Market Structure and Regulation in Pharmaceutical Markets

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TESI DOCTORAL UPF / 2010

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Acknowledgments

I first came to Barcelona in 2004 to enroll in the GPEFM at Universitat Pompeu Fabra not knowing that I was going to spend a relevant part of my life in this amazing academic community and the most wonderful city I ever been. It has been a long way through these years, but I have enjoyed so much every moment at UPF that now is too difficult to me to say good bye, let me leave it in a very Catalan ''fins aviat''. My mind will resist to forget all the good times spent in my office, at the cafeteria, at class, at teaching, UPF is and will be part of my life forever.

First of all I have to thank my tutor, Sergi Jiménez, who convinced me to pursue the Ph.D. when I was clueless on the next step after I finished the first year. In my second year Antonio Cabrales helped me in deciding to focus my research efforts on market structure, competition and performance. Sergi and Antonio have been excellent supervisors and I have only words of gratitude to them for their patience and guide, specially I have to thank their persistence in pushing me to work hard and never give up.

Many professors have also advised me and given me support throughout these years. I would like to specially thank Fran Ruiz-Aliseda who has shared with me too much of his precious time, I appreciate every comment he has given me, from simple notation standards to complex equilibrium existence issues. I also like to deeply thank Jaume García, for helping me in understanding Discrete Choice models, Jaume Puig, Walter García-Fontes, Joel Shapiro, Karl Schlag and Fabrizio Germano, have also been models to follow during my research activities and my teaching duties at UPF.

I am also extremely grateful to my classmates and very good friends I have made during these years, specially Eva and Rhiannon with whom I shared thousands of hours of bad coffees spiced with relaxing conversations and deep

Abstract

This thesis studies entry and competition in pharmaceutical markets. The first chapter presents an oligopoly model of product differentiation in which it is shown that price regulation is entry enhancing only when the size of the market is relatively low with respect to the efficiency of the incumbent. The second chapter shows empirically the interaction between market power redistribution due to multimarket rivalry among drug producers and price regulation. Low levels of regulation increases the redistribution effect whereas stronger regulation wipes out the effect. The third chapter identifies in a structural model empirical price cost margins for a pharmaceutical market for different hypotheses of firms' price interactions. It is concluded that the simulated price cost margins are compatible with a situation in which firms soften price competition with rivals with whom they have contacts across markets.

Resumen

Esta tesis trata sobre la competencia y regulación en mercados farmacéuticos. El primer capítulo presenta un modelo de oligopolio donde se demuestra que la regulación de precios sólo aumenta los beneficios esperados de la entrada de un competidor genérico cuando el tamaño del mercado es pequeño en relación a la eficiencia de un productor incumbente. En el segundo capítulo se estudia empíricamente la interacción entre el efecto de redistribución del poder de mercado debido a los contactos multimercado y la regulación de precios. A bajos niveles de regulación el efecto se incrementa mientras que cuando la regulación es más estricta el efecto desaparece. En el tercer capítulo se estima un modelo estructural de oligopolio en el que se identifican los márgenes de precios de los productores. Se concluye que los márgenes simulados son consistentes con un escenario en el que los productores maximizan beneficios considerando a rivales con los que tienen contacto en otros mercados.

Foreword

This thesis is motivated by the relevance for public policy of understanding the functioning of pharmaceutical markets. In particular, my aim is to explore the interactions of market characteristics such as structure, size and product differentiation with price regulation and competition. It is doubtless that price regulation and price competition are fundamental elements that explain important outcomes of pharmaceutical markets such as the profitability of entry.

In Chapter 1, I explore the role of price regulation in explaining entry in a pharmaceutical market. Controlling the price of an expensive off-patent branded drug is often done through price comparisons with the existing price of reference of a cheaper therapy in the market. However under the expectation of such regulation equilibrium, entrant's expected prices and profitability could be driven down ex-ante. In fact some recent empirical studies have found that Reference Pricing (RP) may discourage entry in the relevant market of close therapies. I present an oligopoly model of vertical differentiation in the context of consumer preferences for varieties à la Hotelling and show that indeed RP regulation reduces the likelihood of entry in that it reduces the entrant's profit. Market size improves entry profit whereas a cost advantage for the provision of perceived quality on the side of the incumbent reduces it. Nevertheless when the size of the market is small RP can increase entry profit, with respect to the unregulated benchmark for a sufficiently high efficiency advantage of the incumbent. Some policy recommendations are: i) Since RP reduces entry profits when the incumbent firm has little or no efficiency advantage for any market size it could be designed at an intermediate level between no regulation and full reference pricing (FRP). ii) RP is expected to increase entry profits when the size of the market is small and the efficiency advantage relatively high, therefore FRP can both reduce prices and promote entry, iii) As market size increases, the efficiency advantage required for the positive effect of FRP becomes larger so that it is expected that the regime most likely reduces entry

profits.

In Chapter 2, I present an empirical study on the interactions between multi-market rivalry and price regulation. Multimarket rivalry theory predicts that firms engaged in price competition in several markets might find it optimal to redistribute market power from more collusive markets to more competitive instances. Price regulation is shown to affect this relation in a non-monotonic way. Mild or low price regulation may encourage further market power redistribution, whereas stronger price controls change the result to the point of blunting the redistribution effect, therefore reducing prices in equilibrium. I use data from the Pharmaceutical industry for nine OECD countries which are known to place different levels of price controls. I find strong evidence of the redistribution effect and the interaction with price regulations when considering contacts between chemically equivalent products; however, widening the contact dimension to consider interactions among substitute therapies make the result less transparent. The results suggests that strong price regulation will reduce the profitability of pharmaceutical markets in a country even if some product markets are not heavily regulated.

Chapter 3 is motivated by recent waves of mergers in international pharmaceutical markets. Competition authorities might be worried about the effect of horizontal mergers, specially unilateral price increases. I present a model of oligopolistic competition with product differentiation to study hypotheses of market power for the international market of antihypertensive drugs. I provide consistent estimations of parameters and the pricing equations from which price cost margins (PCM) are estimated for different hypotheses on the type of equilibrium that may be sustained in the market. These PCM are then compared to margins obtained in other studies from detailed cost or input data as a mean to test the validity of the hypotheses. My results indicates that product differentiation is a very important source of market power, while data appears to reject a model of full tacit collusion or joint profit maximization. Interestingly, my results suggests that multi-market contacts can be a key fac-

tor in sustaining high PCM as well as some implications for the role of *local* producers on the market competitiveness. The results then provide an initial point from which study possible unilateral effects of mergers in international pharmaceutical markets.

Contents

Chapter 1

Entry and competition in a regulated pharmaceutical market

1.1 Introduction

1.1.1 Motivation

In this article we present the findings of a study on how entry of a generic competitor in a prescription off-patent pharmaceutical market may be discouraged by a simple reference pricing (RP) regulatory regime. RP compares the price of an expensive branded originator drug with a price of reference. The idea of the device is to make the consumer cost conscious by introducing an avoidable out-of-pocket co-payment in the event of purchasing an expensive treatment. The consumer is therefore forced to pay the difference of the price of the expensive drug with respect to a reference price, which is usually a function of a set of alternative cheaper products in the market. These products can be generic bio-equivalent versions of the branded originator drug or substitute

therapies based on other active ingredients.[1] The distinctive feature of our model is that we introduce two important structural elements of pharmaceutical markets interacting with price regulation, market size and the length of previous patent protection. The model is able to predict correctly most of the observed and expected effects of RP and moreover can be used as a device to simulate regulatory regime changes that can be designed to promote entry of generic products into the regulated market.

According to a number of studies (c.f. Caves, Whinston, Hurwitz, Pakes, and Temin (1991), Regan (2008)), price competition between branded and generic products is imperfect mainly because of persuasive advertisement as a mean to produce *perceived quality* differentiation.[2] In addition it is assumed that demand price elasticity is low because of the presence of a third party that pays for medical treatments (public or private insurance coverage). Finally, it has been been also noted that given lack of information on available products to treat a certain medical condition an their relative costs, physicians are not aware of the overall cost of treatment when they prescribe a therapy and, in any case, they have no incentives to prescribe cheaper varieties of a product.[3] Therefore it is not surprising that RP is better understood as a demand side instrument in that it ultimately seeks to increase the elasticity of demand and increase price competition between branded originator products and generic or close substitute therapies. Firms under RP are free to select their price strate-

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[1]Still a third version is applied in which given no availability of local cheaper alternative product exists, authorities use as reference the price of the same product in a different country. Implications of these type of alternative scheme are not considered in our paper, nonetheless Danzon and Epstein (2008) provides an interesting analysis of this scheme on entry on prescription drug markets and international diffusion of innovative products.

[2]This feature has promoted the assessment of product differentiation in a vertical fashion in the theoretical literature. This is not a trivial question because it is well known that marketing or detailing investments by brand-name producers is known to surpass the level of investments in R&D.

[3]For instance in a recent survey conducted by the OFT in the UK to around 1,000 general practicioners, the most relevant conclusion is that doctors prescribe with very little knowledge of the cost of treatment, making it reasonable to negotiate price caps and price cuttings for some prescription medicines For a complete analysis of prescriptions refer to "The Pharmaceutical Price Regulation Scheme", Office of Fair Trading, 2007.

gies however introducing this regime is expected to make them closer price competitors. Puig-Junoy (2005) has pointed out that the European Commission has suggested to State Members of the Union to adopt this regime, because according to this institution the RP system delivers price reductions with little market distortions. In fact, as compulsory price comparisons make the consumer aware of a cheaper variety of the treatment, RP is expected to increase the consumption of these products and therefore induce higher expected profits for potential entrants to the generic segment of the market.

In OECD pharmaceutical industries, price regulation of off-patent markets aims basically at keeping public financed health expenditures in line with projected budgets and delivery also improved levels of value for money. Agencies in charge of such policies are concerned with the security and efficacy of treatments, however as noted in Puig-Junoy (2005) a major point of interest is to contain the growth of third party payments for pharmaceutical products by increasing the consumption of a generic therapy. According to OECD health statistics [4], for example, in Germany pharmaceutical products explained 13.6% of national health expenditures in 2000, while in 2007 the figure increased to 15.1%. In Spain, pharmaceutical products explained consistently around 21% of national health expenditures between 2000 and 2007. On average, OECD countries spend almost 17% of health services in consuming pharmaceutical products, with most countries increasing in real terms the costs of treatment per capita (e.g. Germany and Spain had per capita pharmaceutical expenditures in 2007 50% above the observed figures in 2000).

Upon these arguments, the RP policy design might not deliver the expected results if price regulation aims only at short run price cuts. The reason is that ex-ante, price regulation might reduce the expected entry pay-offs of a substitute therapy making it less likely that the RP mechanism will actually produce the expected price reductions. In fact, according to a small set of empirical econometric studies by Kyle (2007), Moreno-Torres, Puig-Junoy, and

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[4]See the database at www.oecd.org

Borrel (2009) and Danzon and Chao (2000) RP is, in general, expected to lag or reduce entry of generic products and other substitute therapies. In other words, the findings of these works suggest that RP may be inconsistent with its own objectives.[5] The scheme and more precisely the agencies adopting the scheme assume that prices will be adjusted downwards by competitive pressures because cheaper products will enter the market after patent expiration, making the price of reference more competitive. As it is evident, if entry is lagged or even discouraged, those expected price reductions will not be realized neither in the short run nor possibly in the medium term. This small set of empirical works though provide a number of interesting regularities:

- First, entry is more feasible whenever the market of the specific product is larger, however there is not a clear-cut conclusion on how this effect can be identified in real data and how might price regulation interact with market size. Market size is often estimated with a measure of revenues or profits which makes it endogenous to the observed equilibrium prices and number of firms.

- Second, entry of generic products is less likely whenever the period of patent protection of the originator drug is longer. It has been suggested that this result is due to the fact that branded drug producers can better invest in conforming an important base of loyal consumers.

- Third, and related to the first finding, generic market shares are larger in markets with larger sizes however this does not mean necessarily that entrants' expected profits are larger due to the interactions between price regulation and the expected price of entry.

In this paper we describe a theoretical model to study in a systematic way the interactions of the RP regime with the structural parameters of interest of

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[5]Nevertheless there has been also at least one empirical work that contrary to the list of papers cited has found the opposite result. This is the case of Strom and Haabeth (2006) in which the Norwegian market for pharmaceutical products is analyzed.

pharmaceutical markets that are thought to explain generic entry: market size and the length of patent protection enjoyed by the incumbent branded producer. The latter is modeled as an efficiency advantage of the incumbent in terms of providing marketing investment to produce perceived quality differentiation.

The model is one of a duopoly where firms can select the amount to invest in an attribute of quality so that we introduce differentiation of branded to generic or alternative substitute products. After selecting the amount of ''quality'' to provide firms compete à la Bertrand in prices. The incumbent originator drug producer has an strategic advantage in that he moves first in the quality game. Likewise the incumbent is endowed with an efficiency advantage to invest so as to model the way in which the length of patent protection ease his capabilities of attracting a loyal base of clients.

The competing products are exogenously differentiated in a linear space of physical characteristics so that we can study the effect of RP in cases in which the potential entrant is more or less interchangeable with respect to the branded originator drug. The model is based on of Shaked and Sutton (1987) and Economides (1993) analysis. The horizontal differentiation space also allows to introduce as a parameter the size of the market in a way that is fundamentally different from the notorious endogenous way it is analyzed in the empirical literature. Here the size of the market refers to the size of the population in terms of the length of different medical conditions that have to be treated with the existing drugs.

We show that most empirical regularities observed in the relevant empirical literature can be simulated with the model but more interestingly, it provides a number of testable hypothesis on the interactions of markets size, efficiency advantages and other parameters with the regulatory policy. This model then suggests a number of ways to better identify how price regulation affects entry controlling for market size effects, for example.

In addition, with the model it is possible to asses how RP can be designed in such a way so as to alleviate the effects of the length of patent protection over entry profits. In terms of this model, the latter circumstance is studied in a context of structural blockaded entry.

1.1.2   Modeling a pharmaceutical market

We aim at modeling an off-patent pharmaceutical market in which three basic structural ingredients are of paramount relevance: i) There is an incumbent producer that commercializes an originator branded drug and a producer that potentially provides a close substitute therapy which can be a generic copy of the original, these two firms are independent, ii) a continuum of consumers distributed along a horizontal line in which each position will be interpreted as an individual specific medical history, the size of the line will be interpreted as a measure of the size of the market, iii) a technological advantage for the incumbent in spending more efficiently in marketing to create a persuasive quality characteristic.

With respect to the first point, there are important elements to consider. First, according to industry information, generic products are not identical to branded originator drugs. Authorities, however, require that a generic proves bio-equivalence with respect to the existing branded drug in the sense that the main active ingredient (molecule) of the product has to be the same and, more importantly, in the same dosage. However, it is well known that products are differentiated mainly in its inactive ingredients such as the main excipient. An excipient is an inactive ingredient that helps the body to absorb the active ingredient. In addition, products are differentiated in that the other components to give it its size, form, resistance, texture and taste are usually distinguishable. Inactive ingredients are known to produce different side effects to different consumers and so the physician has to be aware of the medical history of the patient to prescribe the available variety that better suits

her. For instance, *bisulfites* that are used as preservatives for many drugs are known to cause allergic episodes to asthmatic patients, these allergies can have different levels of severity. We will assume that the generic product has proven bio-equivalence in the sense that it provides the same amount of the active ingredient in the body at fairly the same speed as the branded product. Nonetheless, as it is in reality, it has relevant inactive ingredients that makes interchangeability with the branded drug a relevant issue that the physician is aware of. This does not mean that the generic is not a safety drug, however as in the branded case, it may produce side effects that makes the patient worse off depending on her specific medical history. In this sense, our model will allow for at least some horizontal product differentiation in the spirit of Hotelling (1929) and D'aspremont, Gabszewicz, and Thisse (1979) This model then can also be used to analyze more general cases in which the available substitute therapy to the branded drug is less interchangeable.

The second point introduces in the model the possibility that consumers in the market are ordered according to their most preferred drug variety in terms of the side effects that the available drugs may produce. Physicians are assumed to know perfectly the specific characteristics and medical history of their patients so that they will always prescribe according to this information.

The third element is introduced in the model as a mean to study how the length of previous patent protection enjoyed by the incumbent may affect the way in which the RP regime is expected to determine profits and entry. The assumption of the model is that the larger the patent protection the larger the ability of the incumbent to provide more efficiently the optimal amount of marketing expenditures for creating perceived differences in drug qualities.

1.1.3 Related literature

Price competition in the context of price regulation has been studied before for pharmaceutical markets. Cabrales (2003) developed a model of vertical product differentiation to study how price caps on the price of a high perceived quality drug may affect the penetration of a generic product. He shows, accordingly to Danzon and Chao (2000) that stronger price regulation explains lower market shares for generic products. This work also introduces a technological advantage for the incumbent much in the way we propose in our model and as in our model, he assumes this advantage is positively correlated to the length of previous patent protection enjoyed by the branded drug. In the same model, Merino-Castelló (2003) studied a simple Reference Pricing scheme where she introduced strategic issues in that price and quantity competition could be assessed. Merino's work showed that the RP regime can be expected to be successful in reducing average prices. However, the price of the generic product remains constant and its market share is expected to reduce. Hence, RP cannot be expected to increase the consumption of generic products. In that model, the RP system is modeled as an average of the branded drug price and the generic substitute price which is not commonly observed in reality.

Königbauer (2007) studies how persuasive advertising from the incumbent can induce vertical product differentiation and generic entry by setting the price of the incumbent at a considerably high level. Konigbauers' work also suggests that, contrary to empirical observations, price regulation may further induce vertical product differentiation and so creates larger opportunities for profitable entry. More recently, Brekke, Königbauer, and Straume (2007) studied a model of oligopolistic competition to study how Reference Pricing may distort the incentives to entry of a branded therapeutic close substitute in a market where there the branded originator drug already competes in prices with a generic producer. The model uses a set up with horizontal product differentiation à la Hotelling and given levels of vertical product differentiation, therefore quality differentiation is not studied into a strategically context. Fi-

nally, Miraldo (2009) studies different versions of the Reference Pricing scheme in a model of horizontal product differentiation. She shows that when the price of reference is a linear combination of the price of brand drug of a given high quality level, the scheme provides a mechanism for price coordination and leads to higher prices in respect to a rule which sets the price of reference as the minimum of the observed prices. She does not provide for an analysis of entry, however her work is interesting in that she is the first in analyzing a context in which the demand is not fully satisfied. Yet, her work is not intended to parallel observed features of Reference Pricing in reality.

The model we present and analyze in the next sections has many elements that makes it different from previous theoretical exercises. The fundamental one is that market size and cost advantages from the part of the incumbent branded drug producer are introduced as key drivers for the incidence of Reference Pricing over the equilibrium outcomes. The second one is that vertical product differentiation is made also dependent on horizontal product characteristics, therefore it provides a general approach to assess Reference Pricing by allowing the potential entrant to be a close substitute (generic producer) or a substitute therapy.

The paper evolves in the following manner, Section 1.2 develops the model and the equilibrium for the case in which there is no price regulation, the results are therefore identified as the NPR case. Section 1.3 provides and analysis of the expected effects of introducing the RP regime, those results are identified as the full reference pricing regime or FRP, referring to the typical case in which the authority establishes the avoidable additional co-payment to be the full price differential between the price of the branded drug and the price of reference. Section 1.4 summarizes the results and suggests ways in which those results can be identified in quasi-experiments (regime changes) or with a sample of product markets that are already under the RP regulation.

1.2 The Model

1.2.1 Set up

This model features many characteristics of the one presented by Economides (1993). It has been changed in a number of ways to better fit it to the case of a pharmaceutical market as mentioned in section 1.1.2. There is an incumbent firm (originator) with label 1 and a potential entrant with label 2. Firms (products) are both vertically and horizontally differentiated. We denote by z_j $j = \{1, 2\}$ a firm specific ''quality'' attribute which satisfies $z_1 \geq z_2$ and z_j will be selected from an interval $[0, z]$. Although this approach has been used before to study pharmaceutical markets [See Cabrales (2003) and Merino-Castelló (2003)] the interpretation is somehow different from the traditional view suggested in the seminal work of Shaked and Sutton (1987), for example. In our setting, the idea is that the incumbent provides a branded product which is supposed to ''capture'' an important share of the preferences of heterogeneous physicians prescribing drugs. In the literature mentioned above, it is sustained that vertical product differentiation is an adequate way to model the fact that firms invest in *perceived quality* as a mean to create *brand loyalty* from physicians.

If both firms participate in the market they will be in addition, an in principle, symmetrically and exogenously located in a line segment $[0, S]$ of *physical* attributes. We will assume that $S \geq 1$, where $S = 1$ is the initial size of the market. The reference firm will be at position $a < \frac{S}{2}$ whereas the incumbent will be at $S - a$. An originator drug and a corresponding generic copy will be close to each other in terms of their characteristics, for instance in terms of their efficacy and side effects. We allow, however, for some horizontal differentiation to model the fact that these two drugs are not identical. Therefore, there are relevant characteristics (e.g. inactive ingredients) that cause differentiated side effects. In this sense, horizontal product differentiation is not strategic

but exogenous and due to the form in which each producer prepares its own treatment. Hence, a firm will be ''located'' in a point of the space $[0, z] \times [0, S]$.

Since the relevant exercise implies studying entry conditions for a sufficiently close substitute for the incumbent's product, and in particular a generic variety of the originator drug, we will always study the equilibrium of the model for a close to $\frac{S}{2}$. That is, for a small and positive scalar $\varepsilon > 0$, $a \in [\frac{S}{2} - \varepsilon, \frac{S}{2})$.

Consumers are uniformly distributed along the interval $[0, S]$ of preferred characteristics, where the position is labeled x and S indicates the size of the heterogeneity of preferences for drug physical characteristics. The density at each location is then $f_x = \frac{1}{S}$ and its cumulative distribution function (c.d.f) is $F_x = \frac{x}{S}$. A consumer whose preferred treatment is x but is offered a variety located at l will face a dis-utility for the mismatch which is quadratic: $t(x - l)^2$ where t is a parameter of the substitution of competing varieties which in what follows we normalize to $t = 1$. Other papers have used this type of formulation which is intended to model the fact that varieties produce different side effects and the intensity of those side effects are modeled as a distance of the characteristics of the patient and the treatment. Although the horizontal dimension has limited intuitive interpretations, one might think of a larger size of heterogeneity as an index of the complexity of the disease on the population of patients. Some medical conditions could affect a larger size of the population than others, making it more difficult for one drug to match the multiple individual conditions that must be treated. For example, drugs that are used to treat the flu have often very different intensities of side effects as a larger size of the population is usually affected by this disease.

Although branded and generic drugs are taken in practice as perfect substitutes from the perspective of their therapeutic characteristics: main active ingredient (molecule), dosage, etc., it is the case that branded drugs have different non-trivial characteristics than those of generic products. Hence, we will always allow for at least some degree of differentiation through the horizontal

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dimension as described in section 1.1.2.

At each point of the segment there is a distribution of tastes for quality attributes θ belonging, for simplicity, to the interval $[0, 1]$ with density $dG = 1$, hence the mean valuation parameter is $\bar{\theta} = \frac{1}{2}$. Seemingly controversial, the quality dimension of pharmaceutical products have been used in the literature specially to model and explain price changes for branded drugs in response to entry of other varieties. This type of interpretation would make sense in the U.S. where patients are heterogenous on their insurance coverage bringing about a sense of vertical differentiation due to differences in income levels as a source of market segmentation. In Europe, in general, this type of interpretation is misleading as most patients are insured at the same level by National Health Systems (NHS). Hence, a more sensible interpretation would be the existence of heterogeneity of perceptions on the safeness of a drug. Branded drugs, due to its previous existence and continuous marketing are supposed to have the best reputation of safeness with respect to an unknown variety or non-branded variety.

Nevertheless the discussion in the lines above calls for a specific terminology of the vertical dimension, we will follow the literature and simply refer to it as a ''perceived quality'' dimension as in Cabrales (2003).

Reference pricing and co-payments

There exists a compulsory co-payment, or initial co-payment, that consumers have to make out-of-pocket. This is assumed to be fixed across products at $0 < \alpha \leq 1$. Hence any patient consuming product j has to pay at least αp_j for $j = 1, 2$. The national health authority introduces also an additional co-payment based on the cost differential of the treatment chosen and a price of reference $\widetilde{p}$ for the treatment. This additional co-payment takes the following form: $\beta (p_j - \widetilde{p})$ whenever it is verified that $p_j > \widetilde{p}$ and where $0 \leq \beta \leq 1 - \alpha$.

The upper limit of the regulatory parameter implies that the most stringent regulatory decision is to force the patient to bear the entire cost differential between the cost of the preferred available treatment and the cost of reference. We will refer to the case where $\beta = 1 - \alpha$ as the case of *full reference pricing* or FRP. Nonetheless, the model may allow for different degrees of incidence of the reference price system by modeling the regulatory decision as a continuous parameter, β however, it is most usual that the regulatory decision, in reality, is discrete so that either there is no reference system or there is such a system forcing the patient to bear an out-of-pocket payment of $(p_j - \widetilde{p})$ on top of the initial co-payment based on the price of reference, $\alpha\widetilde{p}$.

The patient, possibly advised by a pharmacist, can lessen or avoid the additional co-payment if she switches to a cheaper treatment. We assume that the alternative cheaper treatment is always available and the pharmacist has full incentives to inform the patient about the existence in the first place. In principle, both drugs are available for the patient at her local pharmacy.

As a matter of comparison with previous papers (cf. Merino-Castelló (2003)) we will set the value of α to $0.4 = \frac{2}{5}$ as it is supposed to be the usual level of initial co-payment for example in Spain.

Consumers' choice and internal RP

Assume consumers have the same valuation for successfully treating a disease v and this is large enough such that all consumers are treated in equilibrium. A consumer i whose most preferred treatment is x_i, is assumed to enjoy the following utility from consuming a product j:

$$V_{j,i} = \begin{cases} \theta_i z_j - (x_i - l_j)^2 - \frac{2}{5}p_j - \beta(p_j - \widetilde{p}) & \text{if } p_j > \widetilde{p} \\ \theta_i z_j - (x_i - l_j)^2 - \frac{2}{5}p_j & \text{if } p_j \leq \widetilde{p} \end{cases} \qquad (1.2.1)$$

For $j = 1, 2$ and $l_1 = S - a$ and $l_2 = a$.

Consumers are assumed to buy only one unit of the desired treatment so that the choice is made over a discrete space. In some sense consumers select a complete treatment rather than a quantity of tablets, therefore competing drugs are assumed to deliver also similar lengths of treatment. To obtain the demand for each drug we first find the indifferent consumer in terms of the preference for varieties. As it is the case of interest, we will assume that $p_1 > \widetilde{p} \geq p_2$ and we will also assume or impose that if firm 2 decides to enter it does so with a lower but positive level of quality such that we observe $z_1 > z_2 > 0$.[6]

In order to construct more easily the demand system we also impose a condition so that $(\frac{2}{5} + \beta)(p_1 - p_2) + \frac{S(S-2a)}{(z_1 - z_2)} \geq 1$. We denote by p and z the corresponding vectors of prices and qualities. Under the set of assumptions adopted so far the demand system is given by:

$$Q_1(p, z) = \frac{S(S - 2a) + \bar{\theta}(z_1 - z_2) - \frac{2}{5}(p_1 - p_2) - \beta(p_1 - \widetilde{p})}{2(S - 2a)} \qquad (1.2.2)$$

$$Q_2(p, z) = \frac{S(S - 2a) - \bar{\theta}(z_1 - z_2) + \frac{2}{5}(p_1 - p_2) + \beta(p_1 - \widetilde{p})}{2(S - 2a)} \qquad (1.2.3)$$

Where, Q_j is the quantity sold by firm $j = 1, 2$. In this paper we will study a circumstance in which the regulator will always design beforehand the RP regime considering that a cheaper substitute of the original drug will always enter the market. In the regulator's plan, once patent expires it will expect to set $\widetilde{p} = p_2$. This assumption is motivated by our interest on studying

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[6]It will be shown later that, in equilibrium, indeed setting $z_2 = 0$ for the potential entrant is equivalent to stay out of the market.

the strategic effects of the regulation over the decisions of undertakings that internalize that with certainty regulation will take this form. In this setting, firm 2 is the firm of reference. This version of the RP scheme is sometimes called internal reference pricing as opposed to a version in which the price of reference is taken from a foreign market. Define the price and quality differentials as following, $\Delta z = z_1 - z_2$ and $\Delta p = p_1 - p_2$. Under the internal RP assumptions the demand system reduces to:

$$Q_1(\Delta p, \Delta z) = \frac{S(S - 2a) + \bar{\theta}\Delta z - \gamma\Delta p}{2(S - 2a)} \tag{1.2.4}$$

$$Q_2(\Delta p, \Delta z) = \frac{S(S - 2a) - \bar{\theta}\Delta z + \gamma\Delta p}{2(S - 2a)} \tag{1.2.5}$$

Where $0 < \gamma = \frac{2}{5} + \beta \leq 1$. Note that γ cannot be equal to zero, otherwise prices will have no importance and most possibly profits will be not-concave in which case we loose some regularity characteristics of the functions that are desirable to ease the analysis. This means that necessarily the initial compulsory co-payment α needs to be bounded away from zero which is the case in reality. For future reference, and for simplicity (as it does not change anything), we will say that there is no price regulation, NPR, whenever $\gamma = \frac{2}{5}$, and we will say that there is a full price regulation regime, FRP, whenever $\gamma = 1$

A complete derivation of the demand system can be found in the Appendix A.1 at the end of this document.

Profit functions and technology

We assume constant marginal costs of production for both types of firms and these are set to be zero for simplicity. Most of the empirical exercises in the literature basically make this assumption based on specific industry data. For

instance some empirical works have calculated that marginal costs are around 5% of the final price (See Caves et. al. (1992)).

We further assume that any level z_j of quality has a convex cost, however the incumbent may have a technology advantage modeled through a parameter $c \geq 2$, so that $\frac{z_1^2}{c} \geq \frac{z_2^2}{2}$ whenever $z_1 = z_2$. As noted before, the incumbent is endorsed a technology advantage that is correlated with the previous length of patent protection much in the spirit of Cabrales (2003). However, in Cabrales' model the cost advantage is linear with respect to the cost parameter of the potential generic entrant. In contrast, in our model the cost advantage function is $1/c$ for the incumbent which delivers lower relative advantage increases the higher is c.

In general, we will look for an equilibrium in which $p_1 > p_2$, then de incumbent profit function is given by:

$$
\pi_1(\Delta p, \Delta z) = \begin{cases} p_1 \frac{S(S-2a) + \bar{\theta}\Delta z - \gamma\Delta p}{2(S-2a)} - \frac{z_1^2}{c} & p_1 > p_2 \\[3mm] p_1 \frac{S(S-2a) + \bar{\theta}\Delta z - \alpha\Delta p}{2(S-2a)} - \frac{z_1^2}{c} & p_1 \leq p_2 \end{cases} \tag{1.2.6}
$$

For the reference firm we assume, although not crucial, that apart from any expenses on a selected level of quality, it has to face a set-up or entry fixed cost of F. This setup cost can be interpreted as the cost associated with proving bio-equivalence and safeness to the standards of the national health authority. Therefore, its profit function is given by:

$$
\pi_2(\Delta p, \Delta z) = p_2 \frac{S(S-2a) - \bar{\theta}\Delta z + \gamma\Delta p}{2(S-2a)} - \frac{z_2^2}{2} - F \tag{1.2.7}
$$

As we will see in the next section, firms are assumed to play a two-stage game

in which firm 2, the firm of reference will decide to enter only if its expected profit levels given the incumbent's decision on its level of quality investment, is at least enough to cover the entry fixed cost $F \geq 0$. Otherwise the potential entrant is assumed the stay out of the market with $z_2 = 0$.

1.2.2 Timing and equilibrium

We model the strategic interactions between the incumbent and the potential entrant in an oligopoly model of price competition, however firms are expected to invest in a quality attribute.

Firms are assumed to play a two-stage game, in the first stage firms play a sequential quality game. In the first period, firm 1 chooses its quality level considering the optimal strategies of firm 2, that is it enjoys a leader's advantage. Firm 2 will decide to enter and its quality entry level if it is capable of covering the entry cost. In the second stage, firms decide simultaneously their prices.

Figure 1.1 shows how the game unfolds. We will solve for a sub-game perfect Nash Equilibrium by means of a backward induction exercise. Quasi-concavity of the game secures the existence of a sub-game perfect Nash Equilibrium in pure strategies, hence we can safely solve it by backward induction solving first the pricing stage game using the Nash Bertrand price equilibrium concept:

Equilibrium in the pricing stage game

We first obtain the reaction functions for the pricing sub-game for both firms by taking their corresponding first order conditions:

$$p_1 = \frac{1}{2\gamma}\left(S(S-2a) + \bar{\theta}\Delta z\right) + \frac{1}{2}p_2 \qquad (1.2.8)$$

Figure 1.1: *Timing and decisions of the game*

Period 1

Firm 1 selects z_1 **internalizing the best reaction of 2**

Firm 2 observes z_1 **and decides to enter or not:**

It enters if $\pi_2 > 0$ **and sets** $z_2 > 0$

It stays out if $\pi_2 \leq 0$

Period 2

Firms select simultaneously p_1 **and** p_2 **à la Bertrand**

Firm 1 behaves as a price constrained monopolist where RP is external
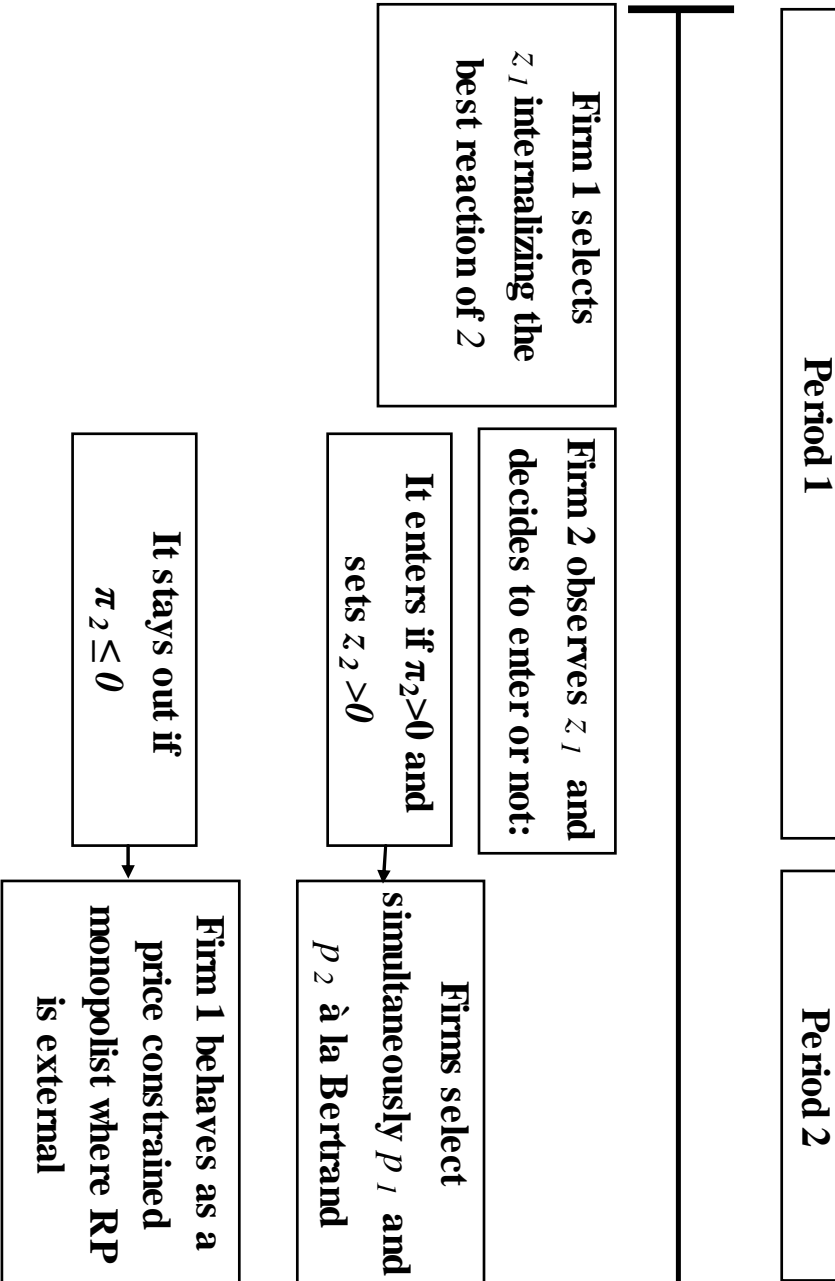
$$p_2 = \frac{1}{2\gamma} \left(S(S - 2a) - \bar{\theta}\Delta z \right) + \frac{1}{2}p_1 \tag{1.2.9}$$

As a regular result, prices are strategic complements. The Nash equilibrium of the pricing stage game is given by:

$$p_1^* = \frac{1}{3\gamma} \left(s_0 + \bar{\theta}\Delta z \right) \tag{1.2.10}$$

$$p_2^* = \frac{1}{3\gamma} \left(s_0 - \bar{\theta}\Delta z \right) \tag{1.2.11}$$

Where the function s_0 is defined as follows:

$$s_0 = 3S(S - 2a)$$

This function s_0 can be understood as an index of symmetric market power that will increase with S, as firms can better profit from their corresponding ''back yards'' and decreases with a as firms become closer substitutes in their physical relevant characteristics. As it can be seen following the price equilibrium $\{p_1^*, p_2^*\}$ that any positive quality differential implies a positive price differential.

