Summary

Japanese government has regulated the official pharmaceutical prices for the purpose of the nation-wide health insurance. It has updated the official prices once in a year or two by lowering them toward the wholesale prices prevailed at market. As a result, the Japanese pharmaceutical prices have declined significantly over the thirty years, which fact is sharply contrasted with the U.S. and other countries. This study analyzes the effects of the "events" of the official price reductions on the firm's rates of return. Based on a standard "market model" relating the rates of return of an individual firm to the market rates of return, we estimate "quarterly beta" of 31 Japanese pharmaceutical firms listed in the period 1977-2006.

We find that that quarterly beta had declined sharply in the period of 1977-1986 and had become more stable. We also find convergence of beta across firms in later periods. Our interpretation of difference-in-difference indicates that directly after the introduction of the new price regime in 1992, the official priced had increased rates of return. The positive effects have decreased steadily, and turned to be negative around 2000. When compared with the over-the-counter drug firms, both large scale firms and medium scale firms have responded to the official price reductions in a similar fashion. We interpret that prescription drug firms could absorb negative effects by promoting sales volume by lowering wholesale prices, but they could no longer absorb them lately.

There are remaining questions. First, we find the effects of the price regulation are rather short-lived in the same quarter. Second, why there is no difference between large scale firms and medium-scale firms in spite of the fact that large scale firms are less dependent on the existing products in domestic market. In order to answer these questions, we have to compare Japanese pharmaceutical firms with foreign pharmaceutical firms by identifying factors determining the rates of return. We expect success rates of R&D, introduction of new products, and country specific factors may account for the rates of return.

Key words: pharmaceutical, price regulation, share, value, research and development
JEL Code: G14

要約

目的

日本政府は，医療保険制度の下で，過去 30 年にわたり，医薬品の薬価低下政策を実施してきた。その政策の結果，日本の医薬品価格は長期的にも大きく低下し，医薬品価格の上昇の顕著なアメリカ合衆国等とは対比される。ところがこの薬価低下政策は，日本において医薬品企業の利益を低下させ，それが R&D を抑制するという批判が経済学を利用してなされる。ところが，実際には日本の医薬品企業は過去 30 年，高い利益率を実現し，R&D 投資を積極的に行ってきた。そこで問題となるのは薬価低下政策が実際にどのように医薬品企業の利益率にどのように影響してきたかという事実の確認である。この報告では 1 あるいは 2 年に一度の間隔で行われてきた薬価低下が，医薬品企業の株式利益率にどのように影響したかを分析する。

研究手法

このような目的で使用される研究手法としては，財務理論における"event study"がある。そこでは，個々の企業の利益率に影響を与える現象を event と特定し，その event 発生前の期間の利益率の決定構造によって，event 発生後の期間の利益率を予測し，それが実際の利益率との差によって"abnormal return"を計測し， event の効果を分析する。薬価低下政策を event と特定し，この event study を採用することが考えられる。ところが薬価低下政策は過去 30 年に 17 回行われたため，event は 1 回でなく，多数ある。このとき，event 前，event 後の期間を明確に区分することは困難となる。さらに代表的な event study では abnormal return の企業平均を使用するが，event がすべての企業において同時に生じる場合にはこれが使用できない。そこで別の方法を採用する必要がある。本論文は日本で株式を上場する 31 社の医薬品企業の株式収益率を被説明変数とし，それを市場全体の収益率で説明する Market Model を採用し，その係数を推定して分析する。市場収益率の係数であるβは 4 半期ごとに変化すると仮定し，薬価低下政策はその四半期の係数の変動に現れると想定する。また，個々の医薬品ごとに薬価低下率は異なり，さらに薬価低下政策は国外市場販売には及ばない。そこで薬価低下政策の影響は，個々の医薬品企業がどのような製品ポートフォリオを保有するか，海外売上高比率が大きいかなどにも影響されるはずである。

そこで，ここではサンプル企業を処方薬を売り上げの中核とする 21 社，さらにそれを大規模で海外販売比率の高い大企業(large scale firms)7 社，中小規模で海外販売比率の低い中企業(middle scale firms) 13 社に区分した。また，薬価低下政策の対象とならない店頭販売薬(over-the-counter)や，その他の事業を中核とする企業 10 社を OTC 企業として分類して，企業種別のダミー変数を作成した。さらに，薬価低下政策のあった四半期(T 期と表示)し，それがなかった四半期(N 期と表示)と区別したダミー変数を作成した。これらのダミー変数を付加して，ベータを推定し，さらに difference-in-difference の手法により，event の効果を分析できる。これは次の考えを利用する。薬価低下政策響は，原理的には OTC 企業には影響せず，処方薬医薬品企業に対して，それも薬価低下政策が実施された四半期に影響するはずである。そこで，薬価低下政策の行われた四半期の処方薬企業のβについて，その 1 年前あるいは 1 年後の四半期で，薬価低下政策が行われていない四半期のβとの差(A)をとる。さらに薬価低下政策の行われた四半期の処方薬企業と OTC 企業を区別しないサンプル全体のβと，そうでない四半期のサンプル全体のβとの差(B)をとる。(A)と(B)の差をとると，理論的には薬価低下政策の影響が抽出できるはずである。

研究結果

まず，個別企業ごとに，マーケットモデルを適用して，αと四半期ごとのβを推定してみた。その結果，αはほ

ぼ一定であること，これに対して，βは四半期ごとに大きく変動する。このためβを年度，あるいは数年間単位で一定と仮定する通常の分析手法はこの研究においては望ましくない。また，大企業(large)，中企業(middle)はOTC 企業よりも高いβ値を持つ。とりわけ，1980 年代半ばまでそれが当てはまる。大企業のβは中企業のそれよりも 1980 年代末まで高いが，1990 年代にはこれが逆転する。その後，両者ともに 0.5 程度に低下し，大企業，中企業，OTC 企業の差は収斂する。また，薬価低下政策が実施された年度ダミーの係数の符号の正負によって薬価低下政策の影響を見ると，1980 年代までは，1978 年を除いて，それが予想されたように負の効果を持ったが，それが 1990 年代になると徐々に不明確になり，2002 年以降は，逆の効果を持つようになった。

