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# AN ECONOMIC ANALYSIS OF THE GENERIC COMPETITION PARADOX IN THE PHARMACEUTICAL MARKET: THE ROLE OF PHYSICIAN'S PRESCRIPTION DECISION

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**Abstract** The objective of this paper is to provide a game theoretic model explaining the generic competition paradox that demonstrates an increase of brand-name drug price in response to generic entry. In the context of a two-stage model with the physician determining whether patients receive either brand-name, or generic drugs, or none, the paper shows that there exist conditions under which the price of brand-name drugs increases following the entry of generic drugs. The generic competition paradox is shown to be more likely to occur when the entire market is served, the marginal cost of production is high, the number of firms of generics is low, the difference in perceived qualities between brand-name and generic drugs is large, the amount of insurance coverage is high, and the reduction in co-payment a patient is entitled to if he/she buys generic drugs as opposed to brand-name drugs is low.

**Key words** pharmaceutical prescriptions, brand-name drug, generic entry, generic competition paradox

## 1 Introduction

In the pharmaceutical market, drug firms apply for patents in order to protect their intellectual property rights. After the patents on brand-name drugs expire, firms can then enter the market and produce generic goods, which are manufactured with the same molecules as the brand-name drugs. One would expect that entry of generics in the market would enhance competition and, consequently, lower the prices for the original brand-name drugs.

Wagner and Duffy[1988] and Grabowski and Vernon[1992] show, however, that substantial price increases for brand-name drugs are associated with large reductions in the prices of generic drugs as entry occurs, which is known as the generic competition paradox (Scherer[1993]). Frank and Salkever[1992] is the first paper modelizing the price increase of the branded good when the generic drug enters in the pharmaceutical market. They develop a market segmentation model based on the persistency of physicians' prescription patterns, explaining strategic pricing of brand name products after generic entry. They show that entry of generics did not completely enhance price competition as only price-sensitive patients shift to generics, while price-insensitive “loyal” patients keep on buying only brand-name products even in the presence of a cheaper generic drug.

In Ferrara and Kong[2008], a theoretical model is developed that explains the generic competition paradox without relying on the assumption of brand loyalty but recognizing that consumers differ in their insurance coverage and that physicians are likely to take these differences into account when prescribing drugs.

In our paper, we extend Ferrara and Kong[2008]. Our treatment differs on two points. On one hand, we set up a demand system with the physician determining whether patients receive either one unit of brand-name, or one unit of generic drugs, or not to buy any drug at all, so that the demand for the drug is induced by the physician that prescribe the medication. We follow a demand function employed in Hellerstein[1998] and Miyamoto[2006] focusing on the role played by physician prescription behavior. On the other hand, patients are heterogeneous in their tastes for quality rather than in their insurance coverage, contrary to Ferrara and Kong[2008].

## 2 The model

In this paper, the pharmaceutical market is characterized by two products (the brand-name drug, produced by a single incumbent firm, and its generic substitute, produced by $n$ quantity-competing firms considering entry), the physician and consumers (or patients). The two drugs are substitutes and the physician has to prescribe one drug, the other one or none for each patient. Patients have the same utility function however they differ in their tastes, which is represented by parameter $\theta$, uniformly distributed over the interval [0, 1]. Specifically, $\theta$ denotes patients' taste for drug "perceived" quality. More precisely, when the brand-name drug is prescribed, utility function derived by a patient $\theta$ from being prescribed and buying the drug of quality $q_b$ and price $p_b$ is given by $\theta q_b - \beta p_b$, where $\beta$ represents the insurance factor or a parameter that captures the amount of insurance coverage. Specifically, $\beta \in (0,1)$ denotes the fraction of expenditures on drugs a patient pays out of his/her pocket. To account for a differential deductible system whereby insurance companies provide a lower deductible or co-payment when generic drugs are purchased, the parameter $t \in (0,1)$ is introduced to capture the reduction in deductible or co-payment a patient is entitled to if he/she buys generic drugs as opposed to brand-name drugs. When the generic drugs become available, utility function derived by a patient $\theta$ from being prescribed and consuming the drug of quality $q_g$ and price $p_g$ is given by $\theta q_g - (1-t)\beta p_g$, where $q_g < q_b$ by assumption.

The physician acts as the agent for their patients, who writes down the name of the form of the drug (generic or brand-name) being prescribed. The physician cares about two things: patient utility, and profits received from the drug prescriptions. We assume that the drug firm and the physician bargain and agree to share the profit margin $p_i - c$ $(i = b, g)$ of the drug: the firm keeps $(1-\gamma_i)(p_i - c)$ while the physician gets $\gamma_i(p_i - c)$, with $\gamma_i \in (0,1)$, where $c$ represents a constant marginal cost of production.

