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Regulation and competition in the Taiwanese pharmaceutical market under national health insurance

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ABSTRACT

This article investigates the determinants of the prices of pharmaceuticals and their impact on the demand for prescription drugs in the context of Taiwan's pharmaceutical market where medical providers earn profit directly from prescribing and dispensing drugs. Based on product-level data, we find evidence that the profit-seeking behavior of the medical providers in the prescription drug market transfers the force of competition from the unregulated wholesale market to the regulated retail market and hence market competition still plays an important role in the determination of the regulated price. We also find that the profit-seeking behavior plays a similar role to advertising in that it increases the brand loyalty and hence lowers price elasticity. An important implication of our study is that the institutional features in the pharmaceutical market matter in shaping the nature of pharmaceutical competition and the responsiveness of pharmaceutical consumption with respect to changes in price.

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1. Introduction

In recent years, a substantial amount of technological progress in medicine has taken the form of pharmaceutical innovation. As a result, an increasing number of studies have paid attention to how the pharmaceutical market operates in the health sector (Berndt, 2002). In particular, the determinants of the prices of pharmaceuticals and their effects on the demand for prescription drugs have long been a focus in this line of research (see, e.g., Berndt et al., 1995; Ellison et al., 1997; Lu and Comanor, 1998; Rizzo, 1999; Danzon and Chao, 2000; Pavcnik, 2002; Ekelund and Persson, 2003; Wang, 2006; Dalen et al., 2006; Iizuka, 2007; Ellison and Snyder, 2010). However, most of these studies used data obtained from Western countries where prescribing and dispensing are separated. The experiences of East Asian countries where physicians prescribe and dispense drugs are much less well researched. A few exceptions include Wang (2006) and Iizuka (2007) who target their research on the pharmaceutical markets in China and Japan, respectively.

Compared to other markets in the economic sector in general and in the health sector in particular, study outcomes of the pharmaceutical market are more likely to be sensitive to the institutional features because of the complex institutional context in this market (Reinhardt, 2007). In many countries, governments provide insurance coverage for prescription drugs and regulate the prices that they reimburse. In addition, physicians act as front-line professional agents, making consumption decisions on behalf of their patients in the prescription drug market. Instead of a simple bilateral relationship between demand (the buyer) and supply (the seller), these characteristics shape the structure of the prescription drug market in a quadrilateral relationship: the pharmaceutical firm, the medical provider, the patient and the payer. Whether or not the study outcomes on the determinants of prices and their effects on the demand for prescription drugs are sensitive to the alternative structures of this quadrilateral relationship is an issue that is well worth exploring.

This article uses the prescription drug market in Taiwan as an example to investigate the question of how the institutional features of the health sector affect the determinants of price and quantity in the pharmaceutical market. In Taiwan, the government provides universal insurance coverage for prescription drugs and regulates the reimbursement price. In addition, physicians both

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prescribe and dispense drugs. As a result, Taiwan's pharmaceutical market provides an interesting setting in which to address the following two questions: (1) Compared to the system where prescribing and dispensing are separated, does the integration of prescribing and dispensing alter the form of price competition in the pharmaceutical market, and how does it do so? (2) How is the price elasticity of demand for prescription drugs influenced by institutional features such as the integration of prescribing and dispensing?

The remainder of this article is organized as follows. Section 2 describes the conceptual framework that is based on the institutional features of the prescription drug market in Taiwan. Section 3 describes the data and methodology used in the analysis. Section 4 presents the results, and Section 5 summarizes our findings and discusses policy implications.

2. Conceptual framework

There are two major institutional features in the Taiwanese pharmaceutical market that make our study setting different from other existing studies which focus on countries in North America and Europe.

First, Taiwan, like many Asian countries such as China and Japan, has a health-care system in which physicians both prescribe and dispense drugs.[1] Under this system, most patients directly receive their outpatient care prescription drugs from the hospitals or clinics that they visit. Second, Taiwan has a social insurance system, known as national health insurance (NHI), which provides universal insurance coverage to all citizens and offers comprehensive benefits, including physician services, hospital care, and prescription drugs. To control the cost of public insurance, the government regulates the reimbursement price of prescription drugs (P), i.e., the price paid on behalf of patients, in the retail market, but it does not regulate the acquisition prices (P_a) that hospitals or clinics obtain from the pharmaceutical manufacturers in the wholesale market. That is, the government regulates public prices only and leaves distribution margins ($P - P_a$) unregulated. These two institutional features together enable clinics and hospitals to profit from the sales of prescription drugs.[2]

We first describe how the regulated prices are set. Then, we explain how the profit margins between the reimbursement and the acquisition prices affect the demand for prescription drugs.

2.1. The determinants of the regulated price

In addition to obtaining authorization to market a new drug, Taiwan, like other countries with direct price controls on pharmaceutical products, requires that the pharmaceutical manufacturer of a new drug obtain approval for coverage and a price for reimbursement from the single public payer, the Bureau of National Health Insurance (BNHI).

At the time of entry, the public payer (BNHI) uses a mix of strategies to determine the reimbursement price (or referring to as the launch price) for each specific brand-name and generic drug, including references to existing products and to international comparisons, and a drug's therapeutic value. In general, the public payer fixes the regulated price product by product and the level of the regulated price is positively associated with the therapeutic value and the version of drugs according to the following four specific criteria.[3] First, BNHI uses the median price of international comparisons (P_{IM}) to set the upper limit on regulated prices for branded drugs still on patent (P_b^{on}), that is, $P_b^{on} \leq P_{IM}$.[4] Second, for off-patent branded drugs, the upper limit of the regulated price is 85% of the international median price, that is, $P_b^{off} \leq 0.85P_{IM}$. Third, for generic drugs that have passed a bio-equivalent test (P_g^{be}), the upper limit of the regulated price is the price of the branded price in the same therapeutic group, that is, $P_g^{be} \leq P_b^{off}$. Fourth, for generic drugs for which a bio-equivalence test is not conducted, the upper limit of the regulated price is 80% of the price of the branded drugs in the same therapeutic group, that is, $P_g \leq 0.8P_b^{off}$ (Hsieh and Sloan, 2008).[5] Based on this practice, the determinant of the launch price (P) can be expressed as follows:

$$P = P(V,\ P_o), \tag{1}$$

where V represents the version and the therapeutic value of the product, P_o represents the price of other existing competing products in the same therapeutic category.[6] Equation (1) states that the public payer considers the therapeutic value and the price of other existing products when setting the regulated price for each product at the time of entry.[7]

Following entry into the market, the public payer uses a market survey on the prices and quantities of sales in the wholesale market as the basis for updating the reimbursement prices for existing drugs. As mentioned, the government only regulates the reimbursement price (the retail price) and does not regulate the wholesale price based on which the clinics and hospitals purchase

[1] In recent years, the government in Taiwan has adopted a series of reforms to separate drug prescribing from dispensing (Chou et al., 2003). However, the reforms have been incomplete in the sense that hospitals can still keep their pharmacy department for outpatient services and physicians practicing in clinics are still allowed to hire pharmacists on site to dispense drugs. Japan and South Korea have also adopted similar reforms to separate drug prescribing from dispensing; see Iizuka (2007) and Kwon (2003). For a more detailed analysis on the historical background of the integration of drug prescribing and dispensing in East Asian countries, see Eggleston and Yang (2009). In Switzerland, physician dispensing is also allowed in some regions where the density of pharmacies is lower (Rischatsch and Trottmann, 2009).

[2] Throughout this paper, the reimbursement price is equivalent to the retail price which is regulated by the public payer and the acquisition price is equivalent to the wholesale price which is unregulated. Thus, in our paper, the terms reimbursement price, retail price and regulated price are interchangeable. Similarly, the terms acquisition price, wholesale price and unregulated price are interchangeable.