A digression on horizontally homogeneous drugs

From the equilibrium prices, (1.2.10) and 1.2.11), it can be seen that if firms produce identical products, meaning $a = \frac{S}{2}$ and so $s_0 = 0$. Then the potential entrant will never have an incentive to enter the market because in general it will have to charge negative prices, as it is always the case that $\Delta z > 0$, which is not possible. Remember that the incumbent can produce the same amount of marketing as the potential entrant more efficiently. The incumbent will have

to serve the entire demand S. In this case, one might expect the incumbent to provide at least some marketing investments to profit from a positive price, in fact in this case the amount invested will be: i) increasing in the parameter of efficiency advantage, c and ii) increasing in the parameter of the market size, S.

Note also that this result depends on the assumption that marginal costs of production are constant and equal to zero. With positive marginal costs prices will depend positively also on this and it can be shown that the potential entrant might enter the market as long as the quality differentials does not offset the marginal cost of production. This will mean that an inefficient entrant, possibly a generic producer, might enter the market. We do not further discuss this case as products are considered to be exogenously horizontally differentiated.

Statics of regulation on the pricing game

As a preliminary inspection we are interested in the sensibility of the second period strategic choices to the regulatory ambience. In our model we have parameterized in a very simple way the regulatory design. In fact, increasing regulation is translated into an increase in γ up to its natural limit 1.

Assume that the quality is exogenously given and is always non-negative. As a preliminary result, this model predicts that increasing the stringiness of price regulation will reduce both the incumbent and the reference firm prices. This is true for positive prices in equilibrium. As noted in the following price derivative:

$$\frac{\partial p_1}{\partial \gamma} = -\frac{1}{3\gamma^2}\left(s_0 + \bar{\theta}\Delta z\right)$$

$$\frac{\partial p_2}{\partial \gamma} = -\frac{1}{3\gamma^2}\left(s_0 - \bar{\theta}\Delta z\right)$$

For an equilibrium in which $p_1^*, p_2^* > 0$, prices will be reduced but the price of

the incumbent will be hurt more than that of the potential entrant. In fact, the higher the expected price differential without pricing regulation, that is the higher $\Delta p|_{\beta=0} = \frac{1}{3\alpha}\Delta z$, the higher the initial effect of a positive level of regulation over the incumbent. Price differentials will go down depending on the regulatory effects over quality differentials.

Intuitively, as price competition is fostered by the introduction of price regulation, then firms may find it optimal to further soften this competition by increasing the degree of product differentiation, in this case their degree of vertical product differentiation. However, thinking twice the problem it also follows that when investing in quality is a costly activity it could be the case that the incumbent would find it optimal to lower its investments in quality. A discussion on this type of result can be found in Noh and Moschini (2006).

Equilibrium in the attribute sub-game

We now solve the first period quality game given the solution for the stage pricing game obtained in the last sub-section. We collect the reduced form equations for the prices in $p(\Delta z) = [p_1(\Delta z), p_2(\Delta z)]$. We define the reduced form profit function from the pricing game for the entrant as follows:

$$\pi_2\left(\Delta z\right) = \frac{1}{18(S-2a)\gamma}\left(s_0 - \bar{\theta}\Delta z\right)^2 - \frac{z_2^2}{2} - F \qquad (1.2.12)$$

The corresponding reaction function of the entrant for the quality sub-game is obtained by taking the first order condition of the above reduced form profit function with respect to z_2 taken as given the quality level of the incumbent:

$$z_2 = \frac{s_0}{s_1}\bar{\theta} - \frac{\bar{\theta}^2}{s_1}z_1 \qquad (1.2.13)$$

where:

$$s_1 = 9\gamma \left(S - 2a \right) - \bar{\theta}^2$$

As a regularity condition we will impose that $s_1 > \bar{\theta}^2$. Whenever the optimal z_1 is greater than $\frac{s_0}{\theta}$ we assume that the best response from the potential entrant is to set $z_2 = 0$. Note however that from equation 1.2.11, this implies a price of zero so that in this case $z_2 = 0$ is equivalent to set $\pi_2 < 0$ for $F > 0$, meaning that the firm will not enter the market. Note also that even with $F = 0$ the potential entrant will not enter the market. In fact with $F > 0$, the value of z_1 that makes entry unprofitable is in general lower than $\frac{s_0}{\theta}$. In Appendix A.2, we show the function ξ_1 which is the threshold, as a function of F, that makes entry unprofitable. There it is shown that when $F > 0$, the value of z_1 that makes entry unprofitable is lower than $\frac{s_0}{\theta}$.

The best response for the firm of reference is, in general, a decreasing function in the level of the quality attribute of the incumbent firm. Attributes are then strategic substitute actions from the point of view of the potential entrant. The reaction function changes both its intercept and slope negatively with the stringiness of price regulation. It can be shown that s_1 is an increasing function on the regulatory parameter. The higher the level of γ the lower the best response of the potential entrant for any level of z_1 provided a positive level of quality investment of the potential entrant.

The latter expected result means that as price competition becomes tougher due to the regulatory intervention, the best response of the potential entrant prescribes a lower margin of vertical product differentiation with respect to the case in which there is no price regulation.

The profit function for the incumbent is:

$$\pi_1\left(\Delta z\right) = \frac{1}{18(S-2a)\gamma}\left(s_0 + \bar{\theta}\Delta z\right)^2 - \frac{z_1^2}{c} \qquad (1.2.14)$$

The reduced form profit function for the incumbent should consider then the best reaction of the potential entrant to any level of its own investment. The profit function for $z_1 < \frac{s_0}{\theta}$ is, therefore:

$$\pi_1\left(z_1\right) = \frac{1}{18\gamma(S-2a)s_1^2}\left(s_1 s_0 - s_0\bar{\theta}^2 + \bar{\theta}9\gamma\left(S-2a\right)z_1\right)^2 - \frac{z_1^2}{c} \qquad (1.2.15)$$

We will assume that this function is strictly concave on z_1. Taking the first order condition with respect to z_1, the optimal level of quality follows for the incumbent firm:

$$z_1^* = \left(\frac{s_1 - \bar{\theta}^2}{\frac{2}{c}s_1^2 - (s_1 + \bar{\theta}^2)\bar{\theta}^2}\right)\bar{\theta}s_0 \qquad (1.2.16)$$

We will assume this function is strictly positive which is in general true. This is indeed the case as for the numerator $s_1 > \bar{\theta}^2$. For the denominator it can be shown that for $c = 2$ (no efficiency advantage) solving for s_1 such that the denominator is zero gives the solution $\frac{\bar{\theta}^2}{2}(1 - \sqrt{5})$, since s_1 is assumed to be greater than $\bar{\theta}^2$ and the numerator is increasing in s_1 then, for $c = 2$ the numerator is positive. However as c increases z_1^* increases but at some point z_1^* will be negative which is not possible by assumption. Therefore z_1^* is positive as long as c is not to big. [7]

---

[7]There is also a solution for the denominator $\frac{\bar{\theta}^2}{2}(1 + \sqrt{5})$ for which some numerical simulations show that still z_1^* is positive.

Equilibrium with no RP: $\gamma = \frac{2}{5}$

As a benchmark case we first show the equilibrium an its characteristics for the case in which there is no RP regulation meaning that the authority sets $\gamma = \frac{2}{5}$, there is no entry cost $F = 0$ and the incumbent has no efficiency advantage $c = 2$.

Proposition 1.2.1 *Assume there is no RP, hence $\gamma = \frac{2}{5}$. Assume also $s_1 > \bar{\theta}^2$ and $c = 2$ so that there is no cost advantage for the incumbent and $F = 0$. Then there exist a Sub-game Perfect Nash Equilibrium (SPE) for the quality-entry-price game. Denote equilibrium variables with NPR, from no price regulation. The equilibrium is such that $z_1^{NPR} > z_2^{NRP} > 0$, $p_1^{NPR} > p_2^{NPR} > 0$, $Q_1^{NPR} > Q_2^{NPR} > 0$, $\pi_1^{NPR} > \pi_2^{NPR}$*

Proof: Under the assumption that $s_1 > \bar{\theta}^2$, $\frac{\partial \pi_2}{\partial z_2} < 0$ and π_2 is a concave function, therefore the potential entrant has no incentives to leapfrog the incumbent therefore the equilibrium obtained by the first order conditions is a SPE. It is relatively easy to see that with this conditions, $z_1^{NPR} < \frac{s_0}{\theta}$ hence under the reaction function for the potential entrant prescribes $z_2^{NPR} > 0$. More over, from the reaction function for firm 2, z_2^* the value of z_1 which makes both quality investments equal is $\frac{s_0 \bar{\theta}}{s_1 + \theta^2}$ comparing z_1^* with the former indicates that the latter is greater if $s_1 \bar{\theta}^2 > 0$ which always holds true provided some level of horizontal differentiation. Then it is the case that $z_1^{NPR} > z_2^{NPR}$. From the equilibrium of the pricing sub-game, and the fact that $z_1^{NPR} < \frac{s_0}{\theta}$, it is straightforward that $p_1^{NPR} > p_2^{NPR} > 0$.

Showing that $\pi_1^{NPR} > \pi_2^{NPR}$ is a bit cumbersome. This is true whenever $\frac{\pi_1^{NPR}}{\pi_2^{NPR}} > 1$. Using z_2^* the profit ratio is greater than one if $8\bar{\theta}s_0 s_1 - (s_1 - \bar{\theta}^2)z_1^* - s_0\bar{\theta} > 0$. This condition is more difficult to observe whenever z_1^* is greater since, by assumption $s_1 > \bar{\theta}^2$. Assume $z_1^* = \frac{s_0}{\theta}$, the level that makes entry

unprofitable. At this level, the condition is shown to be $s_0 s_1 (8\bar{\theta}^2 - 1) > 0$ which is always true. Therefore, since we have shown before that $z_1^{NPR} < \frac{s_0}{\theta}$ then $\frac{\pi_1^*}{\pi_2^*} > 1$, therefore $\pi_1^{NPR} > \pi_2^{NPR}$.

end of proof.

Proposition 1.2.1 tells us that from the most favorable conditions for entry, meaning $c = 2$ and $F = 0$, the model predicts an intuitive equilibrium in which the entrant enters with a lower marketing investment with respect to the incumbent, lower price, lower market share and lower profit. In this case the incumbent has the advantage to anticipate the reaction of the entrant which gives it incentives to invest in marketing so that products are vertically differentiated and the difference in marketing investments delivers all the results.

Now, we can study the predictions of the model under more difficult circumstances for entry. Although the strategic advantage of the incumbent in the quality investment sub-game already describes an equilibrium consistent with empirical regularities, it has been suggested that the length of patent protection gives the incumbent an advantage that makes entry more difficult. In our model this implies increasing c from 2, since it has been suggested that the advantage of patent protection is related to the efficiency of the incumbent to invest in marketing so as to obtain some consumer loyalty. We propose the following lemma:

Lemma 1.2.2 *Consider the equilibrium in Proposition 1.2.1. Then as c increases from 2, meaning an efficiency advantage for the incumbent, the entry profits follows $\frac{\partial \pi_2^{NPR}}{\partial c} < 0$. Therefore, there exists a value of c that makes entry unprofitable.*

Proof: Substitute z_2^* in $\pi_2(\Delta z)$ for $F = 0$ and consider the optimal level of investment of the incumbent, z_1^*:

$$\pi_2(z_1^*) = \left(s_0 - \bar{\theta}z_1^*\right)^2 \left(\frac{1}{2s_1}\right)$$

From the equation of z_1^* and as long this is positive, this quality investment increases as c increases, therefore, the entrant's profit will always decrease with the efficiency advantage of the incumbent. Furthermore, since the level of investment that makes entry unprofitable is $z_1 = \frac{s_0}{\theta}$ then c that makes entry unprofitable is:

$$\tilde{c} = \frac{s_1}{\bar{\theta}2}$$

end of proof.

From the above Lemma and its corresponding proof it is straightforward to see that the efficiency level that makes entry unfeasible is increasing in the size of the market through the function s_1. Hence this model predicts three of the observations in un-regulated markets: First, the potential entrant, if enters, it does so at a lower price and market share than the incumbent. Second, the longer the period of patent protection (in this model, the larger the efficiency advantage for the incumbent) the lower the expected profits for the potential entrant. Third, expected entrant's profits are higher in size the larger the size of the market.

Whenever the structure of the market prescribes that the incumbent's optimal investment is greater or equal than $\frac{s_0}{\theta}$ then we can say that entry is *blockaded* in the usual sense, for example, explained in Tirole (1988). The natural way of analyzing blockaded entry is through the efficiency advantage of the incumbent. Entry will most likely be blocked in markets where the incumbent producer has enjoyed a longer period of patent protection and the

size of the market is relatively small.

Figure 1.2:   *Optimal expected entrant's profit as a function of c for different market sizes S*
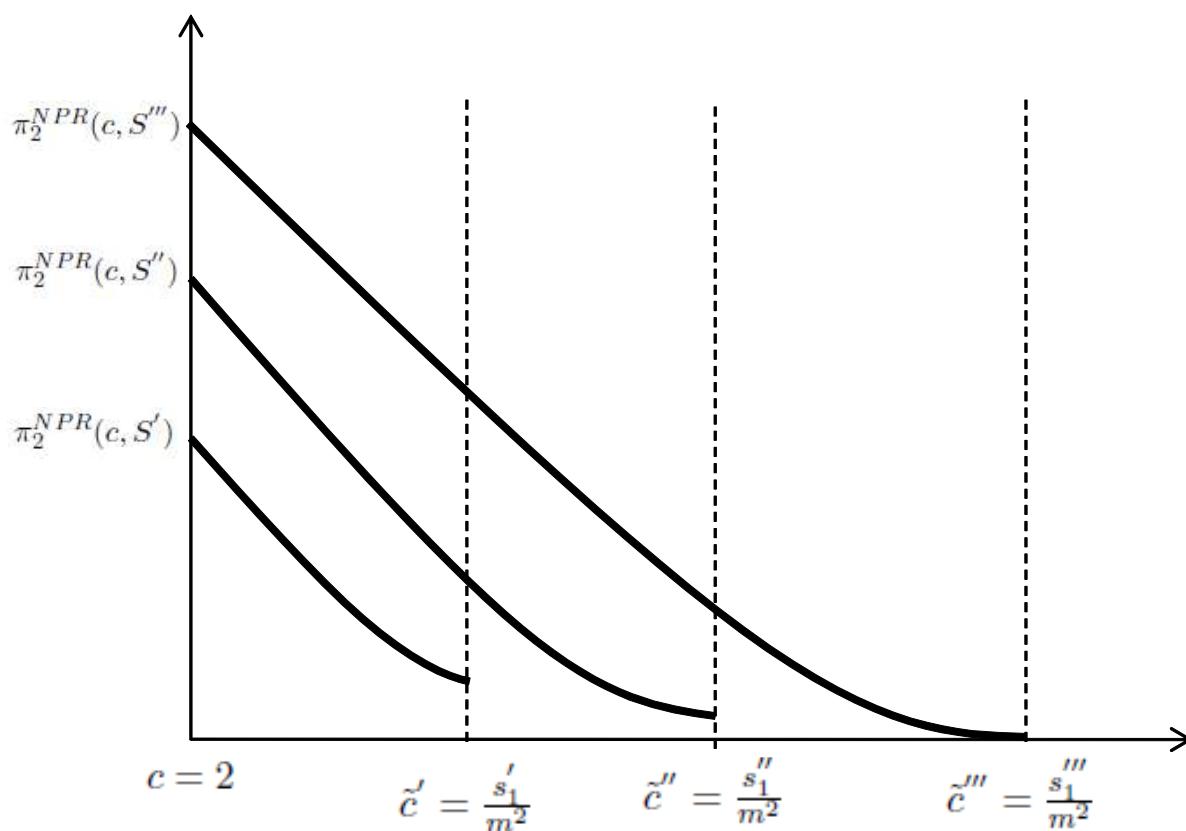
More over, for any given efficiency advantage, the size of the market always increases the expected profits of the potential entrant. Figure 1.2 shows the expected evolution of profits for the potential entrant as c increases. The figure is shown for three different levels of the size of the market, where

$$S' = 1 < S'' < S'''.$$

The intuition of this result is straightforward. As the incumbent increases its level of investments, because it is cheaper for greater c, the best reaction of the potential entrant is to reduce its own investment and concentrate in the low quality individuals. Therefore quality differential increases, which reduces the price of the incumbent (it will concentrate in providing a low quality low price product) but not enough so as to compensate for the quality differential so that its expected demand is smaller, therefore its expected profits will always be lower.

Numerical example

We clarify the predictions of the market by showing a numerical example for the findings discussed in the previous section. In the following Table 1.1 we show the expected profits for the entrant as a function of the efficiency advantage from the incumbent, c, which increases from no efficiency advantage $c = 2$. The table also show variations of the result for different market sizes from the smallest $S = 1$ specified in the model.

Table 1.1: *Expected entry profits π_2^* for the NRP for different c and S*

c	S=1	S=1,25	$S = 1,5$
2,0	0,148	0,352	0,665
2,5	0,090	0,278	0,570
3,0	0,033	0,199	0,471
3,5	-	0,120	0,367
4,0	-	0,048	0,262
4,5	-	0,002	0,160
5,0	-	-	0,070

As it is shown, for the smallest market size, entry is only feasible as long as $c \leq 3$, that is fifty percent above the level where the incumbent has no advantage. For higher values, then entry is not profitable. The result changes when the size of the market increases to $S = 1,25$, the expected profit increases with respect to the initial market size until the efficiency advantage takes a value of $c = 5$. For a much larger market size, fifty percent above the initial level, entry is profitable for every level of the efficiency advantage.

For the non regulatory case, the model then delivers sensible results in that as efficiency increases for the incumbent, most possibly because of a larger period of previous patent protection, the expected profits decreases. However, as market size increases the expected profits are in general greater, meaning that even with a large efficiency advantage from the incumbent, the size of the market can give room to entry.

Horizontally differentiated products

The model, moreover, is robust in its predictions whenever we explore the situation in which the potential entrant's product and the incumbent's are more differentiated in its, say, physical characteristics. We have claimed that the analysis so far is valid for products that, although, not identical are close enough so as to suggest that they are interchangeable for consumers whenever perceived quality differentials are large enough. When products are more differentiated in terms of the horizontal dimension of the model, then this can be interpreted as situation in which the incumbent originator producer faces the entry of an alternative therapeutically equivalent product, as in Brekke, Königbauer, and Straume (2007) or Miraldo (2009). In this case, products are supposed to be differentiated more significantly, say, in its main active ingredient. Then the extreme case is that in which $l_1 = S$ and $l_2 = 0$, that is firms are located in the edges of the line segment $[0, S]$

Therefore, the expected result when products are far apart from each other in its characteristics are the following: i) As products are more imperfect substitutes from the demand point of view, price competition is softened, ii) the latter translates in lower investments in perceived quality from the incumbent as its relative return decreases, iii) However, the potential entrant has incentives to increase its marketing expenditures as it its best response to the optimal decision of the incumbent. Then quality differentiation is much lower than when products are closer substitutes.

Prices are overall greater than in the case of Proposition 1.2.1, profits are also greater, and therefore entry is much more feasible. Therefore, the model predicts that it is easier for a potential entrant to profit from the market if it does so with a new therapeutically equivalent product provided, of course, that the expected profits are enough to cover the sunk costs of the investments required to produce the innovation. This, for example, will be the case of a large laboratory seeking to enter a market with a new product that has already been developed.

This analysis is shown more schematically in the Appendix A.3.

1.3   Analysis of the Price Regime

In this section we perform the analysis and review the predictions of the model in terms of the price regime designed so as to promote price competition. To begin with, let us recall that the price regime is supposed to deliver up to three important results for policy makers: i) As it promotes price competition by increasing the price elasticity of demand, then overall costs of treatment are reduced (average prices reduces), ii) the usage of the potential entrant increases, provided it enters the market, iii) the regime is supposed to increase the likelihood of entry of the potential generic producer.

1.3.1 Internal RP regime with no efficiency advantage

As described in section 1.2, the RP regime implies for the consumer of the expensive originator drug that, on top of paying the initial copayment corresponding to the product of reference $\frac{2}{5}$ she will have to pay the entire difference differential $p_1 - p_2$. Note that the full price regulation regime implies $\gamma = 1$ as $\beta = 1 - \alpha$.

Considering the result of Proposition 1.2.1, introducing the full price regulation regime implies decreasing z_1^* as increased price competition reduces the incentives to invest in the marketing. However, note that from the reaction function of the potential entrant z_2^* it is not clear whether the best reaction will be to increase its marketing effort or reduce them, basically because increasing γ towards 1 implies increasing the function s_1 which reduced both the intercept and the slope (in absolute value) of the reaction function.

In fact, the quality differential reduces but reducing also the marketing investment of the potential entrant. Hence this is a positive effect for the entrant as its equilibrium price depends negatively in the quality differential. However, there is a direct effect of price regulation over its equilibrium price because price regulation makes price competition more profound (as prices are strategic complements). This direct effect prevails and the equilibrium price of the potential entrant is reduced by the regulatory regime.

The following Proposition shows the result in which the essential assumption is that the size of the market is relatively small, in terms of S this happens when $S = 1$.

Proposition 1.3.1 *Consider Proposition 1.2.1 and additionally assume $S = 1$, that is the market is relatively small. The full reference pricing regime $\gamma = 1$ makes the expected profit of the potential entrant under this regime π_2^{FRP} (full reference pricing) to satisfy $\pi_2^{NPR} > \pi_2^{FRP}$.*

Proof: Consider first the optimal investment in quality for the incumbent, z_1^* when there is no efficiency advantage, $c = 2$, $z_1^*(c = 2)$. This optimal investment is decreasing in the regulatory regime γ, since:

$$\frac{\partial z_1^*(c = 2)}{\partial \gamma} = -\left(\frac{(s_1 - \bar{\theta}^2)(1 - \bar{\theta}^2) + \bar{\theta}^4}{(s_1 - (s_1 + \bar{\theta}^2)\bar{\theta}^2)^2} \right) s_0 \theta \frac{\partial s_1}{\partial \gamma} = H(s_1) s_0 \theta \frac{\partial s_1}{\partial \gamma}$$

is decreasing because $\frac{\partial s_1}{\partial \gamma} > 0$ and $H(s_1) < 0$. Now recall the expected profit function for the potential entrant as a function of the optimal investment of the incumbent:

$$\pi_2(z_1^*) = \left(s_0 - \bar{\theta} z_1^* \right)^2 \left(\frac{1}{2 s_1} \right)$$

Taking the first order condition with respect to γ follows the expression:

$$\frac{\partial \pi_2(z_1^*)}{\partial \gamma} = H(s_1) s_0 \theta \frac{\partial s_1}{\partial \gamma} - \frac{(s_0 - \theta z_1^*)}{2 s_1^2} \frac{\partial s_1}{\partial \gamma}$$

Since $\frac{\partial s_1}{\partial \gamma} > 0$ for this partial derivative to be negative it suffices to show that:

$$z_1^* < \frac{s_0}{\theta} - 4 s_1^2 H(s_1) s_0$$

From Proposition 1.2.1 we know that $z_1^* < \frac{s_0}{\theta}$ when $c = 2$. Therefore since $H(s_1) < 0$, then the latter condition is always satisfied.

end of proof.

The full implications of the introduction of the regulatory regime can be better shown with the numerical solution for $\gamma = \frac{2}{5}$, the NRP case, and $\gamma = 1$, the full regulatory regime. In the Table 1.2 it is shown that the regulatory regime

succeeds in reducing the price of the incumbent, however it also reduces the price of the potential entrant. It is also successful in increasing the consumption of the generic variety, as Q_2 increases however, the price effect offsets the grow in the market share of the entrant to the point that the expected profit of the entrant decreases.

Table 1.2: *Equilibrium for $c = 2$ and $S = 1$*

	z_1^*	z_2^*	$\frac{z_2^*}{z_1^*}$	p_1^*	p_2^*	Q_2^*	π_2^*
$\gamma = \frac{2}{5}$	0,484	0,290	0,732	0,565	0,435	0,435	0,148
$\gamma = 1$	0,148	0,132	0,978	0,202	0,198	0,494	0,089

Therefore, whenever there is no efficiency advantage, or in other words, whenever this advantage is not relevant, introducing the full RP regime will always reduce the expected profits of the entrant, hence RP might explain a reduced likelihood of entry in this case.

1.3.2   Internal RP regime with an efficiency advantage

Now, let us show the most relevant result of the paper. We have shown that for no efficiency advantage, the model suggests that introducing the RP regime although successful in reducing prices and increasing the consumption of the generic entrant might actually induce less entry as entry profits are driven down.

Recall that from equation 1.2.16, which showed the level of quality investment from the incumbent, that z_1^* is an increasing function on the efficiency advantage c. In fact we also showed that for small market size, say $S = 1$, expected profits for the entrant are much lower whenever c increases from $c = 2$.

Therefore we might think of a circumstance in which the initial level of efficiency advantage is high enough so that with no regulation the initial expected profit for the entrant is low enough so that the effect of price regulation, by which the quality investment of the incumbent is severely reduced, does so to the point that this effect prevails to the direct effect of such regulation over the price of the entrant. Hence, it is possible to find a market configuration in which the RP actually increases the expected profits of the entrant.

The following proposition suggests this result:

Proposition 1.3.2 *There exists a level of efficiency advantage, that is sufficiently long period of previous patent protection, $\bar{c}^{RP}$ for which the full RP regime $\gamma = 1$ implies that $\pi_2^{NPR}(c = \bar{c}^{RP}) < \pi_2^{FRP}(c = \bar{c}^{RP})$*

Proof: (Sketch) Imagine that for no price regulation, that is the NPR case seen before, $\pi_2^{NPR} = 0$. This is so whenever $z_1^* > \frac{s_0}{\theta}$ which is true, as seen before in Lemma 1 whenever $c > \tilde{c} = \frac{s_1}{\theta^2}$. It is relatively easy to see that for $S = 1$ and sufficient horizontal product differentiation, meaning $a < \frac{1}{2}$ that $c > \tilde{c} = \frac{s_1}{\theta^2} > 2$ which has to be true otherwise we would be contradicting Proposition 1 which has been proven.

Now, it is necessarily true that since z_1^* always decreases with γ irrespective of the value of c, the efficiency advantage, therefore for this extreme case $\pi_2^{FRP} > \pi_2^{NPR} = 0$. Then by continuity of the profit function of the potential entrant, it will always be possible to find a value of c, call it, $\bar{c}^{RP}$ below $\tilde{c}$ but arbitrarily close so as to observe $\pi_2^{FRP} > \pi_2^{NPR} > 0$ under such c^{RP}

end of proof (Sketch)

So far we have not been able to show the exact closed form solution for the problem by which with small $S = 1$, the values of the efficiency advantage can

be divided so that below an specific threshold c^{RP}, the full reference pricing always delivers lower profits for the entrant than with NPR, and above that threshold the full regulatory regime actually increases entry profits with respect to the NPR case. We so far have shown, first, in Proposition 1.3.1, that with no efficiency advantage passing from NPR to full RP always reduces the profits of the entrant. We have also shown, at least in a sketch proof, that must exist some $\bar{c}^{RP}$ which intuitively satisfies $c^{RP} < \bar{c}^{RP}$ in which price regulation has a positive effect over the expected profits of entry.

However we have found the solution by a numerical algorithm in MATLAB, assuming, as noted before the market size $S = 1$ and different values of $a < \frac{1}{2}$, starring from $a = 0,45$. The algorithm solves for the solution of the following expression:

$$\pi_2^*(c|\gamma = 1, a, S = 1, \bar{\theta} = \frac{1}{2}) - \pi_2^*(c|\gamma = \frac{2}{5}, a, S = 1, \bar{\theta} = \frac{1}{2}) = 0$$

The following table summarizes the results for different values of a. For the first value, it shown that $c^{RP} = 2$ (it actually is $c^{RP} < 2$ but it cannot be) meaning that for such close substitutes, introducing the RP regime by setting $\gamma = 1$ always reduces the expected profit of the entrant. For the next value of $a = 0,40$, whenever the efficiency advantage is lower than $c^{RP} = 2,55$, the RP regime reduces the expected profits of entry whereas if the efficiency advantage is higher than this threshold the the RP regime can promote entry.

Table 1.3: *Value of the threshold c^{RP} for some a*

a	c^{RP}
0,45	2,00
0,40	2,55
0,35	3,08
0,30	4,20
0,00	10,90

As the most interesting case is that in which RP is set to a generic substitute, meaning sufficiently close to the branded producer, the numerical solution suggests that, for example, if the generic is located at $l_2 = 0,4$ (conversely the incumbent at $l_1 = 0,6$), the price regulation can have a positive role in promoting entry as long as the efficiency advantage for the incumbent is large enough. Translated into policy making, this results suggest the important Corollary that RP can deliver price reductions as well as improved expectations of entry (as entry profits increases) as long as the regime is put in practice in a relatively small product market in which an incumbent has enjoyed a relatively long patent protection period.

This result might be contrasted for instance for a recent case in Portugal. In a case study, Portela (2009), studied markets before and after the introduction of the RP system and found that generic entry increased which suggests that economic expectations on the market were improved.

Now in the next section we propose an analysis of the results extending it to study the conclusions with respect to market size.

1.3.3   Market size and the efficiency advantage

Note that intuitively, with growing market size, both the incumbent and the potential entrant can take advantage of an increased backyard in the sense that there will be a larger set of consumers to the left of $l_2 = a$ and to the right of $l_1 = S - a$. In this sense, market power will be symmetrically increased for both firms, making it easier to profit from market. In section 1.2.2 we have already shown that for the NPR case, the expected profits for the potential entrant increases with the size of the market, irrespective of the level of efficiency advantage of the incumbent. Market size will not in general change the results for RP, however the profit levels will in general be greater for a larger size.

The effects on the relation between c and FRP that were shown schematically in the last section may be altered though by the size of the market. To recall, FRP was shown to be entry improving for a sufficiently large efficiency advantage of the incumbent. Therefore there was a role for FRP in promoting entry as the expected profits for the potential entrant were shown to be greater under the reference pricing scheme with respect to NPR. Market size, however, will increase the level of efficiency that makes entry unprofitable, that is $\tilde{c} = \frac{s_1'}{\theta^2} < \frac{s_1''}{\theta^2}(FRP)$, for $S' < S''(FRP)$, profits for the entrant as a function of c will be in general flatter for FRP than for NRP. Therefore the level of the efficiency advantage for which FRP has the entry promoting effect will also be increased.

Hence, the model suggests that it will be more difficult to observe the positive effect over entry for the FRP whenever market size is bigger. Notwithstanding, market size always delivers greater profits in equilibrium when comparing two markets with FRP.

Figure 1.3, shows the scheme of the interactions of the size of the market with the efficiency advantage and FRP. The bold lines, as in Figure 1.2, show the expected entrant's profit for two different levels of market size for the NPR case and the corresponding efficiency advantage that makes entry unprofitable. The dotted lines present the corresponding optimal expected profits for the entrant for each of the market sizes for the FRP case. The intersection of each bold line with the corresponding dotted line defines the efficiency value c^{RP} discussed in the previous section. As it can be seen, for the larger market size that intersection occurs at a much higher c, hence FRP cannot deliver the positive result of promoting entry with respect to the NPR case unless the efficiency advantage is very large.

This result suggests that FRP might be designed in a way that consider the

Figure 1.3:   *Optimal expected entrant's profit as a function of c for different market sizes S, $S'' > S'$: NPR vs FRP*
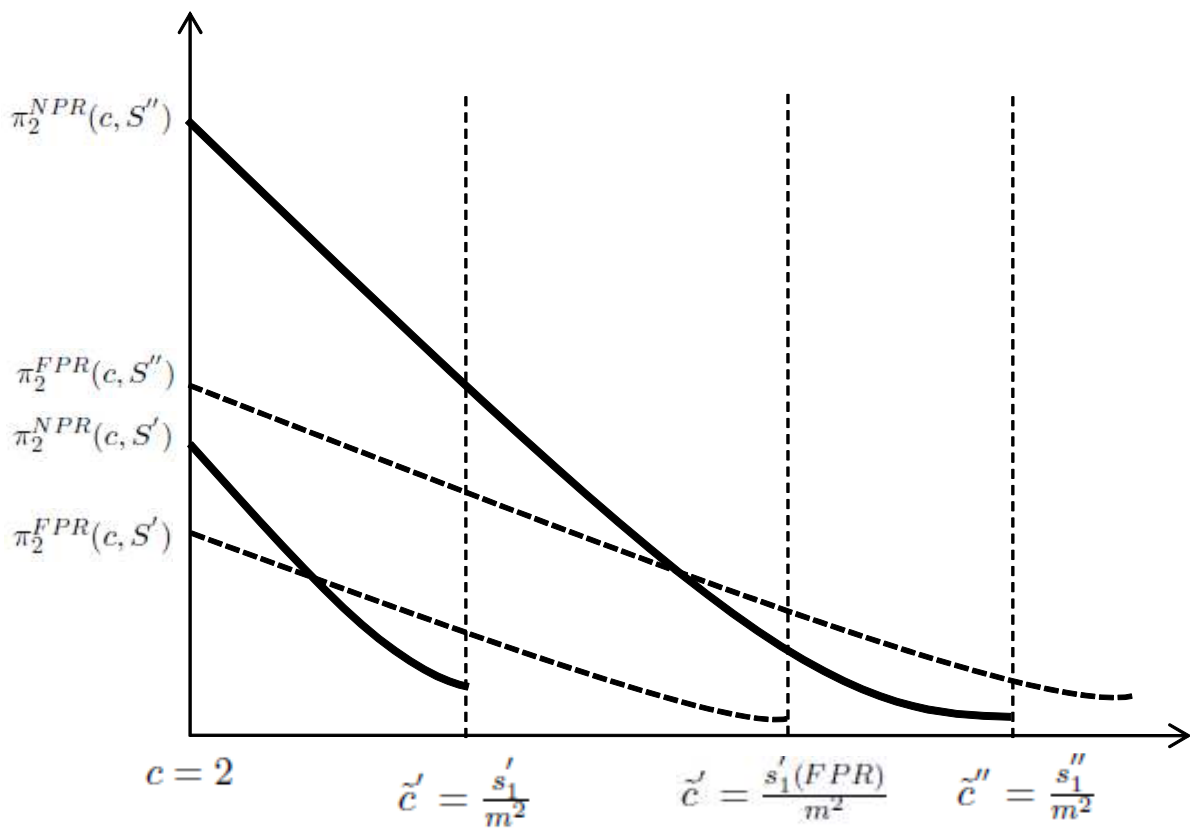
entry discouraging effect for small levels of advantage. For small levels of efficiency advantage, RP could be, for instance, designed at an intermediate level so that $\alpha < \gamma < 1$. For product markets where it is reasonable expected the the incumbent enjoys a high efficiency advantage that can easily make it to invest in marketing for create the perceived quality differential with respect to the potential entrant, then FRP can put in place in the expectation of delivering the entry promoting effect.

