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## **Generic-Branded Drug Competition and the Price for Pharmaceuticals in Procurement Auctions**

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## Abstract

This paper studies the effects of generic drug's entry on bidding behavior and participation of drug suppliers in procurement auctions for pharmaceuticals, and the consequences on procurers' price paid for drugs. Using an unique data set on procurement auctions for off-patent drugs organized by Brazilian public bodies, we find that some branded drug suppliers leave the auctions in which there exists a supplier of generics. However, the remaining ones lower their bidding price in a presence of generics in an auction. Due to a fierce price competition between generic and branded suppliers, the price paid for pharmaceuticals reduces by 7 percent in auctions in which a generic's supplier participates vis-à-vis auctions without generics. As a result of such generic-branded competition, we find no statistical difference between bids and prices paid for generic and branded drugs. To overcome potential estimation bias due to generic's entry endogeneity, we exploit variation in the number of days between drug's patent expiration date and the tendering session. The two-stage estimations document the same pattern as the generalized least square estimations find. This evidence indicates that generic competition affects branded supplier's behavior in procurement auctions differently from other markets.

*Keywords:* Generic-Branded Competition; Pharmaceuticals; Procurement Auctions.

*JEL classification:* H51; K32; I18; L1; L65.

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# 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 and thus overall health expenditure (Berndt, 2002). Indeed, several worldwide public policies involving pharmaceuticals have attempted to stimulate 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 substitutes for branded drugs (Scherer, 1993).

Many empirical studies investigate the price and volume response of branded products to generic's 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, public health expenditure, and equilibrium price in the private sector (McRae and Tapon, 1985; Gorecki, 1986, Dranove, 1989; Moore and Newman, 1993; Duggan and Scott-Morton, 2006; and Vandonos 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.

In this paper, we study the causal effects of the presence of generic substitutes in procurement auctions on generic and branded drug suppliers bidding behavior and participation, and the consequences on price paid by public procurers for off-patent drugs. From the best of our knowledge, it is the first work to examine the impacts of generic's entry on procurement markets. Hence, this paper contributes to the existing literature by identifying the pattern of competition that arises between generic and branded suppliers in auctions for pharmaceuticals, and its impact on public expenses of health care.

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).<sup>1</sup> Public hospitals and ambulatory cares acquire pharmaceuticals to be used in inpatient medical treatments, whereas public pharmacies and health agencies often

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<sup>1</sup>Kanavos et al., (2009) document that some health insurance companies in Europe also have started to use competitive bidding to select providers and determine reimbursement prices for pharmaceuticals.

distribute gratuitously or sell them to outpatients at subsidized prices in developing countries (Foster, 1991; Kremer, 2002). Hence, our investigation can provide insightful information on how procurement for drugs may be designed to reduce public health expenditure on pharmaceuticals. Complementarily, it may shed some light on the recent debate in the U.S. about the adoption of modern auction methods to acquire medicare supply.<sup>2</sup>

Second, in procurement auctions, differently from other pharmaceutical markets, there is a pure price competition between generic and branded drug suppliers. In such environment, suppliers either engage in an intense price competition to serve buyers, or let it for the ones who are more willing to cut prices. This nature of competition between drug suppliers in auctions is singular because it allows us to empirically identify the effects of a pure price competition between generics and brandeds on drug suppliers' market participation and pricing strategy. Previous works looked at the generic-branded competition in other markets, as pharmacy and retail ones (Caves et al., 1991; Grabowski and Vernon, 1992; Frank and Salkever, 1997). However, contrary to our work, those studies cannot isolate the pure price competition effects from non price competition strategies (e.g, advertising, product differentiation) because in those markets buyers have different price-sensitivities, varying in the values that they attach to differences in drug characteristics (Scherer, 2000; Berndt, 2002).<sup>3</sup>

The auction theory literature does not provide unambiguous predictions of generic's entry effects on participation and bidding behavior of branded's suppliers. As the number of potential generic's bidders increases, branded bidders may leave or keep participating in an auction for a certain drug. The exact brandeds' decision will depend on their production and logistics costs, and also on generics' one (Samuelson, 1985; Levin and Smith, 1994). Likewise, the presence of actual generic's bidders in auctions does have univocal effect on branded's bidding price. According to Maskin and Riley (2001), for instance, brandeds's bidding reaction to generic's entry in an auction will depend on the cost distribution of generic and branded's bidders.

This paper empirically investigates the different predictions on the generic-branded competition in procurement auctions by testing three set of hypotheses. First, it examines empirically how the presence of a generic's supplier in a competitive bidding affects branded drug supplier's auction participation decision. Suppliers may prefer to abstain from bidding in auction with generic suppliers, rather than engaging in a fierce bidding competition with

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<sup>2</sup>See Cramton and Katzman (2010) for more information on that debate.

<sup>3</sup>In those markets, drug suppliers compete also in other dimensions, like advertising, physician loyalty, packing and others, what leads to the well documented market segmentation phenomenon in pharmaceutical markets (Scherer, 2000; Berndt, 2002).

them. Secondly, it 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's entry may affect the price paid for drugs. To conclude, it investigates whether there exists different bidding price between generic and branded pharmaceutical suppliers, and if the prices paid (i.e., winning bids) by public bodies for them are unlike.

In order to identify the patterns displayed by bids, prices and suppliers participation in procurement markets, we perform an econometric analysis of an unique micro database on auctions for off-patent 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.<sup>4</sup> 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 30,448 procurement transactions between 2008 and 2012 (more than 6,000 transactions per year), through which was acquired 3,859 different drugs from 425 active ingredients and various therapeutic classes.

Note that, differently from previous studies, our empirical investigation relies on a transaction-based data. Past works, as 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 revenue. Our micro data allows us to control for observable and unobservable characteristics of each procurement transaction in the estimations, what could not be done in previous works.

Looking at branded drug supplier's participation decision in auctions for pharmaceuticals, we find that the presence of a generic supplier in an auction reduces branded's participation by 35 percent in average in our GLS estimations, what could suggest that generic-branded competition has diminished after generic's entry occurs. However, our estimations also show that the presence of any supplier of generics in a tendering makes branded competitors to decrease their bids by 3 percent in average. Those findings indicate that generic's entry

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<sup>4</sup>Sao Paulo is the richest state of Brazil, and it has the largest population, industrial complex, and economic production in the country.

crowds out branded supplier's participation, but it induces the remaining branded suppliers-bidders lower their bidding price in those auctions. 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, our results provide evidence that generic's entry indeed leads to an intense price competition between generic and branded suppliers. Those results are robust to different econometric specifications and controls.

One may think that all branded suppliers might prefer to leave procurement markets rather than cutting down prices in competitive auctions. Instead, we observe an opposite behavior: some suppliers of branded drugs are more aggressive in auctions in which there exists any supplier of generics. Exploiting variation in the volume of drugs acquired by public bodies in different auctions, we find that branded drug suppliers lower their offers in a presence of generic competitor only when they bid for high volume contracts. They probably reduce price for high volume contracts due to economies of scale, which may reduce marginal cost and increase profits.

As a result of such fierce competition between generic and brandeds in procurement auctions, one should observe no difference between generic and branded supplier's bids and prices in our estimations. Consistently, we find no statistical difference between generic and branded supplier's bids in our GLS estimations. At the same time, the regressions suggest that acquisition prices (i.e., winning bids) for generic and branded drugs are statistically identical. This generic-branded price convergence phenomenon indicates that both types of drug suppliers offer the same price in procurement markets.

An important empirical challenge in studies that investigate the effect of entry on pharmaceutical markets is to account for the endogeneity of entry decision. Indeed, generic's entry is endogenous and depends on market profitability.<sup>5</sup> Empirical models that failure to correct for entry endogeneity lead to biased coefficient estimates. Some of this potential bias is eliminated by controlling for observable and unobservable characteristics of the procurement transactions, drugs, public bodies, suppliers and bidders in the GLS estimations. However, the bias remains if generic's entry is correlated to bids, prices, and branded supplier's participation in auctions for pharmaceuticals. For instance, if generic's entry is more likely when bids and drug prices are low, then estimation of a negative effect of generic's entry on supplier's bidding behavior and acquisition price can incorrectly lead to the conclusion that generic's entry reduces supplier's bidding behavior and acquisition price. Alternatively, if generic's entry is more likely

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<sup>5</sup>Scott-Morton (1999, 2000), Reiffen and Ward (2005), and Kyle (2006, 2007) find that generic's entry is more likely in markets with high market revenues, high share of sales to hospitals, and experience firms are more willing to entry.

when bids and drug prices are high, then our estimation will be downward biased.

In order to establish the causal effects of generic drug's entry on bidding behavior and participation of drug suppliers in auctions, it is required an exogenous variation in generic's entry decision. In this paper, we also exploit differences in number of days between drug's patent expiration and auction session as a source of exogenous variation. Using information on dates in which auctions for drugs are conducted and their drug's patent expiration date, we construct an instrumental variable which is defined as the number of days between the drug's patent expiration date and the tendering session.<sup>6</sup>

The proposed instrument solves the unobserved generic's entry decision choice as long as the number of days between patent expiration and the auction has strong effect on the generic's entry decision, without affecting bidding behavior and branded supplier's participation directly conditional on other exogenous covariates. Intuitively, patent expiration can be considered exogenous to generic supplier's entry decision in an auction, since it is determined at the time the patent application was filed, which can date for more than 20 years before that an auction for an off-patent drug occurs. Similarly, the period in which an auction is conducted normally follows the annual budget schedule of each public body, which is determined in the year before an auction takes place. Hence, it can also be considered exogenous to generic supplier's entry decision in an auction. Consistently, statistical tests indicate that public bodies do not manipulate the auction date. As soon as those two dimensions of the proposed instrumental variable are exogenous to generic's entry decision, the difference between them is also exogenous. Unfortunately, we have information on patent expiration date for only 142 drugs in 1,443 different procurement auctions, which leads to a substantial reduction in the sample used for instrumental variable/two-stage estimation.

In a nutshell, our two-stage estimations establish the same pattern as the GLS estimations do. For instance, we also find in the 2SLS estimations that a supplier of branded drugs lowers its bidding price in an auction in which there exists a supplier of generics, and the 2SLS estimates are actually significantly higher than GLS ones. At the same time, we find that the presence of a generic drug in a tender reduces acquisition prices for drugs, even though participation of branded suppliers is diminished. However, those last two estimates lose significance in the IV estimation since the sample is reduced.

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

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<sup>6</sup>A similar instrumental variable estimation is implemented by Caves et al. (1991) when they investigate price and volume response of branded drugs to generic's entry in the U.S. pharmacy and hospital markets.

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's 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.<sup>7</sup> Therefore, the evidence suggests that generic competition affects branded supplier's behavior in public procurement auctions differently from pharmacy and retail markets.

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 describes our data base and presents some descriptive statistics. Section 4 presents the hypotheses and the empirical strategy that we use to test for them. In Section 5 we present the econometric results, showing estimations that describe the bidding behavior of drug suppliers, and the effect of entry generic on bids and acquisition prices. By exploiting variation in the volume of drugs acquired by public bodies in different auctions, in Section 6 we show that branded drug suppliers are more willing to reduce their price-cost margin in high volume contracts than in low volume ones. Section 7 concludes. Tables and figures are in the appendix.

## 2 Institutional Background

This section provides background information on generic's 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's 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.<sup>8</sup> Accordingly, a new generic substitute must show that its active ingredient is

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<sup>7</sup>Previous studies, as Fiuza et al. (2003), Nishijima et al. (2003) and Lopes (2009), estimate the impact of generic drug's 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's entry in the U.S. markets, documented by Frank and Salkever, is also prevalent in Brazil.

<sup>8</sup>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



chemically identical to a branded-approved drug, document bioavailability, pharmaceutical equivalence with the branded product, and compliance with sound manufacturing provisions required by Anvisa.<sup>9</sup> 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.