さらに，サンプル企業の中で大企業，中企業ダミーと，薬価低下政策の実施された四半期ダミーを用いた推計による分析では，1980 年代までのその効果は，薬価改定ごとに異なり，共通した結果がないこと，これに対して，1992 年の新しい薬価改定採用後には，薬価改定が医薬品企業の収益率を逆に上昇させるということが 1998 年まで続いたことが判明した。しかし，その効果は年を追うごとに低下し，2000 年からは予想されるように薬価低下政策が収益率を低下させるようになったことがわかった。薬価低下政策は確かに，処方薬を中心とする企業に影響を与え，OTC 企業には影響を与えていない。しかし，海外売上比率が高い大企業とそれが低い中企業との間で薬価低下政策の影響は異ならなかった。

結論

薬価低下政策は医薬品企業の株式収益率に影響を及ぼした。時系列では，1980 年代半ばに構造変化があり，その前はβが高いレベルで大きく変動したが，それ以降は低下し，企業間の相違は収斂した。個々の薬価低下政策の影響は個々の event によって影響の方向と大きさがことなる。符号テストでは 1980 年代の薬価低下政策は予想通りに収益率を低下させ，β値を低下させた。他方，1990 年代以降はこれが不明確になる。ところがこれを difference-in-difference の手法を採用して分析すると別の結果が示される。とりわけ 1992 年の薬価改定基準の変更が，構造変化をもたらしたことが判明した。1992 年以降，1998 年まで，薬価低下政策が医薬品企業のβを上昇させるという予想とは逆の効果が生じたことが判明した。

以上の結果は，分析手法によって内容が異なり，次の再検討を必要とする。第 1 は，四半期でβを推計したことに対して，これが半期，年度であった場合にどのように結果が異なるか否かを確認する必要がある。第 2 は，医薬品企業以外のサンプル，あるいは外国企業のサンプルを利用して，日本の医薬品企業と比較することである。薬価低下政策は，必ずしも医薬品企業の収益率を明確に低下させたわけではなかった。また，difference-in-difference の手法がもっとも正確な結論を導いているようであるが，サンプルが少ないため，結論の頑健性を別の手段で確認することである。

1. Introduction

This paper examines the economic impact of Japanese pharmaceutical price regulation on shareholders value of the pharmaceutical firms. In the past thirty years, Japanese official pharmaceutical prices have been tightly regulated by the government for the purpose of the universal National Health Insurance Plan (NHI), while the wholesale prices applied to transactions between wholesaler and hospital/pharmacy are left to market competition without direct regulation. The government determines the official price of pharmaceutical products. The wholesalers tend to lower the wholesale prices to gain demand in market competition. In response, the government updates the official prices based on the wholesales prices. Because the wholesale prices are usually deeply discounted from the official prices, the government lowers the official prices in updates. As a result, Japanese pharmaceutical prices have continued to decline in the past thirty years, which phenomena is quite unique among developed countries. Pharmaceutical firms are strongly opposed to the pharmaceutical price reduction by claiming that it would stifle research and development due to restrained profitability of pharmaceutical firms. There is a puzzle, however, that pharmaceutical firms have been profitable and have conducted large scale R&D. If there are no negative effects of the pharmaceutical price reduction on performance of pharmaceutical firms, government can safely pursue the price reduction without worrying about the decline of R&D activities in Japan.

This question is related to a financial economics framework. One approach is to study how firm performance affects firm behavior such as R&D. For example, the literature of investment function theory studies how R&D is determined by firm performance such as profitability, cash flow, and value of the firm or project. The other is to study how firm performance is determined. Although there are number of alternative measurements for firm performance such as profitability and cash flow, the rates of return or the value of the firm are widely used to capture the firm performance.

Because performance of Japanese pharmaceutical firms critically depends on its output price, this study examines the relationship between the events of pharmaceutical price reductions and firm performance. A widely used procedure for estimating the economic effects of "events" is the investigation of "abnormal return" as estimated residual return from a certain model such as market model like CAPM (MacKinlay (1997)). However, there are drawbacks with the method applied to policy change. Schipper and Thompson (1984) discusses (1) multi announcement events for a given policy change; (2) high cross-sectional correlation in the security return of affects companies both because each announcement event occurs on the same calendar date for all affected firs and because the affects firms have industry or other factors in common; (3) relative small sample sizes. They adopt alternative approach to event study by estimating the effects of multiple events on overall firm return. Regression estimation allows straight forward interpretation of event effects.

Pharmaceutical price regulations fall into this category of the policy change. The pharmaceutical price reduction takes multiple events. There are 18 price reductions in the past thirty years in 1977-2006. We are concerned with the changes of effects of a single event as well as the overall effects of the multiple events. We are also concerned with the effects of multi-stage announcements of an individual policy change. Typically, the goal and its general framework are announced several months ahead of the actual price reduction. Then, the official prices list for each product is announced a couple of months before the event. Finally the new official prices are applied to transactions after the specified date. Because it takes from several months to a year for the regulator to implement policy change, it is difficult to identify the exact date when the effects should be reflected in share prices. In this situation, Schipper and Thompson method allows straight forward interpretation of the effects of events. Also there is high cross-sectional correlation in return because the price regulations affect all pharmaceutical firms at the same time. Hence, estimation by GLS and SURE can be applied to the pooled cross-section and time-series data. Finally when we focus on one specific industry such as pharmaceutical industry, one can rarely enjoy enough sample firms which is required for traditional event study method.

