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Generics Demand and Price Competition in Pharmaceutical Markets with Heterogeneous Consumers.

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Generics Demand and Price Competition in Pharmaceutical Markets with Heterogeneous Consumers.

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Abstract

To explain heterogeneous diffusion of generics in OECD countries, we have analysed the effect of information and consumers' misperception on generics demand. A sequential price competition model with perceived vertical differentiation allows to consider the Generics Competition Paradox (GCP) the result of market rivalry between generics and originators, and to discuss dynamic efficiency issues. We have extended our model to evaluate third party insurance and physicians' support to brand- name drugs. In each equilibrium, the originator's price is persistently higher than the generics; however, price competition is not confined to generics. We have reconsidered the GCP as rooted on optimistic misperception concerning the superior quality of brands.

Key words: Perceived Vertical Differentiation, Brand Premium, Information Disparity, Optimistic Misperception, Generics Competition Paradox

JEL Codes: L15, L13, D82

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1 Introduction

Generics diffusion still remains heterogeneous across OECD countries. According to 2019 OECD statistics, and considering the percentage of generics consumption in volume, leading countries were the UK (85.3), Germany (82.6), and The Netherlands (78), followed by Denmark (65), and Turkey (61.4). Norway, Portugal, Ireland, and Spain reached about 40-50%. Countries with the lowest percentage include Greece (27.9), Italy (28.9), and Switzerland (27.6). Moreover, considering the yearly rate of growth of the generic share, in the period 2003-2019[1] , we can notice that: a) In the last few years all Countries achieved just a reduced, one digit, rate of growth; b) leading Countries, having achieved sooner a higher generic share, distinguish themselves for reaching sooner also a reduced rate of growth. Therefore, in all Countries there seems to be structural limits to further expansion of generics demand, though remarkable differences about the achieved generics share remain. Conversely, generics are dispensed 97% of the time in the U.S. when available, with an increment from 78% in 2010 to 90% in 2020 of all dispensed prescriptions.[2]

Most countries across the EU have implemented public policies like the request of INN (International Non Proprietary Name) prescribing from physicians, and substitution at the pharmacy. However, as Wouters et al.(2017) point out, although both procedures are mandatory in Italy, Switzerland, Spain, Greece, and in The Netherlands, generics demand remains heterogeneous in these countries.

Drivers of generics demand beyond price have noticeably been neglected in economic literature. On the contrary, a relevant amount of research in medical journals focuses on outpatients',

[1] See table 1 in Appendix I .

[2] There are country-specific reasons for this success, including mandatory substitution at the pharmacy, as well as the contribution of Pharmacy Benefit Managers. The latter act as intermediaries for drug insurance plans with pharmacies, and drug manufacturers and often require that pharmacies replace brand-name drugs with generics by default, based on agreed insurance plans (Sheperd, 2019)

physicians', and pharmacists' misperception, as one of the main obstacles to the growth of generics demand[3]. Several consumers do not even know about the existence of generic drugs or cannot define exactly what they are. A large share of consumers believes that lower generics prices imply the provision of lower quality drugs: less effective, and not as safe if compared to the originators. A number of them even suppose that generics are just counterfeit pharmaceutical products. Many outpatients, who are willing to switch to generics in case of a minor illness, would prefer brand-name drugs to deal with a more serious disease.

Cross-country reviews (Alrasheedy et al., op. cit.) point out that the share of consumers with biased preferences, and refusing generics substitution frequently include low-income and poorly educated patients. Hence, one of the drivers of generics demand is the share of consumers with higher income and superior education. On the contrary, focusing on the low price of generics, conventional wisdom could attribute generics demand just to lower income consumers, viewed as the price-sensitive segment of the market.

Several medical studies show that also a considerable quota of General Practitioners (GP) and pharmacists mistrust generics and contribute to reduce their diffusion. According to Dunne and Dunne's cross-country review (op.cit. 2015), even though the majority of physicians has accepted the use of generics, many others have expressed a preference for brand-name drugs if required for their own use. Influence from the pharmaceutical industry, including provision of financial incentives, has been reported by pharmacists, as well. However, it is worthwhile to notice that comparing evidence about the U.S. in 2009[4] and in 2016 growing confidence of physicians concerning quality and safety

[3]Among the many contributions, see the reviews by Colgan et al. (2015), Alrasheedy et al.(2014); Dunne and Dunne (2015).

[4]A survey among physicians showed that 23% of them did not think generic were as effective as brands, 50% reported quality concerns, persuading more than 25% of them not to recommend generics as first-line therapy (Shrank W.H., et al., 2011; Kesselheim et al., 2016)

of generic medicines has been reported[5]. Colgan and Colgan et al. (op.cit), covering the same time span, have not found similar results for other countries.

In the vast majority of cases, therapeutic equivalence between generics and originators should be assumed from a scientific point of view[6] Yet striking evidence reported in medical literature demonstrates that perceived quality differences play an important role in pharmaceutical markets affecting consumers' demand. Nevertheless, perceived vertical differentiation has been overlooked in economic literature with the relevant exception of contributions dealing with reference pricing (Miraldo, 2009, Brekke, Holmas and Straume, 2011, and Brekke, Canta and Straume, 2022).

Our contribution aims to bridge this gap by considering competition between originators and generics in a model of perceived vertical differentiation, where biased preferences for brand-name drugs affect a share of consumers with lower income and inferior education. We have focused on consumers' heterogeneity distinguishing outpatients not only according to their willingness to pay for quality, but also on the basis of their information about therapeutic equivalence between generics and brand-name drugs. Informed consumers (IC from now on) are those able to name the active principle contained in the drug and to understand what therapeutic equivalence means. Uninformed consumers (UC from now on) are optimistic, because they expect a greater therapeutic effect from brands and believe the latter are safer than generics. We have followed the behavioral industrial organization approach, where biased consumers' preferences can be exploited by profit maximizing firms (Ellison, 2006; Heidhues and Kozsegi 2018). Information disparities are correlated with education and income [7]. Empirical evidence concerning drugs sold over the counter confirms that brand

[5]Interestingly, generics skepticism remained common among physicians whose source of information were pharmaceutical sales representatives

[6]Therapeutic equivalence has been controversial only for specific generics, as anti-epileptic drugs (Holtkamp and Theodore, 2018) or for drugs with a narrower therapeutic effect (Meredith, 2003)

[7]Gaither et al. (2001) show the heterogeneity of consumers according to education and income, besides age and risk perception. The meta-analysis by Hassali's et al. (2009) confirm different perceptions across consumers, and

loyalty is driven by less educated consumers, who ignore therapeutic equivalence[8]. Therefore, UC with biased beliefs and IC are not randomly distributed among consumers in our model. As education levels depend on income, information disparities are indirectly connected with it by means of the distribution of the willingness to pay for quality.The shares of UC and IC are exogenously given and separated by a cut-off value of the willingness to pay.

A further contribution of ours concerns the effects of choosing a sequential model of price competition. Traditional economic literature has highlighted that after generics entry, originators do not reduce their prices, which can even increase. This is the well-known Generics Competition Paradox (GCP) occurring in certain empirical analyses dealing with the U.S. market. Literature focusing on the theoretical explanation of the GCP is scant and examines sequential price competition on the basis of the Stackelberg model. On the contrary, we claim that the Bertrand model with perceived vertical differentiation is needed to analyze price competition between brand-name and generic drugs. As a result, we have adopted a model with strategic complements.

According to Gal-Or (1985), symmetric duopoly models of sequential price competition with horizontal product differentiation, where reaction functions are strategic complements, indicate the existence of a second mover advantage, while symmetric models, where reaction functions are strategic substitutes, are typically characterized by a first mover advantage. These results have been extended also to sequential price competition with vertical differentiation by Li (2014).

Therefore, within the framework of sequential price competition with product differentiation, it is the price follower (the generics firm) that is expected to achieve a second mover advantage. However, this result holds only in symmetric duopolies, while our model is asymmetric from the demand point of view. Consequently, a second mover advantage cannot be taken for granted and should always be checked by means of a comparison between equilibrium profits. The advantage

more negative attitudes towards generics by individuals with lower incomes and less education.

[8]See Bronnemberg (2015) for an empirical analysis

of this approach is that we can also consider the trade-off between static and dynamic efficiency. Indeed, growth of generics demand improves static efficiency by contributing to the reduction of average prices. Nevertheless, when leading to lower profits for the brand-name firms, it implies also a loss of dynamic efficiency, as R&D expenditure risks to be limited making drug innovation less likely.

In the sub-game perfect Nash equilibrium of our model, the brand producer expects that the generics rival will benefit from being the second mover lowering its price below the one of the brand-name drug, in order to drive enough demand towards generic drugs. Therefore, in the first stage game, anticipating the move of the generics firm, the brand producer maximizes profits by increasing the originator's price, exploiting the demand of optimistic consumers willing to pay for a brand premium because of quality misperception. Such a result, can justify per se, the observed GCP in the traditional literature. However, generics demand is also driven by the IC share including consumers with higher willingness to pay. As generic price also increase with the IC share, the later should be wide enough to allow the generics producer to increase their demand without an excessive price decrease. Therefore, when we check for the existence of a second mover advantage, we obtain results that depend on the extent of the IC share.

Differently from the previous theoretical literature, and similarly to Kong (2009), we shall not consider the GCP as a price increase of the brand-name drug after generics entry, but as an increase of its price compared to the price of the originator before patent expiry. For this purpose, we have assumed that the brand-name producer has been operating as a monopolist during patent validity. Our price comparison shows that, after generics entry, the quality differential expected by UC induces the brand-name drug producer to raise their price above the monopolistic one.

To highlight the role of consumers' misperception and information disparity we have started our analysis from a duopoly. We can consider this version of the model a benchmark, where pure price competition takes place, extending it to competition among generic entrants, as well. With multiple generic entrants the brand price remains peristently higher than the generic one. However there is an inverse relationships between the brand price and the number of generic entrants, demonstrating intenser competion not only among generics but also between generics and the brand name drugs. The effects of insurance and co-payments, in a second version of our model, is just to drive an increase of equilibrium prices compared to the benchmark case. In addition, we have also taken into account an example of Reference Pricing, showing that it boils down to our benchmark case of pure price competition. In the final version of the model we have analyzed the traditional case of agency in health care, where drug choice is driven by physicians and pharmacists, with a share of them preventing the switch to generics either because of misperception, or to support brand-name drugs as a consequence of detailing. We shall show that a first mover advantage can be more likely in this case.

In section 2, we are going to review the economic literature; in section 3, we shall consider the pharmaceutical market model to establish a monopolistic equilibrium during the patent period; then we will derive demand functions in a duopoly with perceived vertical differentiation. In section 4, we shall take into account the duopoly price equilibrium of a sequential game with pure price competition, we will determine the conditions for a second mover advantage, and finally, we will examine the occurrence of the GCP. In section 5, we shall extend our equilibrium analysis to the case of multiple generic sellers' entry, deriving the conditions for the existence of a second mover advantage and the GCP in this case, as well. In section 6, we are going to extend equilibrium analysis to the case of health insurance with co-payments and introduce a version of Reference Pricing in our framework. In section 7, we will consider the agency model of health care, where drug choice is partially driven by medical experts. Section 8 concludes.

2 The Economic Literature.

Competition in the pharmaceutical market has attracted the attention of economic literature especially after the introduction of the Hatch-Waxman Act (1984) in the U.S., facilitating the access of generic drugs into the market[9]. Although a flow of new generics entered the U.S. market, the pattern of observed price competition was quite different from the expected one, as price undercutting strategies did not take place. Not only did relevant differences between the prices of branded drugs and generics persist, but a number of empirical studies[10] demonstrated that the originators' price was even increasing even after generics entry. After Sherer (1993), this result is commonly known as the "Generics Competition Paradox" (GCP). Further evidence of the GCP was also highlighted in regulated European markets by Kanavos et al. (2008), as well as by Vandoros and Kanavos (2013).

However, the analysis performed by Cave*s* et al. (1991) does not confirm the GCP, detecting a price decline for brand-name drugs after generics entry. Similar results are reported in Wiggins and Maness (2004), though restricted to anti-infective medicines. A closer investigation has revealed that Caves et al. (1991) considered both hospital and pharmacy markets, whereas the GCP has always turned up in empirical studies restricted to the latter[11].

Compared to the extension of empirical literature, the theoretical analysis of the GCP is limited and mainly based on Frank and Salkever (1992), and (1997). As far as demand is concerned, they explain the GCP by assuming market segmentation. Price sensitive demand depends on managed care organizations, including Hospitals, HMO (Health Maintenance Organizations), and Medicaid

[9]After this act, producers of generic drugs were only required to demonstrate bio-equivalence with the originators in order to be granted sales authorization avoiding clinical trials required for innovative drugs.

[10]We are mainly referring to Grabosky and Vernon (1992), Frank and Salkever (1992) and (1997), and Regan (2008). Further contributions have involved Ferrara and Kong (2008), and previously Kamien and Zang (1999).

[11]Grabosky and Vernon (1992) are an exception, as they provide separate evidence for hospitals (consistent with Caves et al, 1991); nevertheless, the sample of their econometric analysis is restricted to the pharmacy market and supports the GCP.

patients. Customers at retail pharmacies are all included in the price-insensitive market segment driven by brand loyalty.

Regarding the supply side, Frank and Salkever refer to the Stackelberg model. The seller of the brand-name drug is the leader setting the brand price and facing generic entrants as followers competing à la Cournot, so that the generics price results from the Nash Cournot equilibrium. As to the GCP, their analysis focuses on the positive relation between the price of the brand-name drug and the number of generic entrants, supporting the idea that there is no price competition between brands and generics due to reduced price elasticity of the demand for brand-name drugs after generics entry. Frank and Salkever's empirical analysis (1997) suggests that each new entrant is associated with an approximate 0.7% increase in the brand price. Regan (2008) provides a generalization of the previous results still using a Stackelberg model, where a pioneering brand and generics are consider imperfect substitutes. Yet also in Regan's analysis, what is critical is the theoretical explanation of the positive correlation between the price of the brand-name drug and the number of generic entrants. In her model, obtaining such a result requires that the marginal production cost be"relatively large". However, empirical evidence is consistent with very low marginal production costs for most drugs[12]. Regan claims that also intermolecular competition should be considered, as far as brand prices are concerned (Reiffen and Ward, 2005), and that only this kind of competition could exert downward pressure on brand prices, not rivalry with generic entrants. Regan reports a 1% increase in the brand price for each generic entrant and concludes that price competition is confined to the generics segment of the market.

