Doctoral School of Economics

THESIS SYNOPSIS

Krisztina Antal-Pomázi

Economic tests and expert evidence in antitrust enforcement

Ph.D. dissertation

Supervisor:

Pál Valentiny, CSc.
emeritus research fellow, Hungarian Academy of Sciences

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Contents

1 Antitrust and regulation

Vigorous competition on a market stimulates efficiency, urges to develop performance, and through mutually advantageous exchanges leads to lower prices, to more alternatives available for consumers, and to the advancement of economic welfare on the long run. It is generally beneficial for everyone, but it is not irrelevant on what way it is realized. The misleading of the consumers, the unfair influencing of their decisions, or the abuse of dominant economic position (hindering the entrance to the market, disadvantaged conditions stipulated by contract etc.) as tools used in competition cannot be supported by the society. Firms may try to restrict competition to worsen the chances of new entrants or the chances of those who are already on the market. Competition laws generally prohibit agreements like this, except when it is significantly advantageous for the consumers. Antitrust enforcement is beneficial for consumers as long as they face lower prices, more alternatives to choose from, and get valid information about products and services. But what about the competing firms? Why is it good, or is it good at all for them if they are not allowed to form cartels, not allowed to become a monopoly, or not allowed to use their market power? The first part of the paper aims to answer questions like these. If we look beyond the idea of a welfare-maximizing social planner that creates competition policy in order to promote competition and put restraint on firms willing to monopolize markets, we might ask why such institutions emerge and who really benefits from them? Apart from the evident answer of consumers benefiting from lower prices, we consider the possibility of companies, or rather industries, benefiting from the activity of a competition authority preventing monopolization. In such a setting, the regulating body can also be seen as delivering a service, which might be valuable for particular firms, but normally cannot be purchased on the market.

Research in psychology has given new insights to economic decision making, and also regulation. It became clear that providing more and more information to consumers does not result in better choices. It can also be seen that the mere existence of better alternatives is not enough to result in consumers switching to a new service provider. Concerning price regulation, authorities realised the importance of demand management, the separation of the peak and off-peak consumption (Hausman – Neufeld, 2002). Nowadays, new technologies make even real-time pricing possible. Pilot projects show that households can easily adopt to, and benefit from differential pricing. In the second part of the study we show that firms may be interested in differential pricing either for technological reasons (i.e. high marginal costs of on-peak production or high capacity costs) or for demand-side reasons (if peak consumption is

sufficiently inelastic). However, the higher elasticity of substitution consumers have, the more they can benefit from peak-load pricing. We also show that there exist certain characteristics of supply and demand when peak-load pricing is a Pareto improvement compared to uniform pricing, and thus beneficial for everyone.

The two regulatory systems (antitrust and regulation) match, complement, even substitute each other at several points. The early concessions issued by the local authorities comprised the regulation of prices, quality of service, entry and exit of firms. All of these became the standard regulatory intervention tools of the emerging regulatory bodies. In North America, the antitrust and regulatory bodies evolved as a kind of supplement institutions beside the courts. Some authors stress that the failure of the courts was behind the establishing of these type of institutions (Schleifer, 2012). Litigations concerning concession contracts were settled by arbitration courts, because traditional litigation procedures were lengthy, made the further collaboration of the parties impossible and lacked the expertise needed for the decisions. Different network industries required different and specialised professional knowledge, which supported the creation of new institutions, the regulatory bodies. The variance between the competition and regulatory authorities' enforcement tools might partly be explained by the available specialised expertise. Competition authorities and courts seldom reach a decision which requires sustained and continuous monitoring[1]. The expertise of the regulatory authorities makes this monitoring much easier. Both types of authorities are subject to political interference, both might be "captured". Sectoral regulators are natural targets of sectoral lobbies, especially while they have repeating interactions (Baker, 2013). The same lobby activity might be present at competition authorities mixed with the debates on the definition of social and consumer welfare (Katsoulacos – Ulph, 2009, Werden, 2011).

As the workload began to grow, courts and authorities needed some screening process to select among the cases according to their importance. There are legal tests employed by the courts. The set-up of the *illegal per se* rule on the "in itself anticompetitive" behaviour reduced court system workload. Similar tests in defining relevant markets or predatory pricing etc. are used expansively in competition and regulatory authorities. Competition authorities created priorities to make their work more efficient. The seventies onward the rise of game theory and the more economic approach in decision making of the courts and authorities led to the growing role of experts and expert witnesses. This progress found a new wave of tests for evaluating

[1] The Microsoft cases were the exceptions which proved the rule (US and EU). The antitrust claims against the firm indicated the break-up of the monopoly, but finally settlements with remedies were reached. There were several breaches of the settlement and continuous errors in monitoring (Economides – Lianos, 2010).

economic evidence and selecting experts. In the third part of the study, we discuss the problem of an uninformed judge who wants to select a neutral expert and decide the case upon this impartial expert testimony. To be able to do this, he needs to make the well-informed parties reveal their information on the types of the experts. We provide a mechanism for selecting a neutral court-appointed expert that Nash implements the social choice rule of fair jurisdiction.

Besides the use of game theoretic models in the analysis of potentially anticompetitive behaviour in regulation or in the legal process, auction theory gathered ground in the allocation of scarce resources (e.g. frequencies) or in public procurement. More insight on the author's work in this field can be found in Antal-Pomázi (2012, see attached). In the next chapters we show some more details and our contributions connected to the above problems.

2 Corporate interest in antitrust enforcement

2.1 Introduction

The purpose of this chapter is to point out that in certain cases the maintenance of a competition authority, from the corporate viewpoint of a concrete industry, is as beneficial as from the consumers' point of view. We demonstrate this argument with a simple game theoretic model. Our model shows that such effect exists under certain (sufficiently general) conditions, that is to say, firms in specific oligopolistic settings would be definitely willing to pay for the maintenance of an authority controlling unfair competition (abuse of dominance, misleading consumers etc.) and thus preserving the status quo on the market. Finally, we test our results empirically, based on the practice of the competition authorities of the United Kingdom and the Netherlands. The data support the interest group theory of regulation and they match the predictions of our model.

2.2 Theories of regulation

There are several rival theories concerning the emergence of regulation. In current European market economies we are surrounded by the government almost everywhere. We often do not even realize it. We may find its intervention natural from providing public schools through the determining of the price of natural gas to the regulation of competitive markets. Why is it needed to coordinate the markets (where there are natural competitors, so this is not about natural monopoly), if the market itself is known as a coordination mechanism? What type of regulation will emerge and how will the government choose among the different possible alternatives? Our ideas concerning the government's role could strongly influence our

judgement on antitrust enforcement. One might wonder whether competition policy is only in the interest of consumers. Or is it possible that the maintenance of an organization which deters market participants from the violation of the "status quo" is in the interest of the competitors? However there is some evidence which can be regarded as the support for either theory of regulation, these are not obvious. Concerning the characteristics of economics it is questionable whether it is possible to find an obvious evidence for any of the previously mentioned theories.

The *normative theory* of regulation indicates that government regulation is necessary where market failures exist.[2] The aim of regulation is to improve economic efficiency and social welfare.[3] However, it is questionable on what extent can the regulator control those circumstances which cause the market failure. It is not sure at all whether a regulator has the proper information in order to cure the problems originating from informational asymmetry, whether it can wind up a monopoly, or whether a better outcome could be achieved by the internalization of a specific economic externality. On the top of it the "faults" of the regulators may favor some well-defined interest groups (Posner, 1974). Based on the normative theory what justifies antitrust enforcement? A market failure has to exist which necessitates the protection of the competition. If fair competition has the characteristics of public goods, it would be reasonable to found an institution for the protection of competition.[4] Considering the traditional definition of public goods, competition itself can be interpreted as a good, which is equally available for the market participants after it had been "produced", and its advantages are enjoyed by everyone. The externalities related to competition may cause that the intensity of competition will be too low compared to its socially optimal level. For instance, on an individual level, all participants of the demand-side of a market are beneficially affected by the growing intensity of supply-side competition (they face lower prices). Nevertheless, because they form a large group, it could happen that they are not able to organize the protection of their interests, i.e. the production of the public good (Olson, 1971). It is not worth bothering with the enforcement of competition individually, so finally it will not happen due to free-riding.