2. Pharmaceutical Price Regulation

The National Health Insurance (NHI) plays a central role in Japanese medical services. It is a universal nation-wide public health insurance plan consisting of several different health insurance plans depending on types of the insured's occupations, age groups, and locations. To make payment from the NHI, the government designates physicians who diagnose and treat the insured and prescribe pharmaceutical products for the NHI purpose. The government determines the types of medical services and products covered and paid the NHI. The government also specifies the price list for each individual medical services and pharmaceutical products. The NHI makes payment with the specified fraction of the official prices of medical services and pharmaceutical products, while the insured should make co-payment of the rest. For prescription pharmaceutical products, NHI currently pays around 70-80 percent of the official prices, while the insured pays the 20-30 percent as co-payment depending on their status.

Pharmaceutical distribution consists of the following players including pharmaceutical firms, wholesalers, hospitals/pharmacies, patients, and the regulator. We distinguish different types of prices depending on types of transactions in distribution system (Table1). The price applied to transactions between pharmaceutical firms and wholesalers is "manufacturer's sales price (P_{hit}^{M})" where *h* stands for *h-th firm's i-th* product in *t-th* period. Firm sells product at market. Each product is distinguished by characteristics including "ingredient", "forms (capsule, tablet, or injective)", "brand", "strength (eg. mg per dose)" and "transaction package (eg. 100 tablets)." The price for transactions between wholesalers and hospitals/pharmacies is the "wholesale price or delivery price (P_{hit})". These two prices are applied to upstream transactions and determined by market competition without direct intervention of price regulation. On the contrary, the "official price ($\overline{P}_{hit}$)" applied to the NHI transaction purpose is closely regulated by the government. The government determines the official prices by corporation, ingredients, brands, forms, and strength, for the transactions held in certain periods. The wholesale prices have been deeply discounted from the official prices reflecting market competition. As a result, there have been significant price difference ($\overline{P}_{hit} - P_{hit}$) in Japanese pharmaceutical market. Hospitals and pharmacies can earn this price difference as their income, physicians have economic incentive to prescribe pharmaceutical products that have larger price difference. At the same time, hospitals/pharmacies negotiate with wholesalers by demanding lower wholesale price. Consequently the price difference ratio ($Dif_{hit} = (\overline{P}_{hit} - P_{hit}) / P_{hit}$) plays a critical role in Japanese pharmaceutical regulation.

The Japanese government has attempted to lower the official prices of pharmaceuticals for several reasons. First, the government intends to reduce total pharmaceuticals cost by lowering official prices. Second, the government intends to reduce the price difference to correct distortion of resource allocation. Third, the government attempts to decrease unjustified income for hospitals/pharmacies. Although the regulator seldom admits the existence of the price difference in public, it has resorted to the official price reduction in a way to equate them toward the wholesale price prevalent at market.

The government has updated the official price $\overline{P}_{hit}$ by lowering them toward the wholesale price prevailed at market. At the same time, the regulator has promoted the institutional separation between prescription by physicians and dispensing by pharmacists. In response, hospitals came to reduce the number of dispensing inside hospitals and transfer them to outside pharmacies.

Prior to 1978, the government regulated the official prices of pharmaceutical products by "ingredients", "forms" and "formula" irrespective of "brands" under the "unified price list system (*To-itsu syusai-hoshiki*)." The government introduced a new price system in 1978 under the name of "trade name price list system (*Meigara-betsu syusai hoshiki*)". Under the new system, the government came to determine the official price ($\overline{P}_{hit}$) by brand. Price of a new product is determined by its cost information including manufacturing cost, R&D expense, and fair return or by a comparison with existing similar pharmaceuticals.

For products already marketed, the government determines the official prices based on the wholesale prices. Because the wholesale price differs significantly across products, transactions, and hospitals/pharmacies, the Japanese government conducts a nation-wide survey of the wholesale prices to obtain information on the wholesale prices. Then the government updates the official prices of each product by applying the pre-specified formula to the surveyed average wholesale prices. The government has attempted to equate the official price with the market wholesale price of each product. Since the introduction of the "trade name price list system" in 1977, the regulator came to update the official prices of existing products by using information on the weighted average of the wholesale prices. For example "90 percent bulk line method" uses the wholesale price at the lower 90^{th} percentile as a benchmark for the updated wholesale prices. In 1992 the government adopted a new update method called "reasonable zone method" as shown in (1).

$$\overline{P}_{hit} = P_{hit-1}(1+u_t) + R_t \cdot (\overline{P}_{hit-1} - P_{hit-1}) \quad (1)$$

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 was 0.03 in the beginning, then it was raised to 0.05 after April 1997. Due to market competition among products, the wholesale prices were usually far below than the official prices, the regulator has continued to reduce the official prices, in turn, the wholesale prices have continued to decline further. Figure 1 shows the wholesale has continued to decline over the periods.

———Table 1 Pharmaceutical Transactions and Prices

———Figure 1 Decline of the Pharmaceutical Price (wholesale prices)

3. Effects of the Official Pharmaceutical Price Reductions

The effects of the official pharmaceutical price reductions may differ across products, firms, and the time periods. Demand for an each pharmaceutical product is expected to be inelastic to the official price change when physicians prescribe pharmaceutical products solely on their medical merits for patients. Demand for an individual product, however, has depended on the official price as well as the wholesale price in the past. For an example, it is the difference between both prices that really affect demand for an individual product. Because sales of the pharmaceutical firms depend on manufacturer's price, we should examine the relationship between the manufacturer's price, wholesale price, and official price. When we expect that demand for individual products may be inelastic to the official price reductions, we expect that we will find the negative effects on the rates of return. Although the official price reductions have been applied to most pharmaceutical products at the same time, magnitude of reduction differ significantly across products based on their wholesale prices. The official prices of certain products have even been raised. Consequently, the overall effects of the official price reductions on firm performance depend on product portfolio of an individual firm. For example, a certain firm relies on a few best selling product whose the official price are heavily reduced, the negative effects might be quite large. On the other hand, there are no negative effects when the firms sell their products in foreign countries, or when their products are over-the-counter products that are not subjected to the official price regulation. We can expect that large scale firms with higher foreign sales ratio may be less affected by the official price reductions. Also medium and small-scale firms mainly relying on over-the-counter products may be less affected. The negative official price reductions may last within a short period or last across periods. We wish to know how they differ. Also the official price reductions differ in magnitude significantly. For example, the overall reductions rates were large in 1981, 1984, 1988, 1990, 1992, and 1998 in Table 2. We should account for the variations of the effects of the official price reductions.