In our theoretical model, instead, there is a negative relationship between the brand price and the number of generic entrants due to intenser price competition taking place, when generics sellers

[12] According to Berntd (2002) "once manufacturing plants are constructed, and a drug has been developed, for many prescription drugs, the marginal costs of producing an additional tablet or capsule are very small - nickels not dollars" p. 56.

face Cournot competition by other generics firms, in addition to contending against brand-name drug producers[13]. What is remarkable in Regan's contribution is her observation that brand price increases are related to outpatients with third-party insurance. In fact, Kong (2009) claims that market segmentation on the basis of insurance coverage is, indeed, the important issue in the U.S. market. Accounting for the variety of conclusions about the existence of the GCP, Kong (op.cit.) verifies its presence by comparing the monopolistic brand price of the patent period with the level of the oligopolistic price after generics entry, as we have done in our model.

Ching (2010) approaches the issue of slow generics diffusion through a dynamic model of consumers' learning with Bayesian updating. Consumers are uncertain about generics quality, and being risk-averse they resist switching until further evidence changes their pessimistic prior conviction about generics therapeutic effectiveness. Ching observes that not only is originators' demand price inelastic, but that elasticity also reduces in magnitude over time. Therefore, the incentive to reduce brand prices also weakens alongside with the learning process, thereby explaining the increasing price trend of originators observed empirically.

Caves et al. (1991) suspect that the persistence of significant price differences between brand-name and generic drugs could be due to product differentiation, a hypothesis also considered by Wiggins and Maness (2004). Actually product differentiation aims to relax price competition avoiding price undercutting, and this could explain why intenser price competition does not occur after generics appear in the U.S. market. Drug variety matters as far as it meets consumers' tastes considering that medication can be available in different forms, sold with different packaging, or identified according to its flavor or color (Kanavos et al., 2008). Mestre-Ferrandiz (2001) introduce horizontal differentiation to analyze the effects of reference pricing, but he has just taken into account generics

[13]Both Saha et al. (2006) and Cavaliere and Moayedizadeh (2022) show a price decrease for originators, after generics entry, followed by a subsequent price increase. Actually, brand prices rise continuously, but discounts in the wholesale market are also widespread (Hernandez et al. 2020).

and brands as imperfect substitutes, like Regan (2008).

To the best of our knowledge, perceived vertical differentiation has been introduced merely in literature about reference pricing. Merino-Castello (2003), for instance, substitutes real with perceived quality in the consumers' utility function. However, by supposing that perceived generics quality is low and the brand perceived one is high, results turn out to be similar to those obtained with a standard vertical differentiation set-up. Miraldo (2009), on the contrary, considers pharmaceutical pricing in markets, where both horizontal and vertical differentiation affect competition within a typical location model. Higher perceived quality for brands is assumed to depend on exogenous variables like marketing efforts and firm reputation viewed as a source of brand loyalty. Brekke, Holmas, and Straume (2011) evaluate perceived quality differentiation between brands and generics as a consequence of advertising intensity.

We have followed a different path consistent with behavioral industrial organization, where firms maximize profits exploiting biased consumers' beliefs due to optimistic misperception. Therefore we explicity introduce consumers' preferences consistent with misperceived quality differentiation and characterizing only uninformed purchasers. Experimental evidence, as far as optimistic misperception is concerned, can be found in Della Vigna (2009) highlighting that economic agents may systematically hold incorrect beliefs because of overconfidence in their personal information. As to competition between generics and brand-name drugs, biased consumers' beliefs are also introduced by Brekke, Canta, and Straume (2016) again in a reference pricing setting. Finally, Cavaliere and Crea (2022) have considered a model of vertical differentiation with consumers' misperception and information disparity in order to explain brand premiums in different types of markets including drugs sold over the counter (OTC). Our demand characterization in then similar to the one included in that contribution.

A model that can provide an empirical foundation for our analysis is taken from Bronnemberg et al. (2015) and includes sales of OTC drugs and other health products in the U.S. with the aim of evaluating the welfare effects of brand loyalty in markets, where identical products are sold at different prices. The authors have emphasized different purchasing behavior between IC and UC in the market for OTC drugs[14]. Either higher education, or an occupation in the product specific domain (physicians, pharmacists, or nurses for health products) enhance consumers' information. Nevertheless, the majority of consumers are uninformed and misperceive the quality of generic drugs, and, therefore, they prefer national brands. Informed (educated) consumers are more likely to buy generics (store brands) than national brands, thus UC misinformation and overestimation of product quality explain brand premiums for originators.

3 The pharmaceutical market model

We have taken into account a pharmaceutical market with a continuum of consumers, where their willingness to pay for quality (WTP from now on) is represented by θ, which is uniformly distributed between $\underline{\theta}$ and $\bar{\theta}$, with $\bar{\theta} = \underline{\theta} + 1$, and density $f(\theta) = 1$. Purchasers buy just one unit of the product (for example, a blister pack of capsules, or tablets) and consumers' preferences are represented by the following utility function U,

$$U = \theta q_i - P_i$$

where P_i is the market price of the drug supplied by firm i and q_i stands for the quality of this drug. Product quality refers to therapeutic effectiveness and drug safety, and it depends on the content of the active principle per dose. Firstly we have considered the drug as an innovator that has received market authorization by a health Authority on the basis of clinical trials. The drug quality included in the market authorization represents quality standard $q_i = q^{\circ}$. As an innovator's drug,

[14]However, the authors have also stated that their conclusion could be extended to the prescription drug market.

it benefits from a patent period, where the producing firm is a monopolist supplying a brand-name drug. When the patent period has expired, generics entry occurs. At the beginning there can be one entrant which may be given temporary exclusivity[15], so that the market structure becomes a duopoly. Subsequently, multiple generics firms can enter the market establishing an oligopoly. Also generics entry can occur after a market authorization that is granted by a health Authority which has evaluated the results of bio-equivalence studies ascertaining that quality (therapeutic effect and safety) is the same of the innovator's drug, i.e. $q_G = q^{\circ}$

In accordance with the evidence taken from industrial studies, we may assume that the cost of capital related to R&D investments made by the firm supplying the innovator's drug is completely recovered during the patent period[16]. It can also be proven that marginal costs in the pharmaceutical sector are very low (Berndt, 2002), and very similar for innovator's drugs and generics[17]. We have, therefore, normalized marginal costs to zero.

3.1 The Monopolistic Market

In this section we have considered the monopolistic equilibrium price as a benchmark to evaluate the changes in prices after generics entry in the market (Tirole 1989). At first, we have taken into account monopolist drug provision without insurance, and then we have introduced insurance and co-payments by outpatients. To define market demand for *a* monopolist selling a drug during the

[15] A six-month temporary exclusivity may be given to the first generic entrant challenging patents that are going to expire, based on "Bolar provisions", i.e legal exemptions for infringement of laws regarding the submission of testing data to a Regulatory Authority.

[16] Evidence about the U.S. shows 11 and half years of market exclusivity, allowing the company to recover its capital cost. Once the market becomes competitive, prices do not include anymore the innovator's cost of capital (Pacific Research Institute, 2014).

[17] A report commissioned by the OECD has demonstrated that "In most instances, manufacturing cost levels for generic medicines are the same as those for an originator product." IMS Health (2010)

patent period, we need to identify a marginal consumer (θ'_M), who is unconcerned about buying a drug unit or not:

$$U = \theta q^{\circ} - P_M \qquad \text{if the consumer buys it}$$

$$U = 0 \qquad \text{if the consumer does not buy it}$$

Therefore, the marginal consumer $\theta'_M = P_M/q^{\circ}$ derives from the following inequality

$$\theta q^{\circ} - P_M = 0 \tag{1}$$

Given the marginal consumer's expression, market demand may be calculated as:$D_M = (\overline{\theta} - \theta'_M)$, and consequently, monopolistic profits as $\Pi_M = P_M(\overline{\theta} - \theta'_M)$. Determining profit maximization with respect to P_M , and given the f.o.c. we can derive the monopolistic price:

$$P^*_M = \frac{(\underline{\theta} + 1)q^{\circ}}{2} \tag{2}$$

In an insurance and co-payments setting, a consumer just pays a fraction γ of the price $c_s = \gamma P_M$,$\gamma < 1$. If the consumer buys, utility becomes $U = \theta q^{\circ} - c_s$, and we can establish a new expression for the marginal consumer $\theta'_{MS} = \gamma P_{MS}/q^{\circ}$. As $\gamma P_{MS} < P_M$, the demand function expands: $D_{MS} = (\overline{\theta} - \theta'_{MS})$. Monopolistic profits become $\Pi_{MS} = P_{MS}(\overline{\theta} - \theta'_{MS})$, and given profit maximization with respect to P_{MS}, from the f.o.c. we can derive the monopolistic price with insurance and co-payments:

$$P^*_{MS} = \frac{(\underline{\theta} + 1)q^{\circ}}{2\gamma} \tag{3}$$

It can be noticed that $P^*_{MS} > P^*_M$, being $\gamma < 1$. In fact, as the price share $P^*_{MS}(1-\gamma)$ is reimbursed by an insurance, the innovator's firm is encouraged to increase prices above the level set without insurance.

3.2 The Duopoly Market

After patent expiry generics entry becomes possible, and the new entrants simply need to replicate the innovative drugs with a therapeutically equivalent copy. [18]. For the sake of simplicity, we will initially assume that only one generics producer has entered into the market to analyze a duopoly equilibrium, where firm B is selling an originator's drug, and firm G a generic one.

3.2.1 Information Disparity and Misperception

Once generics have been introduced into the market, outpatients face a new choice problem, as they can either purchase the pioneering brand or the generic drug. We suppose that substitution at the pharmacy is not mandatory, even though INN prescribing is. GP and pharmacists just inform the consumer about the existence of an alternative. At the moment we are assuming that consumers are paying for drugs out of their own pocket.

To define market demand in this setting, we must establish a distinction between informed consumers (IC) and uninformed ones (UC). In accordance with Bronnemberg et al. (op.cit.), we have defined IC as the ones knowing what an active principle is and being able to name the one contained in prescription drugs because of their superior level of education. Moreover, they know what bio-equivalence means and expect that the therapeutic effect of generics will be equivalent to the one of brand-name drugs, i.e . $q_G = q_B = q^{\circ}$. Uninformed consumers (UC) represent outpatients who are nor sufficiently well-educated to be familiar with the previous information and to process it. UC are optimistic and expect that originators will grant a better therapeutic effect compared to generics. Their biased beliefs can be represented by an optimistic expectation q_E concerning the quality of brand-name drugs, so that $q_E > q_B$ (optimistic misperception).

[18] Generic manufacturers do not bear any R&D expenditure nor any costs for clinical trials, as the pioneering firm did, except for expenses to prove clinical bio-equivalence to get a marketing authorization.

What matters in our model is just the last inequality. We could consider the assumption that each UC has their own quality expectation and introduce a distribution of q_E into the model. However, for the sake of simplicity and tractability of the model, we have set q_E as the average quality expectation. As far as real markets are concerned, what is relevant is that firms be able to identify q_E. We assume that they are, because differently from consumers, they can hire consultants, do market research, use big data to estimate perceived quality (Della Vigna, 2009)[19].

In order to evaluate the distinction between IC and UC, we have split the market according to the distribution of θ by introducing a cut-off value θ^* . Consumers with WTP $\theta \geq \theta^*$ are included in the IC set, while the ones with WTP $\theta \leq \theta^*$belong to the UC set. Therefore, the greater θ^* is, the lower the IC share $(1-\theta^*)$becomes. The value of θ^* is not restricted out of equilibrium, except that $\underline{\theta} \leq \theta^* \leq \overline{\theta}$. Considering $\theta^*$and $(1-\theta^*)$ as the share, of UC and IC respectively, we establish the following range for $\theta^* : 0 \leq \theta^* \leq 1$. A key assumption of this model is that the higher the WTP, the greater the likelihood that a consumer be informed: if a consumer i with WTP for quality θ_i is informed, any consumer j with willingness to pay $\theta_j > \theta_i$ will be, as well. Not only is the WTP correlated with income, which is a standard assumption in vertical differentiation models, but, in addition, we have taken into account that higher income is positively correlated with superior education, i.e. a proxy for information. Therefore, information distribution overlaps that of the WTP. As a result, richer consumers are more likely to be included in the IC share, and consequently, they may decide to buy generics. The empirical foundation for this result can be examined in Bronnenberg at al. (2015)[20] Beyond highlighting the positive correlation between income and higher education, they noticed the opposite effects of income and education on store-brand purchases (like OTC generics). Even though higher income allows richer consumers to buy

[19]This asymmetry between consumers and firms is central within behavioral industrial organization and contributes to justify why firms continue to be considered rational agents maximizing profit facing consumers with biased beliefs.

[20]The authors focused on the market for OTC drugs, but, as they recall, results can extend to prescription drugs

expensive national brands, higher education as a proxy for information, should lead these same consumers to choose cheaper store brands. As the authors point out, the impact of education expands when one adds income controls. The net effect implies greater propensity of richer and informed consumers to buy store brands, i.e. generic drugs..

3.2.2 Misperceived Vertical Differentiation and Market Demand

In the case of a duopoly, we have assumed that the whole market is covered: *i.e.* each consumer will buy one unit of a drug. The generic one is sold at price P_G, whereas the brand-name drug is sold at price P_B. This implies that in equilibrium $P_G^* \leq q_G\underline{\theta}$ if the consumer with the lowest WTP buys a generic drug.

In order to define market demand, we have to find the marginal consumer who is indifferent between purchasing a brand-name drug and a generic one. However, in this model, we have to evaluate two types of marginal consumers. The first one is an uninformed marginal consumer θ' with optimistic misperception, and defined by the following equality: $\theta' q_G - P_G = \theta' q_E - P_B$, leading to

$$\theta' = \frac{P_B - P_G}{q_E - q_G}$$

-

We can set $\Delta_E = (q_E - q_G)$ as the expected quality differential perceived by UC. As a result, UC with WTP $\theta \geq \theta'$ (and $\theta \leq \theta^*$) will choose a branded drug, while UC with WTP $\theta \leq \theta'$ (and $\theta \leq \theta^*$) will ask for a generic one.