[3] In other words, Taiwan has not imposed a referencing price system as adopted in many European countries whereby pharmaceutical manufactures are allowed to have certain range of freedom to set their own retail prices. In Taiwan, the public payer sets the retail price for each individual drug on the basis of "product brand" instead of the "chemical substance". For generic drugs, this is the so-called "branded generics".

[4] The BNHI monitors 10 countries as a reference group for international comparisons, including Australia, Belgium, Canada, France, Germany, Japan, Sweden, Switzerland, the United Kingdom, and the United States.

[5] For more detailed information on the practicing rule of regulation on pharmaceutical prices in Taiwan, see the website of the Bureau of National Health Insurance (http://www.nhi.gov.tw/english/index.asp).

[6] As noted, the median price of international comparisons (P_{IM}) serves as the benchmark or reference point to set the launch prices for brand-name drugs, which in turn provide the reference point for determining the launch prices for generic drugs. Based on this recursive relationship, the effect of P_{IM} is incorporated in the price of other existing competing products (P_o). In addition, P_{IM} is only relevant to the determination of the launch prices for brand-name drugs which only account for 16% of pharmaceutical products selected in our sample as we will discuss in the empirical section. Thus, we will use the price of other existing competing products to serve as a proxy variable to capture the effect of P_{IM} in our empirical estimation.

[7] Since the implementation of the NHI program in March 1995, the public payer in Taiwan (BNHI) has established a task force committee, which consists of representatives from medical professionals and government officials, to decide the level of the launch price for each pharmaceutical product entering the NHI formulary. In practice, the public payer gives the committee judging which measures of therapeutic value count a great deal of discretion in making the final decision regarding the launch price and regarding whether or not to set the launch price close or equal to the median prices based on international comparisons. In short, deciding how the drug's therapeutic value is used and how the regulation measures and defines this value are committee-driven.

drugs from pharmaceutical manufacturers, with the difference between the reimbursement price and the wholesale price becoming the profit margin earned by the clinics and hospitals. To squeeze this profit margin, the public payer regularly conducts market surveys to collect information on the actual average wholesale price and then readjusts the reimbursement price level according to the new estimates of the average wholesale prices. During the period 1996–2006, the public payer updated the reimbursement prices five times after it learned the average wholesale price based on extensive surveys.[8]

Based on these pricing practices, we model the determination of the regulated price in period t (P^t) for the existing product as follows:

$$P^t = P_a^{t-1} + \alpha P^{t-1}, \tag{2}$$

where P_a is the average acquisition (wholesale) price which is defined as follows:

$$P_a = (1-\theta) \times P = P - \theta \times P, \tag{3}$$

where θ is the discount rate offered by the pharmaceutical manufacturers.[9] α is a "reasonable zone" of profit margin which allows medical providers to cover the technical fees and transaction costs of dispensing drugs.[10] Based on current practice, the regulator sets $\alpha = 0.15$, which is similar to the practice adopted by the Japanese government (Iizuka, 2007). Thus, we treat α as a constant.

Equation (2) states that the public payers take the weighted average of the acquisition price in the wholesale market, which is obtained from a market survey, and the reimbursement price in the previous period to set the regulated price in the current period.

From the inception of the NHI program to the writing of this paper, the public payer has never publicly released the results of the market survey. Thus, P_a is unobservable to the outside parties. However, the link between the regulated price and the acquisition price can be deduced based on the theoretical reasoning that uses a set of the observable variables to infer the effect of the unobservable variable. Ellison and Snyder (2010) refer to the discount rate offered by the pharmaceutical manufacturers (θ) as the "countervailing power" in the wholesale pharmaceuticals, that is, the ability of larger buyers (e.g., larger hospitals) to extract discounts from suppliers (e.g., pharmaceutical manufacturers). As noted by Ellison and Snyder (2010), supplier competition is a necessary condition for larger-buyer discounts. Thus, both buyer-size and supplier competition are required for countervailing power. Following this framework, in combination with the institutional features of the pharmaceutical market in Taiwan, we specify that the discount rate (θ) is a function of the number of competing products in the same market (N), the buyer-size (M), and the therapeutic value of drugs (V). That is,

$$\theta = \theta(N,\ M,\ V) \tag{4}$$

Other things being equal, the discount rate is positively associated with N and M, but is negatively associated with V, that is, $\partial\theta/\partial N > 0$, $\partial\theta/\partial M > 0$, $\partial\theta/\partial V < 0$. This is because an increase in the intensity of supplier competition and an increase in buyer-size give buyers more of an advantage in extracting better price concessions from suppliers. Thus, the countervailing power gained by the medical provider (θ) is positively associated with the number of competing products within the same market and the buyer-size. In addition, medical providers are in a better position to gain a larger degree of countervailing power from the pharmaceutical suppliers of lower-quality products, such as generic drugs without conducting a bio-equivalence test, as compared with high-quality products, such as brand-name drugs with significant therapeutic advances over existing products. This inverse relationship between the therapeutic value and the countervailing power can be simplified by observing the relationship between the versions of the drugs and the countervailing power. In general, medical providers could gain larger countervailing power from the suppliers of generic drugs than from the suppliers of brand-name drugs given the fact that the current pricing rule adopted by the regulator in Taiwan generates a higher generic-to-brand price ratio as compared to other countries such as the United States.[11]

Putting equations (3) and (4) into equation (2), we rewrite equation (2) as follows:

$$P^t = [1 + \alpha - \theta(V,\ N,\ M)]P^{t-1}(V,\ P_o) \tag{2'}$$

By omitting the superscript for the time period, equation (2′) can be simplified as the following reduced-form equation:

$$P = P(N,\ M,\ V,\ P_o) \tag{5}$$

Equation (5) states that the level of the regulated price is a function of the number of competing products in the same market (N), the size of the buyer (M), the therapeutic value of the drug (V), and the prices of other existing products (P_o). This equation predicts that the regulated price is influenced by the number of products in the same market through the competition in the wholesale market. As more products enter the market, medical providers gain more countervailing power and hence pharmaceutical firms are more likely to cut the acquisition price to a lower level in order to be selected in the provider's formulary. The public payer in turn learns the lower acquisition price from the extensive market survey and hence updates the reimbursement price accordingly. Thus, we predict that the level of the reimbursement price is negatively related to the number of competing products in the same market, that is, $\partial P/\partial N < 0$.[12]

Following the same theoretical reasoning, we also predict that the regulated prices is positively related to the therapeutic value of the product and price level of other existing products, but is negatively related to the buyer-size.

2.2. The effect of the regulated price on the demand for prescription drugs

Given the institutional features of the pharmaceutical market in Taiwan, the demand for prescription drugs (Q) can be expressed as follows:

$$Q = F(P,\ \pi,\ Z) \tag{6}$$

[8] During the period 1996–2006, the number of products updated by each wave of price surveys varied substantially, ranging from 592 to 9801.

[9] For example, if the reimbursement price for a drug is NT$100 and the discount rate offered by a firm is 10%, then the acquisition price for this drug is NT$90. As a result, medical providers earn NT$10 from prescribing the drug.

[10] Throughout this paper, medical providers refer to clinics and hospitals.

[11] In Taiwan, the generic-to-brand price ratio is concentrated in the range of 0.7–0.8 (Liu et al., 2009). By contrast, in the United States, the average generic-to-brand price ratio declines to about 0.3 over 3 years after the first generic entry (Saha et al., 2006). This comparison suggests that the regulated prices of generic drugs are too high, which in turn give the suppliers of generic products wider space to offer price discounts to medical providers. For a more detailed discussion whereby hospitals or clinics in Taiwan gain a larger countervailing power from the suppliers of generic products than from the suppliers of brand-name products, see Liu et al. (2009).

