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政策科学推進研究事業

医療保険，医療費抑制，医療技術，医療の質の研究
－医薬品価格規制と研究開発

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研究要旨

この研究では医療保険制度の維持，医療費抑制，医療技術の革新と普及，医療の質の向上の4つの異なる政策目的が同時に実現可能かという政策課題を，日本の医薬品を題材にした実証研究，事例研究，理論的考察によって検討する。本研究は，3年計画の研究の2年目の研究である。3年全体の研究は個別研究とそれらを総合する研究によって構成する。第1年度の研究成果を前提として，2年目の本研究では，薬価低下政策を対象にして，それが医療技術の革新と普及にどのように影響したか，薬価低下が，医療の質にどのように影響したかを検討した。この個別研究では，医薬品の剤型（錠剤・カプセル，注射薬，その他），発売後経過期間，ジェネリック製品の有無，成分含有量（力価）の大小，包装容量の個別属性等の相違によって，薬価，納入価格，薬価差がどのように影響されるかを，hedonic priceの分析枠組みによって明らかにした。また，個別研究の結果，薬価の大きい医薬品成分，薬価差の大きい医薬品成分ほど研究開発がなされ，発売される可能性が大きく，発売までに研究開発期間が短い傾向が示された。薬価，納入価格，その他の要因が医薬品企業にとって十分な利益をもたらさないとき，医薬品企業はその医薬品を日本に導入せず，その結果，drug lagが拡大する。他方では，日本企業では薬価低下にもかかわらず，R&D投資額が低下しない可能性が示された。

次に，個々の医薬品の需要量決定の分析を需要関数の推定によって行った。これによって，医薬品需要量が薬価と納入価格の比率で表示される薬価差比率によって影響されることが確認された。しかし，その効果は剤型によって大きく異なることが示された。また，医薬品の属性は必ずしも需要量に影響しないことが示された。他方，需要量は年度，薬価改定年，四半期等の時間効果によって需要量が変動していることが示された。さらに，1990－1994，1995-1998，1999-現在までの期間区別によって，この需要要因の構造変化が生じたことが示される。そこでは1990-1994年では薬価低下が需要量の増加をもたらした。ところがその効果は1990年代末には解消する。日本の薬価制度と薬価低下政策については各種の見解が表明されている。ところが個々の医薬品の価格変数，属性変数，時間効果等のマイクロデータを利用した分析例は少ない。

マイクロデータを利用したアメリカ合衆国医薬品市場の分析は多い。しかし，医療保険と薬価定価政策の役割を分析するにはアメリカ合衆国ではなく，日本の医薬品市場の分析が適切である。他方，薬価低下政策は薬価比率を減少させて，需要量を低下させる効果がある。ところが，実際には薬価低下が行われた年度と四半期の時間効果は需要量を増大させる効果がある。いずれの場合も，需要量に影響を与える。

A. 研究目的

日本の政策担当者が医療保険制度に比べて，医療技術政策に対して十分な関心を払ってこなかったとされる。政策担当者は医療技術政策のみを独立して提案することは適切でなく，医療保険制度の維持，医療費抑制，医療技術の革新と普及，医療の質の向上という 4 つの異なる政策課題の相互関係を明確に把握した上で，それぞれを同時に解決する最適な政策を実施することが必要である。

Weisbrod(1991)は医療保険，医療費，医療技術，医療の質の 4 つの問題を相互に矛盾する可能性のある関係として捉え，アメリカ合衆国を題材を中心とする既存研究を概観している。ところがアメリカ合衆国では公的医療保険が十分には普及していないため，これを題材としても医療保険をめぐるこれらの問題の分析ができない。これに対して，日本を題材として取り上げることで，医療保険の普及した世界第 2 位の規模の医療市場を対象にした実証研究が可能となる。

本研究は医療保険の維持，医療費抑制，医療技術の革新と普及，医療の質の向上という枠組みで医薬品を題材に分析する。

Weisbrod, Burton A. "The Health Care Quadrilemma: An Essay on Technological Change, Insurance, Quality of Care, and Cost Containment, *Journal of Economic Literature,* 1991, 523-552.

B. 研究方法

この研究では医療サービスのうち全体の 20%程度を占める医薬品を題材とする。これには次の利点がある。第 1 は，世界全体の医薬品需要の 10%程度と推定される大規模市場における医療保険制度の影響を検討することができる。第 2 は，医薬品は日本では医療費抑制の手段として薬価低下政策が 20 年以上にわたり継続的に行われ，同時に，医療の技術革新，普及が重要な代表事例でもある。第 3 は，薬価，納入価格，需要量，承認，研究開発や特許取得等の企業行動等の実証研究に必要な客観的データが入手可能な点である。

以上の研究目的を，医薬品を題材として，予備的研究，個別研究，総合研究の 3 段階を 3 年計画で行う。第 2 年度である本年度は，医療保険制度における薬価決定要因分析の拡張を行った。経済学における hedonic pricing の手法を用いて薬価，納入価格，両者の比率である薬価比率の決定要因分析を行った(個別研究 1 の拡張研究)。