The second marginal consumer is the informed one θ'':

$$\theta'' = \frac{P_B - P_G}{q_B - q_G}$$

FIGURE 1

We can then define $\Delta = (q_B - q_G)$ as the real quality differential. The fact that IC know $q_B = q_G = \overset{\circ}{q}$, implies $\Delta = 0$ and $\theta'' \rightarrow \infty$, so that $\theta_i \leq \theta''$for any IC i , and $\theta\prime\prime > \bar{\theta}$. Therefore, every IC will purchase the generic drug because the IC WTP θ is included in the following range: $\theta^* \leq \theta \leq \bar{\theta} \leq \theta''$, and the demand for generics is expected to include the segment $(\bar{\theta}-\ \theta^*)$[21].

Furthermore, demand functions can be defined by the following expression:

$$D_i(P_G, P_B, \Delta, \Delta_E, \theta^*); i = G, B$$

(from now on D_G and D_B). We can specify demand functions according to the following parameter restrictions complying with our previous assumptions:

$$\left(\underline{\theta} \leq \theta' \leq \theta^* \leq \bar{\theta}\right)$$

As far as demand segments are concerned, we have obtained:

$$D_G = \left(\bar{\theta} - \theta^* + \theta' - \underline{\theta}\right) = (1 - \theta^* + \theta')$$

and:

$$D_B = \left(\theta^* - \theta'\right)$$

Generics demand D_G is given by the sum between the demand segment due to the IC share $\left(\bar{\theta} - \theta^*\right)$, and the UC demand segment $(\theta' - \underline{\theta})$ referred to consumers with optimistic misperception but also characterized by very low WTP. These consumers cannot afford brand-name drugs and have to buy generics, despite their preference for brands. D_B derives from UC with "intermediate" WTP allowing them to purchase the brand-name drug according to their preferences. (Fig. 2).

[21]When considering the relative location of the marginal consumers θ' and θ'' in the market, we must necessarily identify two main cases: either $\theta' < \theta''$, or $\theta' > \theta''$. The sign of the previous inequality only depends on the relationship between q_E and q_B. We can define UC optimistic misperception as $q_E > q_B$,therefore, $\theta' < \theta''$. In our specific case, $\theta' < \theta''$ trivially follows from $\theta'' \rightarrow \infty$.

FIGURE 2

Through parameter restrictions, we can also derive price domains consistent with the previous specifications for D_G and D_B implying that:

$$P_B - \theta^* \Delta_E \leq P_G \leq P_B - \underline{\theta} \Delta_E$$

-

$$P_G + \underline{\theta} \Delta_E \leq P_B \leq P_G + \theta^* \Delta_E$$

In accordance with the above-mentioned parameter restrictions, we must also evaluate a "borderline" case, where $\theta' = \theta^*$, and both IC and UC will buy generics, so that we can obtain $D_G = \left(\bar{\theta} - \underline{\theta}\right) = 1$; $D_B = 0$, and the following price domain for D_G :

$$0 \leq P_G \leq P_B - \theta^* \Delta_E$$

By considering another "borderline" case, where $\theta^* = \bar{\theta}$ and $\theta' = \underline{\theta}$, demand segments can be specified as $D_G = 0$ and $D_B = \left(\bar{\theta} - \underline{\theta}\right) = 1$ corresponding to the price domain:

$$0 \leq P_B \leq P_G + \underline{\theta} \Delta_E,$$

Therefore, demand functions can be represented as in Fig. 3.

FIGURE 3

4 An Equilibrium Analysis: Pure Price Competition in a Duopoly

We have analyzed sequential price competition between brand-name drugs and generics as a two-stage game of Bertrand competition with perceived vertical differentiation. In the first stage the brand-name drug producer decides their price after patent expiry and with expected generics entry. The generics producer establishes their price in the second stage given the irreversible price decision of the originator.

Equilibrium analysis implies the solution of the two-stage game by backward induction to find a Sub-game perfect Nash Equilibrium (SPNE). Equilibrium analysis highlights that anticipating the price decrease and the ensuing demand-stealing effect by the generic entrant, so it is optimal for the brand-name firm to increase the price of the originator given the residual demand sustained by UC with optimistic misperception. The following proposition summarizes the main equilibrium results.

Proposition 1 *With pure sequential price competition and perceived vertical differentiation in a duopoly, the price of the brand-name drug* $P_B^* = \frac{\Delta_E(1+\theta^*)}{2}$ *is higher than the generics price* $P_G^* = \frac{\Delta_E(3-\theta^*)}{4}$ *with a majority of IC,* $(1-\theta^*) \geq 2/3$*, or with a majority of UC* ($\theta^* > \frac{1}{3}$) *in a SPNE. As reaction functions are strategic complements, both equilibrium prices increase with expected quality differential* Δ_E *but* P_B^* *increases with the UC share while* P_G^* *increases with the IC share. Equilibrium demands are given by* $D_B^* = \frac{1}{4}(\theta^* + 1)$ *and* $D_G^* = \frac{1}{4}(3 - \theta^*)$ *,therefore,* D_B**increases with the UC share, and* D_G^* *with the IC share.*

See Appendix I for the proof.

The conditions for the existence of price equilibrium in a duopoly are not restrictive, as far as the IC share is concerned. Moreover, because equilibrium demand only depends on θ^*, i.e on the IC share $(1-\theta^*)$, and education is a proxy for information about therapeutic equivalence, the heterogeneity of generics diffusion in different national markets could also be explained by the differences in the education level of the consumers' population.

To see if a second mover advantage arises, we have to check explicitly if the generics firm achieves a greater profit than the seller of the brand-name drug.

Proposition 2 *The generics producer obtains a second-mover advantage if* $\theta^* < 4\sqrt{2} - 5 \cong 0.66$ *. Therefore, the profit advantage of the generics producer requires that the IC.share should not be lower than 1/3.*

See Appendix I for the proof.

According to Proposition 2, the second-mover advantage crucially depends on the IC share. As consumers included in the IC share are distinguished by higher WTP, they are willing to switch to generics. Therefore, the generics producer can increase their demand without resorting to excessive price reduction if the IC share is sufficiently high. Actually the generic price increases with the IC share. On the basis of Proposition 2, even when a minority of consumers is informed $(1-\theta^*) \geq 0.33$, the generics profit is greater than the originator's in the case of a duopoly.

The equilibrium price of the originator after generics entry may even exceed the previous monopolistic price level, giving rise to the "Generics Competition Paradox", as stated in Proposition 3.

Proposition 3 *The Generics Competition Paradox holds in a duopoly model with pure price competition, when the equilibrium price of the originator after generics entry exceeds the monopolistic price because of the quality differential* Δ_E *expected by UC believing that the originator's quality is higher.*

Proof. Let us recall the monopolistic price derived in section 3.1 $P_M^* = \frac{(\theta+1)q^\circ}{2}$ to compare it with the equilibrium brand price in a duopoly $P_B^* = \frac{\Delta_E(1+\theta^*)}{2}$. We have determined that $P_B^* > P_M$, if

$$q_E > q_0 \left(\frac{1+\underline{\theta}}{1+\theta^*} + 1 \right)$$

as $\underline{\theta} < \theta^*$ we have $\frac{1+\theta}{1+\theta^*} < 1$, therefore, $q_0 \left(\frac{1+\theta}{1+\theta^*} + 1 \right) > q_0$, and if $q_E - q_0 \left(\frac{1+\theta}{1+\theta^*} + 1 \right) > 0$, as implied by $q_E > q_0 \left(\frac{1+\theta}{1+\theta^*} + 1 \right)$, even more so $(q_E - q_0) > 0$,i.e. $\Delta_E > 0$ .As a result, UC misperception about the therapeutic effect of the originator is what leads the duopoly price of the brand-name drug to exceed the monopolistic price during the patent period. ■

5 Pure Price Competition with n Generic Entrants

After patent expiry and the first generics entry has occurred, new entrants continue to affect price competition. As has been widely observed and supported by various empirical analyses, generics prices decrease concurrently with the number of entrants, while the price of the originator remains comparatively higher[22]. Considering the U.S. market again, what is interesting to point out is that the negative relationship between generics price and the number of generics manufacturers ($\frac{dP_G^n}{dn} < 0$) also holds with a reduction of n due to the exit from the market of generics producers, especially when competition is so strong that prices are approaching long-run marginal costs. Reduced competition and increasing concentration trends in the U.S. generics industry have, actually, caused price spikes, in particular for older drugs with a small market share even without a brand-name competitor (Gupta, Shah and Ross, 2019)[23]

We have considered this case in our sequential model with just one brand-name drug, that is competing with n symmetric generic entrants. Concerning the strategic interaction among generics firms, we have assumed Cournot competition like in the previous literature. As a consequence, the greater (lower) the number of new entrants the lower (higher) the generics price is. When we add competition among n generic entrants, what should be highlighted is that the brand-name

[22] According to Dave, Hartzema, and Kesselheim (2017), for drugs with a single generics manufacturer the relative price reaches 87%. With a second manufacturer, generic price decreases by a further 10%, and the relative price drops to 77%. With three generic the relative price reduces to 60%. More entry makes the price reduce at a slower rate. However, the relative price collapses to 20% with 10 generic firms or more.

[23] A U.S. Government report pointed out that 315 from a total of 1,441 generic drugs sold in the country experienced price increases of 100% or more in the period 2010-2015

drug seller will also reduce their price, as the best response to the reduction of the generics price ($\frac{dP_B^n}{dn} < 0$). Even though the brand equilibrium price remains higher that the generics one.

Proposition 4 *With one brand-name drug producer and n symmetric generics producers in the SPNE of the sequential price game, both the equilibrium price of the brand-name drug $P_B^{n*} = \frac{\Delta_E(1+n\theta^*)}{2n}$, and the generics price $P_G^{n*} = \frac{1}{n+1}\frac{\Delta_E(n(2-\theta^*)+1)}{2n}$ decrease compared to a duopoly equilibrium. For a given n, P_B^{n*} increases with the UC share, while P_G^{n*} grows with the IC share, as in the duopoly equilibrium. Given θ^*, both equilibrium prices diminish with an expansion of n, though P_G^{n*} decreases more than P_B^{n*}.*

Proof: See Appendix II

Reduction of generics price with an increase of n occurs not only as a strategic reaction to the price choice of the originator in the first stage game, but also as a result of Cournot competition among generic entrants in the second stage. Therefore, there are two drivers for generics price reduction compared to the duopoly case, implying intenser competition among generics firms, as well as more price competition between the generics and the brand-name producer.

In addition, we can demonstrate that the brand price reduces in equilibrium compared to the duopoly case, and that $dP_B/dn < 0$, i.e. the price of the brand- name drug decreases while the number of generic entrants grows, in opposition to what was claimed by Frank and Salkever (1992 and 1997), and Regan (2008), and consistently with the empirical results reported in Cavaliere and Moayedizadeh (2022). However, in equilibrium the brand price remains persistently higher than the generics one. These results do not imply the exclusion of the GCP, as we have defined it (See Proposition 6): even though the price of the brand-name drug diminishes with n , the size of the decrease is smaller compared to the one of the generics price, as shown above. Moreover, we cannot exclude a priori that price of the brand-name drug could still remain higher than the monopolistic one, although decreasing.

As to the relationship between $\theta^*$and equilibrium prices, the results obtained in the duopoly case continue to hold also in an oligopoly. Actually it is easy to check that for a given n, $\frac{\partial P_b^{n*}}{\partial \theta^*} > 0$ and $\frac{\partial P_g^{n*}}{\partial \theta^*}$implying that the price of the brand-name drug increases together with the UC share θ^*, while the generics price grows with the IC share ($\frac{\partial P_g^{n*}}{\partial (1-\theta^*)} > 0$.).

Proposition 5 *In an oligopolistic equilibrium with one brand-name producer and n generic entrants, the price of the brand-name drug is always higher than the generics ($P_b^{n*} > P_g^{n*}$) , and generics demand is greater than the demand for the brand-name drug: $Q_G^* > D_B^*$. The group of generics firms holds a second mover advantage if $\theta^*$is included in the following range: $0 < \theta^* < \frac{2n+1-\sqrt[2]{(n+1)}}{n(\sqrt[2]{(n+1)}+1)}$. Therefore, the greater the number of generic entrants the larger the IC share required for the existence of a second mover advantage is.*

Proof: See Appendix II

As we have determined that a second mover advantage for the group of generics producers exists only if $\theta^* < \frac{2n+1-\sqrt[2]{(n+1)}}{n(\sqrt[2]{(n+1)}+1)}$, consequently when $n \to \infty$ $\theta^* \to 0$ Therefore, the greater the number of generic entrants, the lower the generics price is, and the greater the IC share that is required for the existence of a second mover advantage will be. The result derives from the effect of an increasing n on the reduction of the generics price, that however, cannot decrease too much in order to be consistent with the second mover advantage. A larger generics demand due to an increase of IC has an opposed effect on the generic price and can keep generics profits higher[24]

Indeed, by plotting the inequality $\theta^* < \frac{2n+1-\sqrt[2]{(n+1)}}{n(\sqrt[2]{(n+1)}+1)}$ we obtain the result in figure 4::

FIGURE 4

[24]Even if the brand price will also decrease with n entrants, the reduction in the generics price will be greater. Therefore, a second mover advantage is less likely. On the contrary, an increase of IC benefits generic firms at a disadvantage for the brand producer, making a second mover advantage more likely.

With $n = 1$ we can confirm the restriction on the IC share valid for the duopoly case, as the graph shows that $\theta^* \cong 066$ corresponds to $n = 1$ Furthermore, it can be observed that four new entrants are enough for $\theta^*$to make the IC share represent the majority of consumers in the market (a result which is quite unlikely in market reality), and with a further increase of new entrants, the extension of the required IC share appears to be so large that it is even less realistic. Because generics equilibrium price decreases with the number of new entrants, the existence of a second mover advantage implies a trade-off between the extension of the IC share and the price reduction resulting from multiple new entrants.

We have reconsidered the GCP with n generic entrants

Proposition 6 *The Generics Competition Paradox holds in an oligopolistic model with n generic entrants, and one seller of the brand-name drug if UC are optimistic, i.e.* $\Delta_E > 0$*, as in the duopoly case.*

See Appendix II for the proof, which is very similar to the proof of the existence of the GCP in a duopoly.