Although antitrust enforcement can be explained with the existence of market failures, the normative theory of regulation does not treat the mistakes of regulation endogenously. If a measure failed to improve social welfare, there must be an external reason for that: the objective (for example the protection of national interests by the use of customs or quotas) has a price,

[2] For detailed arguments see: Tirole (2003), Cullis – Jones (2009).
[3] We do not discuss the problems related to the definition and measurement of welfare here.
[4] "Is a competitive market really a public good, and therefore underproduced in the absence of antitrust legislation?" (DiLorenzo, 1985: 74.)

the situation was badly examined (there was some hidden information), or the regulators made bad decisions in spite of their intentions (Stigler, 1971: 3.). Empirical results indicate that there is no strong correlation between the existence of regulation in an industry and the existence of externalities, or monopolistic market structure (Posner, 1974: 336.).

Public choice theory is the extension of self-interest-driven behavior for the examination of non-market circumstances (for instance for examining public sector decisions). Stigler (1971) studies the existence of regulation through the concept of supply and demand. He assumes that market outcomes are not "accidental", but the result of certain rational actions. Government has something which other agents in the economy do not have: the power of enforcement. The demand for regulation emerges from rent-seeking: the possibility of acquiring public resources or economic advantages which can be exploited with the help of the government (for example the reduction of competition through making import more difficult).

If antitrust enforcement does not allow (and sanctions) behaviors like the abuse of dominant position or predatory pricing, this will have a positive effect on the industry. The effect of regulation is similar to the effect of a cartel in its most important features (for example rising the price above the competitive level by restricting entry to the market). So for the firms of an industry, they can be regarded as substitutes. Peltzman's formalized model (1976: 11.) also indicates that substitution is not perfect: the "political" cartel provides less profit for each firm of the industry than the "free market" cartel. We expect that those markets, where the price of forming a cartel is high, will have a larger demand for regulation. The success of influencing regulation also depends on the ability of the industry concerning political influence, which does not coincide certainly with the high costs of forming cartels – these factors jointly form the actual demand for regulation. Regulation becomes mostly a public good for the corporations of the industry, thus during the lobby for it the free-rider problem also occurs. The closer the firms' interests are to each other, the more successful the lobby will become (see also Olson, 1971). Generally, specific groups of firms and customers influence regulation together. So, there is no obvious relation between the size of an industry, the number of employees and the probability of regulation (Posner, 1974: 344-346.).

It is hard to decide which industry benefits from the introduction of competition policy, and which one "suffers" from it. There is no clear evidence for the support of any of these theories (Posner, 1974: 354). The problem can be illustrated by the attempts analyzing the effect of the Sherman Antitrust Act introduced in the United States in 1890, which led to different conclusions. Delorme et al. (1997) compared the production data of nine different "trust" industries. The authors found that during the decade after 1890, relative prices declined only in

one industry and increased in three. The results suggest that the Sherman Act did not have any effect on the functioning of the trust industries, either because it was unenforced or because it was not necessary at all (Delome et al. 1997: 331). The relative output rose slower after the law had been introduced. This suggests that regulation was too broad (also penalizing efficient competitors), or that the introduction of the law has started such a corporate merger wave which finally led to the reduction of competition (ibid.). Also in 1890, a significant increase in tariffs has taken place, which could have compensated firms even if the Sherman Act would have affected them negatively. So, in case of the Sherman Act, the empirical results seem to strengthen the interest group theory of regulation, but the evidence revealed is not obvious in the sense that it is not clear if the effects of regulation were in favor of a specified group. The argument has not been closed yet, but the seek for new evidence points out interesting problems.

We introduce a model which also seems to support the interest group theory of regulation. We consider an industry where there exists a (costly) possibility for the firms to increase their market power. We examine the outcomes of two possible states of the world: with and without competition policy. In this way the actual role of antitrust enforcement can be identified, and its effect on the competitors (and on the market structure) can be examined.

2.3 The model

Let us consider a market with n similar firms, which produce almost the same product (close substitutes). Suppose that it is possible to increase the market share (and profits) with the expenses of C ($C > 0$). The latter can be, for instance, an expenditure appropriated to research, or technological development, or new marketing techniques from which the firm expects the increase of profits. For simplicity's sake let us call this opportunity "innovation". Innovation makes it possible for the innovating firm to raise its profits compared to its competitors. The more companies spend on innovation, the less the acquired advantage will be. In an extreme situation, if all companies invest, market shares remain unchanged. I.e. every firm can decide whether it wants to spend C on innovation, and thus it can get the chance to earn profit π_2, higher than its current profit π_1. If it decides not to spend, it can earn profit π_1 at best. (Those who innovate will grow typically on the expense of those who do not. So the latter, who are not necessarily squeezed out from the market, will realize a lower "normal" profit, like e.g. in perfect competition.) If none of the firms innovate, profits remain the same. The more companies innovate, the less advantage they can acquire, i.e. if a number of companies x decide to innovate, the expected profit will be $(1/x)\pi_2$. Firms are the same, so they face the same decision. A firm will decide to spend C on innovation if the expected profit is positive, that is

$(1/x)\pi_2 \geq C$. The greater the expected increase in profits, the more firms will decide to innovate. Competition will increase until the expected profit diminishes to zero in the end. (As long as the expected profit is positive, new companies will decide to innovate, because they can only loose profits if they do not.) This is the logic of competition (see e.g. the model of perfect competition).

The "competitive escalation paradigm" described by Bazerman – Moore (2009: 105.) refers to similar situations. Sometimes the rules of the game are such that although all agents act in an individually rational way, the process leads to the elimination of potential gains (which were present at the beginning) and competition escalates until parties are worse off. This is because the situation itself is a trap and you can be best off if you do not enter it (the dollar auction of Shubik (1971) is a common example). Bazerman – Moore (2009: 108.) brings several examples of bidding wars in company acquisitions where the escalatory process was clearly present. Management science suggests that the phenomena can be exacerbated if managers tend to be irrationally competitive. That is, they do not mind sacrificing profits in order to harm a competitor (which they consider a "referent"). In different experiments, 46 to 60% of managers chose to make irrationally competitive pricing decisions in order to harm competitors (Arnett – Hunt, 2002). Focusing on the position of their company instead of profits may prevent managers from avoiding traps of competitive escalation. This usually leads to price wars, highly overpriced corporate acquisitions or failure to cooperate although it would be mutually advantageous.

Hereinafter we focus on industries where the above situation holds: π_2/C is high enough so that in equilibrium every firm spends on innovation with positive probability. That means, competition is expected to mop up extra profits. Suppose that this industry faces competition policy, i.e. a competition authority is destined to prevent, discover and punish any behavior that is considered anticompetitive. The possible strategies of firms to earn a higher market share and higher profits become limited: they will not be allowed to deceive consumers, abuse with their dominant position, impose predatory pricing etc. Mergers and acquisitions will also be under control. Can such a guarantee of fair competition be valuable for the firms themselves? Under what circumstances is competition policy a "service" for companies that they would be willing to pay for? We will show that under certain conditions, firms are interested in the maintenance of competition policy, so they would be willing to sacrifice part of their profits for it. An "effective" competition authority reduces expected profits in a dominant position. It deters firms from entering situations characterized by competitive escalation, so they can preserve the original oligopolistic market structure.