The first generic drugs were launched in 2000, when the earliest applications were approved. Fiuza and Caballero (2009) document the evolution of generic registration and entry in Brazil after 2000, and show that has occurred a substantial raise in the number of Anvisa approvals and entries of generic drugs and manufacturers since then. For instance, 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 34 percent of volume market share in the off-patent market in 2007 (Fiuza and Caballero, 2009).<sup>10</sup>

In fact, until the 1999 Generic Drug Act there were no authentic generics in Brazil. The only existing substitutes for off-patent pharmaceuticals were branded drugs produced by non-pioneer drug manufacturer, namely *similar* drugs. As the generics, similar drugs also account for an important fraction of the off-patent market share in Brazil. Every similar drug has its own name. However, they are required to make full disclosure of the active ingredient in the market package. Like the pioneer pharmaceutical firms, similar's manufacturers make substantial investments in advertising, either in the form of physician office visits by firms' representatives, or by advertising in medical journals and selling a drug in many different forms. Since 2003, the registration of similar drugs at Anvisa follows the same procedures for approving generic substitutes for off-patent drugs. Hence, they are also considered interchangeable with pioneer and generic drugs.<sup>11</sup>

In sum, there are 3 different sorts of variations of a same drug in the Brazilian pharmaceutical market: branded-pioneer, branded-similar and generic drugs.

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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).

<sup>9</sup>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.

<sup>10</sup>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..

<sup>11</sup>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).

## 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.<sup>12</sup>

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.<sup>13,14</sup> 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 stage auction.<sup>15</sup>

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.

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<sup>12</sup>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.

<sup>13</sup>In the procurement literature, summarized by Dimitri, Piga and Spagnolo (2006), such auction-based award mechanisms are namely competitive bidding or tendering.

<sup>14</sup>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).

<sup>15</sup>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.

**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.<sup>16</sup>

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.<sup>17</sup> 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 this paper we only use data from first-price sealed-bid auctions since detailed information on all procurement transactions, drugs, public bodies, suppliers and bidders is not available for the two stage auctions.

**First-Price Auctions at BEC Platform.** First-price sealed-bid auctions account for 47 percent of all BEC procurements auctions for off-patent drugs between 2008 and 2012. The total public expenses involved in those transactions comprise around 33 millions of dollars (see Table 3). BEC first-price auctions proceed in two stages. In the first stage, the Pre-bidding stage, a procurement auction's notice and a tender document 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. The second stage is the Bidding stage in which interested bidders must submit a single sealed bid before a pre-specified deadline, after which no bidder

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<sup>16</sup>See <http://www.bec.sp.gov.br>.

<sup>17</sup>In the Brazilian legislation, the first-price sealed-bid and the two stage electronic procurement auctions are, respectively, named as *convite eletrônico* and *pregão eletrônico*.

may enter the auction. At the moment that suppliers bid, they do not know the identity of the other bidders, the number of competitors, neither the brand name of the goods that the other bidders are offering in the tendering. The single lowest bidder wins, and receives what it bids. After that, the contract is formally awarded.

**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 distributed gratuitously or sold to outpatients at subsidized prices in public pharmacies. They obtain prescription drugs, among other goods and services, in a decentralized way: Each public body acquires its own inputs.<sup>18</sup> Purchases are financed by an annual budget assigned to each public body by the public health funds.

All public bodies must rely on any of those 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, which specifies the drug, the quantity, place and time schedule to delivery. A procurement contract specifies a very detailed drug to be supplied, which is an unique combination of active ingredient, form, concentration, number of units, and packing. Public bodies are forbidden to procurer a drug of a specific brand. They are obliged to acquire the drug from lowest bid's supplier, which in principle can be a generic or a branded drug.<sup>19</sup>

Among the potential suppliers, manufacturers and wholesalers are the main bidders. Consequently, suppliers of a same branded (pioneer or similar) or generic drug may end up competition in an auction. Note that there may exist more than one branded supplier bidding in a same auction for drug supply.

### 3 Database

This paper uses a micro data set on procurement auctions for off-patent 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, denom-

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<sup>18</sup>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.

<sup>19</sup>To acquire under patents drugs public bodies purchase them directly from the manufacturer or from the wholesalers.

inated 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 drug 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 allows us 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's 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 4 to 7 present some descriptive statistics of the data set. According to Table 4, the sample contains information on 30,448 procurement transactions, spanning the period from 2008 and 2012. It consists of all the transactions for acquisition of pharmaceuticals which are free to download from BEC website. Along this period, 3,859 different drugs from 425 active ingredients and various therapeutic classes were procured by 188 public bodies through first-price sealed-bid auctions.<sup>20</sup> The drugs were purchased from 293 different drug suppliers that delivered their products in public hospitals, ambulatory cares and health agencies located in 60 different municipalities in State of Sao Paulo. Table 5 presents descriptive statistics on the

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<sup>20</sup>Table 39 provides a list of active ingredients present the drugs investigated in this paper.

distribution of the procurement transactions over year and months. For instance, note that 25% of purchases were made in 2011, and public bodies more frequently purchase prescription drugs in the months of March and November.

Table 6 displays descriptive statistics for bids, acquisition prices, and different measures of generic's 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. Table 6 also shows some measures of generic's entry. For instance, 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. Yet, the variable *Generic Winner* 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. Additionally, the variable *Generic Winner in Auctions with Generics* is a dummy variable which represents the type of drug acquired by the public body (generic or branded) in auctions in which a generic's drug supplier participates. Note that in 41% of the auctions that there is a supplier of generics, a generic's supplier places the lowest bid and, hence, wins the competition with branded suppliers.

Besides information on bids, prices paid and generic's entry, Table 6 also describes other variables that affect price. For example, information on the quantity purchased (volume) 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 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.

Table 6 also provides descriptive statistics for the number of days between a drug's patent expiration and a tendering session for that drug occurs. Drug's patent expiration dates were obtained from Fiuza and Caballero (2009), and Ellison and Ellison (2011). That table shows that the drugs in our sample had their patent expired in average by 19.41 years before that

an auction for them took place. Note that all auctions in our sample occurred after 1.74 years that a drug's patent expired. Unfortunately, Fiuza and Caballero, and Ellison and Ellison have information on patent expiration date for only 40 drug's active ingredients (142 drugs) of our sample, which allows us to compute the number of days between patent expiration and auction session for solely 1,443 procurement transactions.<sup>21</sup> Since we use that variable as an instrument for generic's entry in an auction, then our two-stage estimations inevitably employ a smaller number of observations than our GLS estimations do.

In Table 6 we also show descriptive statistics for the number of days between a drug's first generic ANVISA approval and a tendering session for that drug occurs. Drugs' first generic ANVISA approval dates were obtained at ANVISA website.<sup>22</sup> That table indicates that the drugs in our sample had their first generic approval in average by 3.32 years before that an auction for them took place. It also shows that some auctions for off-patent drugs occurred when no generic substitutes were available on the Brazilian market.

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 7 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.<sup>23</sup> That information allow us to control for any heterogeneity between buyers geographical location. In addition, Table 7 compares the characteristics of our sample with all municipalities in Brazil.

Table 8 tests for differences in unconditional means of the procurement transactions' characteristics. Panel A presents the difference between unconditional mean of the procurement characteristics when there is, or not, a generic drug's bidder in the competitive bidding. The columns (1) and (2) 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 (3) 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, 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 A.

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<sup>21</sup>Table 39 provides a list of all active pharmaceutical ingredients (APIs) in our sample and, when available, their patent expiration date.

<sup>22</sup>See <http://www.anvisa.gov.br>.

<sup>23</sup>That information was obtained from Ministry of Health, which is free to download from DATASUS website - [www.datasus.gov.br](http://www.datasus.gov.br).

Yet in Table 8 Panel B we present 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 (4) and (5) 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 (6) and through asterisks. For instance, tests show that unconditional mean of price paid and bid are statistically different whether a generic drug is acquired or not. That test also show that the generic drug suppliers are located farther from the buyer than the branded ones. Moreover, the number of bidders is lower in procurement transactions that public bodies acquire a generic drug than a branded one. Other differences in 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 that is described in the next section.

## 4 Hypotheses and Empirical Strategy

In this section we formally describe the different hypotheses that we investigate in this paper, and present the empirical strategy that use to test for them.

This paper tests three sets of hypotheses. The first one investigates how the presence of a generic supplier in a competitive bidding affects branded drug supplier's auction participation decision. The second set of hypotheses looks at how the presence of a generic supplier in a competitive bidding affects generics and brandeds' bids, and acquisition price for drugs. The third one examines empirically whether there exists different bidding price between generic and branded pharmaceutical suppliers, and if the price paid (i.e., winning bids) by public bodies for them are unlike.

We start by describing the least squares estimation that we use to test the hypotheses described above, and then we turn to the two-stage estimation model, which accounts for the endogeneity of generic's entry decision, and establishes the causal effects of generic drug's entry on procurement auctions.



## 4.1 Least Squares Estimation

Our least squares estimating equation assumes that equilibrium bidding behavior and participation in an auction satisfy the following log-linear specification:

$$\ln y_{ijpbt} = \beta X_{ijpbt} + W'_{ijpbt} \alpha + g(N_{ijt}, \gamma) + \delta_j + \omega_p + \varphi_b + \tau_t + u_{ijpbt}, \quad (1)$$

where  $y_{ijpbt}$  represents a bidding offer or branded supplier's participation in an auction  $i$  to supply a drug  $j$  to a public body  $p$  from a bidder/supplier  $b$  in the period  $t$ . The variable  $X_{ijpbt}$  represents generic suppliers' participation in an auction. The coefficient  $\beta$  is the effect of  $X_{ijpbt}$  on  $y_{ijpbt}$ . The exact measures assigned to the variables  $y_{ijpbt}$  and  $X_{ijpbt}$  depend on the hypothesis that is tested. The empirical specification in (1) is similar to the one estimated by Porter and Zona (1993) when examining bidding behavior in auctions for highway construction contracts. Note that the econometric model in (1) is a difference-in-difference equation in which the effect of  $X_{ijpbt}$  on  $y_{ijpbt}$  (parameter  $\beta$ ) is identified by comparing auctions in which there is generic's entry/exit over time with those auctions in which there is no entry (or exit) of generic bidders.

To investigate the first set of hypotheses,  $y_{ijpbt}$  refers to the number of branded drug suppliers in an auction, and the variable  $X_{ijpbt}$  to a dummy variable which assumes value equal to 1 if there exists a supplier of a generic drug in the tendering, and zero otherwise.  $X_{ijpbt}$  is constructed to identify whether there exists any generic drug supplier in a competitive bidding. The coefficient  $\beta$  accounts for the effect of generic's entry in auction on branded supplier's auction participation decision.

When we examine the second hypothesis, the variable  $y_{ijpbt}$  refers to the bid offer to supply a drug, and  $X_{ijpbt}$  to a dummy variable which assumes value equal to 1 if there exists a supplier of a generic drug in the tendering. In particular, if we use generics/branded supplier's bid as the dependent variable  $y_{ijpbt}$  in equation (1), and we estimate a negative  $\beta$ , then we can 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 the dependent variable  $y_{ijpbt}$ , and we find that  $\beta$  is negative, then that means that the presence of any supplier of generic drugs in a tendering reduces prices paid for pharmaceuticals.

Yet when investigating the third set of hypotheses,  $y_{ijpbt}$  refers to the bid offer to supply a drug, and  $X_{ijpbt}$  refers to the identity of bidder: branded or generic supplier. In the case that we use firms bid as the dependent variable  $y_{ijpbt}$ , and  $X_{ijpbt}$  as 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 the sign of the coefficient  $\beta$  indicates whether a generic supplier's bid is lower or higher than branded's one. In particular, if we estimate  $\beta$  as a negative parameter, we can conclude that generic drug suppliers offer lower price than branded ones in procurement auctions. Similarly, in the case that we use price paid (i.e. winning bid) as the dependent variable  $y_{ijpbt}$ , and the variable  $X_{ijpbt}$  as a dummy which assumes value equal to 1 if the procurement contract was awarded to a supplier of a generic drug, then the sign of the coefficient  $\beta$  reveals whether a generic drug acquired by a public body is cheaper or more expensive than a branded's one. Therefore, if we find that  $\beta$  is negative, then it means that the price paid for generics is lower than branded ones.

