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Alberto Cavaliere

alberto.cavaliere@unipv.it

University of Pavia

Giovanni Crea

Università Cattolica del Sacro Cuore

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Demand for Off-Patent Drugs and Sequential Price Competition with Heterogeneous Consumers: A Reappraisal of the Generic Competition Paradox

A. Cavaliere* G. Crea†

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Abstract

Considering the heterogeneity in generic uptake across Europe, and based on existing evidence, we specify the demand for off-patent drugs from the theoretical point of view, independently of health insurance. We analyze equilibria resulting from sequential price competition with misperceived vertical differentiation by uninformed consumers and reconsider the Generics Competition Paradox also in markets for non reimbursable prescription drugs. In equilibrium, the brand price is persistently higher than that of generics. However, it reduces with the number of generics entrants. We also consider dynamic efficiency by checking whether either a second-mover advantage or a first-mover advantage arises in equilibrium. We further account for GPs' prescriptions behavior, In this last case, a first-mover advantage always arises in an oligopoly.

Key words: Brand Premium, Generic Drugs, Information Disparity, Optimistic Misperception, Dominant Firm Model

JEL Codes: L15, L13, D82

*Corresponding author. Università di Pavia alberto.cavaliere@unipv.it, Tel +39 0382986477, via S. Felice,5, 27100 Pavia, ITALY

†Department of Economics and Finance, Università Cattolica del Sacro Cuore, giovanni.crea@unicatt.it, Milano, ITALY

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1 Introduction

Generics diffusion remains heterogeneous across European countries in 2021 (OECD, 2023). Considering the percentage of generic consumption in volume across Europe, the leading countries were the UK (80 %), Germany (83 %), and the Netherlands (79 %), followed by Denmark (67%). Norway (53%), Portugal (50%) Ireland (43%), and Spain (45%). Countries with the lowest percentages include Greece (31%) and Italy (27%). Kanavos (2014) conducts a detailed analysis of generic penetration in these countries to examine the effects of public policies. In the final year of his study (2010), the generic share ranking was the same as that shown above for 2021. By considering the generic share, in the period 2003-2021, we can notice that in the last few years, the annual rate of growth has slowed down significantly in all Countries (from a two-digit to a low single-digit figure), so that the generic share has started to plateau at the above percentages. Therefore, there seems to be structural limits to further expansion of generics demand, both in Countries with high generic consumption and in Countries with low generic penetration. Conversely, in 2021, generic prescriptions accounted for 92.1% in the US[1] .

Many Governments across the Europe have implemented demand-side policies, including the request for INN (International Non-Proprietary Name) prescribing and substitution at the pharmacy. As Wouters et al. (2017) point out, although both procedures are mandatory in Italy, Switzerland, Spain, Greece, and the Netherlands, the demand for generics remains heterogeneous among these countries. Let us note that even if INN prescribing is mandatory and embedded in the digital software used by physicians, GPs can still sustain brand-name drugs by simply instructing outpatients to ask pharmacists to dispense them. In some cases substitution at the pharmacy only implies that the pharmacist informs the outpatient about the possibility of choosing a less expensive generic. Therefore, the enforcement of both INN prescribing and substitution at the pharmacy depends on whether physicians or patients can overrule generic substitution. Physicians report cases where outpatients opposed generic prescriptions. Therefore, we argue that public policies are insufficient to explain the heterogeneous generic share in European markets for off-patent drugs. There is a widespread consensus that competition matters more than regulation in terms of generic share growth. However demand specification is an essential premise to analyze competition between generics and brand-name drugs.

[1]See https://www.statista.com/statistics/205042/proportion-of-brand-to-generic-prescriptions-dispensed/. 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 (Shepherd, 2019)

From the theoretical point of view Kong (2009), with reference to the US market, assumes that generic demand depends on private insurance coverage. In the market there are two types of consumers, type I consumers have better insurance coverage than type II consumers. Generic demand results from type I and type II consumers while demand for brand name drugs results only from type I consumers. Bronnemberg et al. (2015), who, in their empirical study concerning the US market, consider the demand for over-the-counter drugs. Although, according to them, their model could be easily extended to prescription drugs. They show that generic demand is correlated with higher income and higher education. Consumers with lower income and lower education misperceive generic therapeutic effectiveness and therefore demand brand name drugs. Such a result is also consistent with evidence reported in medical journals, focusing on outpatients misperception, as one of the main obstacles to the growth of generics demand[2]. Cross-country reviews (Alrasheedy et al., op. cit.) indicate that the share of consumers with biased preferences and brand loyalty is particularly high among low-income and poorly educated individuals, as found also by Gaither et al. (2001) and Hassali et al. (2009). According to the previous evidence, one of the drivers of generics demand should be the share of consumers with higher income and superior education. On the contrary, focusing solely on the low price of generics, conventional wisdom might attribute demand for generics to lower-income consumers.

In the vast majority of cases, therapeutic equivalence between generics and originators should be assumed from a scientific point of view[3]. However, the evidence reported above demonstrates that perceived quality differences affect consumers demand. Actually, perceived vertical differentiation has now become a standard assumption in pharmaceutical economics especially in the economic literature dealing with reference pricing[4]. However reference pricing concerns off-patent drugs reimbursed by public healthcare systems (life-saving drugs). Many off-patent drugs are paid out-of-pocket at the pharmacy, although their prices are negotiated upstream between public health

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

[3]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). Recently, quality issues have been raised in the US for generics manufactured in developing countries, within local production units lacking internal quality control and sufficient inspections by the FDA. However, also some brand name drugs are produced by multinationals in developing Countries, even if most of them are made in the home country. Furthermore, as for physicians and out-patients it is impossible to discriminate between drugs, according to their origin, in the US, beyond the FDA, there are intermediaries at the wholesale level exerting their own informed control, in order to exclude medications that are not reliable (Ishitani, 2025). Similar controls exist across the EU.

[4]A few examples are Miraldo (2009), Brekke, Holmas and Straume (2011), Brekke, Canta and Straume (2016), Gonçalves and Rodrigues (2018), and more recently also Geng and Saggi (2020), which consider perceived vertical differentiation as a first step of their analysis, but this strand of literature extend to many other contributions.

agencies and pharmaceutical companies. Our analysis firstly considers this type of drug and then is extended to drugs reimbursed through third party insurance.

Beyond assuming perceived vertical differentiation, we build on the empirical results presented earlier, specifying that biased preferences for brand-name drugs are more prevalent among consumers with lower incomes and less education, while informed consumers with higher incomes and higher education tend to choose generics. Due to our further assumptions, the demand specification that we derive is different compared to standard vertical differentiation models, as we find that demand for generics (perceived as lower quality products) depends on higher income and higher education consumers, beyond consumers with lowest income, who would prefer brands but cannot afford them. Demand for brand name drugs result from consumer affected by quality misperception, but disposing of higher income compared to the poorest ones.

We have focused on multi-dimensional consumer heterogeneity, distinguishing outpatients not only according to their willingness to pay for quality, but also based on their information about therapeutic equivalence between generics and brand-name drugs. As assumed by Bronnemberg et al. (op.cit,) informed consumers (IC from now on) are those able to name the active principle contained in the drug and to understand what bio-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. Furthermore, UC with biased beliefs and IC are not randomly distributed among consumers. As education levels are strongly correlated with income, information disparities are indirectly connected with it through the distribution of the willingness to pay for quality. The shares of UC and IC are exogenous and separated by a cut-off value of the willingness to pay. We do not impose any restrictions ex ante concerning the IC and UC shares. Markets with different income distributions and varying levels of education tend to be characterized by different extensions of the UC and IC shares and, consequently, a different cut-off value. Restrictions on the latter arise ex-post, either when we specify the demand functions or at the price equilibrium.

A further contribution of ours concerns the effects of choosing a sequential model of price competition, similar with Kong (2009), as brand-name drugs are in the market before generics and can anticipate generic entry after patent expiry. The economic literature has highlighted that originators often increase their prices to account for the demand-stealing effect due to the entry of generics. Common wisdom frequently identifies this result with the well-known Generics Competition Paradox (GCP), firstly highlighted by Sherer (1993). However, we consider that result as a "soft" version of the GCP. At present there is a wider consensus about the "soft" version of the GCP, especially after the contribution of Kong (2009) which has definitely explained it, but only for an healthcare system based on private insurance, like the US. According to the "hard" version of the GCP, not

only does the brand price increase and remain higher after the first generic entries, but there is also a continuous increase in the price of brand-name drugs even after the entry of many generic firms. Most importantly, according to this "hard" version of the GCP, the brand price never decreases, implying there is no competition between generics and brand-name drugs. Controversy has arisen in the economic literature about the "hard" version of the GCP, as we show in next section. However, the "hard version" is not confirmed by the last empirical analysis concerning both the US and some European Countries, as we recall in our literature review.

From the theoretical point of view, and to the best of our knowledge, contributions explaining definitely the soft version of the GCP outside healthcare systems based on private insurance, are lacking. General theoretical contribution contradicting the "hard version" are not available yet, with the exception of the analysis of Brekke, Canta and Straume (2016) devoted to reimbursed drugs through Reference pricing. However, within public healthcare system, we find a lot of off-patents drugs, whose prices are controlled but non reimbursed by third party insurance. That's pretty the case that we deal with in our general model, which is subsequently extended to the case of reimbursed drugs.

We first consider a model with a duopoly, as this allows us to highlight our results, both from an intuitive perspective and in terms of our analysis. In the sub-game perfect Nash equilibrium (SPNE from now on), the brand producer expects the generic rival to benefit from being the second mover, lowering its price below that of the brand-name drug, to drive enough demand towards generics. 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 a brand premium, because of quality misperception [5] Furthermore, the producer of a brand-name drug can credibly commit to a higher price, due to fixed brand prices, resulting from Health Authority negotiations with the pharmaceutical firms and the effects of Resale Price Maintenance. Although we do not model explicitly the bargaining stage. Generics demand in the second-stage game is driven by both the IC share and the subset of UC with the lowest willingness to pay. The poorest consumers included in the UC share would prefer brand-name drugs, but as they cannot afford them, they buy generics. The IC share includes consumers who consider brand-name drugs and generics as perfect substitutes. Therefore, a positive demand by IC would just depend on price undercutting by the generic firm. However, the generic price should

[5]Grabosky et al (2014), for the US, show empirical evidence about the magnitude of market share erosion (in units) for brands one year after first generic entry. With reference to generic entry in 2011–2012, brands retained an average of only 16% of units at 1 year. This was a dramatic market share reduction, when considering that drugs experiencing first generic entry in 1999–2000 maintained a share of 44% of units at one year following first generic entry.

drop even more and enough to also capture UC with the lowest willingness to pay, who cannot afford brand name drugs. Therefore, the price difference between brand-name and generic drugs turn out to be substantial in our model, even with just one generic entrant, precisely as we observe in fundamental markets.

