Generic-Branded Drug Competition and the Price for Pharmaceuticals: New Evidence from Public Procurement Auctions in Brazil*

Paulo Arvate† Klenio Barbosa‡ Dante Gambardella§

February 17, 2013

Abstract

This paper studies the effects of generic drug entry on bidding behavior of drug suppliers in procurement auctions, and the consequences on acquisition prices for pharmaceuticals by public bodies. Using a data set on procurement auctions for pharmaceuticals organized by Brazilian public bodies, we surprisingly find no statistically difference between bids and prices paid for generic and branded drugs. On the other hand, suppliers of branded drugs lower their bidding price in auctions in which there exists a supplier of generics. These findings explain why we find that the presence of any supplier of generic drugs in a tendering reduces the price paid for pharmaceuticals by 7 percent. This evidence indicates that generic competition affects branded supplier's behavior in public procurement auctions differently from other markets.

Keywords: Generic-Branded Competition; Procurement Auctions; Pharmaceuticals.
JEL classification: H51; K32; I18; L1; L65.

*We would like to thank Enlinson Mattos for insightful suggestions. We are also grateful to all participants at the Annual Conference of the Inter-American Network on Government Procurement - INGP (Panama) for very helpful comments. We are also grateful to Luis Fernando Azevedo and Simone Shiine for their research assistance, and Rita Joyanovic and Regina Wong from the government of Sao Paulo's State for helpful information on BEC procurement procedure rules. The authors gratefully acknowledges the Research Grant N. 25000.180692/2011-52 granted by Samaritano Hospital/SUS/Ministry of Health. The usual disclaimer applies.

†School of Business and Center for Applied Microeconometrics (C-Micro), Getulio Vargas Foundation, e-mail: paulo.arvate@fgv.br

‡Sao Paulo School of Economics - FGV. E-mail address: klenio.barbosa@fgv.br

§School of Public Health (University of Sao Paulo) and Samaritano Hospital, e-mail: dante.gambardella@samaritano.org.br

1 Introduction

Public and private spending on pharmaceuticals account for a substantial fraction of the total expenses of health care in developed and developing countries (WHO, 2000; OECD, 2011). High consumption of medicines, large R&D costs and oligopolistic market structure are the main factors explaining pharmaceutical expenditure and thus overall heath expenditure (Berndt, 2002). Indeed, several worldwide public policies involving pharmaceuticals have attempted to stimulate fierce market competition for off-patent drugs in order to decrease price and contain the high and increasing expending on prescription drugs. Accordingly, many countries have regulated and eased the entry of generics in the pharmaceutical market, thereby making an increase in the number of substitute for branded drugs (Scherer, 1993).

Many empirical studies investigate the price and volume response of branded products to generic entry in pharmacy and hospital markets (Caves et. al, 1991; Grabowski and Vernon, 1992; and Frank and Salkever, 1997). Others look at how government reimbursement rules based on the lowest-cost qualified generic substitutes affect generic substitution and public health expenditure (McRae and Tapon, 1985; Gorecki, 1986, Dranove, 1989; Moore and Newman, 1993, and Vandoros and Kanavos, 2013). However, the literature is silent about the influence of generics entry in government procurement markets, which represent a large fraction of public health expenditures and pharmaceutical market in many countries.[1]

In this paper, we study the effects of the presence of generic substitutes in procurement auctions on generic and branded drug suppliers bidding behavior, and the consequences on acquisition prices for pharmaceuticals by public bodies. From the best of our knowledge, it is the first work in the literature to examine the impacts of generic entry on procurement markets. It is interesting to investigate generic-branded competition in auctions for several reasons. First, auction-based mechanisms to acquire off-patent drugs have been widely used by public hospitals and health centers in Europe, Latin America and Africa, covering up to 25 % of all purchased medicines in some countries (Vogel and Stephens, 1989; Leopold et al., 2008; Carone et. al, 2012).[2] Second, in procurement auctions, differently from other pharmaceutical markets, buyers are only price-driven. Therefore, drug suppliers either engage in an intense price auction competition to serve buyers, or let it for the ones who are more willing to cut prices. In other markets, as pharmacy and retail ones, buyers have different

[1] Public hospitals and ambulatory cares acquire pharmaceuticals to be used in inpatient medical treatments, whereas public pharmacies and health agencies often distribute gratuitously or sell them to outpatients at subsidized prices in developing countries (Foster, 1991; Kremer, 2002).

[2] Kanavos et al. (2009) document that some health insurance companies in Europe have started to use competitive bidding to select providers and determine reimbursement prices for pharmaceuticals.

price-sensitivities, varying in the values that they attach to differences in drug characteristics (Scherer, 2000; Berndt, 2002). Consequently, suppliers compete also in other dimensions, like adverting, physical loyalty, packing and others, what leads to the well documented market segmentation phenomenon in pharmaceutical markets (Scherer, 1996; and Frank and Salkever, 1997).

Particularly, this paper tests two hypotheses. First, it examines empirically whether there exists different bidding behavior between generic and branded pharmaceutical suppliers, and if the prices paid by public bodies for them are unlike. Secondly, it looks at how the presence of a generic supplier in a competitive bidding affects generics and brandeds' bids, thereby identifying the channel through which generic entry affects the price paid for drugs. This empirical investigation is important because it potentially sheds light on the impact of generic competition on branded drug suppliers' pricing strategy in auction-based markets for pharmaceuticals.

In order to identify the patterns displayed by bids and prices in procurement markets, we perform an econometric analysis of a micro database on auctions for pharmaceuticals organized by public bodies in Brazil. The database contains information on procurement transactions for public hospitals, health centers and agencies administered by the State of Sao Paulo.[3] All these public bodies use a common electronic platform, namely BEC (*Bolsa Eletronica de Compras*), which manages all aspects of a procurement transaction. All the information about the procurement transactions is recorded in the BEC data warehouse. Every procurement contract in BEC is awarded by an auction-based mechanism. Besides information on prices paid, quantity purchased and bids, the data set provides full description and codification of each procured drug, information on the date of purchase, the awarding procedure, identification of all public bodies and bidders involving in each tendering. In addition, we can identify whether the bidder is offering to supply a generic or a branded drug in a procurement transaction. In total, we have data on 64,752 procurement transactions between 2008 and 2012 (almost 13,000 transactions per year), through which was acquired 7,318 different drugs from several therapeutic classes.

Note that our empirical investigation relies on a transaction-based data, differently from previous studies. Past works (e.g., Caves et. al, 1991; Grabowski and Vernon, 1992; and Frank and Salkever, 1997) use product market-level or aggregate customer-level data on sales revenue and quantities sold, whose generic and branded drug prices are computed as average

[3]Sao Paulo is the richest state of Brazil, and it has the largest population, industrial complex, and economic production in the country.

revenue. Our data allows us to control for observable and unobservable characteristics of each procurement transaction in the estimations, which could not be done in previous works.

Surprisingly, we do not find any statistically difference between generic and branded supplier's bids. At the same time, the regressions suggest that acquisition prices for generic and branded drugs are statistically identical. This suggests that both types of drugs offer the same price in procurement markets. On the other hand, estimations show that the presence of any supplier of generics in a tendering makes branded competitors to decrease their bids by 3 percent in average. It indicates that generic entry induces branded suppliers to reduce price in competitive bidding. Looking at the acquisition prices (i.e., winning bids), we find that the price paid for pharmaceuticals drops by 7 percent when there exists a supplier of generics in the auction. These results are robust to different econometric specifications and controls.

Our results are important for a variety of reasons. First, previous findings indicate that generic prices are lower than branded ones. For instance, Caves et. al (1991) show that generic producers enter the market quoting prices much lower than those of their branded competitors in pharmacy and hospital markets. Differently, our paper show there is no price difference between generic and branded drugs in procurement auctions, providing new evidence on the pattern of price competition on pharmaceutical markets. Second, it documents a novel effect of generic entry on branded drug prices. Grabowski and Vernon (1992) and Frank and Salkever (1997) indicate that branded drug prices rise when generic competition materialize in retail markets. On the contrary, we find that branded suppliers reduce price when competing with generic ones.[4] Third, one may think that branded suppliers would prefer to leave procurement markets rather than cutting down prices in competitive auctions. Instead, we observe the exactly opposite behavior: suppliers of branded drugs are more aggressive in auctions in which there exists any supplier of generics. Given the high volume of public acquisition of pharmaceuticals, they probably reduce their price-cost margin in order to increase volume, therefore maximizing profits.

The paper is organized as follows. Section 2 describes the institutional aspects of the 1999 Generic Law in Brazil, and the Brazilian public procurement legislation for acquisition of pharmaceuticals. Section 3 presents the econometric model, explains the empirical strategy. Section 4 describes our data base and presents some descriptive statistics. In Section 5 we present the econometric results, showing estimations that describe the bidding behavior of

[4]Previous studies, as Fiuza et al. (2003), Nishijima et al. (2003) and Lopes (2009), estimate the impact of generic drug entry and of other substitutes for off-patent drug on Brazilian private wholesale market for pharmaceuticals. Their findings show that the pattern displayed by branded prices after generic entry in the U.S. markets, documented by Frank and Salkever, is also prevalent in Brazil.

drug suppliers and the effect of generic substitutes on acquisition prices. Section 6 concludes. Tables and additional background information are in the appendix.