[12] In practice, the effect of such competition may arise from two sources: (1) generic competition; (2) therapeutic competition. We will discuss the distinction between these two types of competition in the section on the empirical study.

where π represents the profit margin earned by the medical providers, that is,

$$\pi = P - P_a = \theta P, \tag{7}$$

Z represents other determinants of the demand for prescription drugs, such as the prices of other competing products and the therapeutic value. Equation (6) states that the demand for prescription drugs is a function of the regulated price, the profit margin and other determinants.[13]

Based on equations (6) and (7), the effect of the reimbursement price on the demand for prescription drugs can be shown to be as follows:

$$\frac{\partial Q}{\partial P} = \frac{\partial F}{\partial P} + \frac{\partial F}{\partial \pi} \times \frac{\partial \pi}{\partial P} = F_1 + F_2\theta \tag{8}$$

where $F_1 = \partial F/\partial P, F_2 = \partial F/\partial \pi$. In this model, the sign of F_1 is negative if the "law of demand" holds. The sign of F_2 is positive if the physicians' prescription choices are positively affected by the profit margins, that is, the physicians have an incentive to prescribe more drugs if the profit margin is higher. Thus, the demand for prescription drugs is positively associated with the profit margin.[14]

An important implication of equation (8) is that the incentive to earn a profit margin reduces the price sensitivity of demand for prescription drugs and the magnitude of this effect depends on the size of the countervailing power (θ). This is because the profit margin provides an incentive for physicians to "stick" to the specific drug and hence increases the brand loyalty. This mechanism is similar to the effects of advertising and promotion that increase the brand loyalty and hence decrease the price elasticity of demand for prescription drugs (Rizzo, 1999).

Since the discount rate (θ) is unobservable to us, we cannot directly test the hypothesis that the profit margin reduces price sensitivity. However, we can indirectly empirically test the effect of the profit margin on the price elasticity given the fact that the unobservable discount rate is positively related to some observable variables, such as the version of the drugs. As mentioned, medical providers tend to gain a higher countervailing power from the suppliers of generic products as compared to the suppliers of brand-name products, that is $\theta_g > \theta_b$.[15] As a result, according to equation (8), we predict that the demand for generic drugs is less responsive to the change in the regulated price as compared to the demand for branded drugs. That is,

$$\left|\frac{\partial Q_g}{\partial P_g}\right| < \left|\frac{\partial Q_b}{\partial P_b}\right| \text{ as } \theta_g > \theta_b \tag{9}$$

Based on equation (9), we predict that the absolute value of the price elasticity for generic drugs is smaller than that for the brand-name drugs.

3. Data and empirical methods

3.1. Data sources

The data used in this study come from three sources. First, we obtained data on the aggregate quantity of prescription drug consumption from a longitudinal data set which contains one million individuals (about 5% of the total population in Taiwan) randomly selected from the registry of NHI beneficiaries in the year 2005. The sampling file was then merged with insurance claim files that trace back all the medical utilization records of the same individuals in each year and follow their medical utilization data for subsequent years, hereafter referred to as the NHI sampling claims data.

The NHI sampling claims data were made publicly available through the National Health Research Institute. This data set contains detailed records on the utilization of personal health-care services, including outpatient visits, hospital admissions and prescription drugs. We merged the data for outpatient visits and inpatient admissions with the corresponding drugs prescribed and dispensed using anonymous identification numbers. The data on prescription drugs provide the drug identification number (drug ID), the quantity utilized, and total expenditures. The advantage of this data set is that all the medical utilization data can be linked together for the same patient. In addition, this data set is based on national sampling data and serves as a good representation of the population data. Thus, the summation of drug utilization across all patients represents the aggregate demand for the same drug in Taiwan.[16]

Secondly, we collected data on the reimbursement price and other characteristics of prescription drugs from the website of the BNHI which publishes the reimbursement price quarterly for each individual drug listed in the NHI formulary. By linking the drug ID with the NHI formulary dataset, the reimbursement price, ingredient name, brand-name, dosage, entry time, and manufacturers for all of the drugs can be identified.

Third, we used the Anatomical Therapeutic Chemical (ATC) classification system established by the World Health Organization to categorize the therapeutic use of the drugs in the NHI formulary and assigned defined daily doses (DDD) for each drug as a standard unit of measurement.[17]

We selected three common therapeutic markets to test our hypotheses: (1) oral hypoglycemic agents (OHAs); (2) serum lipid reducing agents; and (3) antidepressants. The details of the therapeutic classification of these markets are listed in Table 1.[18] Focusing on these therapeutic markets provides two advantages for our study. First, these drugs are designed to treat several important chronic diseases in terms of their respective prevalence rates and share of health-care expenditure, such as diabetes,

[13] Under the NHI system in Taiwan, office-based physicians are paid on the basis of the services they provide. Thus, the majority of office-based physicians can directly benefit from profit margins because the total amount of reimbursements claimed and received from the single public payer represents the major income sources for office-based physicians (Lin et al., 2005). For hospital-based physicians, they are paid a salary plus a bonus. In this case, they may not directly benefit from the profit margins received by the hospitals. However, given that hospitals operate outpatient pharmacies on their own, hospital-based physicians' prescription choices are subject to the restriction of the hospital's own prescription formulary. As a result, profit margins significantly influence the prescription decisions of both office-based and hospital-based physicians (Liu et al., 2009).

[14] Iizuka (2007) refers to this effect as the agency problem where physicians act as imperfect agents for their patients in the sense that physicians may choose drugs based not on efficacy, safety or cost, but solely on the extent of the profit margins that they or their institutions obtain. One of the focuses of this study is to empirically examine the effect of "imperfect agents" on the demand for prescription drugs and not on the direct test to examine whether the agency problem exists in Taiwan's pharmaceutical market. For the direct test as to whether physicians act as imperfect agents in the pharmaceutical market, see Iizuka (2007), Liu et al. (2009) and Rischatsch et al. (2009).

[15] Here the subscript g refers to generic drugs and the subscript b refers to brand-name drugs.

[16] We compared total pharmaceutical expenditure in our dataset with that of population data published by BNHI at the 1st level of the Anatomical Therapeutic Chemical (ATC) classification, and found that the distribution of drug expenditure by ATC categories in our sampling dataset was consistent with that of the population data.

[17] Since the DDDs for some drugs are not listed on the WHO/ATC website, we referred to the clinical pharmacology references to obtain DDDs for those drugs.

[18] Since some drugs have multiple indications and can be included in more than one ATC coding, using the ATC classification system to define markets may give rise to some challenging issues such as where some competing products can not be included in the same ATC group. Our study might not suffer from these problems given that our analysis only focuses on three therapeutic areas.

Table 1
Number of products classified by the ATC code in the sampling claims data.

ATC code at 4th level	Description	Number of products		
		Generic	Branded	Total
Oral hypoglycemic agents (OHAs)				
A10BA	Biguanides	44	2	46
A10BB	Sulfonamides, urea derivatives	126	7	133
A10BF	Alpha glucosidase inhibitors	9	2	11
A10BG	Thiazolidinediones	3	3	6
A10BX	Other oral blood glucose lowering drugs	8	3	11
Subtotal		***190***	***17***	***207***
Lowering lipid agents				
C10AA	HMG CoA reductase inhibitors	39	18	57
C10AB	Fibrates	66	9	75
C10AC	Bile acid sequestrants	5	4	9
C10AD	Nicotinic acid and derivatives	6	2	8
C10AX	Other lipid modifying agents	7	2	9
Subtotal		***123***	***35***	***158***
Antidepressants				
N06AA	Non-selective monoamine reuptake inhibitors	32	13	45
N06AB	Selective serotonin reuptake inhibitors	39	11	50
N06AG	Monoamine oxidase A inhibitors	4	1	5
N06AX	Other antidepressants	20	11	31
Subtotal		***95***	***36***	***131***
Total		**408**	**88**	**496**

hypertension and depression. Fig. 1 shows the market share (in terms of NHI drug expenditure) of these three therapy areas overall in the Taiwanese market. In 2006, these three therapeutic areas summed together accounted for about 12% of NHI drug spending, indicating a rapid increase from 7.5% in 1997.