With multiple generic entrants, we consider a dominant firm model with a competitive fringe of generic entrants competing à la Cournot (as Kong does with a different demand specification for off-patent drugs). According to the dominant firm model, the demand of the brand producer is the total market demand net of the generic firms supply. Therefore we can account for Stackelberg type behavior by the producer of the brand-name drug. In the first-stage game, the brand producer maximizes profits by exploiting the UC demand from brand-loyal purchasers with biased beliefs. Thereby setting the brand price, anticipating the demand stolen by the supply of generic entrants. In the second-stage game, the generic entrants play Cournot competition for the residual demand due to IC and the UC share with the lowest willingness to pay. The generic price will be the Cournot equilibrium price, which decreases continuously with the entry of additional generic firms, as observed in market reality.

According to our results, the brand price remains persistently higher than the generic one (i.e. the soft version of the GCP holds), but it also decreases with generic entry into the market. As the brand list price is fixed and it takes time to change it, the brand producer can reduce the net price through discount and rebates in the supply chain. Actually, we find an inverse relationship between the brand price and the number of generic entrants, demonstrating not only intense competition among generics but also rivalry between generics and the brand-name drug. Such a result is at odds with the "hard" version of GCP, as the latter implies a positive relationship between the brand price and the number of generic entrants.

As we analyze a sequential model with strategic complements, we could potentially observe a second mover advantage. Indeed, according to Gal-Or (1985), symmetric duopoly models of sequential price competition with horizontal product differentiation, where reaction functions are strategic complements, suggest the existence of a second-mover advantage. These results have been extended to vertical differentiation by Li (2014). However, our model is asymmetric from the demand point of view and applies to the oligopoly case as well. Consequently, we cannot take for granted a second-mover advantage, implying that we must check it by comparing equilibrium profits. The benefit of this approach is that we can also consider the trade-off between static and dynamic efficiency. Indeed, the entry of generic producers improves static efficiency by contributing to the reduction of average prices. Nevertheless, when leading to lower profits for brand-name firms, progressive generic entry implies a loss of dynamic efficiency, as the amount of R&D expenditure

risks to decrease, making drug innovation less likely. However, to explore the eventual existence of a second mover advantage, we compare the profit of a brand name drug with the whole industry profits of generic substitutes, under the assumption that R&D expenditure for the off-patent brand-name drug have been already recovered during the patent period.

A further version of our model accounts for GPs' prescribing behaviour. Some medical studies indicate that a significant proportion of General Practitioners (GPs) and pharmacists mistrust generics, which contributes to their limited diffusion. According to Dunne and Dunne's cross-country review (op. cit., 2015), although the majority of physicians have accepted the use of generics, many others have expressed a preference for brand-name drugs when required for their own use. Influence from the pharmaceutical industry, including the 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 and in 2016, growing confidence of physicians on generic medicines has been reported for that Country. Evidence related to other Countries does not support a similar progress[6]. Therefore an extension of our model to GP support of brand-name drug seems to be justifies by the previous evidence. In this last case, we need to consider that the share of GPs who sustain brand-name drugs further contains generic demand. In a model with strategic complements like ours, the share of GP supporting brand-name drugs drives an increase in the equilibrium price both for brands and generic producers. However, we show that producers of brand-name drugs always obtain higher profits than the generics producers considered as a whole (first mover advantage) when accounting for prescribing behavior in favor of brands.

In Section 2, we will review the economic literature; in Section 3, we will derive demand functions in a duopoly with perceived vertical differentiation. In Section 4, we will consider the duopoly price equilibrium of a sequential game with price competition and perceived vertical differentiation where out-patients pay drugs out-of-pockets. In Section 5, we conduct an equilibrium analysis for the case of multiple generic sellers' entry, deriving the conditions for the existence of a second-mover advantage. Section 6 examines medical misperception and the practice of prescribing brand-name drugs by a share of GPs, according to the agency theory of healthcare. Section 7 concludes.

[6]Colgan et al. (2015), covering the same time span, have not found similar results for other countries. 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). Interestingly, generics skepticism remained common among physicians whose source of information were pharmaceutical sales representatives

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[7]. Although a flow of new generics entered the U.S. market, price undercutting strategies by brands were not observed. Not only did relevant differences between the prices of branded drugs and generics persist, but some empirical studies[8] demonstrated that the originators' price was even increasing even after generics entry and continued to increase with the entry of additional generic producers. After Scherer (1993), this result is commonly known as the "Generics Competition Paradox" (GCP). Contrasting evidence about the GCP was found in regulated European markets by Kanavos et al. (2008), as well as by Vandoros and Kanavos (2013). The latter shows that after generic entry there is a one off increase in the price of the brand name drug. However, further generic penetration has no effect on the brand prices.

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. However they are the only ones who consider both the hospital and pharmacy market[9]. Similar results are reported in Wiggins and Maness (2004), though restricted to anti-infective medicines. Their contribution provided a sort of natural experiment, anticipating the future of generic medicines also in other therapeutic classes. Actually, in the antibiotics case, generic entry took place long before 1984, because of lower entry costs and the early introduction of INN prescribing in the US. At the time of their research, spanning from 1984 to 1990, the authors, could already count on a high number of generic substitutes going from 1 to 61. In practice, observing a reduction of brand prices after generic entry requires time, as both the generic market share and the number of new entrants should achieve a sort of threshold, as we point out below. Therefore for the antibiotic case such a threshold had already been reached. More recent analysis based on US data, finding evidence about the decrease of the brand price with the increase in the number of generic entrants, include Saha et al. (2006) and Saha and Xu (2021). New evidence about Germany by Stargardt (2011) and about Sweden by Grandlung and Bergman (2018) show that increasing the number of generic entrants has a negative effect on the price of brand name drugs. Accounting for the long term effect of generic diffusion in Sweden, Grandlung

[7] 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.

[8] 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).

[9] 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.

and Bergman (op. cit.) show that Generic prices fell by 81% while the price of originators fell by 29% when the number of firms selling generics increased from 1 to 10.

Compared to the extension of empirical literature, the theoretical analysis of the GCP is more limited and originally based on Frank and Salkever (1992), and (1997). They explain the GCP by assuming market segmentation in the US market. Price sensitive demand depends on managed care organizations and Medicaid patients. Customers at retail pharmacies are all included in the price-insensitive 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. Due to the reduced price elasticity of the demand for brand-name drugs, after generic entry, the brand seller raises prices. Frank and Salkever's empirical analysis (1997) suggests that each new generic 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 considered imperfect substitutes, and allowing also the demand of brand loyal customers to depend both on the price of brands and the generics one. 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 theoretical 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[10]. In that case the Regan model predicts a negative relationship between the brand prices and the number of generic entrants, as we do. However in her empirical analysis, she reports a 1% increase in the brand price for each generic entrant and concludes that price competition is confined to the generics market.

What is remarkable in Regan's contribution is her observation that brand price increases are related to outpatients with third party insurance compared to those paying out of pockets. Actually Regan finds third degree price discrimination in the market for brand name drugs, consistent with the market segmentation theory of Frank and Salkever. After generic entry, brand name firms charge higher prices to outpatients covered by 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, underplaying brand loyalty motivations. 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.

Castanheira et al. (2019) beyond considering competition between brand name drugs and gener-

[10] According to Berntd (2002) "For many prescription drugs, the marginal costs of producing an additional tablet or capsule are very small - nickels not dollars" p. 56.

ics, analyzes rivalry between brand name drugs in the same therapeutic class but originated from different molecules, in a model of horizontal differentiation. Based on US data they show that after patent loss there is a significant reduction of the market share for the molecule experimenting generic entry (including both brands and generics), to the advantage of the alternative molecule still protected by patents. This result is due to the concentration of promotion expenditures (detailing and advertising targeted to physicians) on this last molecule, which induces GPs to prescribe it, at a disadvantage for the molecule whose patent has expired. Actually, considering in addition the empirical results included in the study of Kanavos (2014), one can check that after generic entry, the price of concurrent brand-name drugs increases more than the price of the brand subject to generic entry.

To the best of our knowledge, perceived vertical differentiation has been introduced especially in literature about reference pricing by Miraldo (2009), assuming brand loyalty due to the originator reputation, and by Brekke, Holmas, and Straume (2011) attributing quality misperceptions to advertising intensity. Further contributions followed, also based on perceived vertical differentiation. A contribution of Brekke, Canta and Straume (2016) to the reference pricing literature, shows, as we do, that generics entry induces both the price of brand-name drugs and the generic price to decrease when the (endogenous) number of entrants increases in a location model based on Salop circular city. They consider a two stage game where generic entry is followed by price competition with horizontal differentiation. However, they consider both brand biased and brand neutral consumers to account also for perceived vertical differentiation in a completely covered market. Equilibria depend on reimbursement policies. In case of coinsurance the brand market share does not change with price competition. On the contrary with reference pricing both equilibrium prices and the brand market share reduces.

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 $f(\theta) = 1$, therefore the market is composed by a unit mass of consumers. 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:

$$U = \theta q_i - P_i \tag{1}$$

where P_i is the market price of the drug supplied by firm i and q_i stands for the quality of

this drug. We assume that $\bar{\theta} \geq 2\underline{\theta}$, implying there is sufficient heterogeneity among consumers to justify our following analysis (Tirole, 1989) implying $\underline{\theta} < 1$. Product quality refers to therapeutic effectiveness and drug safety, and it depends on the content of the active principle per dose. The drug as an innovator one, has received market authorization by a Health Authority. The drug quality included in the market authorization represents a quality standard q°. When the patent period has expired, generics entry occurs. At the beginning there can be one entrant which may be given temporary exclusivity[11], so that the market structure becomes a duopoly. Subsequently, multiple generics firms can enter the market establishing an oligopoly. Also generics entry occurs thanks to a market authorization that is granted after the Health Authority has evaluated the results of bio-equivalence studies ascertaining that quality is the same of the originator.

We 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[12]. As noticed, marginal costs in the pharmaceutical sector are very low (Berndt, 2002), and very similar for innovator's drugs and generics[13]. We have, therefore, normalized marginal production costs to zero.

3.1 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 [14]. 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.

3.1.1 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 really mandatory, even though INN prescribing is, GP and pharmacists just inform the consumer about the existence of an alternative. The best fit for this version of our model is demand for drugs without reimbursement from the Public Healthcare System, but requiring a

[11] 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.