2 Institutional Background

This section provides background information on generic entry in the Brazilian drug market and describes the key institutional aspects of public procurement for pharmaceuticals in Brazil.

2.1 Generic Drugs in Brazil

Generic drug entry in the Brazilian market is regulated by the 1999 Generic Drug Act (Law 9787), which eased the procedures for approving generic substitutes for drugs whose patents had expired.[5] Accordingly, a new generic substitute must show that its active ingredient is chemical identical to a branded-approved drug, document bioavailability and pharmaceutical equivalence with the branded product, and compliance with sound manufacturing provisions required by Anvisa.[6] Once a generic drug is developed and the Anvisa approval has been obtained, a manufacturer is authorized to engage in a large-scale production of the generic and to sell it to wholesalers, or to directly to pharmacies and governments.

In fact, until the 1999 Generic Drug Act there were no authentic generics in Brazil. The only existing substitutes for off-patent pharmaceuticals were the *similar* drugs. The registration of similar drugs at Anvisa only required safety tests, absolute effectiveness, and full disclosure of active ingredient below the brand name in the market package. Since no comparisons were undertaken between the similars and the pioneer drugs, Brazilian doctors usually do not consider them as interchangeable drugs (Fiuza and Caballero, 2009).[7]

Genuine generic drug were therefore launched in 2000, when the first applications were approved. Fiuza and Caballero (2009) document the evolution of generic registration and entry in Brazil after 2000, and show that has occurred an substantial raise in the number of Anvisa approvals and entries of generic drugs and manufacturers since then. For instance,

[5]The current patent protection legislation for pharmaceuticals in Brazil dates from 1996, when the Trade Related Intellectual Property System (TRIPS) agreement was ratified by the Brazilian Congress in the 1996 Patent Act (Law 9279). This legislation provides market exclusivity rights for up to 20 years from the date the patent application was filed. Pharmaceutical patents are granted only after registration at Anvisa - equivalent agency to U.S. FDA in Brazil - is cleared (Law 10,196 from 2001).

[6]Anvisa is the National Health Surveillance Agency in Brazil. It is responsible for protecting and promoting public health through the regulation and supervision of pharmaceuticals, among other products.

[7]Anvisa (2002) considers that two or more drugs are interchangeable if they are pharmaceutically equivalent (the same active ingredient, strength, dosage form, route of administration, and inactive ingredients) and bioequivalent (the same rate and extent of absorption into the body).

they find that the number generics in the Brazilian market has increased from 135 in 2000 to 2,245 different drugs in 2007. Consequently, generic drugs have achieved an important market participation in Brazil, accounting for 65 percent of volume market share in the off-patent market in 2008 (IMS, 2009).[8]

2.2 Public Procurement for Pharmaceuticals in Brazil

Public Procurement Legislation. All public bodies in Brazil (national, state and local) are subject to the 1993 Public Procurement Act (Law 8,666), which delineates procurement procedures for public acquisitions of goods, works and services (i.e., inputs). Accordingly, before searching for an input supplier, public bodies have to come up with a clear description of their needs, including detailed specification of the input, quantity, quality, place and delivery time. In addition, they have to make all this information publicly available in an official gazette. That legislation also establishes that all procurement of public inputs must be based on the value for money, which is a combination of whole life costs and quality.[9]

For acquisition of standardized good and services, in particular, the Procurement Act determines that public bodies must rely on auction-based mechanisms to select and award a procurement contract to the winner.[10],[11] Purchases of standardized inputs represent a large fraction of the total public procurement expenditure in Brazil, covering from simple common purchased products, as books and A4 papers, to more complex ones, as computers and off-patent pharmaceuticals.

According to the procurement legislation, public bodies can use either physical or electronic reverse auctions to purchase standardized inputs. Among the physical ones, the legislation has established several different auction mechanisms, going from open competitive bidding to invited bidders. The electronic reverse auctions are hold over the internet through official procurement platforms, in which any supplier is allowed to submit a bid. The most commonly used electronic auction formats are first-price sealed-bid auction, English auction, and two

[8]IMS (2009) makes a cross-country comparison with respect to utilization of generic medicines within off-patent markets. It shows that generic market share in Brazil is larger than in Australia, France and Spain, and lower than in Germany, U.K. and U.S..

[9]Dimitri (2012) argues that the value for money awarding rule can be interpreted as a multi-criteria approach where various dimensions of quality, as well as price, are considered to grant a procurement contract.

[10]In the procurement literature, summarized by Dimitri, Piga and Spagnolo (2006), such auction-based award mechanisms are namely competitive bidding or tendering.

[11]Direct purchase without competitive bidding occurs when competition is not possible, either because there is only one supplier, or because the goods can be provided with exclusivity by a single company (or representative office).

stage auction.[12]

Public bodies choose the awarding mechanism according to the monetary values involved in a procurement transaction. For instance, high value contracts must be acquired through open competitive bidding, while those of lower values can be acquired through invited bidders. Electronic auctions can be used for purchasing of standardized goods and services of any value.

Public Procurement in the State of Sao Paulo. In this paper we use a data on procurement auctions for pharmaceuticals organized by public bodies administered by the State of Sao Paulo. Sao Paulo is the richest state of Brazil, and it has the largest population, industrial complex, and economic production in the country. In the terms of health expenditure, Sao Paulo spends around 11 percent of the total public health expenditure in acquisition of pharmaceuticals, almost three times more than the national average (see Table 1 and 2).

Public bodies from Sao Paulo have to follow specific procurement procedures. For instance, they have to use a common electronic platform, namely BEC (*Bolsa Eletronica de Compras*), which manages all aspects of a procurement transaction. BEC is made up of several divisions, comprising several activities in the bidding and contracting process. All the information about the procurement transactions is recorded in the BEC data warehouse. BEC system also advertises the auction and publishes a tender document. The tender document contains a detailed description of each procurement transaction. All procurement transactions at BEC from 2008 to the present are free to download from BEC website.[13]

Every procurement contract at BEC is awarded by electronic reverse auctions, where bidders place offers. The auctions can be of two types: first-price sealed-bid auction or a two stage one. High value contracts are acquired through two stage auctions, whereas those of lower values are acquired through first-price sealed-bid auctions. In any of those two auctions, bidders offer an unit price to supply the total quantity described in the procurement contract. In Appendix A, one can find the sequence of events in those two types of auctions.

Public Acquisition of Pharmaceuticals in Sao Paulo-Brazil. Public hospitals, health agencies and centers in the State of Sao Paulo acquire prescription drugs to be used in inpatient medical treatments, to be distribute gratuitously or be sold to outpatients at subsidized prices in public pharmacies. They obtain prescription drugs, among other goods and services, in a

[12]There are two other awarding procedures which are used for other purposes: Contest and Standard Open Ascending Price Auction. Contest, for example, is used to award technical studies, scientific or art works, while Standard Auction is used for selling public assets.

[13]See http://www.bec.sp.gov.br.

decentralized way: Each public body acquires its own inputs.[14] Purchases are financed by an annual budget assigned to each public body by the public health funds.

All public bodies must use any of the auction-based mechanisms described above to acquire off-patent drugs. In procurement auctions for pharmaceuticals, suppliers bid for a very detailed contract of medicine supply, specifying the drug, the quantity, place and time schedule to delivery.

3 Econometric Model and Empirical Strategy

In order to study the effects of generic entry on acquisitions prices and on drug suppliers' bidding behavior in procurement auctions, this paper tests two sets of hypotheses.

The first set of hypotheses examines empirically whether there exists different bidding behavior between generic and branded pharmaceutical suppliers, and if the prices paid by public bodies for them are unlike. So, following the literature on empirical auctions and procurement (Porter and Zona, 1993, Jofre-Bonet and Pesendorfer, 2000), we use the next econometric equation to investigate those hypotheses:

$$\ln w_{ipbt} = Gen_{ib}\beta + X'_{ipbt}\alpha + g(N_{ipbt}, \gamma) + \delta_i + \phi_p + \theta_b + \lambda_t + u_{ipbt}, \tag{1}$$

where w_{ipbt} is the price for provision of a drug i to a public body p from a bidder/supplier b in the period t. In the case that we are investigating competitors bidding pattern, the variable of interest w_{ipbt} is firm's bid. Yet in the case of examining acquisition prices, that is unit price paid. The parameters δ_i, ϕ_p, θ_b and λ_t are, respectively, fixed effects for each drug, public body, bidder/supplier and time. X'_{ipbt} is a vector of observable variables of the procurement transaction that affects bids and prices. For instance, quantity purchased, distance between bidder/supplier to place to delivery, and other variables related to demand, production or logistic/transportation cost of each product i in a procurement transaction. Variable u_{ipbt} is a random variable which is not correlated to other regressors in equation (1) .