6 Price Competition with Insurance: Co-payment Effects and Reference Pricing

We shall now introduce the more realistic case of third-party insurance. Outpatients can be insured either within a public health-care system, or with a private insurance company, excluding full insurance and assuming that outpatients contribute to pharmaceutical expenditure with an out-of-pocket co-payment. We have distinguished the case of standard co-payment, from the reference-pricing case typical of public health- care systems.

6.1 6.1 Price Competition and Equilibrium Analysis in a Standard Co-payment System

We assumed that co-payment is a variable charge P_i, i.e. a fraction of drug prices:

$$c_i = \gamma P_i \tag{4}$$

In this case utility functions change as follows,

$$U_B = \theta q_E - c_B \tag{5}$$

$$U_G = \theta q_0 - c_G \tag{6}$$

and, consequently, we have a new expression for the marginal uninformed consumer θ'_c :

$$\theta'_c = \frac{c_B - c_G}{\Delta_E} = \frac{\gamma(P_B - P_G)}{\Delta_E} \tag{7}$$

Demand functions are modified accordingly:

$$D_B = \left(\theta^* - \theta'_c\right) = \left(\theta^* - \frac{\gamma(P_B - P_G)}{\Delta_E}\right) \tag{8}$$

$$D_G = (\bar{\theta} - \theta^* + \theta'_c - \underline{\theta}) = \left(1 - \theta^* + \frac{\gamma(P_B - P)}{\Delta_E}\right)$$

Proposition 7 *With third-party insurance and consumers" co-payment, equilibrium prices in a duopoly increase in proportion to the price share* γ:$P_B^* = \frac{\Delta_E(1+\theta^*)}{2\gamma}$; $P_G^* = \frac{\Delta_E(3-\theta^*)}{4\gamma}$. *It can be easily confirmed that* $P_B^* > P_G^*$ *like in pure price competition equilibrium. Equilibrium profits also increase in proposition to* γ. *A secondmover advantage exists for* $\theta^* < 4\sqrt{2} - 5 \cong 0.666$, *just as in the duopoly case without insurance.*

See Appendix III for the proof

Compared to the previous case, the most important difference in the case of third-party insurance and co-payments is the increase in equilibrium prices and profits.

We can, therefore, extend our analysis to the case with n generic entrants. As stated in the following proposition, the increase of equilibrium prices and profits is confirmed in this case, too. Checking for the existence of a second-mover advantage for the group of generic entrants provides the same results obtained in the oligopoly case without insurance, as the comparison of equilibrium profits is independent from $\gamma < 1$. The conditions for the existence of the GCP do not change either.

Proposition 8 *With n generic entrants and a single producer of the brand-name drug, the introduction of co-payments leads to an increase of equilibrium prices in proportion to the price share $\gamma < 1$ paid by consumers: $P_b^{n*} = \frac{\Delta_E(1+n\theta^*)}{2\gamma n}$; $P_g^{n*} = \frac{1}{\gamma(n+1)}\frac{\Delta_E(2n+1-n\theta^*)}{2n}$. As in the previous model without co-payments, we have found that $P_b^{n*} > P_g^{n*}$, and both $P_b^{n*}$and P_g^{n*}decrease with n, but P_g^{n*}reduces more than P_b^{n*}.Moreover, the difference between equilibrium prices diminishes with growth in γ . Profit functions increase with γ.*

See appendix III for the proof.

6.2 Case with Reference Pricing

When a reference pricing policy is introduced, consumers neither pay the full price, nor a simple co-payment, as stated above. The reference price R can be set in many ways considering a group of drugs in the same therapeutic class (R can then be set as equal to the weighted average of these drug prices, or to the lowest price among them, i.e. the generics price). For instance, Brekke et al.(2022) assume that $P_G < R < P_{B.}$ In the following example, the reference price is the generics: $R = P_G$. Reference pricing implies that consumers buying the generic drug just pay a co-payment, a fraction of the generics price as usual. Consumers purchasing the brand-name drug, instead, pay the difference between the price of the brand-name drug and the reference price, i.e. the generics price, in our example. Therefore, with reference pricing the co-payment scheme changes as follows:

$$c_G^r = \gamma P_G \tag{9}$$

$$c_B^r = \gamma P_G + (P_B - P_G) \tag{10}$$

leading to the following utility functions

$$U_B = \theta q_E - c_B^r \tag{11}$$

$$U_G = \theta q_0 - c_G^r \tag{12}$$

under these assumptions the marginal consumer becomes

$$\theta_c' = \frac{c_B^r - c_G^r}{\Delta_E} = \frac{\gamma P_G + (P_B - P_G) - \gamma P_G}{\Delta_E} = \frac{P_B - P_G}{\Delta_E} \tag{13}$$

implying the following demand functions:

$$D_b^r = \left(\theta^* - \theta_c'\right) = \left(\theta^* - \frac{P_b - P_g}{\Delta_E}\right) \tag{14}$$

$$D_g^r = \left(\bar{\theta} - \theta^* + \theta_c' - \underline{\theta}\right) = \left(1 - \theta^* + \frac{P_b - P_g}{\Delta_E}\right)$$

It can be easily checked that the expressions regarding the marginal consumer and demand functions are the same as the ones referred to the case of pure price competition in a duopoly, so that the equilibrium analysis corresponds (See Section 4). This can be explained by the fact that the introduction of a reference price does not allow the brand firm to increase their price, as has occurred in the case of standard co-payments, given that consumers pay the difference with the generics price out of their own pocket. In our sequential framework, where the brand-name drug seller makes the first move, the generics firm, as a second mover, behaves accordingly and will not increase their price either. Consequently, the reference price in our model does not produce any distortion , as both firms act like they have in the case of pure price competition with perceived vertical differentiation (see section 4).

The extension to the case with n symmetric generic entrants does not affect our conclusions, once the reference price coincides with the generics price arising from Cournot competition, and the brand-name price is set accordingly, as in Section 5. Obviously our conclusions cannot be generalized. If the reference price were determined differently, for example if $P_G < R < P_B$ as in Brekke et al. (2022), diverse conclusions would be drawn within the framework of our model.

7 Extension to the Case of Physicians' Misperception

As stated in the introduction, outpatients may be misled in their choice of drugs by physicians' misperception. Therefore, we will now introduce price competition considering the traditional agency model of health-care (Arrow, 1963), whereby outpatients delegate their choice between a brand-name drug and a generic one to medical experts. We have maintained the distinction between IC and UC, and we still suppose that the UC choice is based on optimistic misperception, as in the basic model with pure price competition. However, in this setting, a share of physicians support brand-name drugs either because of misperception about switching to generics, or as a result of detailing efforts from brand-name drug sellers[25] .

[25] Ellison and Ellison (2011) point out that, after generics entry, firms reduce their detailing efforts concerning the originator, in order to sustain another brand in the same therapeutic class. According to Castanheira et al (2019) generics entry produces a drop in the total market share of the molecule losing exclusivity.

Therefore, compared to the basic demand model presented in all the previous cases, now UC with intermediate WTP, who would have chosen a brand-name drug because of optimistic misperception, reinforce their choice according to medical recommendations and stick to the brand-name drug purchase. On the contrary, a share $\alpha < 1$ of consumers that would have switched to a generics, either because they are informed, or because their income is low, change their minds because of the advice of medical experts included in the α share opposing to generics switching. The remaining share $(1 - \alpha)$ of outpatients purchase generics thanks to a share $(1 - \alpha)$ of physicians that do not oppose to such a change. According to these assumptions, demand functions in a duopoly case become:

$$D_B^m = (\theta^* - \theta') + \alpha(\bar{\theta} - \theta^* + \theta' - \underline{\theta}) = \left(\theta^* - \frac{P_B - P_G}{\Delta_E}\right) + \alpha\left(1 - \theta^* + \frac{P_B - P_G}{\Delta_E}\right) \qquad (15)$$

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$$D_G^m = (1 - \alpha)\left(\bar{\theta} - \theta^* + \theta' - \underline{\theta}\right) = (1 - \alpha)\left(1 - \theta^* + \frac{P_B - P_G}{\Delta_E}\right)$$

Given these demand functions, we can derive a new SPNE for the duopoly case (See Appendix IV). Within this new SPNE, as expected, the share α of physicians opposing to generics switching drives an increase of the equilibrium demand for brand-name drugs, and a decrease in the generics one. However, equilibrium prices both raise with α , as a result of strategic complementarity of reaction functions. As usual, the equilibrium price of the brand-name drug remains higher than the generics. By comparing this SPNE with the case where only consumers' misperception affects market demands (See Appendix IV.), both a demand and price advantage for brand-name drugs can be noticed. On the contrary, generics equilibrium demand is comparatively lower. The generics price reduces only if α is small enough, and the IC share is fairly large. Generics producers in the opposite case need to raise prices in order to maximize profits.

Having found a demand and price advantage for the brand-name drug, we have checked for the existence of a first-mover advantage driven by α. By comparing equilibrium profits (Appendix IV), we have detected that the brand-name drug profits are higher respect the case without medical misperceptions. Considering the simulations presented in Appendix V (including the duopoly case), it may be noticed that with a large IC share, a first mover advantage can arise even with lower values of α.,

When extending the analysis to the case of n generic entrants we obtain a new SPNE, whose properties are similar to those arising in the duopoly case (See Appendix V), with the exception of the joint effects of n, α and θ^*. As in the previous analysis of oligopolistic equilibria (See Section 5), generics demand in the current case is still driven by price reductions induced by an increase of n , and by the growth of the IC share. However, the trade-off between n and $(1 - \theta^*)$ is now mediated by α. The larger the share of physicians supporting brand-name drugs is, the bigger is the IC share required to avoid an excessive reduction of the generics price. Establishing conditions either for a first or a second mover advantage, in this case, is rather cumbersome, due to the number of parameters implied by the comparison of equilibrium profits: α, θ^* and n. We have proposed a few simulations in Appendix V. For example, if the market is split exactly between UC and IC: $\theta^* = 0.5$, and there is just one generic entrant, we can observe a second mover advantage up to $\alpha = 0.5$. Conversely, we obtain a first-mover advantag for higher values of α. If $n = 4$, the generics price collapses, and a first-mover advantage arises immediately even though $\alpha = 0.1$ and persists for larger alpha shares

8 Conclusion

Evidence concerning consumers' misperception about generics, related to outpatients with low income and low education levels, has led us to assume that generics demand does not just depend on lower prices compared to brand-name drugs, but also on consumers' education, as a proxy of information. Therefore, sequential price competition between generics and brand-name drugs has been characterized in a model of perceived vertical differentiation with information disparity. By splitting the market between IC and UC, we can derive the demand of brand-name drugs as affected by UC' optimistic misperception that quality of brand-name drugs is higher compared to that of generics. As a consequence, generics demand does not only depend on consumers with the lowest income, who would prefer brand-name drugs and cannot afford them, but also on higher-income consumers, purchasing generics because of their superior information.

Regarding the supply side we claim that duopoly and oligopoly models with sequential price competition and perceived vertical differentiation, where reaction functions are strategic complements, are the proper framework to understand price competition between brand name drugs and generics. Such a choice has also allowed us to consider the eventuality of a second mover advantage for generic entrants that could negatively affect dynamic efficiency in pharmaceutical markets However, given the asymmetric nature of our model, we have checked for the existence of a second (or first) mover advantage in each equilibrium we have considered.

Firstly, we have analyzed pure price competition as a benchmark case in a duopoly. Consumers are free to choose between brands and generics and pay for drugs out of pocket. The price of brand-name drugs in equilibrium is persistently higher than the generics price, which is reduced to increase generics demand in the last stage game. Such an equilibrium is consistent with empirical results supporting the GCP. Moreover, the brand price increases with the UC share, while the generics price grows with the IC share. In this case a second mover advantage can easily arise, because duopolistic competition implies that the single generic entrant does not need excessive price reduction to maximize profits.Consequently the IC share is not a critical variable for the existence of a second mover advantage. Equilibrium demand structurally depends on the share of IC versus UC, implying that the share of educated consumers is a critical factor for generics diffusion in different countries, when one also considers the heterogeneity of education levels among developed Countries.

However, when we introduce multiple generic entrants, competition among generics sellers adds to competition between generics and the originator, and generics prices decrease more significantly. Also the originator producer opts in favor of reducing prices in proportion to the number of generic entrants, despite the persistence of a brand price higher than the generic ones. Such result comes out in favour of the existence of some price competition between brand name drugs and generics, contrary to what was stated in the previous literature, but is not at odds with the GCP. The traditional theoretical literature was emphasising a positive relationship between the originator price and the number of generic entrants, concluding that only intermolecular competition could exert downward pressure on brand prices. We find instead a negative relationship, that however is not at odds with an equilibrium price of the originator remaining greater than the generic price, despite the reduction caused by fiercer competition among generic entrants. In the light of these results, and accounting for other contributions to the literature, we rather consider the GCP as arising from an higher brand price after patent expiry, compared to a monopolistic brand price characterizing the patent period. As such, the increase in the brand price after generic entry, beyond representing an equilibrium result of sequential price competition with vertical differentiation, can be linked to the expected quality difference between brand name drugs and generics, due to optimistic misperceptions arising only when outpatients face a choice between a generic originating from the same molecule of a pioneering brand.

With more generic entrants the conditions for a second mover advantage become more challenging, because generics producers, as a group, need to count on a higher IC share to avoid excessive price reduction. The extension of the IC share required to imply a second mover advantage can counterbalance the reduction in generic prices due to fiercer competition among generic entrants. However such an IC share may be too high compared to what we expect to observe in real pharmaceutical markets. As the share of educated consumers in the population of a country hardly ever represents the majority of drug purchasers. Actually, an impressive decrease of generics prices can be noticed in real markets, when the number of generics producers increases.Therefore, being a second move advantage less likely with multiple generic entrants, also the threat of generic diffusions for dynamic efficiency in pharmaceutical markets appears to be weaker as well. Furthermore, because there are limits to the reduction of generics prices (in the short run), as well as to the expansion of the informed consumers' group (in the long run), and these limits can be empirically different in each national pharmaceutical market, heterogeneity in the diffusion of generics drugs among OECD countries is a less surprising result, once we account for information as a driver of generics demand beyond price reductions.