4. Model and Data

By assuming a market model for the rates of return, we specify a linear relationship among variables.

$$r_{ht} = \alpha_h + \beta_h \cdot R_t^m + \mu_{ht} \qquad (2)$$

where each pharmaceutical firm's daily rate of return is r_{ht}, market return R_t^M. Subscripts stand for the $h-th$ firm and $t-th$ period. Coefficients α_h is an intercept, β_h is a coefficient for the market return, and μ_{ht} is an error term. By applying the OLS to cross section data, $\overline{\alpha}_h$ and $\overline{\beta}_h$ are estimated under the assumption that they differ across firms but are constant over time periods. Traditional "event study" method can be applied when we specify a single event and construct "abnormal return" in the after-event period. Official price reductions took place 17 times in 1978-2006 period and they are applied to all firms at the same time. We cannot apply the traditional event study method to our sample. So we devise our multiple events in a following fashion. We assume that β_h may vary with quarterly periods.

$$r_{ht} = \alpha_h + \sum_{q=1}^{K} \beta_{hq} \cdot R_t^m + \mu_{ht} \qquad (3)$$

where β_{hq} is β coefficients of the $h-th$ firm in the $q-th$ quarterly period. We can estimate equation (3) by applying the OLS to individual firm data. We also specify equation (4) by pooling individual data.

$$r_{ht} = \sum_{h=1}^{H} \left(\alpha_h + \sum_{q=1}^{K} \beta_{hq} \cdot R_t^m \right) + \varepsilon_{ht} \qquad (4)$$

where the subscript of q is q-th quarterly period. We assume that α_h and β_h are constant for the $h-th$ firm in the $q-th$ quarterly period. An intercept differs across firms but are constant over time periods, while the slope coefficients vary both with firms and over time periods. The government has updated the official prices once in every one or two year, which effects might be captured by the change in the quarterly variation of the coefficients β_{hq}. Equation (4) is parameterized as follows.

$$\begin{bmatrix} r_{1t} \\ r_{2t} \\ \cdot \\ r_{ht} \\ \cdot \\ r_{Ht} \end{bmatrix} = \begin{bmatrix} j_t & 0 \ldots 0 & 0 & R^m_{q,t} & 0 \ldots\ldots 0 & \ldots\ldots 0 \\ 0 & j_t \ldots 0 & 0 & 0 & R^m_{q,t}\ 0..0 & \ldots\ldots 0 \\ 0 & 0\ 0 \ldots j_t\ 0 & 0 & 0 \ldots\ldots & R^m_{q,t} & 0\ldots 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & 0 & j_t & 0 & 0 \ldots\ldots & R^m_{q,t} \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \cdot \\ \alpha_h \\ \cdot \\ \alpha_H \\ \beta_{1q1} \\ \beta_{1q2} \\ \cdot \\ \cdot \\ \beta_{Hqn} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \cdot \\ \cdot \\ \cdot \\ \varepsilon_{Ht} \end{bmatrix} \qquad (5)$$

Next we classify our sample firms into large-scale firm (L), medium-scale firm (M), and OTC firms (OTC). In our sample firms, there are 20 prescription drug firms most of whose products are prescription drugs that are subject to the price regulation, and 11 OTC firms most of whose products are not subject to the price regulation. We classify prescription drug firms into 7 large scale and 13 medium scale firms. Large scale firms are Sankyo, Takeda, Yamanouchi, Daiichi, Fujisawa, Chugai, and Eisai. Medium scale firms are Dainippon, Shionogi, Tanabe, Yoshitomi/Wellfide, Banyu, Nippon, Toyama, Kaken, Green, Ono, Nikken-kagaku, Mochida, and Taisyo. OTC firms are Wakamoto, Teikoku, Biofermin, Wakodo, Morishita, Riken, Roht, Hisamitsu, Yukigosei, Tokyotanabe and Santen (Table3 and 4).

In order to evaluate the effects of the price reduction, we use a following method. Equation (6) is specified as a relationship between the rates of return and a constant term α, the slope coefficients of β_q.

$$r_{ht} = \alpha + \sum_{q=1}^{K} \beta_q R^m_t + v_{ht} \qquad (6)$$

Equation (6) differ from (3) in that β_{hq} is common to all firms. Several dummy variables are introduced. The status of large scale firms is L = 0, 1 where 1 indicates large scale prescription drug firm, and 0 otherwise. The status of middle scale firms is M = 0, 1 where 1 indicates medium scale prescription drug firm, and 0 otherwise. Because over-the-counter drugs are not subject to the official price reduction, we assume that small OTC firms are not affected by the official price reduction, while large scale and medium scale firms are affected by the price reduction. The official price reductions usually take place once in one or two year. By assuming that the effects of the price reduction are captured in the rates of return in the same period, we use time dummy T =1, 0 where 1 indicates the period when the official prices are updated and 0 otherwise. We specify a market model as in equation (7) where an intercept α is assumed to be common to all firms and slope coefficients β_q are constant in the quarterly period. We further assume that slope coefficients β_q are modeled as in equation (7).

$$r_{ht} = \alpha + \sum_{q=1}^{K} \left((\overline{\beta} + \omega_t + \gamma\, T_{ht}) + \delta^L L_{ht} + \delta^M M_{ht} + \lambda^L L_{ht} T_{ht} + \lambda^M M_{ht} T_{ht}) \right) R_t^m + \nu_{ht} \qquad (7)$$

where the coefficients $\alpha, \overline{\beta}_q, \gamma, \omega_t, \delta^L, \delta^M, \lambda^L, \lambda^M$ are unknown parameters, and ν_{ht} is an error term.