The function $g(N_{ipbt}, \gamma)$ captures the competition effect on the bidding process and on price paid, and it is expected that this relationship is negative: more competition leads to lower bids and price paid. The variable N_{ipbt} corresponds to the number of suppliers competing in

[14]The legislation permits public bodies to jointly acquire goods and services through pooled procurement (namely price registration system). Such arrangements have allowed public entities to attain potential gains of a bulk acquisition that would not be achieved in standard procurement. Barbosa (2013) and Barbosa and Fiuza (2011) describe the Brazilian pooled procurement system and study its advantages and costs.

a tendering for a drug i. As Rezende (2008) shows, in a selection mechanism such auction, the relationship between price paid and the number of competing suppliers is never linear. Iimi (2006) shows that quadratic and logarithm function capture quite well such competition effect on government price paid.

In the case that we use firms bid as a dependent variable in equation (1), Gen_{ib} is a dummy variable which assumes value equal to 1 if the bidder is offering to supply a generic drug in the tendering, and zero otherwise. Then, if we estimate β as a negative parameter, we can conclude that generic drug suppliers offer lower price than branded ones in procurement auctions. Yet in the case that we use price paid as a dependent variable in equation (1), the variable Gen_{ib} is a dummy which assumes value equal to 1 if the procurement contract was awarded to a supplier of a generic drug, and zero if it was awarded to a supplier of a branded drug. It refers to type of drug acquired by the public body: generic or branded. So, if we find that β is negative, then it means that the acquisition price of generics is lower than branded ones.

The second set of hypotheses looks at how the presence of a generic supplier in a competitive bidding affects generics and brandeds' bids, thereby identifying a potential channel through which generic entry may affect the price paid for drugs. We estimate the following econometric model to investigate those hypotheses:

$$\ln w_{ipbt} = GenIn_i\beta + X'_{ipbt}\alpha + g(N_{ipt}, \gamma) + \delta_i + \phi_p + \theta_b + \lambda_t + u_{ipbt}, \tag{2}$$

where w_{ipbt} is the price for provision of a drug. In the case that we are investigating bidding behavior of generic and branded drug supplier in the presence of a generic drug supplier in the competitive bidding, the variable of interest w_{ipbt} is generic/branded supplier's bid. When we want to examine whether acquisition prices for public bodies are affected by the presence of generics suppliers in the tendering, the variable of interest is unit price paid. The other variables are the same as in equation (1).

The only difference between equation (1) and (2) is the variable $GenIn_i$. In equation (2) $GenIn_i$ is a dummy variable which assumes value equal to 1 if there exists a bidder-competitor of a generic drug in the tendering, and zero otherwise. $GenIn_i$ is constructed to identify whether there exists any generic drug supplier in a competitive bidding. If we use generics/branded supplier's bid as a dependent variable in equation (2), and we estimate a negative β, then we may conclude that suppliers of generics/branded drugs lower their bidding price in auctions in which there exists a supplier of generics. Yet in the case we use price paid

as a dependent variable, and we find that β is negative, then that means that the presence of any supplier of generic drugs in a tendering reduces prices paid for pharmaceuticals.

4 Database

This paper uses a micro data on procurement auctions for pharmaceuticals organized by public bodies administered by the State of Sao Paulo, Brazil. In particular, our database contains information on procurement transactions for public hospitals, health agencies and ambulatory cares. These public bodies use a common electronic platform, denominated as BEC (*Bolsa Eletronica de Compras*), which manages all aspects of a procurement transaction. All the information about the procurement transactions is recorded in the BEC data warehouse, which is free to download from BEC website. Our data was obtained from this source.

Our observation is a procurement transaction for acquisition of a prescription drug. For each procurement transaction, we have information on all activities in the bidding and contracting process. Besides information on bids, acquisition price and quantity actually purchased, the data set also provides full description and codification of each procured drug, which is defined as an unique combination of active ingredient, form, concentration, number of units, and packing. That is the same dug definition used by Scott-Morton (1997). In addition, the database contains information on public body identification (buyer id), awarding procedure, tender and purchase dates, number of competitors (bidders), place and time schedule to delivery. This detailed data structure may allow one to perform an appropriate econometric analysis, and to ensure that the results are not driven by differences in product and procurement transaction characteristics.

This database, besides being interesting by itself as a source of such an amount of available information, has another peculiarity which makes it singular for investigating the effects of the generic drug entry on drug supplier's bidding behavior and on acquisition prices: There is full identification of each bidder taking part in the auction (taxpayer number, location, size category, industry - manufacturer, wholesaler or retailers - legal status, etc.), including the brand-name drug that every bidder is offering to supply. Consequently, we can identify whether the bidder is offering to supply a generic or a branded drug in a procurement transaction. This information is crucial to examine differences in bidding behavior between generic and branded suppliers, and how the presence of a generic supplier in a competitive bidding affects generics and brandeds' bids.

Table 3 to 6 present some descriptive statistics of the data set. According to Table 3, the

sample contains information on 64,752 procurement transactions, spanning the period from 2008 and 2012 (almost 13,000 transactions per year). It consists of all the transactions for acquisition of pharmaceuticals which are free to download from BEC website. Along this period, 7,318 different drugs from several therapeutic classes were procured by 270 public bodies through first price and two stage auctions. The drugs were purchased from 352 different drug suppliers that delivered their products in public hospitals, ambulatory cares and health agencies located in 64 different municipalities in State of Sao Paulo. Table 4 presents descriptive statistics on the distribution of the procurement transactions over year and months. For instance, note that 32% of purchases were made in 2011, and public bodies more frequently purchase prescription dugs in the months of March and November.

Table 5 displays descriptive statistics for bids, acquisition prices, and different measures of generic entry in procurement auctions. Indeed, they are the most important variables for our empirical investigation. That table firstly provides information on unit price paid by a public body (buyer) for a specific drug, and on the bids submitted by firms in a competitive bidding.[15] There is also information on estimated unit price, which is available only for a sub-sample. Estimated unit price is reserve price, and measures public body's willing to pay for a drug.[16]

Table 5 also shows some measures of generic entry. For instance, the variable *Generics* is a dummy which refer to type of drug acquired by the public body: generic or branded. It assumes value equal to 1 if the procurement contract was awarded to supplier of a generic drug, and zero otherwise. Yet the variable *Generics in the Tendering* is a dummy constructed to identify whether there exists any generic drug supplier in a competitive bidding. It is equal to 1 if there exists a bidder-competitor of a generic drug in the tendering, and zero otherwise.

Besides information on bids, prices paid and generic entry, Table 5 also describes other variables that affect price. For example, note that 53% of purchases were made using Two Stage Auction. Other variables such as the quantity purchased can also be found in this table. In the presence of economies of scale and scope in logistics and in the production process, it is expected that the higher the quantity purchase, the lower the price paid by the government. In addition to these variables, information on number of suppliers competing to provide a

[15] In two stage auction it refers to the last offer of each bidder.

[16] Estimated prices are determined through a market survey conducted by the buyer which is responsible for the procurement transaction. It is available only from December 13, 2009 to November 03, 2010. In fact, that information was revealed to all bidders competing for procurement contracts in two stage auctions in the period above. According to BEC adminstration, they removed and stopped publishing it because they realized that the full disclosure of that information was affecting bidding behavior, leading to an increase in supplier's price offer.

particular drug in a tendering (bidders) is also available in the database.

Based on information about the supplier's town location and the place to delivery, we calculated the geodesic distance between buyer and supplier in each procurement transaction (buyer-supplier distance). This variable is a proxy for transportation costs. Using the same approach, we compute the distance between buyer and each bidder in a procurement auction. Certainly the bids and the price paid by the government are affected by this variable.

In this paper we also use data set from Ministry of Health (Department of Information of the Unified Health System - SUS), which provides information on several health indicators for Brazilian municipalities. Table 6 describes some characteristics of the municipalities where the public body (buyer) is located, including the total number of municipalities, the annual resident population, hospitalization and hospital mortality rates.[17] That information allow us to control for any heterogeneity between buyers geographical location. In addition, Table 6 compares the characteristics of our sample with all municipalities in Brazil.

Table 7 tests for differences in unconditional means of the procurement transactions' characteristics. Panel A presents the difference between unconditional mean of the procurement characteristics when the contract is, and not awarded, to a supplier of a generic drug. The columns (1) and (2) correspond, respectively, to the mean of a variable when the public body acquires a generic and a branded drug. The t-statistics and significance tests are, respectively, reported in column (3) and though asterisks. For instance, tests show that the unconditional means of price paid, bid, quantity purchase are statistically identical whether a generic drug is acquired or not. On the other hand, tests show that the generic drug suppliers are located farther from the buyer than the branded ones. Moreover, the number of bidders is higher in procurement transactions that public bodies acquire a generic drug than a branded one. Other differences in procurement transactions are reported in Panel A.