We have extended our model to the case of third-party insurance with consumers' co-payment, but only find an increase of equilibrium prices and profits as a result. Our main results are not affected by the introduction of private or public insurance. Moreover, if we consider the structure of co-payment envisaged by the introduction of reference pricing, we will find no distortion of pure price competition, when the chosen reference price is that of generics either in a duopoly or in an oligopoly. Yet a general extension of our model to account for every type of reference pricing policy is beyond our scope.

We have extended our analysis, to also include the traditional agency theory of health care, in order to account for the existence of a share of physicians that support brand name drugs. In this case, beyond finding an obvious demand advantage for originators, we see that price competition is less affected, as both equilibrium prices are driven up by the existence of a share of physicians that oppose generic switching, though the brand price increases more than the generic one. In the duopoly case we find the existence of a first mover advantage, either when that share of GP supporting brand name drugs is very high or even if such a share is lower, provided the IC share is suffciently high. In the oligopolistic case we cannot find a general result, and some simulations show that either a first mover or a second mover advantage can arise according to the values of the parameters of the model.

A tentative general conclusion could be that the intenser price competition among generic firms due to free entry, coupled with a minority of informed consumers, on the demand side, hardly allows generic producers to gain a second mover advantage and then really threat innovation in pharmaceutical markets. Such a conclusion is reinforced if a considerable share of physicians also support brand name drugs.

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Figure

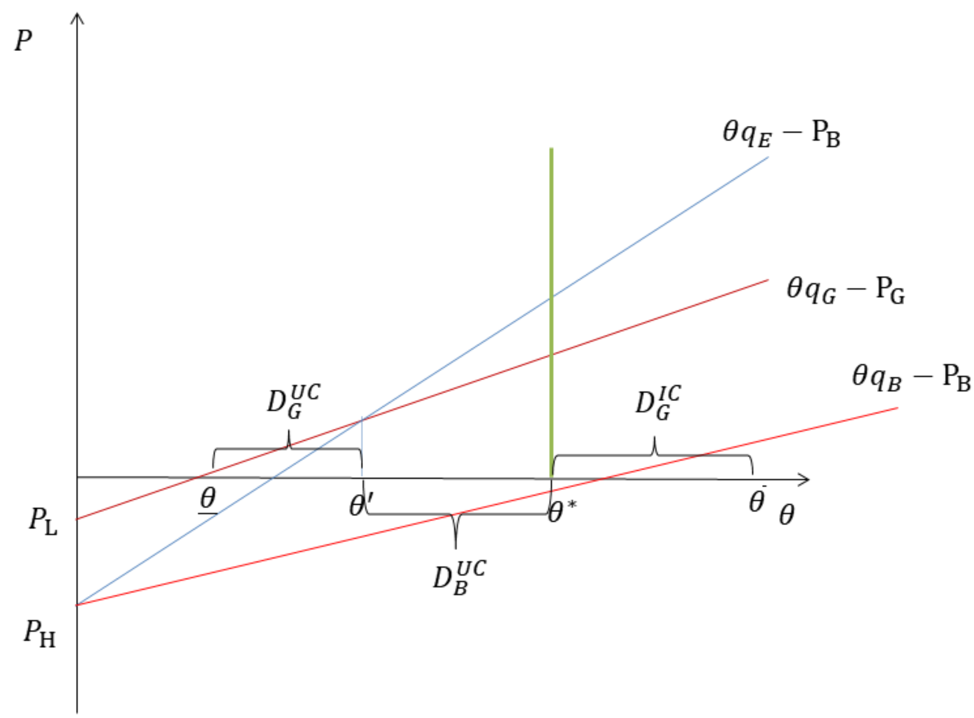

Figure 1: Demand Segments according to utity functions

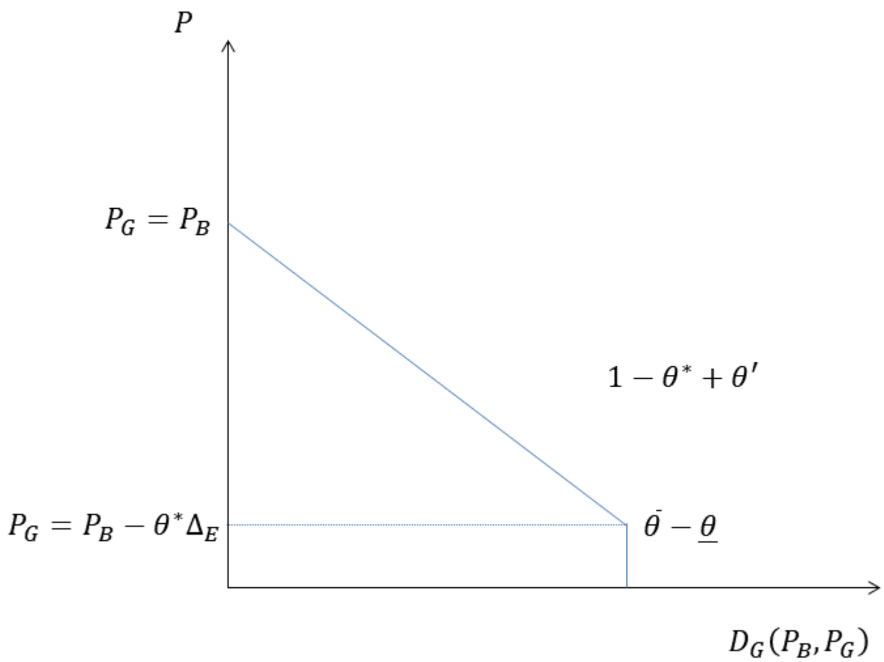

Figure 2: Demand function for Generics

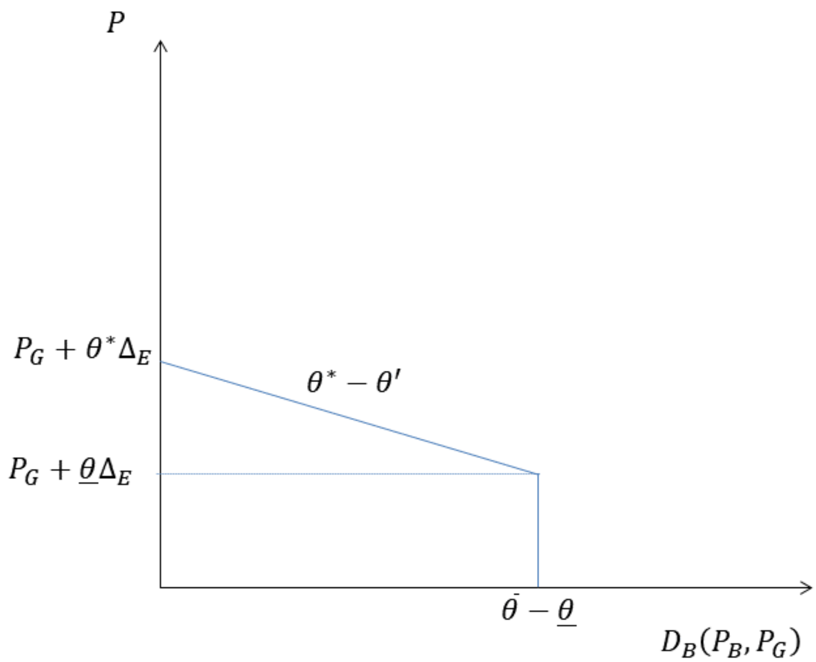

Figure 3: Demand function for Brands

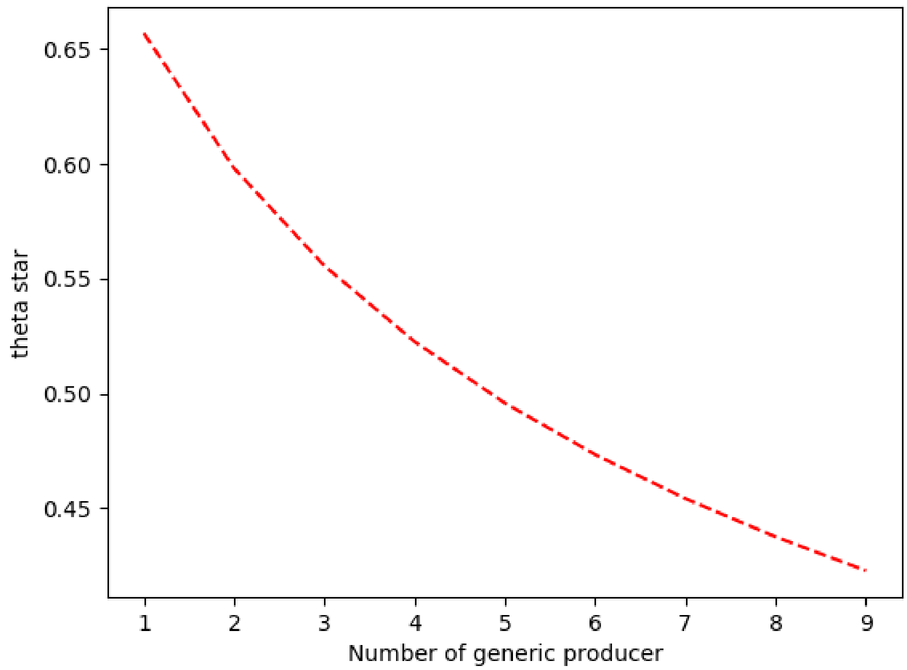

Figure 4: plotcof inequlity presented in proposition 5

Appendix I

	Norway		Italy		Germany		The Netherland		Portugal		Spain		UK	
2003	23.8				52.6		46.5		8.8		8.9		71.5	
2004	26.7	12.18%	4.7		55	4.56%	46.6	0.22%	11.6	31.82%	12	34.83%	72.5	1.40%
2005	32.6	22.10%	5.7	21.28%	59.3	7.82%	49.8	6.87%	17.9	54.31%	14.1	17.50%	73.6	1.52%
2006	34.9	7.06%	6.4	12.28%	63.6	7.25%	53.7	7.83%	20.9	16.76%	16.7	18.44%	68.5	-6.93%
2007	36.5	4.58%	8.1	26.56%	67.6	6.29%	54.1	0.74%	24	14.83%	20.9	25.15%	70.8	3.36%
2008	38.5	5.48%	10.5	29.63%	70.8	4.73%	56.2	3.88%	26.4	10.00%	21.8	4.31%	71.5	0.99%
2009	39.4	2.34%	11.3	7.62%	72.4	2.26%	57	1.42%	30.8	16.67%	23.8	9.17%	72.5	1.40%
2010	41.5	5.33%	13.6	20.35%	73.7	1.80%	60.6	6.32%	37.7	22.40%	27.4	15.13%	73.6	1.52%
2011	41.5	0.00%	16.1	18.38%	76.3	3.53%	63.3	4.46%	42	11.41%	34.2	24.82%	75	1.90%
2012	42.8	3.13%	19.3	19.88%	78.2	2.49%	66.7	5.37%	47.3	12.62%	39.7	16.08%	80.5	7.33%
2013	45.1	5.37%	21.2	9.84%	79.5	1.66%	69.7	4.50%	51.6	9.09%	46.5	17.13%	83.4	3.60%
2014	46.9	3.99%	22.5	6.13%	81	1.89%	71.4	2.44%	52.9	2.52%	47.6	2.37%	84.2	0.96%
2015	48.5	3.41%	22.5	0.00%	81.4	0.49%	72.4	1.40%	53	0.19%	48.1	1.05%	84.9	0.83%
2016	49.4	1.86%	22.9	1.78%	81.2	-0.25%	74.1	2.35%	52.8	-0.38%	47.5	-1.25%	85.2	0.35%
2017	49.1	-0.61%	26.2	14.41%	82.3	1.35%	75.6	2.02%	52.9	0.19%	46.4	-2.32%	85.3	0.12%
2018	51.1	4.07%	27.8	6.11%	82.6	0.36%	77.7	2.78%	53.9	1.89%	46.4	0.00%		
2019	49.3	-3.52%	28.9	3.96%	83	0.48%	77.9	0.26%	54.5	1.11%	46.3	-0.22%		
2020	51.8	5.07%	29.2	1.04%					54.9	0.73%	46.2	-0.22%		

Table 1: Percentage Share and Yearly Rate of Growth of Generic Consumption (Volume) in Some OECD Countries. Generic Consumption in Volume and Value: OECD Statistics

Proof. of Proposition 1

We shall solve the two-stage game by backward induction starting from the last stage where generics entry takes place. Given the expression of market demand D_G (See Section 3.2.2) we can derive the profit function for firm G:

$$\Pi_G = P_G D_G = P_G \left(1 - \theta^* + \theta'\right) \tag{16}$$

according to the f.o.c. we obtain:

$$\frac{\partial \Pi_G}{\partial P_G} = 1 - \theta^* - \frac{P_B - 2P_G}{\Delta_E} = 0$$

and we can solve it for the best reply of firm G :

$$P_G = \frac{P_B + \Delta_E(1 - \theta^*)}{2} \tag{17}$$

In the first stage game, we have considered the profit function for firm B on the basis of market demand D_B(see section 3.2.2):

$$\Pi_B = P_B D_B = P_B \left(\theta^* - \frac{P_B - P_G}{\Delta_E} \right) \tag{18}$$

to solve the sequential game we have substituted the best reply P_G of the generics producer into the previous profit function

$$\Pi_B = P_B D_B = P_B \left(\theta^* - \frac{P_B - \frac{P_B + \Delta_E(1-\theta^*)}{2}}{\Delta_E} \right)$$

$$\Pi_B = P_B \left(\frac{2\theta^* \Delta_E - P_B + \Delta_E - \Delta_E \theta^*}{2\Delta_E} \right)$$

Profit maximization by firm B leads to the following f.o.c..:

$$\frac{\partial \Pi_B}{\partial P_B} = \frac{2\theta^* \Delta_E - 2P_B + \Delta_E - \Delta_E \theta^*}{2\Delta_E} = 0$$

which we have solved for P_B^*

$$P_B^* = \frac{\Delta_E(1 + \theta^*)}{2} \tag{19}$$

By substitution we obtain P_G^*

$$P_G^* = \frac{\Delta_E(3-\theta^*)}{4}$$

At equilibrium, we find that $P_B^* > P_G^*$ for $\theta^* > 1/3$. As to equilibrium demand functions, by substitution of equilibrium prices P_B^* and P_G^* into the expression of θ', we obtain:

$D_B^* = (\theta^* - \theta') = \frac{1}{4}(\theta^* + 1)$

$D_G^* = (1 - \theta^* + \theta') = \frac{1}{4}(3 - \theta^*)$

and it is easy to check that in equilibrium, D_B^* increases with the UC share θ^*, while D_G^* does with the IC share $(1 - \theta^*)$. ■

Proof. of Proposition 2:

From equilibrium demands and prices, we can derive equilibrium profits:

$\Pi_B^* = \left(\frac{\Delta_E(1+\theta^*)}{2}\right)\left(\frac{1}{4}\theta^* + \frac{1}{4}\right) = \frac{\Delta_E(1+\theta^*)^2}{8}$

$\Pi_G^* = \left(\frac{\Delta_E(3-\theta^*)}{4}\right)\left(\frac{3}{4} - \frac{1}{4}\theta^*\right) = \frac{\Delta_E(3-\theta^*)^2}{16}$ We can now check for the existence of a second mover advantage, i.e $\Pi_G^* > \Pi_B^*$, implying:

$\frac{\Delta_E(3-\theta^*)^2}{16} - \frac{\Delta_E(1+\theta^*)^2}{8} > 0$

The solution of the previous inequality is $\theta^* = \left(-4\sqrt{2} - 5, 4\sqrt{2} - 5\right)$. As the first root is negative, we can neglect it. Considering the second root: $\theta^* = 4\sqrt{2} - 5 \cong 0.6568$, given our assumption: $0 < \theta^* < 1$, we find that the previous inequality holds if $0 < \theta^* < 4\sqrt{2} - 5 \cong 0.6568$, therefore we find a second mover advantage if $\theta^* < 0.66$, implying that the IC share $(1 - \theta^*)$ cannot be lower than $(1 - 0.66) = 0,33$, i.e. at least 1/3 of consumers have to be informed to allow a second mover advantage ■

Appendix II

Proof. of Proposition 4:

We have reconsidered the generics demand, as well as the demand for the unique brand-name drug with n generics entrants.

$$Q_G = (\bar{\theta} - \theta^* + \theta' - \underline{\theta}) = \left(1 - \theta^* + \frac{P_B^n - P_G^n}{\Delta_E}\right)$$

solving for P_G we derive the inverse demand function for generics drugs:

$$P_G^n = (1 - \theta^* - Q_G)\Delta_E + P_B^n \tag{20}$$

assuming symmetry for generics producers $Q_G = q_i + \sum_{j \neq i}^{n} q_g$ we obtain:

$$P_G^n = (1 - \theta^*)\,\Delta_E + P_B^n - q_i\Delta_E - \sum_{j \neq i}^{n} q_j \Delta_E$$

and the profit function for the generics producer i

$$\Pi_{iG} = P_G^n q_i = \left((1 - \theta^*)\Delta_E + P_B^n - q_i\Delta_E - \sum_{j \neq i}^{n} q_j \Delta_E\right) q_{iG} \tag{21}$$

Profit maximization by any generics firm i, implies the following f.o.c.:

$$\frac{\partial \Pi_G}{\partial q_i} = (1 - \theta^*)\,\Delta_E + P_B^n - 2q_i\Delta_E - \sum_{j \neq i}^{n} q_j \Delta_E$$

by symmetry $q_i = q_j$

$$\frac{\partial \Pi_G}{\partial q_i} = (1 - \theta^*)\,\Delta_E + P_B^n - 2q_i\Delta_E - (n-1)q_j\Delta_E = 0$$

solving for q_i

$$q_i^* = \frac{(1 - \theta^*)\Delta_E + P_B^n}{\Delta_E(1 + n)} \tag{22}$$

we can then derive Q_G as the total generics demand:

$$Q_G = nq_i^* = \frac{n}{(1+n)} \frac{(1-\theta^*)\Delta_E + P_B^n}{\Delta_E} \tag{23}$$

and replacing equation (22) in equation (20) we get the inverse demand function for generics drugs

$$P_G^n = \frac{1}{(1+n)} \left[(1-\theta^*)\Delta_E + P_B^n\right] \tag{24}$$

We shall solve the first stage game by considering the new demand and profit function for the brand producer:

$$\Pi_B = P_B^n(\theta^* - \frac{P_B^n - P_G^n}{\Delta_E}) \tag{25}$$

replacing P_G^n we obtain

$$\Pi_b^n = P_b^n \frac{\Delta_E(1+n\theta^*) - P_B^n n}{(n+1)\Delta_E}$$

Brand producer's profit maximization implies the following f.o.c.:

$$\frac{\partial \Pi_B}{\partial P_B^n} = \frac{(1+n\theta^*)\Delta_E - 2nP_B^n}{(n+1)\Delta_E} = 0$$

and solving for P_B^n we obtain the equilibrium price for the brand-name drug

$$P_B^{n*} = \frac{\Delta_E(1+n\theta^*)}{2n} \tag{26}$$

By replacing (26) in (24) we can achieve the generics equilibrium price P_G^{n*}:

$$P_G^{n*} = \frac{1}{n+1} \frac{\Delta_E(n(2-\theta^*)+1)}{2n} \tag{27}$$

It can easily be checked that we obtain the same equilibrium prices derived for the duopoly case when $n=1$. When comparing P_B^{n*} with the duopolistic price P_B^* the following difference is acquired

$$P_B^{n*} - P_B^* = \frac{\Delta_E(1+n\theta^*)}{2n} - \frac{\Delta_E(1+\theta^*)}{2}$$

which reduces to $\frac{1-n}{n} < 0$, confirming that the equilibrium price of the brand-name drug in an oligopoly is lower than in a duopoly. Likewise we can compare the generics equilibrium prices $P_G^{n*}$and P_G^* to obtain the subsequent difference

$$P_G^{n*} - P_G^* = \frac{n(1-\theta^*)+2+n^2(\theta^*-3)}{2(n+1)n} < 0 \tag{28}$$

showing that $P_G^{n*} < P_G^*$. Given θ^*, with an increasing number of generics entrants n, both equilibrium prices decrease:

$$\frac{\partial P_B^{n*}}{\partial n} = -\frac{\Delta_E}{2n^2} < 0 \tag{29}$$

$$\frac{\partial P_G^{n*}}{\partial n} = \frac{\Delta_E\left[(\theta^*-2)\,n^2-2n-1\right]}{2n^2(n+1)^2} < 0, \text{ as} \theta^* < 2 \tag{30}$$

However the decrease of P_G^{n*} is greater than that of P_B^{n*}, as shown below:

$$\frac{\left[(\theta^*-2)\,n^2-2n-1\right]}{2n^2(n+1)^2} > -\frac{1}{2n^2}$$

reducing to the following inequality:

$$\frac{\left[(\theta^*-2)\,n^2-2n-1\right]}{(n+1)^2} < 1$$

As $\left[(\theta^*-2)\,n^2-2n-1\right] < 0$, we can state that $\left[(\theta^*-2)\,n^2-2n-1\right] < n^2+1+2n$, implying that the above inequality is true. ■

Proof. of Proposition V

By considering the difference ($P_B^{n*} - P_G^{n*}$) and simplifying it, we obtain :

$$\frac{\Delta_E(1+n\theta^*)}{2n} - \frac{1}{n+1}\frac{\Delta(2n+1-n\theta^*)}{2n} = \frac{1}{2}\frac{\Delta_E}{n+1}(2\theta^* + n\theta^* - 1) > 0$$

$$\text{as } 0 < \theta^* < 1, \text{ and } n \geq 2$$

confirming that it is optimal for the producer of the brand-name drug to raise their price in order to maximize profits, anticipating the price decrease that is optimal for generics producers in the second stage game. We shall proceed now to the proof that generics demand Q_G^* in equilibrium is higher than the one for the brand-name drug D_B^* . Concerning generics demand we have found:

$Q_G^* = nq_i^* = \frac{n}{(1+n)}\frac{(1-\theta^*)\Delta_E + P_b^{*n}}{\Delta_E} = \frac{n}{(1+n)}\frac{(1-\theta^*)\Delta_E + \frac{\Delta_E(1+n\theta^*)}{2n}}{\Delta_E} = \frac{(2n-n\theta^*+1)}{2n+2}$. The equilibrium demand for the brand-name drug is given by the substitution of equilibrium prices into θ'. Recalling the expression of the demand for the brand-name drug $D_B = \theta^* - \theta'$ we achieve:

$D_B^* = (\theta^* - \frac{\frac{\Delta_E(1+n\theta^*)}{2n} - (\frac{1}{n+1}\frac{\Delta_E(2n+1-n\theta^*)}{2n})}{\Delta_E})$. Through simplification we obtain $D_B^* = \frac{(2\theta(n+1)-(n\theta+1)(n+2)-2n)}{2(n+1)}$.

Therefore, we must check that either $Q_G^* > D_B^*$ or $Q_G^* - D_B^* > 0$, i.e. $\frac{(2n-n\theta^*+1)}{2n+2} - \frac{(2\theta(n+1)-(n\theta+1)(n+2)-2n)}{2(n+1} > 0$. The previous inequality simplifies to the following one: $3n - 2\theta^* - 2n\theta^* + 2n + n\theta^* + n^2\theta^* + 3 > 0$ or $n(2 + \theta^* + n\theta^*) + 3(1 + n) > 2\theta^*(1 + n)$. As $\theta^* < 1$ we can state that $3(1 + n) > 2\theta^*(1 + n)$ and even more so $n(2 + \theta^* + n\theta^*) + 3(1 + n) > 2\theta^*(1 + n)$, being $n(2 + \theta^* + n\theta^*) > 0$ QED.

Concerning the group of generics firms, now we have to verify if a second mover advantage exists for all of them, i.e. $\Pi_G^* > \Pi_B^*$

As $\Pi_G^* = P_G^{*n} Q_G^* = (\frac{1}{n+1}\frac{\Delta_E(2n+1-n\theta^*)}{2n})(\frac{1}{2n+2}(2n - n\theta^* + 1)) = \frac{\Delta_E(2n-n\theta^*+1)^2}{2n(2n+2)(n+1)}$,

and $\Pi_B^* = P_B^{*n} D_B^* = \frac{\Delta_E(n\theta^*+1)^2}{4(n^2+n)}$, therefore $\Pi_G^* > \Pi_B^*$ implies $\frac{\Delta_E(2n-n\theta^*+1)^2}{2n(2n+2)(n+1)} > \frac{\Delta_E(n\theta^*+1)^2}{4n(n+1)}$, an inequality depending both on n and θ^*. Actually it can easily be checked that the second mover advantage of generics producers decreases both in θ^* and n. After further simplifications of the previous inequality we obtain:

$\frac{(2n-n\theta^*+1)^2}{(n+1)} > (n\theta^*+1)^2$,or $(2n-n\theta^*+1)^2 > (n+1)(n\theta^*+1)^2$ that can be written as: $2n-\theta^* n+1 > \theta^* \sqrt[2]{(n+1)}n + \sqrt[2]{(n+1)}$ leading to this final version of the inequality:

$2n+1-\sqrt[2]{(n+1)} > n(\sqrt[2]{(n+1)}+1)\theta^*$ implying in turn $0 < \theta^* < \frac{2n+1-\sqrt[2]{(n+1)}}{n(\sqrt[2]{(n+1)}+1)}$ ∎

Proof. of Proposition VI

In order to determine if the GCP also holds with n new entrants, we can compare the monopolistic price P_M^* with the equilibrium price of the brand-name drug $P_B^{n^*}$. Because the GCP requires

$$P_b^{n^*} > P_M$$

the following inequality ought to be valid:

$$q_E > q_0\left(\frac{n(1+\underline{\theta})}{1+n\theta^*}+1\right)$$

Being $n(1+\underline{\theta}) > (1+n\theta^*)$, then $\frac{n(1+\underline{\theta})}{1+n\theta^*} > 1$, and $q_0\left(\frac{n(1+\underline{\theta})}{1+n\theta^*}+1\right) > q_0$. As according to $q_E > q_0\left(\frac{n(1+\underline{\theta})}{1+n\theta^*}+1\right)$ we derive that $q_E - q_0\left(\frac{n(1+\underline{\theta})}{1+n\theta^*}+1\right) > 0$, being $q_0\left(\frac{n(1+\underline{\theta})}{1+n\theta^*}+1\right) > q_0$, consequently $(q_E - q_0) > 0$, i.e $\Delta_E > 0$. Therefore, if the GCP implies $q_E > q_0\left(\frac{n(1+\underline{\theta})}{1+n\theta^*}+1\right)$ there has to be optimistic misperception $\Delta_E > 0$

∎

Appendix III

Proof. Proof of Proposition 7

By solving the sequential game with backward induction,at first, we have considered the profit function of the generics producer as:

$$\Pi_g = P_G D_G = P_G\left(1-\theta^*+\frac{\gamma(P_B-P_G)}{\Delta_E}\right)$$

Through profit maximization, we can find the reaction function of the generics firm in the second stage game determining the f.o.c.:

$$\frac{\partial \Pi_G}{\partial P_G} = 1 - \theta^* - \frac{\gamma(P_B - 2P_G)}{\Delta_E} = 0$$

And solving for P_G

$$P_G = \frac{\gamma P_B + \Delta_E(1 - \theta^*)}{2\gamma} \tag{31}$$

Then we can find the reaction function of the brand-name drug producer in the first stage game. The brand producer's profit is given by

$$\Pi_B = P_B D_B = P_B \left(\theta^* - \frac{\gamma(P_B - P_G)}{\Delta_E}\right) \tag{32}$$

To work out the solution of the sequential entry game we need to incorporate the reaction function of the generics firm into the expression of the brand producer's profit function

$$\Pi_B = P_B D_B = P_B \left(\theta^* - \gamma \left(\frac{P_B - \frac{\gamma P_B + \Delta_E(1-\theta^*)}{2\gamma}}{\Delta_E}\right)\right)$$

to get:

$$\Pi_B = P_B \left(\frac{2\theta^* \Delta_E - \gamma P_B + \Delta_E - \Delta_E \theta^*}{2\Delta_E}\right)$$

Then, by considering the f.o.c., we obtain

$$\frac{\partial \Pi_B}{\partial P_B} = \frac{2\theta^* \Delta_E - 2\gamma P_B + \Delta_E - \Delta_E \theta^*}{2\Delta_E} = 0$$

which can be solved in P_B to achieve the equilibrium price for the brand-name drug:

$$P_B^* = \frac{\Delta_E(1+\theta^*)}{2\gamma} \tag{33}$$

By substitution of P_B^* into equation *(31)* we can obtain the equilibrium price P_G^*

$$P_G^* = \frac{\Delta_E(3-\theta^*)}{4\gamma} \tag{34}$$

These results show that the introduction of co-payments increases both equilibrium prices proportionally to γ. However, the brand price augments more than the generics. It can be verified that $P_B^* > P_G^*$ if $\theta^* > \frac{1}{3}$ like in the duopolistic case without insurance.