次に，医療保険制度が医薬品企業の研究開発の方向と程度にどのように影響するかに関する実証分析(個別研究 3)を行った。

さらに医薬品価格が医薬品の国際的普及にどのように影響するかを需要量の決定要因分析としての検討した(個別研究 4)。

これらの研究の途中で，個別医薬品の価格，取引，属性について第 1 年度に作成したデータよりも詳細なデータが必要であることが判明した。そこで，循環器官用薬 50 成分，抗菌剤 50 成分ほどを対象とした取引データを入手して，新たなデータベースを作成した。そこでは日本での発売の有無，海外の代表的市場で発売の有無を区別し，医薬品別に，薬価，納入価格，薬価差，取引量を精査した。

C. 研究結果

抗生剤 36 成分の四半期データを対象とした分析結果を報告する。これは 1990 年から 2002 年のサンプル期間に，薬価低下政策によって，薬価と納入価格が急速に減少した結果，薬価比率も大きく変動している。また，需要量の変動も大きい。その結果，分析結果が明瞭に現われた。

まず，薬価と納入価格の比率である薬価比率の説明要因を分析した。個別属性については，医薬品の発売後経過年数は薬価比率に影響しない。また，ジェネリック製品の存在は薬価比率を低下させる。力価の大きい医薬品，販売包装単位の大きい医薬品，

共同販売されている医薬品，薬価の高い医薬品は薬価比率を高くする。発売後経過年数は1990年代初めは薬価比率に影響がないが，1990年代後半になって変化し，古い医薬品の薬価比率は低い。

次に医薬品の需要量を分析した。医薬品需要量は薬価比率に強く影響される。これは既存研究の結果と同じである。ここでは薬価比率が 1%低下すると，需要量は平均で0.4%，カプセル剤・錠剤に限定すれば3.5%低下する。薬価低下政策は，薬価比率を低下させ，それが需要量を低下させる効果を持つ。

医薬品の個別属性の需要量に対する影響は必ずしも明確ではない。

他方，四半期ごとのダミー変数は第3四半期は正，第4四半期は負の値を取る。これは医薬品需要量の季節変動効果が大きいことを示している。

ここで薬価改定の行われた年は需要量が増加する傾向が判明した。これが薬価比率が低下することで需要量が減少する効果を相殺している。この薬価改定による需要量拡大効果は 2000 年以降減少している可能性が示された。

また，薬価比率の決定と需要量の決定において，1990年代半ばに構造変化が生じていることが判明した。以上の研究結果は下記の文献に要約されている。

Anegawa Tomofumi (2007) "Pharmaceutical Price and Demand in Japan-Empirical Study of Anti-infective Products".

D. 考察

医薬品の個別属性は薬価比率に対して影響するが，需要に対しては影響しない。これは医薬品の属性が薬価比率には影響し，それが需要に影響するという関係があるからと推察される。この研究では薬価比率の決定要因分析と，需要決定要因分析とを独立して推計したが，実際には両者は同時に決定され，推計方法もそれに応じた工夫が必要である。

薬価低下政策は長期にわたって継続されているが，それが薬価比率に与える影響，需要量に与える影響は1990年代末に構造変化が生じた。この構造変化を反映した政策実現が必要である。

E. 結論

日本の薬価制度と薬価低下政策については各種の見解が表明されている。ところが個々の医薬品の価格変数，属性変数，時間効果等のマイクロデータを利用した分析例は少ない。他方，このようなマイクロデータを利用したアメリカ合衆国医薬品市場の分析は多い。しかし，医療保険と薬価定価政策の役割を分析するにはアメリカ合衆国ではなく，日本の医薬品市場の分析が適切である。

他方，薬価低下政策は薬価比率を減少させて，需要量を低下させる効果がある。ところが，実際には薬価低下が行われた年度と四半期の時間効果は需要量を増大させる効果がある。いずれの場合も，需要量に影響を与える。

F. 研究発表

1. 論文発表

姉川知史「日本の医薬品産業」吉森賢二編『世界の医薬品産業』東京大学出版会，2007（平成17年度研究の成果を利用した原稿を改定して発表した。）

2. 学会発表

Anegawa, Tomofumi, "Price Regulation and Competition in Japanese Pharmaceutical Market,-A Case of Anti-infective, " The Far Eastern Meeting of the Econometric Society, July 10, 2006, Tsinghua University, Beijing, China.(今年度の研究の一部を反映させた。)

G. 知的所有権の取得状況

1. 特許取得
   なし
2. 実用新案登録
   なし
3. その他
   なし

Pharmaceutical Price and Demand in Japan
-Empirical Study of Anti-infective Products-

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Pharmaceutical Price and Demand in Japan
-Empirical Study of Anti-infective Products-

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Abstract

This study investigates price regulation and competition in Japanese pharmaceutical market. The government determines the official price of each product for the transaction purpose of the public health insurance plan (National Health Insurance). The wholesaler lowers the wholesale price reflecting market competition. The government in turn lowers the official price by equating it with the wholesale price. Thereby the price regulation has established a long-term downward trend of pharmaceutical prices in Japan. The price difference between the official price and the wholesale price has played a significant role in pharmaceutical market.