Yet in Table 7 Panel B we present the difference between unconditional mean of the procurement characteristics when there is, or not, a bidder of a generic drug in the competitive bidding. The columns (4) and (5) correspond, respectively, to the mean of a variable in competitive bidding that there exists and does not exist a bidder of a generic drug in the tender. The t-statistics and the significance tests are, respectively, reported in column (6) and though asterisks. Tests show that the unconditional means of price paid, bid, quantity purchase are statistically different whether there exists, or does not, a generic drug supplier in the tendering. Additionally, tests show that buyer-supplier distance, the number of bidders,

[17] That information was obtained from Ministry of Health, which is free to download from DATASUS website - www.datasus.gov.br.

quantity purchased, among other variables, are statistically different when there is, or not, a bidder of a generic drug in the procurement transaction. Other differences in the procurement transactions are reported in Panel B.

It is worth highlighting that such evidence is a quite crude statistical analysis of unconditional means, and it only displays some characteristics of the database. Observable differences in purchases made may explain the potential differences in branded and generic drug supplier's bidding behavior, and in prices paid by the government for branded and generic pharmaceuticals. To control for observable and unobservable characteristics, we will perform an econometric analysis.

5 Estimation and Results

In order to test the hypotheses described in Section 3, we estimate equations (1) and (2). We first examine whether there exists different bidding behavior between generic and branded pharmaceutical suppliers, and if the prices paid by public bodies for them are unlike. Secondly, we investigate how the presence of a generic supplier in a competitive bidding affects drug suppliers' bids and acquisition prices.

5.1 Bids and price paid: generic versus branded suppliers

■ **Generic and branded suppliers' bids.** Table 8 presents several estimates of equation (1), in which the dependent variable is a firm's bid. The goal is to identify differences in generic and branded drug suppliers bidding behavior in procurement auctions. The variable Generic Drug' Bidder in Table 8 is a dummy which assumes value equal to 1 if the bidder is offering to supply a generic drug in the tendering, and zero otherwise. If the estimated coefficient associated with that variable is equal to zero, then we can conclude that generic and branded suppliers offer the same price to supply pharmaceuticals in procurement auctions. Otherwise, their offers are unlike.

Each column in Table 8 corresponds to a different estimated specification of equation (1). In column (1) we estimate that equation by generalized least squares (GLS) in which we only correct for heteroskedasticity. Note that in column (1) we do not include any control variable. Yet in column (2) we take into account the panel structure of the data set, and we include a fixed effect for each different drug, bidder and buyer in the estimated equation. The aim is to control for unobservable drug, supplier and public body characteristics. In the specification

of column (3) we add year and month fixed effects to the ones already included in column (2). In the regressions at column (2) and (3) we also correct for heteroscedasticity.

The results of column (1) suggest that generic drug suppliers bid lower than the branded ones, since it estimates that the coefficient associated with the dummy variable Generic Drug' Bidder is negative and statistically different from zero. However, the estimates in column (2) and (3) show that, after controlling for unobservable characteristics, the coefficient associated with the variable Generic Drug' Bidder is statistically equal to zero. It indicates that there is no significant difference between generic and branded suppliers bids.

In column (4) we estimate the coefficient of interest including observable characteristics of the procurement transactions in the regression. The characteristics are quantity purchased, distance between bidder to place to delivery, and others that affect bids. Note that the unobservable characteristics (i.e., drug, bidder, buyer, year and month fixed effects) are maintained in the estimated equation, and the estimated standard errors are robust to heteroskedasticity.

First, we observe that the coefficient associated with quantity purchased at column (4) in Table 8 is significantly negative. It means that the greater the quantity purchased by public bodies in each procurement transaction, the lower the bids. Secondly, the results of column (4) suggest that the distance between bidder to place to delivery affects bids in a quadratic way. It estimates a positive coefficient for the quadratic term and a negative one for the linear term of the distance. This U-shape suggests that when the distance between the buyer and supplier is very small, the bids decreases; whereas the distance is large, bids increase. It is similar to Iimi (2006)'s findings for auction of official development assistance. Thirdly, the results of column (4) does not find evidence that the number of bidders affects bidding behavior. Probably, the sort of bidders that a drug supplier faces in a tendering (i.e., generic or branded) capture better the competition intensity in a auction than the number of bidders, thereby having a more important impact on bidding behavior.[18] This hypothesis is closely investigated at the estimations of equation (2) in the next section.

The results of column (4) also find that the coefficient associated with the variable Generic Drug' Bidder is statistically equal to zero. Indeed, it is an additional evidence showing there is no significant difference between Generic and branded suppliers bids.

In column (5) we add to the previous variables some health indicators of the municipalities where the public body (buyer) is located in the estimated equation. They are hospitalization and hospital mortality rates. The aim is to control for some heterogeneity between buyers geographical location that were not accounted by other variables. The results of column (5)

[18]This result still holds if we replace the logarithm specification for the quadratic one.

show that hospitalization seems to reduce prices paid, whereas hospital mortality rate does not have a statistically significant effect on bidding. However, the estimation in column (5) also finds that the coefficient associated with the variable Generic Drug' Bidder is statistically equal to zero.[19]

Once having performed several different estimations of equation (1), which are reported in Table 8, we find that that, after controlling for observable and unobservable characteristics of the procurement transactions, the coefficient associated with the variable Generic Drug' Bidder is statistically equal to zero. Therefore, we can conclude there is no significant difference between generic and branded suppliers bids.

■ **Price paid for generic and branded drugs.** Table 9 presents several estimates of equation (1), in which the dependent variable is the price paid by public bodies for a pharmaceutical. The aim is to identify whether the acquisition price for a generic drug is different from a branded one in procurement auctions. The variable Generics in Table 9 is a dummy which assumes value equal to 1 if the procurement contract is awarded to supplier of a generic drug, and zero if it was awarded to a supplier of a branded drug. It refers to the sort of pharmaceutical is acquired by a public body in the tendering: generic or branded. If the estimated coefficient associated with that variable is equal to zero, then we may conclude that price paid for generic and branded drugs are the the same price: generics are neither cheaper nor more expensive than branded drugs. Otherwise, the generic and branded acquisition prices are unlike.

As in the section above, each column in Table 9 corresponds to a different estimated specification of equation (1). Similarly, in column (1) we estimate equation (1) by generalized least squares (GLS), but we do not include any control variable. Yet in column (2) we include fixed effects for each different drug, supplier and buyer in the estimation in order to control for unobservable characteristics. In the specification of column (3) we add year and month fixed effects to the ones already included in column (2). In column (4) we estimate the coefficient of interest including observable characteristics of the procurement transactions in the regression, and in column (5) we add to our estimated equation some health indicators of the municipalities where the public body (buyer) is located. In all regressions in Table 9 we correct for heteroskedasticity.

Firstly, note that the results of column (1) suggest that generic drugs are cheaper than a branded ones. It occurs because it estimates that the coefficient associated with the variable

[19]In the regressions at column (5) we also correct for heteroskedasticity.

Generics is negative and statistically different from zero. However, the estimates from column (2) to (5) show that, after controlling for observable and unobservable characteristics, the coefficient associated with the variable Generics is statistically equal to zero. Those robust estimations provide evidence that there is no significant difference between price paid for generic and branded drugs.

The results reported in Table 8 and Table 9 are interesting because they are different from what previous studies find for wholesale and retail pharmaceutical markets. For instance, Caves et. al (1991) show that generic prices are lower than branded ones in pharmacy and hospital markets. Differently, our estimates document new evidence on the pattern of price competition between generic and branded drug suppliers on pharmaceutical markets.

5.2 The effect of generic entry on bids and acquisition price

Once we have examined the differences between generic and branded suppliers bidding behavior and acquisition prices, we turn to the investigation the impact of the presence of generic suppliers on drug suppliers' bids and prices paid.

■ **Generics in the tendering and suppliers' bid.** Table 10 presents several estimates of equation (2), in which the dependent variable is a firm's bid. The goal is to identify how the presence of generic suppliers in procurement auctions affects drug suppliers bidding behavior. The variable Generics in the tendering in Table 10 is a dummy which assumes value equal to 1 if there exists any bidder-supplier of a generic drug in the tendering, and zero otherwise. If the estimated coefficient associated with that variable is negative, then we can conclude that the presence of generics in a tendering reduces suppliers' offer to supply pharmaceuticals in procurement auctions. Otherwise, they do not.

Each column in Table 10 corresponds to a different estimated specification of equation (2). In column (1) we estimate that equation by generalized least squares (GLS) in which we only correct for heteroskedasticity. Note that in column (1) we do not include any control variable. Yet in column (2) we include a fixed effect for each different drug, bidder and buyer in the estimated equation. In the specification of column (3) we add year and month fixed effects to the ones already included in column (2). In the regressions at column (2) and (3) we also correct for heteroscedasticity.

The results of column (1) suggest that the presence of a generic drug supplier in procurement auctions reduces suppliers' bids since it estimates that the coefficient associated with

the variable Generics in the tendering is negative and statistically different from zero. The estimates in column (2) find that, even after controlling for unobservable characteristics, the coefficient associated with the variable Generics in the tendering is negative and statistically different from zero, although smaller the the one estimate in column (1). Yet in column (3) we find that the coefficient associated with the variable Generics in the tendering is statistically equal to zero. It suggests that the generic entry effect on suppliers bidding behavior reported in column (1) and (2) are capturing the month and year effects omitted in those specification.