Second, these three classes of prescription drugs are similar in that patients typically continue to be prescribed such drugs for months or years, once they find a drug that is effective for them. As a result, the relatively large market size has attracted many products into this market and hence these three therapeutic markets are highly competitive. Our sampling claims data show that the total numbers of products in the same therapeutic market for oral hypoglycemic agents, serum lipid reducing agents and antidepressants are 207, 158, and 131, respectively (Table 1).[19] Among these 496 products, there are 408 generics and 88 brands. This suggests that drugs used for the treatment of chronic diseases provide ideal markets in which to investigate the effect of regulation and competition on the demand for prescription drugs.

We use the product-quarter as our observation unit. That is, we match the quantity and price of prescription drugs by product and by quarter. The analysis covers a period of 10 years from the first quarter of 1997 to the fourth quarter of 2006. During this study period, some old drugs may exit the market while other new drugs enter the market. Thus, the data are in the form of an unbalanced panel that contains quarterly time series of price and quantity for 496 products.

3.2. Variable definitions

Table 2 reports the definitions of the empirical variables and their summary statistics. The first key variable in our empirical analysis is the quantity of drug consumption. After aggregating the prescription consumption of each visit and admission by quarters, we first transformed the quantity of drug consumption in terms of DDD according to the following equation:

$$Q_i = \frac{q_i}{\mathrm{DDD}_i} \tag{10}$$

where q_i indicates the quantity of drug consumption for the ith drug (by brand-name) in terms of its package unit obtained from NHI sampling claims data, and Q_i indicates the quantity of drug consumption for the ith drug expressed in terms of DDD.

Our data show that the average quarterly sale per drug is 12,071 DDDs (Table 2). Since our data set represents 5% of the total population, this result implies that the average annual market size per drug is about 1 million DDDs ($12{,}071 \times 4 \times 20$). In addition, the mean market size for a generic drug is only about one-third of the mean market size for a branded drug, suggesting that many generic products compete within the same therapeutic market.

The second key variable in our empirical analysis is the reimbursement price (P). Since the public payer in Taiwan regulates reimbursement prices product by product, drugs with the same ingredient but produced by different manufacturers are treated as

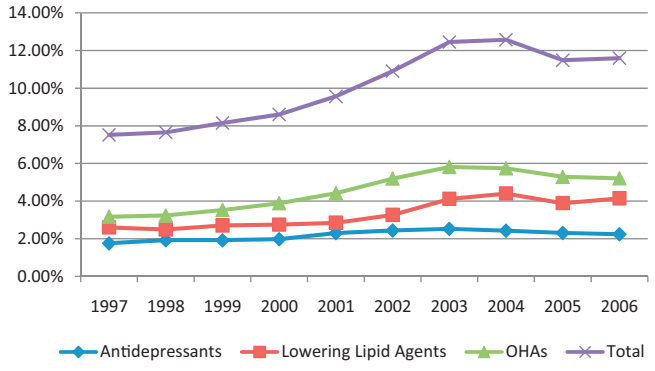

Fig. 1. Time trend of market shares in dollars.
Source: 2005 NHI sampling claims data, calculated by authors.

[19] We define a "product" of the prescription drug at the level of the manufacturer and drug presentation which consists of a particular choice of packaging and dose form for a drug. This definition is similar to the one used in Ellison et al. (1997). In addition, all drugs in our sample are pills.

Table 2
Variable names, definitions, and descriptive statistics.

Variable	Definition	Mean (standard deviation)		
		Full sample	Branded sub-sample	Generic sub-sample
Quantity	Quantity of drug consumption measured in terms of defined daily doses (DDDs)	12071.45 (39291.27)	26887.84 (68060.97)	9327.21 (31357.75)
Price (P)	NHI reimbursement price per DDDs (in NT$)	24.07 (25.73)	41.73 (35.78)	20.44 (21.25)
N_{GC}	Number of products within the same ingredient and dosage form, i.e. number of generic competitors	16.71 (13.30)	5.35 (7.51)	18.75 (13.14)
N_{TC}	Number of products within the same therapeutic market, i.e., number of therapeutic competitors	7.02 (8.59)	5.35 (1.84)	7.34 (9.32)
P_O^{TM}	Mean NHI reimbursement price per DDDs of other competing products within the same therapeutic market (in NT$)	25.71 (22.22)	35.43 (26.19)	23.82 (20.84)
P_O^{GM}	Mean NHI reimbursement price per DDDs of other competing products within the same generic market (in NT$)	26.08 (24.57)	–	23.71 (21.62)
Market share	Market share of products purchased by medical centers and metropolitan hospitals	0.29 (0.34)	0.65 (0.29)	0.23 (0.30)
Brand	Dummy = 1 for brand-name drug	0.16 (0.37)		
Stock company	Dummy = 1 if the generic drug is produced by domestic firms with stock publicly issued in the Taiwan market			0.17 (0.37)
Drug vintage (DV)	Number of months from the entry into the NHI formulary to December 2006	61.80 (34.67)	60.29 (36.08)	61.56 (34.51)
Number of observations		10,639	2042	8924

Note: The average exchange rate was around US$ 1 to NT$ 32.5 in 1997–2006.

different products.[20] In addition, different products may be packed in different formulations which make the reimbursement price in terms of its package unit (p) not directly comparable across drugs. Thus, we employed defined daily doses (DDDs) as a standard unit of measurement and used the price per DDD (P) to empirically measure the reimbursement price set by the public payer. That is, we transformed the directly observable reimbursement price (p) into price per DDD (P) according to the following equation:

$$P = \left(\frac{p}{y}\right) \times \text{DDD}, \tag{11}$$

where y indicates the dosage unit per package (or strength of product). We further deflated the nominal reimbursement price to 2006 New Taiwan dollars using the consumer price index for all goods.

Our data show that the mean real price per DDD is about NT$24 for all drugs.[21] In addition, the data show that the mean real reimbursement price of brand-name drugs is more than two times higher than that of generic products. This result is consistent with the current regulation that the brand-name drugs receive a higher reimbursement price than the generic drugs, other things being equal.

As shown in equation (5), the major explanatory variables in our study include competition (N), buyer-size (M), the prices of other products (P_o) and therapeutic value (V). In the pharmaceutical market, there are two types of competition: (1) generic competition between products with the same chemical ingredient; and (2) therapeutic competition between products of similar molecules in the same therapeutic class (Ellison et al., 1997; Wang, 2006). We measure generic competition by the number of competing products with identical ingredients and dosage forms (N_{GC}). Similarly, we measure therapeutic competition by the number of competing products within the same therapeutic market which is defined by the ATC code at the 4th level (chemical subgroup) (N_{TC}).[22] Our data show that the mean number of generic competitors is 16.71 and the mean number of therapeutic competitors is 7.02, suggesting that the drug markets selected in our study are highly competitive in Taiwan (Table 2).

Since our measure of drug consumption is in aggregate form, we are not able to measure the size of buyer for the individual purchaser. However, we use the concentration of larger buyers as a proxy variable to measure the buyer-size. The regulatory agency in Taiwan classifies medical providers into four accreditation levels: (1) local clinics; (2) local community hospitals; (3) metropolitan hospitals; and (4) academic medical centers. The accreditation level is closely correlated with the size of the medical providers.[23] Thus, we group academic medical centers and metropolitan hospitals as larger hospitals and use the market share of products purchased by larger hospitals to measure the buyer-size. From Table 2, it is

[20] As mentioned in note 3, this is the so-called "branded generics".
[21] The average exchange rate was around US$ 1 to NT$ 32.5 in 1997–2006.

[22] One of the key drivers in the therapeutic competition is the quality of the newer drugs relative to the older ones. In the literature, there are several alternative approaches to measure the quality of the newer drugs, such as whether there is a major therapeutic advance over existing competitive products, whether the new products are first-in-class or global products which are defined as those introduced in at least four major countries (Lu and Comanor, 1998; Grabowski and Wang, 2006). However, the NHI sampling claims data do not contain information on such quality measures.