This study investigates two empirical questions. One is how the price difference ratio (the ratio of the official price to wholesale price) is determined, the other is how demand for each product is determined. We focus on various product profiles including "age", "corporation" , "ingredient", "form", "strength", "package volume transaction", "generic competition", "co-promotion/co-marketing". We also focus on "quarterly effects" on the price difference and demand. This study uses detailed transaction data on popular anti-infective and cardio-vascular products in 1990-2002 when the government had conducted aggressive price reduction.

This study finds that the price difference ratio is well explained by individual characteristics in the framework of "hedonic price model". The ratio is higher for "co-promoted products", "higher strength products", "larger package volume product", "INJECTION" form, and "HIGH_PRICED_PRODUCT". However, the ratio is found to be lower for products facing with generic competition (GE_COMPETITION). There is no difference between "OLD_PRODUCT" and "NEW_PRODUCT". The structural change is found to exist between the early 1990s (1990-1994) and the rest of the period. Although OLD_PRODUCT enjoyed higher price ratio in the early 1990s, its effects disappeared in the late 1990s.

This study also finds that demand for product is well explained by our model. The price ratio is an important determinant of demand. Individual characteristics do not capture demand. It might be due to the fact they are already reflected in the differences in the price ratio as shown in our hedonic price model. Significant differences in dose forms are found. Our model does well explain demand for "Capsule & Tablet" while it fails to explain demand for "Injection".

This study concludes that Japanese pharmaceutical price regulation has significantly affected pharmaceutical

prices as well as demand. Because the government applies the same pricing formula across products, it does not reflect product-specific characteristics. In particular, it fails to captures the differences between "Capsule & Tablet" and "Injection". Also it fails to unexpected response of the regulation. In particular, the official price reduction increased demand. These results have policy implications for countries like Taiwan, Korea, and others who have newly establish a nation-wide health insurance and are committed to tight price regulation.

Key Words: Japan, pharmaceutical, price, regulation, competition

1. Introduction

Pharmaceutical price regulation has achieved widespread attentions of policy makers worldwide. In the United States, in response to the increased pharmaceutical prices, policy makers have debated on pharmaceutical price regulation. The government has introduced price regulation for products used in the "Medicare" for the aged people. European countries including UK, France, Germany, or Italy have adopted some forms of pharmaceutical price regulation. Furthermore establishment of the European Union makes people and pharmaceutical products move freely across borders. In response, a national price regulation can be bypassed and should be coordinated among member countries. Many newly developed countries like Korea or Taiwan, which have lately established a nation wide health insurance plan, have resorted to price regulation to contain pharmaceutical expenditure. Debates on pharmaceutical prices are not limited to developed countries. In many developing countries suffering form the AIDS breakout and facing with threat of infectious diseases, people are more keenly concerned with pharmaceutical prices. They require a certain form of price regulation to make pharmaceutical prices low enough.

Pharmaceutical firms came to be worried about these price regulations. Trade associations like PhRMA (U.S. Pharmaceutical Research and Manufacturers Association) and JPMA (Japan Pharmaceutical Manufacturers Association) have frequently expressed their views on pharmaceutical prices. They are summarized in three theses. First, pharmaceuticals are cost effective tools compared with other medical services. Second, government price control does not necessarily lower overall pharmaceutical prices. Third, too much price control would stifle R&D activities of pharmaceutical firms by reducing economic incentives. These views of pharmaceutical firms are supported by various empirical studies. Name a few, Lichtenberg (1996) supports the first view by showing that decline of mortality rate in the U.S. is achieved by use of pharmaceuticals. He estimates that every dollar spent on pharmaceuticals is associated with a $ 4 decline in fees for hospital services. Danzon et al. (2000) supports the second view by exhibiting pharmaceutical prices of the United States are not higher than those of other countries that have adopted price regulation. Various empirical studies and anecdotal evidences support the third view. For example, countries with tight pharmaceutical price regulation like France, Germany, and Japan are frequently criticized as countries which are lagging behind the U.S. in pharmaceutical innovation.