In column (4) we estimate the coefficient of interest including observable characteristics of the procurement transactions in the regression. As in the section above, the characteristics are quantity purchased, distance between bidder to place to delivery, and others that affect bids. Note that the unobservable characteristics (i.e., drug, bidder, buyer, year and month fixed effects) are maintained in the estimated equation, and the estimated standard errors are robust to heteroskedasticity.

First, we observe that the coefficient associated with quantity purchased at column (4) in Table 10 is significantly negative. Secondly, the results of column (4) suggest that the distance between bidder to place to delivery affects bids in a quadratic way. It estimates a positive coefficient for the quadratic term and a negative one for the linear term of the distance. Note that the results of column (4) also find that the coefficient associated with the variable Generics in the tendering is statistically equal to zero.

In column (5) we add to the previous variables the health indicators in the estimated equation. They are hospitalization and hospital mortality rates. The results of column (5) show that hospitalization seems to reduce prices paid, whereas hospital mortality rate does not have a statistically significant effect on bidding. The estimation in column (5) also finds that the coefficient associated with the variable Generics in the tendering is statistically equal to zero.

In a nutshell, we find that, after controlling for observable and unobservable characteristics of the procurement transactions, the coefficient associated with the variable Generic in the tendering is statistically equal to zero. Therefore, we cannot conclude that the presence of generic suppliers in procurement auctions affects drug suppliers' bids.

One may argue that we have not found any statistically significant effect of generic entry on bidding behavior because we are pooling generic and branded drug's suppliers bids in the same estimation. Indeed, the presence of generic suppliers in procurement auctions may affect branded drug suppliers in a different manner than supplier of generics.

In order to investigate that asymmetric effect of generic entry, we first analyzes the effect

of the presence of generic suppliers in a tendering on branded drug suppliers' bids, and then we turn to examine the effect on generic suppliers' bids.

Table 11 reports several estimates of equation (2), in which the dependent variable is a branded drug supplier's bid in procurement auctions. Each column in Table 11 corresponds to a different estimated specification of equation (2). Column (1) reports the estimates of equation (2) obtained by generalized least squares (GLS), in which we do not include any control variable. Yet in column (2) we include fixed effects for each different drug, bidder and buyer in the estimation in order to control for unobservable characteristics. In the specification of column (3) we add year and month fixed effects to the ones already included in column (2). In column (4) we estimate the coefficient of interest including observable characteristics of the procurement transactions in the regression, and in column (5) we add to our estimated equation some health indicators of the municipalities where the public body (buyer) is located. In all regressions in Table 11 we correct for heteroskedasticity.

First note that that in all regressions the coefficient associated with the variable Generics in the tendering is negative and statistically different from zero. It indicates that generic entry in procurement auctions makes a significant reduction in branded suppliers' bids. Additionally, it shows that the estimated coefficient is robust, remaining negative and statistically different from zero under serveral specifications and controls. Secondly, we observe that the magnitude of the coefficient of interest reduces when we increase the number of control variables. For instance, the results of column (1) suggest the presence of a supplier of generic induces a dramatic reduction in branded supplier's bid. Yet the estimates from column (4) to (5) show that, after controlling for observable and unobservable characteristics, the presence of a supplier of generic reduces branded bids by 3 percent in average.

The estimates reported in Table 11 document a novel effect of generic entry on branded drug prices. Previous studies, as Grabowski and Vernon (1992) and Frank and Salkever (1997), indicate that branded drug prices rise when generic competition materialize in retail markets. On the contrary, we find that branded suppliers reduce price when competing with generic ones. It indicates that branded suppliers prefer to cut down prices rather than leave public procurement auctions. Given the high volume of public acquisition of drugs, branded suppliers probably reduce price-cost margin in order to increase volume, therefore maximizing profits. It shows that generic competition affects branded supplier's behavior in public procurement auctions differently from other markets.

A natural criticism that one could make to the results above is that perhaps there is some kind of endogeneity that could explain it. For instance, one may argue that the cheapest drugs

are purchased in auctions where there are suppliers of generic drugs, while the most expensive ones are purchased when there is no supplier of generics. Our estimation corrects for such bias since we include a fixed effect for each different drug (we use fixed-effects estimation).

Another criticism that one could make to our estimations is that there may exist endogeneity problem due a possible correlation between the presence of a supplier of generic drugs in the tendering and unobservable branded supplier's characteristics. For instance, one may argue that the most efficient branded suppliers enter in the same auctions as the suppliers of generic drugs, while the less efficient branded suppliers would not enter in the auctions where there would not be suppliers of generics. That would lead to the same pattern documented above (branded drug suppliers bids are lower in auctions that there exists a supplier of generics) because the most efficient bidders are more likely to place lower offer. Our estimation corrects for such bias since we use control for bidder fixed effects.

Our estimates of the effect of generic entry on branded drug supplier's bidding behavior may be subject to other endogeneity biases. For instance, generic entry is related to expected bids, and they are correlated with actual bids. Then our estimates are a lower bond for the competitive effects of generic on branded bidding.

Once we have examined the impact of the presence of generic suppliers on branded drug suppliers' bids, we turn to the investigation on how the presence of a generic supplier in the tendering affects the other generic supplier's bids. Table 12 presents several estimates of equation (2), in which the dependent variable is the generic drug suppliers' bids. The variable Other Generics in Table 12 is a dummy which assumes value equal to 1 if there exists any other supplier of generic drug in the tendering than the own bidder, and zero otherwise.

The estimates reported in Table 8 show that that, after controlling for observable and unobservable characteristics of the procurement transactions, the coefficient associated with the variable Other Generics is statistically equal to zero. These findings indicate that the presence of generic suppliers in a tendering has no effect on other generic suppliers' bids.

In summary, we find that suppliers of branded drugs lower their bidding price in auctions in which there exists a supplier of generics, whereas generic suppliers apparently do not change their bids in a presence of other supplier of generics.

■ **Generics in the tendering and price paid.** Table 13 presents several estimates of equation (2), in which the dependent variable is the price paid by public bodies for pharmaceuticals. The aim is to identify how the presence of generic suppliers in procurement auctions affects acquisition prices for drugs. As in Tables 10 and 11, the variable Generics

in the tendering in Table 13 is a dummy which assumes value equal to 1 if there exists any bidder-supplier of a generic drug in the tendering, and zero otherwise. If the estimated coefficient associated with that variable is negative, then we can conclude that the presence of generics in a tendering reduces price paid for pharmaceuticals.

As in the section above, each column in Table 13 corresponds to a different estimated specification of equation (2). Similarly, in column (1) we estimate equation (2) by generalized least squares (GLS), without any control variable. Yet in column (2) we include fixed effects for each different drug, supplier and buyer in the estimation in order to control for unobservable characteristics. In the specification of column (3) we add year and month fixed effects to the ones already included in column (2). In column (4) we estimate the coefficient of interest including observable characteristics of the procurement transactions in the regression, and in column (5) we add health indicators to the estimated equation. In all regressions in Table 13 we correct for heteroskedasticity.

We first observe that in all regressions the coefficient associated with the variable Generics in the tendering is negative and statistically different from zero. It indicates that generic entry in procurement auctions makes an important reduction in acquisition prices. In addition, it shows that the estimated effect is robust, maintaining its negative sign and a statistically significance to several different specification and controls. Secondly, note that the magnitude of the coefficient of interest reduces when we increase the number of control variables, although it remains negative and statistically different from zero. The results of column (1) suggest the presence of a supplier of generic induces a dramatic reduction in the price paid for drug by public bodies. However, the estimates from column (4) to (5) show that, after controlling for observable and unobservable characteristics, the presence of a supplier of generic reduces price paid for drugs by 7 percent.

The channel through which generic entry affects the price paid for drugs seems to be the competition pressure that generic entrants make on branded supplier's bidding behavior. It is consistent with the findings described in previous section, when we show that the presence of any supplier of generics in a tendering makes branded competitors to decrease their bids.

A criticism that one could make to our estimations is that there may exist endogeneity problem due a possible correlation between the presence of a supplier of a generic drug in the tendering and unobservable buyer's characteristics. For instance, one may argue that the best buyers (good payers) manage to attract more generic suppliers to their tendering, while the worst buyers (bad payers) are not able to bring suppliers of generics to make an offer. That would lead to the same pattern documented above (acquisition prices are lower when there is

supplier of generics) because suppliers are winning to make lower offers to good buyers than to bad ones. Our estimation corrects for such bias since we use control for buyer (public body) fixed effect.

Our estimates of the effects of generic competition on prices may be subject to other endogeneity biases. For instance, if generic entry is related to expected prices, and they are correlated with actual and prices, then our estimates are a lower bond for the competitive effects of generic on prices.

6 Conclusion

This paper investigates the effects of presence of generic substitutes in procurement markets on generic and branded drug suppliers' bidding behavior, and the consequences on acquisition prices for pharmaceuticals by public bodies. In order to identify the patterns displayed by bids and price paid in auctions for pharmaceuticals, we use a micro data on procurement auctions for prescription drugs organized by public bodies in Brazil.