The other variables in equation (1) are observable and unobservable characteristics of the procurement auctions and transactions that affect bidding prices and decision to participate in an auction. For instance, the parameters  $\delta_j$ ,  $\omega_p$ ,  $\varphi_b$  and  $\tau_t$  are, respectively, fixed effects for each drug, public body, bidder/supplier and time.  $W'_{ijpbt}$  is a vector of observable variables of the procurement transaction in auction  $i$  that affects bidder  $b$ 's probability of winning, or its observable cost to supply drug  $j$  to the public body  $p$  in the time  $t$ , thereby determining firms' bid and acquisition 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  $j$  in a procurement transaction.

The function  $g(N_{ijt}, \gamma)$  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  $N_{ijt}$  corresponds to the number of suppliers competing in a tendering  $i$  for a drug  $j$  in the period  $t$ . 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.

Variable  $u_{ijpbt}$  represents private information, such as idiosyncratic cost effects, for bidder  $b$  in auction  $i$  to supply drug  $j$  to the public body  $p$  in the time  $t$ . The error term is assumed to have expectation zero and an drug-specific variance, denoted  $\sigma_j^2$ . The variance of the error term can be a function of many variables, including the dispersion of private information on drug supply. The variable  $u_{ijpbt}$  is assumed to be uncorrelated to other regressors in equation (1). Those assumptions are relaxed in a two-stage estimation, which accounts for the endogeneity of generic's entry decision, which will be described in details in the next section.<sup>24</sup>

Least squares can be applied directly to bid and participation data to estimate the parame-

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<sup>24</sup>Equation (1) is potentially restrictive. It imposes a form of symmetry in that bidders are assumed to respond similarly to changes in the observable factors.

ters in equation (1). Fixed-effect estimation applied to that equation gives consistent estimates of the parameters (assuming that the error term  $u_{ijpbt}$  is not correlated to other regressors). Residuals can then be constructed from the fixed-effects estimates. The drug-specific variance is estimated by the drug mean-squared residual. A feasible generalized fixed-effect estimate is then obtained by using the drug-specific variances to weight the data.

## 4.2 Instrumental Variable and Two-stage Estimation

To estimate the causal effect of generic drug’s entry on bidding behavior and participation of branded suppliers in an auction, the generic’s decision to entry in auction must be uncorrelated with the unobserved determinants of bids and suppliers participation captured in the error term  $u_{ipbt}$ , conditional on fixed effects and observable characteristics. If unobservable variables that determine generic’s entry decision are omitted, the estimates of  $\beta$  derived from GLS regressions in equation (1) are inconsistent. Indeed, generic’s entry is endogenous and depends on market profitability. Danzon and Chao (2000), for instance, argue that generic’s entry may depend on the drug price level. So, if generic’s entry is more likely when bids and drug prices are low, then the estimation of a negative effect of generic’s entry on supplier’s bidding behavior and acquisition price can incorrectly lead to the conclusion that generic’s entry reduces supplier’s bidding behavior and acquisition price. Alternatively, if generic’s entry is more likely when bids and drug prices are high, then our estimation will be downward biased.

A consistent estimate for the effect of generic’s entry on bidding behavior and suppliers’ participation in an auction can be recovered if there is at least an instrumental variable  $Z$  that is uncorrelated with the error term  $u_{ijpbt}$  in equation (1), and it is a strong predictor of the probability of generic’s entry decision in an auction as in the following first-stage regression:

$$X_{ijpbt} = \theta Z_{ijt} + W'_{ijpbt} \Gamma + g(N_{ijt}, \lambda) + \pi_j + \kappa_p + \mu_t + \varepsilon_{ijpbt}, \quad (2)$$

where  $X_{ijpbt}$  is the indicator variable which assumes value equal to 1 if there exists a supplier of a generic drug in the auction  $i$  for the drug  $j$  to supply public body  $p$ , in which there is a set of bidders  $b$  in the time  $t$ , and zero otherwise. The variables  $\pi_j$ ,  $\kappa_p$ ,  $\mu_t$  are, respectively, drug, public body, and time fixed effects.  $W_{ijpbt}$  and  $N_{ijt}$  are observable characteristics of the procurement transactions, drugs, public bodies, suppliers and bidders, and  $\varepsilon_{ijpbt}$  is an error term. The causal effect of generic’s entry can then be estimated using a two-stage least squares (2SLS).

In this paper, we exploit differences in number of periods passed between an auction

session and drug’s patent expiration as an instrumental variable  $Z_{ijt}$  for generic’s entry in an auction. Using information on dates in which auctions for drugs are conducted and drugs’ patent expiration date, we construct the instrumental variable which is precisely defined as the number of days between the drug’s patent expiration date and the tendering session. The identification assumption is that our proposed instrument has no direct effect on branded supplier’s participation and bidding behavior, conditional on other exogenous covariates.<sup>25</sup>

Temporal trend, drug specificities, buyer and contract features are expected to be correlated with both generic’s entry, bidding behavior and participation of branded suppliers in an auction. However, because we include data on procurement contract characteristics, time, drug and buyer fixed effects in the first and in the second-stage estimations, we only consider variations on the number of periods passed between an auction session and drug’s patent expiration that is orthogonal to those auctions characteristics. Note that, having controlled for those covariates, we argue that the only remaining channel whereby our proposed instrument could be correlated with bidding behavior and participation of branded suppliers is through generic’s entry in an auction.

For that variable to be a good instrument for generic’s entry, two conditions are also required. First, the number of days between the drug’s patent expiration date and the tendering session should have a strong effect on the probability of generic’s entry in auction as established by expression (2). Implicitly, this equation assumes that there is a continuous entry of generics of a particular drug overtime since its patent expiration, thereby increasing the chance of generic’s suppliers entering in an auction. The existing literature has documented evidence which is consistent with that relationship. For instance, Barbosa e Silva (2013) estimate the relationship between the number of periods after the first generic’s entry in Brazilian market and the number generic’s suppliers for the same active ingredient that entered in that market. They find that there is a continuous entry of generic’s suppliers on the market after the first generic’s entry.

Second, for instrument validity, 2SLS should retain only the variation in the probability of generic’s entry which is generated by the quasi-experimental exogenous variation of the instrumental variable. It means that number of days between the drug’s patent expiration date and the tendering session should not be correlated with other unobservable determinants of bidding behavior and participation of branded suppliers in an auction. Patent expiration is exogenous to generic supplier’s entry decision in an auction, since it is determined at the time

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<sup>25</sup>The idea of using the number of days between patent expiration and the market operation date as an instrument for entry of generics in a market was first exploited by Caves et al. (1991) when they investigated the price and volume response of branded drugs to generic’s entry in the U.S. pharmacy and hospital markets.

the patent application was filed, which can date for more than 20 years before that an auction for an off-patent drug occurs. Similarly, the period in which an auction is conducted normally follows the annual budget schedule of each public body, which is determined in the year before an auction takes place. Hence, it can also be considered exogenous to generic supplier's entry decision in an auction. As soon as those two dimensions of the proposed instrumental variable are exogenous to generic's entry decision, the difference between them is also exogenous.

One may argue that the auction date cannot be exogenous to bids and acquisition prices since a public body can time the auction to maximize the number of bidders, thereby reducing acquisition prices. Indeed, a public body could, in principle, strategically schedule an auction for a drug to a period that its patent has just expired to potentially increase the number of suppliers bidding in the auction. If that is the case, then one would see a large number of auctions being held just after a patent expiration. Figure 1 inspects such argument looking at the distribution of auctions according to the number of days between patent expiration and the tendering session. Since our data set comprises only auction for off-patent drugs, all auctions take place after the drug's patent has expired. Figure 1 shows the distribution of auctions has no significant mass probability in the periods just after a patent has expired. It suggests that a public body does not seem to schedule auctions according to that reasoning.

Similarly, a public body could schedule an auction to a period that ANVISA has just authorized a generic drug supplier to enter in the Brazilian market to have generic's suppliers bidding in the auction. In that case, one should see a large number of auctions being held just after a drug's first generic ANVISA approval. Figure 2 inspects such argument looking at the distribution of auctions according to the number of days between drug's first generic approval and the tendering session. Panel (a) in Figure 2 shows that the distribution of auctions has no significant mass probability around zero. Panel (b) implements the graphical version of the McCrary (2008) density test in a subsample of auctions around zero. It suggests that there are no graphical differences (jumps) between the two separate estimates of the density around zero. Panel (c) and (d) show that the results hold in a smaller subsample around zero. Figure 3 implements the graphical version of the McCrary (2008) density test for low and high value auctions around zero. Those tests also suggest that there are no graphical differences (jumps) between the two separate estimates of the density around zero. Hence, the evidence shows that there is no perfect manipulation of the auction date, and we therefore conclude the auction date is exogenously determined.

In the estimation section we show that the proposed instrument is both a valid and relevant instrument for generic's entry in an auction.

## 5 Estimation and Results

In this section we implement the empirical strategy described in Section 4, aiming to investigate the effects of the presence of generic substitutes in procurement auctions on generic and branded drug suppliers bidding behavior and participation, and the consequences on acquisition prices for pharmaceuticals by public bodies.

We first investigate how the presence of a generic supplier in a competitive bidding affects branded drug supplier’s auction participation decision. Secondly, we look at how the presence of a generic supplier in a competitive bidding affects drug suppliers’ bids and acquisition prices. Third, we examine whether there exists different bidding price between generic and branded pharmaceutical suppliers, and if the prices paid by public bodies for them are unlike.

### 5.1 The effect of generic’s entry on branded drug suppliers’ participation in auctions

In this section we look at how the presence of a generic supplier in an auction affects branded drug supplier’s decision to participate in that auction. Potentially, some suppliers of branded drugs may prefer to abstain from bidding in auction with generic suppliers, rather than engaging in a fierce competition with them.

Table 9 presents several estimates of equation (1), in which the dependent variable is the natural logarithm of the Number of Branded Suppliers in an auction. The independent variable of interest is Generics in the tendering, which 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. The goal is to identify how the presence of generic suppliers in procurement auctions affects the number of branded suppliers in a tendering. If the estimated coefficient associated with that variable is negative, then we can conclude that the presence of generics in a tendering reduces branded suppliers’ participation in procurement auctions. Otherwise, they do not.

Table 9 reports several estimates of equation (1). Each column in Table 9 corresponds to a different specification of equation (1). Column (1) reports the estimates obtained by generalized least squares (GLS), in which we include only Generics in the tendering as an independent variable. Yet in column (2) we include fixed effects for each different drug 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 as Average Distance Buyer-Bidders, which

is the average distance between bidders location and place to delivery. In column (5) we add to our estimated equation some health indicators of the municipalities where the public body (buyer) is located.

First, note 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's entry in procurement auctions makes a reduction in number of branded suppliers. Additionally, it shows that the estimated coefficient is robust, remaining negative and statistically different from zero under several specifications and controls. Secondly, we observe that the magnitude of the coefficient of interest increases 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 reduction in the number of branded supplier in an auction by 1.9 percent. Yet the estimates from column (4) to (5) show that, after controlling for observable and unobservable characteristics, a presence of a supplier of generic reduces branded's participation by 35 percent. Such pattern displayed by the estimated coefficient of Generics in the tendering in Table 9 is consistent with a story that suppliers of generics enter in auction for drugs which there are many branded suppliers, what leads to a downward bias in the generic's entry coefficient estimated in column (1).

One may argue that the decision of a generic supplier to bid in an auction is endogenous and depends on the number of branded suppliers that is expected to compete in a tendering. Therefore, the GLS estimates of the casual effects of generic's entry on branded suppliers' participation will be biased, even though we control for observable and unobservable characteristics of the procurement transactions, drugs and public bodies. To overcome such potential bias, we implement a 2SLS estimation using the number of days between drug's patent expiration date and tendering session. Since we have information on patent expiration date for only 142 drugs, we can construct the instrumental variable for only 1,421 procurement auctions (out of 29,643 used in the estimation at column (5) in Table 9). That makes a substantial reduction in the sample used in the 2SLS estimation. Therefore, our estimation should be interpreted with caution since the sample is reduced.

Table 10 details the instrumental variable estimations of equation (1), in which we report the estimated causal effects of generic's entry on branded's participation in auction. Column (1) in Table 10 shows the GLS estimation for the full sample. It is the same as the estimation at column (5) in Table 9. Yet in column (2) we report the GLS estimation of equation (1) for the procurement transactions that we have information on patent expiration date (i.e., restricted sample). Note that the GLS estimates for the effect of generic's entry on branded's

participation in the full sample (column (1)) and in the restricted sample (column (2)) are about the same.