Suppose that beside having to decide if they will spend C on innovation, firms also have an opportunity to spend on antitrust enforcement. Let us assume that for the creation of the competition authority an $n \cdot V$ value of contribution is needed from the side of the industry. The firms being equal, supporting the authority with the value of V is a reasonable expenditure from everyone.[5] There are two possible outcomes. (i) it is worth spending the value of V on the competition authority on an individual level, that is why everyone supports the authority which comes into being, increasing the costs of acquiring a dominant position, or (ii) it is not worth supporting, therefore the agency does not come into being. Hereinafter the question can be simplified to a situation in which every firm decides to contribute the same value $V < \pi_1$, where π_1 is the currently available profit in the oligopoly without innovation. First, all firms have to decide if they want to contribute to antitrust enforcement with the amount of V. If it does not contribute, there will be no competition authority, and the expected profit depends on how many firms will innovate. If it contributes, the authority comes into existence, but the achievable profit declines with V. Then all firms can decide whether they want to innovate at a cost of C or not. If not, the highest obtainable profit will be $\pi_1 - V$. If the firm proceeds to innovation, then it has to expect the intervention of the competition authority when it starts to increase its market share. The competition authority works the following way: anyone who tries to grow at the cost of others[6] will be levied with the fine of T.[7] In this case, expected profit is $(1/y)/(\pi_3 - T) - C - V$, where y is the number of firms innovating under the operation of the competition authority, and π_3 is the obtainable profit with innovation.

[5] More precisely, if it is worth creating the authority, then for no one it is worth supporting it with a value which is bigger than V. Because if it is worth spending the value of V on it, then it is worth doing this for every corporation. If everyone puts V in it, then the authority exactly comes into existence. No one will spend a bigger amount on it, because it would not be beneficial, it would only prosper others (they cannot be excluded from "consumption"). Similarly, if it is worth giving V (creating the authority on an amount of money referred to as V), then it does not worth spending less than that, because the others will not give more, and the authority cannot be created by less than $n \cdot V$.

[6] The ground for increasing market share is not necessarily illegal, it is enough if the authority can label it anticompetitive, e.g. excessive pricing.

[7] The operation of the competition authority can be given by the relationship $T(V)$, where $\partial T(V)/\partial V > 0$, i.e. the more the industry supports the competition authority, the more it can increase the costs of a dominant position. For simplicity's sake it is assumed that the support is provided in money, in reality however, it can be another kind of help as well, for example information given to the authority about the planned steps of the competitors, or their use of their connections in order to promote cases pending.

The possible outcomes for the firm can be illustrated with the following figure:

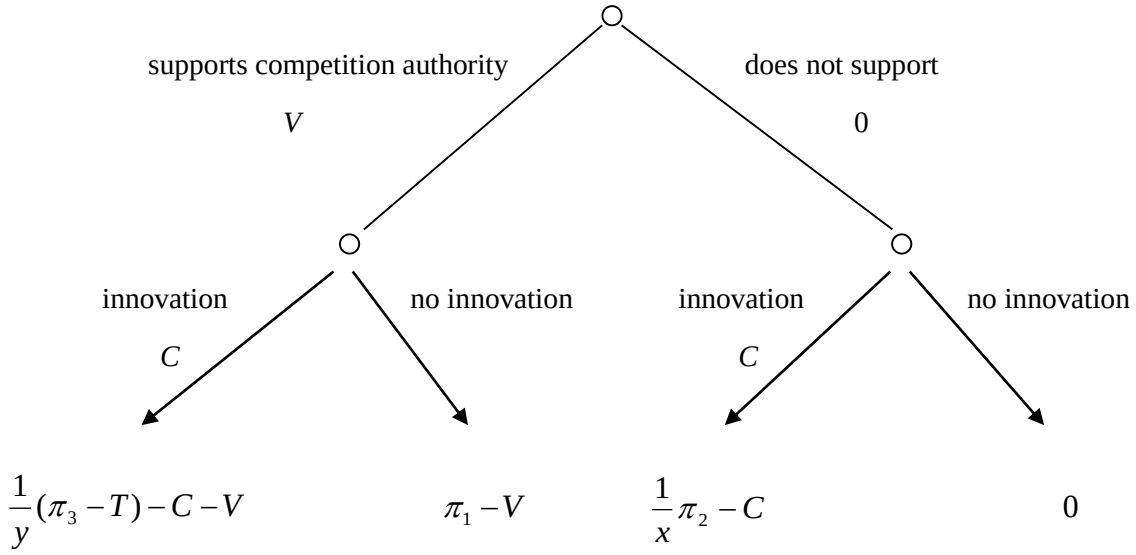

Figure 1. Decision tree of the firms.

Which outcome will be chosen? For this, we have to examine, whether the firm innovates in specific subgames (with and without competition authority). Then it has to be examined which case is more profitable for the firm. If it does not support the competition authority, then the previously mentioned situation draws up. It is worth to spend C on innovation with a probability of $\pi_2(n/C)$. We call a competition authority "effective" if it uses detection and setting fines to such extent that the expected profits of innovating will be lower than $\pi_1 - V$. That means, effective competition policy deters firms from the escalating competition for a higher market share, and "no innovation" will be the dominant strategy in the "supports competition authority" subgame.

When does a firm support antitrust enforcement? Of course only if the profit that can be obtained with it is higher than what is expected in the other case. Because of the fact that firms do not fight in case of effective competition policy, and they fight without it, the condition of supporting is the following: $\frac{1}{x}\pi_2 - C < \pi_1 - V$. Firms are willing to spend only a part of their profits on antitrust enforcement, thus the right-hand side of the inequality will be positive. The expected value of the left side will be zero.[8] *And this means that it is worth spending money on effective competition policy, because it preserves the status quo on the market.*

[8] The expected value of x is π_2/C.

2.4 Validity of the model

The predictions of the model hold if two important conditions are fulfilled. First, the circumstances and incentives for competitive escalation have to be present. Companies could avoid escalating competition if they could organize monitoring and punishing those who want to depart form the status quo. So we expect these to be markets where collusion (forming or maintaining a cartel) is hard. Second, competition policy has to be effective in order to prevent companies from "harmful competition". Firms themselves are not able to enforce an agreement "not to innovate". So they have to hire an agent to provide a credible threat of reducing profits in case someone would break the "status quo". It is similar to taking out an insurance.

At the same time effective competition policy also fulfils the requirements expected by other stakeholders: it serves the maintenance of fair competition. This could provide an explanation for the generally high acceptance of competition authorities: their activity is beneficial for everyone, for the consumers and for the industry as well. Our findings at this point correspond with the normative theory of regulation. Nevertheless, they seem to support the interest group theory. Within the frames of this model there is a group (the firms of the industry), which is not only interested in the enforcement of competition policy, but also willing to pay for it.

2.5 Empirical findings

To test for the consequences of the model, we need to look at real cases in competition policy. We will examine the practice of two competition authorities, the British and the Dutch. We compare "problematic markets" as predicted by economic theory (industrial organization) with the industries which were actually examined by the competition authorities. First, we expect that competition authorities (in a significant proportion of the cases) deal with markets where collusion is difficult for the firms. Second, we expect that competition authorities deal with the same industries repeatedly.

An OFT (2004) study aims to screen industries in order to identify "problem markets" in terms of effective competition and consumer protection. The authors used several indicators to select industries in a top-down way. The study ranks the industries (data applied to the United Kingdom) according to indicators such as concentration, barriers to entry, productivity etc. that suggest that competition is not satisfactory. The 515 industries were identified using 4-digit

SIC codes. The authors use a Borda method for ranking. Based on 8 indices[9], the overall ranking of the worst 15 UK industries is shown in Appendix A. Economic theory suggests that these markets are the most problematic. If regulation is aimed to increase welfare, we can expect competition policy to deal frequently with these 15 sectors, because of the high risk of restricting competition.