[12] 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 cost of capital (Winegarden 2014).

[13] 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)

[14] 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.

medical prescription. Therefore we are assuming that consumers are paying for drugs out of their own pocket. We do not consider explicitly the stage of price control by the public health agency, which is different from Country to Country (ranging from negotiated prices to price caps) and we just assume that the final prices paid by consumers is just a re-scaling of the price levels arising from our equilibria. An extension to the demand for drugs with reimbursement by public insurance is provided in a separate section.

To define market demand in this setting, we must establish a distinction between IC and UC[15]. In accordance with Bronnemberg et al. (2015), 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. UC represent outpatients who are nor sufficiently well-educated to be familiar with the previous information and to process it. They expect $q_B > q_G$, although $q_B = q_G = q^\circ$. Therefore, according to UC originators will grant a better therapeutic effect compared to generics. Such an expectation implies that brand name drug quality is perceived to be greater than it really is. Biased consumers beliefs can be represented by an optimistic expectation q_E such that $q_E > q_B$. Therefore q_E represent the perceived quality of brand name drugs, greater than the real quality: $q_E > q^\circ$ [16].

For the sake of simplicity and tractability, we have set q_E as the perceived quality on average. 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)[17]. Furthermore available evidence supports the assumption of optimistic economic agents and overconfidence about personal judgement, rather than consumers skepticism[18]

[15]Such a distinction is not relevant during the patent period, when consumers could just choose to buy or not to buy the brand name drug.

[16]Though at a first glance it may seem straitforward just to assume that consumers' misperception consist in $q_B > q_G$, when considering real quality: $q_B = q_G = q^\circ$, assuming $q_G < q_B$ also implies $q_G < q^\circ$. The last inequality states that UC believe that generics'quality is not complying with the minimum quality standard set by the Government. Such an assumption about consumers'beliefs is too strong, as it implies that consumers think that the Government is neither checking for compliance nor enforcing the quality standard in a delicate sector as public health.

[17]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.

[18]De Bondt and Thaler (1995) state that the most robust finding in the psycology of judgement is that people are overconfident. As far as consumers are concerned overconfidence is widely analyzed by Grubb (2015) who points out that neither competition nor learning protect consumers from the negative welfare effects of choice based on overconfident beliefs. More recent work by Bar-Gill & Sustein (2024) confirm the negative welfare effects of optimistic misperceptions.

In order to evaluate the distinction between IC and UC, we have split the market according to the distribution of θ by introducing an exogenous 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. The value of θ^* is not restricted out of equilibrium, except that $\underline{\theta} \leq \theta^* \leq \overline{\theta}$. We consider $(\theta^* - \underline{\theta})$ and $\left(\overline{\theta} - \theta^*\right)$ as the demand segment of UC and IC respectively. Therefore UC increase with θ^* and IC decrease if θ^* increases.

A key assumption 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 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, consumers with an higher WTP are more likely to be included in the IC share, and consequently, they may decide to buy generics if their price is lower.

The empirical foundation for this result can be examined in Bronnenberg at al. (2015). Focusing in the market for OTC drugs the authors have emphasized different purchasing behavior between IC and UC. Either higher education, or an occupation in the health care domain enhances consumers' information. According to the authors their results can be extended to prescription drugs. One extension can be found in Janseen (2023), considering competition between generics and brands in a dynamic oligopoly model applied to the Swedish market, accounting both for switching costs and brand premiums. Janseen shows the latter are dependent on consumer information. He considers a counterfactual where drugs purchasers are all medical experts, i.e. informed consumers, showing a significant reduction of brand premiums in that case.

3.1.2 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 what follows we define market demand segments, that are also shown in fig.1, where they are defined according to the maximization of utility functions.

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 specify that the marginal consumer is uninformed. The uninformed marginal consumer θ' with optimistic misperception, is defined by the following equality: $\theta' q_G - P_G = \theta' q_E - P_B$, leading to

$$\theta' = \frac{P_B - P_G}{q_E - q_G} \tag{2}$$

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 brand name drug, their demand segment will be $(\theta^* - \theta')$. While UC with WTP $\theta \leq \theta'$ (and $\theta \leq \theta^*$) will ask for a generic one, giving rise to the demand segment $(\theta' - \underline{\theta})$, as shown in fig. 1.

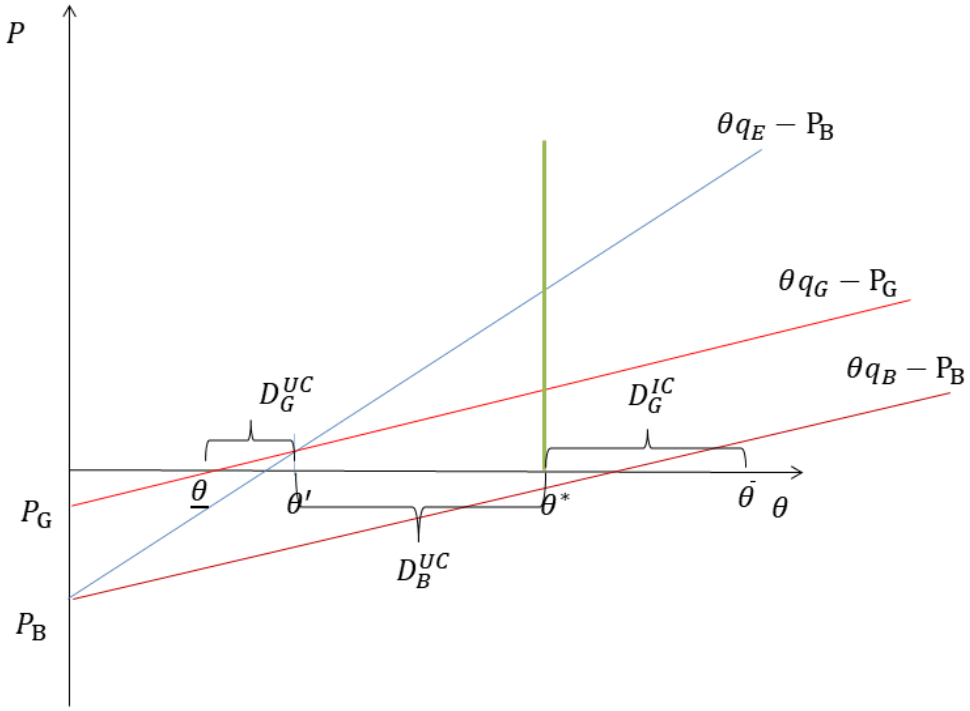


Figure 1: Demand Segments according to utility functions

We can then define $\Delta = (q_B - q_G)$ as the real quality differential. The fact that IC know that $q_B = q_G$, implies $\Delta = 0$. Therefore, provided that $P_G < P_B$, IC will purchase the generic drug. The IC WTP θ belongs to the following range: $\theta^* \leq \theta \leq \bar{\theta}$, and the demand for generics includes the IC segment $(\bar{\theta} - \theta^*)$[19] (see fig. 1). Actually, for consumers in this segment, brand name drugs and generics are perfect substitutes.

[19]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. As we have defined UC optimistic misperception as $q_E > q_B$, $\theta' < \theta''$then follows. In our specific case, $\theta' < \theta''$ trivially follows from $\theta'' \to \infty$.

Demand functions can be generally defined by the following expression:

$$D_i(P_G, P_B, \Delta, \Delta_E, \theta^*); i = G, B \tag{3}$$

(from now on D_G and D_B). We can specify demand functions according to the following parameter restrictions complying with our previous assumptions, represented in fig.1:

$$\left(\underline{\theta} \leq \theta' \leq \theta^* \leq \bar{\theta}\right) \tag{4}$$

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

$$D_G = \left(\bar{\theta} - \theta^* + \theta' - \underline{\theta}\right) = (1 - \theta^* + \theta') \tag{5}$$

and:

$$D_B = \left(\theta^* - \theta'\right) \tag{6}$$

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 referred to consumers with optimistic misperception and characterized by very low WTP. These consumers cannot afford brand-name drugs and buy generics. Their share is $(\theta' - \underline{\theta})$. D_B derives from UC with "intermediate" WTP allowing them to purchase the brand-name drug (Fig. 2). We need to point out that equation 5 complies with our previous assumptions about demand segments if and only if $(1 - \theta^*) > 0$, implying $\theta^* < 1$. Indeed, in the opposite case, $(1 - \theta^*) < 0$ implies a reduction D_G under θ'. Hence in what follows we always assume $\theta^* < 1$ Actually being $D_G = (1 - \theta^* + \theta') > 0$, let us consider the case where $\theta^* > 1$. For example if $\underline{\theta} = 0,5$, we obtain 1.35 as the upper limit of θ^*. Therefore if $\theta^* = 1,3$ generics demand becomes: $D_G = (1 - 1.3 + \theta') = -0.3 + \theta'$, with the effect of moving θ' towards the left of the unit segment and making $(\theta' - \underline{\theta})$ disappear.

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

$$P_B - \theta^* \Delta_E \leq P_G \leq P_B - \underline{\theta} \Delta_E \tag{7}$$

$$P_G + \underline{\theta} \Delta_E \leq P_B \leq P_G + \theta^* \Delta_E \tag{8}$$

In accordance with the 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 $D_G = \left(\bar{\theta} - \underline{\theta}\right) = 1$; $D_B = 0$, with the following price domain for D_G :

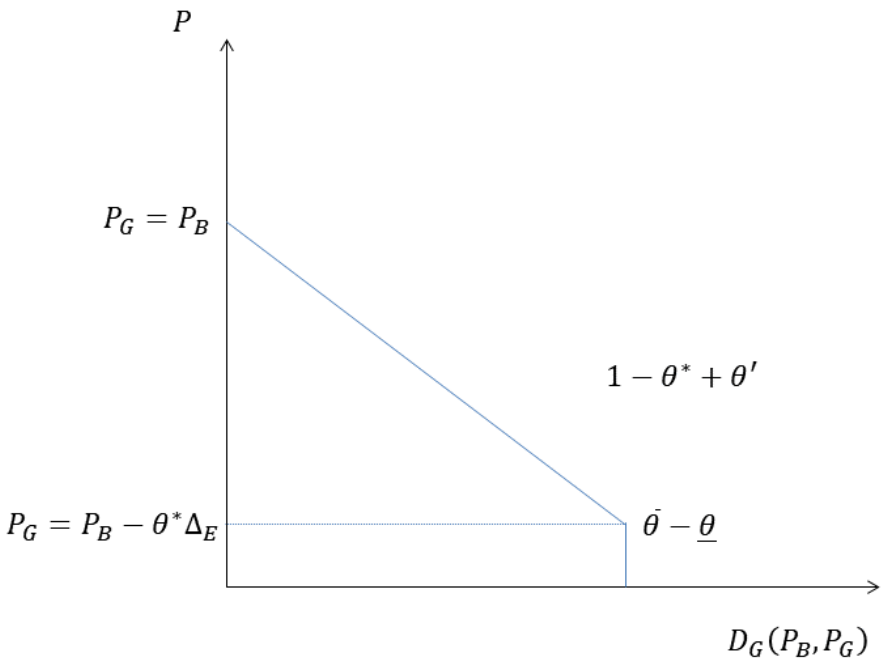


Figure 2: Demand function for Generics

$$0 \leq P_G \leq P_B - \theta^* \Delta_E \tag{9}$$

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:

$$0 \leq P_B \leq P_G + \underline{\theta} \Delta_E, \tag{10}$$

Therefore, demand functions[20] can be represented as in Fig. 2 and Fig. 3.