Columns (3) and (4) in Table 10 present the results of our instrumental variable empirical strategy. So, they report the estimates for equations (2) and (1), which are, respectively, the second-stage and first-stage of the 2SLS estimation. Particularly, column (3) reports the first-stage estimation using a linear probability model, in which the dependent variable is the dummy Generics in the tendering, and the instrumental variable (IV) is a natural logarithm of the number of Days from Drug's Patent Expiration Date and the tendering session. Note that the estimated coefficient of the IV is positive, which is consistent with the story that suppliers of generics enter in auction for drugs which there are many branded suppliers. However, the estimated coefficient is not statistically significant. Probably it occurs because the sample with IV is small compared to the full sample. Thus, the existing degrees of freedom are used to estimate the effect of interest and to control for observable and unobservable characteristics associated with the procurement transactions.

Column (4) shows the second-stage estimation. As in column (1) and (2), the dependent variable is the natural logarithm of the Number of Branded Suppliers in an auction. The parameter of interest is the one associated with the dummy Generics in the tendering, which is instrumented by the number of Days from Drug's Patent Expiration Date and the auction session. Our 2SLS estimation finds that the coefficient of the interest is negative, which means that some suppliers of branded drugs prefer to abstain from bidding in auction with a generic supplier. Note that the magnitude of our 2SLS punctual estimation for the generic's entry effect is higher than the GLS one. However, the estimated coefficient is not statistically significant. As discussed above, it may occur because the sample with IV is small compared to the full sample.

In sum, from the estimations Table 9 and Table 10 we find evidence that some suppliers of branded drugs decide to abstain from bidding in auction with generic suppliers, showing that participation of generic drug supplier in auction crowds out branded's participation. That result show that generic's entry in the pharmaceutical markets has mixed effects on competition. On one hand, generic's entry increases the number of substitutes for off-patents drugs, thereby increasing competition and lowering prices. On the other hand, generic's entry reduces the number of branded suppliers in auctions, which may soften competition and bound price reduction. Note that either an intense or a soft competition leads the same patten of price converge between branded and generic drugs documented in the previous section. In order to estimate the effective impact of generic's entry on bids and price paid, in the next



section we look at how the presence of a generic supplier in a competitive bidding affects generics and brandeds' bids and acquisition prices.

## 5.2 The effect of generic's entry on bids and acquisition price

Once we have examined the effect of generic's entry on branded's auction participation, in this section we examine the impact of the presence of generic suppliers on drug suppliers' bids and prices paid by public bodies, thereby identifying a potential channel through which generic's entry may affect bidding behavior and acquisition prices.

■ **Generics in the tendering and suppliers' bid.** Table 11 presents several estimates of equation (1), in which the dependent variable is the natural logarithm of a firm's bid. The independent variable of interest is Generics in the tendering, which 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. The goal is to identify how the presence of generic suppliers in procurement auctions affects drug suppliers bidding behavior. 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 9 corresponds to a different specification of equation (1). In column (1) we estimate that equation by generalized least squares (GLS), in which we include only Generics in the tendering as an independent 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).

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 drug characteristics, the coefficient associated with the variable Generics in the tendering is statistically equal to zero. It suggests that the generic's entry effect on suppliers bidding behavior reported in column (1) is capturing the drug characteristic effects omitted in that specification. In column (3) we find that the coefficient associated with the variable Generics in the tendering is also statistically equal to zero.

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. 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 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, our GLS estimations show 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.

One may argue that the decision of a generic supplier to bid in an auction is endogenous and depends on the number of expected branded suppliers that expected to compete in a tendering. Therefore, the GLS estimates of the casual effects of generic's entry on branded suppliers' participation will be biased, even tough we control for observable and unobservable characteristics of the procurement transactions, drugs and public bodies. Indeed, in the case that generic's entry is more likely when bids and drug prices are high, then our estimation are downward biased. If that is the case, then we have a possible reason for why we have found that the presence of generic suppliers in procurement auctions does not affect drug suppliers'bid in the GLS estimations.

In order to obtain unbiased estimator for the effect of generic's entry on suppliers's bid, we implement a 2SLS estimation using the number of days between drug's patent expiration date and tendering session. Using information on patent expiration date for 142 drugs, we can construct the instrumental variable for 8,172 observations on bids in 1,421 procurement auctions (out of 112,643 used in the estimation at column (5) in Table 11). Clearly, it leads to a reduction in the sample used in the 2SLS estimation. Note that because there are more than one bid in each procurement auction, the sample is bigger than the one used in the IV estimation in Table 10.

Table 12 details the instrumental variable estimations of equation (1), in which we report the estimated causal effects of generic's entry on supplier's bid. Column (1) in Table 12 shows the GLS estimation for the full sample. That is the same estimation as the one column (5) in Table 11. Yet in column (2) we report the GLS estimation of equation (1) for the procurement transactions that we have information on patent expiration date (i.e., restricted sample). Note

that the GLS estimates for the effect of generic's entry on suppliers' bid in the full sample (column (1)) and in the restricted sample (column (2)) are both statistically different from zero.

Columns (3) and (4) in Table 12 present the results of our instrumental variable estimation. They report the estimation of the second-stage and first-stage of the 2SLS estimation. In particular, column (3) reports the first-stage estimation using a linear probability model, in which the dependent variable is the dummy Generics in the tendering, and the instrumental variable (IV) is a natural logarithm of the number of Days from Drug's Patent Expiration Date and the tendering session. Note that the estimated coefficient of the IV is positive and statistically different from zero. It means that the higher the number of periods passed between an auction for a drug and drug's patent expiration, the more likely a supplier of generics enters in auction. Note also that the  $F$ -test does reject the hypothesis that all coefficients of the first-stage estimation are equal to zero. It provides evidence that our instrument is valid.

Column (4) shows the second-stage estimation. As in column (1) and (2), the dependent variable is the natural logarithm of a supplier's bid. The parameter of interest is the coefficient associated with the dummy Generics in the tendering, which is instrumented by the number of Days from Drug's Patent Expiration Date and the auction session. Our 2SLS estimation finds that the coefficient of the interest is not statistically different from zero, which means that suppliers lower their bids in auctions in which there is any supplier of generics. Note that the magnitude of our 2SLS punctual estimation of the generic's entry effect is higher than GLS one. That result shows evidence that the IV strategy provides an unbiased estimation of the causal effect of generic's entry on bids.

Another potential reason why we have not found any statistically significant for the effect of generic's entry on bidding behavior is that in estimations we are pooling generic and branded drug's suppliers bids in the same regression. Indeed, the presence of generic suppliers in procurement auctions may affect branded drug suppliers in a different manner than suppliers of generics.

In order to investigate that asymmetric effect of generic's entry, we first analyze 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 13 reports several estimates of equation (1), in which the dependent variable is the natural logarithm of a branded drug supplier's bid. Each column in Table 13 corresponds to a different specification of equation (1). Column (1) reports the estimates of equation (1) obtained by generalized least squares (GLS), in which we only include the variable Generics

in the tendering as an independent 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.

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's 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 several 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.

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. However, our estimation corrects for such bias since we use control for bidder fixed effects.

Our estimates of the effect of generic's entry on branded drug supplier's bidding behavior may be subject to bias as long as generic's entry decision is endogenous. In order to obtain unbiased estimator for such effect, we implement a 2SLS estimation. Using information on

patent expiration date for the drugs in our sample, we construct the instrumental variable for 6,167 observations on branded's bids in 1,421 procurement auctions (out of 97,576 used in the estimation at column (5) in Table 13). Clearly, it leads to a reduction in the sample used in the 2SLS estimation. Note that because there are more than one branded's bid in each procurement auction, the sample is bigger than the one used in the IV estimation in Table 10.

Table 14 details the instrumental variable estimations of equation (1), in which we report the estimated causal effects of generic's entry on branded supplier's bid. As in Table 12, column (1) in Table 14 shows the GLS estimation for the full sample. That is the same estimation as the one column (5) in Table 13. Yet in column (2) we report the GLS estimation for the procurement transactions that we have information on patent expiration date (i.e., restricted sample). Note that the GLS punctual estimates for the effect of generic's entry on branded suppliers' bid in the full sample (column (1)) and in the restricted sample (column (2)) are the same. Although, the latter is statistically equal to zero.

Columns (3) and (4) in Table 14 present the results of our instrumental variable estimation. They report the estimation of the second-stage and first-stage of the 2SLS estimation. In particular, column (3) reports the first-stage estimation using a linear probability model. Note that the estimated coefficient of the IV is positive and statistically different from zero, as in Table 12. Note also that the  $F$ -test also does reject the hypothesis that all coefficients of the first-stage estimation are equal to zero. Column (4) shows the second-stage estimation. Our 2SLS estimation finds that the coefficient of the interest is not statistically different from zero, which means that suppliers of branded drugs lower their bids in auctions with suppliers of generics.

The estimates reported in Table 13 in Table 14 document a novel effect of generic's 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 some 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.

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 15 presents several estimates of equation (1), in which the dependent variable is the generic drug suppliers' bids. The variable Other Generics in Table 31 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 15 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. The 2SLS estimates in Table 16 document the same pattern. Those findings may 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 17 presents several estimates of equation (1), in which the dependent variable is a natural logarithm of the winning bid, which is price paid by public bodies for a pharmaceutical. As in Tables 9 to 16, the independent variable of interest in Table 17 is Generics in the tendering, which 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. The aim is to identify how the presence of generic suppliers in procurement auctions affects acquisition prices for drugs. 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 17 corresponds to a different specification of equation (1). Similarly, in column (1) we estimate equation (1) by generalized least squares (GLS), in which we include only Generics in the tendering as an independent 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.

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's 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's 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. Nevertheless, our estimation corrects for such bias since we use control for buyer (public body) fixed effect.

Our estimates of the effect of generic's entry on acquisition prices may be subject to bias if generic's entry decision is endogenous. In order to obtain unbiased estimator for such effect, we implement a 2SLS estimation. Using information on patent expiration date, we construct the instrumental variable for only 1,421 procurement auctions (out of 29,643 used in the estimation at column (5) in Table 17). As in section 5.2, that leads to a substantial reduction in the sample used in the 2SLS estimation. Therefore, our estimation in those regression should be interpreted with caution since the sample is reduced.

Table 18 details the instrumental variable estimations of equation (1), in which we report the estimated causal effects of generic's entry on branded's participation in auction. Column (1) in Table 18 shows the GLS estimation for the full sample. It is the same as the estimation at column (5) in Table 17. Yet in column (2) we report the GLS estimation of equation (1) for the procurement transactions that we have information on patent expiration date (i.e., restricted sample). Note that the GLS estimates says the effect of generic's entry on branded's

participation in the full sample (column (1)) is bigger than the one estimated in the restricted sample (column (2)).

Columns (3) and (4) in Table 18 present the results of our instrumental variable empirical strategy. Particularly, column (3) reports the first-stage estimation using a linear probability model, in which the dependent variable is the dummy Generics in the tendering, and the instrumental variable (IV) is a natural logarithm of the number of Days from Drug's Patent Expiration Date and the tendering session. Note that the estimated coefficient of the IV is positive. However, the estimated coefficient is not statistically significant. Probably it occurs because the sample with IV is small compared to the full sample, and the existing degrees of freedom are used to estimate the effects of the observable and unobservable characteristics of the procurement transactions.

Column (4) shows the second-stage estimation. As in column (1) and (2), the dependent variable is the natural logarithm Number of Branded Suppliers in an auction. The parameter of interest is the one associated with the dummy Generics in the tendering, which is instrumented by our IV. Our 2SLS estimation finds that the coefficient of the interest is negative, which means that price paid by public bodies in auctions with a generic supplier. Note that the magnitude of our 2SLS punctual estimation of the generic's entry effect is higher than GLS one. However, the estimated coefficient is not statistically significant. As discussed above, it may be occurred because the sample with IV is relatively small.

The fierce competition between generic and brandeds in procurement auctions documented in this section suggests that we should observe no difference between generic and branded supplier's bids and prices in our estimations. In order to examine, in the next section we investigate whether there exists different bidding price between generic and branded pharmaceutical suppliers, and if the prices paid by public bodies for them are unlike.