1.4 Summary of the results and concluding remarks

In this paper we have presented a model of a pharmaceutical market to study the effects of a reference pricing system (RP) over the likelihood of entry of a generic substitute to the branded originator drug producer. We have shown that the model predicts that under no price regulation, the NPR, case, the likelihood of entry, measured as the expected profits for the generic entrant always reduces with the efficiency of the incumbent firm in providing for perceived quality. At a certain level of the incumbent's efficiency, entry is blocked as this advantage give incentives to the incumbent to increase its efforts in investing in quality differentials. The entrant cannot profit from the market. Market size increases the entrant's profit, as market size implies increased market power. The size of the market also alleviates the problem of blockaded entry as the efficiency advantage required to make entry unprofitable grows larger with this parameter. The efficiency advantage from the incumbent and market size have the expected effects over entry for markets with no price regulation, the NPR case.

In regards to the effects of full price regulation, the FRP case, we divide the results and discussion in two groups, one that refers to the findings of the model

and other referring to suitable hypothesis testing suggested by the model and that can enrich the empirical discussion that is gaining attractiveness.

1.4.1 The effects of RP over entry

In this model we have shown that RP always reduces entry profits when efficiency advantage of the incumbent, either because it has enjoyed before a period patent protection or because it is a large multinational firm, is low. Reduced entry profits are compared to the NPR in which firms compete in a situation in which the only source for direct price elasticity comes from the existence of the initial co-payment $\gamma = \frac{2}{5}$. There are two effects over entry, one positive due to the reduction of quality differentials, and one negative due to the increased price competition that drives down the expected entrant's price. However relatively high efficiency of the incumbent, FRP may alleviate the problem of blockaded entry.

Table 1.4: *Summary of the effects of FRP on the entrant's profit*

	$S = 1$ (Low)	$S = 1,25$ (High)	$S = 1,5$ (Very High)
$c = 2$ (Low)	$\pi_2^{NPR} > \pi_2^{FRP}$	$\pi_2^{NPR} > \pi_2^{FRP}$	$\pi_2^{NPR} > \pi_2^{FRP}$
$c = 3$ (High)	$\pi_2^{NPR} = 0 < \pi_2^{FRP}$	$\pi_2^{NPR} > \pi_2^{FRP}$	$\pi_2^{NPR} > \pi_2^{FRP}$
$c = 5$ (Very High)	$\pi_2^{NPR} = 0 < \pi_2^{FRP}$	$\pi_2^{NPR} = 0 < \pi_2^{FRP}$	$\pi_2^{NPR} < \pi_2^{FRP}$

Table 1.4 summarizes the results of the effect of FRP over the entrant's profit with respect to the NPR case. As it is shown, for the extreme case of no efficiency advantage, when $c = 2$, FRP always reduces the entrant's profits with respect to the NPR equilibrium irrespective of the size of the market. For a high c, in the table $c = 3$, FRP can actually alleviate the problem of blockaded entry for a small market size, as shown in the table, the expected entrant's

profit is positive whereas for the NPR case there will be no profitable entry. As market size increases the effect disappears and FRP reduce the incentives to entry.

For the case of a very high efficiency advantage, c, FRP can actually explain entry, which has important policy implication as it is suggesting a role for FRP, not only as a device to deliver short run price reduction but as a driver to entry as even for a high market size it could alleviate the problem of blockaded entry. Even for a very high market size, FRP explains higher profits for the entrant, however at this point as market size is big enough still the NPR profits are positive.

1.4.2 Testable hypotheses

As for the testable hypotheses that can be studied in an empirical context, we first make a caution comment in that recent empirical studies have used both the length of the previous patent protection and the size of the market as control variables, for example in Moreno-Torres, Puig-Junoy, and Borrel (2009) for the Spanish case. Indeed, our model suggests that controlling for the market size, RP always reduce entry profits. However, controlling for the length of the previous patent protection enjoyed by the incumbent, which we claimed is positively correlated to its ability to deliver more efficiently perceived quality investments, might not be enough to identify the effect of FRP. There appears to be a non-linear interaction between FRP and the length of patent protection, or in our model, the level of the incumbent's efficiency.

In fact, an important question is whether the positive role of FRP can be identified in data. Note that for this it is not necessary to have a policy change from NPR to FRP. With a sample of product markets already working at a FRP regime it could be possible to test whether the entry rates can be explained by a positive role of the FRP regime, interacting the regime with in-

formation on the length of patent protection enjoyed by the incumbent before entry was a potential event.

Additionally, the model suggests that the size of the market might not explain entry at very high levels of this parameter unless the efficiency advantage is very large. The key identification assumption requires the regime change from NPR to FRP. This is radically different with respect to the empirical strategies that has been discussed in the introductory section of this paper. In these empirical papers, market size is a control variable but it could have some interesting interaction with FRP that might be identified in data as long as the policy change can be observed in data.

In this paper we have not play with the level of horizontal product differentiation. This means that all the results requires controlling for the attribute differences in the competing drugs. These attributes have to be introduced in an empirical model in regards to relevant effects as side effects, for instance. Hence, a large set of information might be needed that could be difficult to find and implement in practice.

Chapter 2

Multimarket contact and price regulation: Evidence from pharmaceutical markets

2.1 Introduction

Edwards (1955) introduced the intuitive idea that firms that meet each other in several independent markets may soften price competition in some markets to avoid industry wide tough price competition. In their seminal work Bernheim and Whinston (1990) presented a modern approach to formalize the expected effects of multimarket contacts resorting to competition games with infinitely repeated interactions and trigger strategies. A well known result is that multimarket contact may sustain higher prices if firms are able to transfer slack of collective market power in one market to others where no slack is available. More interestingly in contexts where product differentiation is relevant firms could optimally redistribute their market power across markets, even if no slack in individual markets incentive constrains is available. According to this result, competing firms create slack in more collusive markets, reducing

prices, an allocate the slack to more competitive markets, increasing prices. [1]

Phillips and Mason (1996) took a step further and study the case of multimarket contact under price regulation in which products are homogenous within markets and firms compete in quantities à la Cournot. On one hand, the main result suggests that binding mild price constrains in one market might further increase prices in other markets in comparison with the unregulated case. On the other hand, when price ceilings are further adjusted downwards then no slack might be available so prices in the second market will reflect only the competitive conditions of this market considered in isolation. This findings can be taken as a testable hypothesis with real data.

Price regulation is of paramount relevance in pharmaceutical markets in most OECD countries. Puig-Junoy (2005) asserts that price regulation across OECD countries is basically designed so as to control the financial burden for national health systems. Price constrains according to a large Applied Health Economics literature are responsible for distorting competition and entry in this industry (c.f.Danzon and Chao (2000), Danzon and Epstein (2008) or Kyle (2007)), however there has been little empirical research on plausible market mechanisms through which such distortions are realized.

Our main contribution is to identify empirically whether multimarket competition could interact with price regulations (price ceilings) such that observed prices are in general distorted in ways that might be compatible with the underlying theory. In particular, taken as given that price competition in pharmaceutical markets develops in a product differentiation frame, we aim at testing the hypothesis that the expected market power redistribution effect is distorted according to the theory.

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[1]Ease of collusion depends on a number of factors such as the number of firms operating in the market, product homogeneity, speed of interaction, cost asymmetries, demand stability, etc. Other theoretical works on the multimarket contact structure of industries are Spagnolo (1999) and Matsushima (2001).

To this end we use a unique database of pharmaceutical markets to perform a cross country analysis for nine OECD countries which are known to place different levels of price regulations. We use the U.S. as the industry of reference as it is well known pharmaceutical markets are mostly free of price regulations in this economy. The other eight countries are ordered from those with more market friendly policies to those with stricter price ceilings. Within a country we study multimarket contact in terms of the simultaneous presence of corporations in various product markets. For that aim we adopt several of the contributions by Danzon and Chao (2000), Danzon and Furukawa (2003), Danzon, Wang, and Wang (2005), Kyle (2007) specially to classify countries in our sample according to their stringiness of price regulation.

Confirming the theory with pharmaceutical data has a number of important implications for policy making. Mild price restrictions are expected to further increase prices in markets that where not subject to price regulation or price controls are not binding, producing short run undesirable welfare effects. Strong price regulations in some markets will reduce prices also in more competitive markets with respect to the unregulated case, therefore stringent price restrictions in one market may reduce expected profits in more competitive instances of the industry with respect to the un-regulated benchmark lagging or possibly deterring entry.

Although there has been some interest in contrasting the multimarket theory in several industries, to our knowledge our work is the first in aiming at identifying the theoretical prediction of multimarket contacts in a context of price regulation. Evans and Kessides (1994) , Jans and Rosembaum (1996), Parker and Roller (1997) and Pilloff (1999), provide evidence that multimarket contact is expected to increase prices for the airline, cement, mobile and banking US industries respectively. These studies basically assume that multimarket contact will have the same marginal effect across markets. Indeed they are able to show that firms are expected to place higher prices in mar-

kets where their rivals are also present in a larger set of independent contact markets.[2]

Fernández and Marín (1998) performed an empirical strategy to test for the market power redistribution hypothesis in the Spanish Hotel industry. Their functional form for multimarket contact interacts a contact variable with a variable correlated with ease of collusion[3] with the main result that markets with lower ease of collusion are expected to have higher prices due to multimarket contacts.[4]

The most salient feature of our work is the testing, in the context of Fernández and Marín (1998) strategy, whether price regulation affects the redistribution effect in ways compatible with the underlying theory. Other relevant difference of this paper with respect to the existing literature is related to the way we define contacts. In all the studies reviewed contacts are counted in terms of geographical areas, in our case we define contacts across product markets much in the way is suggested in Bernheim and Whinston (1990, Sec. 7) for industries with various degrees of product differentiation across markets. We maintain this approach is suitable for the pharmaceutical industry in light of the presence of several monopolistic product markets (due to patent protection) which provides a source of identification of the significance of multimarket contacts in explaining price variation.

We have found evidence of the market power redistribution effect for the US, where markets for drugs are supposed to be free of price controls. When considering contacts among corporations with products having an equivalent composition prices are expected to increase for product markets below a con-

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[2] More recently, Fu (2003) has shown also for the newspaper industry that multimarket contact reduces substitutability among competing products.

[3] This functional form is taken from an unpublished paper by Gimeno and Woo (1994)

[4] This approach was also present in Jans and Rosembaum (1996), however they did not intend to test for the market power redistribution hypothesis. Nevertheless the latter found that prices are expected to be higher due to contacts across markets whenever concentration is higher in a market.

centration level of ≈ 0.6 considering the Herfindähl-Hirschman index and decrease above that level. For Canada, a medium or mild regulated country, data is also consistent with the redistribution effect, however the size of the effect is larger than for the US. That is, prices are expected to be higher for Canada than the US at low levels of concentration, and prices are expected to be lower for high levels of concentration. We interpret this result as evidence of the expected interaction between mild price regulation and the redistribution effect. For EU medium regulated countries there is some evidence of the redistribution power, however the size is lower compared to the US case. In this case, prices are predicted to be unambiguously lower for any level of ease of collusion with respect to the to first country cases. For strong price regulators, such as Japan and Spain, price variations across products and markets are not determined by multimarket contacts, which is taken as an indication that strong price controls severely reduces market power slackness.

The paper develops the streamline of analysis in the following structure: In section 2.2 we offer a brief description of relevant institutional aspects of markets for drugs as well as common issues related to competition analysis. Section 2.3 presents the theoretical implications of multimarket contacts; we also show how observed prices can be approached from this framework; section 2.4 describes the data set and the variables to be used; next, section 2.5 presents the empirical specification based on the discussion of section 2.3 and also present the relevant aspects of the econometric methods, identification problems and solutions; finally, section 2.6 describes the results and their interpretations as well as some robustness exercises and extensions.

2.2 Markets for pharmaceutical products

2.2.1 Agents and institutional issues

According to Puig-Junoy (2005) there are three different market types in pharmaceutical markets, on-patent markets for prescription drugs, off-patent markets for prescription drugs and markets where products are sold Over the Counter (OTC) without a prescription. Perhaps the most crucial complexity for the economic study of prescription drug markets is the number of agents involved in shaping demand and so the difficulty to approach market analysis by standard means. It is a doctor who is responsible for the choice given its specialized knowledge both of therapies available and patient´s condition. Hence, doctors might or might not be concerned about the economic standing of the patient, or even doctors might prescribe based on other type of incentives additional to the objective of successfully treating a patient. Hence, knowledge of the efficacy of a drug, brand reputation and other factors might induce small substitutability of available therapies in these markets. In addition in most OECD countries a public third party provides different levels of insurance coverage for different therapies, so that in principle patients and doctors are not aware of the treatment costs providing low price and income elasticity of demand.

Although price regulation is easily justified for on-patent drugs (regulation aims at constraining the exercise of monopoly power), OECD countries, with the exception of US, also regulate price levels for off-patent markets whereby in principle competition is possible but affected by the aforementioned institutional factors. Given patients are insured by National Health systems, price regulation focuses in reducing the fiscal burden of public pharmaceutical expenditures. Given this simple approach to price regulation the kinds and size of distortions that these policies may produce are of course diverse and have been explored from many angles by a vast literature within the field of Health

Economics.

Table A: *Market Share by Type of Product*
(Standard deviation in parenthesis)

Country	US	Can	Ger	Neth	UK	Fra	Ita	Jap	Spa
Branded	.5286	.8889	.7602	.9277	.6530	.6284	.8311	.8540	.8248
	(.4527)	(.2609)	(.3488)	(.2103)	(.4131)	(.4266)	(.3123)	(.2797)	(.3170)
Generic	.4236	.0898	.2103	.0534	.3098	.3350	.1390	.1171	.1435
	(.4550)	(.2439)	(.3372)	(.2015)	(.4056)	(.4126)	(.2912)	(.2626)	(.2965)

Danzon and Chao (2000), Danzon and Furukawa (2003), Danzon, Wang, and Wang (2005), Kyle (2007) have found evidence that price regulations reduce competition and delay entry of competitors in drug markets. In particular, some relevant findings suggest that price regulations reduce the incidence of competitive constrains for branded (originator) products by generic drugs, therefore the importance of generic products in off-patent markets differ across countries. Using these papers as references, OECD countries can be grouped by different levels of price constrains. In particular we investigate nine OECD countries from less regulated, US, medium regulated, Canada, Germany, UK and Netherlands to heavily regulated, France, Italy, Japan and Spain. Table A presents information for these countries on the average market share for off-patent drug markets for the period 1999-2003. Information comes from the IMS-Midas database which covers a large number of national drug markets for the aforementioned countries. The US markets have the highest average market share of generic products consistent with the claims of related Health Economics studies. The rest of the data is at least weakly consistent with the evidence provided by the literature, medium regulated countries have lower relative importance of generics in market shares (with the exception of Netherlands) but higher than the more regulated countries.

Regulatory mechanisms are diverse, and even if countries use the same mech-

anism differences can be identified in the implementation among national regulatory bodies. Most EU countries, and Canada, used Reference Prices (RP) to control price levels during our sample period. Reference Prices compare individual prices to an index (mean, median or delike) of prices of chemically equivalent products or therapeutically equivalent products and make the consumer/patient pay a fraction (or the total) of the difference of the targeted drug price with respect to the index of reference. The idea is to promote cost consciousness among patients and to provide incentives to firms to reduce prices by facing them with the risk of loosing market positions. Key alternative versions of RP are internal (local) and external based reference indexes. In EU countries, according to a very recent work by Danzon and Epstein (2008), international RP creates interdependence in strategic firm´s decisions across nations, a situation which is considered in our work in that it might place certain constrains for the identification assumptions.

A similar source of interdependence is related to the so called parallel imports of drugs, that have risen serious concerns specially in the US. In the US and some EU counties, firms are affected by imports of their same products they offer in the national market that come from countries whereby price regulation and specific market conditions allow distributors to commercialize them at much lower prices. US markets suffer from parallel imports from Canada, whereas UK, for example, suffer from parallel imports from other EU nations. The relevance of the interdependence produced either by regulations or parallel imports depends on the price differentials of the countries involved in such interdependence. Table B presents average prices considering all types of drugs and also distinguishing the type of drugs within off-patent lines. In general prices in the US are much higher than in Canada, whereas prices in Germany, UK and Netherlands are higher than in the rest of European countries considered in our study. Although Japan is considered a heavy price regulator, prices are much higher than in the other highly regulated countries which can be explained by differences in income levels.

Table B: *Average prices in current USD*

Country	US	Can	Ger	UK	Neth	Fra	Ita	Jap	Spa
Total	17.8111	5.9955	9.0021	7.8167	8.7802	3.4664	5.5500	16.6381	4.7829
Off Patent									
Branded	9.6495	2.5219	8.7252	1.9661	6.5864	2.8242	6.6625	10.7473	2.3777
Generic	4.9311	1.8916	2.2553	0.4299	2.8478	0.2205	0.7829	2.5400	0.4182

Source: IMS MIDAS

2.2.2 Competition in pharmaceutical markets

Market competitive conditions are often considered in this industry as a function of market segmentation between branded products and generic copies, product differentiation of distinguishable nature and the life cycle of drugs. On-patent drugs might compete with alternative drugs of close therapeutical effects but different chemical composition (molecule), off-patent markets needs to consider the relevance of generic competition and competition in general is expected to place stricter constrains over pricing the more mature is the product market. A precise product market definition is therefore not straightforward.

In the light of these considerations price competition in pharmaceutical markets are thought to be imperfect due to product differentiation coming from different sources. Products with equivalent composition might be vertically differentiated due to advertisement outlays [5] and firm reputation. Products with close therapeutical effects but different composition are differentiated in their characteristics (recommended dosage, side effects, etc.) for a version of horizontal differentiation. Finally two products can be differentiated in both

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[5]Advertisement is known in the pharmaceutical jargon as detailing as it is directed to doctors and not to the general public.

vertical and horizontal dimensions[6]. Theoretical works on pharmaceutical markets, however have placed more weight to the fact that goods are vertically differentiated, basically because it is considered that the most important source of competition in a market comes from the entry of generic products. Competition in pharmaceutical markets place two important questions for our study: First, market definition will have an impact on the source of product differentiation. In simple words, a wide definition will introduce horizontal product differentiation to our analysis, whereas a narrower definition will tend to omit horizontal product differentiation in favor of quality differentiation. Second, product market segmentation due to vertical differentiation may introduce a segment specific structure of contacts among rivals.

2.3 Multimarket contact and price regulation

2.3.1 Market power redistribution

We study an industry where there exist K product markets so as to approach what is observed in the pharmaceutical industry and N firms in each market. The detailed theoretical argumentation is reserved for Appendix B.1, here we present a synthesized version of the results. Firms compete in prices and the one shot game equilibrium prices form a Nash Equilibrium, p_{ik}^n, $\forall i$. Assume firms compete in prices in a repeated fashion with infinite horizon. Firms may sustain in equilibrium higher than the stage game price equilibrium using trigger strategies in which any deviation of the collusive strategy is penalized by reverting forever to p_k^n. If p_{ik}^c is the sustainable price for firm i in the

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[6]Some theoretical works on price competition in pharmaceutical markets are Cabrales (2003) Königbauer (2007). Structural models of price competition with product differentiation in this industry are scarce, Berndt, Bui, Reiley, and Urban (1995) and Cleanthous (2004) are prominent examples.

repeated game in market k, it satisfies the incentive constrain:

$$\frac{\delta}{1-\delta}[\pi_{ik}^c - \pi_{ik}^n] \geq \pi_{ik}(R_{ik}(p_{-ik}^c), p_{-ik}^c) - \pi_{ik}^n \qquad (2.3.1)$$

where π_{ik}^n and π_{ik}^c are firm i's profits when prices are p_{ik}^n and p_{ik}^c respectively, $\pi_{ik}(R_{ik}(p_{-ik}^c), p_{-ik}^c)$ are firm i's profits when all firms other that i set the collusive prices, p_{-ik}^c, and firm i chooses its best response to them, $R_{ik}(p_{-ik}c)$, and $\delta \in (0,1)$ is the discount factor. Here we assume what is called the best collusive outcome so that at any given δ firms select the highest possible price. In the technical appendix we show that for certain usual assumptions about the profit function there is some δ_k^0 above which the monopolistic price, p_{ik}^m is sustainable and the incentive constrain preserve some slack. Below this threshold, the equilibrium price saturate the incentive constrain. Assuming collusive prices are non-decreasing in the discount factor, from (2.3.1) a product market equilibrium price can be characterized by the stage game price and a function of the discount factor:

$$p_{ik}^c = \Phi(\delta)\, p_{ik}^n \qquad (2.3.2)$$

where

$$\Phi(\delta) = \begin{cases} \frac{p_{ik}^m}{p_{ik}^n} & \text{if } \delta \geq \delta_k^0 \\ \frac{\tilde{p}_{ik}(\delta)}{p_{ik}^n} & \text{if } \delta < \delta_k^0 \end{cases}$$

where $\tilde{p}_{ik}$ is the best collusive function whenever $\delta < \delta_k^0$. Following Bernheim and Whinston (1990) a collusive strategy across markets can be sustained if firms realize that defection in one market will trigger retaliation of its rivals in the whole set of K markets. Accordingly, under multimarket contact a firm participating in the multimarket *coalition* will pool its K individual market

incentive constrains:

$$\sum_{k=1}^{K} \frac{\delta_k}{1 - \delta_k} [\pi_{ik}^c - \pi_{ik}^n] \geq \sum_{k=1}^{K} \left\{ \pi_{ik}(R_{ik}(p_{-ik}^c), p_{-ik}^c) - \pi_{ik}^n \right\} \qquad (2.3.3)$$

Bernheim and Whinston (1990) analysis suggest that when markets differ in the number of firms, demand conditions or there are economies of scope, the pooled incentive constrain can be used to sustain higher prices in equilibrium. It is also claimed that asymmetries within markets, which are known to hinder collusion, might be softened through the multimarket contact setting. Absence of such differences across markets makes contacts irrelevant for sustaining more collusive outcomes. However, it is not the mere existence of multimarket contact across differing markets which expands the set of collusive outcomes, but the ability of firms in the coalition to transference market power across markets. Imagine for instance that in some of the K markets firms are able to sustain p_k^m in equilibrium so that the individual incentive constrains are verified in some of them with inequality (in our setting $\delta > \delta_k^0$ for some k). This slack can be used in markets where no collusive price is possible to sustain at the corresponding δ, for example markets where N_k is sufficiently large. Indeed firms in the multimarket coalition can increase prices in more competitive markets violating the individual incentive constrains as long as (2.3.3) is verified. Under this result, average prices in the industry are expected to be higher than in a case where multimarket contacts are irrelevant.

More interestingly, whenever markets differ in their degrees of product differentiation firms can find it optimal not only to transfer but to redistribute their market power. Differences in the degrees of product differentiation across markets will also produce different levels of sustainable collusive prices. In the technical appendix we show that even if firms have no slack in any of the mar-

ket specific incentive constrains, they may find it optimal to create slackness of one market's incentive constrain by reducing the equilibrium price and use this slack to increase prices in markets where in isolation there are less favorable conditions for doing so. The mechanism is somehow complex however the intuitive reasoning goes in the following direction: If prices close to p_{ik}^m are sustainable, a small reduction in the price will produce individual market power slack that can then be used to increase prices in other markets. In the latter markets, the corresponding individual incentive constrains will be violated up to the point (2.3.3) is satisfied with equality. It turns out that this is the case for markets where the marginal profitability of violating the incentive constrain is relatively high with respect to the marginal profitability of defection.

Given the structure of each k market and as a consequence the structure of multimarket contacts for firm i, we can represent the firm's equilibrium price of the repeated game in market k as a function of three separable components:

$$p_{ik}^* = \Gamma(AVMMC_{ik}) \; \Phi(\delta) \; p_{ik}^n \qquad (2.3.4)$$

where $\Gamma(AVMMC_{ik}) > 0$ measures the effect of the multimarket contact structure given by the index $AVMMC_{ik}$ and the other two components come from the definition of the single market price equilibrium. The redistribution of market power can be tested in terms of the value of the multimarket function. $\Gamma(AVMMC_{ik}) < 1$ will be expected for markets where a collusive price is easier to support (less toughness of price competition) in equilibrium and $\Gamma(AVMMC_{ik}) > 1$ in markets with less favorable conditions to sustain collusion. Differences in toughness of price competition among markets can be obtained by looking at the number of varieties available in a market, market concentration, product differentiation and so on.

2.3.2 Multimarket contact and price regulation

The main point of this article is that price regulation, or price ceilings, may distort markets through the multimarket contact structure of the industry. Regulatory agencies for the pharmaceutical industry not only control on-patent product prices but also potentially competitive markets supposedly keeping prices below the imperfect competition equilibrium. Lack of entry, segmentation and price rigidities due to reputation, insurance coverage and other aspects are though to preclude the emergence of strong competition in product markets that are therefore subject to price regulation. We assume that price regulation is not efficient, because as noted in Puig-Junoy (2005), the objective of regulation is to reduce the public financing of national health systems.

In the technical Appendix B.1 we show that price regulation in markets where prices close to the monopolistic prices are sustainable, will have an impact on the optimal price selected by firms under the multimarket contact setting. In particular, mild price regulations, that is binding price ceilings close to the monopoly price, are expected to further increase prices in other markets where price ceilings are not binding or are un-regulated. In this case, the size of market power redistribution is expected to be larger with respect to the un-regulated case. For stronger price regulations, no slack will be available to be redistributed to the rest of the markets, therefore multimarket contact will have no effect over price variations.

By a continuity argument, it is expected that medium price ceilings will have at some point a negative effect over the sustainable prices in other markets.

In terms of observables, we require a very large set of prices and market conditions to analyze in practice whether it is possible to identify on one hand the un-regulated multimarket effect and on the other the predicted distortions incurred by mild, medium and strong price regulations. In the next section we

present our data set and discuss the strategy followed to extract information that can be connected to the regulated multimarket contact analysis.

2.4 The data

2.4.1 Data set description and relevant considerations

We use a multi-country and multi-product Panel Data set from the IMS MIDAS international dataset for the period 1998-2003[7]. This dataset encompasses a large number of countries including the top ten in terms of medicine expenditures, as well as medium size and small countries. We restrict the analysis to data from nine OECD countries, namely US, Canada, Germany, UK, Netherlands, France, Italy, Japan, and Spain. Following the comprehensive study by Danzon and Chao (2000) as well as the advice of recognized experts[8] we group the countries considered in the sample in three regulatory categories. (I) US and Canada belong to the group of more market friendly policies, however Canada is considered to place relevant price controls and might also be included in the next category or in an intermediate category of mild regulated industry; (II) Germany, UK, Netherlands belong to the group of medium intensity of price regulation; and, finally, (III) France, Italy, Japan, and Spain belong to a family of countries that are known to keep lower regulated prices.

In our dataset products are classified in terms of their chemical, therapeutical and pharmacological characteristics using the standard Anatomical Therapeutic Chemical classification or ATC code[9]. This classification is used regularly

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[7]The dataset gather information from the 4th quarter of each year, apart from 2003, for which the information is provided for the 2nd quarter.

[8]We are indebted to Guillem López (UPF) and Vicente Ortún (UPF) and Félix Lobo (UC3M) for helpful advice on this regard.

[9]The ATC classification is supported and maintained by the World Health Organization Collaborating Centre for Drug Statistics Methodology with a base in the Norwegian Institute of Public Health.

in defining and analyzing product markets in this industry. Notwithstanding studies analyzing specific product markets are able to confer more substance to the set of products considered, in this study it is crucial to consider all the information available which implies loosing precision at the time of shaping product markets.

One drawback of the IMS Midas database is related to the units used to measure sales quantities. The IMS Midas uses a standard unit (SU) to measure a particular product sales based on a reference product or recommended daily dosage which may vary across countries. Unfortunately prices are also connected to these standard units introducing a measurement error in this variable. This will cause that some portion of price variation cannot be controlled in our model increasing the variance of the estimates, but leaving the consistency of our estimates unaffected, provided the validity of the identifying assumptions.

2.4.2 Market definitions

The pharmaceutical industry represents a complex exercise for market definition in practice for a number of reasons. Considering geographical boundaries within a country or clear mutually exclusive sets of substitute products is not straightforward. First, we disregard any delimitation of regional markets within a country, as it is reasonably to assume that value to transportation cost in this industry is high, therefore we study product markets at the country level. Second, to avoid subjective market definitions we adopt a strategy, commonly fitted into cross country pharmaceutical market studies in the Health Economics literature, by defining product markets in terms of the ATC classification. However, we first define a market to be the set of products belonging to the same chemical component or molecule and second the set of products belonging to the same ATC-4 classification which groups medicines that have close therapeutical and pharmacological effects.

Both market definitions has disadvantages. Defining a market with respect to a single molecule will not capture possible competitive constrains that on-patent drugs may face from substitute therapies, which is equivalent to assume that on-patent drugs are pure monopolists. Although this limitations are expected to be (partially) solved by using the ATC-4 level classification as our reference market definition, yet we have to bear in mind that this broadened definition might be imposing irrelevant competitive constrains. Hence, individual product prices might appear to have lower covariance with the multimarket structure, compared to the case of the molecule definition.

Albeit some limitations of our market definitions, we can also persuade the reader that having this two somehow different exercises are beneficial at least in two aspects. First, using the molecule definition will still be valid to study the relevance of the multimarket contact structure derived from the interplay of firms with their closer rivals in off-patent markets. This is an original way to test whether the expected competitive climate among products with the same active ingredient are softened by their interactions across markets. Second, once we adopt the wider market definition comparisons with the previous molecule-based results can help us to discuss whether the new set of estimates are possibly due to the inclusion of too many irrelevant contacts. Note also that if multimarket rivalry appears not to explain price variation at the molecule level it is intuitive to expect that it will not explain it at the ATC-4 level either.

2.4.3 Variable definitions and expected marginal effects

The list of variables that we construct is the following. The variable price, called *Price*, corresponds to prices in SU terms. We convert the computed prices to current US dollars. As pointed out by several authors marginal costs are almost irrelevant in the industry [c.f. Stern (1996)]. This suggests the use

of a *hedonic* approach.[10] Accordingly, in our pricing regressions we incorporate variables that are considered to be correlated with some relevant characteristics of an individual product to proxy the stage game equilibrium price. These variables are: The firm's size, *Fsales*, constructed as total corporation sales correcting it by excluding sales of the product under analysis. *Generic* is a dummy variable which takes the value of one if the product is a generic (zero if its a branded or originator drug), and *Composite* is a dummy variable which takes the value one if the product is a combination of two or more molecules. Molecule age, *Molage*, is the time elapsed since the molecule was launched to December 31, 2003. Competition variables related to the mark-up are also computed. These variables are: Number of generics in each market, *Ngenerics*, number of available molecules at the ATC-4 level, *Nmols* as a surrogate to control for the presence of substitute therapies, the Hirschmand-Herfindähl concentration index, $\widetilde{HHI}$, constructed using corporation sales, with squared market shares of the corporation under analysis excluded from the index. We also compute the market share of each variety in the market, *Mshare*, and the aggregate market share of all other varieties supplied by the same corporation in each market (if available), *Cshare*. For the regression analysis we use log transformations of *Price*, *Fsales* and *Molage*, so we value more the differences in smaller than in larger values.

A number of dummy variables are also defined: *New* is a dummy variable equal to one if the product was launched in the previous year and zero otherwise, *Censormol* equals 1 if the molecule was launched before January 1, 1991 and zero otherwise, *Censorlag* equals one for products launched before January 1, 1991 and zero otherwise. These dummies are part of the quality variables used to capture price variation.

Table B.1 in the Appendix B.3 presents the mean and standard deviation of our control variables by country. Market share variables and the concentra-

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[10]See Berndt, Cockburn and Griliches, 1996, Berndt, Pindyck and Azoulay, 1999, Cockburn and Anis, 1998, and Suslow, 1996.

tion index is presented for the two market definitions used in our sample. We have a total number of 67582 observations, Germany being the country with most data (17306 observations) and the Netherlands being the one with least observations (2614).

2.4.4 Alternative measures for multimarket contact

A contact of firm i with its rivals in the focal (or reference) market k in other markets should reflect the importance of these contact markets for the firm. This approach is not only motivated by a clear intuitive reasoning. Bernheim and Whinston (1990) has shown that multimarket rivalry can also be studied in terms of what Edwards (1955) called each firm's ''spheres of influence''. Following this argument, the plain average contact statistics cannot reflect the relevant multimarket structure because market power transference needs to consider the quality of each contact market either as a source or destination of such market power. One firm will consider the contact with a rival present in the market of reference if the contact occurs in a market where the former has a specific interest or if both firms have sufficient market power.

Keeping in mind the discussion of the treatment of a contact we define a generic multimarket contact variable in the following way: A contact occurs when a corporation i and its competitor l in the focal market k, are also rivals in an independent contact market m. If this is the case we define a binary variable $C_{il,km} = 1$, otherwise $C_{il,km} = 0$. The multimarket contact variable relative to this contact is defined as:

$$MMC_{il,km} = C_{il,km} \; w_m \qquad (2.4.1)$$

where w_m is a weight aim at measuring the corporations' interests in the contact market m or both firms' combined market power. We construct two alternative multimarket contact variables changing weight w_m. First we use the

Herfindähl-Hirschman index of the contact market, second, we use the combined corporations' operations in that market with respect to their respective total operations in sales. Finally, an individual firm is assumed to average its weighted contacts across markets relevant to the focal market in the following way:

$$AVMMC_{ik} = \frac{1}{(N_k - 1)} \sum_{l \neq i} \sum_{m \neq k} MMC_{il,km} \qquad (2.4.2)$$

where N_k is the number of competitors in the focal market. Therefore, for each of the three alternative definitions the average multimarket contact variable will change for a firm across markets and across time due to entry/exit of firms as well as each firm's commercial evolution. Whenever a firm is a monopolist in a product market the variable takes the value of zero. In this way we will extract the most of our Panel dataset as price variation will have many sources for identification.

An important element of pharmaceutical markets is related to licensing. At any point of the life cycle of a drug, the originator firm may produce the drug by itself or grant licenses to one or more manufacturers to produce and commercialize it independently. This situation is reflected in the IMS Midas dataset. To avoid the introduction of irrelevant contacts to the multimarket contact structure, if a firm has given more than one license within a market to produce its original drug we count the presence of the originator corporation in that market rather than the presence of the manufacturers. Implicitly we assume that all corporations granting licenses do not allow for intrabrand competition whenever more than one license is given within a product market.

The mean and standard deviation of the two alternative definitions are presented in Table B.2 in the Appendix B.3, figures are also presented by country and market definition. Note in this table that the mean levels are different which is not surprising given the different sizes in the weights.