[23] For example, in 2006, the mean numbers of hospital beds in metropolitan hospitals and academic medical centers were about 650 beds and 1300 beds, respectively. By contrast, the mean number of beds in local community hospitals was only 120 beds.

shown that larger hospitals account for 29% of drug consumption. For brand-name drugs, this share increases to 65%. This suggests that the major purchasers of brand-name drugs are larger hospitals, while the major purchasers of generic drugs are small hospitals and clinics.

As our measures of market competition, we measure the prices of other products in two different forms. The first one is the mean price of other competing products within the same therapeutic market (P_O^{TM}). The second one is the mean price of other competing products within the same generic market (P_O^{GM}).[24]

With regard to empirical measures of the therapeutic value, our data do not provide information on the rating of the therapeutic value for individual drugs. Instead, we define a series of proxy variables to measure the therapeutic value of drugs. First, a binary variable "brand" is set to equal 1 if the individual drug is produced by the branded firm in the same chemical-substance market and to equal 0 otherwise. Although pharmacologically the chemical compound for generic drugs is similar to that for brand-name drugs, many physicians and patients may still perceive generic drugs to be lower-quality products compared to branded drugs (Hellerstein, 1998; Lundin, 2000).[25] Thus, the dummy variable for branded drugs serves as a proxy for therapeutic value. In our data set, about 16% of products are brand-name drugs.

Second, we define the binary variable "stock company" as equaling 1 if generic products are produced by local firms with their stocks openly issued in the Taiwanese market, and as equaling 0 otherwise. This variable captures the size effect and assumes that the quality of generic products is positively related to the size of firms. For example, larger firms tend to have better capacity to conduct bio-equivalence tests for their generic products. We define this variable only for the sub-sample of generic products and find that only about 17% of generic products are produced by larger firms which have their stocks openly issued in the local stock market.[26]

Third, we calculate the drug vintage by counting the number of months from the entry into the NHI formulary to December 2006, the end point in our study sample. Since Taiwan established the NHI program in March 1995, the maximum length of the drug vintage in our sample is 141 months. As shown in Table 2, the mean drug vintage is about 5 years and there is no significant difference in drug vintage between generic and brand-name drugs.

We also provide further simple descriptive analysis by the therapeutic areas, including relative prices and market shares between brands and generics. The results suggest that there are no important differences across the three therapeutic areas. Due to space limitations, these descriptive analyses are contained in an appendix available as supplementary data.

3.3. Empirical implementation

Following our conceptual framework, the empirical strategy for testing our hypotheses is specified as the following two equations:

$$\mathrm{Log}(P_i) = \alpha_0 + \alpha_1 N_i + \alpha_2 X_i + e_i, \quad (12)$$

$$\mathrm{Log}(Q_i) = \beta_0 + \beta_1 \mathrm{Log}(P_i) + \beta_2 Z_i + u_i \quad (13)$$

where P_i represents the reimbursement price for the ith drug; Q_i represents the quantity of consumption for drug i; N_i includes a vector of variables that represents the number of competing products available in the same generic market and the same therapeutic market; X_i and Z_i indicate the vectors of other control variables for hypotheses testing, including the size of the buyer, mean price of other competing products, the therapeutic value of drugs, drug vintage and dummy variables representing the year and drug categories; α_j and β_j ($j = 0, 1, 2$) are parameters to be estimated; and e_i and u_i are random error terms.

The major characteristic of our empirical specification is that equation (13) includes price as an endogenous explanatory variable. Under this framework, we will first estimate price by means of the ordinary least squares (OLS) method. Then, the two-stage least square (2SLS) procedure will be used to estimate equation (13) to identify the endogenous nature of the price.

In the first stage, we use the number of products available in the same ingredient market (N_{GC}) as an instrument from supply regimes to identify the demand for drug consumption in the full and generic sub-samples, as well as the number of products within the same therapeutic market (N_{TC}) as an instrument in the branded sub-sample.[27] The validity of the instrument depends on the assumption that the change in the competitive environment is not correlated with e_i and u_i. Since pharmaceutical firms might enter or exit a market because of the change in quantity demanded, a weak instrument test is performed to make sure that N_{GC}/N_{TC} is valid. After estimating the semilogarithmic equation (12), we obtain the predicted value of the natural log of the reimbursement price and use this predicted value to estimate equation (13) by means of a logarithmic functional form in the second stage.

4. Estimation results

Table 3 reports three alternative specifications that represent different estimations of equation (12). In the first specification, we estimate the determinants of the reimbursement price using the full sample which includes both brand-name and generic drugs. In the second and third specifications, we estimate the same model by splitting the data into two sub-samples: brand-name and generic drugs. The weak instrument test for the explanatory power of our instrument (N_{GC}/N_{TC}) generates F-statistics of 1503.08, 30.93 and 1881.47, respectively, which are larger than the critical value of 10 suggested by Staiger and Stock (1997). In addition, the partial R^2 values are 0.1241, 0.0151 and 0.1746, respectively. These statistics indicate that our instrument (N_{GC}/N_{TC}) is not weak with respect to the reimbursement price (P).

Moreover, we also perform Hausman tests, which compare the changes in the reimbursement price's coefficients in estimating equation (13) with and without allowing the variable to be endogenous, in order to examine the endogeneity of the reimbursement price. Regardless of whether the models pertain to the all drugs,

[24] The mean price here refers to a quantity weighted average.

[25] In Taiwan, the bio-equivalence test for generic drugs is not mandatory. This is another reason why the quality of brand-name drugs is perceived to be more stable and reliable than that of generic drugs.

[26] At the time of writing this paper, Taiwan had not built its industrial capability to develop an innovative product in the prescription drug market. Thus, the brand-name drugs used in Taiwan are foreign drugs in the sense that these products are produced by other pharmaceutically advanced countries, such as Japan, the United States and other European countries. By contrast, most generic drugs used in Taiwan are produced by local firms. For the details on pharmaceutical innovation and industrial development in Taiwan, see Hsieh and Lofgren (2009).

[27] Similar instruments are also proposed by Ellison et al. (1997) and Iizuka (2007). It is worth noting that OLS is asymptotically biased and inconsistent, whereas the instrumental variable (IV) approach is consistent but has small sample bias. The two-stage least squares method uses an instrumental variable approach to produce consistent estimates, which is the standard method used to deal with the endogeneity problem and has been widely adopted in the field of health economics (Hsieh and Lin, 1997; Ellison et al., 1997; Iizuka, 2007; Morris and Gravelle, 2008). For more technical details, please refer to chapter 12 in Greene (2003).

Table 3
First-stage regression on the reimbursement price.

	Full sample: Log(P)		Branded sub-sample: Log(P_b)		Generic sub-sample: Log(P_g)	
	Coef.	SE	Coef.	SE	Coef.	SE
N_{GC}	−0.018**	0.0005	−0.010**	0.001	−0.021**	0.0005
N_{TC}	−0.0004	0.0007	−0.087**	0.014	−0.0004	0.0007
Market share	0.220**	0.016	0.036	0.045	0.253**	0.017
Log(P_O^{GM})	1.009**	0.009	–		1.023**	0.011
Log(P_O^{TM})	0.044	0.035	−0.141	0.081	0.187**	0.039
Brand	0.181**	0.014	–		–	
Stock company	–		–		0.075**	0.008
Drug vintage	−0.004**	0.0005	−0.001	0.001	−0.005**	0.0006
Drug vintage^2	0.00002**	3.63e − 06	8.31e − 06	9.22e − 06	0.00002**	4.00e − 06
Year+						
1998	0.003	0.022	−0.020	0.047	0.016	0.040
1999	0.009	0.022	0.011	0.048	0.024	0.038
2000	−0.016	0.022	0.026	0.053	−0.007	0.039
2001	−0.033	0.023	0.010	0.058	−0.017	0.039
2002	−0.048*	0.023	−0.007	0.061	−0.069	0.040
2003	−0.008	0.025	−0.159*	0.076	0.023	0.041
2004	−0.023	0.025	−0.206**	0.077	0.002	0.042
2005	−0.026	0.026	−0.238**	0.084	0.004	0.042
2006	0.014	0.027	−0.283**	0.093	0.054	0.043
Const.	−0.059	0.103	3.370**	0.219	−0.427**	0.115
ATC4	(Significant)		(Significant)		(Significant)	
Adj. R^2	0.8692		0.7491		0.8726	
Partial R^2	0.1241		0.0151		0.1746	
F-statistics++	1503.08 (0.00)		30.93 (0.00)		1881.47 (0.00)	

SE is the White standard error. ATC4 includes 13 drug class dummy variables at the 4th level of the ATC as listed in Table 1 with the reference being A10BA.
** 1% significance level.
* 5% significance level.
+ Reference year = 1997
++ P-values are in parentheses.