### 5.3 Bids and price paid: generic versus branded suppliers

■ **Generic and branded suppliers' bids.** Table 19 presents several estimates of equation (1), in which the dependent variable is the natural logarithm of a firm's bid. The independent variable of interest is Generic Drug' Bidder, which 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. The goal is to identify differences in generic and branded drug suppliers bidding behavior in procurement auctions. 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 19 corresponds to a different estimated specification of equation (1). At column (1) in Table 19 we estimate equation (1) by generalized least squares (GLS) in which we include only the variable Generic Drug' Bidder as an independent variable. Yet in column (2) we take into account the panel structure of the data set, and we include a fixed effects 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).

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 drug, firm and buyer characteristics, the coefficient associated with the variable Generic Drug' Bidder is statistically equal to zero. Those results indicate that there is no significant difference between generic and branded suppliers bids. Hence, the negative estimated parameter for the coefficient associated with the variable Generic Drug' Bidder in column (1) means that generic drug suppliers place their bid in auctions for cheap drugs, whereas the branded ones bid for the expensive ones.

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 location and 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.

First, we observe that the coefficient associated with quantity purchased at column (4) in Table 19 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 location and 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.<sup>26</sup> This hypothesis is

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<sup>26</sup>Our results still hold if we replace the logarithm specification for the quadratic one.

closely investigated at the estimations 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 bidding price.

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) 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.<sup>27</sup>

Once having performed several different estimations of equation (1), which are reported in Table 19, 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 20 presents several estimates of equation (1), in which the dependent variable is the natural logarithm of a price paid (i.e., winning bid) by public bodies for a pharmaceutical. The independent variable of interest is Generics , which 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. So, it refers to the sort of pharmaceutical is acquired by a public body in the tendering: generic or branded. Our aim is to identify whether the acquisition price for a generic drug is different from a branded one in procurement auctions. If the estimated coefficient associated with the variable Generics 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 20 corresponds to a different estimation of equation (1). Similarly, in column (1) we estimate that equation by generalized least squares (GLS), in which we only include the variable Generics as an independent variable. Yet in column (2) we include fixed effects for each different drug, supplier and buyer in the estimation

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<sup>27</sup>In the regressions at column (5) we also correct for heteroskedasticity.

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.

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 *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 then provide evidence that there is no significant difference between price paid for generic and branded drugs. Hence, the negative estimated parameter for the coefficient of the variable *Generics* in column (1) indicates that generic drug suppliers win the auctions for cheap drugs, and the brandeds win the ones for expensive drugs.

The results reported in Table 19 and Table 20 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.

## **6 Suppliers Participation and Bidding Behavior in Auctions for High and Low Volume of Pharmaceuticals**

In the previous section, we documented that some branded drug suppliers leave auctions in which there exists a supplier of generics, whereas the remaining ones lower their bidding price. We argue that those 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.

One may wonder why some branded suppliers would prefer to be more aggressive in auctions in which there exists a generic competitor rather than leave procurement markets. A potential explanation for such behavior is that branded drug suppliers reduce their bidding price in auction with generic suppliers in order to keep their market shares in procurement markets. If that is the true story behind our findings, then the brandeds' bid reduction shall be greater in the most profitable procurement contracts than in the less profitable ones.

In principle, it is hard for an econometrician to identify which are the most profitable

procurement contracts. However, in a presence of economies of scale in logistics and in production process, such that the marginal cost reduce when volume of sales increases, high volume contracts are more profitable than low volume ones. Hence, brandeds' bid reduction due to generic's entry in a tendering shall increase as the volume in the contract to supply pharmaceuticals increases.

In this section we test that hypothesis. Exploiting variation in the volume of drugs acquired by public bodies in different auctions, we investigate the effects of generic's entry on bidding behavior and branded supplier's participation, and the consequences on acquisition prices in high and low volume of contracts to supply pharmaceuticals.

To identify in the sample which are the high and low volume contracts for drug supply, we look at the quantity purchased by public bodies in each procurement auction. Table 21 presents a detailed descriptive statistics of the variable Quantity Purchased, which is the total number of items of a certain drug that a public body acquires in a auction from the winning bidder. That table shows the main percentiles of that variable. Note that, the median is 560 units, which means that public bodies acquire 560 units in 50% of the procurement auctions.

Table 22 reports the estimated effect of generic's entry (i.e., Generics in the tendering) on branded supplier's bid in the tendering in high and low volume contracts. In Panel A we show the GLS estimates and in Panel B the 2SLS ones. To obtain these estimates we divide the sample in low and high volume contracts. We classify a procurement auction as a low (resp. very low) volume one if the quantity purchased is lower than the median 560 units (resp. 150 units - percentile 25%). Similarly, a procurement auction is classified as a high (resp. very high) volume contract if the quantity purchased is higher than the median (resp. 2,700 units - percentile 75%).

Panel A in Table 22 shows that the GLS estimated effect of generic's entry on brandeds' bids is statistically significant only in the very high volume auctions (i.e., more quantity purchased is higher than the 2,700 units). Note that the estimated effect in high volume contract is about 4 percent, greater than the effect estimated in the full sample. Despite the fact that generic's entry impact on branded bids is not statistically different from zero for high and low volume contracts, the punctual estimates in negative.

Panel B in Table 22 we report the 2SLS estimated effect of generic's entry on brandeds' bids. We also find a similar pattern: branded drug suppliers lower their bidding price in a presence of a generic supplier only in auctions for high volume contracts. However, that estimated effect is not statistically different from zero in the very high volume auctions. Probably, that happens because our sample is reduced in the 2SLS estimation, and it becomes

even smaller when we estimated generic's entry using the subsample of very high volume contracts. Consequently, the estimate loses significance.

Based on that evidence, one may argue that we should also observe that branded supplier's bid are higher than generic ones in low volume contracts vis-à-vis high ones. In order to test it, we estimate the difference between generic and branded suppliers' bidding price in low and high volume auctions. It is similar to the empirical test that we implement in Section 5.1. As in Table 19 and Table 20, we estimate such difference by regressing the natural logarithm of a firm's bid on the variable Generic Drug' Bidder, and on all control variables, for high and low volume contracts. The estimated coefficient associated with Generic Drug's bidder is our parameter of interest.

Table 23 reports the estimated difference between generic and branded's bids. We find that generic bidding price is 6-8 percent lower than branded ones in very low (less than 150 units) and low (less than 560 units) volume contracts. On the other hand, we find that generic and branded's bids are statistically equal in high (more than 150 units) and very high (more than 2,700 units) volume contracts. Similarly, we find that price paid (winning bid) for generic is 11 percent cheaper than branded ones very low volume auctions, but there is no statistically different between generic and branded's price in high and very high volume contracts.

In sum, these results provide evidence that branded's suppliers seem to reduce their bidding prices in the more profitable auctions to supply drugs, which we assume to be the high volume ones.

## 7 Conclusion

This paper investigates the causal effects of the presence of generic substitutes in procurement auctions on generic and branded drug suppliers bidding behavior and participation, and the consequences on acquisition prices for pharmaceuticals by public bodies. In order to identify the patterns displayed by bids, prices and suppliers participation in procurement markets, we perform an econometric analysis of a unique micro database on auctions for pharmaceuticals organized by public bodies in Brazil.

We find that some branded drug suppliers leave the auctions in which there exists a supplier of generics. However, the remaining ones lower their bidding price in a presence of generics in an auction. Due to a fierce price competition between generic and branded suppliers, the price paid for pharmaceuticals reduces by 7 percent in auctions in which a generic's supplier participates vis-à-vis auctions without generics. As a result of such generic-

branded competition, we find no statistical difference between bids and prices paid for generic and branded drugs. To overcome potential estimation bias due to generic's entry endogeneity, we exploit variation in the number of days between drug's patent expiration date and the tendering session. The two-stage estimations document the same pattern as the generalized least square estimations find. Our estimations also document that branded drug suppliers lower their offers in a presence of generic competitor only when they bid for high volume contracts. They probably reduce their price-cost margin in order to increase volume, thereby maximizing profits. Hence, we conclude that generic's entry causes an important change in branded drug suppliers' strategy in procurement auctions.

In a nutshell, our results indicate 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 vis-à-vis private (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 assess how much generic's entry reduces branded suppliers' markup.

Those empirical questions could be addressed in a further research.

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## A 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 (%) Total Public Health Expenditure

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: BEC Procurement Auctions for Off-Patent Drugs:  
Awarding Mechanisms

Variable	First Price Sealed Bid Auction	Two Stage Auction	Total
Panel A - Number of Procurement Auctions			
2008	7,632	1,987	9,622
2009	6,829	5,166	11,995
2010	6,050	7,465	13,515
2011	7,594	12,929	20,523
2012	2,340	6,757	9,097
Total	30,448	34,304	64,752
Panel B - Fraction of Each Awarding Mechanism			
2008	0.79	0.21	1.00
2009	0.57	0.43	1.00
2010	0.45	0.55	1.00
2011	0.37	0.63	1.00
2012	0.26	0.74	1.00
Total	0.47	0.53	1.00

Table 4: Descriptive Statistics - Procurement Transactions Characteristics (I)

Variable	Number of Observations
Panel A - Characteristic	
Procurement Transactions	30,448
Number of Bids	118,814
Products (drugs)	3,859
Active Ingredients	425
Suppliers	293
Public Bodies	188
Bidders	361
Municipalities	60
Panel B - Year	
2008	7,632
2009	6,829
2010	6,050
2011	7,594
2012	2,340

Table 5: Descriptive Statistics - Procurement Transactions Characteristics (II) - Distribution over Years/Months

Variable	Number of Observations	Mean	Standard Deviation	Min	Max
Panel A - Year					
Dummy 2008	30,448	0.25	0.43	0.00	1
Dummy 2009	30,448	0.22	0.42	0.00	1
Dummy 2010	30,448	0.20	0.40	0.00	1
Dummy 2011	30,448	0.25	0.43	0.00	1
Dummy 2012	30,448	0.08	0.27	0.00	1
Panel B - Months					
Dummy January	30,448	0.03	0.17	0.00	1
Dummy February	30,448	0.11	0.31	0.00	1
Dummy March	30,448	0.13	0.34	0.00	1
Dummy April	30,448	0.10	0.30	0.00	1
Dummy May	30,448	0.10	0.29	0.00	1
Dummy June	30,448	0.09	0.28	0.00	1
Dummy July	30,448	0.09	0.28	0.00	1
Dummy August	30,448	0.08	0.27	0.00	1
Dummy September	30,448	0.07	0.25	0.00	1
Dummy October	30,448	0.09	0.28	0.00	1
Dummy November	30,448	0.12	0.32	0.00	1
Dummy December	30,448	0.01	0.09	0.00	1

Table 6: Descriptive Statistics - Procurement Transactions Characteristics (III)

Variable	Number of Observations	Mean	Standard Deviation	Min	Max
Price paid (price per unit)	30,448	19.59	161.47	0.00	4,397.14
Bid of a Bidder (price per unit)	118,815	13.03	183.74	0.00	43,211.95
Generics in the tendering (dummy)	30,448	0.27	0.44	0.00	1.00
Generic Winner (dummy)	30,448	0.11	0.31	0.00	1.00
Generic Winner in Auctions with Generics (dummy)	8,230	0.41	0.49	0.00	1.00
Number of Bidders	30,448	3.85	2.99	1.00	52.00
Number of Branded Bidders	30,448	3.40	2.83	0.00	52.00
Number of Generic Bidders	30,448	0.45	0.86	0.00	8.00
Distance Buyer-Supplier (km)	29,803	269.01	264.21	0.00	2,378.46
Distance Buyer-Bidder (km)	115,146	270.98	246.59	0.00	2,378.46
Quantity Purchased (units)	30,448	5,337	57,650	1.00	5,232,000
Days between Patent Expiration Date and Tendering Session (in years)	1,443	19.41	4.78	1.74	25.30
Days between Drug's First Generic Approval Date and Tendering Session (in years)	7,558	3.32	1.96	-2.35	6.87

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

Table 7: 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	60	-	-	-	-	5592*
Population	28,108	5,346,052	5,431,342	1,239	11,300,000	34,295
Hospitalization	29,723	26,938	25,916	37	58,778	3,743
Hospital Mortality rate	30,448	4.95	0.64	0.97	8.83	2.51