2.5 Empirical specification and Econometric methods

In section 2.3 we have shown an expression for the observed price of a product considering the multimarket structure of the industry. Therefore the observed price for a product j of firm i in market k, denoted p^*_{jik}, can be represented as a separable function of its equilibrium price in the stage game, p^n_{jik}, a mark-up on this price which depends on the discount factor, δ, and a function of the multimarket contact structure. We consider the following log-linear specification:

$$log(p^*_{jikt}) = \alpha + \Omega(AVMMC_{ikt}) + \Phi(\delta_i) + log(p^n_{jikt}) \qquad (2.5.1)$$

where t denotes time, $\Omega(AVMMC_{ikt}) = \log \Gamma(AVMMC_{ikt})$, and α is an intercept. The log of the stage game equilibrium price is specified in the following way:

$$log(p^n_{jikt}) = X^{1'}_{jikt}\beta_1 + X^{2'}_{jik}\beta_2 + Z^{1'}_{kt}\gamma_1 + Z^{2'}_k\gamma_2 + \eta_i + v_{jikt} \qquad (2.5.2)$$

where the Xs and Zs are vectors of respectively time-variant and time-invariant variables concerning product j of firm i on one hand, and market k on the other, that potentially affect the stage game equilibrium prices through different meaningful ways, β, and γ are the corresponding parameter vectors, η_i is a corporation fixed effect and v_{jikt} is a random variable with zero mean and finite variance. Given the product differentiation nature of pharmaceutical markets we can interpret the pricing equation as a function of variables affecting marginal costs (which are usually thought to be negligible in this industry) and

the product's mark-up affected by attributes that are fixed or vary through time. From a structural point of view these attributes will affect the firm's product market shares. At the same time, the fixed effect is included to control for elements of vertical (quality) product differentiation which are one of the most highlighted peculiarities of this industry. The v_{jikt} can be regarded as that information on attributes that are not observed by the econometrician but firm's do take into account when taking their pricing decisions. To complete the specification we include time dummy variables for the last four time periods of the sample to provide a control for the discount factor function.

Therefore the specification is:

$$log(p^*_{jikt}) = \alpha + \Omega(MMC_{ikt}) + X^{1'}_{jikt}\beta_1 + X^{2'}_{jik}\beta_2 + Z^{1'}_{kt}\gamma_1 + Z^{2'}_{k}\gamma_2 + \eta_i + \lambda_t + v_{jikt}$$

$$(2.5.3)$$

where λ_t denotes the presence of the time dummy variables. In practice our specification is a version of the two-way error component model as described in Baltagi (2005). We do not consider product specific fixed effects first because we are considering already some product specific regressors that are invariant across time, and second because the usual consideration for this is to provide a control for vertical product differentiation which we consider to be firm specific rather than product specific. Although this assumption may lead to some debate, we consider here that branded products gain reputation because they belong to certain corporations that are able to invest in quality differentiation[11]

In section 2.2 we discussed the implications of different levels of insurance coverage over the price responsiveness to market conditions. National health

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[11]In some of the related works reviewed [e.g. Evans and Kessides (1994)] market specific individual effects are also included in the specification because price variation across markets depends heavily in some exogenous characteristics of markets. We do not consider such fixed effects although some time invariant market characteristics are included in the list of control variables.

systems usually offers wider insurance over necessary therapies such as drugs controlling high blood pressure to other drugs that are designed mainly to increase the comfort of the consumer. Danzon and Chao (2000) proposed to study price competition controlling for different levels of insurance by including fixed effects at the first level of classification of the ATC code. The ATC-1 level groups drugs that act through the same organ of the body. We use a total of 12 ATC-1 dichotomous variables for the available groups in the data omitting the first group (drugs acting through the Alimentary Tract and Metabolism). We perform the same exercise in all our estimations following this line of argumentation so that finally the estimated regressions are versions of a third way error component model.

We estimate equation (2.5.3) country by country using a Within Groups panel data method where the firms' specific heterogeneity effect η_i wipes out of the estimation and considering the rest of the error components as dummy variables. Given the short length of the time dimension (five years) and relatively small number of ATC-1 groups with respect to the available observations by country (above 2,500 by country) this approach does not entail critical problems with our degrees of freedom.

2.5.1 Multimarket contact specification

Two specifications for $\Omega(MMC_{ikt})$ are used. In the first place we follow a simple specification:

$$\Omega(AVMMC_{ikt}) = \alpha_1 \ AVMMC_{ikt} \tag{2.5.4}$$

which is independent of the characteristics of the focal market. This simple linear function will collect the sign and significance of the effect that the variable measuring multimarket contact has on prices on average. A second specification assumes that multimarket contact will have a distinguishable effect across

markets depending on a variable correlated with ease of collusion, the HHI index:

$$\Omega(AVMMC_{ikt}, \widetilde{HHI}_{kt}) = AVMMC_{ikt} \times (\alpha_1 + \alpha_2 \, \widetilde{HHI}_{kt}) \qquad (2.5.5)$$

We use the variable HHI_k, to measure ease of collusion adopting the result of most dynamic oligopoly models by which the higher the market concentration the more collusive the output of the repeated game. According to the market power redistribution effect described in the model 2.3, we expect to observe $\alpha_1 > 0$, which means that in markets with little capacity of collusion, i.e., low $\widetilde{HHI}_k$, $AVMMC$ has a positive effect on prices. This effect has to decrease as the ease of collusion, measured by $\widetilde{HHI}_k$, increases, i.e., we expect $\alpha_2 < 0$ and $|\alpha_1| < |\alpha_2|$. By continuity the multimarket effect is expected to be equal to zero for a value of $\widetilde{HHI}_k$ between the minimum and the maximum values in our set of observations. Summing up, the effect of multimarket contact is expected to be greater in absolute terms if the variable measuring ease of collusion in the focal market, $\widetilde{HHI}_k$, is among either the largest or the smallest in the sample, being positive in markets with very low values for $\widetilde{HHI}_k$ and negative in markets with very high values for $\widetilde{HHI}_k$.

2.5.2 Identifying approach to potential endogeneity

Concerns on the endogeneity of some of the regressors related to the simultaneous nature of quantities used to construct shares and concentration indexes call for an identification strategy. The simplest way to avoid biased estimates is to assume independence of markets across time, much in the way it is implicitly assumed in the competition game presented in section 2.3. Therefore, we lag potential endogenous variables to minimize this risk while keeping the estimation procedure simple.

We also include an additional regressor in the specification to control for possible relevant omitted data. The argument is that in pharmaceutical markets, product differentiation in terms of attributes is of particular relevance. However many important brand attributes are not observable from the econometrician's point of view because are not measurable or as it is in this case are absent from our data set. The stage game price p_{jikt}^n will be a reduced form equation of marginal costs and a mark-up term which depends on product $j's$ attributes as well as its rival products' characteristics within market k. As information on attributes such as strength of a drug or type of package under which the drug is commercialized are not available we approach the mark-up value with some available characteristics (as noted in the last section) and data on product and corporation market shares. These observed mark-up elements will be correlated with unobserved characteristics of product i as well as competitor´s attributes whose effects by definition will be located in the error term. Abusing the language of the Instrumental Variables approach to the problem, we put forward an identification assumption that the independence of markets across countries gives us the opportunity of using the price or an index of prices of other products in the same market definition in other countries to control for the unobserved attributes. At any point of time these prices will be correlated with unobserved attributes of a number of products that interact with product i in market k, information that is also relevant to the firm to determine its prices. However these attributes of other products are not correlated with product's i own characteristics and as such helps us to control for some of the unknown price variability. The variable constructed is a global price, *Priceg*, which is the average price of the products belonging to the same molecule group of product i considering other countries in sample.

This independence assumption might be controversial for some products that, as noted in section 2.2, could be subject to parallel imports or external Reference Pricing regulations. In effect, this condition is not satisfied for a number of products in the UK which are subject to parallel imports from other EU markets. Likewise, in EU countries external reference pricing has been used to

set launch prices for new drugs reducing the effectiveness of our strategy. For this reason we lag *Priceg* again resorting to the Panel configuration of our data set to further provide for an independent correlate with unobserved product characteristics.

2.6 Results, interpretation and analysis

2.6.1 Results from baseline specifications

Tables B.3 to B.5 in Appendix B.5 present the set of basic results for the molecule market definition. We run within groups estimations for the Log(Price) on the set of quality and competition characteristics as well as the multimarket contact variables. In these and other tables the results are shown with the countries grouped from the more market friendly ones to the more heavily regulated in prices. The regressions in all cases include time trends and fixed effects at the corporation level as well as ATC-1 level fixed effects to control for differences in price variation due to different insurance coverage. Accordingly, the t-statistics shown in parenthesis are computed with robust standard errors. Table B.3 does not include multimarket contact variables. Its purpose is to show to what extent the remaining variables explain prices in the different countries and the type of consequences that the omission of relevant structural variables entails. It can be seen that variables *Fsales*, *New*, *Molage* and *Generic* have the expected signs in all the cases, however not significant in very few of them. Firm size, *Fsales*, is highly significant, indicating that large corporations enjoy higher prices either because its products are of higher quality or perceived as such. *New* has a negative and significant effect which means that on average products that enter an existing market bear a price discount. *Molage* has a negative impact showing that the prices fall with the life-cycle of the molecule. However, *Censormol* which is expected also to have a negative effect appear to be with the wrong sign but with weak significance

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in most cases. These variables proxy molecule efficiency since new molecules are expected to improve upon previously existing molecules. *Generic* has a negative impact which is fairly intuitive, with the exception of Canada for which the signs is reversed but the marginal effect is not significant. *Nmols* has a negative effect in the US and other countries indicating that available substitute therapies reduce equilibrium prices.

Consistently, *Censorlag* is positive in most cases, showing that products launched in the market before January 1991 maintain higher prices than those launched later within the same market. This effect however is not significant for most countries and appear with the wrong sign for Italy, Japan and Spain. Regarding *Generic* we find that the price of generics are, with the exception of Canada, significantly lower than other prices. Results for the number of *Ngenerics*, the number of generics in a market, are counter intuitive in that prices are predicted to be higher the greater the number of generic products available. As briefly mentioned in section 2.2, the presence of generics on a market does not mean that brand name products will reduce their prices. The evidence presented by the specialized literature is mixed. In some cases, the presence of generics will have the impact of concentrating brand name products over the inelastic portion of the demand which will then increase the price of these products. Hence, the expected sign of the number of generics will be positive. In our results this is the case of US, Germany, Netherlands, UK –the strongest effect, and France. On the other hand, the number of generics or generic competition, will reduce prices for everyone whenever, for instance, the quality of the existing products is not necessarily perceived to be high enough. In our results this seems to be the case of Canada alone. Note finally, that the effect of the number of generics is also positive for the heavy regulators (Italy, Japan, and Spain). Except for the case of US and Canada, this result is in line with the previous comprehensive analysis of regulation and competition performed in Danzon and Chao (2000).

The HHI concentration index, $\widetilde{HHI}$, is not significant and in some cases ap-

pear with the wrong sign for less regulates countries. For the market share of the product, $Mshare$, and of other corporation's products in the same market, $Cshare$, the expected signs are observed except for the particular cases of Canada, and Spain. Also, for the majority of less regulated countries, $Mshare$ is significant while $Cshare$ is not.

From these first set of results interesting preliminary conclusions can be drawn. First, it appears that most attributes and quality characteristics explains a reasonable portion of price variations which is robust across countries. This suggest that different degrees of regulation does not distorts the effects of these attributes. The only attribute that seems to have a different effect with respect to the level of regulation is $Censorlag$, although the significance of the variable is in general poor. With respect to variables controlling competition, apart from the number of generics, although not significant in many cases at least the signs appear correct for most less regulated countries.

Table B.4 presents the results of the same regressions after including the average multimarket contact variable in its first version. The estimate for the parameter α_1 capture the average effect of the multimarket structure weighted by the HHI of the contact markets. All other coefficients remain fairly stable. This variable appears not significant for the US, UK and most of the highly regulated countries.

Table B.5 allows for a differentiated effect of the multimarket contact variable on prices depending on the concentration of the reference market, a variable that proxies ease of collusion. The effect is collected in parameter α_2. According to the theory outlined in section 2.3, prices are expected to fall in markets where it is easier to reach collusive outcomes whilst they are expected to increase where it is more difficult to collude. This means that the coefficient α_1, is expected to be positive and the coefficient α_2, is expected to be negative, with the latter larger in absolute value than the former. Notice that with respect to Table B.3, in general the competition variables, either turn to

be positive for some of the cases they where incorrectly negative or increase its value above zero. This suggest that omitting the multimarket structure in explaining price variations is relevant enough so as to bias the effect of competitive variables.

Turning back to the multimarket contact effect, the results for the US where pharmaceutical markets are free, is consistent with the theory. An increase on one weighted contact for a firm is expected to increase prices whenever $0.030 - 0.052 \times HHI > 0$ that is for markets where concentration is below ≈ 0.58. Canada in its turn is also consistent and the size of the effect is greater than that of US countries showing evidence that mild price controls provides additional slackness in less competitive markets then redistributed to more competitive ones. Prices are expected to be higher in Canada with respect to the US for low levels of the HHI and lower for higher values of the HHI. In this case, all markets where HHI is below ≈ 0.73 are expected to have higher prices. Germany is also consistent with the theory although the size of the effect is smaller than that of the US and in particular show that the multimarket contact effect is relatively flat for different levels of concentration. For the remaining of the medium regulated countries, Netherland and UK, the corresponding coefficients are individually not significant nevertheless the sign of the coefficients is correct. France is strongly consistent with the theory even though it is classified as highly regulated. For Italy the coefficients are significant but contradicts the predictions of the market power redistribution hypothesis. Finally, Spain and Japan show that multimarket contact does not explain price variations which is also consistent with the theory; strong price regulation is expected to hinder the conditions for the redistribution effect. For all the estimated equations in Table B.5 we report the results for the linear hypothesis test of joint significance of the contact variables. The null is rejected for the UK, Japan and Spain.

As highlighted in the previous section, for the countries where the theory is supported it is possible to show a threshold for the concentration index below

which the equilibrium price is affected positively and above which it is reduced through the multimarket contact mechanism. We show these thresholds graphically in Figure B.4 in Appendix B.4.

The first set of results are completed by Table B.6 showing the fixed effects at the ATC-1 level and Table B.7 reporting comparative results of the multimarket contact effect for the two alternative definitions for $AVMMC$. Apart from obvious scale effects in the estimates for the second definition there are no specially interesting differences. The only relatively important difference refers to Germany for which multimarket contact appears to deliver higher prices irrespective of the level of concentration of the market of reference with the second definition. This result is interpreted as evidence of market power transference.

We have found that the theory is consistent in the US and appears to be statistically significant. The same is obtained for Canada, however, as predicted by the theory, mild price regulations enlarges the effect of market power redistribution. For EU mild or medium regulated countries in general the signs of the coefficients α_1 and α_2 are in line with the theory but the size relation is difficult to find or not statistically significant. For these countries, multimarket contact is expected to increase prices no matter the level of concentration. This is in contrast with the market power redistribution hypothesis, as tested with our specification, but can be reconciled with the market power transference hypothesis. France is highly consistent with the theory, although it is considered a heavy price regulator. Anyhow, in all two alternative definitions, multimarket contact is expected to deliver lower prices compared to the US for a wide range of values of the HHI. Japan and Spain have no multimarket contact effect showing that the theory also correctly predicts that for highly regulated markets stringent price constrains hinders the multimarket contact effect, possibly precluding some prices to increase and others to be reduced.

The next set of basic results are shown in Tables B.8 to B.10. We have repeat-

ed the estimation strategy for the ATC-4 market definition, however we only show the estimation output for the complete multimarket specification (comparable to Table B.5). No significant changes are identified regarding the control variables with respect to the molecule market definition results. Nonetheless, the variable $Nmols$, number of molecules available at the ATC-4, has negative and significant effects for US, Canada, Italy and Spain, whereas it is not significant for Netherlands and UK. Substitution among available molecules within an ATC-4 definition are either significant or absent for these countries. For the rest this variable appears with a positive signs contradicting what was expected in the first place. Tables B.9 and B.10 contain the fixed effects at the ATC-1 level and the comparative results for alternative multimarket contact definitions respectively. For space reasons it is more relevant to concentrate on the last table. Again, the multimarket contact prediction of market power redistribution can be found for the US for definition 1, however now it is predicted that prices are expected to increase due to this effect for markets with concentration indexes below, 0.89 ($0.147 - 0.164 \times HHI > 0$). Extending the market definition increases the set of markets for which prices are expected to be positively correlated with multimarket contact compared to the molecule definition results. For definition 2, however we find a threshold of 0.65 similar to what was found at the molecule level.

With the ATC-4 definition it is not possible to find the redistribution effect for Canada and Germany, in these cases now either multimarket contact has no significant effect over prices or prices are predicted to increase for any level of concentration. Same as before, Netherlands and UK show a positive effect of multimarket contact irrespective of the level of concentration. For the highly regulated countries, France is still consistent with the theory, now for Italy the theory has no significance as predicted for a strong regulator. Spain remains unaffected by the multimarket structure and Japan now appears to suggest a negative effect of the contact variable which is inconsistent with the theory.

In sum, for the ATC-4 definition, US is consistent with the redistribution

hypothesis as expected for an un-regulated case. Now for medium regulated countries the redistribution hypothesis is not verified, however multimarket contact is expected to increase prices for all levels of concentration in some cases. The model outlined in section 2.3 predicts this result both for product differentiation and homogenous goods and some slackness is available to be transferred to other markets. However, the ATC-4 definition was expected to absorb precisely more dimensions of product differentiation given that we consider competitive constrains coming from alternative varieties with close therapeutical effects. Therefore, our results does not support the underlying theory.

2.6.2   A restricted model for regulatory effects

To study further whether the theoretical predictions can be supported in our dataset we perform a series of restricted versions of our approach. Our aim is to test if the marginal effects for different groups of countries are statistically different and meaningful from the point of view of the theory of the multi-market contact redistribution effect. We first run three restricted models to compare three groups of countries with respect to the US benchmark. First we compare the US with Canada, then the US with the medium regulated countries in Europe, and finally the US with Japan and Spain which are the strong price regulators for which the results seems to be in accordance of the theory. Finally we pool Canada with medium EU regulators.

To perform this restricted version we estimate the following specification for the multimarket contact effect:

$$\Omega^R(\ldots) = AVMMC_{ik}\Big(\beta_{10} + \beta_{11}Dreg + (\beta_{20} + \beta_{21}Dreg) \times HHI_{ik}\Big) \quad (2.6.1)$$

All the control variables used in the baseline regressions are kept and the

specification is completed by allowing a differentiated effect of the number of generics as well as a dummy variable ($Dreg$) to allow for a different intercept for each group in a regression. Results are shown in the following table:

Table C: _Estimates by group of countries_ [a]

Coefficient	US/CAN	US/(Medium EU)	US/(Jap,Spa)	Can/(Medium EU)
β_{10}	0.296**	0.271**	0.104	1.020***
	(2.60)	(2.74)	(0.95)	(15.52)
β_{11}	0.629***	-0.019	-0.263*	-0.878***
	(5.89)	(-0.20)	(-2.03)	(-13.08)
β_{20}	-0.846***	-0.795***	-0.556**	-1.539***
	(-4.68)	(-5.03)	(-3.26)	(-13.49)
β_{21}	-0.746***	0.693***	0.695***	1.552***
	(-4.21)	(4.63)	(3.43)	(13.65)
$H_0: \beta_{11} = \beta_{21} = 0$	17.72	25.82	6.38	101.90

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

(1) The estimates correspond to the third definition of the multimarket contact variable

(2) t-stats in parenthesis are computed with robust standard errors

(3) The null hypothesis's statistic $2 \times F(2, \infty)$ has a critical value of 5.99 at 0.05

A test of the joint significance of the interacted variables with the dummy are also presented. The first column confirms that Canada, the mild regulator with respect to the rest of countries in our sample, is expected to deliver a more profound market power redistribution with respect to the benchmark case. Significance of the interactions of the redistribution effect specification with the dummy cannot be rejected. The second column suggests that prices are lower for low concentration values for medium regulated countries in EU with respect to the US, although β_{11} appears to be not significant. The third column shows that in general an extra average contact will have a flatter effect over price with respect to the benchmark, however the profile estimated in this regression is increasing with respect to the concentration index. In the baseline results Spain and Japan showed no significant effect for the multimarket contact specification which we interpreted as the extreme case of regulation in which prices will follow only market specific conditions. This results cannot be confirmed in this restricted model. The fourth column show that medium regulated countries

will experience lower prices with respect to a mild regulator, Canada, for low levels of concentration which is also consistent with the theory. Note that the different sub-samples used in each column does not suggest instability of the estimated marginal effects for US and Canada.

2.6.3 Analyzing segmented multimarket rivalry

In this subsection we are interested in asking the question whether segmentation of product markets between branded and generic products can either modify our baseline results or give additional insights concerning the relevant strategic effects of the multimarket structure for the special case of the pharmaceutical industry. Introducing segmentation in our analysis means that the relevant contacts for a corporation producing (or commercializing by a third party under license) a branded product are those with rivals producing branded drugs and likewise for generic producers.

We interact the multimarket contact variable with dichotomous variables, D_b and D_g indicating whether the observation belongs to the branded segment or the generic one respectively. The contacts are re-set to formulate multimarket rivalry in terms of the relevant contacts in the corresponding segment of the market. Therefore, we redefine the contact variable in (2.4.1) following:

$$MMCS_{il,km} = C_{il,km} \; w_m \prod_{k'=k,m} \left(D_{bik'} \times D_{blk'} + D_{gik'} \times D_{glk'} \right) \qquad (2.6.2)$$

In this way, the contact variable will be strictly positive whenever firm i and l belong to the same segment in market k as well as in the contact market m. If we separate the number of corporations in the focal market, N_k, between those producing branded, N_{bk}, and generics, N_{gk} the average multimarket contact

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variable for corporation i in market k is re-defined in the following manner:

$$AVMMCS_{ik} = \sum_{s=b,g} \frac{D_{sik}}{(N_{sk}-1)} \sum_{l \neq i} \sum_{m \neq k} MMCS_{il,km} \qquad (2.6.3)$$

Where the added ''S'' in the variable's name stands for the segmentation exercise. The market power redistribution hypothesis is tested by handling a modified version of our original specification:

$$\Omega^S(\ldots) = AVMMCS_{ik}\Big((\gamma_1 D_{bik} + \gamma_2 D_{gik}) + (\gamma_3 D_{bik} + \gamma_4 D_{gik}) \times HHI_k\Big)$$
$$(2.6.4)$$

Coefficient estimates for the molecule market definition and the third multi-market contact definition are reported in Table D. It also shows the result of a test for the null hypothesis that the multimarket contact redistribution effect is equal for both segments. The third definition seemed more appealing for this specification because it weights each contact by firm specific weights, the other two definitions consider information of the whole contact market which is difficult to make compatible with a segmentation analysis. For the US it appears that the redistribution effect is present in both segments and the corresponding marginal effects have statistically the same size. Interestingly, estimates for Canada and UK seem to support evidence of the redistribution effect only for branded products, γ_2 and γ_4 are individually not significant. This is weakly observed also for the Netherlands, although the coefficients do not preserve the size relation. For France the result indicates that the redistribution effect appears stronger in the generic segment.

Table D: *Segmented analysis of the redistribution effect*

Variable	US	CAN	GER	NETH	UK	FRA	ITA	JAP	SP
γ_1	0.350*	0.583***	0.106*	0.365*	0.850*	0.175	-0.648***	0.221	0.045
	(2.15)	(6.37)	(2.14)	(2.54)	(2.10)	(0.88)	(-3.91)	(1.33)	(0.23)
γ_2	0.359**	0.100	0.144**	-0.149	0.169	0.271***	-0.328*	0.066	0.022
	(2.88)	(0.39)	(2.74)	(-0.84)	(0.47)	(4.11)	(-2.38)	(0.24)	(0.19)
γ_3	-1.084***	-0.695***	0.009	-0.341*	-1.468*	-0.688*	1.136***	-0.028	-0.067
	(-4.46)	(-4.62)	(0.12)	(-2.00)	(-2.41)	(-1.98)	(4.20)	(-0.10)	(-0.17)
γ_4	-0.760***	0.266	0.381***	0.249	-0.007	-0.881***	-0.656*	0.195	0.274
	(-3.73)	(0.58)	(3.61)	(1.15)	(-0.01)	(-8.01)	(-2.22)	(0.28)	(1.53)
$H_0: \gamma_1 = \gamma_2$	2.40	2.13	13.39	4.82	2.81	.16	18.18	.15	.87
$\gamma_3 = \gamma_4$									

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

(1) The estimates correspond to the third definition of the multimarket contact variable

(2) t-stats in parenthesis are computed with robust standard errors

(3) The null hypothesis's statistic $2 \times F(2, \infty)$ has a critical value of 5.99 at 0.05

2.6.4 Lag of entry as a source of instability

We have argued that corporation fixed effects helps us to control for vertical product differentiation, considered to be an important source for price variation across products. However we have been suggested that quality differentiation across markets might change the results of the redistribution effect. The argument goes in the direction of a result by Häckner (1994) who showed that quality product differentiation might hinder collusion. Therefore, as market concentration is a result of this source of product differentiation, our results might be collecting these effect.

Consider the molecule market definition where vertical differentiation may be a more influential feature as opposed to the ATC-4 definition where possible horizontal product differentiation is more relevant. In this section we aim at evaluating whether our results are changed by including a variable that is expected to be correlated to quality differentiation within the group of drugs belonging to the same active ingredient.

We assume that branded (originator) products are those regarded of high quality within the group of chemically equivalent products. Using originator drugs as a quality benchmark we calculate the average time in years elapsed until entry of other drugs within a molecule group. This variable is called $Entrylag_{kt}$ and varies only across markets and time in our sample. The idea is that molecules where the originator has been more time alone in the market are thought to be more vertically differentiated because the originator has been able to accumulate more reputation.

To control for the variable vertical product differentiation we perform the following specification for the multimarket effect:

$$\Omega(MMC_{ikt}, HHI_{kt}, Entrylag_{kt}) = (\lambda_0 + \lambda_1\ HHI_{ikt} + \lambda_2\ Entrylag_{ikt}) \times AVMMC_{ikt}$$
$$(2.6.5)$$

Table E presents the results for the first contact variable definition. The results are comparable to those in Table B.7 in the Appendix B.5. For the US, our benchmark case, introducing $Entrylag$ within a molecule market changes the profile of the multimarket contact effect. In all three definitions, the higher the average lag of entry of competitors increases prices due to multimarket contacts. Still, prices are expected to be negatively affected for more concentrated markets, however for sufficiently high average years of lag of entry, this last effect dominates. In particular for definitions 1 , an average entry lag of around ≈ 4 years offsets the expected redistribution effect for a highly concentrated market. For definition 2, average entry lag that offsets the redistribution effect for highly concentrated markets is estimated to be around 7 years. This result suggest that whenever the originator is allowed to accumulated greater reputation within a market, concentration does not necessarily commands the redistribution effect. In Canada and Germany where the multimarket contact effect is present entry lag of rivals seems not to place any sizeable effect, and in any case the sign of the effect is negative. The same applies to France. For

UK, Japan and Spain the multimarket contact effect is not jointly significant.

Table E: *Average entry lag and market power redistribution*

Variable	US	CAN	GER	NETH	UK	FRA	ITA	JAP	SP
1st Definition									
λ_0	-0.003	0.096***	0.023***	0.013	0.067	0.032***	-0.140*	-0.017	0.105
	(-0.19)	(9.85)	(7.31)	(1.47)	(1.41)	(3.92)	(-2.35)	(-0.66)	(1.61)
λ_1	-0.043	-0.132***	-0.024***	-0.005	-0.067	-0.089***	0.248*	-0.015	-0.316*
	(-1.90)	(-8.89)	(-5.68)	(-0.46)	(-1.17)	(-5.55)	(2.52)	(-0.34)	(-2.08)
λ_2	0.012***	-0.000	-0.001	-0.004	0.001	-0.005***	-0.002	0.003	-0.004
	(7.10)	(-0.31)	(-1.56)	(-1.54)	(0.20)	(-4.96)	(-0.43)	(1.06)	(-0.88)
$H_0:\lambda_j = 0, \forall\, j$	18.47	33.24	18.20	3.71	.78	16.62	2.75	1.04	2.08

* p<0.05, ** p<0.01, *** p<0.001

(1) t-stats in parenthesis are computed with robust standard errors

(2) The null hypothesis's statistic $3 \times F(3, \infty)$ has a critical value of 7.82 at 0.05

For the regulated countries it might be the case that entry lag is not necessarily a good measure for vertical differentiation because price regulation may distort the profitability of investing in publicity and reputation. It is also important to highlight that this exercise, absent an observable measure of vertical product differentiation, implies inducing measurement error bias in our estimates, hence this results are to be taken with caution.

2.7 Concluding remarks and discussion

2.7.1 Reconciling theory with observations

We have focused to study whether a model of multimarket contact, whose source of asymmetry among markets is product heterogeneity, can be reconciled with observed data. The model predicts that if slack of market power in the sense of dynamic competition games is available, firms can *transfer* this slack to market with less favorable environments for collusion, hence prices

will be higher in general whenever multimarket contacts increases. If firms cannot monopolize any market (or the industry), they may find it optimal to create slack by reducing prices in more collusive markets and apply this to sustain higher prices in more competitive markets. Firms are then expected to *redistribute* market power.

The main point of the paper is that price regulation can have quite different effects over firms' pricing which can be characterized by differences with respect to what is predicted for the unregulated case. The pharmaceutical industry is a paramount case of an industry where products are differentiated within markets and price regulation is a common issue. Our strategy is to estimate a specification for pricing equations that seeks to capture the redistribution effect for market power with information from different countries which are known to place different intensities of drug price regulation among them.

Our results suggests that for the US, our un-regulated benchmark, the redistribution effect is present and is statistically significant for various contact definitions and market definitions. We have also obtained that Canada, a mild regulator, will produce the redistribution effect, however the size of the effect is significantly larger with respect to the US, which can be interpreted in terms of the multimarket contact theory. For medium regulated countries, belonging from the EU, it is not clear the presence of the redistribution effect, however in general it can be inferred that prices will be lower than the un-regulated case for more competitive product markets, a result that is at least weakly consistent with the theory. Finally, results for some countries that are known to place stricter price ceilings suggests as expected that firms are not able to use the existing multimarket structure as a collusive device.

In terms of significance of the size effect of the multimarket contact structure over prices, we have calculated predicted average elasticities for the different contact definitions and market definitions. In general, prices are inelastic to

changes in the multirmaket structure of a market. For the US we calculate a very small but positive average elasticity (standard deviations in parenthesis) of 0.006(0.031) considering the molecule market definition, and 0.122(0.132) considering the ATC-4. Therefore, market definitions matters for the size of the average price effect in this case. For Canada, the average elasticity is around 0.10(0.18) for both markets definitions, for Germany the case is similar to the US.

2.7.2 Policy implications

From the point of view of policy evaluation, considering the multimarket contact structure of the industry is helpful to highlight interesting implications for regulators. The redistribution of market power creates price increases and price decreases in different product markets for the unregulated case. Hence consumer welfare might be improved with respect to a case in which corporations consider product markets in isolation. Mild price regulations can reduce this welfare effects because, as in Canada, they are expected to produce higher relative prices in more competitive product markets with respect to the unregulated benchmark.

On the other hand, medium regulators, for which prices are expected to be lower than for the un-regulated benchmark and the mild regulation case, might be in effect enjoying larger consumer welfare effects. However, this is expected to be a short-run effect. As price regulation in some product markets is translated into lower prices in more competitive markets, entry will be discouraged as the return on investments will be lower than in a un-regulated case. On aggregate, lack of entry or postponing entry decisions can be explained in terms of the multimarket contact mechanism. The same idea applies to strong price regulators. Therefore, our evidence suggest effectively that a plausible source for observing less dynamic entry, in EU with respect to the US for example, is the way in which regulation affects the profile of multimarket contact pricing.

Although in the end welfare effects of price constrains cannot be determined unambiguously, our results provide evidence of a mechanism by which price intervention may distort firm's decision. Discussions on the expected effects of introducing price regulation for the US (Santere and Vernon (2005)), have focused basically in the disincentives to research and development with the crude conclusion that consumer welfare will suffer from the reductions of availability of innovative drugs. From our perspective, regulation might also reduce incentives to enter markets where barriers to entry are lower (more competitive markets) reducing also the availability of varieties or substitute treatments.

Chapter 3

Empirical price-cost margins in pharmaceutical markets

3.1 Introduction

3.1.1 Motivation

In past February 2009, Merck & Co. the second largest pharmaceutical laboratory operating in the international market by sales announced the acquisition of Shering-Plough Corporation, for an operation involving a total value of EUR 32.500 millions. Around a month before this operation was posted in the news, Pfizer Co., the largest (by sales) laboratory operating in the pharmaceutical markets worldwide announced its intention of acquiring 100% of the assets of Wyeth for more than EUR 51.000 millions. These concentrations resemble those observed in the late 80s and 90s, for example when Bristol-Myers Company merged with E.R.Squibb Corporation to form Bristol-Myers Squibb in 1989 and to a lesser extend the merger between Astra AB and Zeneca Group PLC to form AstraZeneca in 1999. In essence these are concentration operations between R&D large multinational laboratories which basically entail the reduction of inter-brand competition constraints in the international market.

The products marketed by R&D based multinational are thought to enjoy brand reputation and might compete with each other in a segment of *high quality* products [1]

Nonetheless, in 2005, Novartis AG, took over two important medium sized (and relatively local) laboratories specialized in producing generic, or bio-equivalent, drugs, Hexal AG (Germany) and Eon Labs (US) which were to be merged with Novartis' generic branch: Sandoz. Hence, international pharmaceutical markets are apparently gaining momentum after almost a decade of inaction in the field of market concentrations. Along the picture depicted, competition authorities will have to face two distinct avenues of potential problems. First, the merging of multinationals which are basically present in all developed countries with on-patent and off-patent branded products will certainly affect pricing strategies, specially for off-patent markets as intra-brand competition of differentiated products might be softened. Second, the potential take over of generic producers and small size innovators by large multinationals might blunt incentives to compete in the *low quality* segments and, more importantly, it could lead to reduction in price competition in mature off-patent markets where there is already an important number of generic producers exerting some competitive constraints to branded drugs.

An important starting point for a correct analysis of mergers on industry prices is to determine what is the current relevant benchmark that explains price costs margins. For example, there could be important structural characteristics of international drug markets that if not considered can lead to several biases in understanding the effects of mergers. Consider, for example that the current price cost margin is explained by a combination of imperfect competition and tacit collusion. If not considered, both unilateral price effects and collective price effects cannot be identified correctly.

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[1]We will discuss later what could be understood by *high quality.*

3.1.2 Objective

As a general concern, this paper provides an exercise that analyzes empirically what are the structural features that may explain actual price cost margins from which future merger analysis can be pursued. We focus in an off-patent mature pharmaceutical market. This decision is based upon the assumption that in mature off-patent markets, price competition among differentiated products is tougher than in relatively younger off-patent markets. Mature markets have been subject to considerable generic entry which drive down average prices to marginal costs. For example, Reiffen and Ward (2002)estimated that prices for the first generic product entering a market is 35 to 50 percent above marginal costs and they converge to marginal costs in the long run when 8 or more generic firms entered the market. Therefore, we avoid modeling the effects of price regulations which are known to vary a great deal across countries and might introduce serious complications for an analysis of an international drug market. The specific objective of this research paper is twofold:

1. Assess empirically price cost margins (PCM) for the prescription pharmaceutical products from a market structure framework and identify the source of market power by testing different tacit collusion structures: Pure product differentiation, Multimarket contacts and Full Price Collusion.

2. Provide a benchmark to which compare unilateral and collective effects that can be expected from the mergers observed recently in international pharmaceutical markets. Unilateral effects are those corresponding to the increase of market power of the merging firms, due to the reduction of the number of competitors. Collective market power effects are those corresponding to expected price increases due to the

Although industry specific legal restraints (patents) and other institutional aspects explain high prices in the industry [see Danzon (1999) for a description of such], interestingly, prices for prescription drugs are of concern even in the event of patent expiration and the subsequent entry of generic products. Generic products are marketed products that have proven bio-equivalence with the main active ingredient of the pioneer drug, they are commercialized under the name of the main active ingredient so that two generic versions can be regarded as very close substitute alternative products. For instance, prices of pioneer products which are thought to enjoy brand reputation increases after generic substitutes (possibly products marketed by local manufacturers) enter the market [See Grabowsky and Vernon (1992)]. These interesting phenomena has been labeled as the *Generic Competition Paradox* by Scherer (1993) and is possibly due to the fact that brand-name products are redirected to loyal consumers (doctors) with higher willingness to consume a proved quality product rather than an uncertain generic copy [2]. Therefore market segmentation in terms of perceived *quality* attributes seems to be relevant in defining product interactions in a particular market. In general, however, high prices in off-patent markets are explained within the health economics literature [See Puig-Junoy (2005)] as a combination of low levels of competition (due to sources such as product differentiation and lack or delay of entry) and the presence of insured consumers, however these analyzes are focused in market specific conditions rather than in industry wide peculiarities that are often of great importance.