We reviewed the key cases of OFT in order to compare theory with practice. The whole list of markets can be found in Appendix B. Data indicates that during the examined period the competition authority dealt with roof contractors several times, with newspaper editing, medication/chemical production, road transportation, aviation, television broadcasting, private schools, and the wholesale trade of toys.

From among the sectors predicted as the worst 15 however, the key cases of the OFT include only passenger land transport (7th), the retail sale of books, newspapers and stationery (8th), and gambling and betting activities (11th).

A few years later the Dutch competition authority (NMa) developed a "*competition index*" (CI) based on a similar top-down method in order to identify "problematic" markets. Nine indicators[10] were selected to rank the 502 4-digit Dutch industries. According to Petit (2012: 29.) the top industries prone to anticompetitive behavior included the manufacture of malt, manufacture of lime, manufacture of other non-distilled fermented beverages, manufacture of plaster, manufacture of basic iron and steel and of ferro-alloys, transport via pipelines, production of mineral waters and soft drinks, manufacture of cement, manufacture of beer, air transport, youth hostels, transport via railways, ship renting and the manufacture of leather clothing.

Reviewing the cases of NMa between 2008-2011[11], it seems that the Dutch authority dealt repeatedly with the construction industry, telecommunications, rail transport, the wholesale of natural gas, supermarkets and local transport. However, among the industries most prone to anticompetitive behavior based on the CI were only the production of soft drinks (6th), the manufacture of beer (7th), transport via railways (8th) and national post services (16th), with one case each during the 4 years of observation. Although NMa "developed the

[9] The indices used were the following: (i) Concentration (C3), (ii) Profitability, (iii) Import Penetration, (iv) Concentration Volatility, (v) Churn Rate, (vi) TFP Growth, (vii) LP Growth, (viii) Cost Disadvantage Ratio.

[10] The indicators were the following: (i) number of trade associations, (ii) price index (NL vs. EU Prices), (iii) number of firms, (iv) HHI, (v) import rate, (vi) churn rate (vii) survival rate, (viii) R&D rate, (ix) market growth. Data refer to year 2008.

[11] The data stem from the Annual Reports of the NMa. Because cases might be pending for several years, we included the three subsequent years after 2008.

Competition Index (CI) for its cartel detection and deterrence objective" (Petit, 2012: 8.), they only dealt with a few of the detected industries.

2.6 Conclusion

The empirical results show that the British and Dutch competition authorities deal with only a few of those markets, which were identified as "problematic" regarding anticompetitive behavior. This seems to support the interest group theory of regulation. We also found that competition authorities dealt with the same industries repeatedly. This seems to support the predictions of our model. Our findings, however, have to be interpreted carefully. We have observed only two of the many competition authorities, and only the key cases of the OFT. The data used to identify problematic markets have also limitations. Classification systems are not the same as relevant markets. Substitute goods made of different raw materials (metal, timber, plastic etc.) can easily get different sector classifications, whilst categories like "pipeline transport" obviously do not stand for one specific market.

It can be stated that the conclusion of the above described model (i.e. there are markets where firms would be willing to pay for antitrust enforcement) supports the interest group theory of regulation. However, on the empirical level (as competition authorities detect anticompetitive behavior) it does not contradict the normative theory either. The empirical findings of our investigation seem to strengthen the interest group theory (competition authorities do not necessarily focus on those sectors which can be identified as problematic based on economic theory) and our model as well (authorities deal with the same markets repeatedly). Based on all of these findings it can be said that the model demonstrated above supports the interest group theory of regulation, and the empirical results do not contradict its conclusions.

3 Lessons in peak-load pricing

3.1 Introduction

Peak-load pricing can be found in a variety of industries from tourism through telecommunications to electricity. The fact that the same product has different prices according to the time of consumption raises interesting economic questions. Why and when is it profitable to set different prices in different periods? Fluctuation of demand can be a good explanation. But peak-load pricing itself can cause demand fluctuation. If it is profitable for firms, is it also worth for consumers? When does peak-load pricing lead to reductions in price or to the increase of consumer welfare? Is there a combination of consumer and firm characteristics that make peak-load pricing a Pareto improvement compared to uniform pricing? Is there a reason to encourage the use of peak-load pricing? The study seeks to answer such questions.

3.2 Peak-load pricing in general

Although the product in typical peak-load pricing industries (tourism, electricity, transport etc.) seems to be unchanged through time, consumers value them differently according to the time of consumption. Usually there is some possibility for substitution. If consumers are flexible, they can benefit from peak-load pricing: someone who is willing to travel on New Year's Eve will get to her destination anyway, and will be able to spend more on other products.

On the supply side, fluctuating demand may cause capacity problems. Investment in new capacity (buying an additional aircraft, building a new runway etc. and further maintaining them) is costly, which is also a barrier for possible entrants. The firm's maximum output depends on capacity, so the decisions regarding capacity must be made with respect to possible peak demands. Increasing output is cheap when demand is low (there is sufficient capacity to serve new customers), and expensive in peak times, when capacity is scarce. This makes marginal cost low in off-peak and high in peak periods. If consumers face the same rates over time, they will tend to consume too much when marginal costs are higher than the price (peak periods), and too little when marginal costs are lower than the price (off-peak periods). This leads to inefficiency and distortions in investment decisions (Joskow-Wolfram, 2012: 382.). Better utilization of capacity makes it desirable to set different prices in different periods for the "same" product. For instance, airways are better off by selling the last few seats on an aircraft for €50 than not selling them at all. More generally, optimal price decreases in the

number of seats left at a given time, and the optimal price decreases over time with a given number of seats left (Escobari, 2009: 60.).

Then again, firms can smooth demand by differential pricing. This is of special importance on markets where extremely high demand may lead to the collapse of the system. As Faruqui – Earle (2006: 24.) point it out, "the lack of demand response was one of the contributing factors in the 2000–2001 California energy crisis". As for electricity, economic prosperity is expected to make peak periods even tougher: in Ontario, for instance, peak demand has been growing more quickly than overall demand between 2003-2007 (Rowlands, 2008: 8.). System reliability requires shifting part of the peak demand to less congested periods. The experience of various peak-load pricing programs shows that total consumption of electricity is not likely to decrease with the introduction of dynamic pricing, it is only shifted to cheaper periods. Most people are willing to sacrifice their preferred consumption pattern for a more reliable electricity grid (i.e. they tolerate if room temperature is 2 degrees higher than the preferred setting due to a controlled air conditioner). It also seems to be desirable to leave an "override" option for those who are not able to reduce demand (e.g. for medical reasons), which makes load control programs more acceptable (Newsham – Bowker, 2010: 3294.).

Consumption patterns may vary according to certain characteristics, e.g. size of a company, age, income etc. The more inelastic the demand it faces, the more the supplier can win by price discrimination. This may motivate firms to introduce dynamic pricing.

New technologies make it easier to adapt to flexible pricing. Programmable household appliances and holidays in September have become common. Smart meters are more costly to install, but energy providers can save half of the costs by avoiding meter-reading (Faruqui – Earle, 2006: 26.).

3.3 Models of peak-load pricing

Although differential pricing may be welfare-increasing on both sides of the market, it is still not a general method. In the United States, for instance, less than 1% of households were on a time-varying tariff of electricity in 2010 (FERC, 2011: 98-99.). Although more than 20 million smart meters (13% of households) had been installed by the end of 2011, "real-time pricing has diffused much more slowly than have smart meters" (Joskow-Wolfram, 2012: 383.). In the case of airports, the most common pricing method in Europe is slot allocation. However, economic literature suggests that peak-load pricing "would be more efficient in reducing airport congestion than slot allocation" (Nagy, 2012: 85.).

