (s_1 - s_2)(1 - \sum_{i=3}^{N} s_i) \) can be said to describe how existing competition from established rivals restricts the ability of firm one to dominate the market.

The constraint imposed by potential competition on firm one’s dominance is represented by the parameter \( \gamma \). It is treated as an exogenous parameter and it can be
interpreted as an assessment of the entry barriers relevant for the industry. Lower values of $\gamma$ represent lower entry barriers and vice versa. Lower barriers to entry means that potential competition will limit the ability of firm one to use its market power effectively. This increases the threshold level required for declaring firm one to be dominant. Higher entry barriers should result in a higher value of $\gamma$, which lowers the threshold level.

The threshold level defined can be simplified to depend only on the market shares of the two largest firms instead of on the market shares of all firms. This is done by substituting $s_1 + s_2$ for $1 - \sum_{i=3}^{N} s_i$ which yields

$$s^D = g(s_1, s_2, \ldots, s_N) \equiv \frac{1}{2} [1 - \gamma (s_1^2 - s_2^2)]$$  \hspace{1cm} (3.3)

Very moderate information is needed for using this measure to assess market dominance. It can be done based on the knowledge of the market shares of the two largest firms in an industry. In addition, the measure includes a parameter which allows the choice of how much weight should be placed on potential competition. The largest firm is said to be dominant when its market share is larger than or equal to 50 percent. The dominance measure further implies that the threshold for market dominance is always 50 percent when the two largest market shares are equal, $s_1 = s_2$. 


In this chapter the results from the calculations are presented. The Herfindahl-Hirschman Index was calculated using equation (3.1) and the threshold dominance was calculated using equation (3.3). An estimate of how the measures respond to changes in market share constellation was conducted. The HHI was first calculated for the Swedish market and then for the Nordic market. The threshold dominance measure was also applied on first the Swedish market, and then the Nordic electricity market. The data used was market shares based on electricity production from the largest companies in the year 2007.

**4.1 Simulations and Comparisons**

In the table below different markets share constellations are assumed. It demonstrates the HHI and the measure of dominance and how they would respond to different assumed distributions of market shares. The parameter $\gamma$ represents the entry barriers facing potential future competition.

<table>
<thead>
<tr>
<th>Table 4.1 Comparison of HHI and the Dominance Measure</th>
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<tbody>
<tr>
<td>Firms</td>
</tr>
<tr>
<td>Market</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>E</td>
</tr>
</tbody>
</table>
Market A in the table above consists of five companies with a market share of 20 percent each. The HHI sums to 2000 for this industry constellation. In market B there are only two firms which produce 50 percent of the industry output each. The HHI sum to 5000 and is significantly higher than for market A. While the HHI’s differ considerably, the dominance threshold level, 0.50, is however the same for both markets. This is a result of the measure reflecting the fact that the two largest firms are equally large in both markets. In market A the firms cannot be classified as dominant since 0.20 is smaller than the threshold level of 0.50. In market B, however, both firms are precisely at the threshold level for dominance.

The distribution of market shares in market C is somewhat similar to the distribution in the Swedish wholesale electricity market. The concentration is high according to the HHI at 3390. The largest firm in this constellation is dominant at all three levels of entry barrier γ since the market share of the largest firm, 0.48, is larger than all three threshold levels. It is then assumed that the market share distribution changes to the case in market D. According to the new HHI of 3750, the market concentration has increased compared to market C, which should reflect less competition in the market. Now, however, the largest firm is not considered to hold a dominant position according to the dominance measure. 0.45 lies below all three threshold levels. A firm is then less likely to hold a dominant position in market D than in market C. The last case, market E, exhibits a lower HHI of 2500. The largest firm can however be said to hold a dominant position at γ = 2 and is right at the threshold level for dominance at γ = 1.5. But at the lower barrier of entry at γ = 0.5, the largest firm cannot be said to hold a dominant position.

The two measures studied seem to give different results when measuring competition in different market constellations. When comparing the markets C, D and E, the one with the highest HHI was market D. This market should then be the worst from a competition point of view according to the HHI. But the same market was the most preferred, in view of competition, when considering the potential dominance of the firms. Market D was the market constellation most appropriate for preventing the occurrence of a dominant position. As described in chapter 3, economic theory suggests that the level of competition is related positively to the number of firms in the industry and competition is also affected by the concentration of the firms in the relevant
industry. When applying the HHI, it is assumed that an increased number of firms in a market leads to a more competitive situation. Contrary to this, the dominance measure suggests that rather than the number of firms in the market, the critical factor is the relationship between the two largest firms on the market. A large number of smaller firms entering the electricity market do not necessarily make any difference from a competition point of view. When assessing competition on a market, the focus should perhaps be more on the balance between the two largest companies than the total number of firms.

4.2 Concentration and Dominance in the Swedish Market

The market concentration on the Swedish wholesale electricity market was measured with the Herfindahl-Hirschman Index. The result was a HHI value of 2838. According to the U.S. Department of Justice and the Federal Trade Commission a HHI above 1800 characterises a highly concentrated market. The concentration for Sweden as a separate electricity market can be said to be very high.