The utility function of the physician prescribing the brand-name drug and the generic drug for the patient of type $\theta$ are given by

$$u_b = \alpha(\theta q_b - \beta p_b) + (1-\alpha)\gamma_b(p_b - c),\ \ u_g = \alpha(\theta q_g - (1-t)\beta p_g) + (1-\alpha)\gamma_g(p_g - c),$$

where $\alpha \in [0,1]$ indicates the proportion of the patient's utility that is internalized by the physician. If $\alpha = 1$, the physician internalizes the full utility to the patient. If $\alpha = 0$, the physician does not care about the patient's preferences at all. Patients are segmented by the physician based on their taste for quality; in particular, when both the brand-name drug and the generic drug are available, the physician prescribes the generic drug for patients with lower $\theta$, while the brand-name drug for patients with higher $\theta$. Let denote $\tilde{\theta}$ as the value of the taste parameter that segments the market between patients who consume the brand-name drug ($\tilde{\theta} \le \theta \le 1$) and patients who consume the generic drug. Moreover, denote as $\hat{\theta}$ the type of patient that segments the market between patients who consume the generic drug ($\hat{\theta} \le \theta \le \tilde{\theta}$) and patients not consuming any of the drugs. The physician does not prescribe any drug for patients whose types are in the interval $[0, \hat{\theta}]$.

In the absence of generic entry, the utility of the physician prescribing the brand-name drug is given by

$$U = \int_{\tilde{\theta}}^{1} [\alpha(\theta q_b - \beta p_b) + (1-\alpha)\gamma_b(p_b - c)] d\theta .$$

Utility maximization with respect to $\tilde{\theta}$ yields $\tilde{\theta} = [\{\alpha\beta - (1-\alpha)\gamma_b\} p_b + c(1-\alpha)\gamma_b]/(\alpha q_b)$. The market demand for the brand-name drug is given by $X_b = 1 - \tilde{\theta}$. The brand-name firm's profit maximization task is the selection of $p_b$ so as to maximize $\pi_b = (1-\gamma_b)(p_b - c)X_b$, and the monopolist charges according to $p_b^{ng} = \dfrac{\alpha(q_b - \beta c)}{2\{\alpha\beta - (1-\alpha)\gamma_b\}} + c$, and supplies according to $X_b = \dfrac{1}{2} - \dfrac{\beta c}{2 q_b}$, where the superscript $ng$ serves to indicate that there are no generic drugs.

### 2.1 A two-stage game with generic entry

When generic drugs become available, the physician prescribes the brand-name drug for patients of higher type; however, the generic drug is prescribed for patients of lower type. The benefit to the physician from prescribing both type of drugs is

$$U=\int_{\hat{\theta}}^{\tilde{\theta}}[\alpha(\theta q_g-(1-t)\beta p_g)+(1-\alpha)\gamma_g(p_g-c)]d\theta+\int_{\tilde{\theta}}^{1}[\alpha(\theta q_b-\beta p_b)+(1-\alpha)\gamma_b(p_b-c)]d\theta .$$

Utility maximization with respect to $\tilde{\theta}$ and $\hat{\theta}$ yields the threshold values of $\theta$;

$$\tilde{\theta}=\frac{\{\alpha\beta-(1-\alpha)\gamma_b\}p_b-\{\alpha\beta(1-t)-(1-\alpha)\gamma_g\}p_g-(1-\alpha)(\gamma_g-\gamma_b)c}{\alpha(q_b-q_g)},$$

$$\hat{\theta}=\frac{\{\alpha\beta(1-t)-(1-\alpha)\gamma_g\}p_g+(1-\alpha)\gamma_g c}{\alpha q_g}.$$

We assume that $\alpha\beta(1-t)-(1-\alpha)\gamma_i>0$ to ensure that demand functions are well defined. Demands for brand-name and generic drugs are

$$X_b=1-\tilde{\theta}=1-\frac{\{\alpha\beta-(1-\alpha)\gamma_b\}p_b-\{\alpha\beta(1-t)-(1-\alpha)\gamma_g\}p_g-(1-\alpha)(\gamma_g-\gamma_b)c}{\alpha(q_b-q_g)}, \quad (1)$$

$$X_g=\tilde{\theta}-\hat{\theta}=\frac{-\{\alpha\beta(1-t)-(1-\alpha)\gamma_g\}q_b p_g+\{\alpha\beta-(1-\alpha)\gamma_b\}q_g p_b-(1-\alpha)c(\gamma_g q_b-\gamma_b q_g)}{\alpha q_g(q_b-q_g)}.$$