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



Table 8: Mean Difference Tests

Variables	Panel A			Panel B		
	Generic supplier in tendering		t-test	Contract Awarded to a		t-test
	Yes (1)	No (2)	t-statistic (3)	Generic Supplier (4)	Branded Supplier (5)	t-statistic (6)
Price paid (price per unit)	1.01	26.46	-12.25***	0.90	21.92	-7.14***
Supplier's Bid (price per unit)	2.28	19.34	-15.46***	1.48	14.47	-7.66***
Quantity Purchased (units)	8,400.23	4,201.96	5.65***	5,009.84	5,377.50	-0.35
Number of Bidders	5.13	3.37	47.31***	3.68	3.87	-3.49***
Number of Branded Bidders	3.47	3.37	2.85***	1.93	3.58	-32.60***
Number of Generic Bidders	1.66	0	280.00***	1.75	0.29	110.00***
Distance Buyer-Supplier (km)	273.20	267.47	1.66*	272.34	268.58	0.78
Distance Buyer-Bidder (km)	283.81	263.55	13.44***	288.93	268.73	8.75***
Hospitalization	29,047	26,139	8.64***	26,656	26,973	-0.66
Hospital Mortality rate	4.86	4.95	-5.47***	4.89	4.93	-1.94*

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 9: Existence of a generic bidder in the tendering and branded bidders' participation

Independent variables	Ln (Number of Branded Bidders)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Generics in the tendering (dummy)	-0.019** (0.006)	-0.103*** (0.011)	-0.101*** (0.011)	-0.149*** (0.010)	-0.372*** (0.007)	-0.342*** (0.007)	-0.355*** (0.008)
Quantity Purchased (ln)				0.129*** (0.003)	0.007*** (0.001)	0.008*** (0.001)	0.010*** (0.001)
Number of Bidders (ln)					0.748*** (0.003)	0.752*** (0.003)	0.760*** (0.004)
Average Distance					-0.049 (0.060)	-0.049 (0.060)	-1.251*** (0.286)
Buyer-Bidders†						0.488* (0.247)	16.718*** (4.112)
Average Distance							0.217 (0.317)
Buyer-Bidders† (square)							-0.001 (0.001)
Hospitalization‡							
Hospital Mortality rate							
Observations	64,752	64,752	64,752	64,752	64,752	53,690	29,643
R-Square	0.000	0.154	0.163	0.294	0.908	0.906	0.911
Fixed-Effects							
Drug Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes

Notes:

All regressions are estimated with intercept.

Robust standard errors in parenthesis. \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

† The variable *Average Distance Buyer-Bidders* is divided by 10,000.

‡ The variable *Hospitalization* is divided by 1,000,000.

Table 10: Impact of Generics in the tendering on Branded Supplier's Participation: Addressing Causality

Independent variables	Ln(Number of Branded Bidders)			
	GLS		2SLS	
	Full Sample	Restricted Sample	1st Stage*	2nd Stage
	(1)	(2)	(3)	(4)
Generics in the tendering (dummy)	-0.355*** (0.008)	-0.361*** (0.037)	- -	-0.810 (0.501)
Days from Drug's Patent Expiration Date (ln)	-	-	0.442 (0.495)	-
Control Variables				
Quantity Purchased (ln)	0.010*** (0.001)	0.010 (0.006)	0.005 (0.009)	0.012 (0.007)
Number of Bidders (ln)	0.760*** (0.004)	0.843*** (0.022)	0.108** (0.032)	0.891*** (0.056)
Average Distance Buyer-Bidders <sup>†</sup>	-1.251*** (0.286)	-1.368 (0.842)	3.686 (1.884)	0.231 (2.082)
Average Distance Buyer-Bidders <sup>†</sup> (square)	16.718*** (4.112)	12.317 (8.055)	-25.661* (12.782)	1.022 (14.492)
Hospitalization <sup>‡</sup>	0.217 (0.317)	4.330* (2.041)	-2.572 (3.224)	3.134 (3.169)
Hospital Mortality rate	-0.001 (0.001)	-0.012* (0.006)	0.003 (0.010)	-0.011 (0.008)
Observations	29,643	1,421	1,421	1,421
F-Statistics	-	-	0.00	-
Fixed-Effects				
Drug Fixed-Effect	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	Yes	Yes	Yes	Yes
Month Fixed-Effect	Yes	No	Yes	Yes
Year Fixed-Effect	Yes	No	Yes	Yes

Notes:

All regressions are estimated with intercept.

GLS Restricted Sample refers to the estimation using only the sample whose drug patent expiration date is in Fiuza and Caballero (2009), or in Ellison and Ellison (20011).

Standard errors in parenthesis. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

\* It is estimated a linear probability model in the 1st stage.

<sup>†</sup> The variable *Average Distance Buyer-Bidders* is divided by 10,000.

<sup>‡</sup> The variable *Hospitalization* is divided by 1,000,000.

Table 11: Impact of the existence of a generic bidder in the tendering on suppliers' bid

Independent variables	Ln (Drug Supplier's Bid)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Generics in the tendering (dummy)	-1.263*** (0.012)	-0.030 (0.017)	-0.024 (0.017)	0.001 (0.014)	-0.003 (0.014)	-0.006 (0.014)	-0.005 (0.014)
Quantity Purchased (ln)				-0.144*** (0.012)	-0.149*** (0.015)	-0.150*** (0.014)	-0.148*** (0.014)
Number of Bidders (ln)				0.028 (0.017)	0.028 (0.017)	0.029 (0.017)	0.029 (0.017)
Distance Buyer-Bidder†					-2.205*** (0.587)	-2.205*** (0.587)	-2.417*** (0.617)
Distance Buyer-Bidder† (square)					46.842*** (9.285)	46.842*** (9.285)	50.064*** (9.515)
Hospitalization†							-2.858** (0.914)
Hospital Mortality rate							-0.003 (0.003)
Observations	227,201	167,349	167,349	118,815	118,815	115,146	112,701
R-Square	0.044	0.654	0.655	0.259	0.26	0.26	0.261
Fixed-Effects							
Bidder Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Supplier Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes

Notes:

All regressions are estimated with intercept.

Robust standard errors in parenthesis. \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

† The variable *Distance Buyer-Bidder* is divided by 10,000.

‡ The variable *Hospitalization* is divided by 1,000,000.

Table 12: Impact of Generics in the tendering on Drug Supplier's Bid: Addressing Causality

Independent variables	Ln(Drug supplier's bid)			
	GLS		2SLS	
	Full Sample	Restricted Sample	1st Stage*	2nd Stage
	(1)	(2)	(3)	(4)
Generics in the tendering (dummy)	-0.005 (0.014)	0.005 (0.031)	- -	-2.330** (0.814)
Days from Drug's Patent Expiration Date (ln)	-	-	0.533*** (0.140)	-
Control Variables				
Quantity Purchased (ln)	-0.148*** (0.014)	-0.138*** (0.025)	0.037*** (0.004)	-0.055 (0.031)
Number of Bidders (ln)	0.029 (0.017)	0.033 (0.047)	0.020* (0.010)	0.080* (0.034)
Distance Buyer-Bidder <sup>†</sup>	-2.417*** (0.617)	0.365 (2.987)	0.366 (0.841)	0.920 (2.624)
Distance Buyer-Bidder <sup>†</sup> (square)	50.064*** (9.515)	55.214 (47.747)	-5.871 (12.219)	43.844 (38.225)
Hospitalization <sup>‡</sup>	-2.858** (0.914)	-8.776 (4.954)	1.055 (1.318)	-6.354 (4.189)
Hospital Mortality rate	-0.003 (0.003)	0.022 (0.012)	-0.004 (0.004)	0.012 (0.014)
Observations	112,701	8,172	8,172	8,172
F-Statistics	-	-	11.41	-
Fixed-Effects				
Drug Fixed-Effect	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	Yes	Yes	Yes	Yes
Bidder Fixed-Effect	Yes	Yes	Yes	Yes
Month Fixed-Effect	Yes	No	Yes	Yes
Year Fixed-Effect	Yes	No	Yes	Yes

Notes:

All regressions are estimated with intercept.

GLS Restricted Sample refers to the estimation using only the sample whose drug patent expiration date is in Fiuza and Caballero (2009), or in Ellison and Ellison (2001).

Standard errors in parenthesis. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

\* It is estimated a linear probability model in the 1st stage.

<sup>†</sup> The variable *Distance Buyer-Bidder* is divided by 10,000.

<sup>‡</sup> The variable *Hospitalization* is divided by 1,000,000.

Table 13: Generic Drug's influence on the Branded Drug Supplier's Bid

Independent variables	Ln (Branded Supplier's Bid)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Generics in the tendering (dummy)	-1.235*** (0.014)	-0.052** (0.017)	-0.046** (0.017)	-0.019 (0.015)	-0.023 (0.014)	-0.027* (0.014)	-0.028* (0.014)
Quantity Purchased (ln)				-0.137*** (0.013)	-0.140*** (0.016)	-0.141*** (0.015)	-0.140*** (0.015)
Number of Bidders (ln)					0.022 (0.018)	0.023 (0.017)	0.023 (0.018)
Distance Buyer-Bidder†						-2.229*** (0.596)	-2.484*** (0.626)
Distance Buyer-Bidder† (square)						49.366*** (9.629)	52.826*** (9.832)
Hospitalization†							-2.196* (0.889)
Hospital Mortality rate							-0.004 (0.003)
Observations	196,454	148,042	148,042	103,461	103,461	99,854	97,576
R-Square	0.037	0.657	0.658	0.232	0.233	0.233	0.234
Fixed-Effects							
Drug Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Bidder Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes

Notes:

All regressions are estimated with intercept.

Robust standard errors in parenthesis. \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

† The variable *Distance Buyer-Bidder* is divided by 10,000.

‡ The variable *Hospitalization* is divided by 1,000,000.

Table 14: Impact of Generics in the tendering on Branded Supplier's Bid: Addressing Causality

Independent variables	Ln(Branded supplier's bid)			
	GLS		2SLS	
	Full Sample	Restricted Sample	1st Stage*	2nd Stage
	(1)	(2)	(3)	(4)
Generics in the tendering (dummy)	-0.028* (0.014)	-0.027 (0.037)	- -	-2.123** (0.790)
Days from Drug's Patent Expiration Date (ln)	-	-	0.580*** (0.163)	-
Control Variables				
Quantity Purchased (ln)	-0.140*** (0.015)	-0.111*** (0.026)	0.034*** (0.005)	-0.041 (0.029)
Number of Bidders (ln)	0.023 (0.018)	-0.014 (0.045)	0.089*** (0.013)	0.174* (0.080)
Distance Buyer-Bidder <sup>†</sup>	-2.484*** (0.626)	1.941 (3.551)	0.140 (1.017)	1.940 (2.864)
Distance Buyer-Bidder <sup>†</sup> (square)	52.826*** (9.832)	54.667 (56.821)	1.173 (14.904)	59.380 (42.018)
Hospitalization <sup>‡</sup>	-2.196* (0.889)	-8.316 (4.829)	2.252 (1.553)	-3.665 (4.712)
Hospital Mortality rate	-0.004 (0.003)	0.022 (0.012)	-0.006 (0.006)	0.011 (0.016)
Observations	97,576	6,167	6,167	6,167
F-Statistics	-	-	10.35	-
Fixed-Effects				
Drug Fixed-Effect	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	Yes	Yes	Yes	Yes
Bidder Fixed-Effect	Yes	Yes	Yes	Yes
Month Fixed-Effect	Yes	No	Yes	Yes
Year Fixed-Effect	Yes	No	Yes	Yes

Notes:

All regressions are estimated with intercept.

GLS Restricted Sample refers to the estimation using only the sample whose drug patent expiration date is in Fiuza and Caballero (2009), or in Ellison and Ellison (20011).

Standard errors in parenthesis. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

\* It is estimated a linear probability model in the 1st stage.

<sup>†</sup> The variable *Distance Buyer-Bidder* is divided by 10,000.

<sup>‡</sup> The variable *Hospitalization* is divided by 1,000,000.