$\alpha =$ constant term

$\overline{\beta}_q =$ coefficients of R_{ht}^m common to large scale firms, medium scale firms, and small/OTC firms

ω_t = time specific effect for each quarter period.

γ = coefficient of T_{ht} which is effects specific to period when the official prices are reduced.

δ^L = effect specific to large scale firms

δ^M =effect specific to medium scale firms

λ^L = coefficient of $L \cdot R_{ht}^m$ which is effect specific to large scale firms in the period of official price reduction.

λ^M = coefficient of $M \cdot R_{ht}^m$ which is effect specific to medium scale firms in the period of official price reduction.

Slope coefficients β_q in equation (6) is modeled in equation (7) as the sum of a constant part of $\overline{\beta}_q$, the time effect specific ω_t , the time effects specific to the period when the official prices are reduced γ, the individual effect specific to large scale firms δ^L, the individual effects specific to medium scale firms δ^M, and the effect specific to large scale firms in the period of official price reduction λ^L, and the effect specific to medium scale firms in the period of official price reduction λ^M. What we are concerned is to find λ^L and λ^M. A preliminary estimation indicates that an intercept is common to all firms.

$$r_{ht} = \alpha + \sum_{q=1}^{K} \beta_q^{All} R_t^m + \sum_{q=1}^{K} \beta_q^L R_t^m + \sum_{q=1}^{K} \beta_q^M R_t^m + \nu_{ht} \qquad (8)$$

β_q^{All} = coefficients of R_{ht}^m common to large scale firms, medium scale firms, and OTC firms

β_q^L = coefficients of R_{ht}^m common to large scale firms.

β_q^M = coefficients of R_{ht}^m common to medium scale firms.

We assume that the following conditions met and apply the OLS to obtain unbiased estimates.

$\text{cov}(\nu_{ht}, \omega_t R_t^m) = 0$, $\text{cov}(\nu_{ht}, \gamma\, T_{ht} R_t^m) = 0$, $\text{cov}(\nu_{ht}, \delta^L L_{ht} R_t^m) = 0$, $\text{cov}(\nu_{ht}, \delta^M M_{ht} R_t^m) = 0$

$\text{cov}(\nu_{ht}, \lambda^L L_{ht} R_t^m) = 0$, $\text{cov}(\nu_{ht}, \lambda^M M_{ht} R_t^m) = 0$

$$E(\hat{\beta}_{q,T}^L) = \overline{\beta} + \omega_t + \gamma + \delta^L + \lambda^L \quad (9)$$

$$E(\hat{\beta}_{q,T}^M) = \overline{\beta} + \omega_t + \gamma + \delta^M + \lambda^M \quad (10)$$

$$E(\hat{\beta}_{q,T}^{All}) = \overline{\beta} + \omega_t + \gamma \quad (11)$$

$$E(\hat{\beta}_{q-4,N}^L) = \overline{\beta} + \omega_{t-4} + \delta^L \quad (12)$$

$$E(\hat{\beta}_{q-4,N}^M) = \overline{\beta} + \omega_{t-4} + \delta^M \quad (13)$$

$$E(\hat{\beta}_{q-4,N}^{All}) = \overline{\beta} + \omega_{t-4} \quad (14)$$

Where subscript T stands for the quarterly periods when the official prices are reduced, and N for the periods the official prices are not updated. What we are concerned is to find the unbiased estimates of λ^L and λ^M.

$$D_{T,N}^L = E(\hat{\beta}_{q,T}^L) - E(\hat{\beta}_{q-4,N}^L) = \omega_q - \omega_{q-4} + \lambda^L \quad (15)$$

$$D_{T,N}^M = E(\hat{\beta}_{q,T}^L) - E(\hat{\beta}_{q-4,N}^L) = \omega_q - \omega_{q-4} + \lambda^M \quad (16)$$

$$D_{T,N}^{All} = E(\hat{\beta}_{q,T}^{All}) - E(\hat{\beta}_{q-4,N}^{All}) = \omega_q - \omega_{q-4} \quad (17)$$

$$DD_{T,N}^{L-All} = D_{T,N}^L - D_{T,N}^{All} = \lambda^L, \; DD^{M-All} = D^M - D^{All} = \lambda^M \quad (18)$$

In the same manner we have the following equations.

$$D_{N,T}^L = E(\hat{\beta}_{q,N}^L) - E(\hat{\beta}_{q-4,T}^L) = \omega_q - \omega_{q-4} - \gamma - \lambda^L \quad (19)$$

$$D_{N,T}^M = E(\hat{\beta}_{q,N}^L) - E(\hat{\beta}_{q-4,T}^L) = \omega_q - \omega_{q-4} - \gamma - \lambda^M \quad (20)$$

$$D_{N,T}^{All} = E(\hat{\beta}_{q,N}^{All}) - E(\hat{\beta}_{q-4,T}^{All}) = \omega_q - \omega_{q-4} - \gamma \quad (21)$$

$$DD_{N,T}^{L-All} = D_{N,T}^L - D_{N,T}^{All} = -\lambda^L, \; DD_{N.T}^{M-All} = D_{N,T}^M - D_{N,T}^{All} = -\lambda^M \quad (22)$$