The dominance threshold measure for assessing whether a firm holds a dominant market position or not was calculated using the market shares for the two largest Swedish electricity producers, Vattenfall and E.ON. The parameter $\gamma$ represents the entry barriers facing potential future competition, which is considered high in electric power markets. Four different values for $\gamma$ were applied. Lower values of $\gamma$ correspond to lower entry barriers and higher values of $\gamma$ correspond to higher barriers of entry. The calculations resulted in four threshold levels for when to classify the largest company, Swedish Vattenfall, as dominant, depending on the values of $\gamma$. The threshold levels were market shares of 35, 38, 42 and 46 percent.

<table>
<thead>
<tr>
<th>The Threshold Dominance, $s^D$</th>
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<tbody>
<tr>
<td>$\gamma = 0.5$</td>
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<tr>
<td>0.460</td>
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</table>
For the levels where γ equals 1.5, 1 and 2, Vattenfall’s market share of 45 percent of the Swedish electricity output is higher than the threshold level results. Vattenfall can thus be said to hold a dominant position in these cases. When the barrier of entry is lower, 0.5, Vattenfall cannot be said to hold a dominant position. The barrier of entry is likely to be higher than one since entry barriers are considered high in electric power markets.

4.3 Concentration and Dominance in the Nordic Market
The HHI for market concentration on the Nordic wholesale electricity market summed to 691. The U.S. Department of Justice and the Federal Trade Commission considers a market with a HHI of less than 1000 to be unconcentrated. The Nordic market can therefore not be viewed as concentrated when considered as one single market.

The threshold level for dominance was calculated using the market shares of the two largest electricity producers on the Nordic Market: Swedish Vattenfall and Finnish Fortum. The results are shown in table 4.3 below.

<table>
<thead>
<tr>
<th>The Threshold Dominance, $s^D$</th>
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<tbody>
<tr>
<td>$\gamma = 0.5$</td>
</tr>
<tr>
<td>0.495</td>
</tr>
</tbody>
</table>

The market share of Vattenfall in the deregulated Nordic market for electricity was 19 percent. That is considerably lower than the threshold levels for dominance calculated and shown in the table above, which lie between 48 and 49.5 percent. Vattenfall can thus not be said to hold a dominant position in the common Nordic wholesale electricity market.

4.4 Comparison
The HHI and the measure of dominance do not seem to be consistent with each other. They appear to occasionally indicate different directions of competitiveness when changes are imposed on market share distributions. When comparing the markets C, D and E, the one with the highest HHI was market D. This market should then be the
worst from a competition point of view according to HHI. But the same market was the most preferred, in view of competition, when considering the potential dominance of the firms. Market D was the market constellation most appropriate for preventing the occurrence of a dominant position. But of course, a constellation where all firms hold smaller market shares would have been preferred from both the HHI perspective and the dominance view.

For the Nordic wholesale electricity market the HHI is below the range that classifies a moderately concentrated market and the Nordic market can hence be classified as unconcentrated. According to the measure of dominance there does not appear to be a dominant actor on the market. As for the Swedish market as separate, the HHI reached the level for when to classify the market as highly concentrated. According to the measure of dominance the largest firm was dominant with an entry barrier of one and two but not for when it was only a half. We should however keep in mind that one is the reference case for entry barriers in the model and that the electricity industry is considered to have high costs of entry.
Chapter 5
CONCLUSIONS

The purpose of this thesis was to study the market concentration and potential dominance in the Swedish and Nordic electricity markets using two measures; the Herfindahl-Hirschman Index and a measure of dominance. The purpose was also to compare these measures’ responses to changes in market constellations.

When applied to different market share constellations, the HHI and the measure of dominance responded differently to changes in market share distributions. Out of the three markets C, D and E, the market with the highest HHI was at the same time the market with the least tendency towards a situation with a firm in a dominant position. The question then might be what is most important for a well functioning competitive industry; a weight between size of market shares and the number of firms or just the balance between the two largest. The result indicates that the two measures should be used more as complements rather than substitutes or used alone.

The wholesale market for electricity was studied both as one single Nordic market and with Sweden alone as one single market. The Nordic market was found to be unconcentrated according to HHI and there were no potential for market dominance by the largest firm according to the threshold measure of dominance. When assessing the wholesale electricity market viewing Sweden as a separate market the result was quite different. The Swedish market alone was classified as a highly concentrated market. The dominance measure indicated that the largest producer, Vattenfall, held a dominant position. Being in such a position is not illegal and nothing can however be said about any abuse or not of such a position using these measures.

The results naturally differ because of how the markets are defined. The truth is, of course, somewhere in between. The Nordic region was, in 2007, one single market with one price during 28 percent of the time. The price area Sweden usually appears in different constellations with one or more other areas and acts as one single market.
during short periods. The concentration and potential dominance in the Swedish market is probably not a problem. However, the possibility of market power being exercised during very short periods cannot be ruled out. Removing bottlenecks from and expanding the transmission system might increase competition since it increases the time the Nordic price area acts as one market. Further research could be carried out taking price areas into consideration and also perhaps applying other or additional structural measures.
REFERENCES

European Court Treaty, Article 82.