In order to evaluate the role of price regulation, however, we need empirical research based on micro-data. In fact there are various empirical studies on the U.S. individual pharmaceutical market. Just name a few, Berndt et al. (1997) studies a relationship between price and quantity of anti-ulcer products. Ellsion et al.(1997) examines cephalosporins. However the U.S government has no price regulation. Japanese experience of pharmaceutical price regulation could provide an interesting and valuable case study. First, the National Health Insurance plan (NHI)

has made virtually all Japanese accessible to wide range of pharmaceutical products with fairly low co-payment as much as 20 to 30 percent of pharmaceutical prices. Second, the Japanese government has adopted extremely detailed price regulation on the "official prices" depending on ingredients, brands, dose forms, and strength. These official prices are used for the National Health Insurance reimbursement purpose. Third, unlike the official prices, the wholesale prices are left to market competition without regulation. As a result, there are "price difference" between the official price and the wholesale price. The difference is called "Yakka-sa (literally *pharmaceutical price difference* in Japanese)" has been a major source of income for hospitals and pharmacies. Prescription by physicians may be affected by the price difference when physicians are concerned with this income. Accordingly, demand and supply for pharmaceutical products have been distorted considerably by the price regulation. Japanese government has been engaged in aggressive reduction of the official pharmaceutical price.

Several research questions are raised on Japanese pharmaceutical price regulation. First question is how individual pharmaceutical price is determined in association with the price regulation. Second question is how pharmaceutical price regulation has distorted demand for pharmaceuticals. This study addresses these two empirical questions using popular anti-infective products as sample. Anti-infective was once the largest therapeutic category in the early 1980s whose market share exceeded 20 percent of all therapeutic categories. At the same time, anti-infective products exhibited large price difference. It was estimated to exceed one-thirds of the official price for popular products in the early 1980s. Japanese government had attempted to reduce the official price over the period through the 1980s and 1990s. Consequently, market share of anti-infective has declined sharply from 20 percent to 11 percent in 1990 and 7 percent in 2000. Significant fall in prices as well as market share makes anti-infective products valuable case study on prices and quantity. We can also raise question, however, whether Japanese government has succeed in price regulation as intended. In particular, we raise question how a new price control regime introduced in 1992 changed the role of price regulation.

The rest of this paper consists of the following sections. Section 2 portrays institutional background of Japanese pharmaceutical price regulation. Section 3 specifies a model for estimation. Section 4 explains data and Section 5 summarizes empirical results. Section 6 provides interpretation and concluding remarks.

2. Background

The National Health Insurance (NHI) plays a central role in Japanese medical services. The government designates physicians who could provide medical services and prescribe pharmaceuticals for the purpose of the NHI. Second, the government determines the types of medical services and products covered by the NHI. Third, the

government specifies the price list for these services and products. The NHI bears the specified fraction of medical expenses of patients, while patients bear the rest. For pharmaceuticals covered by the NHI, typical payment by patients ranges from 20 to 30 percent depending on the types of the prescriptions and status of the insured person.

A pharmaceutical distribution consists of pharmaceutical firms, wholesalers, hospitals/pharmacies, and patients. Several different prices are used for each stage of pharmaceutical distribution (Table 1). The price for transactions between pharmaceutical firms and wholesalers is "manufacturer's sales price (P^M)". The price for transactions between wholesalers and hospitals/pharmacies is "wholesale price or delivery price (P)". These two prices are market prices that are not subject to price regulation. The benchmark of payment by the NHI and patients is the "official price ($\overline{P}$)." Under the NHI system, the official price of pharmaceuticals usually exceeds the wholesale price because wholesalers and pharmaceutical firms lower the wholesale prices in price competition. The price difference ($\overline{P} - P$) has played a significant role in Japanese pharmaceutical market. Hospitals and pharmacies can earn the price difference as their income. When physicians are concerned with income of hospitals, physicians have strong economic incentive to prescribe pharmaceuticals with large price difference. At the same time, hospitals/pharmacies demand wholesalers to discount the wholesale price. In turn, wholesalers and pharmaceutical firms are forced to lower the wholesale price (P) to gain sales volume. Consequently the price difference ratio (Dif), which is defined as the difference between the official price and the wholesale price divided by the wholesale price, plays a critical role in Japanese pharmaceutical regulation. We call this ratio ($\overline{P}/P$) as the "price difference ratio" or simply "price ratio".

— Table 1. Prices and Transactions

The Japanese government regulates the official price of pharmaceuticals for two reasons. First, the government intends to reduce total pharmaceuticals cost which constitutes 20 percent of total medical cost in Japan. The government assumes that reduction of the official price could contain pharmaceutical cost because demand for pharmaceutical is inelastic to the official price. Second, the government intends to reduce the price differences themselves. The government is concerned with the fact that resource allocation might be distorted by the price differences. Furthermore the government is concerned with unreasonable income earned by hospitals and pharmacies. The government, however, rarely articulates the existence of the price difference officially. In stead, the government claims that the reduction of official price is required because the official price should be equated with the wholesale price prevailed at market.