Thus we obtain the unbiased estimates of λ^L and λ^M both by equations (18) and (22). Also we have

$$D_{T,T}^L = E(\hat{\beta}_{q,T}^L) - E(\hat{\beta}_{q-4,T}^L) = \omega_q - \omega_{q-4} \quad (23)$$

$$D_{T,T}^M = E(\hat{\beta}_{q,T}^L) - E(\hat{\beta}_{q-4,T}^L) = \omega_q - \omega_{q-4} \quad (24)$$

$$D_{T,T}^{All} = E(\hat{\beta}_{q,T}^{All}) - E(\hat{\beta}_{q-4,T}^{All}) = \omega_q - \omega_{q-4} \quad (25)$$

$$DD_{T,T}^{L-All} = D_{T,T}^L - D_{T,T}^{All} = 0, \; DD_{T.T}^{M-All} = D_{T,T}^M - D_{T,T}^{All} = 0 \quad (26)$$

$$D^{L}_{N,N} = E(\hat{\beta}^{L}_{q,N}) - E(\hat{\beta}^{L}_{q-4,N}) = \omega_q - \omega_{q-4} \quad (27)$$

$$D^{M}_{N,N} = E(\hat{\beta}^{L}_{q,N}) - E(\hat{\beta}^{L}_{q-4,N}) = \omega_q - \omega_{q-4} \quad (28)$$

$$D^{All}_{N,N} = E(\hat{\beta}^{All}_{q,N}) - E(\hat{\beta}^{All}_{q-4,N}) = \omega_q - \omega_{q-4} \quad (29)$$

$$DD^{L-All}_{N,N} = D^{L}_{N,N} - D^{All}_{N,N} = 0,\ DD^{M-All}_{N.N} = D^{M}_{N,N} - D^{All}_{N,N} = 0 \quad (30)$$

We have daily rates of return from January 1, 1977-December, 31, 2006. There are total 236,599 daily observations. Data on the daily stock rates of return are taken from Nikkei Media Marketing "*Nippon Kabushiki Nichiji Return File* (Japanese Daily Rate of Return File, 2007)" which is defined as the sum of capital gain/loss and dividend divided by previous share prices after adjusting the number of shares and the effects of the days of dividend payment. "Market return (R^m_t)" is constructed as the differences of the TOPIX divided by the same TOPIX at previous day.

———Table 2. History of the Official Price Reduction (1978-2006)

———Table 3. Firm List

———Table 4. Classification of Sample Firms

5. Empirical Results

a. Individual Estimates and Overall Trend

Appendix Table reports the estimation of equation (3) for individual firms. Figure 2 exhibits the estimates of some representative firms (Sankyo, Takeda, and Yamanouchi). Figure 3 exhibits the estimates of all firms, large scale firms, medium scale firms, and OTC firms. The last four columns are the estimation by pooling 31 all firms, 7 large scale firms, 13 medium scale firms, and 11 OTC firms with assumption that coefficients are common to firms in the same category. The model accounts for the rates of return for large scale firms and medium scale firms as expected. The model, however, fails to account for small OTC firms as shown by low adjusted R-squared and insignificant coefficients. The estimates of $\overline{\beta}_q$ for most large scale firms and medium scale firms have similar time profiles. The results indicate a significant structural change around the mid-1980s. In the earlier period (1977-1986), coefficients of $\overline{\beta}_q$ are far higher than 1.0 in most periods and they vary widely across time periods. These coefficients have declined sharply through the period 1977-1986. The official price reductions in the early 1980s seem to have negative effects on the rates of return within the same quarterly period. Large scale firms and medium scale firms have higher $\overline{\beta}_q$ than OTC firms (Figure 3). In the first period (1977-1986), the average coefficients of $\overline{\beta}_q$ for large-scale and medium-scale firms had declined sharply from 1.0-2.0 to 0.5-1.0 level. As a result, the differences of $\overline{\beta}_q$ across firm types are significantly reduced.

b. The Negative Effects of the Official Price Reductions

We are concerned with a question whether the price reduction has really decreased the rates of return. By adding the year-time dummy variables YR_t which takes unity when t=Year, zero otherwise.

$$r_{ht} = \sum_{h=1}^{H}\left(\overline{\alpha}_h + \sum_{q=1}^{K}(\overline{\beta}_{hq} + \tau_{hT}YR)\cdot R_t^m\right) + \varepsilon_{ht} \qquad (31)$$

We examine the year effects under the assumption that the changes in the estimates associated with year time dummy variables τ_{ht} are zero on the average. Based on the sign test and the Wilcoxon test, we test whether τ_{ht} is positive or negative. When the official prices reductions decrease β_q, we will find the negative sign of the year time dummy variables. Table 5 summarizes that the expected negative effects are associated with the official price reduction for the year 1979, 1981, 1983, 1985, 1988, 1992, and 1998. On the other hand, unexpected positive effects are found for the price reduction for 1978, 1986, 1990, 2002, and 2004. These results suggest that although the negative effects are associated by the price reductions mostly in the events in the early 1980s, they have become less clear in the later periods.

c. Difference-in-Difference Interpretation

We examine the effects of the official price reduction by equation (8).

$$r_{ht} = \alpha + \sum_{q=1}^{K}\beta_q^{All}R_t^m + \sum_{q=1}^{K}\beta_q^{L}R_t^m + \sum_{q=1}^{K}\beta_q^{M}R_t^m + \nu_{ht} \qquad (8)$$

Table 6 summarizes the estimation results. When we simply plot coefficients of $\overline{\beta}_q^{All}, \overline{\beta}_q^{L}, \overline{\beta}_q^{M}$ as in Figure 4, our results do not seem to indicate any consistent effects. As discussed in the model and data, we should identify the effects of the price reductions by the coefficients of the two cross dummy variables in equation (7).

$$r_{ht} = \alpha + \sum_{q=1}^{K}\left((\overline{\beta} + \omega_t + \gamma T_{ht}) + \delta^L L_{ht} + \delta^M M_{ht} + \lambda^L L_{ht}T_{ht} + \lambda^M M_{ht}T_{ht})\right) R_t^m + \nu_{ht} \qquad (7)$$

What we are concerned are

$$DD_{T,N}^{L-All} = D_{T,N}^{L} - D_{T,N}^{All} = \lambda^L, \quad DD^{M-All} = D^M - D^{All} = \lambda^M \qquad (18)$$

$$DD_{N,T}^{L-All} = D_{N,T}^{L} - D_{N,T}^{All} = -\lambda^L, \quad DD_{N.T}^{M-All} = D_{N,T}^{M} - D_{N,T}^{All} = -\lambda^M \qquad (22)$$