4 Equilibrium Analysis: Pure Price Competition in a Duopoly

Equilibrium analysis consist of the solution of the two-stage game to find a Sub-game Perfect Nash Equilibrium (SPNE). Considering the price choice in the second stage, we must consider that the

[20] Our demand characterization is similar to the one included in Cavaliere and Crea (2022)

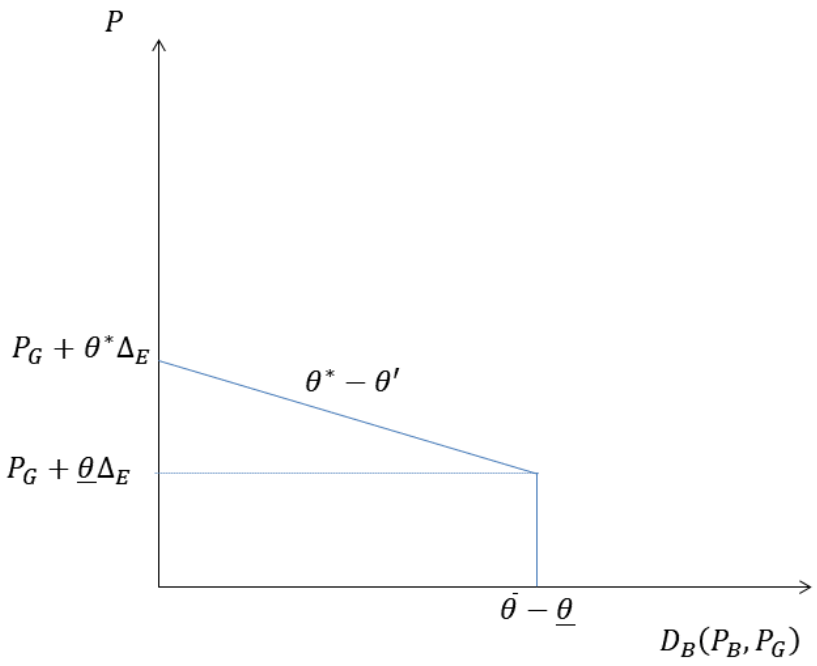


Figure 3: Demand function for Brand name drugs

generic firm caters to both IC and UC. IC buy generics if $P_G < P_B$. Furthermore, $P_G < P_B$ is also the optimal strategy considering the sequential nature of the price game, given the choice of P_B in the previous stage. To capture IC the generic firm need only to undercut the brand price P_B. However, as the generic firm also caters to UC with the lowest WTP, P_G needs to drop enough, compared to P_B, to catch their demand. This fact is consistent with the empirical observation of a large difference between the originator and the generic price even in a duopoly. Equilibrium analysis highlights that anticipating the price decrease and the ensuing demand-stealing effect by the generic entrant, it is optimal for the brand-name firm to increase the price of the originator to serve the residual demand sustained by UC with optimistic misperception and a sufficient WTP to buy brands.

The seller of the brand-name drug can credibly commit to a higher equilibrium price and cannot undercut the generic seller ex-post, because in most Countries with a Public Health system, brand prices are fixed list prices, also due to the operation of the Resale Price Maintenance clause, imposed

by manufacturers on retailers. Therefore, revisions of the list price take time (revisions cycles may last months or even years).

The following proposition summarizes the main equilibrium results.

Proposition 1 *With pure sequential price competition and perceived vertical differentiation in a duopoly, in the SPNE, the price of the brand name drug is* $P_B^* = \frac{\Delta_E(1+\theta^*)}{2}$*, and the generic price is* $P_G^* = \frac{\Delta_E(3-\theta^*)}{4}$*. Equilibrium restrictions imply that* $\theta^* > \frac{1}{3} + \frac{4}{3}\underline{\theta}$ *. As reaction functions are strategic complements, both equilibrium prices increase with* Δ_E *but* P_B^* *increases with the UC share while* P_G^* *decreases with it. Equilibrium demands are* $D_B^* = \frac{1}{4}(1+\theta^*)$ *and* $D_G^* = \frac{1}{4}(3-\theta^*)$*, therefore* D_B^* *increases with the UC share, and* D_G^* *decreases with it.*

See Appendix I for the proof.

As θ^* increases, IC reduces, and we can have equilibria with most UC. Therefore, the equilibrium exists even with a minority of IC. With a larger UC share, P_G^* decreases, and P_B^* increases. The price difference shrinks with a majority of IC.

As to equilibrium demands, they only depends on θ^*. As a larger UC share implies higher prices and higher demand for the brand producer, we can state that the latter profits from UC. Being education a proxy for consumers' information, the differences in the education level of the consumers' population could explain the heterogeneity of generics diffusion in different national markets.

In order to ensure that the candidate equilibrium of proposition 1 is actually a Nash equilibrium one would also want to check the eventual existence of profitable deviations from equilibrium strategies. As IC will always buy the generic drug, as long as P_G is slightly below P_B, one could think that a potentially profitable deviation for the generic producer could be to extract more profits from the IC segment by setting P_G marginally lower than P_B^* ,i.e $P'_G = \frac{\Delta_E(1+\theta^*)}{2} - \epsilon \approx P_B^*$. In that case, the generic producer could earn a profit $\Pi'_G = \frac{\Delta_E(1+\theta*)(\overline{\theta}-\theta^*)}{2}$, by just catering to IC. Therefore we need to check if $\Pi'_G > \Pi_G^*$, i.e. the profit obtained by the generic producer in our candidate equilibrium.

When checking the above inequality , i.e $\frac{(1+\theta^*)(\overline{\theta}-\theta^*)}{2} > \frac{(3-\theta^*)^2}{16}$, by simplification one can easily show that it reduces to the following one $\frac{8\overline{\theta}(1+\theta^*)-2\theta^*-9(1+\theta^{*2})}{16} > 0$, which in turn implies: $\frac{9(1+\theta^{*2})+2\theta^*}{(1+\theta^*)8} < \overline{\theta}$. As $\overline{\theta} = (1+\underline{\theta})$, and based on our initial assumptions: $0 < \underline{\theta} < 1$, we can find the values of θ^* that solve $\frac{9(1+\theta^{*2})+2\theta^*}{(1+\theta^*)8} < \overline{\theta}$, for any value of $\underline{\theta}$ belonging to the previous interval. Indeed for the lowest values of $\underline{\theta}$, i.e. $0.1 \leq \underline{\theta} \leq 0.2$, we find $\theta^* < 1$ (for example if $\underline{\theta} = 0.1, \theta^* < 0.724$ and if $\underline{\theta} = 0.2, \theta^* < 0.917$). On the contrary for higher values of $\underline{\theta}$, we find that the upper limit of θ^* is greater than 1 (for example if $\underline{\theta} = 0.3, \theta^* < 1,078$ and if $\underline{\theta} = 0.99, \theta^* < 1.94$). In this last case the

results about θ^* do not comply with the restrictions on generics market demand, requiring $\theta^* < 1$ (see subsection 3.1.2 and our comments on equation (5)). As a consequence we can exclude that the above inequality implies a profitable deviation from our candidate equilibrium for $0.25 \leq \underline{\theta} \leq 0.99$. On the contrary a profitable deviation from the candidate equilibrium exists for $0.01 \leq \underline{\theta} \leq 0.24$. However in that case the profitable deviation implies that precisely the consumers with the lowest willingness to pay will not buy and the market will not be completely covered, contrary to our initial assumptions. Indeed the generic price $P'_G = \frac{\Delta_E(1+\theta^*)}{2} - \epsilon$ implied by the deviation from the candidate Nash Equilibrium is too high for the consumers included in the share $(\theta' - \underline{\theta})$. At the step of demand definition, we explained that these UC would like to purchase the brand name drug, but they cannot afford it and buy the generics in the candidate equilibrium. Therefore, at a generic price close to the price of the brand-name drug: $P\prime_G \approx P^*_B$, these consumers will be excluded from the market. Such a high generic price is actually not consistent with our assumption about full market coverage, as one can easily show that $P'_G > \underline{\theta} q_G$, while on the contrary to get complete market coverage we assumed from the start that $P^*_G < \underline{\theta} q_G$.

Indeed the profitable deviation implies an uncovered market where IC buy generics at the price $P\prime_G = \frac{\Delta_E(1+\theta^*)}{2} - \epsilon$, and the UC included in the share $(\theta^* - \theta')$ buy the brand name drug, because of their optimistic misperceptions. Moreover, generic producers can obtain higher profits even if they do not cater to the consumers included in the segment $(\theta' - \underline{\theta})$ because, as we have ascertained above, the willingness to pay of these consumers is as low as possible, being included in the range $0.01 \leq \underline{\theta} \leq 0.24$. As we assumed that the market is completely covered there is no profitable deviation from the equilibrium shown in proposition 1.

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 for* $\frac{1}{3} + \frac{4}{3}\underline{\theta} < \theta^* < 4\sqrt{2} - 5$ *implying* $0.47 < \theta^* < 0.66$.

See Appendix I for the proof related to the upper bound of θ^*. The lower bound follows from equilibrium restrictions exposed in Proposition 1 and detailed in Appendix 1.

Proposition 2, showa that the second-mover advantage depends on the UC and the IC share. According to the restriction on θ^* either UC cover about one half of the market so that the IC size is similar or UC can reach a greater size, covering 2/3 of market and implying a minority of IC. Considering the lower bound on θ^* for the range of $\underline{\theta}$, i.e $0,1 < \underline{\theta} < 0.5$, we find that $0.47 < \theta^* < 1$, which is consistent with equiibrium and demand restrictions.