In addition, we can also check for the existence of a second mover advantage in this case:

Let us find the equilibrium demand function for the brand-name drug: $D_B^* = (\theta^* - \frac{\gamma(\frac{\Delta_E(1+\theta^*)}{2\gamma} - \frac{\Delta_E(3-\theta^*)}{4\gamma})}{\Delta_E}) = \theta^* - \gamma(\frac{(1+\theta^*)}{2\gamma} - \frac{(3-\theta^*)}{4\gamma}) = \frac{1}{4}(\theta^*+1)$ noticing that it does not depend on the co-payment share, in order to determine the expression of equilibrium profits $\Pi_B^* = P_B^* D_B^* = \left(\frac{\Delta_E(1+\theta^*)}{2\gamma}\right)\left(\frac{1}{4}(1+\theta^*)\right) = \Delta_E(1+\theta^*)/8\gamma$. The profit of the brand-name drug producer also increases with γ. Then we shall consider the equilibrium demand function for the generic drug: $D_G^* = 1 - \theta^* + \frac{\gamma(\frac{\Delta_E(1+\theta^*)}{2\gamma} - \frac{\Delta_E(3-\theta^*)}{4\gamma})}{\Delta_E} = \frac{1}{4}(3-\theta^*)$, which is not affected by γ, either, and finally we can obtain equilibrium profits for the generic drug producer $\Pi_G^* = P_G^* D_G^* = \left(\frac{\Delta_E(3-\theta^*)}{4\gamma}\right)\frac{1}{4}(3-\theta^*) = \left(\frac{\Delta_E(3-\theta^*)^2}{16\gamma}\right)$. Once we have checked for the existence of a second mover advantage : $\Pi_G^* > \Pi_B^*$ we can easily observe that the inequality is independent from γ, and, therefore, profits comparison and our final conclusion are identical to the ones reported in the case of a duopoly without insurance. ■

Proof. of Proposition 8

With n generics producers and consumers' co-payment we can determine the following generics demand function

$$Q_G = (\bar{\theta} - \theta^* + \theta' - \underline{\theta}) = \left(1 - \theta^* + \frac{\gamma(P_b^n - P_g^n)}{\Delta_E}\right)$$

$$Q_G = \left(\bar{\theta} - \theta^* + \theta' - \underline{\theta}\right) = \left(1 - \theta^* + \frac{\gamma P_b^n}{\Delta_E} - \frac{\gamma P_g^n}{\Delta_E}\right)$$

solving for P_g^n , we acquire the inverse demand function:

$$P_G^n = \frac{(1 - \theta^* - Q_g)\Delta_E}{\gamma} + P_B^n \tag{35}$$

Assuming symmetry among generics producers $Q_G = q_i + \sum_{j \neq i}^{n} q_j$, we obtain the following expression for the price of generics with n generics entrants

$$P_G^n = \frac{(1 - \theta^*)\,\Delta_E - q_i\Delta_E - \sum_{j \neq i}^{n} q_j\Delta_E}{\gamma} + P_B^n$$

as well as the profit function for the generics producer i

$$\Pi_{iG} = P_G^n q_i = (\frac{(1 - \theta^*)\,\Delta_E - q_i\Delta_E - \sum_{j \neq i}^{n} q_j\Delta_E}{\gamma} + P_b^n)q_{ig} \tag{36}$$

now we can find the optimal q_i and Q_G

$$\frac{\partial \Pi_{iG}}{\partial q_i} = \frac{(1 - \theta^*)\Delta_E - 2q_i\Delta_E - \sum_{j \neq i}^{n} q_j\Delta_E}{\gamma} + P_b^n$$

by applying the symmetry $q_i = q_j$

$$\frac{\partial \Pi_g}{\partial q_i} = \frac{(1 - \theta^*)\,\Delta_E - 2q_i\Delta_E - (n-1)q_i\Delta_E}{\gamma} + P_b^n = 0$$

solving it for q_i , we get the optimal output for a generics producer:

$$q_i^* = \frac{(1 - \theta^*)\Delta_E + \gamma P_B^n}{\Delta_E(1+n)} \tag{37}$$

and for the generics producers considered as a whole:

$$Q_G = nq_i^* = \frac{n}{(1+n)}\frac{(1 - \theta^*)\Delta_E + \gamma P_B^n}{\Delta_E} \tag{38}$$

Through substitution of equation 31 in equation 28 we can compute:

$$P_G^n = \frac{1}{(1+n)\gamma}\left[(1-\theta^*)\Delta_E + \gamma P_B^n\right] \tag{39}$$

And now we can determine the equilibrium prices:

$$\Pi_B^n = P_B^n \left(\theta^* - \frac{\gamma(P_B^n - P_G^n)}{\Delta_E}\right) \tag{40}$$

Substituting P_G^n in *equation 40* we get:

$$\Pi_B^n = P_b^n \frac{\Delta_E(1+n\theta^*) - \gamma P_b^n n}{(n+1)\Delta_E}$$

And considering the f.o.c.:

$$\frac{\partial \Pi_b}{\partial P_B^n} = \frac{(1+n\theta^*)\,\Delta_E - 2n\gamma P_B^n P_B}{(n+1)\Delta_E} = 0$$

solving it for P_B, we can achieve the equilibrium price of the brand-name drug:

$$P_B^{n*} = \frac{\Delta_E(1+n\theta^*)}{2\gamma n} \tag{41}$$

Through substitution of equation 41 in equation 39 the generics equilibrium price is

$$P_G^{n*} = \frac{1}{\gamma(n+1)} \frac{\Delta_E(2n+1-n\theta^*)}{2n} \tag{42}$$

It can be proven that the equilibrium prices become those found in the previous duopoly analysis if $n = 1$. Furthermore, we shall show that both equilibrium prices decrease with an increase in the number of new entrants:

$$\frac{\partial P_B^{n*}}{\partial n} = -\frac{\Delta_E}{2n^2} < 0 \tag{43}$$

$$\frac{\partial P_G^{n*}}{\partial n}=\frac{\Delta_E\left[\left(\theta^*-2\right)n^2-2n-1\right]}{2n^2(n+1)^2}<0\,\text{as}\,\theta^*\leq 2 \tag{44}$$

As in the case without third-party insurance, we can point out that P_G^{n*} decreases more than P_B^{n*}, with a growing number of generics entrants:

Because $\Delta_E\left[\left(\theta^*-2\right)n^2-2n-1\right]/2n^2(n+1)^2<-\frac{\Delta_E}{2n^2}$ reduces to $\frac{\left[(\theta^*-2)n^2-2n-1\right]}{(n+1)^2}>-1$, we can apply further simplifications of the LHS ratio to get:

$2n+1-\left(\theta^*-2\right)n^2<+n^2+2n+1$, and as $\left(\theta^*-2\right)n^2<0$, the previous inequality holds confirming that P_G^{n*} decreases more than P_B^{n*} with an expansion of n.

Also in this case we can show that $P_B^{n*}>P_G^{n*}$

$\frac{\Delta_E(1+n\theta^*)}{2\gamma n}>\frac{1}{\gamma(n+1)}\frac{\Delta_E(2n+1-n\theta^*)}{2n}$

which after a few simplifications shortens to: $\frac{(1+n\theta^*)}{\gamma}>\frac{(2n+1-n\theta^*)}{\gamma(n+1)}$

as $(1+n\theta^*)>(2n+1-n\theta^*)$ and $\gamma<\gamma(n+1)$, then $P_B^{n*}>P_G^{n*}$ always holds

Moreover, considering $\frac{(1+n\theta^*)}{\gamma}-\frac{(2n+1-n\theta^*)}{\gamma(n+1)}=n\frac{2\theta^*+n\theta^*-1}{\gamma(n+1)}>0$ we can check the variation of the difference in equilibrium prices with a change in the main parameters of the model

$\frac{d(n\frac{2\theta^*+n\theta^*-1}{\gamma(n+1)})}{d\gamma}=-\frac{n}{\gamma^2(n+1)}\left(2\theta^*+n\theta^*-1\right)<0$ as $\left(\theta^*(n+2)-1\right)>0$ and

$\frac{d(n\frac{2\theta^*+n\theta^*-1}{\gamma(n+1)})}{dn}=\frac{1}{\gamma(n+1)^2}\left(\theta^*n^2+2\theta^*n+2\theta^*-1\right)>0,$

$\frac{d(n\frac{2\theta^*+n\theta^*-1}{\gamma(n+1)})}{d\theta^*}=\frac{n}{\gamma(n+1)}\left(n+2\right)>0$

showing that $\left(P_b^{n*}-P_g^{n*}\right)$ decreases with the growth of consumers' co-payments and expands with an increase of generics entrants, or with the reduction of the IC share.

Now we have to verify the existence of a second mover advantage for the group of generics producers.

Through substitution of P_b^{n*} into the total generics demand Q_G we can find its equilibrium value:

$Q_G = \frac{n}{(1+n)} \frac{(1-\theta^*)\Delta_E + \gamma P_b^n}{\Delta_E} = \frac{n}{(1+n)} \frac{(1-\theta^*)\Delta_E + \gamma \frac{\Delta_E(1+n\theta^*)}{2\gamma n}}{\Delta_E}$

becoming $Q_G^* = \frac{1}{2n+2}(2n - n\theta + 1)$ after further simplification,

in order to detect the equilibrium value of profits for n generics producers:

$$\Pi_G^{n*} = P_G^{n*} Q^* = \frac{1}{\gamma(n+1)} \frac{\Delta_E(2n+1-n\theta^*)}{2n} \left(\frac{(2n - n\theta^* + 1)}{2n+2} \right) = \frac{1}{2n} \frac{\Delta_E (2n - n\theta^* + 1)^2}{\gamma (2n+2)(n+1)} = \frac{1}{2n} \frac{\Delta_E (2n - n\theta^* + 1)^2}{\gamma (2n+2)(n+1)}$$

The optimal profit for the brand producer is established by substitution of P_B^{n*} into the following expression:

$$\Pi_B^{n*} = P_B^n \frac{\Delta_E(1+n\theta^*) - \gamma P_b^n n}{(n+1)\Delta_E} = \frac{\Delta_E(1+n\theta^*))}{2\gamma n} \frac{\Delta_E(1+n\theta) - \gamma \frac{\Delta_E(1+n\theta^*)}{2\gamma n} n}{(n+1)\Delta_E} = \frac{1}{4n} \frac{\Delta_E}{\gamma} \frac{(n\theta^*+1)^2}{n+1}$$

Therefore, we have to check which conditions can determine the existence of a second mover advantage: $\Pi_G^{n*} > \Pi_b^{n*}$

$\frac{1}{2n} \frac{\Delta_E (2n - n\theta^* + 1)^2}{\gamma(2n+2)(n+1)} > \frac{1}{4n} \frac{\Delta_E}{\gamma} \frac{(n\theta^*+1)^2}{n+1}$

Once simplified for γ, the inequality is the same one we obtained to check for a second mover advantage in the oligopolistic case without insurance. Therefore, the final result is identical: $0 < \theta^* < \frac{2n+1-\sqrt[2]{(n+1)}}{n(\sqrt[2]{(n+1)}+1)}$.

Concerning the existence of the GCP in this case, as usual we need to compare P_M^* and P_B^{n*}. By considering $P_B^{n*} > P_M^*$ the inequality reduces to:

$$q_E > q_0 \left(\frac{n + n\underline{\theta}}{1 + n\theta^*} + 1 \right)$$

Here, too, this inequality is the same as the one that we found in the case of an oligopoly with n generics entrants without insurance (See the Proof for Proposition VI). Therefore, the analogous conclusion is: the GCP holds if $\Delta_E > 0$. ■

Appendix IV

In what follows, we shall determine the SNPE for a duopoly case with medical support to brand-name drugs. Solving the two-stage game by backward induction we are going to consider the profit function for a generics seller in the second stage:

$$\Pi_G^m = P_G^m D_G^m = P_G^m (1-\alpha)(1-\theta^* + \frac{P_B^m - P_G^m}{\Delta_E}) \tag{45}$$

By computing the f.o.c. we obtain

$$\frac{\delta \Pi_G^m}{\delta P_G^m} = (1-\alpha)\left(1-\theta^*\right) + (1-\alpha)\frac{\left(P_B^m - 2P_G^m\right)}{\Delta} = 0$$

and calculating th result for P_G^m we can define the best reply function for the generics seller:

$$P_G^m = \frac{P_B^m + \Delta_E(1-\theta^*)}{2} \tag{46}$$

It can easily be checked that the reaction function in equation 46 is the same as in equation 17. This result is due to the fact that we have just rescaled the demand by a constant $(1-\alpha)$ in this case.