Based on these results, we obtain Table 6. In spite of our initial expectation, the negative effects in the period 1977-1990 are not clear except for the official price reductions in 1983, 1985, and 1990. The reforms of the price regulation in 1992 had significantly caused structural change. Directly after the introduction, positive effects are found for 1992, 1994, 1996, and 1997, the effects have declined and turned into negative around 2000. We conclude that the 1992 price reform may have positive effects on firm rates of return both for large-scale and medium-scale firms. There are no significant differences between the large scale firms and medium scale firms. Since 1998, however, the effects decline and finally the official price reductions turn to be negative in 2000, 2002, and 2004. So we conclude that the official price reductions have the negative effects. Still there are exceptions in 2006 when the positive effects are found again. Another expectation that large-scale firms with higher foreign sales ratio would be less affected than medium-scale firms with higher domestic sales ratio do not hold in our sample.

——Table 5. Sign Test and Wilcoxon Test of the Effects of Year Time Dummy on Changes in Rates of Return

——Table 6. The Effects of the Official Price Reduction

——Figure2 Coefficients of β of Representative Firms

——Figure3 Coefficients of β by Firm Group

——Figure4 Effects of the Price Reduction by Firm Size(I)

——**Figure 5. Effects of the Official Price Reduction (DID inter)**

6. Conclusion and Future Studies

This study investigated the effects of pharmaceutical price reduction on shareholders' rates of return. By using the simple market model relating the rates of return to the market rates of return, we estimated quarterly beta for individual firms. We found that the beta of the Japanese pharmaceutical firms had declined sharply around the mid-1980s and had become more stable over time periods. The differences across firms had become smaller. Thus, the Japanese pharmaceutical firms came to follow the similar time profiles in terms of quarterly beta. We also estimated an equation where the rates of return are affected by the time-specific effects in general, time-specific effects when the official price are reduced, individual specific effects associated with firm scale, and the cross effects of the official price reductions and firm scale. What we found is puzzling. We initially expected that the aggressive price reduction in 1981/6/1 (-18.6%), 1983/1/1(-4.9%), and 1984/3/1(-16.6%) may have negative effects on beta. This does not hold. Instead we found that 1992 new price regime caused structural change after 1992. Directly after the introduction, the official price reductions had positive effects instead of negative. This underscores the notion shared by executives of pharmaceutical corporations that the new price regime could increase firm value. But after series of the official price reductions, the differences between the official prices and wholesale prices came to be very small, and firms no longer lower the wholesale prices. In year 1998, 2000, 2002, and 2004, the official price reductions had negative effects on firm value. These results do not seem to be comprehensive. Because we only have limited number of years, these results might be only artifact. In order to obtain comprehensive results, we need to compare Japanese pharmaceutical firms with foreign firms thereby identify the unobserved effects on the rates of return. They might include success/failure of R&D, introduction of new products, patent expiration, entry by generic products, and M&A.

Reference

MacKinlay, A. (1997). Event Studies in Economics and Finance. *Journal of Economic Literature,* 35: 13-39.

Schipper Katherine and Rex Thompson (1983), "The Impact of Merger-Related Regulations on the Shareholders of Acquiring Firms," *Journal of Accounting Research,* 21(1), Spring, 184-221.

Figure 1. Decline of the Pharmaceutical Price (wholesale prices)