5 Price Competition with n Generic Entrants.

After patent expiry, new entrants continue to affect price competition. Generics prices decrease concurrently with the number of entrants, while the price of the originator remains comparatively higher[21]. 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. Reduced competition and increasing concentration trends in the U.S. generics industry have caused price spikes in the last decade, in particular for older drugs with a small market share (Gupta, Shah and Ross, 2019)[22].

We have considered the case with just one brand-name drug competing with n symmetric generic entrants. Concerning the strategic interaction among generics firms, we have assumed Cournot competition as 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, the brand-name drug seller will also reduce their price as the best response to the reduction of the generic price ($\frac{dP_B^n}{dn} < 0$). Even though the brand equilibrium price remains higher that the generics one. As the list prices for brand-name drugs are fixed, brand producers can reduce net consumers prices through discounts and rebates in the supply chain.

Proposition 3 *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*} *decreases with it, 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 the generic price

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

[22] 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. The recent analysis by Clarlk, Fabilli and Lasio (2023) shows that price increases were the result of extended collusion across the generic industry.

reduction compared to the duopoly case, implying intense competition among generics firms, and more price competition between the generics and the brand-name producer.

The brand price reduces as well, compared to the duopoly case, as we find that $\frac{dP_B^{n*}}{dn} < 0$, i.e. the price of the brand-name drug decreases with the growth in the number of generic entrants, in contrast with the "hard" version of the GCP, which excluded price competition between generics and brand name drugs. However, the brand price remains persistently higher in equilibrium than the generics one due to sequential price competition with perceived vertical differentiation. An outcome that is consistent with the "soft" version of the GCP. In the following proposition we, further investigate the features of the oligopolistic equilibrium and discuss the conditions for a second mover advantage to arise in oligopoly.

Proposition 4 *In an oligopolistic equilibrium with one brand-name producer and n generic entrants, the price of the brand-name drug is higher than the generics:* $P_B^{n*} > P_G^{n*}$, *provided* $\theta^* > \frac{1}{2+n}$. *Equilibrium restrictions also imply* $\theta^* > \frac{1+2\underline{\theta}(1+n)}{(2+n)}$. *As* $n \geq 2$, $\frac{1+2\underline{\theta}(1+n)}{(2+n)} > \frac{1}{2+n}$. *Equilibrium generics demand is always greater than equilibrium demand for the brand-name drug:* $Q_G^* > D_B^*$. *Generic firms as a whole hold a second mover advantage for* $\frac{1+2\underline{\theta}(1+n)}{(2+n)} < \theta^* < \frac{2n+1-\sqrt[2]{n+1}}{n(\sqrt[2]{n+1}+1)}$ *and* $\underline{\theta} < 0.23$. *In case* $\theta^* > \frac{2n+1-\sqrt[2]{n+1}}{n(\sqrt[2]{n+1}+1)}$ *and* $\underline{\theta} > 0.23$ *the brand seller holds a first mover advantage.*

See Appendix II for the Proof.

A second mover advantage arises for $\frac{1+2\underline{\theta}(1+n)}{(2+n)} < \theta^* < \frac{2n+1-\sqrt[2]{n+1}}{n(\sqrt[2]{n+1}+1)}$. According to the upper bound of $\theta^*$when $n \to \infty$ then $\theta^* \to 0$. Indeed, with an increase of n, equilibrium prices will be reduced in the generic market. Such a reduction negatively contributes to a second-mover advantage. However the reduction of θ^*, can counterbalance it to the extent that it positively affects the generics price, contributing to obtaining a second mover advantage. Moreover, reducing θ^*also implies a greater generics demand due to a larger IC share, increasing the aggregate profits of the generics firms, further contributing to the second mover advantage. However, the lower bound of θ^*restrains the reduction of θ^*that can contribute to counterbalance the reduction of the equilibrium generics prices, according to the mechanism explained above.

Furthermore, according to Proposition 4, the second mover advantage also depends on the value of $\underline{\theta}$, as $\underline{\theta} < 0.23$. By limiting downwards the value of the WTP of consumers with the lowest income, this last restraint implies that there is also a sufficient demand from UC that would prefer brands but cannot afford them. Such a demand also positively contributes to the profits of generics firms and then to the second mover advantage.

On the contrary, if $\underline{\theta} > 0.23$ and $\theta^* > \frac{2n+1-\sqrt[2]{n+1}}{n(\sqrt[2]{n+1}+1)}$ a first mover advantage arises to benefit the brand name drug producer, as shown in detail by the proof of Proposition 4 in Appendix II

6 Extension to the Case of Physicians' Misperception

Physicians misperception may mislead outpatients in their choice of drugs. Therefore, we will introduce sequential 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 physicians' prescriptions. We have maintained the distinction between IC and UC, and the UC choice depends on optimistic misperception, as in the basic model with pure price competition. However, in our new setting, a share of physicians supports brand-name drugs either because of misperception about generics therapeutic effectiveness or as a result of detailing efforts by brand-name drug sellers[23]. The low generic consumption registered in Greece, Italy[24], quoted in our introduction could also be explained by the prescribing behavior of GPs, eventually coupled with pharmacists misperception about generic substitution when the latter is not really mandatory. In what follows, we shall introduce medical support of brand-name drugs, keeping our assumptions about information heterogeneity and misperception characterizing UC behavior

Compared to the demand model presented in the previous sections, now UC with intermediate WTP, 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 generic, either because they are informed or because their income is low, change their minds because of the advice of medical experts opposing generics switching[25]. Therefore we assume that outpatients belonging to the share $\alpha < 1$ closely follow medical advice.The remaining share $(1-\alpha)$ of outpatients continue to purchase generics, according to the prescribing behavior of the residual physician share

[23]Ellison and Ellison (2011) point out that, after generics entry, firms reduce their detailing efforts concerning the originator, to sustain another brand in the same therapeutic class. According to Castanheira et al. (2019), the entry of generics produces a drop in the total market share of the molecule after patent expiry. However, to capture these last effects, one should introduce additional competition between different brand-name drugs in the same therapeutic class. Such an introduction could represent an extension of our present model. While we are persuaded that this kind of prescription switching from out-of-patent drugs to patented drug takes place in the US, where large generic diffusion is now a fact, we suspect that such a switching behavior is not so widespread in European Countries.

[24]For example, in Italy, a share of medical experts remain skeptical about generic switching because of the tolerance about the content of the active principle allowed to generics. Regarding bioequivalence, the content of the active principle may range from 80% to 120% compared to the originator. Some doctors believe that generics may be less effective because of the risk that the medication contains less of the active principle. Alternatively, they believe generic producers will always stick to 80% of the active principle to save money. However, other doctors working in Hospitals where generic use is mandatory believe that generics are as effective as originators, even if they contain 80% of the active principle.

[25]Obviously one can use the same model to account for generic prescribing by a share $\alpha < 1$ of GPs. However we do not explore such an extension as we mainly deal with the explanation of a reduced share of generics in some European Countries, also due to the GPs habit of prescribing brand-name drugs.

$(1-\alpha)$.

Based on the above assumptions, demand functions become:

$$D_B^m = (\theta^* - \theta') + \alpha(\bar{\theta} - \theta^* + \theta' - \underline{\theta}) = \left(\theta^* - \frac{P_B - P_G}{\Delta_E}\right) + \alpha\left(1 - \theta^* + \frac{P_B - P_G}{\Delta_E}\right) \tag{11}$$

-

$$D_G^m = (1-\alpha)\left(\bar{\theta} - \theta^* + \theta' - \underline{\theta}\right) = (1-\alpha)\left(1 - \theta^* + \frac{P_B - P_G}{\Delta_E}\right) \tag{12}$$

Given these demand functions, we can derive a new SPNE, whose properties appear in the following Proposition. The higher is α, the larger the IC share required to compensate for the reduction in the generics price, implied by an increase of n.

Proposition 5 *When a share α of physicians supports the brand name drug, and there are n new entrants in the generic market, in the oligopoly SPNE, the price of the brand-name drug is higher than the generics: $P_B^{mn*} > P_G^{mn*}$ provided $\theta^* > \frac{2\alpha}{n(n+\alpha)}$. Equilibrium restrictions also imply $\theta^* > \frac{\underline{\theta}(n+1)2n(1-\alpha)-\alpha n(n+2)}{(n-\alpha)(n+2)}$ Both equilibrium prices increase with α and decrease with n. P_B^{mn*} increase more with α than P_G^{mn*}. With an increase of n, P_G^{mn*} decreases more than P_B^{mn*}. An increase of θ^* implies an increase of P_B^{mn*} and a decrease of P_G^{mn*}. Equilibrium demands are such that $D_B^{mn*} < D_G^{mn*}$ provided $\theta^* < 1$. D_B^{mn*} increases with α and θ^* and decreases with an increase in n. D_G^{mn*} decreases with an increase of α and θ^* and increases with n.*

(see the Proof in Appendix III) According to the previous Proposition, an increase of n exerts a downward pressure not only on the generic price but also on the equilibrium price of the brand name drug, like in the case of oligopoly without α. As reaction functions are strategic complements, both equilibrium prices increase with α, though the price of the brand name drug increases more than the generics price. Furthermore, the price of the brand name drug is greater than the generics if $\theta^* > \frac{2\alpha}{n(n+\alpha)}$ as the price difference increases with α and with n, that drives a reduction of the generics price. Equilibrium restrictions derive from checking that $\theta' > \underline{\theta}$. So that $\theta' - \underline{\theta} > 0$. Trough the development of the last inequality we obtain $\theta^* > \frac{\underline{\theta}(n+1)2n(1-\alpha)-\alpha n(n+2)}{n(n+2)-\alpha(n+2)}$, if we set $\alpha = 0$ we obtain the same equilibrium restriction presented in proposition 4. The equilibrium demand of the brand name drug is lower than the generics demand in equilibrium if $\theta^* < 1$ implying a reduction of the UC share and of the demand for the brand name drug independent from α.

The next step is to check if the firm selling the brand-name drug can obtain a first-mover advantage.

Proposition 6 *When there is a share α of physicians supporting the brand name drug and n new entrants in the generic market, if we compare the equilibrium profit of the firm supplying the brand new drug Π_B^{mn*} with the profits obtained by the n generic sellers $n\Pi_G^{mn*}$, we can check that $\Pi_B^{mn*} > n\Pi_G^{mn*}$, i.e the brand name drug supplier always obtains a first mover advantage.*

See the Proof in Appendix III. We point out that when we add to the demand and price advantage of the brand name drug, the price drop of all the generic firms in an oligopoly, a first mover advantage definitely arises independently of the value of α. Only $n \geq 2$, i.e., being in the oligopoly case, is necessary to observe a first-mover advantage.