Table 4
Estimates of the demand for prescription drugs for the full sample.

	Dependent variable: log(Q)							
	Specification (1)				Specification (2)			
	OLS		2SLS		OLS		2SLS	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Log(P)	0.570**	0.031	−0.876**	0.129	0.578**	0.042	−0.967**	0.127
Log(P)* brand	−0.483**	0.065	−0.280*	0.067	–		–	
Log(P_O^{TM})	0.034	0.179	0.136	0.181	0.053	0.180	0.123	0.191
Log (P_O^{GM})	−0.392**	0.059	1.056**	0.129	−0.482**	0.058	1.096**	.136
N_{TC}	0.0098**	0.002	0.0099**	0.0023	0.009**	0.002	0.010**	0.002
Brand	1.828**	0.219	1.576**	.173	0.342**	0.060	0.672**	0.072
DV	0.034**	0.002	0.036**	0.002	0.033**	0.002	0.036**	0.002
DV^2	−0.0002**	0.00002	−0.0002**	0.00002	−0.0002**	0.00002	−0.0002**	0.00002
Market share	3.760**	0.066	4.194**	.074	3.782**	.066	4.221**	.078
Year+								
1998	−0.257**	0.095	−0.298**	0.096	−0.251**	0.095	−0.299**	0.101
1999	−0.365**	0.094	−0.396**	0.095	−0.352**	0.094	−0.394**	0.100
2000	−0.458**	0.097	−0.536**	0.098	−0.433**	0.097	−0.529**	0.103
2001	−0.501**	0.100	−0.580**	0.101	−0.476**	0.100	−0.574**	0.106
2002	−0.570**	0.102	−0.638**	0.103	−0.540**	0.102	−0.630**	0.109
2003	−0.378**	0.111	−0.314**	0.112	−0.347**	0.111	−0.304**	0.118
2004	−0.208	0.113	−0.155	0.114	−0.170	0.114	−0.139	0.121
2005	0.020	0.120	0.106	0.121	0.063	0.120	0.124	0.127
2006	−0.183	0.127	−0.034	0.1129	−0.140	0.128	−0.014	0.136
Const.	5.703**	0.491	5.127**	0.497	5.888**	0.133	5.282**	0.523
ATC4	(Significant except A10BF, A10BG)		(Significant except A10BF, A10BG)		(Significant except A10BF, A10BG)		(Significant except A10BF, A10BG)	
R^2	0.4342		0.4251		0.4300		0.3577	
Hausman test++	142.20 (0.00)				167.11 (0.00)			

SE is the White standard error. ATC4 includes 13 drug class dummy variables at the 4th level of the ATC as listed in Table 1 with the reference being A10BA.
** 1% significance level.
* 5% significance level.
+ Reference year = 1997.
++ P-values are in parentheses.

Table 5
Estimates of the demand for prescription drugs for the branded and generic sub-samples.

	Dependent variable: Log(Q)							
	Branded sub-sample				Generic sub-sample			
	OLS		2SLS		OLS		2SLS	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Log(P)	−0.489**	0.068	−1.721**	0.591	0.777**	0.045	−0.549**	0.115
Log(P_O^{TM})	0.397	0.281	0.270	0.308	−0.217	0.201	−0.014	0.211
Log(P_O^{GM})	–		–		−0.535**	0.063	0.841**	0.127
N_{GC}	0.049**	0.005	0.035**	0.009	–		–	
N_{TC}	–		–		0.008**	0.002	0.008**	0.002
Stock company	–		–		1.331**	0.056	1.216**	0.059
DV	0.039**	0.004	0.036**	0.004	0.037**	0.003	0.039**	0.003
DV^2	−0.0003**	0.00003	−0.0003**	0.00003	−0.0002**	0.00002	−0.0002**	0.00002
Market share	5.193**	0.120	5.264**	0.133	3.097**	0.074	3.551**	0.085
Year+								
1998	−0.187	0.156	−0.213	0.168	−0.304**	0.104	−0.339**	0.109
1999	0.014	0.158	0.029	0.169	−0.503**	0.103	−0.578**	0.108
2000	0.042	0.163	0.048	0.175	−0.657**	0.106	−0.734**	0.111
2001	0.096	0.171	0.089	0.183	−0.743**	0.109	−0.805**	0.114
2002	0.279	0.177	0.257	0.190	−0.890**	0.112	−0.945**	0.117
2003	0.730**	0.193	0.530**	0.228	−0.784**	0.122	−0.681**	0.127
2004	1.185**	0.199	0.925**	0.246	−0.742**	0.125	−0.657**	0.131
2005	1.358**	0.213	1.005**	0.284	−0.563**	0.132	−0.438**	0.138
2006	1.275**	0.2235	0.859**	0.320	−0.799**	0.140	−0.604**	0.147
Constant	6.012**	0.820	9.837**	2.022	6.185**	0.546	5.242**	0.576
ATC4	Significant in 12 group dummies		Significant in 6 group dummies		Significant in 11 group dummies		Significant in 11 group dummies	
R^2	0.6508		0.5937		0.4086		0.3529	
Hausman test++	5.51 (0.02)				159.06 (0.00)			

SE is the White standard error. ATC4 includes 13 drug class dummy variables at the 4th level of the ATC as listed in Table 1 with the reference being A10BA.
** 1% significance level.
+ Reference year = 1997.
++ *P*-values are in parentheses.

brand-name drugs or generic drugs, the Hausman test statistics, with *P*-values of 0.00, 0.02 and 0.00 are significant at the 5% level, suggesting that the reimbursement price is endogenous. The Hausman test statistics are reported in Tables 4 and 5.

In the first-stage regression that is reported in Table 3, we find that the number of generic competitors has a significantly negative impact on the level of the reimbursement price. As more generic products enter the market, the level of the reimbursement price becomes lower. This result is quite robust across different specifications. In addition, we find that the effect of generic competitors on the reimbursement price is larger for generic drugs than for brand-name drugs. The estimated coefficients indicate that the reimbursement price of the brand-name drugs is reduced by 1% for each additional product entering the market, holding other things constant. For generic drugs, this effect is 2.1%.

By contrast, we find that the number of therapeutic competitors does not have a significant effect on the reimbursement price in the regression analyses of the full sample and generic sub-sample. However, the number of therapeutic competitors has a significantly negative impact on the level of the reimbursement price for brand-name drugs. This effect (−0.087) is larger than the effect of generic competitors on the price of the brand-name product (−0.010), indicating that brand-name drugs are more responsive to therapeutic competition than generic competition.

Putting the estimation coefficients of generic competitors and therapeutic competitors together, we summarize the major features of price competition in the Taiwanese pharmaceutical market as follows. First, generic competition not only drives down the price of generic products, but it also drives down the price of branded products. This result is inconsistent with the finding in China where generic competition only drives down the price of local generic products, but has no effect on the price of global branded products (Wang, 2006).[28] This comparison suggests that the overall quality of generic products is better in Taiwan than in China, and hence the local generic products produced by domestic firms serve as a good substitute of brand-name products produced by global firms. Second, therapeutic competition has a significant negative effect on the price of brand-name drugs but has no effect on the price of generic products. This result is consistent with the finding obtained from China (Wang, 2006), indicating that therapeutic competition has no additional effect on the generic prices given that generic competition has already driven generic prices to a lower level. Overall, these results suggest that the profit-seeking behavior of the medical providers arising from the integration of prescribing and dispensing in Taiwan creates a strong linkage between the regulated reimbursement (retail) prices and unregulated acquisition (wholesale) prices for prescription drugs. As a result, the competition in the wholesale market has a significant impact on the level of the reimbursement price in the retail market, even though the government regulates this price.