We surprisingly find no statistically difference between bids and prices paid for generic and branded drugs. At the same time, the regressions suggest that acquisition prices for generic and branded drugs are statistically identical. This suggest that both types of drugs have the same price in procurement markets. On the other hand, estimations show that the presence of any supplier of generics in a tendering makes branded competitors to decrease their bids by 3 percent in average. It indicates that generic entry induces branded suppliers to reduce price in competitive bidding. Looking at the acquisition prices (i.e., winning bids), we find that the price paid for pharmaceuticals drops by 7 percent when there exists a supplier of generics in the auction. Hence, we conclude that generic entry causes an important change in branded drug suppliers' strategy in procurement auctions.

This evidence suggests that branded suppliers prefer to cut down prices rather than leave public procurement auctions. Given the high volume of public acquisition of drugs, branded suppliers probably reduce price-cost margin in order to increase volume, therefore maximizing profits. It indicates that generic competition affects branded supplier's behavior in public procurement auctions differently from other markets. Given that evidence, a potential interesting investigation could make a comparison between prices of branded drugs in public procurement, wholesale and retail markets.

Our results suggest that the use of auction-based mechanisms to acquire pharmaceuticals enhance generic-branded competition, leading to lower prices paid for drugs. From the

short-term perspective, it indicates that the auctions for drugs policy reduces public health expenditure. However, it would be interesting to investigate the effects of the tender policy on the characteristics of the drugs acquired in the procurement auctions. As pointed by Berndt (2002), even within interchangeable drugs, there is a great heterogeneity among generics and branded drugs, as tolerability, side effects, dosing convenience and risk of adverse interactions with other medications. Thus, the awarding procedure used to procure for pharmaceuticals may determine the characteristics of the drugs acquired. In addition, there is a lack of evidence about the long-term implications of such policy. An examination of the effects of use auction for pharmaceuticals on the incentives for innovation and development of new drugs is also an interesting research question.

Another potential extension that can be done is to apply structural econometrics of auction data to estimate the supply cost function of pharmaceuticals. Such investigation would be interesting for a variety of reasons. Firstly, that empirical strategy would allow one to examine whether there exists different supply cost between generic and branded pharmaceutical drugs. Secondly, once such estimation is made, one can compute price-cost margin for branded drug suppliers, and access how much generic entry reduces branded suppliers' markup.

Those empirical questions could be addressed in a further research.

References

Anvisa, 2002. Medicamentos Genéricos: Oriente-se. Ministry of Health.

Barbosa, Klenio, 2013. The Brazilian Procurement System of Price Registration. In *Aperfeiçoando a Qualidade Regulatória*, Eduardo Fiuza and Lucia Helena Salgado(eds.), IPEA, Rio de Janeiro (Brazil).

Barbosa, Klenio and Eduardo Fiuza, 2011. Demand Aggregation and Credit Risk Effects in Pooled Procurement: Evidence from the Brazilian Public Purchases of Pharmaceuticals and Medical Supplies, *FGV-EESP C-Micro Working Paper*, No. 299.

Berndt, Ernst, 2002. Pharmaceuticals in U.S. Health Care: Determinants of Quantity and Price. *Journal of Economic Perspectives*, 16 (4), 45-66.

Caves, Richard, Michael Whinston and Mark Hurwitz, 1991. Patent Expiration, Entry, and Competition in the U.S.Pharmaceutical Industry. *Brookings Papers on Economic Activity: Microeconomics*, 1-48.

Carone, Giuseppe, Christoph Schwierz and Ana Xavier, 2012. Cost-containment Policies in Public Pharmaceutical Spending in the EU. European EC, European Commission, Directorate-General for Economic and Financial Affairs, Economic Papers, No. 461.

Dimitri Nicola, Gustavo Piga and Giancarlo Spagnolo, 2006. Introduction, in Dimitri Nicola, Gustavo Piga and Giancarlo Spagnolo (eds.), 2006, *Handbook of Procurement*, Cambridge (UK): Cambridge U.P., Cambridge (UK).

Dimitri, Nicola, 2012. Best Value for Money in Procurement, *Maastricht School of Management Working Paper*, No. 2012/02.

Dranove, D., 1989. Medicaid Drug Formulary Restrictions. *Journal of Law and Economics*, 32, 143-162.

Fiuza, Eduardo P. S. and Marcos de B. Lisboa, 2003. Credence Goods and Market Power: An Econometric Study on the Brazilian Pharmaceutical Industry. *Estudos Econômicos*, 33 (4), 601-638.

Fiuza, Eduardo and Barbara Caballero, 2009. Estimations of Generic Drug Entry in Brazil Using Count vs. Ordered Models, *IPEA Working paper*, No. 1511.

Foster, Susan, 1991. Supply and Use of Essential Drugs in Sub-Saharan Africa: Some Issues and Possible Solutions. *Social Science and Medicine*, 32(11), 1201-1218.

Frank, R.G. and D.S. Salkever, 1997. Generic Entry and the Pricing of Pharmaceuticals. *Journal of Economics and Management Strategy*, 6, 75-90.

Gorecki, P.K., 1986. The Importance of Being First: The Case of Prescription Drugs in Canada. *International Journal of Industrial Organization*, 4, 71-396.

Grabowski, H.G., and J.M. Vernon, 1992. Brand Loyalty, Entry, and Price Competition in Pharmaceuticals After the 1984 Drug Act. *Journal of Law and Economics*, 35, 331-350.

IMS, 2009. Generic Medicines: Essential Contributors to the Long-term Health of society. IMS Health Publishing, London.

Iimi, Atsushi, 2006. Auction Reforms for Effective Official Development Assistance, *Review of Industrial Organization*, 28, 109-128.

Jofre-Bonet, M., and M. Pesendorfer, 2000. Bidding Behavior in a Repeated Procurement Auction: a Summary, *European Economic Review*, 44, 1006-1020.

Kanavos, P., E. Seeley and S. Vandoros, 2009. Tender Systems for Outpatient Pharmaceuticals in the European Union: Evidence from the Netherlands, Germany and Belgium. DG Enterprise and Industry, European Commission, Brussels, Belgium.

Kremer, Michael, 2002. Pharmaceuticals and the Developing World. *Journal of Economic Perspectives*, 16(4), 67-90.

Leopold, C., C. Habl and S. Vogler, 2008. Tendering of Pharmaceuticals in EU Member States and EEA Countries. Results from the country survey. ÖBIG Forschungsund Planungs GesmbH, Vienna.

Lopes, J.A., 2009. A Study on the Reaction of Leader Drug Prices to the Introduction of Generic and Similar Competitors. In portuguese. São Paulo: EESP/FGV. Unpublished Master.s Dissertation.

Lopez-Casasnovas, Guillem and Jaume Puig-Junoy, 2000. Review of the Literature on Reference Pricing. *Health Policy*, 54, 87-123.

McRae, J.J., and F. Tapon, 1985. Some Empirical Evidence on Post-patent Barriers to Entry in the Canadian Pharmaceutical Industry. *Journal of Health Economics*, 4, 43-61.

Moore, W.J., and R. Newman, 1993. Drug Formulary Restrictions as a Cost-Containment Policy in Medicaid Programs. *Journal of Law and Economics*, 36:71-114.

Nishijima, M. and G. Biasoto Jr, 2003. Prices of Branded pharmaceuticals after the Entry of Generic Drugs on the Market. Annals of the 2003 Brazilian Economic Association Meeting (ANPEC 2003). In portuguese.

OECD (2008), Pharmaceutical Pricing Policies in a Global Market, OECD Publishing, Paris.

OECD (2011), Health at a Glance 2011: OECD Indicators, OECD Publishing, Paris.

Porter, R., and D. Zona, 1993, Detection of Bid Rigging in Procurement Auctions, *Journal of Political Economy*, 101, 518-538.

Rezende, Leonardo, 2008. Econometrics of Auctions by Least Squares, *Journal of Applied Econometrics*, 23, 925–948.

Scherer, F.M., 1996. Industry Structure, Strategy, and Public Policy (Harper-Collins, New York).

Scherer, F. M., 1993. Pricing, Profits, and Technological Progress in the Pharmaceutical Industry. The Journal of Economic Perspectives, 7(3), 7-115.

Scherer, F. M., 1993. The Pharmaceutical Industry, In: A. J. Culter and J. P. Newhouse (ed.), *Handbook of Health Economics*, Edition 1, volume 1, chapter 3, 119-180. Elsevier.

Scott-Morton, F., 1997. The Strategic Response by Pharmaceutical Firms to the Medicaid Most-favored Customer Rules. *RAND Journal of Economics*, 28, 269-290.

Vandoros, Sotiris and Panos Kanavos, 2013. The Generics Paradox Revisited: Empirical Evidence from Regulated Markets. *Applied Economics*, 45(22), 3230-3239.

Vogel, Ronald J. and Betsy Stephens, 1989. Availability of Pharmaceuticals in Sub-Saharan Africa: Roles of the Public, Private and Church Mission Sectors. Social Science and Medicine, 29(4), 479-486.