The government regulates the official price in a following method. For new pharmaceuticals, the official price ($\overline{P}$) has been determined either by cost information including production and R&D expense, or by comparison with existing similar pharmaceuticals. For already marketed pharmaceuticals, the official price has been determined by the wholesale price (P) as a benchmark. Because the wholesale prices differ significantly by transactions or by hospitals and pharmacies, the Japanese government conducts a nation-wide survey of the wholesale prices before the revision. The government updates the official price by applying the special formula to surveyed data on the wholesale price in market. For example, in 1992 the government adopted the formula called "reasonable zone method" as shown in (1).

$$\overline{P}_t = P_{t-1}(1+u_t) + R_t \cdot (\overline{P}_{t-1} - P_{t-1}) \qquad (1)$$

The rate of R_t was initially set 0.15 for fiscal year of 1992. It was reduced in stepwise at every update. As of fiscal year of 2000, R_t was reduced to 0.02. Consumption tax u_t had been 0.03, it was raised to 0.05 after April 1995. The Japanese price regulation affect income of participants.

Economic loss of wholesalers due to lowering the wholesale price is mostly compensated through rebates provided by pharmaceutical firms. A distribution system consisting of pharmaceutical firms, wholesalers, hospitals/physicians, and the National Health Insurance has institutionalized the long-run decline of pharmaceutical price, which fact is quite unique of Japanese pharmaceutical regulation.

3. Estimation Model

a. Hedonic Price Model for the Price Ratio

This study applies "hedonic price model" to data. The simplest hedonic price model is given by equation (2).

$$P_{hit} = \beta_{hi}^0 + \sum_{m=1}^{M} \beta^m X_{hit} + \varepsilon_{hit} \qquad (2)$$

where price P_{hit} is explained by a constant term, product characteristic X_{hit} and its coefficient β^m, and error term ε_{hit}. Hedonic price is marginal contribution of price with respect to a change in X_{hit}.

$$\frac{\partial P_{hit}}{\partial X_{hit}} = \beta^m \qquad (3)$$

This study applies hedonic price model to Japanese pharmaceutical price data. There are three candidates for price

indexes; official price $\overline{P}_{hit}$, wholesale price p_{hit}, and the price ratio $\overline{P}_{hit}/P_{hit}$. Because a relationship between the official price and the wholesale price is a special concern in price regulation, we use the price ratio to be accounted for in equation.

$$\text{Price\_Ratio}_{hit} = \frac{\overline{P_{hit}}}{P_{hit}} = \beta_{hi}^{0} + \sum_{m=1}^{M} \beta^{m} X_{hit} + \varepsilon_{hit} \qquad (4)$$

The equation indicates that the "price ratio (Price_Ratio_{hit})" defined as the ratio of the official price ($\overline{P}_{hit}$) to the wholesale price (P_{hit}) is explained by a constant term β_{hi}, explanatory variables X_{hit} and its coefficients β^{m}, and error terms ε_{hit}. The subscripts represent the *i-th* "product" of the *h-th* firm's in the *t-th* period. Explanatory variables X_{hit} include various individual product characteristics M_{hi} which vary with products but are constant over time periods. They are product age, generic competiton, strenth, package volume, does form, co-promotion/co-marketing, level of official price (highly priced product).

$$M_{hi} = \{product\ \ age, generic\ \ competitio\ n, strength, package\ \ volume, dose\ \ form, copromotio\ n, level\ \ of\ official\ \ price\} \qquad (5)$$

We distinguish products by marketing firm (h), ingredients (i), and time periods (t). Product profiles M_{hit} are captured by several product-specific dummy variables. Products have different dose forms and strengths. For example, a certain anti-infective has both table and capsule forms of 50mg or 100mg ingredient per unit. Because the prices are applied to each product by dose forms and different strength, we classify individual dummy variables. This study uses "dose forms" by using "capsule and table", and "injection" dummy variables compared with "Powder, Syrup, and Others". Product strength is classified into two "LOW_STRENGTH (weak strength)" and "HIGH_STRENGTH(strong strength) by using the "recommended minimum daily dosage" as criteria. A product faces with competition by generic drug is denoted as "GE_COMPETITION". Because volume discount is applied to the wholesale prices, the price ratio may change by transaction volume. We use "small volume package," "medium volume package", and "large volume package" depending on how many doses in patient-days are transacted in a transaction package. This is particularly important in transaction of capsule and tablet because transaction volume differ significantly, for example, 50 tablets, 100 tablets, and 500 tables. By using the total ingredients in a transaction divided by "recommended minimum daily dosage", we form dummy variables for "small package" (less than 50 patients days)," "medium package (50-149 patients days)", "large package (more than 150 patient days)". Products

are classified into "new products" and "old products" by the number of time-periods since the introduction to market[1]. Co-promoted products are defined as "Co-PROMOION". Highly priced product (HIGH_PRICED_PRODUCT) is one that official price for a minimum recommended dosage is higher than 3500 yen (350 Points).

$$\Pr ice\_ratio_{hit} = \mu_{hi} + \sum_{m=1}^{M} \alpha_m M_{hit} + \sum_{y=1990}^{2001} \beta_y T_{hit}^{y} + \sum_{s=1}^{3} \sum_{d=0}^{3} \gamma_{-d}^{s} REV_{hit}^{s}(-d) + \upsilon_{hit} \qquad (6)$$