There have been three common objections against dynamic pricing of electricity for years. The first is metering difficulties. Nowadays, smart meters seem to have solved the problem. Consumers can react to varying prices without having to control manually. The second is consumers' ability to adopt to flexible pricing. The third is the occurring redistribution. These will be discussed below in detail.

Several studies evaluated the pilot projects introducing different forms of dynamic pricing (see e.g. Faruqui – Sergici (2010), Newsham – Bowker (2010), Wolak (2010), Faruqui – Wood (2008)). Based upon these results, it is unnecessary to worry about the ability of consumers to adopt to prices. Households reduced peak consumption by 3 to 44%. Those with enabling technology managed to save twice as much on electricity bills. As Faruqui – Sergici (2010: 221.) conclude, "the higher the price that customers face during peak periods, the greater is the amount of demand response they are likely to exhibit. However, higher prices do not induce proportionately higher responses, confirming once again that the law of diminishing returns is at work." Marginal costs during peak periods may be extremely high, making even a small reduction in demand important for utilities (p. 195.). Engaged customers reduce their peak consumption even without enabling technology. Targeting future load reduction programs towards them might be even more cost-effective (Newsham – Bowker, 2010: 3294.). So, the second objection seems to be irrelevant.

Consumers clearly respond to prices, but to different extents. Firms are interested in discovering systemic differences across consumer groups in demand response in order to achieve better price discrimination and higher profits. If the product in question is consumed by almost everyone (such as natural gas or electricity), price discrimination becomes important from a policy perspective. By uniform pricing, those households who have a "flat" consumption profile cross-finance the energy bills of those with a "peaky" load profile. If, instead, the on-peak/off-peak price ratio changes to 2.4-3 (as happened in experiments), those will be better off, whose demand is more elastic. In the case of natural gas in Hungary, for instance, the poorest would presumably not be heavily affected by such a price change, because they are typically not using gas for heating. In the case of electricity, it can be presumed that most of the advantages of dynamic pricing would go to those who use a significant part of their consumption for pool heating or charging electric vehicles. Unfortunately, there are no sufficient data to predict redistribution effects precisely. One of the few empirical studies on the question is Borenstein (2013) that segments customers by income, level of usage and region of residence. The results suggest that load profiles do not differ significantly by income. That is, lower-income households would not be worse off by dynamic pricing in that sample. Coastal

areas would benefit since they consume a smaller share of their power on hot summer days (p. 142.). However, "wealthier customers […] live disproportionately on the coast" (p. 145.). The extent of redistribution relies on the elasticity of substitution between periods, but only few studies examine that. Wolak (2010) found that lower-income households adapt more flexibly, and so can benefit more from peak-load pricing. On the contrary, Charles River Associates (2005) evaluated a California program and found that wealthier households were more responsive to prices. This might be due to their likely ownership of flexibly timeable devices (central air conditioning, spa heating, electric vehicles), while households with electric cooking or more residents were less responsive (p. 74.).

Earlier models in the peak-load pricing literature concentrated on regulated monopolies with a fixed rate of return. After deregulation in some countries, however, new market structures developed over the past few decades with new entrants and separated networks. Although these markets are said to be competitive, it does not mean that the market power of firms has vanished. Closely examined, it seems that market power is sustained due to the preferences of customers and bounded rationality. For instance, if only one airway operates a direct flight between two cities, but there is also a possibility to travel with a stop (that takes more time), then those travelers who have a high evaluation of time will respond inelastically to the price increase of the direct flight. If there is a high number of such customers, the airway is able to behave like a monopoly towards them. Due to the above mentioned difficulties associated with capacity, new entrants cannot be expected to provide direct service on the short run (until the number of potential travelers reaches the amount sufficient for two direct flights). Similarly, competitive energy markets have several suppliers who are real competitors, but locally they are able to behave like a monopoly towards customers (Joskow – Wolfram, 2012: 382., CMA, 2016: 38-39., Valentiny, 2019: 121., Borenstein – Holland, 2005). Customer biases are of special interest here. People are more sensitive to losses than to gains, and usually prefer inactivity to changing an earlier decision. These "imperfections" make them stick to the "status quo" even if they have better choices. As for energy markets, they tend to be loyal to their current service provider even if another company's offer would be beneficial for them. Thus, firms are able to exploit inactive customers. In the United Kingdom, the Six Large Energy Firms were estimated to have caused a yearly detriment of £1.4 billion on average over 2012 to 2015 (CMA, 2016: 45.). This is the amount of money domestic customers could have saved by switching to another supplier, but as they did not, domestic retail market prices remained high. Furthermore, customer inertia weakens competition because a new entrant would find it very difficult to attain customers.

Bailey – White (1974) model a monopoly facing two time periods with different demands. The paper analyzes the welfare maximizing outcome (marginal cost pricing) and highlight that the monopoly may reverse the pricing of the periods (off-peak will be more expensive) if peak demand is sufficiently more elastic. However, the customers are not able to substitute between the two periods in this model.

Bergstrom – MacKie-Mason (1991) examine a utility (a regulated monopoly with fixed rate of return) changing its pricing from uniform to peak-load pricing, profits remaining the same. The paper concludes that if the elasticity of substitution is high enough, then both periods will become cheaper under peak-load pricing. Thus, the introduction of peak-load pricing leads to a Pareto improvement if customers are able to react flexibly enough to prices.

3.4 Towards a more general model of peak-load pricing

In this part of the study we generalize former models of peak-load pricing, especially that of Bergstrom – MacKie-Mason (1991). Instead of a regulated monopoly with fixed rate of return, we assume a firm with market power (a local monopoly) that provides service in two periods, with different marginal costs. Consumers may consume in any period.

First, we consider a revenue-neutral introduction of peak-load pricing. Several pilot projects of demand response in energy markets are designed like this: expected profits of the utility remain the same, and the average consumer's annual energy bill also remains the same if they do not change their load profile. This may not be the best achievable outcome with dynamic pricing. But it is surely a Pareto improvement, if prices fall while the firm's profits remain unchanged. We examine what circumstances are needed for this to occur. Our results can be summarized by the following theorem (see proof in Appendix C).

Theorem 1. The introduction of peak-load pricing instead of uniform pricing at a local monopoly that provides service in two periods, day (*D*) and night (*N*) with constant marginal costs of production leads to a Pareto improvement (both periods' prices decrease while profit remains unchanged) if the following two properties hold for consumers' elasticity of substitution:

(i) $\sigma > \dfrac{p_N}{p_N - c_N}$ and (ii) $\sigma > \dfrac{p_N(1-\varepsilon_N)-1}{\dfrac{p_D x_D}{x_N}-1}$.

where p_D and p_N are the prices of the corresponding periods, x_D and x_N are the quantities consumed, c_D and c_N are marginal costs of production, $\rho = \frac{p_D}{p_N}$, $\varepsilon_N = \frac{\rho}{x_N}\frac{\partial x_N}{\partial \rho}$, $X = \frac{x_D}{x_N}$ and $\sigma(\rho) = -\frac{\partial \ln X(\rho)}{\partial \ln \rho}$.

Second, we examine if it is profitable for a firm to introduce peak-load pricing. We compare peak-load to uniform pricing and analyze what properties of customers make it advantageous in terms of profits. Our results are summarized by the following theorem (see details in Appendix D).

Theorem 2. The introduction of peak-load pricing instead of uniform pricing at a local monopoly that provides service in two periods, day (*D*) and night (*N*) with constant marginal costs of production, and faces consumer groups with different demand characteristics is profitable for the company (i) for *technological reasons* (independent from demand characteristics) if the marginal cost of peak production or the cost of capacity is sufficiently high or (ii) for *reasons of demand* if a consumer group's peak demand is sufficiently inelastic.