7 Conclusions

Starting from existing evidence on the drivers of generic (and brand) demand beyond prices, we have specified demand for off-patent drugs from a theoretical perspective, which is relevant for Countries with healthcare systems that are not based on private insurance. Based on our demand specification, we have analyzed the competition between generics and brand-name drugs, both for non-reimbursable drugs and for those covered by public third-party insurance.

Regarding competition, we have chosen sequential price competition with misperceived vertical differentiation, based on our demand functions specification. Given our results, referencing a vertical differentiation model is correct, as we find that quality misperceptions allow firms to relax price competition through perceived product differentiation. The seller of a brand-name drug (perceived as a higher quality good) can set higher prices, while the generic seller (perceived as a producer of lower quality goods) sets lower prices. In the standard model of vertical differentiation, the producer of higher-quality goods also earns higher profits. We can also observe this result in the real market for off-patent drugs: sellers of brand-name drugs typically lose market share in volume due to generic entry, but continue to show an advantage over generics when we look at the value of their total revenues. Within our model, where we assume that R&D expenditure has already recovered during the patent period, sellers of brand-name drugs obtain higher profits if the WTP of the poorest consumers is relatively high, and if the segment of generic demand deriving from them is contained, and the IC share is sufficiently low to reduce their generic consumption. However, we have shown that in markets where prescription habits favor brands, the brand producer's profits are always higher than the sum of the generic sellers' profits. In that kind of market, pharmaceutical multinationals can allocate more resources to their R&D, so that generic entry is unlikely to threaten dynamic efficiency, compared to markets where prescription habits favor generics.

Results from our competition model confirm the "soft" version of the GCP, also outside markets

dominated by private insurance (Kong, 2009) but not its "hard" version: as more generics enter the market, the brand price is negatively affected and progressively reduced, consistent with the latest empirical analysis of the GCP both in the US market and in some European Countries. A further extension of our theoretical analysis would be to investigate, in a similar framework, competition between brand-name drugs in the same therapeutic class before and after generic entry, given the empirical results previously quoted and concerning the US, pointing out an increase in the share of concurrent brands, whose patent has not expired yet, driven by GPs' prescribing behavior.

According to our theoretical specification, demand for off-patent drugs depends on price differences between brand-name drugs and generics, income, and education level. Empirical analysis is needed to test our theory, and it appears as a natural extension of our research. Available evidence on educational achievements across European Countries (Eurostat data for 2017) shows an interesting correlation consistent with our assumptions, though it is obviously not sufficient to prove it empirically. Indeed, looking at the percentage of people in the age bracket 55-74 (the consumption of medicines is notoriously concentrated in this age bracket) who have achieved tertiary education across the same European Countries we considered in the introduction, we find a nearly identical ranking to the generic share. At the top, we find the UK (33%), followed by Norway (31%) and Denmark (28%). Germany and Ireland share the same percentage (26%), close to that of the Netherlands (25%). At the bottom, we find Greece (19%) and Italy (12%), just as in the previous ranking. The only exception is Portugal, which follows Italy in terms of education achievements, with a percentage of 11%. Still, it is a second-tier Country regarding generic uptake, with a generic share of 50%. However, in the case of Portugal, we need to account for a policy measure that provides 100% reimbursement for retired people buying generics, which helps explain why this Country is an outlier.

Actually, an empirical research extended to a group of European Countries with varying education levels and different achievements in generic consumption is challenging, considering that prices and availability of off-patent drugs are also expected to vary at the Country level. Moreover, institutional differences in reimbursement and the way reference pricing provisions and price controls are applied across countries make comparability a complex exercise. However, thanks to a Report from the National Court of Auditors, we also discovered significant variability across Italian Regions in the consumption of off-patent brand-name drugs and generics. The data collected by the Court primarily concern out-of-pocket expenditures for reimbursable off-patent drugs, for outpatients who choose brand-name drugs and, under Reference pricing, must pay the difference between the brand price and the reference price. The data appear counter-intuitive from the Court's point of view, as they show a preference for brands over generics in the poorest southern Regions (with lower edu-

cational attainment, even after controlling for secondary education, and lower per capita income). In contrast, generic uptake is greater in the richest northern Regions, with a higher average level of education.[26] As we dispose of regional data about consumption of both reimbursable and non-reimbursable off-patent drugs, beyond prices, which in this case are uniform across the Country, given the variability in income and education, we can carry out an equally interesting empirical estimation for the demand of generics and brands to support the theoretical demand specification provided in this paper.

Regarding policy implications, assuming that generic uptake across countries depends on education levels suggests that we expect an increase in the generic share only in the very long run, as changes in a country's education levels take a long time. As cohorts of people with higher education get older and start consuming more drugs, we should also observe positive changes in the generic share. However, physicians' education matters too and can lead to a higher generic share in a shorter time frame. For example, high generic uptake in the UK is also said to depend on medical school education, where students already learn to prescribe generics rather than brand-name drugs before becoming GPs. It is possible to extend this kind of education model to other European Countries that aim to increase the generic share within their markets for off-patent drugs.

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[26]The Court of Auditors shows that per-capita co-payments are larger (double or more) in southern Regions (with lower per-capita income) than in northern Regions, implying greater demand for brand-name drugs in less developed Regions and greater generic demand in Regions with higher income and superior levels of education.

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Appendix I

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 3.1.2) we can derive the profit function for firm G:

$$\Pi_G = P_G D_G = P_G \left(1 - \theta^* + \theta'\right) \tag{13}$$

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 :

$$P_G = \frac{P_B + \Delta_E(1 - \theta^*)}{2} \tag{14}$$

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):

$$\Pi_B = P_B D_B = P_B \left(\theta^* - \frac{P_B - P_G}{\Delta_E}\right) \tag{15}$$

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^*

$$P_B^* = \frac{\Delta_E(1 + \theta^*)}{2} \tag{16}$$

By substitution we obtain P_G^*

$$P_G^* = \frac{\Delta_E(3-\theta^*)}{4} \tag{17}$$

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 $(1 - \theta^*)$.

The conditions for the existence of price equilibrium in a duopoly derive from checking $P_B^* > P_G^*$, and the parameter restrictions $\theta' > \underline{\theta}$, contributing to defining market demands. At the price equilibrium $P_B^* > P_G^*$ implies $\theta^* > \frac{1}{3}$, and $\theta' = \frac{\frac{\Delta_E(1+\theta^*)}{2} - \frac{\Delta_E(3-\theta^*)}{4}}{\Delta_E}$, so that $\underline{\theta} > \theta'$ implies $\theta^* > \frac{1}{3} + \frac{4}{3}\underline{\theta}$. As we assumed $\overline{\theta} > 2\underline{\theta}$, then $\underline{\theta} < 1$. Moreover, the assumption of complete market coverage ($P_G^* \leq \theta q_G$), rules out $\underline{\theta} = 0$. Therefore, the range for $\underline{\theta}$ must be the following one: $0 < \underline{\theta} < 1$. For example, by considering the range: $0.1 \leq \underline{\theta} \leq 0.9$, by substitution into the inequality $\theta^* > \frac{1}{3} + \frac{4}{3}\underline{\theta}$ we find the corresponding range of θ^*: $0.47 \leq \theta^* \leq 1.45$. However, as we must keep track of the assumption $\theta^* < 1$, which is necessary to define market demands correctly, the range of θ^* is truncated. Regarding the upper bound of θ^*, the range to consider is given by $0.47 < \theta^* < 1$. Moreover, being $\theta^* > \frac{1}{3} + \frac{4}{3}\underline{\theta}$ if the upperbound of θ^* must be lower than 1, we can rule out cases where $\underline{\theta} > \frac{1}{2}$. ■

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 $\theta^* < 0.66$. By keeping track of the previous equilibrium restriction $0.47 < \theta^* < 1$, we can state that a second mover advantage requires the following range for θ^*: $0.47 < \theta^* < 0.66$ ■

Appendix II

Proof. of Proposition 3:

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:

$$P_G^n = (1 - \theta^* - Q_G)\Delta_E + P_B^n \tag{18}$$

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

$$\Pi_{iG} = P_G^n q_i = \left((1 - \theta^*)\Delta_E + P_B^n - q_i\Delta_E - \sum_{j \neq i}^{n} q_j \Delta_E\right) q_{iG} \tag{19}$$

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

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

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

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

we can then derive Q_G as the total generics demand:

$$Q_G = nq_i^* = \frac{n}{(1+n)} \frac{(1 - \theta^*)\Delta_E + P_B^n}{\Delta_E} \tag{21}$$

and replacing equation (21) in equation (18) we get the inverse demand function for generics drugs

$$P_G^n = \frac{1}{(1+n)}\left[(1-\theta^*)\Delta_E + P_B^n\right] \tag{22}$$

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

$$\Pi_B = P_B^n(\theta^* - \frac{P_B^n - P_G^n}{\Delta_E}) \tag{23}$$

replacing P_G^n (equation 22 we obtain

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

Brand producer 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

$$P_B^{n*} = \frac{\Delta_E(1+n\theta^*)}{2n} \tag{24}$$

By replacing (24) in (22) we can achieve the generics equilibrium price P_G^{n*}:

$$P_G^{n*} = \frac{1}{n+1}\frac{\Delta_E(n(2-\theta^*)+1)}{2n} \tag{25}$$

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

$$P_G^{n*} - P_G^* = \frac{n(1-\theta^*) + 2 + n^2(\theta^* - 3)}{2(n+1)n} < 0 \tag{26}$$

showing that $P_G^{n*} < P_G^*$ if $0 < \theta^* \leq 3$ and $n > 1$ that is true given the model restrictions

Given θ^*, with an increasing number of generics entrants n, both equilibrium prices decrease:

$$\frac{\partial P_B^{n*}}{\partial n} = -\frac{\Delta_E}{2n^2} < 0 \tag{27}$$

$$\frac{\partial P_G^{n*}}{\partial n} = \frac{\Delta_E \left[(\theta^* - 2)\, n^2 - 2n - 1\right]}{2n^2(n+1)^2} < 0, \text{ as } \theta^* < 1 \tag{28}$$

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 $\left[(\theta^* - 2)\, n^2 - 2n - 1\right] < -1 * (n+1)^2$, the above inequality is true if $0 < \theta^* < 1$ as we assume in our analysis. . ■

Proof. of Proposition 4

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

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

the previous inequality holds for $\theta^* > \frac{1}{(2+n)}$.

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 $Q_G^* > D_B^*$ or $Q_G^* - D_B^* > 0$, i.e. $\frac{(n(2-\theta^*)+1)}{2(n+1)} - \frac{(2\theta^*(n+1) - (n\theta^*+1)(n+2) - 2n)}{2(n+1)} > 0$. The previous inequality simplifies to the following one: $n(2-\theta^*) + 1 - 2\theta^*(n+1) + (n\theta^*+1)(n+2) + 2n > 0$ or $5n + 3 + \theta^*(n(n-1) - 2) > 0$. For $n > 2$ the last inequality always holds.