The objective of this paper is to assess market power and the peculiarities of an off-patent pharmaceutical market by turning the attention to structural aspects of the industry that have been in general absent of pricing analysis. By analyzing a mature off-patent market we control out possible pricing

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[2]It has also been suggested that branded products when facing generic competition are targeted to more income inelastic consumers, therefore this phenomena will appear whenever the income distribution is heterogeneous enough so as to provide for a version of vertical product differentiation as suggested in Shaked and Sutton (1987)

drivers such as legal barriers to entry, and binding regulatory constrains. High PCM are plausibly due to a great extent to physicians being *captured* by firms (through brand loyalty for example) though.

Why turning the analysis to structural and competition features of the industry are of interest?. Although the mere existence of particular structural characteristics that may or may not affect competition is not enough to turn our attention to some structural aspects of the industry, a number of policies aim at increasing entry and competition in the industry [See Scherer (1993), Scherer (2000)] implemented by various governments is a good indicator of the relevance of assessing this particular topic. For instance, if firms can sustain high prices without explicitly coordinating with each other based on a powerful incentive mechanism, then there will be a limited impact of such competition policies. Therefore it is of high relevance to test other hypotheses of market power based on firms' interactions and structural elements of the industry.

3.1.3   Strategy and related literature

As mentioned above, we consider a mature pharmaceutical market to study structural drivers for pricing decisions. In particular we have selected markets for mature antihypertensive drugs. There are a number of active ingredients that have been marketed in this market for at least 20 years. Henceforth, alternative products produced either by the pioneer laboratory, other branded products produced by large global laboratories and generic versions share positions in a collection of markets. We define a market to be a country at a certain point in time, therefore we can think of the collection of all the markets considered in this study as the global industry for antihypertensives. It is important to mention that we consider only OECD countries so that income differences as well as national health system differences are not as relevant as they could be if we consider a much larger set of countries. In this way we can play with different hypothesis of strategic behaviour that can be modeled

and identified thanks to the different relevant market structures that can be approached.

In particular, large pharmaceutical firms are present in the same markets (countries) for particular products and compete with different products to treat the same disease within a single market. Due to marketing globalization an international market for pharmaceutical has been emerging in the last decade. However, it is important to clarify that this trend has involved basically counterfeit products with still little impact over country-based markets. Therefore it is safe to treat countries as independent markets. As suggested in recent empirical studies for many different industries, multimarket contact among firms in independent markets can be a very relevant source for sustaining high PCM. Bernheim and Whiston (1991), Spagnolo (1999) and others have studied the implications of multi-market contacts in terms of firms' competitive behavior from a theoretical perspective. It is usually thought that multi-market contacts will lessen price competition because firms will find it optimal to stick to some high price equilibria in all the markets and do not compete aggressively to avoid retaliation of rivals. The fear of retaliation is supposed to be increased by the fact that it will spread to the whole industry rather than stay at the market local level. [3]. Evans and Kessides (1994) , Jans and Rosembaum (1996), Parker and Roller (1997) and Pilloff (1999), provide evidence that multimarket contact is expected to increase prices for the airline, cement, mobile and banking US industries respectively. These studies basically assume that multimarket contact will have the same marginal effect across markets. Indeed they are able to show that firms are expected to place higher prices in markets where their rivals are also present in a larger set of independent contact markets. More recently, Fu (2003) has shown also for the newspaper industry that multimarket contact reduces substitutability among competing products.

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[3]These has been quoted as *living by the Golden Rule* which suggest not to do to others what you do not want them to do to you

Multimarket contact among firms appears to be a plausible alternative explanation for the observation of high prices for products produced by large corporations (that are affected by multi-market contacts) and lower prices for fringe local firms producing generic products. However, if the multi-market contacts (or any other hypothesis) is to be considered as a source for market power, it is crucial to analyze at the same time other characteristics of the industry that may also expand the ability of firms to sustain tacitly high PCMs. In the case of the pharmaceutical industry, the fact that brand-name products are more expensive than generic drugs may be due to other relevant aspects of the industry that have to be factored in. Other example is the availability of more than one chemical entity to treat some medical condition which introduces complexities on assessing decision making in this industry because of the presence of different substitute therapies. Stern (1996), Cleanthous (2004) have studied the demand particularities of pharmaceutical products within a framework of discrete choice theory which allows for the presence of differentiated products. Product differentiation, and in particular horizontal product differentiation, in the pharmaceutical industry may be defined as a situation in which consumers (patients/physicians) demand attributes of the medicines given their preferences and needs, for example particular medical condition and medical history (e.g. allergies). Since product differentiation is a source of market power [See for example Tirole (1988, Chap. 8)] it has to be accounted for in competitive analysis.

In this paper we provide a flexible structural framework to compute PCMs considering product differentiation and the particularities of each market. In this sense my approach differs substantially from the previous literature studying empirically the effect of multimarket contact over pricing. PCMs are calculated for the multimarket contact hypothesis for each market rather than simply identifying the marginal effect. The framework also alow us to predict the relevance of the multimarket contact by comparing its PCMs with respect to those computed under less restrictive hypotheses.

By comparing our predictions to detailed calculations of PCMs for the industry, provided by expert researchers in the topic, we are able to test whether our hypotheses of behavior based on different structures of the industry are within a range of values that can be considered plausible. In particular our simulations considering a multimarket contact structure appear closer to the observed empirical PCMs provided in the literature than simulations under the hypothesis of full collusion.

To perform the empirical exercises I use the well known approach developed by Bresnahan (1987), Berry (1994), Bresnahan, Stern, and Trajtenberg (1997), Berry, Levinsohn, and Pakes (1995) Davis (2000, 2005), Nevo (2000b,a, 2001) for the study of market power in oligopolistic markets with product differentiation. This literature base its applied analysis on estimations using market level data which is usually easier to find than individual consumption information. The fact that consumer level information is not available does not play too serious restrictions for parameter identification when certain conditions apply.

To my knowledge this would be the first empirical IO paper aim at discussing structural features of the pharmaceutical industry to analyze PCMs. In particular, treating multi-market contacts within a framework of product differentiation is also original to most industries including the one selected for the application[4].

The sample is obtained from the IMS-MIDAS dataset which has been extensively used for pharmaceutical pricing studies within the Health Economics literature. The dataset provides information on market variables such as prices and sales for pharmaceutical products, divided by year, countries, therapeutic categories, and chemical composite. One possible limitation of my work

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[4]Barros (1999) offers a model of spatial product differentiation for the Portuguese banking industry. He explicitly studies the case of multi-market contact and localized competition. He is able to separate the sources of market power as predicted by the theory: i) Product (spatial) differentiation and ii) Collusion, therefore in spirit his work is close to the one developed in this paper.

is due to the fact that institutional arrangements such as differences in the regulatory environments across countries may influence both consumers (and consumer preferences) and firm's price reaction functions. This can produce heterogeneity across markets that may not be accounted for in the estimation procedures. In this respect, more detailed information at the country level can help to overcome this potential weakness. For example if data at the level of cities in a certain country is available parameter estimation can be better analyzed and institutional heterogeneity will no longer be a problem.

This research paper is divided in the following manner: After this introduction a brief description of institutional, structural and other relevant aspects of the pharmaceutical industry are described and discussed in Section 3.2. Also the sub-market to be analyzed is described. In Section 3.3 the model is carefully presented and testable hypotheses of firm conduct are obtained. In Section 3.4 the estimation strategy is described as well as the data and the main results. Concluding remarks are provided at the end.

3.2 Relevant Aspects of the Pharmaceutical Industry and markets for drugs

3.2.1 Demand and Supply Considerations

To begin with, it is worth to spend some lines on the way drugs are classified. This is important because it helps to better think about relevant markets, sub-markets and segments. The system called *Anatomical Therapeutic Chemical* classification or ATC is the most widely used to identify the characteristics of a drug and its close and more imperfect substitutes. The system divides drugs into five levels. The first level has fourteen divisions called Anatomical Main Groups (AMG) and classify drugs in association to the part of the body, system or organ that they are used for. Then each AMG is further divided in

a second level by therapeutic groups or categories. That is, drugs are grouped according to the disease(s) they are meant to treat. The third and fourth levels identify the pharmacological and chemical characteristics respectively. The basic chemical composite is usually referred to as the "molecule" and indicates the name of the main active ingredient or chemical composite.

From the supply side, the pharmaceutical industry is characterized by high outlays both in R&D and advertisement/marketing. These outlays are sometimes thought to represent barriers to entry, however there is not a clear cut answer to this question and typically after the expiration of a patent in many cases it is observed important entry episodes [See Scott (1998)]. Sutton (1998) suggests that investing in R&D can be seen as a way of product differentiation in the quality dimension and for the case of the pharmaceutical industry spending in research for one potential drug does not create complementarities for the creation of others, therefore it is expected that many differentiated products are created after one successful drug is developed to treat some disease(s). Interestingly, the successive profitable introduction of related drugs (although chemically different) by rivals after the pioneer will depend on advertisement and marketing efforts to influence on the preferences of physicians and loyalty which may also be seen as a way of vertically differentiating products. We will discuss on this matter some paragraphs below. Importantly, when patent protection expires and depending on the previous profitability of a drug, many producers may enter the market. Therefore, in mature drug markets, the structure may host the pioneer producer (typically a large corporation) which supplies the so-called brand-name product, other large corporation that are brand holders in the sense that are also well known and experienced, and generic producers which are mainly local producers which does not hold a brand-name inasmuch they cannot spend as much in advertisement and marketing as large corporations. A generic product is easy to identify because it is commercialized under the name of the main active ingredient of the drug.

At the AMG level it is usual to observe very many producers and relative-

ly small levels of market concentration. However at the therapeutic category and further molecule level concentration can be very high and market structure may strongly influence firms' behavior. Therefore, if the analysis is planned to be conducted at the therapeutic category and/or lower levels of market classification, it is reasonable to think about relevant markets structured as oligopolies.

From the demand side, the industry shows particular institutional features that are very important. The process of consumer decision making for pharmaceutical products, and more important prescription drugs, can be simplified as follows: A patient goes to see her doctor who knows her health (clinical) history (which is not critical to assume). Based on the examination of the patient and the doctor's previous knowledge of her old diseases and physical characteristics, the physician determines the appropriate type of drug, dosage and length to treat the patient. However, in deciding the specific product, the physician will choose conforming to her preferences. After the medical consultation, the consumer go to the pharmacy and the pharmacist, depending on availability, regulations, or her own perception of qualities of competing products, offers the prescribed product or a close substitute[5]. At this point, the consumer have to decide which product and there finishes the decision making process [6] Since the physician will typically prescribe one drug for a treatment period, it is reasonable to assume that consumption decision making is of the discrete choice type. In addition, as patients/physicians will consume a medicine that is suitable for a certain medical condition and also previous medical history, the process of decision making is better assessed by assuming that consumers demand attributes rather than simple quantities of the prod-

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[5]Danzon (1999) explains that pharmacists get more involved in the process of decision making when certain types of regulations are in effect. Reference price systems for instance limit (public) reimbursements of drugs consumed by an insured consumer to the price of a generic, the consumer has to pay the difference. In this case, pharmacists capture the difference between the reimbursement price and the actual cost so they may increase the elasticity of demand for drugs.

[6]See Coscelli (2000) for a study of the interaction between patients' and doctors' preferences in drug consumption decision making.

uct. Therefore the industry can also be fitted into a framework of horizontal product differentiation case. Stern (1996), Cleanthous (2004) use this line of argumentation to motivate the use of discrete choice models of product differentiation in estimating pharmaceutical demand parameters.

Given that, at least in developed countries, patients are heavily insured and do not bear directly the cost of medical treatment, it is usually expected that physicians do consider the cost of treatment [7]. Therefore, price elasticities are expected to be relatively low even if many substitutes exists. However, as explained in Danzon (1999), recent (and not too recent) public policies and regulations aim at reducing the cost and increasing the efficiency of public medical systems have introduced limited reimbursement of drug costs using different mechanisms. For instance the so called Reference Price System mechanism, combined with other regulations, points directly to involve patients and pharmacists in the selection of cheaper substitutes of a drug prescribed by a physician. This can be seen as a countervailing (relaxing) effect on the rigidity of demand price and income sensitiveness, therefore assessing price elasticities remains an important empirical question.[8]

In addition to the demand side discussion in the precedent paragraph , an important interaction between the supply and demand sides is observed through advertisement and marketing efforts. Advertisement, marketing and promotions may increase the availability of information on the qualities and characteristics of competing drugs, therefore these activities may be welfare improving as they may increase competition. This activities are usually called *detailing*. However, some empirical studies have focused on the role of advertisement/marketing/promotion on shaping demand price sensitivity. In this

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[7]However, very recently a series of regulation has been introduced in some European countries by which doctors in public hospitals are given instructions to prescribe drugs from an approved list of low cost treatments.

[8]Puig-Junoy (2004) offers a discussion on the recent reforms on pharmaceutical reimbursement policies in the health care system in Spain. His discussion is certainly applicable to many other countries.

dimension detailing can be used as a device to segment markets for drugs and limit the effects of potential or effective competition. Berndt, Bui, Reiley, and Urban (1995) found important effects of marketing and advertising outlays on the elasticity of demand for drugs. Rizzo (1999) and more recently Windmeijer, de Laat, Douven, and Mot (2004) have studied the systematic effects of promotion efforts (detailing) of large drug corporations whose products hold brand-name based reputations on price elasticities. They cannot reject the hypothesis of an advertising effect on reducing price sensitiveness in the markets studied.

3.2.2 Selection of the Sub-Market for the Empirical Exercise

Our main objective is to study PCMs in a mature pharmaceutical market. We therefore will study pricing conducts in a market where effective competition should be expected to play a fundamental role. Although there is no official definition about how a mature market looks like, the idea is to control out some aspects of the industry briefly described in the last section that might be difficult to model in a partial equilibrium framework. For instance, effects of patent protections, and other legal barriers to entry, heavy price regulations or current advertisement outlays are often difficult to assess in practice. These aspects although might have dynamic effects over current market observable data are less relevant in older drug product markets. In this way we are at least close to our main objective of studying possible explanations for observed high PCMs that are more likely to be due to market structure and pricing strategies.

The sub-market that will be studied is that of non-innovative drugs that are designed with the primary aim to treat high blood pressure conditions (hypertension) and related cardiovascular diseases. High blood pressure is an interesting case of study first because it may be due to different conditions (which are usually understood after a long medical study) and so different

kinds of medications are recommended in accordance to the specific case. For instance it is usual that high blood pressure is associated with other type of conditions (e.g. kidney problems, migraine headaches). Therefore a specific treatment can be selected so as to use the appropriate type of drug that not only reduce hypertension but helps with the second disease. This wide range of medications have also implications in terms of contraindications. Physicians have to be sure which drugs may have undesired side effects in treatment depending on the general health condition of the patient. This is mainly because different types of drugs work through different principles that have the desirable effect of lowering blood pressure. Hence preferences for these type of drugs can be reasonably modeled by clustering groups so as to mimic the fact that some drugs are better substitutes than others in treating a certain medical condition. The main groups of drugs that act over blood pressure are (Alpha and)Beta Blockers, (General) Antihypertensives, Diuretics, Calcium Channel Blockers, Angiotensin Converting Enzines (ACE) and Angiotensin Receptor Blockers (ARB).

Nevertheless the discussion above, public information on medical recommendations for the use of these types or groups of drugs gives us the idea that they are basically designed with the primary objective of reducing high blood pressure and so are considered by many sources substitutes of each other. For instance, this considerations are offered by the National, Heart, Lung and Blood Institute of the U.S. government in its Website [9]. We selected five specific non-innovative molecules or chemical entity groups: Atenolol, Captopril, Diltiazem, Enalapril and Hydrochloriazide. Box 1 provides brief notes on the history on these products. In particular, these five molecules were already free of patent protection before the beginning of the statistical information available. Furthermore, these molecules or active ingredients have experienced a wide diffusion in international markets meaning that are commonly prescribed in most OECD countries.

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[9]Specifically visit the link: http://www.nhlbi.nih.gov/hbp/

> **Box 1: Brief history of the selected molecules**
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> Atenolol is an off-patent drug. This means that the drug was always considered generic. It was developed in 1976 and is considered in the group of Beta Blockers. It has some minor side effects on the nervous system. Captopril was developed by the American Squibb (now Bristol-Myers Squibb) in 1975. The U.S. patent was granted in 1977 and ended in 1996 when the product become generic. It is an (and was the first) ACE and as with most of them the common side effect is coughing. Diltiazem is a Calcium Channel Blocker which is also an off-patent chemical entity. Information on critical side effects was not found. Enalapril was developed by Merck & Co. as an effort to develop a substitute for Squibb's Captopril with less side effects. It enjoyed patent protection until 1999. Hydrochloriazide is a very popular Diuretic and is an off-patent chemical entity. Some side effects are breath difficulties, fatigue and confusion.
>
> *Sources:*   Fink (2000), Federal Register, Vol. 70 No. 17 2005

3.3   A Structural Model of Oligopoly under Product Differentiation

3.3.1   The Demand: Discrete Choice Approach

In this section we follow Berry (1994) and Nevo (2000b) on developing a discrete choice model for a demand system, however we modify some important characteristics intending to adapt better the framework to the pharmaceutical industry. The best guide we have found to analyze product differentiation in the drug industry is that of Cleanthous (2004) and Stern (1996). These authors present demand estimations for the US pharmaceutical market using a similar approach to the one we present here.

We begin by assuming that there are T independent markets for drugs that are intended to treat high blood pressure (hypertension). Given that these

drugs have the same therapeutic effects they shall be considered substitutes, although due to differences in attributes these products may be close or bad substitutes of each other. To ease the exposition of the model, we will assume that in each market there is a set of J mutually exclusive differentiated products including an outside option labeled $j = 0$ whose importance will be explained later [10]. We begin first defining a linear (indirect) utility function with random coefficients for individual i with respect to product j in market t[11]:

$$V_{i,j,t} = \alpha_i(y_i - p_{j,t}) + x_{j,t}\beta_i + \xi_{j,t} + \varepsilon_{i,j,t} \qquad (3.3.1)$$

Where y_i is individual's income, p_j is the price of object j in market t, $x_{j,t}$ is a K-dimensional vector of attributes observed by the analyst that are given exogenously to the present model $\xi_{j,t}$ are unobserved (by the analyst) product attributes and so not possible to parameterized and assumed to have zero mean, $\varepsilon_{i,j,t}$ are individual-product-market based idiosyncratic shocks over which some distributional assumption is to be adopted. α_i and β_i are (possibly random) coefficients. Then using the principle of consumer's utility maximization the decision rule of individual i choosing alternative j from a set of available alternatives J given the randomness of the utility function and the discrete nature of the demand is given by:

$$Pr_i(j : j \in J) = Pr(V_{i,j} = \max_{l=0,...,J} V_{i,l}) \qquad (3.3.2)$$

Equation 3.3.1 can be rewritten to account for the fact that the parameters may depend on individual characteristics. Say that there are a set of D_i individual characteristics and that in general parameterize the coefficients in 3.3.1 as:

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[10]As we will explain later the actual data structure is such that not all the products are present in all the markets. This generates that some computations are cumbersome given the unbalanced nature of the panel

[11]Notation is close to that used in Berry (1994) and Nevo (2000b) and help to refer to these two main sources of previous work.

$$\alpha_i = \alpha + A(D_i; \Gamma_\alpha) \tag{3.3.3}$$

$$\beta_i = \beta + B(D_i; \Gamma_\beta) \tag{3.3.4}$$

Where A and B are linear transformations over D_i with matrix representations by Γ_α and Γ_β such that they keep dimensional concordance with the correspondent coefficients of 3.3.1. Therefore express 3.3.1 as:

$$V_{i,j,t} = \delta_{j,t}(p_{j,t}, x_{j,t}, \xi_{j,t}; \alpha, \beta) + \mu_{i,j,t}(p_{j,t}, x_{j,t}, \varepsilon_{i,j,t}; A(D_i; \Gamma_\alpha), B(D_i; \Gamma_\beta)) \tag{3.3.5}$$

Since $\alpha_i y_i$ places no variation across products it is not relevant for decision making so we ignore it from know on. Hence the utility function comprises two elements, $\delta_{j,t}$ which is interpreted as the mean utility level that all consumers in market t enjoy from choosing j which is linear in the explanatory variables and parameters α and β, and $\mu_{i,j,t}$ which is a zero mean idiosyncratic shock that explicitly recognize that consumer preferences may affect the way in which the attributes of alternative j are valued. Note that if data on $\delta_{j,t}$ for a considerable number of T independent markets are available from 3.3.5 we could identify α and β by a simple linear Instrumental Variables regression to account for the typical endogeneity of $p_{j,t}$. To obtain the own and cross price elasticities of the differentiated products we require to make some distributional assumptions on the idiosyncratic shocks that underlie the consumer's preferences and tastes. The following subsection discusses simplifying assumptions and their relevance for demand estimation of pharmaceutical products.

Discussion on Alternative Distributional Assumptions

There are some alternatives available so as to model the pattern of substitution among differentiated competing products. These patterns of substitution are

to be modeled through distributional assumptions on the consumer characteristics. Among the alternative distributional assumption we have at hand the most widely used are the (conditional) logit or type I extreme value assumption, due to McFadden (1978)[12], the nested multinomial logit or hierarchical logit assumption [Ben Akiva 1973], the Generalized Extreme Value assumption [See MacFadden, 1978] and the Principles of Differentiation Extreme Value Assumption [See for example Bresnahan, Stern, and Trajtenberg (1997)][13].

Anderson, de Palma, and Thisse (1992), Berry (1994), Nevo (2000b) and others have shown that assuming a conditional logit distribution for the idiosyncratic taste random variable $\mu_{i,j,t}$ places too strong restrictions on the way different products are compared to each other from the consumer's point of view, first because randomness only enters additively from $\varepsilon_{i,j,t}$ and these shocks are assumed to be i.i.d.. Anderson, de Palma, and Thisse (1992) shows that what is called the Independence of Irrelevant Alternatives (IIA) property is at the core of the rigidity of the aforementioned substitution patterns. The IIA property implies that the $\varepsilon_{i,j}$ shocks are i.i.d. as in the conditional logit model. With the conditional logit the shocks are i.i.d with a type I extreme value. It is very easy to check that with this assumption the cross elasticity of the probability of choosing alternative j with respect to a change in the mean valuation of alternative l (say because a of change in its price) has the following form: $\eta_{\delta_l}^{Pr(j;j\in J)} = -Pr(l; l \in J)\delta_l$ which is true for all $j \in J$ with $l \neq j$. Hence no matter which j we compare with l the cross elasticities will always be the same. This of course does not seem sensible to the description of consumer's decision making in the pharmaceutical industry. In other words, if we think that some alternatives are closer substitutes among each other than with re-

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[12]Some authors refer to the multinomial logit as an alternative, however, as shown in Wooldridge (2002) the conditional logit contains the multinomial logit as a special case. Also Anderson, de Palma, and Thisse (1992) mention that the original derivation of the multinomial logit is attributed to Holman and Marley who used the double exponential distribution function

[13]A comprehensive reference of discrete choice models of product differentiation is Anderson, de Palma, and Thisse (1992). Other less popular assumption however useful is the multinomial probit model as noted in Anderson, de Palma, and Thisse (1992).

spect to some other alternatives then this will have to be modeled accordingly. Because of this problem, in general the literature on the empirical analysis of market power for differentiated products recommend to be very careful (or even discard) with the use of this assumption [14].

The next three assumptions are closely related and overcome the IIA problem because they imply some correlation between the idiosyncratic shocks in the demand system. In fact the Generalized Extreme Value (GEV) assumption happens to be a generalization for the Nested Logit[15] and the Principles of Differentiation Extreme Value assumptions (and also de multinomial logit model). It can be shown that in the context of the random utility system, the choice probabilities implied by the GEV assumption is expressed including the non random part of the utiliy for product j not only as a function of its observed characteristics (p_j, x_j) but also as a function of the observed characteristics of the other alternatives included in J. Therefore the cross elasticity of the probability of choosing alternative j whenever the mean utility for an alternative l changes crucially depends on the characteristics of other alternatives.

A Nested Logit Derivation and simplifying assumptions

Now as we discussed in section 3.2, the consumer decision making for pharmaceutical products appear to follow a series of alternative elimination processes, due to the fact that physicians can select first the type of drug to prescribe and

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[14]Yet another way to understand the implications about the IIA axiom is to question ourselves about the relevance of this property in our case of study. The way we have motivated our work clearly remarks that the IIA will not hold in the consumer's decision making over pharmaceutical products. Note however that it is not the conditional logit assumption that creates the problem but the more fundamental assumption of the i.i.d. distribution of the shocks.

[15]The nested logit model receives other names in the literature as Hierarchical Logit or Tree Extreme Value model a diversity of labels that have lead to confusion.

within this type select from two sets, a branded product or a generic one[16]. As noted by McFadden (1983) this can be interpreted as clustering options in different steps of the decision making and deciding among the clusters (or in another way eliminating not relevant options). An schematic representation of the process of consumer decision making is presented in Figure 3.1 below. The objective of the second level of clustering is two-fold. First it is intended to capture the fact that advertisement expenditures by brand-holder firms can affect the perception of doctors/patients towards well-known brands against generic products. The second is to capture the idea for which doctors remain loyal to a brand they know even though cheaper products are available that can reasonably be though as close substitutes (or even identical in their therapeutic properties). What is left to determine is how to proceed to determine transition probabilities from one top cluster to a correspondent lower one and so on. Ben-Akiva (1973), as cited by Anderson, de Palma, and Thisse (1992) proposed that each transition probability is to be modeled as a conditional logit form, a frame that gives raise to the so called multi-level nested logit models.

Say we identify M disjoint subsets defined over J that we believe are valid segments for a therapeutic class. We call this segments, molecule segments. Within the $m - th$ molecule segment we further identify B disjoint subsets that we call sub-clusters, the brand-name and the generic sub-clusters.

In a very important paper, Cardell (1997) offers an approach to discrete choice models that are based on the extreme value distribution assumption. In particular, the author shows that a multi-level nested logit model can be obtained by giving the appropriate variance components structure to a system of stochastic utilities in which the error term is assumed to follow an i.i.d process with a type one extreme value distribution. Following Theorem 2.1 in Cardell (1997) a variance component is a variable $\nu_{1,j}$ such that there exists a number $\lambda_{1,j}$,

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[16]Stern (1996) differentiate products in two categories within a molecule that he call the pioneer product and the rest (generics), this was because the author was interested in evaluating the returns to innovations on the industry
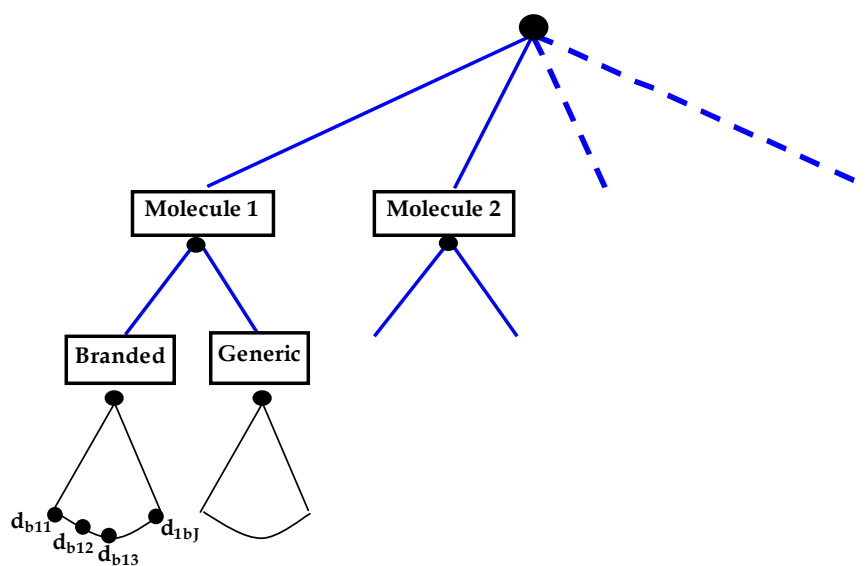
Figure 3.1: Sequential consumer's decision making process

where $0 \leq \lambda_{1,j} \leq 1$, and $\nu_{1,j} \sim C(\lambda_{1,j})$. This is saying that there exists a parametrization of the distribution of $\nu_{1,j}$ by $\lambda_{1,j}$. Then there is a random variable $\epsilon_j \sim$ Type-I-Extreme Value independent of $\nu_{1,j}$ that combined with the latter in the structure $\nu_{1,j} + \lambda_{1,j}\epsilon_j$ also follows a type-I extreme value distribution. In our case, the ϵ_j will be our random preference shock and so the subindex j will refer to the alternative products. Also, the structure can be specialized as required by the case of study. Cardell (1997) explains that the variance component can be associated with a set of alternatives that share this component in their variance structures. Therefore, if it is constructed a structure with as many components as nests (or levels) of consumer's decision, it is possible to represent represent in a very straight forward way the demand system and place clearly appropriate restrictions. To use this structure together with the discussion so far we first make the first simplifying assumption:

Assumption 1: $\mu_{i,j,t}$ in 3.3.5 depends only on dummy variables d_{j_b} that takes the value of one if product j belongs the the sub-cluster b and d_{b_m} takes the value of one if the sub-cluster belongs to the segment m. This implies that random coefficients will be placed only on "nest's" dummy variables. In addition, $\varepsilon_{i,j}$ follows a type-I extreme value distribution as in Cardell (1997)..

Based on equation 3.3.5 and **Assumption 1**, the random utility of individual i with respect to product j can be expressed as:

$$V_{i,j} = \delta_{j,t}(p_{j,t}, x_{j,t}, \xi_{j,t}; \alpha, \beta) + \sum_{m=1}^{M} \nu_{i,m,j} d_{b_m} + \sum_{m=1}^{M} \sum_{b=1}^{B} \rho_{m,j} \nu_{i,m,b,j} d_{i,j_b} d_{i,b_m} + \rho_{m,j} \rho_{bm,j} \varepsilon_{i,j}$$

$$(3.3.6)$$

Comparing 3.3.6 to 3.3.5 the simplifying assumption reduces the randomness of the parameters due to individual tastes to variables that indicates to which segment and sub-cluster a product belongs; as such the parameters for the price and attributes are invariant with respect to consumer tastes. Equation

3.3.6 is of aid to see the way in which clustering works. For example, consider a situation in which the therapeutic class of interest has a total of $J = 9$ products including the outside option $j = 0$. Now consider that we can identify two segments as defined by molecules, so $M = 2$ with $m = 0$ the segment corresponding to the outside good. Further on we divide the products within a molecule into $B = 2$ groups, branded and generic each with two products. First, note that the outside option is alone in $m = 1$ with no further divisions so its error term reduces to $\mu_{i,j,t} = \nu_{i,1,0}$. Second, let the products $j \in 1, 2, 3, 4$ belong to molecule $m = 2$, then by they share the same variance component at the molecule level and by construction they share the same correlation parameter such that $\nu_{i,2,1} = \nu_{i,2,2} = \nu_{i,2,3} = \nu_{i,2,4}$ and $\rho_{2,1} = \rho_{2,2} = \rho_{2,3} = \rho_{2,4}$. Similarly, let products $j \in 1, 2$ belong to the sub-cluster of branded drugs $b = 1$ within $m = 2$. Therefore the products belonging to $m = 2$ will satisfy the following restrictions: $\nu_{i,2,1,1} = \nu_{i,2,1,2}$ with $\rho_{21,1} = \rho_{21,2}$ and $\nu_{i,2,2,3} = \nu_{i,2,2,4}$ with $\rho_{22,3} = \rho_{22,4}$. Under this setting, each sub-cluster within a segment will have a different preference correlation parameter and also each segment at the molecule level will have a different correlation parameter. Hence the number of parameters may severely increase due to segmentation and further clustering. To reduce the number of parameters and ease the estimation process we will take the following further simplifying assumption which is common in the literature [See for instance the discussion offered in Berry (1994)]:

Assumption 2: Set $\rho_{m,j} = \rho_{l,k}$ for all $m \neq l$ and (redundantly) $j \neq k$. In addition, $\rho_{mb,j} = \rho_{lc,k}$ for all $m \neq l$, for all $b \neq c$.

Therefore, it is required that the same correlation parameters are observed across molecules on one side and across sub-clusters of branded and generic products within a molecule segment on the other. To keep track of notation we call the two parameters of the variance components ρ_{mb} and ρ_m. Although it is not frequently acknowledged in the empirical literature that make use of discrete choice models that come from an exercise of random utility maximiza-

tion, it has been shown that whenever the information at hand is supposed to be produced from individual preferences, **Assumption 2** is required for consistency of the model with the underlying utility maximization process. For example, Koppelman and Wen (1998) shows that a general class of variance components models are not consistent with random utility maximization data, while a restricted version imposing equal within clusters correlation across segments is compatible with consumer's choice theory.

Market shares and the usage of market level data

The type-I extreme value assumption and the two-nest assumption determines the following expression for the share (probability of being chosen) of product j within the sub-cluster J_{mb} it belongs to:

$$s_{j/mb} = \frac{e^{\delta_j/\rho_{mb}\rho_m}}{D_{mb}} \qquad (3.3.7)$$

where $D_{mb} = \sum_{j \in J_{b,m}} e^{(\delta_j/\rho_{bm}\rho_m)}$

Now the market share (or probability) of sub-cluster b within its corresponding molecule segment is given by:

$$s_{b/m} = \frac{D_{mb}^{\rho_{mb}}}{\left[\sum_{b \in J_m} D_{mb}^{\rho_{mb}}\right]} \qquad (3.3.8)$$

Finally the expression for the share of molecule m segment with respect to the

entire market is given by:

$$s_m = \frac{\left[\sum_{b \in J_m} D_{mb}^{\rho_{mb}}\right]^{\rho_m}}{\left[\sum_{m \in J_m} \left(\sum_{b \in J_m} D_{mb}^{\rho_{mb}}\right)^{\rho_m}\right]} \quad (3.3.9)$$

Therefore the market share (probability of choosing) for product j is simply:

$$s_j = s_{j/mb} s_{b/m} s_m \quad (3.3.10)$$

In addition, if we set the market size to be a number M then the quantity sold of product j in the market will be $q_j = s_j M$.

It is common to assume for the special case of the outside option that $\rho_0 = 0$, hence, $D_{00} = 1$. Therefore its market share has the following expression:

$$s_0 = \frac{1}{\left[\sum_{m \in J_m} \left(\sum_{b \in J_m} D_{mb}^{\rho_{mb}}\right)^{\rho_m}\right]} \quad (3.3.11)$$

Then the price of the outside good is not part of the simultaneous solution of the market. To understand the importance of having an outside good we quote Berry (1994):

> *"In the absence of an outside good, consumers are forced to choose from the inside good and demand depends only on differences in prices. Therefore, a general increase in prices will not decrease aggregate output; this is an unfortunate feature of some discrete models that have been applied to the empirical study of differentiated products markets."* Berry (1994, p.247)

A bit of algebra allows to find the expressions for own and cross partial derivatives for a change in product j share with respect to a change in the mean utility of product l considering the different possibilities for its location in the molecule and cluster structure of our problem. The expressions are the following:

$$\frac{\partial s_j}{\partial \delta_l} = \begin{cases} \{-\frac{1}{\rho_{mb}\rho_m} + \frac{1}{\rho_m} - \frac{s_{b/m}}{\rho_m} + s_{b/m} - s_{b/m}s_m\}s_j s_{l/mb} & \text{if } l \in J_{m_b} \\ \{1 - \frac{1}{\rho_m} - s_m\}s_j s_{b`/m} s_{l/mb`} & \text{if } l \notin J_{m_b} \text{ and } l \in J_m \\ -s_j s_l & \text{if } l \notin J_m \end{cases}$$

Given the assumptions so far the cross elasticities within a market differ wether the change of the mean utility occurs in a competing product in the same sub-cluster, in a different sub-cluster but same molecule segment or when it happens in a product located in a different molecule than the product of interest [17]. These cross partial derivatives can be specialized for a change in any of the components of the linear mean utility function. The partial derivatives with respect to prices are of interest and are obtained by simply multiplying the above expressions by $-\alpha$.