With regard to the buyer-size effect, we find that the market share of larger hospitals has a positive effect on the reimbursement price, but this effect is not statistically significant in the sub-sample of brand-name drugs. This result is inconsistent with our prior expectation. A plausible explanation for this result is

[28] Wang (2006) investigates price competition in the Chinese pharmaceutical market with a special focus on the competition between high-quality global products (mainly brand-name drugs) and low-quality local products (mainly generic drugs), which provides an interesting reference point for comparison with our results because both China and Taiwan have the same institutional background in the pharmaceutical market in that physicians both prescribe and dispense drugs. However, Wang (2006) did not investigate the effect of price on the pharmaceutical consumption as we did in this paper.

that the market share of larger hospitals may reflect not only the buyer-size effect, but also the quality of generic products. As noted, the bio-equivalence test of generic products is not mandatory in Taiwan. The public payer only uses the "price premium" as an incentive mechanism to induce generic firms to perform a bio-equivalence test. That is, generic drugs receive a higher price if a bio-equivalence test is conducted. Larger hospitals may only purchase bio-equivalent generics because generic products which are not tested for bio-equivalence are deemed to be of lower quality. As a result, we observe that generic products with a higher market share in larger hospitals are associated with a higher reimbursement price.

We also find that the mean price of other products within the same generic market has a significantly positive effect on the reimbursement price in the analyses of the full sample and generic sub-sample.[29] By contrast, the mean price of other products within the same therapeutic market is not significantly associated with the reimbursement price in the analyses of the full sample and branded sub-sample. The mean price of other products within the same therapeutic market only has a significantly positive effect on the reimbursement price in the generic sub-sample. However, this effect is smaller than the effect of the mean price of other products within the same generic market. These results worked together suggest that the prevailing prices of the existing products in the generic market are more relevant than those in the therapeutic market when the regulator sets the reimbursement price, which in turn, in combination with the finding on the number of competing products, indicates that generic competition plays a more important role than therapeutic competition in affecting the publicly regulated price in Taiwan.

Overall, our results also indicate that the level of the reimbursement price is positively associated with the therapeutic value of the drugs. Specifically, we find that the reimbursement price of brand-name drugs is significantly higher than that of generic drugs. The estimated coefficient indicates that the price premium for brand-name drugs is about 20%.[30] This result is consistent with the pricing rule adopted by the public payer whereby the brand-name drugs receive a higher level of the reimbursement price compared to generic products, other things being equal, suggesting that the BNHI takes the return on R&D investment into account in setting the regulated price for brand-name drugs. However, this result also indicates that the generic-to-brand price ratio is about 0.83 (1/1.2), which is significantly higher than the average generic-to-brand price ratio observed in unregulated markets such as the United States (Saha et al., 2006). This comparison suggests that the public payer in Taiwan gives a low premium to brand-name products, or alternatively, that the prices of generics are too high, although they did value the therapeutic value in setting the regulated price.

In addition, we find a significant price premium for generic drugs produced by larger domestic firms. The estimated coefficients indicate that larger domestic firms on average receive price premiums of about 7.8% for their products, indicating that the public payer offers a price premium for quality improvement even for generic products. We find that the level of the reimbursement price is negatively associated with drug vintage, indicating that new entrants in the NHI formulary receive a higher price. However, this effect is not statistically significant in the sub-sample of brand-name products.

Our estimation also finds that the regulated price did not decline over time after accounting for the above-mentioned variables. An exception is the price of brand-name drugs. As compared to the base year (1997), the regulated price of the brand-name products does not significantly decline over time between 1998 and 2002. However, there is a significant effect of the time trend on the regulated price after 2003. A plausible explanation for this result is that the public payer is more likely to choose off-patent brand-name drugs as the target of the cost-containment effort. Since the growth rate of expenditure steadily exceeded the growth rate of the premium after Taiwan introduced the NHI program in March 1995, the accumulated financial deficits of the NHI program increased over time and hence forced the public payer to cut the reimbursement price in a more significant way in recent years. Many brand-name drugs went off-patent during our study period and hence became the target of cuts in regulated prices.[31]

We now turn to the regression estimates for the demand equation. The empirical estimates of the demand for prescription drugs (equation (13)) are presented in Tables 4 and 5. Table 4 shows the coefficient estimates for the full sample, while Table 5 shows the coefficient estimates for two sub-samples. In both tables, we first estimate equation (13) using ordinary least squares (OLS) regression that treats the reimbursement price (P) as an exogenous explanatory variable. We then estimate the same model by means of two-stage least squares (2SLS) that treats the reimbursement price as an endogenous explanatory variable. As previously mentioned, the Hausman test rejects the null hypothesis that price is an exogenous variable. In addition, the coefficient estimates vary significantly with the models. This suggests that the coefficient estimates are biased if we do not take the endogeneity of the price variable into account. Thus, we focus our discussions on the results of the 2SLS model.[32]

The estimated results indicate a significantly negative effect of the reimbursement price on drug consumption. This result is quite robust across different specifications. Since we include the double-log form in our estimation, the estimated coefficient represents the price elasticity of demand for prescription drugs. Based on specification (2) in Table 4, the estimated price elasticity is −0.97 for the full sample, indicating that a 10% decrease in the reimbursement price causes the consumption of the prescription drugs to increase by 9.7%.[33]

The estimated results also reveal that brand-name drugs are more responsive to price changes than generic drugs. We obtained this finding from two alternative specifications. First, we added an interaction variable between the price and brand dummy in estimating equation (13). As reported in the first specification of Table 4, this interaction variable is significantly negative. This result suggests that the price elasticity for generic drugs is −0.88, while the price elasticity for brand-name drugs is −1.16.[34] Secondly, we split the full sample into the two versions of drugs and report the results of the sub-sample analysis in Table 5. The results indicate that the price elasticity for brand-name drugs is −1.72, while the price elasticity for generic drugs is −0.55. Although

[29] In order to avoid zero values of P_o^{GM} for on-patent drugs, we drop the P_o^{GM} variable in the branded sub-sample.

[30] We estimate this value by taking the antilog of the estimated coefficient reported in Table 3 (0.181) and subtract 1 from the result of the antilog. See Halvorsen and Palmquist (1980).

[31] For example, during our study period, the patents of several OHA drugs expired, including glimepiride, acrbose, repaglinide, nateglinide and pioglitazone.

[32] For a more detailed discussion on the application of the 2SLS model, please refer Angrist and Krueger (2001) which provides a non-technical review regarding the estimation of the demand/supply elasticity and IV methodology.

[33] In the literature, with a few exceptions, the price elasticity estimates for prescription drug demand obtained from product-level data fall within the range from −0.48 to −3.4 (Berndt et al., 1995; Ellison et al., 1997; Rizzo, 1999; Dalen et al., 2006; Iizuka, 2007).

[34] This result is obtained from the summation of two coefficients: Log(P) and Log(P)*Brand.

the absolute values of the price elasticity vary with the models used, the empirical findings are consistent in terms of the relative values of the price elasticities between brand-name and generic drugs.