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

To verify that the equilibrium of proposition 4 is consistent with both the parameter restrictions that define the demand functions, we must check if $\theta' > \underline{\theta}$ holds in equilibrium too. Given equilibrium prices, we obtain:

$\theta' = \left[\frac{\Delta_E(1+n\theta^*)}{2n} - \frac{1}{(n+1)}\frac{\Delta_E(n(2-\theta^*)+1)}{2n}\right]\frac{1}{\Delta_E}$ that simplifies to $\theta' = \frac{\theta^*(2+n)-1}{2(1+n)}$. Therefore we have to check if $\frac{\theta^*(2+n)-1}{2(1+n)} - \underline{\theta} > 0$. As the previous inequality reduces to $\frac{\theta^*(2+n)}{2(1+n)} > \frac{1+2\underline{\theta}(1+n)}{2(1+n)}$ we can easily find the value of θ^* consistent with the equilibrium restriction: $\theta^* > \frac{1+2\underline{\theta}(1+n)}{(2+n)}$.

Therefore, the existence of a second mover advantage depends on the following range, as far as θ^* is concerned:

$$\frac{1+2\underline{\theta}(1+n)}{(2+n)} < \theta^* < \frac{2n+1-\sqrt[2]{n+1}}{n(\sqrt[2]{n+1}+1)} \tag{29}$$

As to the range of θ^*, we need to check that $\frac{1+2\underline{\theta}(1+n)}{(2+n)} < \frac{2n+1-\sqrt[2]{n+1}}{n(\sqrt[2]{n+1}+1)}$,i.e. $\frac{1+2\underline{\theta}(1+n)}{(2+n)} - \frac{2n+1-\sqrt[2]{n+1}}{n(\sqrt[2]{n+1}+1)} < 0$. This inequality simplifies to $\frac{2}{n^2}\frac{n+1}{n+2}\left(2n-2\sqrt{n+1}+n^2\underline{\theta}-n\sqrt{n+1}+2\right) < 0$. With further simplifications we obtain $(2n+n^2\underline{\theta}+2) < \left((2+n)\sqrt{n+1}\right)$ and we can express $\underline{\theta}$ as a solution of the last inequality: $\underline{\theta} < \frac{\sqrt[2]{n+1}(2+n)-2(1+n)}{n^2}$ that, in turn limits the values of the lowest WPT, which are consistent with a second mover advantage. Moreover, we can point out what is the effect of increasing n on the value of $\underline{\theta}$, by computing the following first derivative: $\frac{d(\frac{\sqrt[2]{n+1}(2+n)-2(1+n)}{n^2})}{dn} = -\frac{8(1+n)-(4n+8)\sqrt{n+1}+n^2}{2n^3\sqrt{n+1}}$, as $\left(8(1+n)-(4n+8)\sqrt{n+1}+n^2\right) > 0$ for $\forall n$, we can state $\frac{d(\frac{\sqrt[2]{n+1}(2+n)-2(1+n)}{n^2})}{dn} < 0$.

The latter implies that the feasible $\underline{\theta}$, that keeps the inequality that determines the range of θ^* consistent with a second mover advantage, reduces with the increase of n. [27] Indeed by considering as an example $2 \leq n \leq 10$ we obtain the corresponding range for $\underline{\theta}$: $0.23 \geq \underline{\theta} \geq 0.18$.Therefore the existence of a second mover advantage requires $\underline{\theta} < 0.23$.

As finding a second mover advantage requires $\underline{\theta} < 0.23$, in markets where $\underline{\theta} > 0.23$, there must be a first mover advantage. Indeed, in that case the demand segment $\theta' - \underline{\theta}$ due to consumers with a low WTP who cannot afford brands shrinks. Moreover, if a second mover advantage requires $\theta^* < \frac{2n+1-\sqrt[2]{n+1}}{n(\sqrt[2]{n+1}+1)}$, on the contrary a first mover advantage occurs with $\theta^* > \frac{2n+1-\sqrt[2]{n+1}}{n(\sqrt[2]{n+1}+1)}$. In that case, we must consider the consistency between the last inequality and the one arising from the equilibrium restriction: $\theta^* > \frac{1+2\underline{\theta}(1+n)}{(2+n)}$. Which one of the two inequality prevails depends on $\underline{\theta}$ and n.

Let us consider the inequality:$\frac{2n+1-\sqrt[2]{n+1}}{n(\sqrt[2]{n+1}+1)} - \frac{1+2\underline{\theta}(1+n)}{(2+n)} < 0$, implying $\frac{1+2\underline{\theta}(1+n)}{(2+n)} > \frac{2n+1-\sqrt[2]{n+1}}{n(\sqrt[2]{n+1}+1)}$. By simplification $\frac{2n+1-\sqrt[2]{n+1}}{n(\sqrt[2]{n+1}+1)} - \frac{1+2\underline{\theta}(1+n)}{(2+n)} = -\frac{2}{n^2}\frac{n+1}{n+2}\left(2n-2\sqrt{n+1}+n^2\underline{\theta}-n\sqrt{n+1}+2\right) < 0$. As

[27] Indeed, with an increase of n, the generic price is decreasing, and therefore choosing the generic is a more and more attractive option for consumers with the lowest WTP.

$\frac{2}{n^2}\frac{n+1}{n+2} > 0$,the inequality above holds if $\left(2n - 2\sqrt{n+1} + n^2\underline{\theta} - n\sqrt{n+1} + 2\right) > 0$. We rewrite the previous inequality as $2(1+n) + n^2\underline{\theta} - \sqrt{n+1}(2+n) > 0$ and find $\underline{\theta}$ as a solution: $\underline{\theta} > \frac{\sqrt{n+1}(2+n)-2(1+n)}{n^2}$.For example if $n = 2$ we obtain $\underline{\theta} > 0,23$. Therefore, finding a first mover advantage implies considering $\theta^* > \frac{1+2\underline{\theta}(1+n)}{(2+n)}$ and high values for $\underline{\theta}$.

Based on the previous results, prooving the existence of a first mover advantage is straightforward. Let us compare the profit function for the brand producer $\Pi_B^* = \frac{\Delta_E(n\theta+1)^2}{4n(n+1)}$ and for the generic producers as a whole $\Pi_G^* = \frac{\Delta_E(2n-n\theta+1)^2}{2n(2n+2)(n+1)}$(see Appendix II). A first mover advantage implies:

$$\frac{(n\theta^* + 1)^2}{4n(n+1)} > \frac{(2n - n\theta^* + 1)^2}{2n(2n+2)(n+1)} \tag{30}$$

As $\underline{\theta} > 0,23$, let us consider $\underline{\theta} = 0.5$,and substitute this value into $\theta^* = \frac{1+2\underline{\theta}(1+n)}{(2+n)}$ to get $\theta^* = \frac{1+2(0.5)(1+n)}{(2+n)}$. Then by substitution of θ^* into the profit functions we obtain: $\Pi_B^* = \frac{(n(\frac{1+2(0.5)(1+n)}{(2+n)})+1)^2}{4n(n+1)} = \frac{0.25}{n}(n+1)$ and $\Pi_G^* = \frac{(2n-n(\frac{1+2(0.5)(1+n)}{(2+n)})+1)^2}{2n(2n+2)(n+1)} = \frac{0.25}{n}$. As $\Pi_B^* > \Pi_G^*$, we have proven the existence of a first mover advantage.

■

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

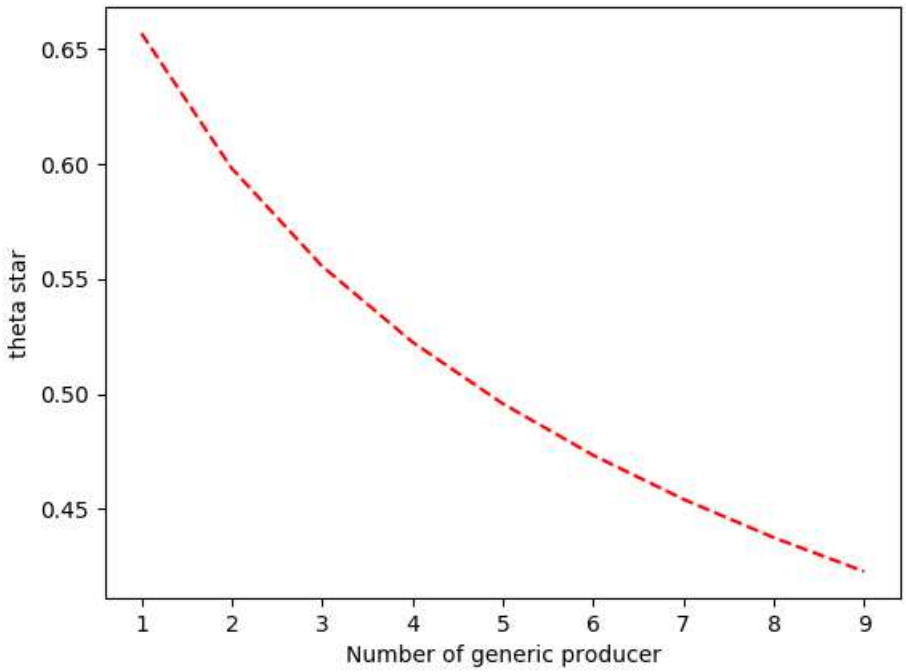


Figure 4: Plot of inequality presented in proposition 4

With $n = 1$ we can confirm the restriction on the UC share valid for the duopoly case, as the graph shows that $\theta^* \cong 0.66$ corresponds to $n = 1$. Furthermore, it can be observed that with a few new entrants ($n = 3$) as the price reduction induced by entry is comparatively contained, a lower UC share implied by $\theta^* = 0.55$, compared to the duopoly case sustains the second mover advantage, to the extent that it contributes to contain the price decrease and in the meantime to catch consumers with the lowest WTP, included in the wider UC share. In this case we have a minority of IC contributing to generic demand expansion. On the contrary, with many new entrants ($n = 9$), the generic price collapses. Therefore, keeping a second mover advantage requires a lower and lower UC share ($\theta^* \approx 0.4$). In the meantime the IC share becomes larger implying a larger contribution of IC demand to sustain the profit for generic firms as a whole. Considering real markets in developed Countries, in the first example a second mover advantage appears to be more likely as it depends on a majority of UC, while the second one appears to us hardly cosistent with market reality, as it requires a majority of IC, i.e. too many consumers with higher education.