In addition to product specific characteristics, time dependent variables are included to account for the time-specific effects. First we use "fiscal year dummy variables (T_y)" for each year ranging from 1990 to 2002, which dummy variables take unity when an observation falls into the year. Second we use "time dummy for the period of the official prices revision R_{-d}^{s}, $d = 0,1,2,3$ ". Price revisions usually occur once in two years. So R_0 is the periods when the official prices are revised (Quarter of April-June of 1990, 1992, 1994, 1996, 1997, 1998, 2000, 2002). In order to examine persistent effects of the price reduction, we use lagged dummy variables by 1 to 3 quarters. The effects of price reduction may differ across time periods, so we use dummy variables depending on three sub-samples, s=1 for the sub-sample 1990-1994, 2 for 1995-1998, and 3 for 1999-2002 fiscal year.

b. Determinants of Demand

The second empirical question is how pharmaceutical demand is determined in Japan. Based on economic theory, demand for a product is usually specified as a function of prices and income. Japanese pharmaceutical demand, however, requires a different specification. Because major part of medical expenditure is paid by the insurer, the insured only paid 20 or 30 percent medical expenditure as co-payment. Under this institutional setting, physicians prescribe drug, they are not concerned with patient's income but with the official price and the wholesale price. We specify a demand equation (7) where demand for pharmaceutical (q_{hit}) depends on three types variables as explanatory variables. They are price related variables ($price_{hit}$), individual characteristics variables (M_{hi}), and time related variables ($time_t$). This study uses panel data of the h-th firm's i-th product at –th period. Among them price related variables ($price_{hit}$) vary with h-th firm and i-th product and t-th time period. Individual characteristics

[1]To be more specific, each product is defined by the "four years plus periods since the introduction multiplied by 0.21 as mean laps of the years. Sample observations are classified into "old products" whose years of lapse is longer than the average on rolling base.

(M_{hi}) are assumed to vary with h-th firm's i-th product but be constant over time periods.

$$q_{hit} = f\{price_{hit}, M_{hi}, time_t\} + \varepsilon_{hit} \tag{7}$$

In equation (7) , there are three price related variables including the official price ($\overline{P_{hit}}$) , wholesale price (p_{hit}) , and the price ratio ($\overline{P_{hit}} / P_{hit}$). Individual characteristics (M_{hi}) in a previous section are used to account for product-specific effects on demand. Time related variables ($time_t$) are assumed to be constant with h-th firm's i-th product. As time related variables, this study uses "each quarterly period dummy variables" as ($Q\_YearMonth_t$) where $YearMonth$ stands for the beginning month of each period. In order to account for the quarterly effects of the official price revision, this study uses time dummy variables by denoting them as ($Q\_YearMonth$). In order to capture the effects of the periods when the government revises the official price, we use time dummy variables around the periods when the official prices are revised. For the seasonally time effects, "quarterly dummy variables ($QUARTER\_d_t$) are used as d=1 for April-June period, d=2 for July-September period, d=3 for October-December period, and d=4 for January-March period. For year effects, "year dummy variables "($YEAR\_Y_t$)" are used for periods representing fiscal year. To capture the structural change over periods, this study also uses "sub-sample period dummy variables (S_Period_t)" for the period of 1990-1994, 1995-1998, and 1999-2002. Because quarterly effects differ in the sub-sample, we construct the "the price revision dummy variables ($\mathrm{Re}vision_t$)" as a product of S_Period_t and $QUARTER\_d_t$.

This study measures demand for a product in number of "patient-days" which is constructed based on a recommended standard minimum dosage. The price of a product is measured in prices for a patient-day. The price differs significantly across products. In equation for estimating demand, we use price and quantity in percent change. This general specification has some drawbacks. First, because the official prices change only in periods when the official prices are revised, the changes in the official price ($\Delta\overline{P_{hit}} / P_{hit}$) take zero value for most observations. Second, when the official price is reduced, wholesale prices are reduced accordingly to fend off rival products. Our trial estimation does not yield significant coefficients for the official price and the wholesale price when they are included with the price ratio. So we specify equation (8) instead.

$$\frac{\Delta q_{hit}}{q_{hit}} = \delta\left(\frac{\Delta(\overline{P}_{hit} / P_{hit})}{\overline{P}_{hit} / P_{hit}}\right) + \sum_{m=1}^{M}\phi_m M_{hit} + \sum_{d=1}^{4}\eta^d QUARTER\_d_{hit} + \sum_{n=1}^{N}\omega^n (Q\_YearMonth)^n_{hit} + \varepsilon_{hit} \tag{8}$$

In order to examine the effects of year and quarterly period for the period of the official price revision, we also specify equation (9).