(2)

The timing of the game is the following: in the first stage the brand-name firm sets price, in the second stage $n$ generic firms competing in quantity, taking the price of the brand-name product as given, decide their quantities. The equilibrium for this game will be found by backward induction. The profit of firm $k$ (for $k=1,\ldots,n$) is then $\pi_g^k=(1-\gamma_g)(p_g-c)x_g^k$, where $p_g$ is computed from Eq. (2) and can be expressed as

$$p_g=\frac{\{\alpha\beta-(1-\alpha)\gamma_b\}q_g p_b-\alpha q_g(q_b-q_g)X_g-(1-\alpha)c(\gamma_g q_b-\gamma_b q_g)}{\{\alpha\beta(1-t)-(1-\alpha)\gamma_g\}q_b}.$$

In order to maximize its profit, firm $k$ thus chooses $x_g^k$ such that

$$p_g^k-c=\frac{\alpha(q_b-q_g)q_g}{\{\alpha\beta(1-t)-(1-\alpha)\gamma_g\}q_b}x_g^k .$$

As the $n$ firms are identical, they produce the same equilibrium quantity, so that $x_g^k=X_g^s/n$, where $X_g^s$ denotes the market supply of generic drugs. Upon substitution for $x_g^k=X_g^s/n$, the equilibrium price of generic drugs is given by

$$p_g=\frac{\{\alpha\beta-(1-\alpha)\gamma_b\}q_g p_b-(1-\alpha)c(\gamma_g q_b-\gamma_b q_g)}{(n+1)\{\alpha\beta(1-t)-(1-\alpha)\gamma_g\}q_b}+\frac{nc}{n+1}. \quad (3)$$

In the first stage of the game, the brand-name producer sets the price. Incorporating $p_g$ from Eq. (3) into Eq. (1) yields

$$X_b=1-\frac{\{\alpha\beta-(1-\alpha)\gamma_b\}[(n+1)q_b-q_g]p_b+[(1-\alpha)\gamma_b\{(n+1)q_b-q_g\}-\alpha\beta(1-t)nq_b]c}{\alpha(q_b-q_g)(n+1)q_b},$$

so that the inverse demand for brand-name drugs is given by

$$p_b=\frac{\alpha(q_b-q_g)(n+1)q_b(1-X_b)+[\alpha\beta(1-t)nq_b-(1-\alpha)\gamma_b\{(n+1)q_b-q_g\}]c}{\{\alpha\beta-(1-\alpha)\gamma_b\}[(n+1)q_b-q_g]}.$$

The objective of the brand-name producer is to maximize:

$$\pi_b=(1-\gamma_b)(p_b-c)X_b=(1-\gamma_b)\left[\frac{\alpha(q_b-q_g)(n+1)q_b(1-X_b)-\alpha\beta[tq_b n+(q_b-q_g)]c}{\{\alpha\beta-(1-\alpha)\gamma_b\}[(n+1)q_b-q_g]}\right]X_b .$$

The brand-name drug producer chooses its quantity by equating marginal revenue to marginal cost so that

$$X_b = \frac{1}{2} - \frac{\beta[tq_b n + (q_b - q_g)]c}{2(q_b - q_g)(n+1)q_b} \text{ and } p_b^g = \frac{\alpha(q_b - q_g)(n+1)q_b - \alpha\beta c(tnq_b + q_b - q_g)}{2\{\alpha\beta - (1-\alpha)\gamma_b\}[(n+1)q_b - q_g]} + c,$$

where the superscript $g$ signifies the presence of generic drugs.

A comparison of the brand-name drug prices prior to and after generic entry ( $p_b^{ng}$ and $p_b^g$ , respectively) shows that $p_b^g - p_b^{ng} = -\beta ctnq_b / [2\{\alpha\beta - (1-\alpha)\gamma_b\}\{(n+1)q_b - q_g\}] < 0$. This yields the following result:

**Proposition 1**: *The brand-name drug price after generic entry is below the price prior to generic entry*, *i. e.* ,

$p_b^g < p_b^{ng}$ .

We can see that under a scenario with partial market coverage the price of brand-name drugs would not increase following the entry of generic drugs. Therefore, the paradox does not arise from the above settings. However, the level of market coverage, in turn, has an important impact on the generic competition paradox. Also in presence of a co-payment reimbursement, in fact, depending on market coverage, competition might be tighter or softer. In the next subsection, we investigate how exogenous full market coverage affects the paradox.