Appendix III

Proof. of Proposition 5 We can extend the assumption regarding physicians' misperception and their support of brand name drugs to the case of n generics producers' entry.

To compute the SNPE in oligopoly we shall define the profit functions:

$$\Pi_G^{mn} = P_G^{mn} D_G^{mn} = P_G(1-\alpha)\left(1-\theta^* + \frac{P_B^{mn} - P_G^{mn}}{\Delta_E}\right) \tag{31}$$

$$\Pi_B^{mn} = P_B^{mn} D_B^{mn} = P_B^{mn}\left[\left(\theta^* - \frac{P_B^{mn} - P_G^{mn}}{\Delta_E}\right) + \alpha\left(1-\theta^* + \frac{P_B^{mn} - P_G^{mn}}{\Delta_E}\right)\right] \tag{32}$$

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

$$P_B^{mn*} = \frac{\Delta_E(1+n\theta^* + \alpha(n-\theta^*))}{2n(1-\alpha)} \tag{33}$$

$$P_G^{mn*} = \frac{1}{n+1}\frac{\Delta_E(2n+1-n\theta^* - \alpha(n-\theta^*))}{2n(1-\alpha)} \tag{34}$$

We are going to show that $P_B^{mn*} > P_G^{mn*}$. By simple inspection, we can simplify the inequality, that reduces to:

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

Through further simplifications, we obtain the following inequality:

$$2n\theta^* - n + 2n\theta^* + n^2\theta^* + n^2\alpha - 2\theta^*\alpha - n\theta^*\alpha > 0$$

that, by collecting n, reduces to:

$$n(2\theta^* + n\theta^* + 2\alpha + n\alpha - \theta^*\alpha - 1) - 2\theta^*\alpha > 0$$

and by collecting θ^* and α we obtain:

$$n(\theta^*(2+n) + \alpha(2+n-\theta^*) - 1) - 2\theta^*\alpha > 0$$

As $0 < \alpha < 1$; $0 < \theta^* < 1$and $n \geq 2$, we can state that $\theta^*(2+n) > 0$; $\alpha(2+n-\theta^*) > 0$ and $(\theta^*(2+n) + \alpha(2+n-\theta^*) > 1$. Being $\theta^*\alpha < 1$, then $n(\theta^*(2+n) + \alpha(2+n-\theta^*) - 1) > 2\theta^*\alpha$ so that the last inequality is verified.

We are now going to show that both P_B^{mn*} and P_G^{mn*} increase with α, as $\frac{dP_B^{mn*}}{d\alpha} = \frac{d(\frac{\Delta_E(1+n\theta^*+\alpha(n-\theta^*))}{2n(1-\alpha)})}{d\alpha} = \frac{1}{2n}\frac{\Delta_E}{(\alpha-1)^2}\left(n(1+\theta^*) - \theta^* + 1\right) > 0$

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

Moreover $P_B^{mn*}$and P_G^{mn*} decrease with an increase of n, as:

$\frac{dP_B^{mn*}}{dn} = \frac{d(\frac{\Delta_E(1+n\theta^*+\alpha(n-\theta^*))}{2n(1-\alpha)})}{dn} = -\frac{1}{2n^2}\frac{\Delta_E}{\alpha-1}(\alpha\theta^*-1) < 0$

$\frac{dP_G^{mn*}}{dn} = \frac{d(\frac{1}{1+n}\frac{\Delta_E(2n+1-n\theta^*-\alpha(n-\theta^*))}{(2n(1-\alpha))})}{dn} = \frac{1}{2n^2}\frac{\Delta_E}{(\alpha-1)(n+1)^2}\left(2n+\theta^*\alpha-n^2\theta^*-n^2\alpha+2n^2+2n\theta^*\alpha+1\right),$

As $\frac{1}{2n^2}\frac{\Delta_E}{(\alpha-1)(n+1)^2} < 0$, $\frac{dP_G^{mn*}}{dn} < 0$ if $\left(2n+\theta^*\alpha-n^2\theta^*-n^2\alpha+2n^2+2n\theta^*\alpha+1\right) > 0$ To check the sign of the previous expression, let us reconsider it by collecting $\theta^*\alpha$ and n^2 : $1+2n+\theta^*\alpha(1-2n)+n^2(2-\theta^*-\alpha) > 0$. As $(1-2n) < 0$, then $(1+2n) > (1-2n)$ and being $\theta^*\alpha < 1$, $\theta^*\alpha(1-2n) < (1-2n)$, therefore $(1+2n) > \theta^*\alpha(1-2n)$. As $n^2(2-\theta^*-\alpha) > 0$, ve can definetly state that $1+2n+\theta^*\alpha(1-2n)+n^2(2-\theta^*-\alpha) > 0$, that implies $\frac{dP_G^{mn*}}{dn} < 0$.

We show now that P_B^{mn*} increases and P_G^{mn*} decreases with an increase of θ^*:

$\frac{dP_B^{mn*}}{d\theta^*} = \frac{d(\frac{\Delta_E(1+n\theta^*+\alpha(n-\theta^*))}{2n(1-\alpha)})}{d\theta^*} = -\frac{1}{2n}\frac{\Delta_E}{\alpha-1}(n-\alpha) > 0$

$\frac{dP_G^{mn*}}{d\theta^*} = \frac{d(\frac{1}{1+n}\frac{\Delta_E(2n+1-n\theta^*-\alpha(n-\theta^*))}{(2n(1-\alpha))})}{d\theta^*} = \frac{1}{2n}\frac{\Delta_E}{\alpha-1}\frac{n-\alpha}{n+1} < 0$

Let us move now to equilibrium demands, to show firstly that $D_B^{mn*} < D_G^{mn*}$, i.e.$\frac{1+n\theta^*+\alpha(1-\theta^*)}{2(n+1)} < \frac{2n+1-n\theta^*-\alpha(1-\theta^*)}{2(n+1)}$. By simple inspection we can simplify the inequality to get: $1+n\theta^*+\alpha(1-\theta^*)-2n-1+n\theta^*+\alpha(1-\theta^*) < 0$ that reduces to:

$$n\theta^*+\alpha(1-\theta^*)-n < 0$$

so that we have to check if $n\theta^*+\alpha(1-\theta^*)-n < 0$ or $n\theta^*+\alpha-\alpha\theta^* < n$. As $\alpha\theta^* < \alpha$, then $0 < (\alpha-\alpha\theta^*) < 1$. Moreover $n\theta^* < n$ and being $n \geq 2$, it must be: $n\theta^*+(\alpha-\alpha\theta^*) < n$ QED.

In what follows we show that D_B^{mn*} increases with α and θ^* and decreases with an increase in n. D_G^{mn*}decreases with an increase of α and θ^* and increases with n. By inspection of the equilibrium demands expressions, shown above, it is clear that D_B^{mn*} increases with α and that D_G^{mn*} decreases with an increase of α. Below, we show the effect of an increase of n and θ^*, firstly on $D_B^{mn*}$and then on D_G^{mn*}:

$\frac{dD_B^{mn*}}{dn} = \frac{d(\frac{1+n\theta^*+\alpha(1-\theta^*)}{2(n+1)})}{dn} = \frac{1}{2}(\theta^*-1)\frac{\alpha+1}{(n+1)^2} < 0$

$\frac{dD_B^{mn*}}{d\theta^*} = \frac{d(\frac{1+n\theta^*+\alpha(1-\theta^*)}{2(n+1)})}{d\theta^*} = (n-\alpha)/2(n+1) > 0$

$\frac{dD_G^{mn*}}{dn} = \frac{d(\frac{2n+1-n\theta^*-\alpha(1-\theta^*)}{2(n+1)})}{dn} = -\frac{1}{2}(\theta^*-1)\frac{\alpha+1}{(n+1)^2} > 0$

$\frac{dD_G^{mn*}}{d\theta^*} = \frac{d(\frac{(2n+1-n\theta^*-\alpha(1-\theta^*))}{2(n+1)})}{d\theta^*} = (\alpha-n)/2(n+1) < 0$

■

Proof. of Proposition 6

A first mover advantage, implies the following inequality concerning equilibrium profits $\Pi_B^{mn*} > n\Pi_G^{mn*}$:

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

By simple inspection, and resorting to the square root simplification, the inequality becomes:

$$\frac{(1+n\theta^*+\alpha(1-\theta^*))}{\sqrt[2]{4n(n+1)}}-\frac{(2n+1-n\theta^*-\alpha(1-\theta^*))}{2n(n+1)}>0$$

By expanding the above expression, and then collecting $\sqrt{n\,(n+1)}$ in the polynomial, we obtain:

$$\frac{1}{2n\,(n+1)}(\alpha-2n+n\theta^*-\theta^*\alpha+(\alpha+n\theta^*-\theta^*\alpha+1)\sqrt{n\,(n+1)}-1)>0$$

Moreover, by collecting θ^* into the expression in brackets, we get:

$$\frac{1}{2n\,(n+1)}((1-\theta^*)\alpha+n(\theta^*-2)+(\alpha+\theta^*(n-\alpha)+1)\sqrt{n\,(n+1)}-1)>0$$

By moving $2n$ from the LHS to the RHS we obtain:

$$\frac{1}{2n\,(n+1)}((1-\theta^*)\alpha+n\theta^*+(\alpha+\theta^*(n-\alpha)+1)\sqrt{n\,(n+1)}-1)>2n$$

By dividing for $2n$ both the LHS and the RHS of the inequality, we get

$$\frac{1}{4n^2\,(n+1)}\left[(1-\theta^*)\alpha+(\alpha(1-\theta^*)+\theta^*n+1)\sqrt{n\,(n+1)})+n\theta-2\right]>0$$

As the denominator is positive, also the expression included into square brackets should be positive to get a first mover advantage. Except for -2, all terms included in the square brackets are positive. Therefore, we must check if:

$$(1-\theta^*)\alpha+(\alpha(1-\theta^*)+\theta^*n+1)\sqrt{n\,(n+1)})+n\theta^*>2$$

To see if the last inequality is verified, we can consider the lowest number of new entrants in an oligopolistic equilibrium, i.e., $n=2$. If the inequality holds for $n=2$, it will also hold for $n>2$. . By substitution of $n=2$ just into the expression within brackets, we obtain $(\alpha(1-\theta^*)+\theta^*2+1)\sqrt{6})=(\alpha(1-\theta^*)+\theta^*2+1)\,2.45)$. As $2.45+\theta^*4.45+2.45\alpha(1-\theta^*)>2$, even more so $(1-\theta^*)\alpha+2\theta^*+2.45+\theta^*4.45+2.45\alpha(1-\theta^*)>2$

■