Turning to the first stage game, let us consider the profit function for a brand-name drug:

$$\Pi_B^m = P_B^m D_B^m = P_B \left(\left(\theta^* - \frac{P_B^m - P_G^m}{\Delta_E} \right) + \alpha \left(1 - \theta^* + \frac{P_B^m - P_G^m}{\Delta_E} \right) \right) \tag{47}$$

To solve the sequential entry game we need to incorporate the optimum response of the generics firm into the brand producer's profit function

$$\Pi_B^m = P_B^m D_B^m = P_B^m \left(\left(\theta^* - \frac{P_B^m - \frac{P_B^m + \Delta_E(1-\theta^*)}{2}}{\Delta_E} \right) + \alpha \left(1 - \theta^* + \frac{P_B^m - \frac{P_B^m + \Delta_E(1-\theta^*)}{2}}{\Delta_E} \right) \right)$$

$$\Pi_B^m = P_B^m\left(\left(\frac{2\theta^*\Delta_E - P_B^m + \Delta_E - \Delta_E\theta^*}{2\Delta_E}\right) + \alpha\left(\frac{2\Delta_E - 2\Delta_E\theta^* + P_B - \Delta_E + \Delta_E\theta^*}{2\Delta_E}\right)\right)$$

Through the f.o.c. we can compute the optimum response for the brand producer:

$$\frac{\partial \Pi_B^m}{\partial P_B^m} = \frac{2\theta^*\Delta_E - 2P_B^m + \Delta_E - \Delta_E\theta^*}{2\Delta_E} + \alpha\left(\frac{\Delta_E - \Delta_E\theta^* + 2P_B^m}{2\Delta_E}\right)$$

The result for P_B becomes

$$P_B^{m*} = \frac{\Delta_E(1+\theta^*+\alpha(1-\theta^*))}{2(1-\alpha)} \tag{48}$$

and substituting equation 48 in equation 46 we obtain P_g^*

$$P_G^{m*} = \frac{\Delta_E(3-\theta^*-\alpha(1-\theta^*))}{4(1-\alpha)} \tag{49}$$

It can easily be shown that $P_B^{m*} > P_G^{m*}$ only if $\theta^* > \frac{1-\alpha 3}{3-\alpha 3}$ when $\alpha = 0$, we can recall the case without medical misperception. Moreover $\frac{\partial\theta^*}{\partial\alpha} < 0$ which implies that an increase of α requires growth of the IC share $(1-\theta^*)$

Through the substitution of equilibrium prices into demand functions, the values of generic and brand-name drug demand at equilibrium can be determined

$$D_G^{m*} = (1-\alpha)\left(1-\theta^* + \frac{P_b^* - P_g^*}{\Delta_E}\right) = \frac{3-\theta^*-\alpha(1-\theta^*)}{4} \tag{50}$$

$$D_B^{m*} = \left(\theta^* - \frac{P_b^* - P_g^*}{\Delta_E}\right) + \alpha\left(1-\theta^* + \frac{P_b - P_g}{\Delta_E}\right) = \frac{1+\theta^*+\alpha(1-\theta^*)}{4} \tag{51}$$

In addition, by checking if $D_B^{m*} < D_G^{m*}$ we obtain that $\alpha < 1$ and $\theta^* < 1$.

Now we shall compare the SPNE with medical misperception to the one we obtained in the duopoly with pure price competition, but without medical misperception.

First we can evaluate the comparison between equilibrium demands to show that the demand for the originator is higher than in the pure price competition case, as expected when it is supported by medical misperception, while the generics demand is lower. Starting from the demand for brand-name drugs we must check that $D_B^{*m} > D_B^*$, i.e.:

$$\frac{1 + \theta^* + \alpha(1 - \theta^*)}{4} > \frac{1 + \theta^*}{4} \tag{52}$$

which is always true given $0 \leq \alpha < 1$ and $\theta^* < 1$.

As for equilibrium generics demands we foresee that $D_G^{*m} < D_G^*$:

$$\frac{3 - \theta^* - \alpha(1 - \theta^*)}{3} < \frac{(3 - \theta^*)}{4} \tag{53}$$

which is also true with the same assumptions about α and θ^* specified above.

Furthermore, equilibrium prices in the case of medical misperception can be compared to the ones with pure price competition (and only consumers' misperception) . As for the price of a brand-name drug we must check for $P_B^{*m} > P_B^*$:

$$\frac{\Delta_E(1 + \theta^* + \alpha(1 - \theta^*))}{2(1 - \alpha)} > \frac{\Delta_E(1 + \theta^*)}{2} \tag{54}$$

always true given $0 \leq \alpha < 1$ and $\theta^* < 1$. ISimilarly we could verify if the equilibrium generics price with medical misperception is lower than this same price with pure price competition and misperception only on the part of consumers, i.e $P_G^{*m} < P_G^*$ implying:

$$\frac{\Delta_E(3 - \theta^* - \alpha(1 - \theta^*))}{4(1 - \alpha)} < \frac{\Delta_E(3 - \theta^*)}{4} \tag{55}$$

which is also true on the basis of the same assumptions about α and θ^* specified above.

Therefore, independently of the IC share, the generics firm has to charge lower equilibrium prices when the brand-name drug is supported by medical misperception with respect to the pure price competition case.. Now we shall compare equilibrium profits to detect the existence of a first mover advantage.

We are going to compute equilibrium profits $\Pi_B^{*m}$and Π_G^{*m}:

$$\Pi_G^{*m} = P_G^{*m} D_G^{*m} = \frac{\Delta_E \left(3 - \theta^* - \alpha(1-\theta^*)\right)^2}{16(1-\alpha)} \tag{56}$$

$$\Pi_B^{*m} = P_B^{*m} D_B^{*m} = \frac{\Delta_E \left(1 + \theta^* + \alpha(1-\theta^*)\right)^2}{8(1-\alpha)} \tag{57}$$

We can also check if $\Pi_B^{*m} > \Pi_G^{*m}$ or : $\Pi_B^{*m} - \Pi_G^{*m} > 0$, After a few simplifications the outcome is: After a few simplifications the outcome is:

$$\alpha > \frac{3 - \sqrt{2} - \theta^*(\sqrt{2}+1)}{(1-\theta^*)(\sqrt{2}+1)} \tag{58}$$

In picture 5 we can observe that for very high values of α we find a first mover advantage even when all consumers are informed ($\theta^* = 0$). When α reduces obtaining a first mover advantage requires a high θ^* i. e. a minority of IC

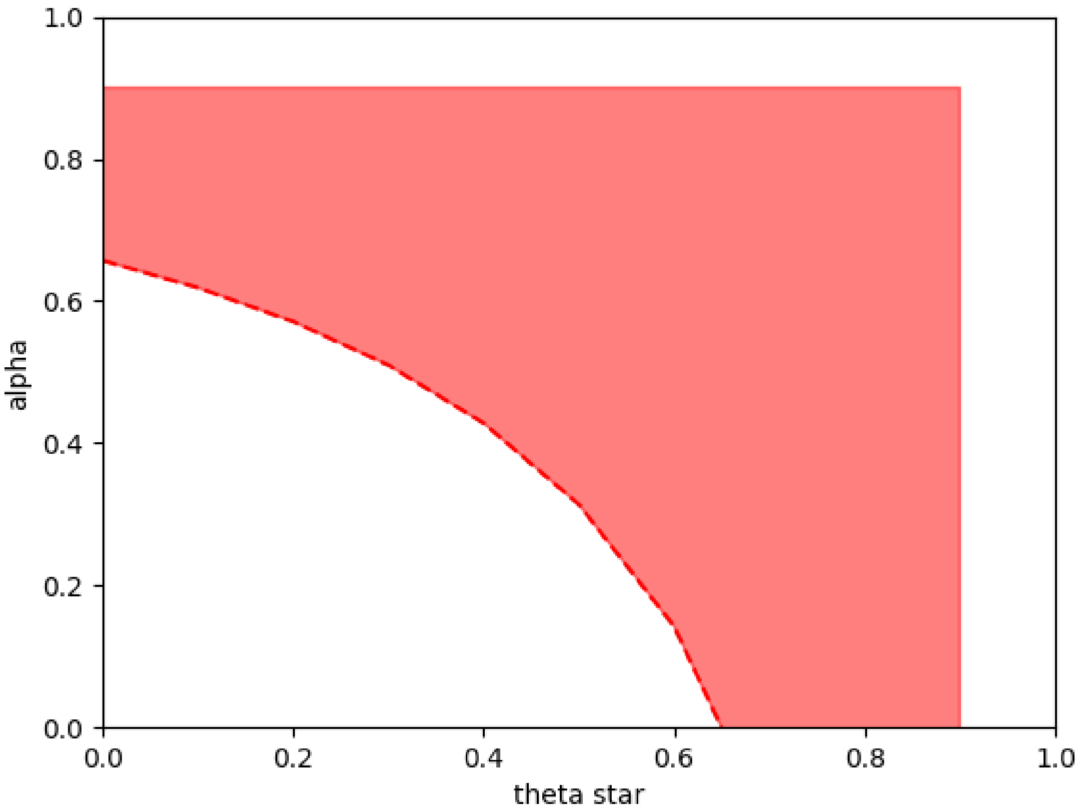

Figure 5: In red the area for values of α and θ^* which the inequality holds

Appendix V

We can extend the assumption regarding physicians and pharmacists' misperception to the case of n generics producers' entry.

To compute the SNPE we shall define the profit functions:

$$\Pi_G^{mn} = P_G^{mn} D_G^{mn} = P_G(1-\alpha)\left(1-\theta^* + \frac{P_B^{mn} - P_G^{mn}}{\Delta_E}\right) \tag{59}$$

$$\Pi_B^{mn} = P_B^{mn} D_B^{mn} = P_B^{mn}\left[\left(\theta^* - \frac{P_B^{mn} - P_G^{mn}}{\Delta_E}\right) + \alpha\left(1-\theta^* + \frac{P_B^{mn} - P_G^{mn}}{\Delta_E}\right)\right] \tag{60}$$

And then, by backword induction, the equilibrium prices P_B^{mn}, P_G^{mn} follow

$$P_B^{mn*} = \frac{\Delta_E(1 + n\theta^* + \alpha(n - \theta^*))}{2n(1-\alpha)} \tag{61}$$

$$P_G^{mn*} = \frac{1}{n+1}\frac{\Delta_E(2n + 1 - n\theta^* - \alpha(n - \theta^*))}{2n(1-\alpha)} \tag{62}$$

It can be noticed that $P_B^{mn*} > P_G^{mn*}$ only if $\theta^* > \frac{1-\alpha(2+n)}{2+n-\alpha(2/n+1)}$. $n = 1$ corresponds to the duopoly case, and with $\alpha = 0$ to the case without medical misperception. As $\frac{\partial\theta^*}{\partial\alpha} < 0$ for $n > 0$, once again we have found that with higher values of α , θ^* reduces, so that the inequality holds with a higher IC share $(1 - \theta^*)$

solving for q_i with optimal P_B^{mn*}

$$q_i^* = \frac{(1-\theta^*)\Delta_E + P_B^{mn}}{\Delta_E(1+n)} = \frac{2n + 1 - n\theta^* - \alpha(1 - \theta^*))}{2(n+1)n} \tag{63}$$

and $Q^* = nq_i^* = D_G^{mn*}$

$$D_G^{mn*} = nq_i = \frac{2n + 1 - n\theta^* - \alpha(1-\theta^*)}{2(n+1)} \tag{64}$$

$$D_B^{mn*} = \left(\theta^* - \frac{P_B^{mn*} - P_G^{mn*}}{\Delta_E}\right) = \frac{1 + n\theta^* + \alpha(1-\theta^*)}{2(n+1)} \tag{65}$$

Therefore, optimal profits for all the generics producers are given by:

$$\Pi_G^{mn*} = P_G^{mn*} D_{iG}^{mn*} = \frac{\Delta_E\left(2n + 1 - n\theta^* - \alpha(1-\theta^*)\right)^2}{n\left[2n\left(n+1\right)\right]^2} \tag{66}$$

The aggregate profit for all the generics producers is:

$$n\Pi_G^{mn*} = P_G^{mn*} D_G^{mn*} = \frac{\Delta_E\left(2n + 1 - n\theta^* - \alpha(1-\theta^*)\right)^2}{\left[2n\left(n+1\right)\right]^2} \tag{67}$$

The profit function for a brand product is:

$$\Pi_B^{mn*} = P_B^{mn*} D_B^{mn*} = \frac{\Delta_E \left(1 + n\theta^* + \alpha(1-\theta^*)\right)^2}{4n\left(n+1\right)} \tag{68}$$

We shall now consider a few simulations to see if a first move advantage exists: $\Pi_B^{mn*} > n\Pi_G^{mn*}$

Table 2: θ^* value for different n if $\alpha = 0.1$

n	θ^*	θ^* Value
1	$\theta^* > \frac{1}{9}(40\sqrt{2} - 51)$	0.618727
2	$\theta^* > \frac{1}{19}(12\sqrt{6} - 23)$	0.33652
3	$\theta^* > \frac{1}{319}(160\sqrt{3} - 201)$	0.238646
4	$\theta^* > \frac{1}{741}(200\sqrt{5} - 309)$	0.186523
10	$\theta^* > \frac{1}{981}(20\sqrt{110} - 129)$	0.082326

Table 3: θ^* value for different n if $\alpha = 0.5$

n	θ^*	θ^* Value
1	$\theta^* > (8\sqrt{2} - 11)$	0.31178
2	$\theta^* > \frac{1}{5}(4\sqrt{6} - 9)$	0.159592
3	$\theta^* > \frac{1}{55}(32\sqrt{3} - 49)$	0.11683
4	$\theta^* > \frac{1}{133}(40\sqrt{5} - 77)$	0.093554
10	$\theta^* > \frac{44}{2071}(44\sqrt{110} - 371)$	0.043687

In tables 2 and 3 we have reported the values of θ^* leading to a first mover advantage given the number of generics producers. In table. In table 2 we use a value of $\alpha = 0.1$ and in table 3 a value of $\alpha = 0.5$ .By comparing the results, it is clear that for a higher value of α a first mover advantage can be observed for a lower share of uninformed consumers.

Table 4: profit values for different values of α when $\theta^* = 0.5$ and $n = 1$

α	Π_b^{n*}	$n\Pi_g^{n*}$
0	0.28125	0.39062
0.1	0.3003	0.3751
0.2	0.0.32	0.36
0.3	0.3403	0.3451
0.5	0.3828	0.3164

Table 5: profit value for different values of α when $\theta^* = 0.5$ and $n = 4$

α	Π_b^{n*}	$n\Pi_g^{n*}$
0	0.1125	0.03
0.1	0.1162	0.03
0.2	0.1201	$0.s$
0.3	0.1240	0.0293
0.5	0.1320	0.0284

In tables 4 and 5 the profit values for a given θ^* and a given n are accounted for. When $\alpha = 0$ we can evaluate the "standard case" without medical misperception; when α grows, we observe an increase in brand producers' profits, and a reduction of the generics producers'. In Table 5 we can see that for values of αlower than 0.3, a second mover advantage still exists. However, when α is higher than 0.3, a first mover advantage appears.