Third, we examine the former problem if the firm faces consumers with different types of demand functions. We assume that the following properties hold for the demand functions of consumers: $\frac{\partial x_D}{\partial p_D} = a\frac{\partial x_N}{\partial p_D}$ (where $a < -1$) and $\frac{\partial x_N}{\partial p_N} = b\frac{\partial x_D}{\partial p_N}$ (where $b < -1$). That is, peak and off-peak demand is more responsive to changes in its own price than to the price of the other time period. Our results are summarized in the following (see details in Appendix E):

Theorem 3. A differentially pricing local monopoly will apply positive margins in both periods. The optimal price-pair depends on cost and demand parameters. The following inequalities have to be fulfilled: $|a| > \frac{p_N - c_N}{p_D - c_D - r} > \left|\frac{1}{b}\right|$.

The optimal price domain is marked by grey on *Figure 2*.

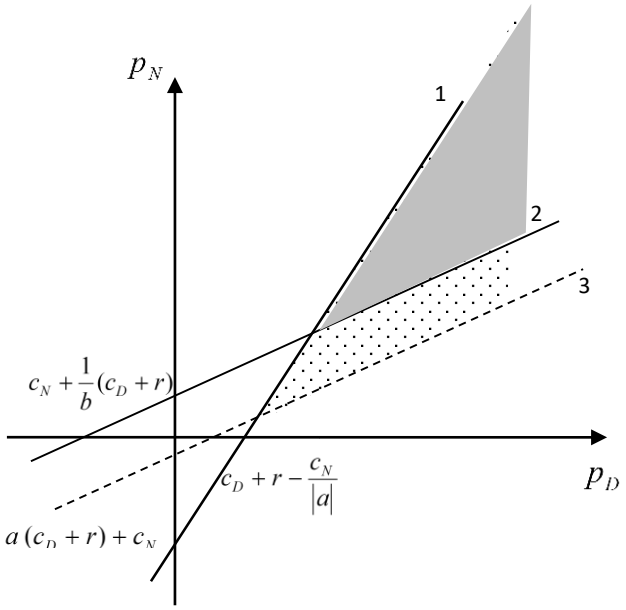

Figure 2. Optimal price domain on the $p_D - p_N$ plane.

3.5 Conclusion

Peak-load pricing is advantageous for firms: it increases cost-efficiency through better use of capacity and increases profit through price discrimination. We have shown above what conditions are needed for differential pricing to be more profitable than uniform pricing. The results show that two kinds of conditions may make peak-load pricing profitable. The first is technology. High marginal costs of capacity maintenance or high peak production costs (that are typical of industries with fluctuating demand) can themselves make differential pricing profitable. The second is demand characteristics: if on-peak demand is sufficiently inelastic (i.e. consumers weakly react to a price increase by reducing peak demand or shifting it to off-peak periods). The more inelastic consumers' demand is, the more profit the firm can earn by price discrimination. On the contrary, consumers can benefit from peak-load pricing if they can flexibly shift their consumption between periods. Our analysis showed that there exist certain characteristics of firms and consumers that make differential pricing mutually beneficial. Earlier models of peak-load pricing assumed several simplifications (such as consumers not able to substitute between periods, firms with zero production costs, regulated monopolies with fixed rate of return etc.). Adding some generalizations to these, our results show that there still exist such characteristics of a firm and the consumers it faces that make peak-load pricing a Pareto improvement compared to uniform pricing. Consumers benefit more if they can adopt

to prices more flexibly. Innovative technology, such as smart meters, may help consumers benefit from real-time pricing. Such technology is expensive to install (only half of the costs is covered by the utility's savings). This makes it necessary that consumers cover part of the costs. If they are myopic, or other effects of bounded rationality hinder their commitment, regulatory intervention might be needed to increase welfare. The more accessible enabling technology (price comparison websites, cheap smart meters etc.) will be, the more everyone will benefit from time-varying pricing.

4 Economic evidence in court

4.1 Introduction

The use of economic evidence in court has become more and more general in the past few decades, especially in connection with damages and antitrust. Economic analysis is used to discover hidden (potentially illegal) behavior or to estimate its effects.

The paper discusses the principal-agent aspect of hiring experts in general, and especially regarding economic experts in court. The question is how could a lay person (e.g. a generalist judge who hears only few antitrust cases) choose a proper expert witness, or decide whether the expert evidence presented is correct and acceptable. Jurisdiction in the United States is adversarial: the parties present their conflicting standpoints and the court has to make a synthesis of the evidence. However, drawing a clear conclusion from contradictory evidence in a field very distinct from your profession might be hard, and requires the judge and jury to take into account other aspects of the expert testimony in deciding whether to trust it. Usually, several privately-retained expert witnesses are called for testimony by the parties to support their point of view in the case. This relationship creates incentives for the experts to formulate and present their testimony in favor of their principal. The emphasis on contradicting standpoints together with the principal-agent relationship may veil scientific consensus even in fields where a broad community of scientists agree. This is especially problematic in economics (antitrust), where the rationality or harmfulness of a specific behavior is usually disputed among scientists as well. Other witnesses may not be neutral either, but there is a higher risk of expert witnesses misleading the court. They can better avoid being unveiled by cross-examination, and even if other experts would discover problems with their arguments, lay members of the jury would not be able to do the same. If expert testimonies are too controversial, the judge can disregard all of them and decide the case upon other evidence. This outcome is socially not desirable: it is wasting resources and might lead to a less effective jurisdiction in general.

Since 1975 there is an opportunity[12] that the court can appoint its "own" expert witness. Nevertheless, the use of court-appointed experts is rather rare (Cecil – Willging, 1993: 7.) and is limited to special cases (Sidak, 2013: 362.). Such an expert can help the judge decide on the admissibility of expert evidence, may help interpret the partisan experts' testimony and suggest questions that the judge should ask them. The use of neutral experts may enhance decision-making and lead to an earlier resolution of the case (Butler Reisinger, 1998: 234.), or even make

[12] In federal courts (Federal Rules of Evidence 706.), but also in more than 30 states.

the parties settle before trial (see Erichson, 1998: 1983. for examples). However, judges usually see this institution as if it was undermining the adversarial system. Posner (1999a) argues that a judge cannot be sure that the court-appointed expert will be truly neutral, although the jury may give more credit to its testimony. This would mislead adjudication instead of making it better. There is weak empirical evidence on juries being stronger influenced by "neutral" experts (see Cecil – Willging (1993), Rubin – Ringenbach (1991) or Brekke et al. (1991) for empirical results), although it would be rational for the jury to rely more on the testimony of a court-appointed expert.[13]

Several authors argue (see e.g. Posner (1999a) and (1999b), Sidak (2013)) that the benefits of applying a court-appointed expert outweighs its disadvantages, so it would be desirable to make it more prevalent. The court would save a significant amount of resources if they would not have to judge the partisan experts' testimonies, but only take into account the neutral expert evidence. Posner (1999a, 1999b) recognizes the difficulty of choosing a proper court-appointed expert and suggests that the parties should be required to agree on a neutral one.

The paper shows that if the parties' financial conditions and their information regarding the experts themselves and the details of the case are sufficiently good, we cannot rationally expect that the solution suggested by Posner (and others) will work.

4.2 The model

Suppose that both parties in a case present their own expert witnesses, but the testimonies are so controversial that the court cannot decide. Suppose there is a possibility to hire a "neutral" expert. If the parties can agree who should be appointed, the court hires her and will decide according to the neutral expert's opinion. If they cannot agree, both parties' expert evidence will be disregarded.

First, it is easy to see that a neutral expert can only be someone, of whom either party knows, in whose favor she will testify. If this was not the case, the opposing party would put a veto on hiring her. Second, even if the parties cannot agree, the case won't remain undecided: it will be judged upon other evidence. This causes either parties to be interested in not hiring a neutral expert. Suppose that both parties know who would win the case if no neutral expert was hired. If the potential winner would agree to hire a neutral expert, she would risk her position

[13] It is not compulsory to tell the jury that an expert was hired by the court (Federal Rules of Evidence 706 (d)), but judges usually do so.

in the case. So it is worth for her to oppose any neutral expert suggested, even if they are truly thought to be neutral by both parties.