Berry (1994) notes that in general a system of implied market shares s_j for $j = 0, \ldots, J$ is a function of the mean utility levels and the parameters involved in the distribution of the random idiosyncratic shock. In our case we

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[17]Note that when the change occurs in a product located in a different segment we obtain the same result as in the multinomial logit which is precisely because in this case the idiosyncratic shocks of the consumer associated with the two alternatives are independent from one another. Also note that if we set $\rho_{mb} = \rho_m = 1$ in each case we go back to the implications of the IIA axiom discussed before.

have that:

$$\mathbf{s}(\delta, \rho_m, \rho_{mb}) = S \tag{3.3.12}$$

where S is a $J \times 1$ vector of observed market shares from public data. In an extremely useful result, Berry (1994) shows that under mild conditions on the probability density function of the idiosyncratic consumer shocks and the existence of the inverse of $\mathbf{s}$, there is a unique vector δ that satisfies $\delta = \mathbf{s}^{-1}(S)$ [Berry (1994, p.249 and Appendix)]. It is shown that the family of the extreme value functions not only satisfies the conditions for the solution of system 3.3.12 but also under the simplifying assumption taken in the previous part it is possible to obtain a closed form solution. After some additional cumbersome algebra it can be shown that for a given δ_j the analytical solution as a function of the observed market shares is the following:

$$\ln(\frac{s_j}{s_0}) - \ln(\frac{s_j}{s_m}) + \rho_{mb}\rho_m \ln(s_{j/mb}) - \rho_{mb} \ln(s_m) + \rho_m \ln(s_m s_{bm}) = \delta_j = \alpha p_j + x_j \beta + \xi_j \tag{3.3.13}$$

The aim of the estimation procedures will be to identify the parameters of equation 3.3.13. Since the parameters of the variance components enter 3.3.13 in a non-linear fashion alternative strategies for estimation are available and described in the next section. Since prices and market shares are endogenous in that they are the result of the interaction of demand and supply we will estimate regressions by Instrumental Variables techniques.

3.3.2 The Supply: Price-Cost Margins

For the supply side, the strategy is very simple. First we need to obtain the form of the first order conditions of profit maximization from a general multi-product firm. Given certain assumptions we can solve the system of first order conditions for the price-cost margin. Let a multi-product firm in the industry produce a certain number of the products in the therapeutic class. Label the firm by f and the set of products it produces by J^f a sub set of J. Then define the profit function of firm f as:

$$\Pi^f(\mathbf{p}) \equiv \sum_{j \in J^f} \left\{ p_j q_j(\mathbf{p}, \mathbf{x}, \xi, \theta) - C(q_j, w_j, \omega_j, \gamma) \right\} \tag{3.3.14}$$

where $C(q_k, w_k, \omega_k, \gamma)$ is the $k - th$ element of a separable cost function that depends on the level of sales q_k, a vector of observed cost side attributes w_k and unobserved cost attributes ω_k that follows the same logic as the demand side attributes. For simplicity we assume that this is a linear function in quantities so that the marginal cost is constant and depends only on supply side attributes. Taking into account that $q_j = s_j M$ then the first order condition for the choice of the optimal p_k is:

$$s_j M + M \sum_{j'=1}^{J^f} \left\{ p_{j'} - \frac{\partial C(q_{j'}, w_{j'}, \omega_{j'}, \gamma)}{\partial q_j} \right\} \frac{\partial s_{j'}}{\partial p_j} = 0 \tag{3.3.15}$$

Then for firm f we can define a system of first order conditions in the following form:

$$\mathbf{s^f} + \Omega^f(\mathbf{p^f} - \mathbf{c^f}) = \mathbf{0} \tag{3.3.16}$$

where Ω^f is a $K^f \times K^f$ non-singular matrix of cross derivatives of shares with respect to prices assuming that the portfolio of products hold by the firm involves K^f products and c^f is a column vector of marginal costs. The result in 3.3.15 is obtained by assuming that the firm acts as a multi-product Bertrand profit maximizer taking as given the prices of its rivals. Therefore if a unique equilibrium exists in pure strategies we can solve for $\mathbf{p^f}$ for all f.

The system 3.3.16 provides a starting point to model different assumptions on the strategic behavior of firms. For example, if we follow the literature on strategic interactions in repeated games where it is usually assumed that collusion takes the form of colluding firms jointly maximizing their profits then we can account for this situation by appropriately choosing the elements in each sub-set J^f for $f = 1 \ldots F$. This will be done in the next subsection.

3.3.3 Hypotheses on the Strategic Behavior

For most of these subsection we follow Nevo (2000b). We will first change slightly the notation used in the last subsection to that presented by Nevo (2000a). Lets define first the following dummy variable:

$$\Lambda_{j,j'} = \left\{ \begin{array}{ll} \text{entry } (j, j') = 1 & \text{if } \{j, j'\} \subset J^f \\ \text{entry } (j, j') = 0 & \text{otherwise} \end{array} \right.$$

Therefore, we can define the $J \times J$ matrix Ω with its (j, j') entry equal to $\Lambda_{j,j'} \times \frac{\partial s_{j'}}{\partial p_j}$. This matrix is called *Ownership Matrix* because it helps to model different cases of firm behavior by setting the dummy variables appropriately to account for the implied ownership structure. Two initial structures can be

defined to account for the effects over market power of (1) Product differentiation, and (2) The portfolio effect, as proposed in Nevo (2000b).

To account for the effect of product differentiation over market power, understood as the ability to price above marginal cost unilaterally [see for example the discussion in Motta (2004)], the appropriate structure is to set a problem of single product profit maximization. That is, all the firms act as if they maximize the profit obtained from one of its product in isolation at a time. Therefore, we will have J first order conditions of the form:

$$s_j + \left\{ p_j - \frac{\partial C(q_j, w_j, \omega_j, \gamma)}{\partial q_j} \right\} \frac{\partial s_j}{\partial p_j} = 0 \qquad (3.3.17)$$

For this case it is possible to find a closed solution for each p_j since it only requires solving for the price and substituting the expression of the share and the partial derivative of the share with respect to the price implied by the structure of the demand. The expression for the pricing equation in this case is:

$$p_j = \frac{\partial C(.)}{\partial q_j} + \frac{\rho_{mb}\rho_m}{\alpha} \frac{1}{\left\{ 1 - (1 - \rho_{mb})s_{j/bm} - \rho_m(1 - \rho_{mb})s_{j/bm}s_{mb} - \rho_{mb}\rho_m s_j \right\}} \qquad (3.3.18)$$

From 3.3.18 it is straight forward to get price-cost margins without using actual firm level cost data given that the second term of the right hand side can easily be computed once consistent estimates for the demand parameters are obtained.

For the portfolio effect, firms maximize their profits considering all the products they produce in a market. The portfolio effect is expected to have a non

negative impact over the PCM with respect to the level implied by product differentiation. This is because firms avoid cannibalization of other products within a market by optimally setting prices at relatively higher levels. Given that firms produce only one version of a product in a molecule segment, then we need to consider that each product a firm produces in a market correspond to one different molecule segment. It is also possible to obtain a closed for solution for each pricing equation in this case, although algebra is a bit more cumbersome. Using the expression for the cross partial derivative with respect to a price of a product that belongs to a different molecule segment, the general pricing equation for each j is given by:

$$p_j = \frac{\partial C(.)}{\partial q_j} + \frac{1}{\alpha\left\{\frac{1}{\rho_m \rho_{mb}} - \sum_{j'}^{J^m} \frac{s_{j'}}{\zeta_{j'}}\right\}} \cdot \frac{1}{\zeta_j} \qquad (3.3.19)$$

where

$$\zeta_{j'} = \frac{1}{[1 - (1 - \rho_{mn})s_{j'/m'b'} - \rho_{mb}(1 - \rho_m)s_{j'/m'b'}s_{mb}]}$$

$$\zeta_j = \frac{1}{[1 - (1 - \rho_{mn})s_{j/mb} - \rho_{mb}(1 - \rho_m)s_{j/mb}s_{mb}]}$$

Apart from these two basic pricing equations, we propose two alternative hypotheses for firm behavior. First we suggest that firms act as joint profit maximizers considering all the products in the market. This amounts to assume that one possible sustainable tacit collusion equilibrium is that firms take into account the profits of rivals within a market in addition to its own profits. Second, we suggest that firms tacitly collude with those firms with which the firm also interacts in other markets. This is the multi-market contacts hypothesis of firm collusive behavior, by which firms form in a tacit way coalitions

with firms that are rivals not only in a given market but in other independent markets. The two hypotheses are further explained below.

Hypothesis 1: Joint Profit Maximization within Market or Full Collusion

In this case each firm that supplies a product within a certain market will consider in the corresponding first order condition of profit maximization of this product not only the other products it produces within this market but the its rival products. This corresponds to the static result of an equilibrium with full tacit collusion. Since each market will typically have a different set of firms and products with respect to others, the pricing equations have to be formulated in a case by case. This situation creates some computational complications because different sub sets of the J products are present in different markets and it is necessary to keep track of the different combinations of the partial derivatives of market shares with respect to prices in each market, considering the substitution patterns. For each of the T independent markets we defined the appropriate *ownership matrix* and compute the corresponding PCM using a procedure in MATLAB.

A typical ownership matrix for a generic market t will have the following structure:

$$\Omega_{\mathbf{t}}^{\mathbf{Joint}} = \begin{pmatrix} \frac{\partial s_{1t}}{\partial p_{1t}} & \frac{\partial s_{2t}}{\partial p_{1t}} & \frac{\partial s_{3t}}{\partial p_{1t}} & \cdots \\ \frac{\partial s_{1t}}{\partial p_{2t}} & \frac{\partial s_{2t}}{\partial p_{2t}} & \frac{\partial s_{3t}}{\partial p_{2t}} & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix}$$

Hypothesis 2: Multi-market contacts-driven tacit collusion

Following the logic of the setting of testable hypotheses on strategic behavior, tacit collusion based on multi-market contacts can be tested by defining a

pricing equation that include the cross partial derivatives of shares of those products that are present in the same markets as $j \in J^f$. Across markets, the set of firms that jointly maximize profits will be different and so adds an additional computational requirement. To define de appropriate *ownership matrix* for each market it is necessary to exclude those firms that only produce locally (so that they do not contact with rivals in other markets) since they will not be part of the joint solution of the implied system. We assume that the relevant contact with rivals is observed across countries and not across time.

A typical ownership matrix for a given market t where multi-market contact tacit collusion is in effect will have the following form:

$$
\Omega_{\mathbf{t}}^{\mathbf{MMC}} = \begin{pmatrix}
\frac{\partial s_{1t}}{\partial p_{1t}} & 0 & 0 & 0 & \cdots \\
0 & \frac{\partial s_{2t}}{\partial p_{2t}} & \frac{\partial s_{3t}}{\partial p_{2t}} & \frac{\partial s_{4t}}{\partial p_{2t}} & \cdots \\
0 & \frac{\partial s_{2t}}{\partial p_{3t}} & \frac{\partial s_{3t}}{\partial p_{3t}} & \frac{\partial s_{4t}}{\partial p_{3t}} & \cdots \\
0 & \frac{\partial s_{2t}}{\partial p_{4t}} & \frac{\partial s_{3t}}{\partial p_{4t}} & \frac{\partial s_{4t}}{\partial p_{4t}} & \cdots \\
\vdots & \vdots & \vdots & \vdots & \ddots
\end{pmatrix}
$$

In this case, product one is produced by a local firm and so this firm has no possibilities of contacting with other firms outside market t (e.g. the firm(s) producing product 2,3 and 4). Then, this firm will only take into account its own price partial derivative. On the other hand, say products 2 and 3 are produced by a multi-product firm and product 4 is produced by a single product firm. However these two firms face each other with this or other products in a market $k \neq t$. Then, the multi-market contact hypothesis implies that in the corresponding first order conditions for these three products the whole combined set of market share partial derivatives should appear. Note also that these two firms will form a (tacit) coalition from which the first firm is absent.

3.4   Specification, Parameter Estimation and Inference

As mentioned before, prices and market shares are endogenous. This is easily seen by looking first at equations 3.3.7 to 3.3.9. All these expressions depend on the mean utility level and so depend directly on the unobserved product attributes. Second 3.3.18 and 3.3.19 show that the pricing equations depend in its turn on these market shares Therefore, since the unobserved product attributes are treated as the unsystematic shock in regression equation 3.3.13, market shares and prices are correlated with it. Therefore, consistent estimation requires the use of instrumental variables. There are a number of strategies available to estimate consistently (and efficiently) the parameters in equation 3.3.13. We perform here two of these strategies. First, we estimate Instrumental Variables regressions using an efficient GMM estimator without imposing any restriction to account for the non-linearity of the parameters in 3.3.13. After this we test a simple non-linear hypothesis on the restriction implied by the mean utility model. Second, we estimate the parameters using a Two Stage Least Squares estimation in which the second stage performs a non-linear Least Squares regression explicitly imposing the parameter restrictions (not shown). The GMM estimations appear to be better in correcting the endogeneity problems and are used to compute the PCM implied by the different hypotheses described in the last section. These PCM will then be compared with computations performed by other authors on PCM computed from accounting and other primary source data on prices and costs. The exercise is concludes by suggesting that firm behavior is close to the hypothesis whose estimated PCM is closer statistically to the computations made in other studies from detailed cost or production input information. This strategy is followed by the seminal works of Berry, Levinsohn, and Pakes (1995) and Nevo (2000a).

3.4.1 Description of the Data and Discussion on Key Variables

We use a sample of pharmaceutical data for drugs divided at the molecule level from the IMS-MIDAS database. The data includes prices, sales in standard units, the year of launch of the product, the manufacturer, the corporation that developed the drug (can be the same as the manufacturer) the nationality of the corporation and other characteristics of the products.

As mentioned in section 3.2, we selected drugs on the basis of active ingredients that are intended to treat high blood pressure, these are: Atenolol, Captopril, Diltiazem, Enalapril and Hydrochloriazide. In the sub-sample we have considered, there are 27 firms which may or may not produce their own version of all the molecules. In addition we considered information from 14 OECD countries (including the US) through the period between years 2000 and 2003 both inclusive. We define a market to be a pair country-year, and following the model in section 3.3 these markets are assumed to be independent to each other, therefore we have $14 \times 4 = 56$ independent markets. Not all the firms are present in all the markets and not all the firms produce a drug in all the molecules considered which implies an unbalanced (panel) structure. The sample size is of 1,112 observations. Table 3.1 below shows the average number of products in a market by country as well as the average number of products in a specific molecule. Note however that the information we will use consider data from more product/firms than those that appear in this table. This is because we relegate products with too small market shares as outside options in the decision making process.

Prices where converted to USD (pd) and the different market shares where computed from information on quantities sold in standard units. Standard units are defined by IMS to compare quantities of sales of products that are

Table 3.1: *Average Number of Products by Country*

Country	No. Obs	Total Market	Molecule
AUS	76	19.079	4.974
		(1.197)	(1.883)
BEL	67	17.328	4.463
		2.925	1.645
CAN	64	16.000	4.250
		0.000	1.069
DEN	60	15.233	4.333
		1.952	1.434
FRA	161	40.752	8.764
		4.282	1.434
GER	140	35.043	7.786
		1.246	2.118
ITA	74	19.432	5.973
		3.993	1.887
NOR	39	9.923	2.744
		1.285	1.229
POL	38	9.632	2.053
		1.125	0.517
POR	55	14.418	4.418
		3.047	2.114
SPA	82	20.756	5.195
		2.225	2.069
SWE	74	19.054	5.000
		3.096	1.858
UK	49	12.306	3.000
		0.822	1.041
US	133	33.271	7.511
		0.827	2.106
Total	**1112**	**24.406**	**5.865**
		10.633	2.627

marketed in a variety of presentations such as liquid, pills or tablets. Product characteristics available in the database where basically two; the time since launch of the product (tsl) and the presence of a second molecule combined with the basic molecule (comp). We also considered in some of the regressions a dummy variable indicating a branded product or a generic (or non-branded). To select the corporations whose products are to be considered as branded we used information from the European Federation of Pharmaceutical Industries and Associations (EFPIA). The biggest companies that are full members of these federation are considered brand-name holders. Table C.1 in Appendix C summarizes the description of all the variables used (except dummy variables associated with corporations to be discussed after), likewise Table C.2 presents descriptive statistics of the variables used.

3.4.2 Instruments

As noted before, prices and market shares are endogenous in that they are functions of the unobserved product attributes which are taken as the non-systematic shocks in my regressions. Consistent estimation requires the selection of appropriate instruments. For the case of the price we have sought for variables that move the pricing schedules of products that are not correlated with the error term. For the type of exercise conducted in my work, the literature suggest a number of sets of valid instrumental variables. The following is a list of all of them we have considered:

1. **Number of products offered.** In this case for a product j in a certain market we considered as instruments the number of products that other firms offer in the market, the number of products other firms offer within molecule and within sub-cluster groups in the market. Also the number of products that the firm producing j offers in a market excluding product j. Changes in the number of own products in a market and products produced by other firms will change the pricing schedules while they are

uncorrelated with unobserved product characteristics. Also, the number of products are considered to be an indicative of the competitive situation of a market, therefore they are related to the observed level of market shares and so are valid instruments for these (endogenous) variables.

2. **Observed Product Characteristics.** By definition observed product characteristics are not correlated with unobserved attributes. This is due to the assumption for which the selection of attributes of a product from a space of characteristics is exogenous to the model. We use own product characteristics and sums of the product characteristics of other products in the market.

3. **Brand, Corporation and Country Dummies.** Nevo (2000b) suggests using brand/product dummy variables as explanatory variables and instruments. He considers that the objective in using these variables is twofold; first, brand or product dummy variables may capture the effects of vertical product differentiation that are otherwise considered in the error term, second, once these effects (if any) are controlled there will be no need to instrument endogenous variables for these. However in my exercise, brand dummy variables had the inconvenience that given the structure of my sample, where not all firms are present in all markets and all molecules, it is likely that collinearities may appear and they in fact do. For that reason we instead use dummy variables for corporations. We would like to point out that in works aim at estimating demand parameters for the drug industry considering product differentiation (and actually other industries) authors do not incorporate brand or corporation dummies. We consider here that this may create identification problems as suggested by Nevo (2000b) specially in the pharmaceutical industry where the name of the corporation may be associated with differentiated levels of advertising outlays. The latter, as noted in section 2, is likely to create important brand price premiums in the sense of lower elasticities of demand (This is often discussed in the literature of hedonic prices).

4. **Average Price of the Product in Other Markets** Nevo (2000b) suggests this instrument when brand-name dummy variables are present. Since the structure of my data is that of an unbalanced panel, with countries as the cross sectional portion, we take advantage of the assumption of the independency across markets to consider as valid instruments averages of prices of the product to be instrumented in other markets. This average will be correlated with the price of product j inasmuch as they share the same marginal costs structure, however since markets are independent this average price will be independent from the mean utility levels of other markets.

Tables C.1 and C.2 present descriptions and statistics for the instruments used respectively.

3.4.3 Estimation Results and Analysis

Estimations of Instrumental Variable Regressions

From 3.3.13, the dependent variable of the estimations is obtained as $\ln(\frac{s_j}{s_0}) - \ln(\frac{s_j}{s_m})$. The model implies also that the coefficient for $\ln(s_{j/mb})$ is expected to be equal to $\rho_{mb}.\rho_m$. This restriction provides also a simple way to test the validity of the model proposed with respect to the information available to perform the exercise.

Different Instrumental Variables estimations where performed. A set of four GMM estimations are shown in Table C.3 as well as the J-Statistic for the Hansen test of Overidentifying Restrictions which tests the joint validity of the parameter identifying moment conditions implied by the set of instruments [See Wooldridge (2002) for a reference]. In column (1) we present an estimation without including firm dummy variables. The next three columns present estimation considering these variables. With respect to the test of

Overidentifying Restrictions, the last three regressions appear to perform better which may be due to the effect suggested by Nevo (2000b) in that brand (or in my case firm) dummy variables can control for the effects of vertical product differentiation and so are not included in the error term of the regression and does not require any identifying condition from the set of instruments. To be precise, the results of the Hansen Test suggest no systematic violation of the moment equations implied by the model. With respect to the test for the non-linear restriction implied by equation 3.3.13, the critical values for the $\chi(1)$ are of 3.84 (95%) and 5.02 (97.5%). The restriction is rejected for equations (1) and (2) and cannot be rejected for equations (3) and (4). Therefore, the model appear to be reasonably consistent with the data at hand.

We used the estimated parameters for column (4) in Table C.3 to compute the share price elasticities. We present in Table C.4 the implied share-price elasticities for a sub-sample of products. Firms (corporations) are identified by a three digit number beginning with 101 (Alpharma), molecule segments are identified by a number between 1 (for Atenolol) and 5 (for Hydroclorotiazide), and sub-clusters are identified by a 0 for a non-branded or generic product and 1 for brand-name holders. Two important results are to be highlighted from these computations. First, own price elasticities are relatively low which is a result in line with previous discussions on some institutional aspects of the market. The fact that consumer decision making is usually done through a physician was mentioned before as a source for low own price elasticities. This result will be reflected in the implied PCM presented in the next section. Second, typically the cross price elasticity of a product j with respect to a product l will be higher whenever product l belong to the same molecule segment and sub-cluster and lower otherwise. This result was expected because of the way in which we have approached the demand system, however the data seems to fit this pattern of substitution suggesting that in fact product differentiation and rich substitution patterns are relevant features of the market.

In addition Table C.5 presents mean and median own price elasticities by

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molecule. We distinguish for the cases of Captopril and Enalapril the own-price elasticity of the pioneer firm. In both cases the pioneer own-price elasticity is close to the mean elasticity computed. On the other hand, at least for the off-patent molecules Diltiazem and Hydrochloriazide the demand elasticities are much more higher perhaps due to the fact that being always off-patent products introduces higher price sensitiveness.

Price Cost Margins in the Industry

Estimation of price cost margins from accounting information or other primary source is problematic due to lack of data that reveal unbiased economic measures of costs. However, some studies have done so and are taken as a benchmark to which compare my results. Interestingly, all the calculations of PCMs are done using information from the most prominent laboratories in pharmaceutical markets. Therefore, since we are able to identify the source of a branded drug in our data set, those PCMs are comparable to some specific simulated PCMs as those computed from the hypothesis of multimarket contact coalitions.

Scherer (2000), estimated from sales, materials purchase costs and pay-roll costs in-plant price cost margins for the US pharmaceutical industry. He obtained a high figure of 61.4 % , which is in line with the common idea that the industry is of low marginal costs and high prices specially in the US [18]. Scherer and Ross (1990), however pointed out before that these calculations are likely to be biased downwards due to the fact that some payroll costs are fixed and hence are erroneously included in the marginal cost. Linnosmaa, Hermans, and Hallinen (2004) computed price cost margins for the Finnish pharmaceutical industry based on a productivity analysis that uses firm level data on cost side information as capital stock and labor force. They estimated that the higher price cost margin could be of around 67 % on average. Using

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[18]He pointed out that on average in the US the price cost margins of manufacturing industries are of around 30.5 %

the same methodology and detailed data on production (cost) inputs, Hermans (2004) calculated that the price cost margins in the U.S. are between 51.2-67.1 % when R&D is not considered as input and 40-58 % when it is. Martikainen, Kivi, and Linnosmaa (2005) present a comparison of prices of selected drugs across countries in Europe. From their findings it can be inferred that retail margins over wholesale prices are of around 30 to 50 % . The Public Citizen Congress Watch of the US estimated that profitability of pharmaceutical firms in 2002 (measured as profits over revenues) had a median of 17 % on average, however the variability of this profits were sizeable with many top corporations earning around 30 %. These figures suggest that once fixed costs and advertisement and marketing outlays are removed the margin can increase substantially. Hopkins (2002) computed the percentage of revenues allocated to profits, advertisement, marketing, administration outlays and R&D expenditures for top US drug corporations. From his analysis price cost margins can be calculated to be between 30 to 60 % approximately [19]. Berndt, Bui, Reiley, and Urban (1995) study the case of the antiulcer drug market. They use a price cost margin benchmark of between 75 to 90 % based on price and cost information. Note that the numbers mentioned so far on PCM give an idea of low price elasticities in the industry, which is mainly due to the fact that in general those computations include information for on-patent and off-patent drugs. For the exercise of comparing these PCM with those implied by my estimations, we consider that the relevant ones are the calculated by Scherer (2000), Linnosmaa, Hermans, and Hallinen (2004) and Hermans (2004) because they are closer estimated from detailed information on the cost/input side and they include a considerable number of off-patent mature product markets.

A benchmark PCM of around 50 to 60 % appear a reasonable figure for a mature pharmaceutical market, keeping in mind that these range of numbers

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[19]For instance, once advertisement outlays are added to net income (profits), the figure for Pfizer is of 52 %, for Bristol-Myers of 56 %, for Eli-Lilly of 58 % and for Schering-Ploug of 61 %.

are compatible with average mark-ups for large laboratories. Thus, it is expected that once information on smaller firms, possibly generic producers, is accommodated into the computations the implied margins will be revised downwards.

Estimated PCM for Alternative Hypotheses and Discussion

Table C.6 summarizes the mean PCM and confidence intervals implied by the different hypotheses suggested in section 3.3. For the case of the means of PCM due to product differentiation and the portfolio effect we have considered the whole data set used in the estimations. For the two firm behavior hypotheses we focused on information for year 2003 because of the complexities of the computations. However we might expand this analysis to the whole set of information, considering the last year available information gives the most relevant picture of the current PCMs for this industry.

The results give some interesting implications for competition analysis. In one hand, it appears that market power due to product differentiation is not different statistically to market power due to the portfolio effect, although the latter is slightly greater. This result can be explained by the fact that firms produce drugs within a market that belong to different molecule segments and so the cross elasticities were estimated to be low. Therefore, at the therapeutic category level my results suggests that portfolio effects are not of high relevance. The mean PCM in the former case is of around 35.5 % which is much lower than those margins estimated in previous works with cost data mentioned in the last sub-section. Nevertheless market power due to product differentiation is a very appreciable one, therefore it deserves an extended discussion. First, note that the existence of a product differentiation effect is not a great surprise. Other studies both theoretical and empirical, as noted in section 3.2, have proposed and find that this characteristic is relevant for the industry. However, my result for the sub-market of anti-hypertensives is

suggesting that product differentiation is alone responsible for at least a cost margin of 34 % (lower bound of the confidence interval).

This result can be interpreted from at least two interesting points of view. **First** consider a set of policies aim at increasing competition. Suppose that public measures to increase competition in the market for anti-hypertensives are introduced, and further suppose that these measures succeed in their aims. Even if this is true still an important high PCM will be observed due to product differentiation and more importantly this PCM will be a lower bound to what competition policies can hope to obtain. **Second**, this result may have important implications for the sustainability of tacit collusive pricing. Think about the classic Bertrand duopoly market with infinitely repeated interactions. We know that under product homogeneity pricing above marginal costs (e.g., joint profit maximization) can be sustained if firms are patient enough to give considerable weight to future gains of collusion with respect to a defecting strategy that will trigger a punishment forever. The core of this simple result is the severity of the punishment which involves zero profits forever (the static Bertrand equilibria) after a deviation is detected. However, for the case of study in this paper, the severity of the punishment is reduced due to the fact that the Bertrand competitive equilibrium involve considerable price margins. Hence, it could be the case that market power due to pure product differentiation complicates the sustainability of a joint profit maximization outcome. In this sense, the important result of market power based on product differentiation will impose also bounds on tacit collusion [20].

On the other hand my preliminary results on the PCM implied by the multi-market based tacit collusion are very close to the benchmark proposed in the last section. In Table C.5 we present two results for multi-market contacts. The first with a mean close to 65 % corresponds to implied PCM of firms

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[20]The key, however, is the cross-price elasticities of rival products. If they are high enough, avoiding cannibalization within the collusive coalition will considerably increase the gains of collusion offsetting the effect of product differentiation.

that jointly maximize their profits based on multi-market contacts, while the second additionally averages-in those (local) firms that are not part of the multi-market solution and are assumed to behave based only on product differentiation. The latter correction reduced the margin to an average of 52.6 %. The benchmark falls by little inside the confidence interval computed for multi-market hypothesis considering only the colluding firms. Although not conclusive, there seems to be a role for multi-market contacts in shaping tacit collusion, however the lower estimated figures when considering all the firms (not only the colluding *coalition*) gives room for further analysis on other hypotheses. The fact that PCM are reduced when the local or generic producer firms are considered is of course not surprising. However, it is interesting to analyze empirically the role that local firms play in shaping the average PCM in individual markets. This will be suggested and implemented in the next sub-title.

Finally, my results for the joint profit maximizing hypothesis within a market suggest a preliminary figure of around 93% which is much higher than the benchmark, but is in the range of the PCM suggested in Berndt, Bui, Reiley, and Urban (1995) for the anti-ulcer market. However, even the lower bound of the confidence interval is high enough so as to strongly reject the hypothesis of full tacit collusion. This result together with the important margin estimated for the pure product differentiation case may be suggesting that the latter severely limits the ability of the whole set of firms in a given market to tacitly collude. That is, the fact that the joint profit maximization hypothesis is rejected by the available information on the industry's PCM may be due to the reduced severity of the punishment because of the already sizeable market power enjoyed by firms due to product differentiation.

Assessing the role of *local* producers in the sustainability of PCM[21]

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[21]We thank professor Antonio Cabrales for suggesting the interesting analysis that can be done for the role of local producers

An important issue that comes about from the way the behavioral hypotheses has been set and the empirical exercise performed, is the one related to the role that *local* producers, that we identify with generic products, have in the determination of market power. First, the empirical results say that if the static equilibrium in the market is that of a jointly maximized profits, observed PCM can be of at least 86.1 % (lower bound of the confidence interval for the joint profit maximization hypothesis). In this case, it is assumed that the coalition of firms includes all firms in a given market. On the other hand, note that the multi-market hypothesis is constructed by selecting from the set of firms in a market those whose products share presence in at least one other independent market. Then, the multi-market hypothesis is a class of joint profit maximization equilibrium which includes in the coalition a sub-set of relevant firms (and their respective products in a market). Therefore, the difference between the PCM of the joint maximizing hypothesis and the PCM of the multi-market hypothesis (specifically that which incorporates the solution for the local firms) is the PCM *lost* on average due to the presence of local producers that are not involved in multi-market contacts. This difference is of at least of 30.8 % (consider the difference of the lower bound of the fifth row with and the upper bound of the fourth row in Table C.6).

Note that this statistical result is true whether or not a local producer of generic drugs is efficient or not. This is because that the model we use is static. Evidently, in a dynamic setting, only efficient producers are expected to remain. Nevertheless, what is important here is that *local* producers appear to have an important effect on the competitive levels of the market by limiting or reducing the ability to sustain a large coalition of tacit collusive firms. This finding is original to my work and can be further explored in the future.

3.5   Concluding Remarks

We have proposed a model to assess empirically the PCM and market power for a sub-market in the pharmaceutical industry, specifically in the sub-market for antihypertensive drugs. The model from the demand side provides a framework flexible enough to approach plausible substitution patterns in the industry. The selection of the sub-market was made based on the fact that there is a variety of products (chemical entities) that are close/or imperfect substitutes due to the fact that high blood pressure can be related to an important number of different medical conditions. Therefore it is reasonable to model patients/physicians consumption as a choice process of desired or preferred characteristics from a set of available attributes. Therefore, product differentiation appears to be a good assumption. Demand parameters where estimated using a result for which the mean utility levels from consuming pharmaceutical products can be obtained from market level data on observed market shares; no individual level data is required. Instrumental Variables regression within a GMM model provided preliminary results that appear to support the model suggested in the paper. We obtained pricing equations that depend on demand parameters and variables that are estimated and observed respectively. Therefore, different hypotheses of firm behavior imply different pricing equations and different ways in which parameters and variables are combined. PCM where estimated from these pricing equations without using actual data on marginal or variable costs. One concern about high cost margins was argued to be due to multi-market contacts which has been suggested in other industries as an important source to sustain collective market power or tacit collusion. Once we estimated the PCM implied by the different hypotheses, four main conclusions can be drawn. First, product differentiation appear to be an important source of market power and so it should be taken into account when analyzing price behavior. Not doing so can produce erroneous conclusions when conducting competition analysis or other approaches to understand pricing in the industry. Second, the portfolio effect appear to be statistically

unimportant, a result that can be understood by the fact that firms diversify the products they offer and so usually supply one version of a certain molecule and so substitutability among products produced by one firm are typically low. Third, the PCM implied by the multi-market hypothesis seems to be in line with what has been obtained from detailed cost level data in previous results. Therefore, at the sub-market level, multi-market rivalry appears to be a relevant fact that is to be further analyzed. From these perspective, the result opens a new interpretation for the role of local (generic) producers in lowering PCM. Since local producers are (by definition) less likely to be involved in a situation of multi-market contacts than large corporations, and they are expected to enjoy lower margins, expanding the scope of influence of generic producers in a certain market should unambiguously reduce prices on average because they reduce the ability of the whole set of firms to collude.

Fourth, PCM implied by joint profit maximization within markets are much higher than the margins calculated from cost and input data on previous works. Therefore this hypothesis seems to be strongly rejected. Such high PCM are not likely to appear in the industry at least given the institutional characteristics, market structure and other aspects of the market taken into account in the model.

Considering the recent waves of mergers, there might be two distinctive effects that can be expected. First, mergers among large multinational firms that are usually present in all the national markets will reduce the effect of market contacts as one competitor will disappear from the landscape. More weight will be given to the portfolio effect, a unilateral effect that might not be a relevant source of market power since the difference in market power from pure product differentiation and the portfolio effect is statistically small. Second, and more importantly, the merger of large multinational laboratories with local producers (most possibly generic producers) may reduce the positive effect over average PCM in international markets.

Appendix A

Appendices to chapter 1

A.1 Demand derivation

Consider first the demand for firm 2, the firm of reference. A consumer x_i will consume from firm 2 as long as:

$$V_{i2} > V_{i1} \qquad \text{(A.1.1)}$$

Considering the assumptions

$$\theta_i z_2 - t(x_i - a)^2 - \alpha p_2 > \theta_i z_1 - t((S-a) - x_i)^2 - \alpha p_1 - \beta(p_1 - \widetilde{p}) \quad \text{(A.1.2)}$$

Solving this equation for the position of the consumer on the horizontal segment we obtain:

$$\frac{S(S-2a)t - \theta_i(z_1 - z_2) + \alpha(p_1 - p_2) + \beta(p_1 - \widetilde{p})}{2(S-2a)t} > x_i \qquad \text{(A.1.3)}$$

We first integrate over the density of x_i conditional on the preference for the quality attribute so that the expected length of the horizontal segment that corresponds to firm 2 is the following:

$$q_2 = \frac{S(S - 2a)t - \theta_i(z_1 - z_2) + \alpha(p_1 - p_2) + \beta(p_1 - \widetilde{p})}{2(S - 2a)t} \tag{A.1.4}$$

The next step is to simplify the density for the distribution of preferences for the quality attribute so that $dF(\theta) = \frac{1}{\theta_H - \theta_L}$ which implies that at any point of the horizontal segment, the mean preference for any level of quality is given by $\bar{\theta} = \frac{\theta_H + \theta_L}{2}$. In addition we have imposed an upper bound to θ_H so that $(\alpha + \beta)(p_1 - p_2) + \frac{S(S - 2a)}{(z_1 - z_2)t} \geq \theta_H$. Therefore, integrating over the space of the distribution of θ_i we obtain the demand function for the firm 2:

$$Q_2(p, z) = \frac{S(S - 2a)t - \bar{\theta}(z_1 - z_2) + \alpha(p_1 - p_2) + \beta(p_1 - \widetilde{p})}{2(S - 2a)t} \tag{A.1.5}$$

where p and z are the corresponding vectors of prices and qualities.