Our finding that the consumption of the brand-name drugs is more sensitive to price changes than that of generic drugs is opposite to the empirical finding obtained from the US pharmaceutical market (Frank and Salkever, 1997; Ellison et al., 1997), but is consistent with our theoretical prediction.[35] This result indicates that the institutional features matter in shaping the price sensitivity of drug consumption. Our result indicates that the integration of prescribing and dispensing in Taiwan, in combination with a direct regulation on the reimbursement price, creates a profit-seeking opportunity that medical providers can make profits in the prescription drug market. The profit margin earned through prescription drugs plays a similar role to advertising to form the habit (or the brand loyalty) of drug prescription and hence decreases the price elasticity of demand. Given the above evidence that generic competition plays a more important role than therapeutic competition, in combination with the fact that the regulator's pricing practices favor generic products, medical providers in general earn a higher profit margin through prescribing generic drugs than brand-name drugs.[36] Therefore, the finding that the demand for generic drugs is less responsive to price changes than brand-name drugs is consistent with the empirical finding that advertising in the prescription drug market, especially in terms of the form of detailing effort, reduces price sensitivity (Rizzo, 1999).

In addition to the own-price effect, our estimation also controls the cross-price effect. We find that the mean price of other products in the same therapeutic market does not have a significant effect on demand, but the mean price of other products within the same generic market has a significantly positive effect on the demand for prescription drugs. This result suggests that the cross-price effect only occurs in the generic market instead of the therapeutic market. In addition, the positive coefficient of the cross-price effect indicates that products within the same generic market are "substitutes". The estimated cross-price elasticity ranges from 0.84 to 1.10.

We also find that the number of therapeutic competitors has a positive effect on the demand for prescription drugs. A plausible explanation for this result is that the number of therapeutic competitors may capture the effect of the marketing effort such as advertising. In general, the stock of advertising within the same therapeutic market is positively associated with the number of competing products. In addition, the empirical evidence suggests that the effect of advertising on prescription drugs mainly reflects the increase in the overall demand of the same therapeutic market (the market expansion effect) instead of an increase in the market share of the individual firms (the market switching effect) (Berndt et al., 1995; Berndt, 2007).

Overall, our estimated results also indicate that the demand for prescription drugs is positively related to the "quality" of the product. First, Table 4 shows that the demand for brand-name drugs is as much as 96% higher than that of generic drugs in specification (2) after accounting for the effects of other factors. This result suggests that brand-name drugs possess a competitive advantage over generic drugs that might stem from the entry of new drugs during our study period. For example, there are five new chemical entities entering the OHAs market after 2000 (Liu et al., 2011).

Second, Table 5 shows that the demand for generic drugs is higher if the products are produced by large firms. A plausible explanation for this result is that generic products produced by larger firms are deemed to be of higher quality as compared to those produced by smaller firms.

Third, we also find that the drug vintage has a significant effect on the demand for prescription drugs. The estimated results indicate that the quantity of drug consumption increases with the drug vintage, but rises at a decreasing rate. Based on the results of Table 4, the drug vintage reaches its maximum impact on drug consumption at 90 months (or 7.5 years). That is, holding other factors constant, the quantity of drug consumption increases over time after the drug is included in the NHI formulary. However, as the drug vintage passes the threshold of 7.5 years, the demand for such a drug starts to decline. This result suggests that the prescription drug market in Taiwan is competitive in the sense that many new products enter the market and the newcomers have an advantage in that they increase their market share during the first 7 years of their product life cycle.

Fourth, we find that the quantity of drug consumption is significantly positively associated with the market share of larger hospitals. This reflects the buyer-size effect in the sense that the demand for a specific drug is higher if the buyers of this drug are concentrated in larger hospitals.

Finally, the estimated results show that the time dummy variables have a significant effect on the demand for prescription drugs. For the full sample and the generic sub-sample, the estimated results indicate that the demand for prescription drugs declines over time. However, the demand for prescription drugs increases over time for the sub-sample of brand-name drugs. A plausible explanation for these results is that the time dummies may capture the trend of patent expiration. As the period of patent protection expires for some brand-name drugs during our study period, many generic firms enter the market. As more firms enter the market to share the overall demand for prescription drugs, the demand for individual products may decline over time. As expected, the effect of new entry is more significant in the generic market than in the brand-name market. Therefore, we observe that the demand for individual products decreases over time for all drugs in general and for generic drugs in particular.

5. Conclusions

This article empirically investigates the determinants of the regulated price and its impact on the demand for prescription drugs in a setting in which the single public payer regulates the reimbursement price for prescription drugs and medical providers earn profit directly from prescribing and dispensing drugs. Using a product-level data set that contains quarterly time series of price and quantity for 496 pharmaceutical products consumed in Taiwan, our study has several important findings. First, we find that the regulated price is responsive to the degree of market competition as measured by the number of competing products in the same generic and therapeutic markets. Specifically, we find that generic competition (measured by the number of generic competitors) affects regulated prices for both branded and generic drugs, but therapeutic competition (measured by the number of therapeutic competitors) only affects the price of brand-name drugs and has no additional effect on the price of generic products. Secondly, we also find that the demand for prescription drugs is responsive to changes in the regulated price. The estimated price elasticity of

[35] For example, Ellison et al. (1997) found that the conditional (unconditional) elasticity of brand-name drugs ranges from 1.16 to 1.99 (0.38–1.93). By contrast, the conditional (unconditional) elasticity of generic drugs ranges from 1.45 to 2.96 (1.04–2.97). This result suggests that the consumption of generic drugs is more sensitive to price changes than that of brand-name drugs in the United States.

[36] Although the direct evidence of this reasoning is lacking, Liu et al. (2009) provide evidence to support this argument through an indirect test.

demand for prescription drugs is −0.97. Compared to brand-name drugs, the consumption of generic drugs is less responsive to price changes.

Our findings have two policy implications. First, the profit-seeking behavior of the medical providers in the prescription drug market serves as a transmission mechanism to transfer the force of competition from the wholesale market to the retail market through a market price survey. As a result, regulation does not weaken the competition in the pharmaceutical market, and market competition still plays an important role in the determination of the regulated price. Although this profit-seeking behavior introduces competition to the regulated market, this competition may not enhance the efficiency of the pharmaceutical market. Rather, the profit-seeking behavior of the medical providers in the pharmaceutical market gives rise to two distortions in the relative prices in the health sector, which in turn lead to a loss of efficiency in resource allocation.

The first distortion is of the price of prescription drugs relative to health-care services. Compared to prescription drugs, health-care services such as providing diagnostic information and surgical treatment are very labor-intensive. In contrast to physical products, there is no wholesale market for services, and hence no profit margin between reimbursement and acquisition prices. In view of the margin on prescription drugs, medical providers have a financial incentive to substitute prescription drugs for other inputs, which in turn leads to an increase in pharmaceutical consumption and inefficiently high drug expenditure (Iizuka, 2007; Trottmann, 2010).

The second distortion attributable to the integration of prescribing and dispensing is between the prices of brand-name and generic drugs. Profit margins induce medical providers to include drugs in their own formularies based on the size of the margin instead of efficacy, safety, or cost. Several studies find evidence of the physicians' choice of brand-name or generic drugs being influenced by profit margins (Liu et al., 2009; Rischatsch and Trottmann, 2009; Rischatsch et al., 2009). Given the fact that the regulation of the bio-equivalence test is not strictly enforced in some countries, such as Taiwan and China, and hence brand-name and generic drugs are not *always* perfect substitutes, the generic substitution induced by profit margins will in turn lower the quality of health care.

Second, our finding that price has a significantly negative effect on the quantity of drug consumption indicates that the demand curve for prescription drugs is downward sloping instead of being a vertical line. This suggests that quantity increases induced by cutting regulated prices offset part of the cost-containment effort although the demand is inelastic in that cutting prices leads to a saving in the overall expenditure. Since we find that the demand for generic drugs is less responsive to price changes as compared to brand-name drugs, this suggests that the offsetting effect of lowering price is smaller for generic products than for brand-name products. As a result, generic drugs are better targets for cutting prices with a view to containing costs, which in turn would reduce the profit margins of generic drugs and is beneficial to reducing the distortion in the relative prices between generic and brand-name products.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jhealeco.2012.03.003.

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