**2.2 Exogenous Full Market Coverage**

As, by the full market coverage assumption, all patients are prescribed one unit of the drug, the utility of the physician is given by

$$U = \int_0^{\tilde{\theta}} [\alpha(\theta q_g - (1-t)\beta p_g) + (1-\alpha)\gamma_g(p_g - c)]d\theta + \int_{\tilde{\theta}}^1 [\alpha(\theta q_b - \beta p_b) + (1-\alpha)\gamma_b(p_b - c)]d\theta. \quad (4)$$

The utility-maximizing physician maximizes (4) with respect to $\tilde{\theta}$. From the first-order conditions, the optimal levels of $\tilde{\theta}$ is

$$\tilde{\theta} = \frac{\{\alpha\beta - (1-\alpha)\gamma_b\}p_b - \{\alpha(1-t)\beta - (1-\alpha)\gamma_g\}p_g - (1-\alpha)(\gamma_g - \gamma_b)c}{\alpha(q_b - q_g)}.$$

We then get the market shares;

$$X_b = 1 - \tilde{\theta} = 1 - \frac{\{\alpha\beta - (1-\alpha)\gamma_b\}p_b - \{\alpha(1-t)\beta - (1-\alpha)\gamma_g\}p_g - (1-\alpha)(\gamma_g - \gamma_b)c}{\alpha(q_b - q_g)},$$

$$X_g = \tilde{\theta} = \frac{\{\alpha\beta - (1-\alpha)\gamma_b\}p_b - \{\alpha(1-t)\beta - (1-\alpha)\gamma_g\}p_g - (1-\alpha)(\gamma_g - \gamma_b)c}{\alpha(q_b - q_g)}.$$

Proceeding in the same way as in the previous section, we have

$$p_b^g = \frac{\alpha(q_b - q_g)(n+1)}{2n\{\alpha\beta - (1-\alpha)\gamma_b\}} + \frac{2\{\alpha(1-t)\beta - (1-\alpha)\gamma_b\} + t\alpha\beta}{2\{\alpha\beta - (1-\alpha)\gamma_b\}}c.$$

A comparison of the brand-name drug prices prior to and after generic entry ( $p_b^{ng}$ and $p_b^g$ , respectively) shows that full market coverage regulation could lead to the generic competition paradox. More precisely, there exist conditions under which the price of brand-name drugs increases following generic market entry (i.e., $p_b^g > p_b^{ng}$ ), if

$$q_b > (n+1)q_g - (1-t)\beta cn. \quad (5)$$

**Proposition 2**: *Under a full coverage regulation, the generic competition paradox will be occur if and only if*

$q_b > (n+1)q_g - (1-t)\beta cn$ .

As $\theta q_g - (1-t)\beta p_g > 0$ , $\theta < 1$, and $p_g > c$ in the equilibrium, so that $q_g - (1-t)\beta c > 0$, then the right-hand side of Eq. (5) , denoted by $N$, $N > (n+1)(1-t)\beta c - (1-t)\beta cn = (1-t)\beta c > 0$. It can be shown that $dN/dq_g = n+1 > 0$, $dN/dt = \beta cn > 0$, and $dN/dn = q_g - (1-t)\beta c > 0$, so that lower values of $n$ , $t$ , and $q_g$

make the paradox more likely to result, and $dN/dc = -(1-t)\beta n < 0$, and $dN/d\beta = -(1-t)cn < 0$, so that higher values of $\beta$ and $c$ make the paradox more likely to result. The conditions of Eq. (5) are affected neither by $\alpha$ nor by $\gamma_i$. Therefore, the paradox will be independent from both of these variables.

## 3 Conclusion

In this paper, a model is developed that explains the generic paradox, in which there is a physician determining whether patients receive either brand-name, or generic drugs, or none. The main question considered is under what conditions the price of brand-name drugs rises after generic entry. We found that the market coverage is the essential determinant in this problem. Our specific findings are that when the entire market is served, the marginal cost of production is high, the number of firms of generics is low, the difference in perceived qualities between brand-name and generic drugs is large, the amount of insurance coverage is high, and the reduction in co-payment when a patient buys generic drugs as opposed to brand-name drugs is low, the paradox is more likely to occur.

In this paper, we have focused on the drug market where the brand-name firm, threatened by the generic entry, accommodates entry. It would be interesting for future research to analyze the possibility that the brand-name firm markets its own generic drug, called pseudo-generic drug, before or after the generic firm entry.

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