Given our assumption of full coverage of the population and the assumption that $\theta_H - \theta_L = 1$, then $\bar{\theta}(\theta_L) = \frac{1}{2} + \theta L$ and the total demand for firm 1 is:

$$Q_1(p, z) = \frac{S(S - 2a)t + \bar{\theta}(z_1 - z_2) - \alpha(p_1 - p_2) - \beta(p_1 - \widetilde{p})}{2(S - 2a)t} \tag{A.1.6}$$

As noted in the corresponding section, the internal reference pricing implies $\widetilde{p} = p_2$ because it is expected that the generic entrant if it enters it does so providing a low *quality* product. Denote $\Delta z = z_1 - z_2$ and $\Delta p = p_1 - p_2$, and

Figure A.1: *Scheme of the The Demand System*
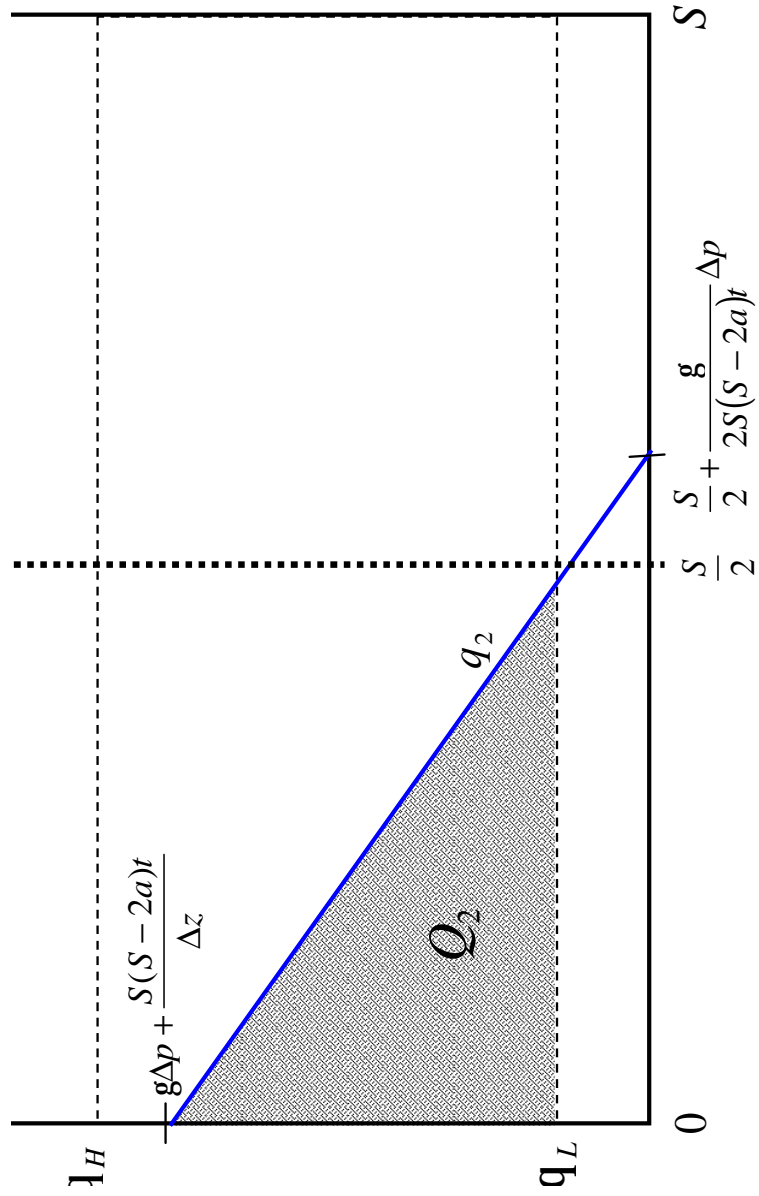
also $\gamma = \alpha + \beta$ then the demand system is:

$$Q_1(\Delta p, \Delta z) = \frac{S(S - 2a)t + \bar{\theta}\Delta z - \gamma\Delta p}{2(S - 2a)t} \tag{A.1.7}$$

$$Q_2(\Delta p, \Delta z) = \frac{S(S - 2a)t - \bar{\theta}\Delta z + \gamma\Delta p}{2(S - 2a)t} \tag{A.1.8}$$

A.2 Derivation of the level of investment of the incumbent that makes entry unprofitable for a general F

We can combine 1.2.12 and 1.2.13 to find a reduced form profit function for firm 2 as a function of the strategic decisions of the incumbent:

$$\pi_2(z_1) = \frac{1}{18(S - 2a)\gamma s_1^2}\left((s_1 - \bar{\theta}^2)(s_0 - \bar{\theta}z_1)\right)^2 - \frac{\bar{\theta}^2(s_0 - \bar{\theta}z_1)^2}{2s_1^2} - F \tag{A.2.1}$$

Consider this expression and equalize $\pi_2(z_1) = 0$. From the definition of s_1 we may rewrite this equation in the following way:

$$\frac{1}{(s_1 + \bar{\theta}^2)s_1^2}(s_1 - \bar{\theta}^2)^2(s_0 - \bar{\theta}z_1)^2 - \frac{\bar{\theta}^2}{s_1^2}(s_0 - \bar{\theta}z_1)^2 = 2F \tag{A.2.2}$$

Next factorize $(s_0 - \bar{\theta}z_1)^2$ and rewrite the latter equation:

$$(s_0 - \bar{\theta}z_1)^2\left(\frac{(s_1 - \bar{\theta}^2)^2}{(s_1 + \bar{\theta}^2)} - \bar{\theta}^2\right) = s_1^2 2F \tag{A.2.3}$$

Now, the latter equation may be solved for z_1:

$$z_1 = \xi_1 = \frac{s_0}{\bar{\theta}} - \frac{1}{\bar{\theta}} 2^{\frac{1}{2}} \cdot \left(\frac{(s_1 + \bar{\theta}^2)s_1}{s_1 - 3\bar{\theta}^2} \right)^{\frac{1}{2}} F^{\frac{1}{2}} \qquad (A.2.4)$$

Therefor whenever $F > 0$ the level of marketing investment of the incumbent that makes entry unprofitable is lower than $\frac{s_0}{\theta}$.

A.3 Predictions with no RP and fully horizontally differentiated products

In this appendix we briefly study the case in 1.2.1 under the circumstance that products are fully horizontally differentiated, that is when firms are located at the corresponding edges of the line segment $[0, S]$, $l_1 = S$ and $l_2 = 0$. To this aim we show the numerical solutions of 1.2.1 for the case in which products are close the center of the line segment, specifically we will show the case for $a' = 0, 4S$ and the case for which $a'' = 0$ and an intermediate level of horizonal product differentiation.

The following table shows the market equilibriums for the corresponding levels of horizontal product differentiation, and additional how the results changes when the efficiency advantage changes from $c = 2$ to $c = 3$ so as to provide some robustness check. As it can be seen, when product differentiation is greater quality differentials reduces as the quality investment from the incumbent reduces and the potential entrant's quality investment increases as it has incentives to profit from higher quality consumers that are now much far away from its competitor. This implies a negative effect for the incumbent's price and a positive effect for the entrant's price, however from the corresponding equilibrium price equations 1.2.10 and 1.2.11, more horizontal product differentiation implies higher market power so that the price of the incumbent

always increases.

The potential entrant is able to capture a relatively larger proportion of the market, therefore its expected profit increases. This result observed is irrespective of the size of the efficiency of the incumbent, however as more efficiency implies higher quality investments, all the levels are changed.

As noted before in the main body text of this paper, the case of full horizontal differentiation can be put in terms of a situation in which the potential entrant is a large laboratory that has already developed an alternative drug based on an alternative active ingredient and is seeking to profit from a market in which the incumbent has already been present with its product for some time. Price competition is softened by the horizontal dimension of the model. Note also that the model predicts that the differences between an equilibrium where the incumbent has no efficiency, or the previous length of patent protection was not relevant in explaining is ability to invest in marketing, and an equilibrium in which the incumbent has an efficiency advantage are smaller whenever the horizontal differentiation is extreme.

Table A.1: **Market equilibrium for different degrees of product differentiation**

	z_1^*	z_2^*	$z_1^* - z_2^*$	p_1^*	p_2^*	Q_2^*	π_2^*
$c = 2$							
a=0,4	0,484	0,290	0,194	0,565	0,435	0,435	0,148
a=0,2	0,363	0,331	0,032	1,511	1,489	0,496	0,685
a=0	0,350	0,333	0,017	2,506	2,494	0,499	1,189
$c = 3$							
a=0,4	1,023	0,136	0,886	0,795	0,205	0,205	0,033
a=0,2	0,571	0,314	0,256	1,585	1,415	0,472	0,618
a=0	0,538	0,324	0,214	2,571	2,429	0,486	1,127

Appendix B

Appendices to chapter 2

B.1 Technical Appendix: Multimarket Contact

B.1.1 Product differentiation case

We study an industry where there exist K product markets so as to approach what is observed in the pharmaceutical industry. Let´s identify a single product market by k and denote by N_k the number of firms producing differentiated products with the same constant returns to scale technology. Assume that firms compete in prices under product differentiation. Denote the individual profit function of a firm in market k as $\pi_k(p_{ik}, p_{-ik})$ and assume it is concave in prices, where p_{-ik} denotes the $N_k - 1$ rival's prices. Equilibrium prices in the one shot pricing game are denoted by p_{ik}^n, $i = 1, ..., N_k$ and form a unique Nash equilibrium. [1]. Let p_{ik}^m denote the price that allow firms to achieve monopoly profits in the market. Assume firms compete in prices in a repeated fashion with infinite horizon. Firms may sustain in equilibrium

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[1]Given concavity and identical technologies we can look for the symmetric price equilibrium in which case, $p_{ik}^n = p_k^n$, $\forall i$

higher than the stage game price equilibrium using trigger strategies in which any deviation of the collusive strategy is penalized by reverting forever to p_k^n. Denote by p_{ik}^c the price for firm i in the repeated game in market k, concavity of the profit function implies $p_{ik}^c \in [p_{ik}^c, p_{ik}^m]$. p_{ik}^c is assumed to be selected such that it maximizes the present discounted value of the firm's expected flow of profits subject to the incentive constraint that loses implied by deviations from the collusive path are greater than the implied gains [2]:

$$\frac{\delta}{1-\delta}[\pi_{ik}^c - \pi_{ik}^c] \geq \pi_{ik}(R_{ik}(p_{-ik}^c), p_{-ik}^c) - \pi_{ik}^c \qquad \text{(B.1.1)}$$

where π_i^* and $\pi_i^{'}$ are firm i's profits when prices are p_i^* and $p_i^{'}$ respectively, $\pi_i(R_i(p_{-i}^{'}), p_{-i}^{'})$ are firm i's profits when all firms other that i set their collusive prices, $p_{-i}^{'}$, and firm i chooses its best response to them, $R_i(p_{-i}^{'})$, and $\delta \in (0,1)$ is the discount factor. Now, note that if p_i^m is to be supported as a sub game perfect equilibrium, then it must be the case that there is no profitable deviation from it, in other words it satisfies:

$$\frac{\delta}{1-\delta}[\pi_i^m - \pi_i^*] \geq \pi_i(R_i(p_{-i}^m), p_{-i}^m) - \pi_i^m \qquad \text{(B.1.2)}$$

Where π_i^m is firm's i profits from the joint profit maximization outcome. While the left hand side of this expression depends on δ, and increases monotonically in this argument, the right hand side is independent of the discount factor. If we denote the left hand side by $F(\delta, \pi_i^m - \pi_i^*)$ the following condition is true:

$$F(0, \pi_i^m - \pi_i^*) < \pi_i(R_i(p_{-i}^m), p_{-i}^m) - \pi_i^m < F(1, \pi_i^m - \pi_i^*) \qquad \text{(B.1.3)}$$

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[2]More precisely, in a symmetric product differentiation set up p_{ik}^c is the price that maximizes joint profits under the constraint that loses from deviations are greater or equal than the gains from such an strategy.

This expression implies the existence of some threshold for the discount factor, call it δ^0, above which the joint profit maximization outcome is a sub game perfect equilibrium. As it is evident, whenever the discount factor is above δ^0, higher than p_{ik}^m prices also conform with , hence if p_{ik}^m is the equilibrium it will be the case that there is some slackness in the incentive compatibility constrain. Below δ^0, p_i^m cannot be supported and we assume that firms will choose the maximum sustainable price defined as:

$$\tilde{p}_{ik}(p_{ik}^*, \delta) = \max\{p_{ik} \in [p_{ik}^c, p_{ki}^m) \mid F(\delta, \pi_{ik} - \pi_{ik}^c) \geq \pi_{ik}(R_{ik}(p_{-ik}), p_{-ik} - \pi_{ik})\}$$
$$(B.1.4)$$

Note that the condition in this function when $\tilde{p}_{ik} = p_{ik}^*$ implies $F(\delta, 0) = \pi_i(R_i(p_{-i}), p_{-i}^*) - \pi_i^* = 0$ and when $\tilde{p}_i \to p_i^m$ implies $F(\delta, p_i^m) < \pi_i(R_i(p_{-i}), p_{-i}^m) - \pi_i^m)$; therefore whenever $\tilde{p}_i > p_i^*$ it should be the case that the condition holds with equality. This result holds also under the assumption that the optimal deviation profit $\pi_i(R_i(p_{-i}), p_{-i}^m)$ is convex in prices [3]. To proceed we place the following assumption:

Assumption: *[Monotonicity] Function* $\tilde{p}_i(p^*, \delta)$ *satisfies* $\partial \tilde{p}/\partial \delta \geq 0$

It is not obvious how equilibrium prices under product differentiation change as the discount factor increases, the above assumption says that whenever future profits are more valuable, short run benefits from defecting are accordingly less preferred. Therefore p_{ik}^c, the collusive price, will be a non-decreasing function of δ [4].

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[3]Under this assumption, net benefits of collusion increases at a slower pace than the net gains of deviation up to the point a marginal increase in the collusive price will be in conflict with the incentive constrain

[4]Bernheim and Whinston (1990) nevertheless mentions that ''Product heterogeneity within each market adds considerable complexity since the maximum sustainable price typically increases continuously as the discount factor, δ, rises''.

At any given $\bar{\delta}$, function B.1.4 shows that $\tilde{p}_{ik}$ will depend on the same cost and demand conditions that determine p_{ik}^n. In fact, the best collusive price can be characterized based on the incentive compatibility constraint and Assumption 1 in the following way:

$$p_{ik}^* = \Phi(\delta) \; p_{ik}^n$$

where

$$\Phi(\delta) = \begin{cases} \frac{p_{ik}^m}{p_{ik}^*} & \text{if } \delta \geq \delta^0 \\ \frac{\tilde{p}_{ik}(\delta)}{p_{ik}^*} & \text{if } \delta < \delta^0 \end{cases}$$

B.1.2 Multimarket contact implications

We assume there is a number of rival firms present in the entire set of the K product markets. When a firm intends to deviate from the collusive equilibrium in any market k it will need to balance the gains of such deviation with the trigger of penalty reactions in the rest of the $K-1$ markets where it compete with its rivals. Therefore, firm i's incentive constraint under the multimarket contact hypothesis becomes a pooling of the K individual market incentive constrains:

$$\sum_{k=1}^{K} \frac{\delta_k}{1-\delta_k}[\pi_{ik}' - \pi_{ik}^*] \geq \sum_{k=1}^{K} \left\{ \pi_{ik}(R_{ik}(p_{-ik}'), p_{-ik}') - \pi_{ik}' \right\} \tag{B.1.5}$$

According to Bernheim and Whinston (1990) analysis, when markets differ in the number of firms, demand conditions or there are economies of scope, the

pooled incentive constrain can be used to sustain higher prices in equilibrium. It is also claimed that asymmetries within markets, which are known to hinder collusion, might be softened through the multimarket contact setting. Absence of such differences across markets makes contacts irrelevant for sustaining more collusive outcomes. Also, it is not the mere existence of multimarket contact across differing markets which expands the set of collusive outcomes, but the ability of firms in the coalition to transference market power across markets. Imagine for instance that in some of the K markets firms are able to sustain p_k^m in equilibrium so that the individual incentive constrains are verified in some of them with inequality (in our setting $\delta > \delta_k^0$ for some k). This slack can be used in markets where no collusive price is possible to sustain at the corresponding δ, for example markets where N_k is sufficiently large. Indeed firms in the multimarket coalition can increase prices in more competitive markets violating the individual incentive constrains as long as B.1.5 is verified. Under this result, average prices in the industry will be unambiguously higher than in a case without multimarket contacts.

More interestingly, whenever markets differ in their degrees of product differentiation firms can find it optimal not only to transfer but to redistribute their market power. To provide further intuition for this result we introduce the following assumption:

Assumption: *[Product differentiation and Collusion] For a given value of the discount factor $\bar{\bar{\delta}}$, the sustainable best collusive price increases with the degree of product differentiation.*

Assumption above although not directly intuitive can be supported by the fact that the one shot pricing game delivers higher profits the higher the product differentiation however under higher product differentiation the net gains of deviation are lower. Under the above assumption we will expect that high prices, perhaps close to the monopoly price, are sustainable in equilibrium

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in some markets whereas in other markets sustainable prices are close to the stage game price equilibrium based only in variations of the degree of product differentiation across markets.

Example: *[Hotelling model] For the case of a duopolistic multimarket contact structure with two independent markets. Both the monotonicity assumption and the effect of product differentiation over the best collusive price are rather observed properties.*

To parallel Bernheim and Whinston (1990) lets assume that each of the K markets in our model is a duopoly and that the coalition cannot sustain monopoly prices in the whole industry which implies that at the equilibrium prices, the pooled incentive constrain must be binding. To simplify the analysis we can look for a symmetric price equilibrium in which each corporation i in market k set p_k. The optimal pricing decision for a firm in the multimarket coalition solves:

$$\max_{\{p_k\}_1^K} \sum_{k=1}^{K} \pi_k(p_k, p_k) \tag{B.1.6}$$

s.t

$$\frac{\delta}{1-\delta} \sum_{k=1}^{K} [\pi_k(p_k, p_k) - \pi_{ik}^*] = \sum_{k=1}^{K} \{\pi_k(R_k(p_k), p_k)) - \pi_k(p_k, p_k)\}$$

The K first order (necessary) conditions together with the incentive compatibility constrain delivers the following optimal conditions for any p_k:

$$\frac{\pi_k'(\hat{p}_k, \hat{p}_k)}{\pi_k'(R(\hat{p}_k), \hat{p}_k)} = \sum_{s, s \neq k}^{K} \frac{\pi_s'(\hat{p}_s, \hat{p}_s)}{\pi_s'(R(\hat{p}_s), \hat{p}_s)} \quad \forall \, k \tag{B.1.7}$$

This last condition relates equilibrium prices in one market, k to market conditions in the rest of the markets where a firm is in contact with its market k rivals providing interesting predictions. For instance, assume that for the given δ, p_k^m is sustainable in market k whenever it is considered in isolation and for the rest of the $K-1$ markets, product differentiation is small enough so that no collusive price is sustainable. Concavity of the profit function implies that $\pi_k'(p_k^m) = 0$. Therefore, the left hand side of condition B.1.7 indicates that it is optimal for the firm to set market's k price below the monopolistic level, $\hat{p}_k < p_k^m$ and at least for one contact market prices will have to be adjusted above the one shot game price. This example shows that multimarket contact may incentive optimal redistribution of collective market power.

Given the structure of each k market and as a consequence the structure of multimarket contacts for firm i, we can represent the firm's equilibrium price of the repeated game in market k as a function of three separable components:

$$p_{ik}^* = \Gamma(MMC_{ik}) \; \Phi(\delta) \; p_{ik}^n \tag{B.1.8}$$

where $\Gamma(AVMMC_{ik}a_k) > 0$ measures the effect of the multimarket contacts structure given by variable $AVMMC_{ik}$ and the other two components come from the definition of the single market price equilibrium. The redistribution of market power can be tested in terms of the value of the multimarket function. $\Gamma(MMC_{jik}) < 1$ will be expected for markets where a collusive price is easier to support (less toughness of price competition) in equilibrium and $\Gamma(MMC_{jik}) > 1$ in markets with less favorable conditions to sustain collusion. Differences in toughness of price competition among markets can be obtained by looking at the number of varieties available in a market, market concentration, product

differentiation and so on.

B.1.3 Multimarket contact and price regulation

This section poses an argument close to the one presented in Phillips and Mason (1996). Consider the example presented in the last sub-section. Consider now that there is a regulatory agency whose only objective is to reduce prices. In particular lets assume the agency focuses in product markets where market conditions allow firms to sustain monopolistic pricing, and the corresponding individual market constrains are not binding according to our model. Assume the agency does not consider the multimarket structure, that is the agency targets each market individually, considering the market specific circumstances. Recall condition B.1.7 and assume the regulatory agency sets an exogenous binding price ceiling with respect to the un-regulated multimarket case for market k (where the monopolistic price was assumed to be just sustainable), $\bar{p}_k < \hat{p}_k$. We highlight three points of interest:

1. Whenever the ceiling close to $\hat{p}_k$ concavity of the profit function and convexity of the deviation profits:

$$\frac{\pi_k^{'}(\hat{p}_k, \hat{p}_k)}{\pi_k^{'}(R(\hat{p}_k), \hat{p}_k)[\frac{\partial R(\hat{p}_k)}{\partial \hat{p}_k} + 1]} < \frac{\pi_k^{'}(\bar{p}_k, \bar{p}_k)}{\pi_k^{'}(R(\bar{p}_k), \bar{p}_k)[\frac{\partial R(\bar{p}_k)}{\partial \bar{p}_k} + 1]}$$

   This situation suggests that not too restrictive price ceilings will increase the slack produced in market k freeing additional market power to be distributed across the rest of the markets involved in the multimarket contact structure. Therefore, additional price increases might be observed in other un-regulated markets or where price ceilings are not binding.

2. Now imagine an extreme case in which $\bar{p}_k = p_k^n$, that is the price ceiling is equal to the stage game price equilibrium. Condition (B.1.1) implies that no slack will be available to re-distribute to the rest of the contact

markets. Therefore, prices in these contact markets will be given by equation (B.1.4). In our example, equilibrium prices in the other markets will reflect only the stage game conditions.

3. By continuity of the profit functions, the reasoning in the last point can be extended to cases in which some of the other $K - 1$ markets may sustain prices above the stage game equilibrium. Given function $\tilde{p}_{is} < \hat{p}_{is}$ for the unregulated case, there must be a level of price ceiling for p_{ik} so that there are corresponding outcomes satisfying $\bar{p}_{is} < \hat{p}_{is}$. That is price regulation in one market might reduce prices in others with respect to the level of the unregulated multimarket case.

B.2 Control Variables Definitions

Variable	Definition
Price_{jikt}	Price in USD of product j belonging to firm i
Priceg_{jikt}	Global Price in USD for product j belonging to firm i
Fsales_{jikt}	Quantity sales of firm i in certain country excluding quantity sales of product j
New_{jikt}	Binary variable, taking 1 if product j was launched in the previous year
Dgeneric_{jik}	Binary variable, taking 1 if product j is a generic
Composite_{jik}	Binary variable, taking 1 if product j is a compound of molecules
$\widetilde{HHI}_{jikt}$	Herfindahl-Hirschman Index for market k excluding product j's share
MShare_{jikt}	Market share of product j in market k
CShare_{jikt}	Corporation share in market k excluding product j's share
Censorlag_{jik}	Binary variable, taking 1 if product j was launch date is censored in the sample
Ngenerics_{kt}	Number of generic products in market k
Molage_{k}	Time elapsed up to 2003 since molecule (market) k was launched
Censormol_{k}	Binary variable, taking 1 if molecule age is censored in the sample
Nmol_{kt}	Number of molecules available in an ATC-4 market k in period t

B.3   Descriptive statistics

Table B.1: Mean and S.D. (in parenthesis) for variables in sample by country

Country	Obs.	Price	Priceg	Fsales	New	Dgen	Comp	Molage	Cmol	Clag	Ngen	Nmols	Molecule Mshare	Molecule Cshare	Molecule HHI	ATC-4 Mshare	ATC-4 Cshare	ATC-4 HHI
Canada	7281	-1.50 (1.98)	-0.94 (1.59)	9.97 (2.59)	0.00 (0.06)	0.11 (0.31)	0.14 (0.35)	8.03 (0.35)	0.01 (0.10)	0.00 (0.05)	1.09 (2.45)	5.53 (4.30)	0.40 (0.40)	0.06 (0.18)	0.64 (0.28)	0.14 (0.24)	0.07 (0.15)	0.41 (0.24)
France	5765	-1.58 (1.71)	-0.90 (1.59)	10.62 (2.34)	0.00 (0.06)	0.32 (0.47)	0.18 (0.39)	7.94 (0.42)	0.08 (0.27)	0.02 (0.13)	3.25 (4.29)	4.33 (3.34)	0.46 (0.43)	0.05 (0.18)	0.63 (0.33)	0.17 (0.26)	0.07 (0.17)	0.40 (0.24)
Germany	17306	-1.31 (1.93)	-0.74 (1.80)	9.82 (2.92)	0.00 (0.00)	0.26 (0.44)	0.19 (0.39)	8.10 (0.39)	0.10 (0.30)	0.02 (0.14)	4.23 (6.49)	8.54 (7.59)	0.31 (0.39)	0.03 (0.11)	0.50 (0.32)	0.07 (0.17)	0.04 (0.10)	0.28 (0.21)
Italy	5754	-0.79 (1.81)	-0.39 (1.84)	9.44 (2.43)	0.00 (0.00)	0.13 (0.34)	0.15 (0.36)	7.92 (0.40)	0.01 (0.11)	0.01 (0.08)	2.18 (4.34)	4.51 (3.10)	0.44 (0.41)	0.05 (0.17)	0.60 (0.34)	0.18 (0.28)	0.06 (0.15)	0.38 (0.27)
Japan	5251	-0.71 (2.30)	-0.42 (2.09)	14.23 (1.99)	0.00 (0.00)	0.09 (0.29)	0.11 (0.32)	7.93 (0.42)	0.01 (0.09)	0.00 (0.06)	0.90 (1.63)	3.78 (2.64)	0.36 (0.38)	0.02 (0.12)	0.55 (0.31)	0.16 (0.27)	0.08 (0.13)	0.44 (0.26)
Nether	2614	-0.19 (1.81)	0.03 (1.67)	9.33 (1.75)	0.00 (0.04)	0.08 (0.27)	0.16 (0.37)	7.92 (0.39)	0.08 (0.27)	0.06 (0.24)	0.71 (2.09)	3.58 (2.37)	0.49 (0.44)	0.04 (0.15)	0.76 (0.25)	0.24 (0.34)	0.05 (0.13)	0.51 (0.27)
Spain	5070	-1.14 (1.81)	-0.49 (1.64)	9.73 (2.10)	0.00 (0.00)	0.22 (0.41)	0.15 (0.36)	7.93 (0.42)	0.04 (0.19)	0.01 (0.08)	3.47 (6.65)	4.32 (2.49)	0.46 (0.41)	0.04 (0.14)	0.61 (0.32)	0.18 (0.28)	0.07 (0.15)	0.39 (0.27)
UK	3077	-0.52 (1.76)	-0.31 (1.79)	9.61 (2.41)	0.00 (0.02)	0.16 (0.36)	0.15 (0.36)	7.93 (0.43)	0.03 (0.18)	0.01 (0.09)	0.88 (1.59)	3.97 (2.75)	0.62 (0.42)	0.05 (0.17)	0.79 (0.27)	0.27 (0.35)	0.07 (0.14)	0.57 (0.27)
US	15464	1.90 (2.28)	-0.96 (1.88)	10.83 (3.40)	0.02 (0.02)	0.36 (0.48)	0.26 (0.44)	8.11 (0.39)	0.08 (0.27)	0.01 (0.08)	3.70 (5.31)	11.91 (13.87)	0.33 (0.40)	0.16 (0.05)	0.59 (0.30)	0.09 (0.20)	0.04 (0.12)	0.26 (0.34)
Total	67582	-1.15 (2.04)	-0.70 (1.81)	10.41 (3.01)	0.00 (0.02)	0.23 (0.42)	0.18 (0.39)	8.02 (0.40)	0.06 (0.24)	0.01 (0.11)	2.91 (5.15)	7.20 (8.59)	0.41 (0.41)	0.04 (0.16)	0.59 (0.32)	0.13 (0.24)	0.05 (0.13)	0.37 (0.25)

Source: IMS MIDAS

Table B.2: **Mean and S.D. (in parenthesis) of multimarket contact measures**

country	where w_m:	Molecule		ATC-4	
		HHI	**Sum of Sales** shares	*HHI*	**Sum of Sales** shares
Canada		3.27	0.38	2.36	0.55
		4.54	0.43	2.29	0.41
France		2.89	0.38	2.72	0.53
		4.33	0.51	3.02	0.47
Germany		4.39	0.41	2.17	0.55
		7.59	0.43	2.39	0.38
Italy		0.31	0.15	0.46	0.27
		0.57	0.23	0.55	0.24
Japan		1.10	0.22	1.15	0.35
		1.57	0.26	1.21	0.28
Nether		6.30	0.53	2.91	0.61
		8.16	0.61	3.28	0.55
Spain		0.47	0.16	0.53	0.31
		0.75	0.25	0.57	0.27
UK		0.72	0.11	0.92	0.25
		1.82	0.21	1.35	0.29
US		1.38	0.20	1.35	0.41
		1.89	0.22	1.31	0.26

*Source:*IMS MIDAS, own calculations

B.4   Graphics

Figure B.1: Effect of multimarket contact in selected markets. Market definition: molecule.
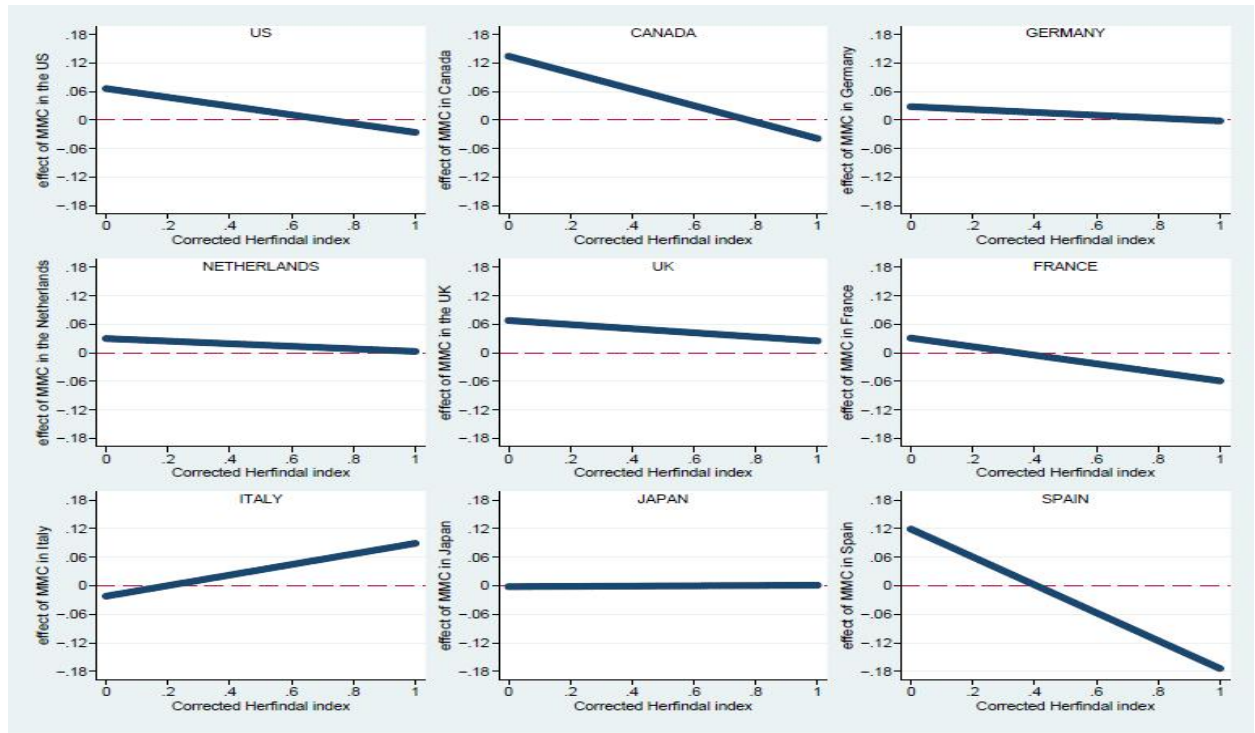
B.5   Estimation results

Table B.3: Pricing regressions for molecule markets: No Multimarket contact

Variable	US	CAN	GER	NETH	UK	FRA	ITA	JAP	SP
$Fsales_{t-1}$	0.242***	0.290***	0.216***	0.113***	0.217***	0.162***	0.160***	0.399***	0.159***
	(44.50)	(36.66)	(40.16)	(9.11)	(19.81)	(18.54)	(21.61)	(42.01)	(16.34)
New_{t-1}	-0.059	-0.333***	-0.219***	-0.239***	-0.296***	-0.146***	-0.191***	-0.215***	-0.187***
	(-1.90)	(-7.90)	(-8.41)	(-3.54)	(-4.68)	(-4.26)	(-5.40)	(-4.33)	(-5.29)
$Molage_t$	-0.310***	-0.232***	-0.185***	-0.105**	-0.206***	-0.220***	-0.189***	-0.060	-0.374***
	(-9.18)	(-4.91)	(-7.95)	(-2.58)	(-3.81)	(-6.18)	(-5.52)	(-1.35)	(-9.76)
$Censormol_t$	-0.036	0.195*	-0.012	-0.040	-0.484**	-0.133*	-0.047	-0.605***	0.470***
	(-0.93)	(2.30)	(-0.45)	(-0.53)	(-2.93)	(-2.06)	(-0.51)	(-3.71)	(5.63)
$Nmols_t$	-0.005***	-0.006	-0.000	0.009	0.024***	0.012**	-0.034***	0.034***	-0.002
	(-4.61)	(-1.84)	(-0.21)	(1.59)	(3.48)	(3.20)	(-6.41)	(5.18)	(-0.30)
$Censorlag_t$	0.385**	0.022	0.068	0.161	0.955***	0.684***	-0.082	-0.283	-0.342*
	(3.15)	(0.09)	(1.28)	(1.93)	(4.40)	(5.37)	(-0.54)	(-1.03)	(-2.37)
$Generic_t$	-0.366***	0.036	-0.044*	-0.132	-0.425***	-0.412***	-0.262***	-0.044	-0.375***
	(-11.34)	(0.64)	(-2.09)	(-1.79)	(-5.95)	(-9.83)	(-6.06)	(-0.68)	(-8.71)
$Composite_t$	-0.098**	-0.188***	0.002	-0.010	-0.129*	0.097*	0.006	0.006	-0.108**
	(-3.01)	(-4.59)	(0.08)	(-0.25)	(-2.29)	(2.35)	(0.16)	(0.10)	(-2.92)
$Ngenerics_t$	0.011***	-0.021***	0.006***	0.030**	0.133***	0.046***	0.019***	0.084***	0.006*
	(4.48)	(-3.75)	(4.33)	(3.12)	(8.08)	(8.94)	(4.55)	(6.64)	(2.29)
$Priceg_{t-1}$	0.388***	0.459***	0.589***	0.835***	0.556***	0.611***	0.576***	0.417***	0.654***
	(34.24)	(30.47)	(62.94)	(52.14)	(25.46)	(36.02)	(45.21)	(29.71)	(35.95)
$Dpriceg_{t-1}$	-0.725***	-1.028***	-1.213***	-1.160**	-0.837***	-1.414***	-0.806***	-0.453***	-0.836***
	(-18.32)	(-14.40)	(-29.99)	(-3.05)	(-7.37)	(-19.43)	(-11.07)	(-9.64)	(-9.43)
$HHI\text{-}corr_{t-1}$	0.072	-0.908***	-0.023	0.075	0.215	0.354***	0.446***	0.287***	-0.655***
	(1.15)	(-10.15)	(-0.42)	(0.78)	(1.34)	(3.53)	(5.05)	(3.30)	(-6.49)
$Mshare_{t-1}$	0.461***	-0.475***	0.448***	0.229*	0.331**	0.673***	0.090	0.547***	-0.473***
	(9.27)	(-6.83)	(12.15)	(2.04)	(2.63)	(8.07)	(1.36)	(7.51)	(-6.54)
$Cshare_{t-1}$	0.362***	-0.669***	0.095	0.047	0.179	0.380**	0.396***	0.032	-0.267*
	(4.48)	(-7.12)	(1.02)	(0.34)	(1.08)	(3.29)	(4.29)	(0.17)	(-2.03)
Cons	0.497	-0.013	-0.099	0.052	0.305	0.017	0.594*	-3.547***	2.419***
	(1.72)	(-0.03)	(-0.50)	(0.14)	(0.61)	(0.05)	(1.97)	(-9.22)	(7.39)
N	15464	7281	17306	2614	3077	5765	5754	5251	5070
R^2	0.624	0.651	0.726	0.859	0.681	0.709	0.758	0.733	0.727
F	313.90	250.51	822.27	466.48	147.41	251.23	383.69	329.49	253.89