$$\frac{\Delta q_{hit}}{q_{hit}} = \delta\left(\frac{\Delta(\overline{P}_{hit}/P_{hit})}{\overline{P}_{hit}/P_{hit}}\right) + \sum_{m=1}^{M}\phi_m M_{hi} + \sum_{d=1}^{4}\eta^d QUARTER_t^d + \sum_{y=1990}^{2001}\psi_y T_{hit}^y + \sum_{s=1}^{3}\sum_{d=0}^{3}\eta_{-d}^s \, REV_{hit}^s(-d) + \varepsilon_{hit} \tag{9}$$

An econometric problem arises because there is an endogenous relationship between demand and the price ratio of a product. This is due to the fact that the firm lowers the wholesale price when it faces with declining demand. We estimate (8) by instrumental variable (IV) method. As instruments of $(\Delta\overline{P_{hit}}/P_{hit})$, we use current and one period lag of the official price, current and one period lag of the wholesale price, and one period lag of the price ratio.

4. Data

This study uses popular 36 ingredients of anti-infective or antibiotics marketed in Japan (Table 2)[2]. This study classifies "product" based on "firm", "ingredient", "dose form" (e.g. "capsule & tablet", "injection", or "syrup, powder, and others"), "strength" (weight of ingredient in a unit of product, e.g. 100mg or 200 mg in a tablet), "transaction volume" in a package (e.g.100 capsules or 500 capsules for transaction purpose). The official price of each product is taken from "*Yakka-kijyun Ten-su Hayami-Hyo* ("Official Price List" in Japanese". In Japan, data on the wholesale price (p_{hit}) and transaction volume are collected and compiled by various wholesalers for their internal. This study uses a data set provided by a major wholesaler for research use. It covers all transactions of products in Tokyo and other two metropolitan prefectures (Chiba, Kanagawa) in the period between January 1990 and July 2002.

The official price and the wholesale price are defined for each product based on "standard daily dose", which is based on "recommended daily dose" of a product for an average adult. The recommended daily dose is taken from a formal label of pharmaceutical product collected in Mizushima et al. "*Kon-nichi no Chiryoyaku,1999* ("*Today's Pharmaceutical Products* " in Japanese). The quantity of transaction volume is converted to "patients days" based on the standard daily dosage. Products are classified into "old product" and "new product" depending on whether years at market exceed the sample mean or not. Marketed date for a product is taken from Kokusai Syogyo Syuppan,

[2]Data is drawn from the same data set in Anegawa (2005).

"*Kokusai Iyakuhin Jyoho* (biweekly)". "Strength" of each product is measured as the ratio of the "strength" of the product to the "standard strength." Dummy variables for "LOW_STRENGTH" is assigned to products whose ratio is less than unity, "HIGH_STRENGTH" to products equal and more than unity. Dummy variables of "GE_COMPETITION" are assigned to products which has generic versions. "CO_PROMOTION" are assigned to products which are co-promoted or co-marketed by other firms. Data on existence of generic products and a status of co-promotion or co-marketing is taken from "*Yakka-kijyun Ten-su Hayami-Hyo*". "Package volume" is measured in the number of "patients-days" in a package unit. Dummy variables for "Small Package" is assigned when a product has less than 50 patients days in a unit package, "Medium Package" between 50 and 150, and "Large Package" more than 150. "All Sample" data is constructed by limiting "product" to those with a popular dose form, strength, package volume, and enough number of transactions in a record. "All Sample" is decomposed into subsets depending on product profiles by "dose form" ("Capsule & Tablet", "Injection", and "Syrup, Powder, and Others") or by "package volume". "All Sample" is divided into subsets by time periods, 1990-1994, 1995-1998, 1999-2002.

5. Empirical Results

a. Determinants of the Price Ratio

In this section, we report estimation results accounting for "price ratio" ($\overline{P}_{hit}/P_{hit}$) by applying "hedonic price model" to data. Table 3 and Figure 1 show that the median "price ratio" was high as 1.40 in 1990. It implies that there is 40 percent difference between the official price and wholesale price. The ratio, however, has continued to decline to 1.12 in 2000. This reflects the official price reduction by the government. In particular, the "new price control regime" introduced in 1992 and the official price reduction n 1992, 1994, 1996, 1997, 1998 contribute to the decline of the ratio. The variance of the price ratio has been shrunken significantly through the period. The downward trend, however, seems to reach the bottom in the late 1990s, and the price ratio has started to increase recently. The government's efforts are no longer effective to reduce the price ratio.

—Table 3—

—Figure 1—

This study uses three types of explanatory variables; individual characteristics, year dummy variables, and quarterly dummy variables. First we focus on the traditional effects of individual characteristics. This study uses product age after marketing (OLD_PRODUCT), existence of generic competition (GENERIC_COMPETITION),

product with high strength (BRAND_HIGH_STRENGTH), transaction volume per package (MEDIUM_PACKAGE, LARGE_PACKAGE), co-promotion with other firms (COPROMOTION). We distinguish dose forms into capsule and tablet (CAPSULE & TABLET), injection (INJECTION), and others (SYRUP,POWDER, OTHERS), Instead of pooling all observations, we divide sample periods into three sub-samples, 1990-1994, 1995-1998, 1999-2002. Table 4 and 5 summarize the estimation of the price ratio by OLS.