Waning, Brenda, Warren Kaplan, Alexis C King, Danielle A Lawrence, Hubert G Leufkensd and Matthew P Fox, 2009. Global Strategies to Reduce the Price of Antiretroviral Medicines: Evidence from Transactional Databases. *Bulletin of World Health Organization*, 87, 520-528.

WHO, 2000. Global Comparative Pharmaceutical Expenditures with Related Reference Information. *Health Economics and Drugs Series*. No. 003.

Appendix

A Sequence of Events in BEC Electronic Auctions

Two types of electronic reverse auctions are used by public bodies at BEC to acquire goods and services: first-price sealed-bid auction or a two stage one. In this section one can find the sequence of events in each of those two types of auctions.

A.1 First-price sealed-bid auction

Pre-bidding Listings appear on BEC at least 5 working days before the letting session. The tender document contains a detailed description of each lot, the date of the letting session, the contract's terms and conditions. It is free to download anonymously from BEC.

Bidding Interested bidders must submit a single sealed bid before a pre-specified deadline, after which no bidder may enter the auction. The single lowest bidder wins, and receives what it bids. After that, the contract is formally awarded.

A.2 Two stage auction

Pre-bidding Listings appear on BEC at least 8 working days before the letting session. The tender document contains a detailed description of each lot, the date of the letting session, the contract's terms and conditions. It is also free to download anonymously from BEC.

Bidding In the first stage, interested bidders must submit a sealed bid before a pre-specified deadline, after which no bidder may enter the auction. Sealed bids are then open, and bidders learn the low bid. It ends the first stage. In the second stage, bidders can now place as many new bids as they want, as soon as they can submit bids strictly lower than their own previous bids. Bidders can, however, submit bids higher than other bidders' previous bids.[20] The second stage lasts for 15 minutes and is automatically extended in 3 minutes every time that a bid is placed 3 minutes to the current scheduled ending. The low bidder at the second stage wins and pays her bid. After that, the contract is formally awarded.

[20]This is to avoid a situation in which that typos (deliberate or otherwise) prevent bidders from placing new bids. The platform software uses an algorithm to spot this sort of typos, but might take a few seconds to exclude mistaken bids, or might simply fail to spot typos.

B Tables

Table 1: Total Public Expenditure with Pharmaceuticals in Brazil - Percentage (%) of Brazilian GDP

Level of government	2002	2003	2004	2005	2006	2007	2008	2009	2010
Federal*	0.11%	0.10%	0.12%	0.12%	0.14%	0.14%	0.12%	0.13%	0.11%
States**	0.07%	0.08%	0.10%	0.10%	0.11%	0.11%	0.13%	0.14%	0.11%
Municipalities**	0.06%	0.06%	0.07%	0.07%	0.07%	0.06%	0.08%	0.07%	0.07%
Total	0.18%	0.18%	0.22%	0.22%	0.25%	0.25%	0.24%	0.26%	0.21%
State of Sao Paulo**	0.02%	0.03%	0.04%	0.05%	0.06%	0.05%	0.06%	0.05%	0.04%

Source: IBGE, and SIOPS - Secretary of Planning and Budgeting - Ministry of Health - Brazil.

* It includes the total expenditures with pharmaceutical of the National Health Fund (Fundo Nacional de Saude) in the programs: "Farmacia Popular" and "Assistencia Farmaceutica (Atencao Basica, DST/AIDS, Medicamentos Excepcionais)", and of the Oswaldo Cruz Foundation (Fundação Oswaldo Cruz) in the program "Farmacia Popular".

** It includes the total direct expenditures with pharmaceuticals from the direct and indirect public administration.

Table 2: Total Public Expenditure with Pharmaceuticals in Brazil - Percentage (%) of Brazilian GDP

Level of government	2002	2003	2004	2005	2006	2007	2008	2009	2010
Federal*	5.67%	5.63%	6.17%	6.41%	7.56%	7.35%	6.47%	6.48%	5.95%
States**	6.16%	6.77%	7.72%	7.23%	7.96%	7.93%	8.91%	9.04%	7.50%
Municipalities**	4.01%	4.43%	4.71%	4.22%	3.90%	3.29%	4.23%	3.76%	3.51%
Average Country	3.91%	4.05%	4.56%	4.52%	5.10%	4.97%	4.83%	4.91%	4.21%
State of Sao Paulo	7.63%	9.33%	10.19%	11.77%	14.22%	13.38%	14.21%	13.68%	11.31%

Source: IBGE, and SIOPS - Secretary of Planning and Budgeting - Ministry of Health - Brazil.

* It includes the total expenditures with pharmaceutical of the National Health Fund (Fundo Nacional de Saude) in the programs: "Farmacia Popular" and "Assistencia Farmaceutica (Atencao Basica, DST/AIDS, Medicamentos Excepcionais)", and of the Oswaldo Cruz Foundation (Fundação Oswaldo Cruz) in the program "Farmacia Popular".

** It includes the total direct expenditures with pharmaceuticals from the direct and indirect public administration.

Table 3: Descriptive Statistics - Procurement Transactions Characteristics (I)

Variable	Number of Observations
Panel A - Characteristic	
Procurement Transactions	64,752
Products	7,318
Suppliers	352
Public Bodies	270
Bidders	394
Municipalities	64
Panel B - Awarding Mechanism	
First Price Sealed Bid Auction	30,448
Two Stage Auction	34,304
Panel C - Year	
2008	9,622
2009	11,995
2010	13,515
2011	20,523
2012	9,097

Table 4: Descriptive Statistics - Procurement Transactions Characteristics (III) - Distribution over Years/Months

Variable	Number of Observations	Mean	Standard Deviation	Min	Max
Panel A - Year					
Dummy 2008	64,752	0.15	0.36	0.00	1
Dummy 2009	64,752	0.19	0.39	0.00	1
Dummy 2010	64,752	0.21	0.41	0.00	1
Dummy 2011	64,752	0.32	0.47	0.00	1
Dummy 2012	64,752	0.14	0.35	0.00	1
Panel B - Months					
Dummy January	64,752	0.03	0.16	0.00	1
Dummy February	64,752	0.09	0.29	0.00	1
Dummy March	64,752	0.12	0.33	0.00	1
Dummy April	64,752	0.10	0.30	0.00	1
Dummy May	64,752	0.10	0.30	0.00	1
Dummy June	64,752	0.09	0.28	0.00	1
Dummy July	64,752	0.07	0.26	0.00	1
Dummy August	64,752	0.07	0.26	0.00	1
Dummy September	64,752	0.08	0.27	0.00	1
Dummy October	64,752	0.09	0.28	0.00	1
Dummy November	64,752	0.10	0.30	0.00	1
Dummy December	64,752	0.05	0.22	0.00	1

Table 5: Descriptive Statistics - Procurement Transactions Characteristics (II)

Variable	Number of Observations	Mean	Standard Deviation	Min	Max
Price paid (price per unit)	62,977	199.14	8,468.82	0.00	2,022,936
Bid of a Bidder (price per unit)	212,582	555.63	55,626.71	0.00	16,600,000
Estimated Price (price per unit)	6,255	35.37	225.34	0.00	5,200
Generics (dummy)	64,752	0.11	0.31	0.00	1
Generics in the tendering (dummy)	64,752	0.26	0.44	0.00	1
Quantity Purchased (units)	64,752	25,090	663,213	1	94,900,000
Two Stage Auction (dummy)	64,752	0.53	0.50	0.00	1
First Price Sealed Bid Auction (dummy)	64,752	0.47	0.50	0.00	1
Number of Bidders	64,752	3.28	2.35	1.00	24
Distance Buyer-Supplier (km)	60,893	309.21	276.09	0.00	2,514
Distance Buyer-Bidder (km)	149,932	306.28	340.27	0.00	2,514

The variables price paid, bid and estimated price are deflated by the monthly official price index (IPCA - base January, 2000).

Table 6: Descriptive Statistics - Characteristics of the Municipality where the Public Body (buyer) is located

Variable	Number of Observations	Mean	Standard Deviation	Min	Max	National Mean
Municipalities	64	-	-	-	-	5592*
Population	54,580	5,106,999	5,379,084	1,239	11,300,000	34,295
Hospitalization	62,313	25,196	25,820	37	58,778	3,743
Hospital Mortality rate	63,042	4.97	0.65	0.97	8.83	2.51

* It corresponds to the total number of municipalities in Brazil.