* $p<0.05$, ** $p<0.01$, *** $p<0.001$
(1) t-stats in parenthesis are computed with robust standard errors
(2) All regressions include corporation and ATC-1 fixed effects and time dummies

Table B.4: Pricing regressions for molecule markets: Average multimarket effect

Variable	US	CAN	GER	NETH	UK	FRA	ITA	JAP	SP
$Fsales_{t-1}$	0.242*** (44.51)	0.293*** (36.90)	0.217*** (40.32)	0.114*** (19.82)	0.217*** (18.54)	0.162*** (21.55)	0.159*** (41.99)	0.399*** (16.40)	0.159*** (16.40)
New_{t-1}	-0.059 (-1.91)	-0.326*** (-8.34)	-0.216*** (-7.72)	-0.243*** (-3.60)	-0.302*** (-4.75)	-0.152*** (-5.41)	-0.192*** (-4.33)	-0.215*** (-5.39)	-0.191*** (-5.39)
$Molage_t$	-0.311*** (-9.18)	-0.200*** (-4.15)	-0.175*** (-7.44)	-0.105** (-2.58)	-0.201*** (-3.71)	-0.233*** (-6.41)	-0.191*** (-5.55)	-0.066 (-1.47)	-0.377*** (-9.86)
$Censormol_t$	-0.036 (-0.93)	0.174* (2.08)	-0.007 (-0.25)	-0.021 (-0.27)	-0.474** (-2.85)	-0.129* (-2.00)	-0.044 (-0.48)	-0.575*** (-3.51)	-0.342* (-2.37)
$Nmols_t$	-0.005*** (-4.62)	-0.006* (-2.01)	-0.000 (-0.26)	0.008 (1.42)	0.023** (3.26)	0.012** (3.21)	-0.034*** (-3.51)	0.034*** (5.21)	-0.002 (-0.36)
$Censorlag_t$	0.385** (3.15)	0.016 (0.07)	0.070 (1.32)	0.151 (1.80)	0.939*** (4.33)	0.690*** (5.41)	-0.081 (-0.53)	-0.305 (-1.11)	0.464*** (5.55)
generic	-0.363*** (-11.04)	0.042 (0.75)	-0.054* (-2.54)	-0.138 (-1.89)	-0.446*** (-6.07)	-0.372*** (-8.31)	-0.259*** (-5.94)	-0.039 (-0.61)	-0.358*** (-8.15)
$Composite_t$	-0.098** (-3.01)	-0.182*** (-4.46)	0.001 (0.06)	-0.016 (-0.39)	-0.132* (-2.35)	0.098* (2.38)	0.008 (0.22)	0.009 (0.14)	-0.099** (-2.69)
$Ngenerics_t$	0.011*** (4.42)	-0.017** (-3.05)	0.006*** (4.74)	0.031** (3.16)	0.132*** (8.01)	0.048*** (9.29)	0.019*** (4.56)	0.083*** (6.53)	0.007* (2.46)
$Priceg_{t-1}$	0.388*** (34.19)	0.459*** (30.49)	0.589*** (62.88)	0.835*** (52.10)	0.557*** (25.53)	0.611*** (36.08)	0.576*** (45.22)	0.416*** (29.74)	0.654*** (35.97)
$Dpriceg_{t-1}$	-0.724*** (-18.28)	-1.034*** (-14.60)	-1.214*** (-30.01)	-1.159** (-3.04)	-0.836*** (-7.38)	-1.414*** (-19.44)	-0.807*** (-11.08)	-0.450*** (-9.58)	-0.838*** (-9.49)
HHI-corr$_{t-1}$	0.071 (1.13)	-0.840*** (-9.24)	-0.012 (-0.22)	0.119 (1.23)	0.214 (1.33)	0.332*** (3.30)	0.445*** (5.04)	0.263** (3.00)	-0.668*** (-6.60)
$Mshare_{t-1}$	0.457*** (9.06)	-0.372*** (-5.11)	0.469*** (12.65)	0.264* (2.32)	0.349** (2.76)	0.638*** (7.58)	0.083 (1.24)	0.512*** (6.74)	-0.503*** (-6.71)
$Cshare_{t-1}$	0.359*** (4.44)	-0.593*** (-6.23)	0.094 (1.01)	0.081 (0.59)	0.196 (1.18)	0.349** (3.01)	0.392*** (4.23)	-0.005 (-0.03)	-0.289* (-2.18)
α_1	-0.003 (-0.45)	0.021*** (4.17)	0.008*** (4.69)	0.009** (2.85)	0.021 (1.32)	-0.015** (-2.90)	-0.016 (-0.59)	-0.020 (-1.38)	-0.057 (-1.72)
Cons	0.507 (1.74)	-0.396 (-0.96)	-0.214 (-1.06)	-0.005 (-0.01)	0.244 (0.49)	0.152 (0.46)	0.619* (2.03)	-3.460*** (-8.92)	2.465*** (7.53)
N	15464	7281	17306	2614	3077	5765	5754	5251	5070
$R^2 - o$	0.625	0.638	0.725	0.858	0.679	0.711	0.758	0.736	0.728
F	303.69	242.35	805.02	451.42	142.69	244.04	371.04	321.06	247.43

* $p<0.05$, ** $p<0.01$, *** $p<0.001$
(1) t-stats in parenthesis are computed with robust standard errors
(2) All regressions include corporation and ATC-1 fixed effects and time dummies

Table B.5: Pricing regressions for molecule markets: Multimarket contact redistribution effect

Variable	US	CAN	GER	NETH	UK	FRA	ITA	JAP	SP
$Fsales_{t-1}$	0.243***	0.298***	0.218***	0.114***	0.217***	0.163***	0.160***	0.399***	0.159***
	(44.53)	(37.53)	(40.46)	(9.12)	(19.81)	(18.62)	(21.59)	(41.99)	(16.65)
New_{t-1}	-0.058	-0.301***	-0.219***	-0.245***	-0.299***	-0.144***	-0.194***	-0.215***	-0.183***
	(-1.87)	(-7.14)	(-8.42)	(-3.62)	(-4.72)	(-4.17)	(-5.46)	(-4.32)	(-5.18)
$Molage_t$	-0.300***	-0.157**	-0.173***	-0.105**	-0.199***	-0.215***	-0.194***	-0.065	-0.374***
	(-8.76)	(-3.27)	(-7.35)	(-2.59)	(-3.66)	(-5.85)	(-5.63)	(-1.44)	(-9.73)
$Censormol_t$	-0.037	0.109	0.005	-0.021	-0.446**	-0.146*	-0.042	-0.574***	0.477***
	(-0.94)	(1.25)	(0.16)	(-0.27)	(-2.65)	(-2.27)	(-0.45)	(-3.44)	(5.69)
$Nmols_t$	-0.005***	-0.005	-0.000	0.008	0.023**	0.013***	-0.033***	0.034***	-0.003
	(-4.65)	(-1.62)	(-0.17)	(1.37)	(3.26)	(3.40)	(-6.32)	(5.21)	(-0.43)
$Censorlag_t$	0.382**	0.005	0.059	0.151	0.916***	0.684***	-0.080	-0.307	-0.355*
	(3.13)	(0.02)	(1.11)	(1.80)	(4.22)	(5.38)	(-0.52)	(-1.10)	(-2.46)
$generic$	-0.368***	0.056	-0.062**	-0.137	-0.446***	-0.365***	-0.251***	-0.039	-0.364***
	(-11.18)	(1.01)	(-2.90)	(-1.87)	(-6.07)	(-8.07)	(-5.75)	(-0.61)	(-8.35)
$Composite_t$	-0.099**	-0.194***	-0.001	-0.017	-0.132*	0.092*	0.012	0.009	-0.104**
	(-3.05)	(-4.78)	(-0.05)	(-0.43)	(-2.35)	(2.23)	(0.32)	(0.14)	(-2.83)
$Ngenerics_t$	0.011***	-0.008	0.007***	0.031**	0.134***	0.046***	0.020***	0.083***	0.005
	(4.39)	(-1.31)	(5.18)	(3.17)	(8.11)	(9.05)	(4.80)	(6.53)	(1.76)
$Priceg_{t-1}$	0.387***	0.458***	0.588***	0.835***	0.557***	0.608***	0.576***	0.416***	0.655***
	(34.08)	(30.64)	(62.78)	(52.10)	(25.51)	(35.91)	(45.22)	(29.72)	(36.58)
$Dpriceg_{t-1}$	-0.729***	-1.035***	-1.219***	-1.156**	-0.840***	-1.424***	-0.804***	-0.450***	-0.847***
	(-18.36)	(-14.60)	(-30.08)	(-3.03)	(-7.40)	(-19.59)	(-11.05)	(-9.57)	(-9.62)
$HHI\text{-}corr_{t-1}$	0.170*	-0.285*	0.117	0.172	0.322	0.597***	0.366***	0.266*	-0.515***
	(2.25)	(-2.53)	(1.89)	(0.98)	(1.67)	(4.99)	(3.76)	(2.45)	(-4.11)
$Mshare_{t-1}$	0.535***	0.063	0.541***	0.295*	0.429**	0.805***	0.037	0.514***	-0.415***
	(8.89)	(0.71)	(13.42)	(1.97)	(2.87)	(8.54)	(0.52)	(5.86)	(-5.05)
$Cshare_{t-1}$	0.431***	-0.178	0.156	0.112	0.277	0.517***	0.340***	-0.003	-0.201
	(5.01)	(-1.66)	(1.66)	(0.68)	(1.51)	(4.20)	(3.52)	(-0.02)	(-1.46)
α_1	0.030*	0.096***	0.022***	0.013	0.070	0.018*	-0.149**	-0.019	0.090
	(2.05)	(9.95)	(7.09)	(1.47)	(1.42)	(2.35)	(-2.71)	(-0.75)	(1.42)
α_2	-0.052*	-0.132***	-0.024***	-0.005	-0.068	-0.077***	0.259**	-0.002	-0.305*
	(-2.49)	(-8.87)	(-5.55)	(-0.47)	(-1.17)	(-4.90)	(2.74)	(-0.06)	(-2.01)
$Cons$	0.352	-1.137**	-0.300	-0.038	0.150	-0.151	0.682*	-3.464***	2.368***
	(1.17)	(-2.72)	(-1.49)	(-0.10)	(0.29)	(-0.45)	(2.22)	(-8.62)	(7.10)
N	15464	7281	17306	2614	3077	5765	5754	5251	5070
R^2-o	0.624	0.639	0.723	0.858	0.678	0.711	0.759	0.736	0.727
F	294.47	236.49	780.48	439.87	138.47	236.45	359.18	311.19	240.36
$\alpha_1=\alpha_2=0$	3.11	49.63	25.48	4.13	1.17	13.82	3.99	.97	2.38

* p<0.05, ** p<0.01, *** p<0.001

(1) t-stats in parenthesis are computed with robust standard errors
(2) All regressions include corporation and ATC-1 fixed effects and time dummies
(3) The null hypothesis's statistic $2 \times F(2, \infty)$ has a critical value of 5.99 at 5%

Table B.6: Pricing regressions for molecule markets: ATC-1 fixed effects

Variable	US	CAN	GER	NETH	UK	FRA	ITA	JAP	SP
a==B	1.639***	0.765***	-0.046	0.606**	0.882***	0.616**	0.154*	0.553***	-0.281*
	(13.74)	(6.83)	(-0.38)	(2.94)	(6.47)	(2.93)	(2.23)	(5.49)	(-2.08)
a==C	0.480***	0.871***	-0.015	0.182***	0.248***	0.107**	0.226***	0.452***	0.185***
	(12.77)	(18.78)	(-0.70)	(4.51)	(3.38)	(3.15)	(5.16)	(7.85)	(4.52)
a==D	0.267***	0.270***	-0.257***	-0.310*	-0.005	-0.186**	-0.327***	0.150*	-0.336***
	(5.39)	(4.63)	(-7.50)	(-2.55)	(-0.05)	(-3.11)	(-5.26)	(2.09)	(-4.62)
a==G	0.776***	0.698***	0.143***	-0.248***	0.235**	-0.204**	0.290***	0.371***	0.010
	(13.19)	(11.16)	(5.27)	(-4.12)	(2.87)	(-3.23)	(5.14)	(5.25)	(0.18)
a==H	0.322***	0.732***	-0.085	-0.002	-0.068	0.065	0.656***	1.025***	0.179
	(3.30)	(4.86)	(-1.04)	(-0.01)	(-0.38)	(0.51)	(3.97)	(9.88)	(0.83)
a==J	0.963***	0.810***	0.467***	0.216***	0.051	0.386***	0.476***	0.560***	0.187**
	(17.36)	(12.85)	(15.40)	(4.66)	(0.58)	(6.67)	(8.96)	(6.80)	(2.96)
a==L	1.570***	1.199***	0.609***	0.279***	0.859***	0.765***	0.684***	0.848***	0.430***
	(17.16)	(11.12)	(11.19)	(4.86)	(6.88)	(10.13)	(6.74)	(7.31)	(5.03)
a==M	0.607***	0.458***	0.178***	-0.108	0.226*	0.067	-0.157***	0.140*	-0.092
	(11.85)	(7.02)	(4.73)	(-1.54)	(2.26)	(1.15)	(-3.55)	(2.34)	(-1.42)
a==N	0.746***	0.728***	0.240***	0.129**	0.163*	-0.159***	0.314***	0.168**	-0.049
	(18.83)	(14.56)	(10.47)	(3.07)	(2.19)	(-3.65)	(5.85)	(2.64)	(-0.91)
a==P	0.866*	-0.562***	0.178	0.757***	0.091		0.007	0.405***	-0.142**
	(2.23)	(-4.28)	(0.32)	(6.33)	(1.06)		(0.13)	(5.66)	(-2.58)
a==R	0.268***	0.446***	-0.182***	-0.045	-0.222	-0.502***	-0.467***	-0.366***	-0.411***
	(6.08)	(8.70)	(-6.56)	(-0.87)	(-1.91)	(-9.91)	(-6.43)	(-4.73)	(-6.04)

* p<0.05, ** p<0.01, *** p<0.001
(1) t-stats in parenthesis are computed with robust standard errors

Table B.7: Comparative estimates by Multimarket Contact Variable Definition (*t-stats based on Robust Standard Errors by Corporation Clusters*)

Variable	US	CAN	GER	NETH	UK	FRA	ITA	JAP	SP
1st Definition									
α_1	0.030*	0.096***	0.022***	0.013	0.070	0.018*	-0.149**	-0.019	0.090
	(2.05)	(9.95)	(7.09)	(1.47)	(1.42)	(2.35)	(-2.71)	(-0.75)	(1.42)
α_2	-0.052*	-0.132***	-0.024***	-0.005	-0.068	-0.077***	0.259**	-0.002	-0.305*
2nd Definition									
α_1	0.407**	0.808***	0.313***	0.305*	0.262	0.283***	-0.686***	0.101	-0.086
	(3.29)	(8.48)	(6.12)	(2.14)	(0.74)	(4.17)	(-4.78)	(0.61)	(-0.67)
α_2	-0.952***	-1.123***	-0.009	-0.188	-0.240	-0.910***	0.977***	-0.020	0.182
	(-4.99)	(-7.41)	(-0.12)	(-1.08)	(-0.51)	(-7.76)	(4.22)	(-0.07)	(0.82)
$H_0:\alpha_1=\alpha_2=0$	14.67	35.97	47.96	7.17	.381	31.87	11.43	.51	.34

* p<0.05, ** p<0.01, *** p<0.001
(1) t-stats in parenthesis are computed with robust standard errors
(2) The null hypothesis's statistic $2 \times F(2, \infty)$ has a critical value of 5.99 at 0.05

Table B.8: Pricing regressions for ATC-4 markets:

Variable	US	CAN	GER	NETH	UK	FRA	ITA	JAP	SP
$Fsize_{t-1}$	0.238***	0.287***	0.214***	0.120***	0.228***	0.169***	0.159***	0.411***	0.158***
	(44.59)	(35.45)	(39.10)	(9.29)	(19.73)	(19.24)	(20.61)	(41.86)	(16.70)
New_{t-1}	-0.085**	-0.336***	-0.248***	-0.221***	-0.308***	-0.165***	-0.179***	-0.212***	-0.213***
	(-2.77)	(-7.94)	(-9.61)	(-3.35)	(-4.92)	(-4.82)	(-5.07)	(-4.30)	(-6.15)
$Molage_t$	-0.425***	-0.215***	-0.255***	-0.106**	-0.238***	-0.272***	-0.161***	-0.048	-0.407***
	(-13.35)	(-4.63)	(-11.16)	(-2.72)	(-4.64)	(-7.95)	(-5.03)	(-1.14)	(-10.98)
$Censormol_t$	-0.031	0.229***	-0.037	-0.088	-0.355*	-0.175**	-0.062	-0.624***	0.491***
	(-0.81)	(2.74)	(-1.37)	(-1.11)	(-2.24)	(-2.61)	(-0.67)	(-3.50)	(5.93)
$Nmols_t$	-0.003*	-0.001	0.006***	0.031***	0.017	0.033***	-0.001	-0.015	-0.037***
	(-2.57)	(-0.21)	(4.72)	(3.62)	(1.75)	(4.74)	(-0.26)	(-0.85)	(-5.02)
$Censorlag_t$	0.445***	-0.053	0.125*	0.216*	0.855***	0.699***	-0.015	-0.220	-0.368**
	(3.61)	(-0.22)	(2.33)	(2.38)	(4.07)	(5.50)	(-0.10)	(-0.85)	(-2.63)
$Generic_t$	-0.455***	0.018	-0.109***	-0.097*	-0.612***	-0.451***	-0.273***	-0.420***	-0.420***
	(-15.07)	(0.33)	(-5.47)	(-2.02)	(-9.17)	(-6.61)	(-5.02)	(-2.63)	(-9.74)
$Composite_t$	-0.095**	-0.164***	0.052*	0.009	-0.158**	0.083*	-0.010	0.064	-0.156***
	(-2.96)	(-4.05)	(2.22)	(0.23)	(-2.84)	(2.02)	(-0.26)	(1.02)	(-4.10)
$Ngenerics_t$	0.005***	0.001	0.003***	0.021***	0.072***	-0.001	0.005*	0.037***	0.011***
	(5.77)	(0.10)	(6.06)	(4.15)	(8.24)	(-0.27)	(2.05)	(4.82)	(8.09)
$Priceg_{t-1}$	0.388***	0.462***	0.593***	0.836***	0.553***	0.595***	0.579***	0.422***	0.657***
	(34.04)	(30.42)	(62.21)	(55.06)	(26.16)	(33.59)	(45.68)	(30.49)	(37.49)
$Dpriceg_{t-1}$	-0.653***	-1.031***	-1.079***	-1.122***	-0.795***	-1.350***	-0.822***	-0.455***	-0.839***
	(-16.65)	(-14.36)	(-27.11)	(-2.99)	(-7.00)	(-18.69)	(-11.48)	(-9.51)	(-9.44)
$HHI\text{-}corr_{t-1}$	0.617***	0.046	0.176**	0.001	0.212	0.301*	0.081	-0.252*	-0.348**
	(7.53)	(0.45)	(2.78)	(0.00)	(1.46)	(2.55)	(0.82)	(-2.16)	(-2.89)
$Mshare_{t-1}$	0.842***	0.194	0.482***	0.274***	0.458***	0.591***	-0.266***	0.374***	-0.416***
	(10.69)	(1.96)	(7.16)	(3.78)	(3.78)	(6.43)	(-3.31)	(3.67)	(-5.02)
$Cshare_{t-1}$	0.821***	-0.134	0.209*	-0.225	0.286*	0.178	-0.035	-0.621**	-0.017
	(7.76)	(-1.24)	(2.05)	(-1.81)	(1.97)	(1.69)	(-0.33)	(-5.02)	(-0.13)
α_1	0.153***	0.080***	0.088***	0.004	-0.040	0.045***	0.049	-0.122***	0.169
	(7.02)	(4.54)	(9.82)	(0.26)	(-0.77)	(4.27)	(0.81)	(-3.61)	(1.91)
α_2	-0.183***	-0.053*	-0.051**	0.048*	0.166*	-0.069***	-0.103	0.072	-0.349
	(-5.55)	(-2.02)	(-2.97)	(2.34)	(2.50)	(-3.68)	(-0.96)	(1.54)	(-1.65)
Cons	1.218***	-0.806*	0.371	0.015	0.574	0.648*	0.622*	-3.320***	2.624***
	(4.47)	(-2.03)	(1.90)	(0.05)	(1.23)	(2.08)	(2.20)	(-8.74)	(8.23)
$\alpha_1=\alpha_2=0$	24.63	12.01	78.24	7.99	8.84	9.85	.46	8.01	1.8209973
N	15464	7281	17306	2614	3077	5765	5754	5251	5070
R^2-o	0.606	0.630	0.700	0.857	0.682	0.704	0.758	0.744	0.728
F	289.64	230.61	763.06	444.19	152.03	248.10	362.06	319.79	253.81

* p<0.05, ** p<0.01, *** p<0.001
(1) t-stats in parenthesis are computed with robust standard errors
(2) All regressions include corporation and ATC-1 fixed effects and time dummies
(3) The null hypothesis's statistic $2 \times F(2,\infty)$ has a critical value of 5.99 at 0.05

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Table B.9: Estimation of ATC–1 fixed effects (*t-stats based on Robust Standard Errors by Corporation Clusters*)

Variable	US	CAN	GER	NETH	UK	FRA	ITA	JAP	SP
a==B	1.619***	0.793***	-0.024	0.522*	0.706***	0.584**	0.135	0.448***	-0.284*
	(13.34)	(6.94)	(-0.21)	(2.48)	(5.33)	(2.87)	(1.94)	(4.58)	(-2.20)
a==C	0.396***	0.891***	-0.057*	0.172***	0.188**	0.124***	0.239***	0.452***	0.082*
	(10.47)	(18.45)	(-2.57)	(4.22)	(2.59)	(3.39)	(5.71)	(7.74)	(2.10)
a==D	0.292***	0.280***	-0.218***	-0.304*	0.061	-0.168**	-0.250***	0.173*	-0.319***
	(5.92)	(4.77)	(-6.32)	(-2.47)	(0.65)	(-2.73)	(-4.30)	(2.42)	(-4.63)
a==G	0.744***	0.687***	0.120***	-0.290***	0.226**	-0.232***	0.335***	0.274***	0.040
	(12.62)	(11.07)	(4.42)	(-4.73)	(2.87)	(-3.66)	(5.89)	(3.84)	(0.70)
a==H	0.335***	0.702***	-0.095	-0.076	-0.171	-0.019	0.713***	0.936***	0.273
	(3.50)	(4.57)	(-1.13)	(-0.38)	(-0.98)	(-0.15)	(4.32)	(9.22)	(1.25)
a==J	0.948***	0.845***	0.474***	0.205***	0.063	0.387***	0.465***	0.540***	0.174**
	(17.36)	(13.20)	(15.66)	(4.23)	(0.73)	(6.65)	(8.55)	(6.51)	(2.93)
a==L	1.630***	1.260***	0.666***	0.278***	0.776***	0.738***	0.703***	0.807***	0.485***
	(17.47)	(11.79)	(12.04)	(4.70)	(6.64)	(9.99)	(6.92)	(7.05)	(5.67)
a==M	0.591***	0.498***	0.181***	-0.123	0.252**	0.105	-0.133**	0.100	-0.042
	(11.45)	(7.55)	(4.78)	(-1.73)	(2.61)	(1.87)	(-2.91)	(1.63)	(-0.67)
a==N	0.719***	0.778***	0.206***	0.111**	0.136	-0.150***	0.360***	0.158*	-0.063
	(18.23)	(15.64)	(8.82)	(2.65)	(1.80)	(-3.45)	(6.78)	(2.46)	(-1.23)
a==P	0.690	-0.603***	0.069	0.828***	0.105	(dropped)	0.051	0.360***	-0.077
	(1.70)	(-4.04)	(0.12)	(4.33)	(1.24)		(0.93)	(5.10)	(-1.44)
a==R	0.229***	0.388***	-0.181***	-0.074	-0.088	-0.559***	-0.420***	-0.467***	-0.352***
	(5.08)	(7.19)	(-6.47)	(-1.44)	(-0.78)	(-11.26)	(-5.81)	(-5.46)	(-5.22)

* p<0.05, ** p<0.01, *** p<0.001
(1) t-stats in parenthesis are computed with robust standard errors

Table B.10: Comparative estimates by Multimarket Contact Alternatives and ATC-4 market definition (*t-stats based on Robust Standard Errors*)

Variable	US	CAN	GER	NETH	UK	FRA	ITA	JAP	SP
1st Definition									
α_1	0.153***	0.080***	0.088***	0.004	-0.040	0.045***	0.049	-0.122***	0.169
	(7.02)	(4.54)	(9.82)	(0.26)	(-0.77)	(4.27)	(0.81)	(-3.61)	(1.91)
α_2	-0.183***	-0.053*	-0.051**	0.048*	0.166*	-0.069***	-0.103	0.072	-0.349
	(-5.55)	(-2.02)	(-2.97)	(2.34)	(2.50)	(-3.68)	(-0.96)	(1.54)	(-1.65)
$\alpha_1=\alpha_2=0$	24.63	12.01	78.24	7.99	8.84	9.85	.46	8.01	1.820973
2nd Definition									
α_1	0.405***	0.147	0.498***	0.032	-0.027	0.371***	0.004	-0.580***	-0.184
	(4.21)	(1.67)	(9.24)	(0.34)	(-0.13)	(5.50)	(0.03)	(-4.16)	(-1.41)
α_2	-0.787***	-0.210	-0.361***	0.272*	0.318	-0.412***	-0.177	0.255	0.110
$H_0:\alpha_1=\alpha_2=0$	11.05	1.50	49.60	5.20	3.47	15.14	.92	13.82	1.58

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

(1) t-stats in parenthesis are computed with robust standard errors

(2) The null hypothesis's statistic $2 \times F(2,\infty)$ has a critical value of 5.99 at 0.05

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Appendix C

Appendices to chapter 3

Table C.1: Definition of Variables

Variable	Definition
pd_j	Price in USD for a standard unit of product "j" in a single market
s_j	Market share of product "j" in a single market
s_{jm}	Market share of product "j" within a molecule segment
s_{jmb}	Market share of product "j" within a sub-cluster
s_m	Market share of all products of molecule "m" in a single market
s_{bm}	Market share of all products of sub cluster "b" within a molecule
comp	Second molecule added to a basic (main) composite
tsl	Time elapsed since product was launched (in years)
np	Number of products in a market
npo	Number of products of other firms in a market
npm	Number of products within a molecule
npom	Number of products of other firms within a molecule
np.f	Number of other products of a firm other than product "j" in a market
stsl	Sum of time since launch of products from other firms in market
stslm	Sum of time since launch of products from other firms in molecule
stslmb	Sum of time since launch of products from other firms in sub-cluster
stsl.f	Sum of time since launch of other products of a firm other than product "j" in a market
siv	Sum of tsl and comp in a market of products from other firms
sivm	Sum of tsl and comp in a molecule of products from other firms
siv.f	Sum of tsl and comp in a molecule of products from other firms
apiv	Average price of product "j" in other markets (by country)
dub	Dummy 1 if firm is a brand-name holder 0 otherwise

Table C.2: Descriptive Statistics of Variables

Variable	Mean	Standard Dev.	No.Observ.	Max.	Min.
pd_j	0,339	0,485	1112	7,444	0,017
s_j	0,012	0,028	1112	0,456	0,000
s_{jm}	0,178	0,221	1112	1,000	0,000
s_m	0,074	0,064	1112	0,511	0,000
s_{jmb}	0,304	0,307	1112	1,000	0,000
s_{bm}	0,671	0,331	1112	1,000	0,000
$comp$	1,788	3,403	1112	12,000	0,000
tsl	4,265	2,920	1112	13,005	0,000
np	24,406	10,633	1112	44	8
npo	21,867	10,204	1112	43	4
npm	5,865	2,627	1112	11	1
$npom$	4,865	2,627	1112	10	0
npf	2,540	1,292	1112	5	1
$stsl$	94,590	53,792	1112	227,515	15,271
$stslm$	20,238	15,063	1112	76,778	0,000
$stslmb$	12,267	10,976	1112	54,277	0,000
$stslf$	6,427	6,969	1112	33,274	0,000
siv	130,729	60,199	1112	268,099	19,923
$sivmb$	19,773	21,528	1112	93,942	0,000
$sivf$	5,375	8,702	1112	35,178	-12,510
$apiv$	0,293	0,252	1112	1,400	0,000

Table C.3: GMM Estimations for the IV regression with the Two-nests Specification (Standard Errors in Parenthesis)

	(1)	(2)	(3)	(4)
α	-0.2187 (0.0679)	-0.6319 (0.3321)	-0.9191 (0.3787)	-1.3213 (0.5124)
β_{tst}	0.0144 (0.0020)	0.0132 (0.0043)	0.0181 (0.0042)	0.0291 (0.0090)
β_{comp}	0.0058 (0.0025)	0.0079 (0.0060)	0.091 (0.0079)	0.0291 (0.0090)
β_{dub}			0.2422 (0.0852)	0.03780 (0.1273)
Variance Components				
ρ_m	0.0144 (0.0020)	0.0132 (0.0043)	0.0181 (0.0042)	0.0291 (0.0090)
ρ_{mb}	0.9792 (0.0116)	0.9760 (0.0202)	0.9761 (0.0255)	0.9908 (0.0438)
ρ	-0.0875 (0.0108)	-0.1011 (0.0185)	-0.1078 (0.0237)	-0.1753 (0.0457)
R^2-2nd stage	0.9958	0.9352	0.8849	0.7606
R^2-1st stage				
pd_j	0.3970	0.5238	0.5300	0.5303
$ln(s_{jmb})$	0.6403	0.6449	0.7056	0.7062
$ln(s_m)$	0.9051	0.8435	0.9073	0.9066
$ln(s_m \cdot s_{bm})$	0.8892	0.8440	0.9039	0.9034
Other Explanatory	–	Corp. Dummy	Corp. Dummy	Corp. Dummy Time trend
Tests				
$J - stat$	$\chi(13) = 13.809$	$\chi(1) = 0.385$	$\chi(3) = 2.521$	$\chi(2) = 0.677$
$H_o : \rho = \rho_m \cdot \rho_{mb}$	$\chi(1) = 15.760$	$\chi(1) = 5.890$	$\chi(1) = 3.120$	$\chi(1) = 4.920$

Notes:
(1) Instruments are sum across attributes and average price in other markets
(2) Instruments are sum across attributes and average price in other markets
(3) Instruments are sum across attributes, average price in other markets and a time trend
(4) Instruments are sum across attributes

Table C.4: Sample of computed cross-price elasticities

F	M	B	101 2 0	101 3 0	101 4 0	101 5 0	102 3 0	103 3 0	104 1 1	104 2 1	104 4 1	104 5 1	105 1 1
101	2	0	-0,8815	0,0001	0,0001	0,0001				0,0151	0,0001	0,0005	
101	3	0	0,0000	-2,7428	0,0000	0,0000	0,4896	0,4896	0,0030				
101	4	0	0,0002	0,0002	-1,1065	0,0002							
101	5	0	0,0002	0,0002	0,0002	-1,8406	0,0002	0,0002	0,0002				
102	3	0		1,6792		0,0102	-3,5965	1,6792	0,0102				
103	3	0		0,0679		0,0004	0,0679	-2,3153	0,0004				
104	1	1		0,0000		0,0000	0,0000	0,0000	-0,5459				
104	2	1	0,1599							-0,2528	0,0006	0,0006	
104	4	1	0,0001							0,0001	-0,6171	0,0001	
104	5	1	0,0037							0,0009		-2,7371	0,0086
105	1	1										0,0002	-0,8122
105	2	1										0,0001	0,0001
105	3	1										0,0001	0,0001
105	5	1	0,0057							0,0021	0,0013	0,3055	
106	2	0	0,0004	0,0004	0,0004	0,0004							
106	4	0	0,0008	0,0008	0,0559	0,0008							
106	5	0	0,0000	0,0000	0,0000	0,0114							
107	3	1		0,0000		0,0000	0,0005	0,0005	0,0000				
107	5	1	0,0006	0,0011	0,0015	0,2437	0,0007	0,0008	0,0014	0,0007	0,0004	0,0402	0,0006
108	2	1											
108	5	1	0,0073	0,0068	0,0073	0,8051	0,0064	0,0048	0,0073			0,2105	0,0009
109	4	0		0,0001		0,0001	0,0001	0,0001	0,0001				
109	5	0		0,0004		0,0352	0,0004	0,0004	0,0004				
110	3	0		1,7868		0,0109	1,7868	1,7868	0,0109				
111	1	0	0,0000	0,0004	0,0002	0,0002		0,0002				0,0002	0,0042
111	2	0	0,0663	0,0002	0,0002	0,0002						0,0001	0,0000
111	3	0										0,0000	0,0000
111	4	0	0,0008	0,0017	0,4924	0,0053				0,0029	0,1760	0,0024	0,0000
112	1	0										0,0000	0,0020
112	3	0										0,0001	0,0001
112	4	0	0,0000			0,0001	0,0001	0,0001	0,0001		0,0177		
112	5	0	0,0001	0,0002		0,2037	0,0005	0,0005	0,0002		0,0005		
113	4	0											
113	5	0										0,2669	
114	4	1										0,0019	

Note:
F: Firm identifying number
M: Molecule market identifier
B: Brand-name product indicator

Table C.5: Mean Own Price Elasticities by Molecule and Pioneer

Molecule	mean	median	se(mean)
Atenolol	-2,0142	-1,8277	0,0910
Captopril	-2,0386	-2,1332	0,0799
Pioneer	-2,7148	-2,6960	0,0733
Diltiazem	-7,1115	-2,7232	1,3442
Enalapril	-3,5075	-2,8100	0,2021
Pioneer	-3,9989	-2,9390	1,1099
Hydrochloriazide	-9,0106	-8,6687	0,2205

Table C.6: Mean and Confidence Intervals for Price Cost Margins by Assumption

Assumption		Mean	Standard Error	95% Confidence Interval		
Product Differentiation (Single Product)	[a]	35,6%	0,0082	(34,0%	-	37,3)
Current Ownership (Portfolio Effect)	[a]	35,8%	0,0083	(34,1%	-	37,4)
Multimarket Contacts (Joint Profit Maximization)	[b]	64,7%	0,0230	(60,2%	-	69,2)
Considering all products	[b,c]	35,8%	0,0082	(35,8%	-	35,8)
Joint Profit Maximization	[b]	93,0%	0,0351	(86,1%	-	99,9)

Notes:

[a] It drops observations with too low price elasticities, which are considered outliers

[b] It considers only year 2003

[c] Computation based on the asymptotic distribution of the means and considering that firms that were not in multimarket contacts set prices as pure single product differentiated firms.

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