Table 15: Generic Drug's influence on Other Generic Drug Supplier's Bid

Independent variables	Ln (Generic Supplier's Bid)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Other Generics (dummy)	-0.471*** (0.034)	-0.087*** (0.020)	-0.071*** (0.020)	-0.005 (0.019)	-0.035 (0.021)	-0.038 (0.021)	-0.033 (0.021)
Quantity Purchased (ln)				-0.168*** (0.014)	-0.188*** (0.015)	-0.188*** (0.015)	-0.187*** (0.015)
Number of Bidders (ln)					0.112*** (0.024)	0.114*** (0.025)	0.115*** (0.026)
Distance Buyer-Bidder†						-0.005 (1.753)	0.148 (1.786)
Distance Buyer-Bidder† (square)						20.347 (24.627)	19.579 (24.961)
Hospitalization†							-5.287 (3.169)
Hospital Mortality rate							-0.002 (0.007)
Observations	30,747	19,307	19,307	15,354	15,354	15,292	15,125
R-Square	0.006	0.672	0.675	0.450	0.452	0.452	0.451
Fixed-Effects							
Drug Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Bidder Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes

Notes:

All regressions are estimated with intercept.

Robust standard errors in parenthesis. \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

† The variable *Distance Buyer-Bidder* is divided by 10,000.

‡ The variable *Hospitalization* is divided by 1,000,000.



Table 16: Impact of Generics in the tendering on Generic Supplier's Bid: Addressing Causality

Independent variables	Ln(Generic supplier's bid)			
	GLS		2SLS	
	Full Sample	Restricted Sample	1st Stage*	2nd Stage
	(1)	(2)	(3)	(4)
Other Generics (dummy)	-0.033 (0.021)	0.021 (0.058)	- -	-2.677 (1.610)
Days from Drug's Patent Expiration Date (ln)	-	-	0.925* (0.461)	-
Control Variables				
Quantity Purchased (ln)	-0.187*** (0.015)	-0.210*** (0.032)	0.046*** (0.009)	-0.093 (0.075)
Number of Bidders (ln)	0.115*** (0.026)	0.184* (0.071)	0.067*** (0.020)	0.358** (0.122)
Distance Buyer-Bidder <sup>†</sup>	0.148 (1.786)	-3.232 (4.668)	-0.868 (2.319)	-6.633 (7.735)
Distance Buyer-Bidder <sup>†</sup> (square)	19.579 (24.961)	45.754 (62.514)	25.643 (31.244)	125.426 (111.385)
Hospitalization <sup>‡</sup>	-5.287 (3.169)	-13.102 (8.036)	9.710* (4.091)	12.948 (20.402)
Hospital Mortality rate	-0.002 (0.007)	0.003 (0.033)	0.024* (0.011)	0.066 (0.052)
Observations	15,125	2,005	2,005	2,005
F-Statistics	-	-	6.03	-
Fixed-Effects				
Drug Fixed-Effect	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	Yes	Yes	Yes	Yes
Bidder Fixed-Effect	Yes	Yes	Yes	Yes
Month Fixed-Effect	Yes	No	Yes	Yes
Year Fixed-Effect	Yes	No	Yes	Yes

Notes:

All regressions are estimated with intercept.

GLS Restricted Sample refers to the estimation using only the sample whose drug patent expiration date is in Fiuza and Caballero (2009), or in Ellison and Ellison (2001).

Standard errors in parenthesis. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

\* It is estimated a linear probability model in the 1st stage.

<sup>†</sup> The variable *Distance Buyer-Bidder* is divided by 10,000.

<sup>‡</sup> The variable *Hospitalization* is divided by 1,000,000.

Table 17: Impact of the existence of a generic supplier in the tendering on acquisition price

Independent variables	Ln (Acquisition Price)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Generics in the tendering (dummy)	-1.764*** (0.026)	-0.171*** (0.019)	-0.168*** (0.020)	-0.102*** (0.020)	-0.075*** (0.020)	-0.075*** (0.021)	-0.073*** (0.021)
Quantity Purchased (ln)				-0.195*** (0.017)	-0.178*** (0.019)	-0.179*** (0.019)	-0.178*** (0.019)
Number of Bidders (ln)					-0.113*** (0.015)	-0.113*** (0.015)	-0.112*** (0.015)
Distance Buyer-Supplier <sup>†</sup>						-2.904** (1.007)	-3.085** (1.067)
Distance Buyer-Supplier <sup>†</sup> (square)						62.187*** (15.728)	65.695*** (16.295)
Hospitalization <sup>‡</sup>							0.779 (1.190)
Hospital Mortality rate							-0.006 (0.004)
Observations	62,977	62,977	62,977	30,448	30,448	29,803	29,038
R-Square	0.068	0.727	0.728	0.330	0.335	0.337	0.337
Fixed-Effects							
Drug Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Supplier Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes

Notes:

All regressions are estimated with intercept.

Robust standard errors in parenthesis. \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

<sup>†</sup> The variable *Distance Buyer-Supplier* is divided by 10,000.

<sup>‡</sup> The variable *Hospitalization* is divided by 1,000,000.

Table 18: Impact of Generics in the tendering on Acquisition Price: Addressing Causality

Independent variables	Ln(Acquisition Price)			
	GLS		2SLS	
	Full Sample	Restricted Sample	1st Stage*	2nd Stage
	(1)	(2)	(3)	(4)
Generics in the tendering (dummy)	-0.073*** (0.021)	-0.017 (0.070)	- -	-2.021 (2.217)
Days from Drug's Patent Expiration Date (ln)	-	-	0.377 (0.319)	-
Control Variables				
Quantity Purchased (ln)	-0.178*** (0.019)	-0.180*** (0.038)	0.002 (0.010)	-0.176*** (0.026)
Number of Bidders (ln)	-0.112*** (0.015)	-0.116* (0.048)	0.119*** (0.023)	0.126 (0.274)
Distance Buyer-Supplier <sup>†</sup>	-3.085** (1.067)	-4.776 (4.449)	1.902 (2.341)	-0.796 (7.552)
Distance Buyer-Supplier <sup>†</sup> (square)	65.695*** (16.295)	126.954 (64.940)	10.948 (38.445)	141.220 (101.692)
Hospitalization <sup>‡</sup>	0.779 (1.190)	-0.895 (6.419)	-2.325 (4.022)	-5.824 (11.868)
Hospital Mortality rate	-0.006 (0.004)	0.014 (0.014)	0.002 (0.010)	0.018 (0.027)
Observations	29,038	1387	1,387	1,387
F-Statistics	-	-	1.88	-
Fixed-Effects				
Drug Fixed-Effect	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	Yes	Yes	Yes	Yes
Supplier Fixed-Effect	Yes	Yes	Yes	Yes
Month Fixed-Effect	Yes	No	Yes	Yes
Year Fixed-Effect	Yes	No	Yes	Yes

Notes:

All regressions are estimated with intercept.

GLS Restricted Sample refers to the estimation using only the sample whose drug patent expiration date is in Fiuza and Caballero (2009), or in Ellison and Ellison (20011).

Standard errors in parenthesis. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

\* It is estimated a linear probability model in the 1st stage.

<sup>†</sup> The variable *Distance Buyer-Supplier* is divided by 10,000.

<sup>‡</sup> The variable *Hospitalization* is divided by 1,000,000.

Table 19: Difference between generic and branded drug supplier's bids

Independent variables	Ln (Drug Supplier's Bid)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Generic Drug's Bidder (dummy)	-0.970*** (0.018)	-0.006 (0.018)	-0.001 (0.018)	-0.004 (0.018)	-0.003 (0.018)	-0.003 (0.018)	0.000 (0.018)
Quantity Purchased (ln)				-0.144*** (0.012)	-0.149*** (0.015)	-0.150*** (0.014)	-0.148*** (0.014)
Number of Bidders (ln)					0.028 (0.017)	0.029 (0.017)	0.029 (0.017)
Distance Buyer-Bidder†					-2.201*** (0.585)	-2.201*** (0.585)	-2.417*** (0.615)
Distance Buyer-Bidder† (square)					46.798*** (9.256)	46.798*** (9.256)	50.065*** (9.486)
Hospitalization†							-2.859** (0.915)
Hospital Mortality rate							-0.003 (0.003)
Observations	227,201	167,349	167,349	118,815	118,815	115,146	112,701
R-Square	0.013	0.654	0.655	0.259	0.26	0.26	0.261
Fixed-Effects							
Drug Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Bidder Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes

Notes:

All regressions are estimated with intercept.

Robust standard errors in parenthesis. \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

† The variable *Distance Buyer-Bidder* is divided by 10,000.

‡ The variable *Hospitalization* is divided by 1,000,000.

Table 20: Difference between price paid for generic and branded drugs

Independent variables	Ln (Acquisition Price)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Generics (dummy)	-1.348*** (0.035)	-0.018 (0.022)	-0.017 (0.022)	-0.013 (0.021)	-0.016 (0.021)	-0.019 (0.022)	-0.015 (0.022)
Quantity Purchased (ln)				-0.196*** (0.017)	-0.177*** (0.019)	-0.179*** (0.019)	-0.178*** (0.019)
Number of Bidders (ln)					-0.120*** (0.015)	-0.120*** (0.014)	-0.119*** (0.015)
Distance Buyer-Supplier†						-2.914** (1.069)	-3.092** (1.069)
Distance Buyer-Supplier† (square)						62.150*** (15.745)	65.596*** (16.310)
Hospitalization‡							0.782 (1.194)
Hospital Mortality rate							-0.005 (0.004)
Observations	62,977	62,977	62,977	30,448	30,448	29,803	29,038
R-Square	0.020	0.727	0.728	0.328	0.334	0.336	0.336
Fixed-Effects							
Drug Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Supplier Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Buyer Fixed-Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effect	No	No	Yes	Yes	Yes	Yes	Yes

Notes:

All regressions are estimated with intercept.

Robust standard errors in parenthesis. \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

† The variable *Distance Buyer-Supplier* is divided by 10,000.

‡ The variable *Hospitalization* is divided by 1,000,000.

Table 21: Detailed Descriptive Statistics  
 - Quantity Purchased in the Procurement  
 Transactions

Variable	Statistics
Mean	25,090
Standard Deviation	663,213
Min	1
Max	94,900,000
Percentiles	
Percentile 5%	12
Percentile 10%	36
Percentile 25%	150
Percentile 50%	560
Percentile 75%	2,700
Percentile 90%	12,000
Percentile 95%	30,000

Table 22: Presence of Generics in a tendering and Branded Supplier's Bidding Behavior: Effect in High and Low Volume Contracts

Dependent Variable	Independent Variable: Generic in the tendering (dummy)				
	Quantity <i>lower</i> than		Quantity <i>higher</i> than		Full Sample
	Perc. 25%	Perc. 50%	Perc. 50%	Perc. 75%	
	(150 units)	(560 units)	(560 units)	(2,700 units)	
	(1)	(2)	(3)	(4)	(5)
Panel A: GLS					
Branded Supplier's Bid	-0.031 (0.035)	-0.023 (0.021)	-0.025 (0.014)	-0.038* (0.017)	-0.028* (0.014)
Panel B: 2SLS*					
Branded Supplier's Bid	-0.105 (0.977)	-0.780 (0.547)	-1.152** (0.433)	-0.680 (0.794)	-2.123*** (0.790)

Notes: All regressions are estimated with intercept, and month, year, drug, bidder/supplier, buyer fixed effects. Standard errors in parenthesis. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

\* It is estimated a linear probability model in the 1st stage.