From these two arguments it follows that in a world of perfect information, where expert testimony and jurisdiction is predictable, and parties have sufficient resources to hire experts, the method suggested above cannot lead to an agreement. The parties will only agree on appointing a neutral expert if they fail to predict who will win the case in the absence of expert testimony, if they fail to predict an expert's opinion on the case, or if they don't have enough financial resources to hire own experts.[14]

Having shown that the solution suggested in the literature is only viable in a limited number of cases (if the parties are sufficiently badly informed or mistaken regarding the key aspects of the case), we suggest an alternative for choosing a court-appointed expert.

Suppose again that in a case, both parties have presented their own expert witnesses, but the testimonies are so controversial that the court decides to disregard them and hire a "neutral" expert. We assume that parties have complete information. That means they know of each expert, which of the following three types they belong to: *1.* those, who would testify in favor of the plaintiff (*P*), *2.* those, who would testify in favor of the defendant (*D*), *3.* and those, whose testimony is uncertain (*N*). This latter group is the group of "neutral" experts: neither party knows their opinion on the case. Suppose the judge is uncertain about the types of the experts.[15] That means, the uninformed judge has to acquire information from the well-informed parties in order to be able to appoint a neutral expert.

The socially desirable outcome of jurisdiction is that a case should be won by the party that is "right". In our case this means that the judge should appoint a neutral expert and decide upon her point of view. In a game theoretic setting, we are looking for a mechanism that implements the social choice rule that the judge chooses a neutral expert without knowing their types. This mechanism has to make the parties reveal their private information on experts. We have seen that asking the parties to agree upon a neutral expert is not a correct revelation mechanism if parties are well-informed.

We suggest the following mechanism for choosing a neutral expert. The judge asks the parties to submit a list of the experts acceptable for them. If the two lists have at least one item

[14] Champagne et al (2001) studied the use of court-appointed experts in family law cases in Texas. They found that in low-budget cases, limited resources may require that only the court-appointed expert is presented. But if money is available, privately-retained experts will be used, increasing the overall costs associated with litigation. It follows that the agreement on a court-appointed expert in these cases is not a matter of principle, but a matter of financial resources.

[15] Attorneys and their clients are supposed to have more information and financial resources in order to discover the types of the experts than the court.

in common, the judge chooses randomly among the common items. If the two lists have no items in common, the judge chooses randomly among those experts who are not listed by either party. Following this rule, the plaintiff's optimal strategy is to list the experts of types *P* and *N*. The defendant's best response is to list the experts of types *D* and *N*. So in a pure strategy Nash equilibrium,[16] the judge chooses a type *N* expert.

The suggested mechanism has at least two favorable properties. First, it simply requires truth-telling. The equilibrium strategy for every agent is reporting the truth. Second, it Nash-implements the social choice rule of fair jurisdiction. The equilibrium outcome is choosing a neutral expert, and based upon her point of view, the judge will be able to decide the case in favor of the party who is right.

In real jurisdiction, of course, information is not complete. Parties may err in judging the types of certain experts. Judges themselves are not completely uninformed either. Facing repeated interactions, they may build their own opinion about an expert's type. Timing can be crucial in appointing a truly neutral expert (see Sidak, 2013: 369–371. for further arguments). If the judge announces hiring a court-appointed expert at an early stage of the case (announces the mechanism for choosing one), parties will have less time to search for experts and discover their types. On the whole, it will be less likely that if the court appoints an expert, parties will be able to accuse her of being partial.

4.3 Conclusion

Assuming that the use of a court-appointed expert improves social welfare (as Posner and others argue), the paper has two main results. First, we show that the solution suggested in economic and legal literature (i.e. parties should agree on a neutral expert) is not viable. Each expert will be vetoed by one of the parties and the negotiation will end without consensus, only lengthening the legal procedure and eroding the effectiveness of jurisdiction. Second, we propose an alternative mechanism and show that applying this rule, the judge can manage to choose a neutral expert and decide the case upon impartial expert testimony. The mechanism described above is simple because it only requires the parties to unveil their private information and tell the truth. And, most important, it Nash-implements the social choice rule of fair jurisdiction.

[16] The specific game and its equilibrium is shown in Appendix F.

Appendix A.

Empirical results of OFT (2004) show that economic theory predicts the following industries to be the most prone to anticompetitive behavior in the UK:

1. Processing of nuclear fuel
2. Retail sale of cosmetic and toilet articles
3. Wholesale of tobacco products
4. Other supporting land transport activities
5. Wholesale of mining, construction and civil engineering machinery
6. Manufacture of sugar
7. Other scheduled passenger land transport
8. Retail sale of books, newspapers and stationery
9. Retail sale of bread, cakes, flour confectionery and sugar confectionery
10. Youth hostels and mountain refuges
11. Gambling and betting activities
12. Retail sale of medical and orthopedic goods
13. Manufacture of other machine tools not elsewhere classified
14. Repair of electrical household goods
15. Wholesale of sugar and chocolate and sugar confectionery

Appendix B.

Examining the key cases of the OFT in the three subsequent years[17] after the period examined in OFT (2004), [18] the British competition authority dealt with the following markets:

2002-2003:
Toy wholesale trade, television broadcasting, car parts trade, sound recording and reproduction (CDs), livestock wholesale trade, china production.
2003-2004:
Nursing services, Newspaper editing, roofing contractors, film production, stock exchange, insurance.
2004-2005:
Distribution of white rum, roofing contractors, road transportation (bus), television broadcasting, horse racing, online services.

[17] 1 April 2002 – 31 March 2005.
[18] Data from the annual reports of the OFT (2002-2003, 2003-2004, 2004-2005). We considered only the key cases highlighted in the reports (which are considered significant from the OFT's point of view), and only cases that are concerned with the restriction of competition.

Appendix C.

Proof of Theorem 1:

We assume a firm with market power (a local monopoly) that provides service in two periods, day (*D*) and night (*N*) with marginal costs c_D and c_N, respectively. The utility's profit function is the following: $\pi = p_D x_D + p_N x_N - c_D x_D - c_N x_N - r\max\{x_D, x_N\}$, where p_D and p_N are prices of the corresponding periods, x_D and x_N are quantities consumed, and *r* is the average cost of a capacity unit. The decision on capacity is valid through one peak and one off-peak period. Consumers may consume in any period. Consumers have the same concave utility function $U_i(y^i; f(x_D^i, x_N^i))$, where x_D^i is consumer *i*'s daytime consumption of the firm's product, x_N^i is night consumption and y^i is consumption from everything else (numeraire). *f* is homothetic and strictly quasiconcave. Consumer *i*'s marginal rate of substitution (*MRS*) is strictly monotonic decreasing in the consumption rate $X = \frac{x_D^i}{x_N^i}$. (Bergstrom – MacKie-Mason, 1991: 242.) We define $X(\rho)$ by $MRS(X(\rho)) = \rho$, where $\rho = \frac{p_D}{p_N}$ is the price ratio.

Elasticity of substitution is $\sigma(\rho) = -\frac{\partial \ln X(\rho)}{\partial \ln \rho}$. Originally, by uniform pricing, $\rho = 1$.