Because old products lower both official price and wholesale price, the ratio of two prices may or may not be large. Our estimates show that coefficient of "OLD_PRODDUC" is insignificant. When we divide the sample into three periods, coefficient is positive (0.090) in the first period, and negative (-0.041) in the third period. Generic competition has negative effects on the third period (-0.035). We can infer that although old products have higher price ratio in the early 1990s either by maintaining high official price or low wholesale price, which facts disappear in the second and third period. Highly priced product (HIGH_PRICED_PRODUCT) has positive effects in the first period (0.068) and its coefficient is much larger in the third period (0.124). We conclude that that the price ratio has been changed to a situation where new and highly priced products have higher price ratio. Compared with "Powder, Syrup, and Other Forms", capsule and tablet used to have negative effects on the price ratio in the first period (-0.062), while it turns to be positive in the third period (0.061). Products with high strength (BRAND_HIGH_STRENGTH) have higher coefficient by 0.062 compared with products with low strength. "LARGE_PACKAGE" has positive and large coefficient as much as 0.183 compared with "SMALL_PACKAGE". The wholesale prices of products sold in a large package are more discounted than in small package. Compared with "Powder, Syrup, and Other" dose forms, "INJECTION" has higher ratio by 0.042, while "CAPSULE & TABLE" form is not significantly different from zero. Co-promoted products have substantially higher coefficient (0.104), which indicates that they either maintain higher official price or lower wholesale price due to co-promotion[3].

In addition to individual characteristics, this study investigates time effects in determining the price ratio. We find that coefficients of year dummy variables (YR_1991, ... YR_2002) are all significant. By transforming equation (6) without a constant term, we estimate effects of each year starting from "YR_1990" to "YR_2002".[4] Coefficients show

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[3]We need to adopt different method to examine which cases hold.

[4]When all year dummy variables are used, they are perfectly correlated with a constant term. So first l"YR_1990" is dropped from an equation, and coefficients of each year dummy variables should be interpreted as the effects of the year compared with those of year 1990. Next a constant term is dropped from equation, and coefficients for each year is interpreted in a straightforward manner.

that year dummy variables have declined from 1.61 for YR_1990 to 0.92 for YR_1998. This downward trend reaches the bottom in 1998 and is reversed. We also investigate the effects of quarterly dummy variables for official price revision. We divide period into sub-sample to first period (1990-1994;FP), second period (1995-1998, SP), and third period (1999-2002;TP). FP_REVSION_D takes unity for the period of April 1990, April 1992 and April 1994. In order to capture persistent effects, we us lagged dummy variables by one, two , three periods (FP_REVISION_D{1}, FP_REVISION_D{2}, FP_REVISION_D{3}). Quarterly dummy variables for the official price reduction have negative effects on the price ratio in the first period 1990-1994, while the same effects are not found in the second and third period. In response to the official price revisions, wholesalers do not lower the wholesale price in 1990, 1992, and 1994, while they lower the wholesale price accordingly in the second and third period.

Our estimation has small R-squared (0.227) and low Durbin=Watson Ratio (D.W.Ratio=0.136). These results imply that some important explanatory variables are omitted in our specification. Possible individual characteristics might be those related to product safety, effects, and quality.

— Table 4 —

— Table 5—

b. Determinants of Demand

Table 6 reports results based on equation (8) for "All Sample", "Capsule & Tablet", and "Injection".

$$\frac{\Delta q_{hit}}{q_{hit}} = \delta\left(\frac{\Delta(\overline{P}_{hit}/P_{hit})}{\overline{P}_{hit}/P_{hit}}\right) + \sum_{m=1}^{M}\phi_m M_{hi} + \sum_{d=1}^{4}\eta^d QUARTER\_d_{ht} + \sum_{n=1}^{N}\omega^n (Q\_YearMonth)_{ht}^n + \varepsilon_{hit} \qquad (8)$$

—Table 6—

Coefficient of the "change in the price ratio" is 0.410 and significant, which result should be interpreted that 1 percent increase in the price ratio would increase demand by 0.41 percent. The effects are much higher for the sub-sample for "Capsule & Table" (3.557) and negative for "Injection" (-0.346). In particular, demand for "Capsule & Tablet" is highly elastic with respect the price ratio compared with other dose forms. These results accord with the previous literatures as Nanbu and Shimada (2000), Onda and Sato (2002)). We conclude that although the price ratio itself decreased substantially, it is still an important determinant for pharmaceutical demand.

Product age dummy variables (OLD_PRODUCT) do not affect demand, and generic competition