Table 23: Difference between Generic and Branded's Bidding Price in High and Low Volume Contracts

Dependent Variable	GLS Estimation				
	Quantity <i>lower</i> than		Quantity <i>higher</i> than		Full Sample
	Perc. 25%	Perc. 50%	Perc. 50%	Perc. 75%	
	(150 units)	(560 units)	(560 units)	(2,700 units)	
(1)	(2)	(3)	(4)	(5)	
	Independent Variable: Generic Drug's Bidder (dummy)				
Supplier's Bid	-0.082* (0.035)	-0.059* (0.024)	0.033 (0.019)	0.038 (0.021)	0.000 (0.018)
Acquisition Price	-0.112** (0.041)	-0.033 (0.027)	0.011 (0.020)	-0.012 (0.024)	-0.015 (0.022)

Notes:

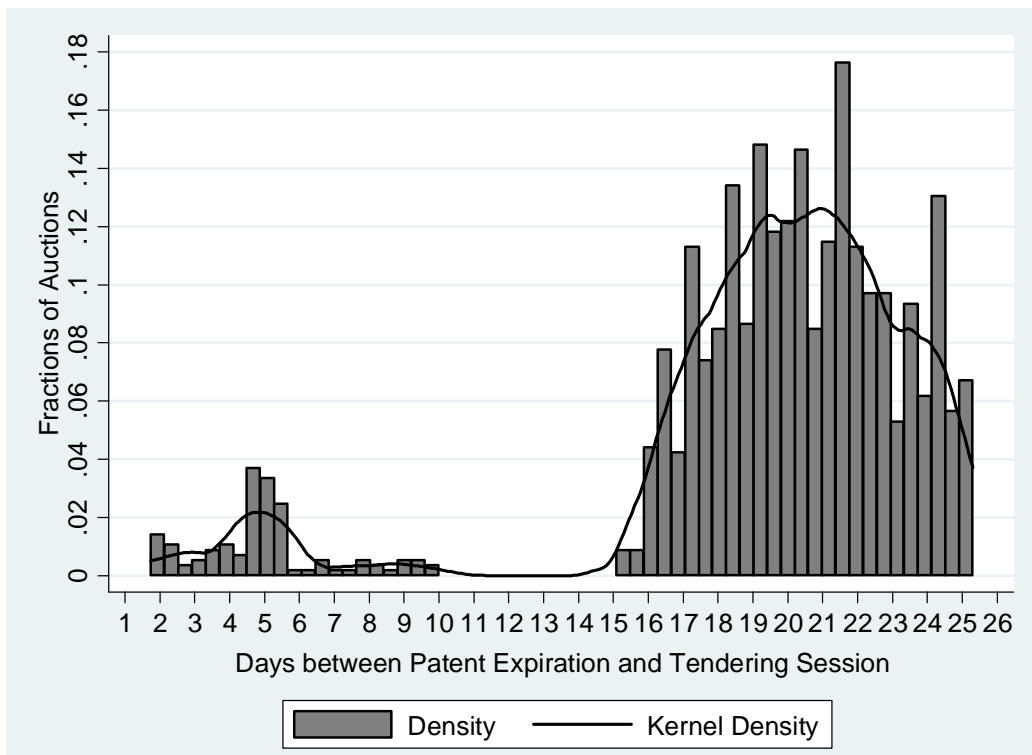
All regressions are estimated with intercept, and month, year, drug, bidder/supplier, buyer fixed effects.

Standard errors in parenthesis. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

\* It is estimated a linear probability model in the 1st stage.

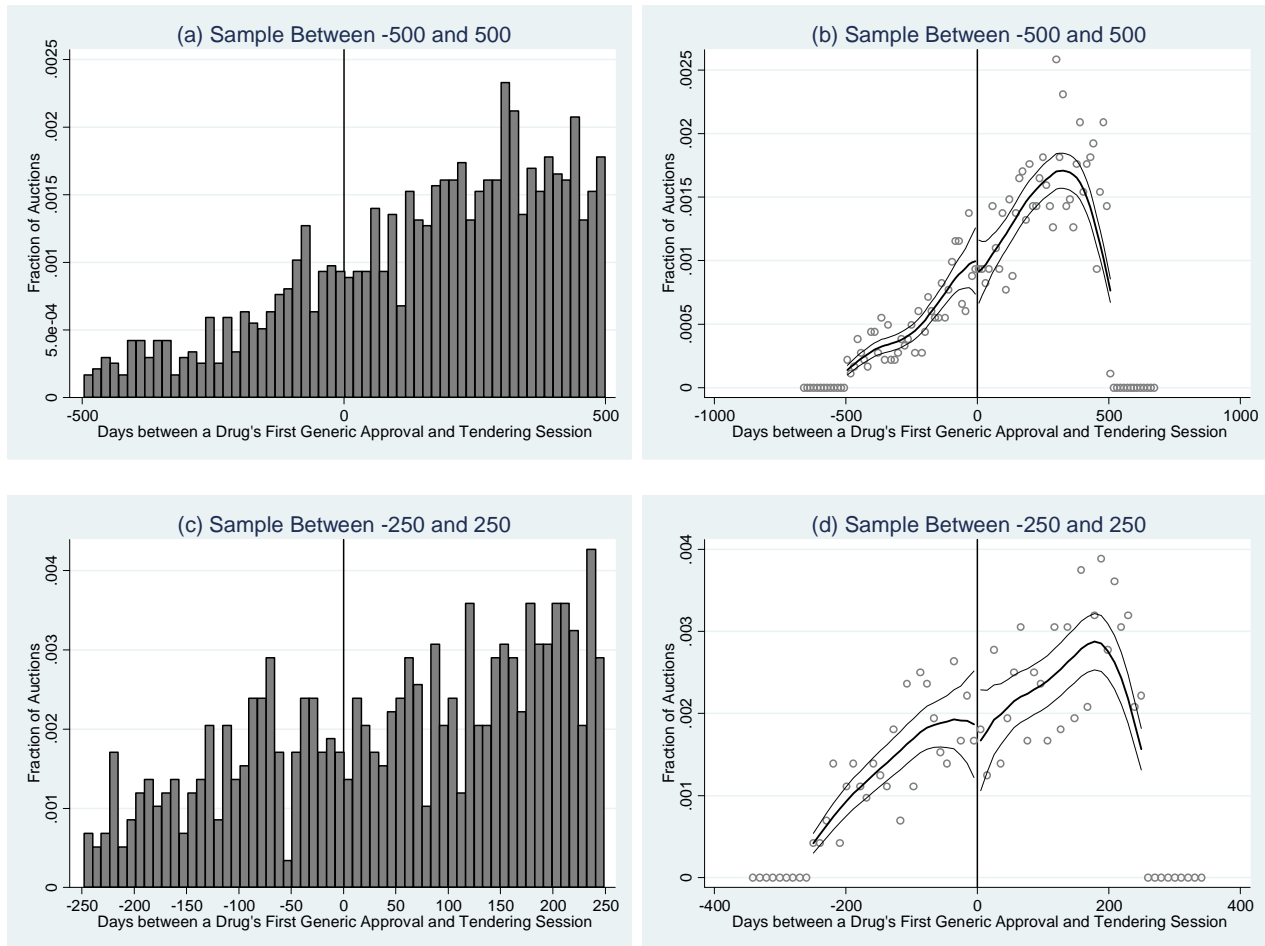


Figure 1: Overall Distribution of Auctions according to the Number of Days between Patent Expiration and Tendering Session



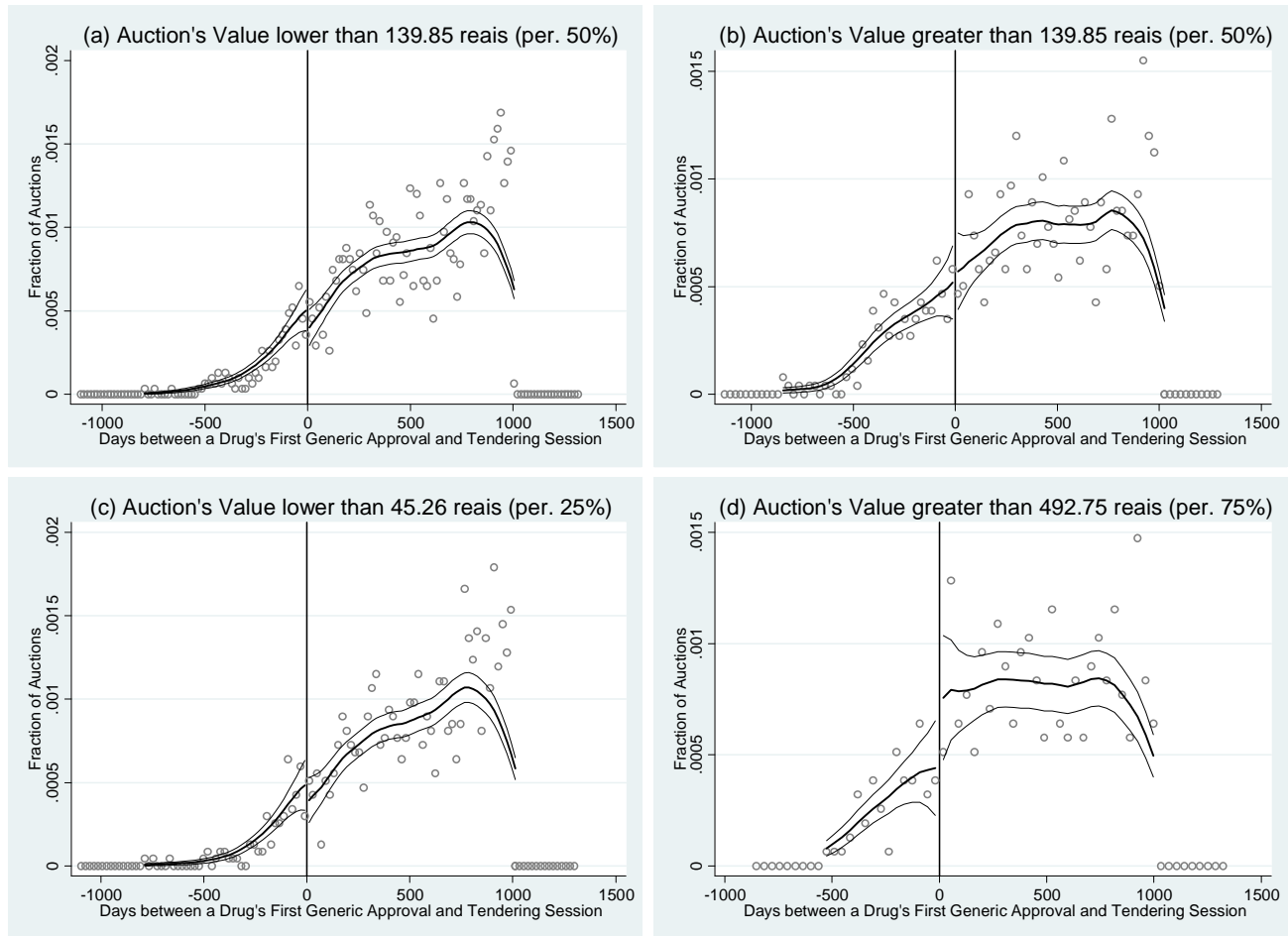
Notes: The bars represent the density of the number of days between a drug's patent expiration date and a tendering Session for that drug using bin size 60. The line denotes the kernel density estimation using Epanechnikov kernel function and the the "optimal" bandwidth.

Figure 2: Overall Distribution of Auctions according to the Number of Days between a Drug's First Generic Approval and Tendering Session



Notes: The (black) vertical line denotes the 0 (zero) days discontinuity. The figure (a) represents the density of the number of days between a drug's first generic approval date and a tendering Session for that drug using bin size 60, with number of days between -500 and 500. The figure (b) denotes the McCrary (2008) density's discontinuity test for the number of days between a drug's first generic approval and tendering session around the threshold 0 (zero) days, with number of days between -500 and 500. The figure (c) represents the density of the number of days between a drug's first generic approval date and a tendering Session for that drug using bin size 60, with number of days between -250 and 250. The figure (d) denotes the McCrary (2008) density's discontinuity test for the number of days between a drug's first generic approval and tendering session around the threshold 0 (zero) days, with number of days between -250 and 250.

Figure 3: Density Auctions according to the Number of Days between a Drug’s First Generic Approval and Tendering Session: Low and High Auction’s Value



Notes: The (black) vertical line denotes the 0 (zero) days discontinuity. All figures denote the McCrary (2008) density's discontinuity test for the number of days between a drug's first generic approval and tendering session around the threshold 0 days, using sample with different auction's. The figure (a) denotes the McCrary's test in the subsample with auction's value lower than 139.85 reais (perc. 50 %). The figure (b) denotes the McCrary's test in the subsample with auction's value greater than 139.85 reais (perc. 50 %). The figure (c) denotes the McCrary's test in the subsample with auction's value lower than 45.26 reais (perc. 25 %). The figure (d) denotes the McCrary's test in the subsample with auction's value greater than 492.25 reais (perc. 75 %).

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