If $\frac{\partial p_D}{\partial \rho} < 0$, it means that peak-load pricing results in a price decrease for both periods. We assume that the firm's profits remain unchanged, i.e. by a certain profit π, $p_D = (c_D + r + c_N \frac{x_N}{x_D} + \pi \frac{1}{x_D})\theta_D$ where $\theta_D = \frac{p_D x_D}{p_D x_D + p_N x_N}$ and $\theta_N = 1 - \theta_D$. From these it follows that $\frac{\partial \ln p_D}{\partial \ln \rho} = (c_D + r - c_N \rho)\frac{\rho}{p_D}\frac{\partial \theta_D}{\partial \rho} + c_N(1-\theta_D)\frac{\rho}{p_D} + \pi \frac{\partial\left(\frac{p_D}{p_D x_D + p_N x_N}\right)}{\partial \rho}$.

Here we use the following lemma:

Lemma 1. $\frac{\partial \ln \theta_D}{\partial \ln \rho} = \theta_N(1 - \sigma(\rho))$.

Proof. Using the definitions of X and ρ: $\theta_D = \frac{p_D x_D}{p_D x_D + p_N x_N} = \frac{\rho X}{\rho X + 1} = 1 - \frac{1}{\rho X + 1}$, from this $\frac{\partial \theta_D}{\partial \rho} = \frac{1}{(\rho X + 1)^2}(X + \rho \frac{\partial X}{\partial \rho})$, and

$$\frac{\partial \ln \theta_D}{\partial \ln \rho} = \frac{1}{(\rho X + 1)^2}(X + \rho \frac{\partial X}{\partial \rho}) \frac{\rho X + 1}{X} = \frac{1 - \sigma(\rho)}{\rho X + 1} = \theta_N (1 - \sigma(\rho)). \qquad QED$$

Using all these, the following expression has to be negative for a Pareto improvement:

$$\frac{\partial \ln p_D}{\partial \ln \rho} = \theta_N \left(1 - \sigma \frac{p_N - c_N}{p_N}\right) - \theta_N{}^2 \frac{1}{p_N x_N} \pi(1 - \sigma) + \pi \frac{\partial \left(\frac{p_D}{p_D x_D + p_N x_N}\right)}{\partial \rho}$$

Assuming that the firm's profits are nonnegative in both periods, and that costs are positive, and using the notation $\varepsilon_N = \frac{\rho}{x_N} \frac{\partial x_N}{\partial \rho}$, it follows that

$(p_D x_D + p_N x_N)\left(\sigma \frac{p_N - c_N}{p_N} - 1\right) + \pi(\sigma p_D X - \sigma + 1) + \pi p_N (\varepsilon_N - 1) > 0$ has to be fulfilled.

From this it follows that the two inequalities of Theorem 1. have to be fulfilled for a Pareto improvement.

Appendix D.

Theorem 2:

We assume a firm with market power (a local monopoly) that provides service in two periods, day (*D*) and night (*N*) with marginal costs c_D and c_N, respectively. The utility's profit function is the following:

$$\pi = p_D x_D(p_D, p_N) + p_N x_N(p_D, p_N) - c_D x_D(p_D, p_N) - c_N x_N(p_D, p_N) -$$

$$- r \max\{x_D(p_D, p_N), x_N(p_D, p_N)\},$$

where p_D and p_N are prices of the corresponding periods, x_D and x_N are quantities consumed, and *r* is the average cost of a capacity unit. The decision on capacity is valid through one peak and one off-peak period. We assume that "day" is the peak period, i.e. capacity is

adjusted to peak demand. There are two types of consumers (*1*, *2*) with demands $x_D^i = A_i \frac{p_D^i}{p_N^i} + T_i$ and $x_N^i = B_i \frac{p_D^i}{p_N^i} + M_i$ ($i = 1, 2$), where $A_i < 0$, $T_i > 0$, $B_i > 0$ and $M_i > 0$.

Assuming that the firm can observe the consumers' types (e.g. students, entrepreneurs, certain age groups), the optimal price can be calculated separately for the two groups and the condition for peak-load pricing to be profitable becomes:

$A_1(c_D + r - 2\rho_1) \le B_1(1 - c_N) + T_1$ and $A_2(c_D + r - 2\rho_2) \le B_2(1 - c_N) + T_2$, where $\rho_i = \frac{p_D^i}{p_N^i}$.

Assuming that the firm's profits are nonnegative, the above conditions hold if $c_D + r - 2\rho_i > 0$. By uniform pricing, $\rho_i = 1$. Differential pricing will be profitable compared to this if $c_D + r - 2 \ge 0$. That is, if the marginal cost of peak production or the cost of capacity is sufficiently high (typically the latter is the case), it is worth offering differential pricing for both groups, independent from their demand characteristics.

Appendix E.

Theorem 3:

We assume a firm facing customers with the following properties of the demand functions: $\frac{\partial x_D}{\partial p_D} = a \frac{\partial x_N}{\partial p_D}$ (where $a < -1$) and $\frac{\partial x_N}{\partial p_N} = b \frac{\partial x_D}{\partial p_N}$ (where $b < -1$). Technology is the same as described before. Profit is $\pi = p_D x_D + p_N x_N - c_D x_D - c_N x_N - r \max\{x_D, x_N\}$ and we assume that "day" is the peak period, i.e. capacity is adjusted to peak demand. Pricing differentially, the first-order conditions of a profit maximum are $x_D + \frac{\partial x_N}{\partial p_D}\left(a(p_D - c_D - r) + p_N - c_N\right) = 0$ and $x_N + \frac{\partial x_D}{\partial p_N}\left(p_D - c_D - r + b(p_N - c_N)\right) = 0$.

Day and night consumptions are substitutes, thus $\frac{\partial x_D}{\partial p_N}$ and $\frac{\partial x_N}{\partial p_D}$ are positive. (Note that the welfare-maximizing marginal cost pricing cannot be optimal for the firm.) From this, the inequalities of Theorem 3 follow.

Appendix F.

The expert-choosing game

Let us suppose that in a case, both parties have presented their own expert witnesses, but the testimonies are so controversial that the court decides to disregard them and hire a "neutral" expert. The set of possible experts consists of three types: *1.* those, who would testify in favor of the plaintiff (*P*), *2.* those, who would testify in favor of the defendant (*D*), *3.* neutral experts, whose testimony is uncertain (*N*). We assume that parties have complete information on experts' types.

The judge is not able to verify the type of the experts. In order to obtain the socially desirable outcome of choosing a type *N* expert, the judge applies the following mechanism. He asks the parties to submit a list of the experts acceptable for them. If the two lists have at least one item in common, the judge chooses randomly among the common items. If the two lists have no items in common, the judge chooses randomly among those experts who are not listed by either party. For example, if the defendant's list consists of type *D* experts and the plaintiff's list consists of type *N* experts, the judge chooses a type *P* expert and the case will be won by the plaintiff. The winning party receives a payoff of 2, and the losing party receives 0. We assume that if all experts (*P* + *D* + *N*) are listed in the two lists, the judge chooses randomly from the complete set of experts. We also assume that the neutral expert gives a testimony in favor of either party with probability 0,5 and that the cardinality of sets *P*, *D* and *N* are equal.

The payoff matrix of the game is the following.

		Plaintiff					
		D	*P*	*N*	*D+P*	*D+N*	*P+N*
Defendant	*D*	2; 0	1; 1	0; 2	2; 0	2; 0	1; 1
	P	1; 1	0; 2	2, 0	0; 2	1; 1	0, 2
	N	0; 2	2, 0	1; 1	1; 1	1; 1	1, 1
	D+P	2; 0	0; 2	1; 1	1; 1	2; 0	0; 2
	D+N	2; 0	1; 1	1; 1	2; 0	1,5; 0,5	**1; 1**
	P+N	1; 1	0, 2	1, 1	0; 2	1; 1	0,5, 1,5

In a pure strategy Nash equilibrium (marked by green) the plaintiff's list consists of the experts of types *P* and *N*. The defendant's list consists of the experts of types *D* and *N*. The type *N* experts being the common elements of the two lists, the judge chooses a neutral expert. The expected payoff of both parties is 1.

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