Table 7: Mean Difference Tests

	Panel A			Panel B		
	Contract Awarded to a		t-test	Generic supplier in tendering		t-test
Variables	Generic Supplier (1)	Branded Supplier (2)	t-statistic (3)	Yes (4)	No (5)	t-statistic (6)
Price paid (price per unit)	81.47	213.69	-1.23	72.97	242.62	-2.19***
Supplier's Bid (price per unit)	315.08	587.35	-0.72	283.46	703.03	-1.66*
Quantity Purchased (units)	32943	24122	1.06	44057	18595	4.26***
Number of Bidders	3.48	3.26	7.62***	4.52	2.86	82.71***
Distance Buyer-Supplier (km)	317.84	308.11	2.75***	289.21	315.94	-10.38***
Distance Buyer-Bidder (km)	315.53	305.20	3.60***	305.23	306.81	0.85
Hospitalization	26,894	24,985	5.80***	28,671	23,987	19.88***
Hospital Mortality rate	4.92	4.96	-2.08***	4.91	4.97	-4.65***

Note: Significant difference t-test: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$ (*t-test* tests whether the variables (1) and (2) have the same mean, assuming paired data)

Table 7: Mean Difference Tests (continued)

	Panel A			Panel B		
	Contract Awarded to a		t-test	Generic supplier in tendering		t-test
Variables	Generic Supplier (1)	Branded Supplier (2)	t-statistic (3)	Yes (4)	No (5)	t-statistic (6)
Distribution over Years						
Dummy 2008	0.10	0.15	-11.57***	0.11	0.16	-16.08***
Dummy 2009	0.17	0.19	-4.10***	0.18	0.19	-3.47***
Dummy 2010	0.22	0.21	2.31***	0.21	0.21	1.97***
Dummy 2011	0.32	0.32	1.31	0.34	0.31	7.82***
Dummy 2012	0.19	0.13	11.98***	0.16	0.13	7.54***
Distribution over Months						
Dummy January	0.03	0.03	-0.27	0.03	0.03	1.66*
Dummy February	0.09	0.09	-1.05	0.09	0.09	-1.82*
Dummy March	0.13	0.12	1.33	0.12	0.12	1.01
Dummy April	0.10	0.10	0.05	0.10	0.10	-0.32
Dummy May	0.09	0.10	-2.30***	0.09	0.10	-3.84***
Dummy June	0.09	0.09	0.43	0.08	0.09	-1.62*
Dummy July	0.07	0.07	-2.75***	0.07	0.07	-0.35
Dummy August	0.07	0.07	-0.14	0.08	0.07	1.72*
Dummy September	0.08	0.08	-1.25	0.08	0.08	-1.25
Dummy October	0.10	0.09	3.20***	0.10	0.09	4.35***
Dummy November	0.11	0.10	1.41	0.10	0.10	0.35
Dummy December	0.06	0.05	1.04	0.05	0.05	-1.74***

Note: Significant difference t-test: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$ (*t-test* tests whether the variables (1) and (2) have the same mean, assuming paired data)

Table 8: Difference between generic and branded drug supplier's bids

	Ln (Drug Supplier's Bid)				
Independent variables	(1)	(2)	(3)	(4)	(5)
Generic Drug's Bidder (dummy)	-0.994***	-0.001	0.003	0.003	0.006
	(0.019)	(0.015)	(0.015)	(0.016)	(0.016)
			Control Variables		
Distance Buyer-Bidder				-0.000***	-0.000***
				(0.000)	(0.000)
Distance Buyer-Bidder (square)				0.000***	0.000***
				(0.000)	(0.000)
Quantity Purchased (log)				-0.151***	-0.150***
				(0.015)	(0.015)
Number of Bidders (log)				0.030	0.030
				(0.018)	(0.018)
Hospitalization					-0.000*
					(0.000)
Hospital Mortality rate					-0.004
					(0.002)
Observations	213,000	157,000	157,000	108,000	106,000
R-Square	0.013	0.656	0.657	0.260	0.261
Fixed-Effects					
Drug Fixed-Effect	No	Yes	Yes	Yes	Yes
Supplier Fixed-Effect	No	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes

Note: Robust standard errors in parenthesis. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 9: Difference between price paid for generic and branded drugs

	Ln (Acquisition Price)				
Independent variables	(1)	(2)	(3)	(4)	(5)
Generics (dummy)	-1.348***	-0.018	-0.017	-0.016	-0.012
	(0.035)	(0.022)	(0.022)	(0.022)	(0.022)
			Control Variables		
Distance Buyer-Supplier				-0.000**	-0.000**
				(0.000)	(0.000)
Distance Buyer-Supplier (square)				0.000***	0.000***
				(0.000)	(0.000)
Quantity Purchased (log)				-0.178***	-0.177***
				(0.019)	(0.019)
Number of Bidders (log)				-0.121***	-0.120***
				(0.014)	(0.015)
Hospitalization					0.000
					(0.000)
Hospital Mortality rate					-0.005
					(0.004)
Observations	62,977	62,977	62,977	29,803	29,038
R-Square	0.020	0.727	0.728	0.335	0.336
Fixed-Effects					
Drug Fixed-Effect	No	Yes	Yes	Yes	Yes
Supplier Fixed-Effect	No	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes

Note: Robust standard errors in parenthesis. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 10: Impact of the existence of a generic supplier in the tendering on suppliers' bid

	Ln (Drug Supplier's Bid)				
Independent variables	(1)	(2)	(3)	(4)	(5)
Generics in the tendering (dummy)	-1.279***	-0.038*	-0.031	-0.011	-0.010
	(0.013)	(0.017)	(0.017)	(0.016)	(0.016)
			Control Variables		
Distance Buyer-Bidder				-0.000***	-0.000***
				(0.000)	(0.000)
Distance Buyer-Bidder (square)				0.000***	0.000***
				(0.000)	(0.000)
Quantity Purchased (log)				-0.151***	-0.150***
				(0.015)	(0.015)
Number of Bidders (log)				0.031	0.031
				(0.018)	(0.018)
Hospitalization					-0.000*
					(0.000)
Hospital Mortality rate					-0.004
					(0.002)
Observations	213,000	157,000	157,000	108,000	106,000
R-Square	0.044	0.656	0.657	0.260	0.261
Fixed-Effects					
Drug Fixed-Effect	No	Yes	Yes	Yes	Yes
Supplier Fixed-Effect	No	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes

Note: Robust standard errors in parenthesis. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 11: Generic Drug's influence on the Branded Drug Supplier's Bid

	Ln (Branded Supplier's Bid)				
Independent variables	(1)	(2)	(3)	(4)	(5)
Generics in the tendering (dummy)	-1.259***	-0.060***	-0.054**	-0.035*	-0.035*
	(0.015)	(0.017)	(0.017)	(0.015)	(0.015)
			Control Variables		
Distance Buyer-Bidder				-0.000***	-0.000***
				(0.000)	(0.000)
Distance Buyer-Bidder (square)				0.000***	0.000***
				(0.000)	(0.000)
Quantity Purchased (log)				-0.143***	-0.142***
				(0.016)	(0.016)
Number of Bidders (log)				0.028	0.028
				(0.018)	(0.018)
Hospitalization					-0.000
					(0.000)
Hospital Mortality rate					-0.005*
					(0.003)
Observations	185,000	140,000	140,000	94,412	92,178
R-Square	0.036	0.660	0.660	0.233	0.234
Fixed-Effects					
Drug Fixed-Effect	No	Yes	Yes	Yes	Yes
Supplier Fixed-Effect	No	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes

Note: Robust standard errors in parenthesis. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 12: Generic Drug's influence on Other Generic Drug Supplier's Bid

	Ln (Generic Supplier's Bid)				
Independent variables	(1)	(2)	(3)	(4)	(5)
Other Generics (dummy)	-0.484***	-0.087***	-0.072***	-0.036	-0.032
	(0.036)	(0.020)	(0.021)	(0.021)	(0.021)
			Control Variables		
Distance Buyer-Bidder				-0.000	-0.000
				(0.000)	(0.000)
Distance Buyer-Bidder (square)				0.000	0.000
				(0.000)	(0.000)
Quantity Purchased (log)				-0.188***	-0.187***
				(0.016)	(0.016)
Number of Bidders (log)				0.101***	0.105***
				(0.025)	(0.026)
Hospitalization					-0.000
					(0.000)
Hospital Mortality rate					-0.001
					(0.006)
Observations	27,326	17,084	17,084	13,573	13,415
R-Square	0.006	0.672	0.674	0.459	0.457
Fixed-Effects					
Drug Fixed-Effect	No	Yes	Yes	Yes	Yes
Supplier Fixed-Effect	No	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes

Note: Robust standard errors in parenthesis. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 13: Impact of the existence of a generic supplier in the tendering on acquisition price

	Ln (Acquisition Price)				
Independent variables	(1)	(2)	(3)	(4)	(5)
Generics in the tendering (dummy)	-1.764***	-0.171***	-0.168***	-0.072***	-0.071***
	(0.026)	(0.019)	(0.020)	(0.021)	(0.021)
			Control Variables		
Distance Buyer-Supplier				-0.000**	-0.000**
				(0.000)	(0.000)
Distance Buyer-Supplier (square)				0.000***	0.000***
				(0.000)	(0.000)
Quantity Purchased (log)				-0.179***	-0.178***
				(0.019)	(0.019)
Number of Bidders (log)				-0.114***	-0.113***
				(0.015)	(0.015)
Hospitalization					0.000
					(0.000)
Hospital Mortality rate					-0.005
					(0.004)
Observations	62,977	62,977	62,977	29,803	29,038
R-Square	0.068	0.728	0.728	0.336	0.337
Fixed-Effects					
Drug Fixed-Effect	No	Yes	Yes	Yes	Yes
Supplier Fixed-Effect	No	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes

Note: Robust standard errors in parenthesis. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.