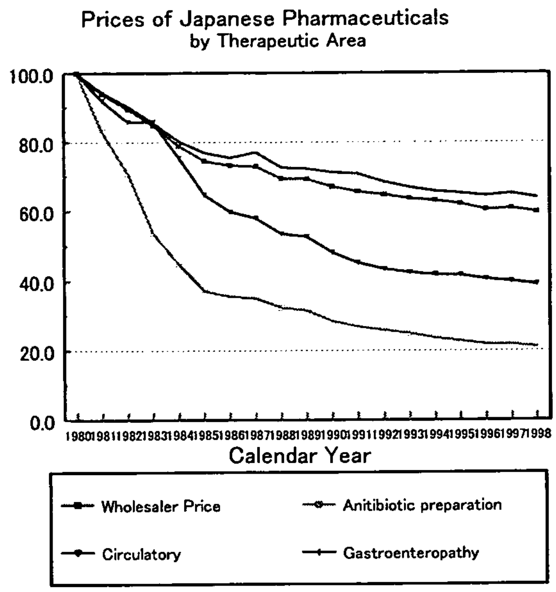
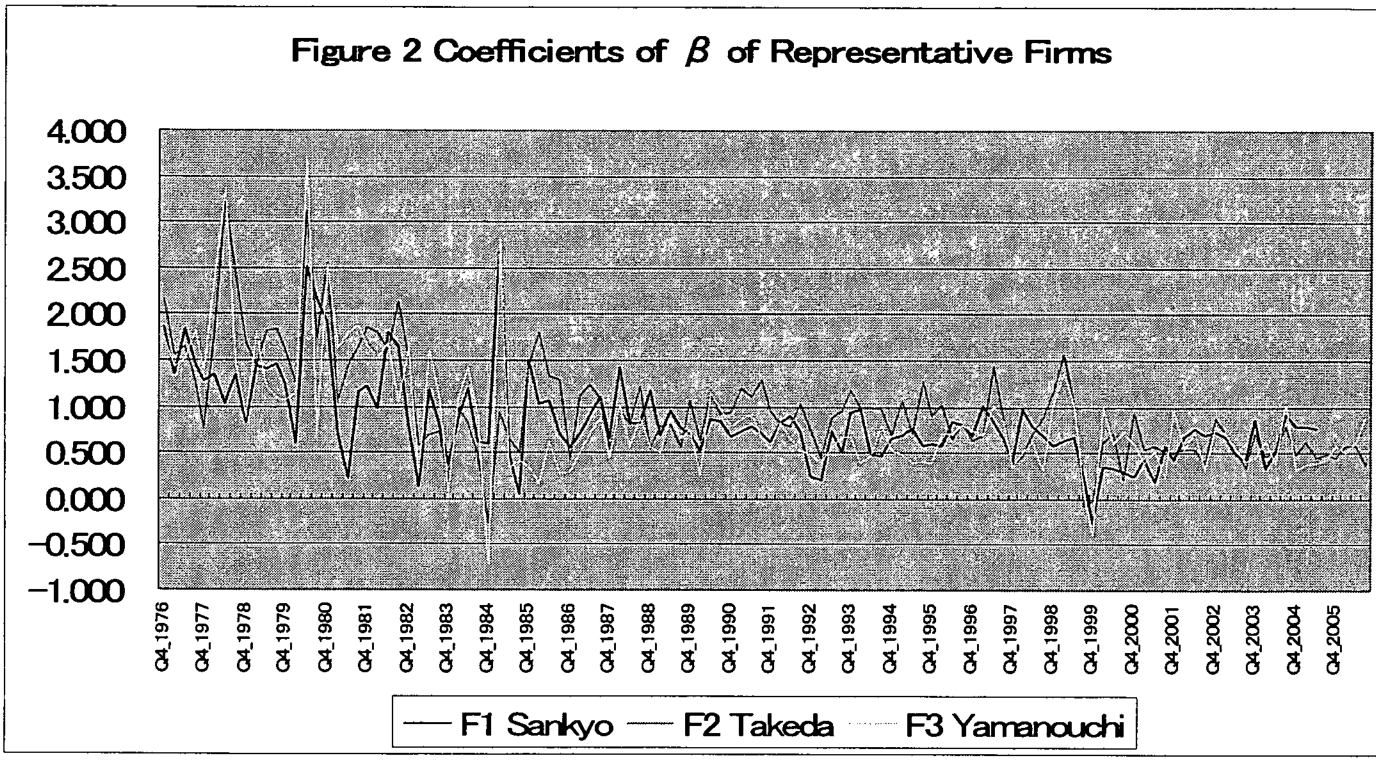
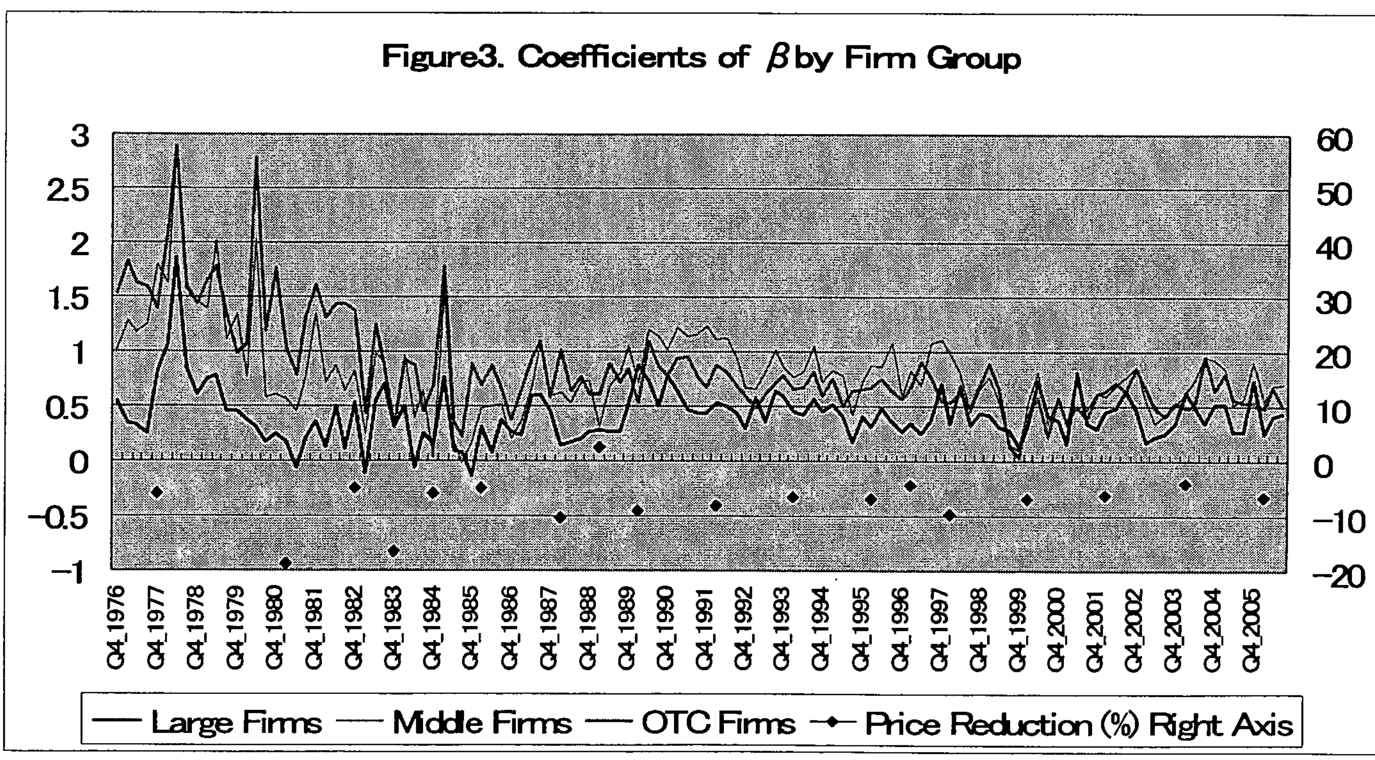


Figure2 Coefficients of β of Representative Firms



Note: Estimation equation (4). Estimates are found in Appendix Table.

Figure 3. Coefficients of β by Firm Group



Note: Estimation equation (4)' under assumption coefficients are common to firms in the same sample (Sample of All firms, Large-scale Prescription Firms, and Smaller OTC Firms.)

Figure 4 Effects of the Price Reduction by Firm Size(I)

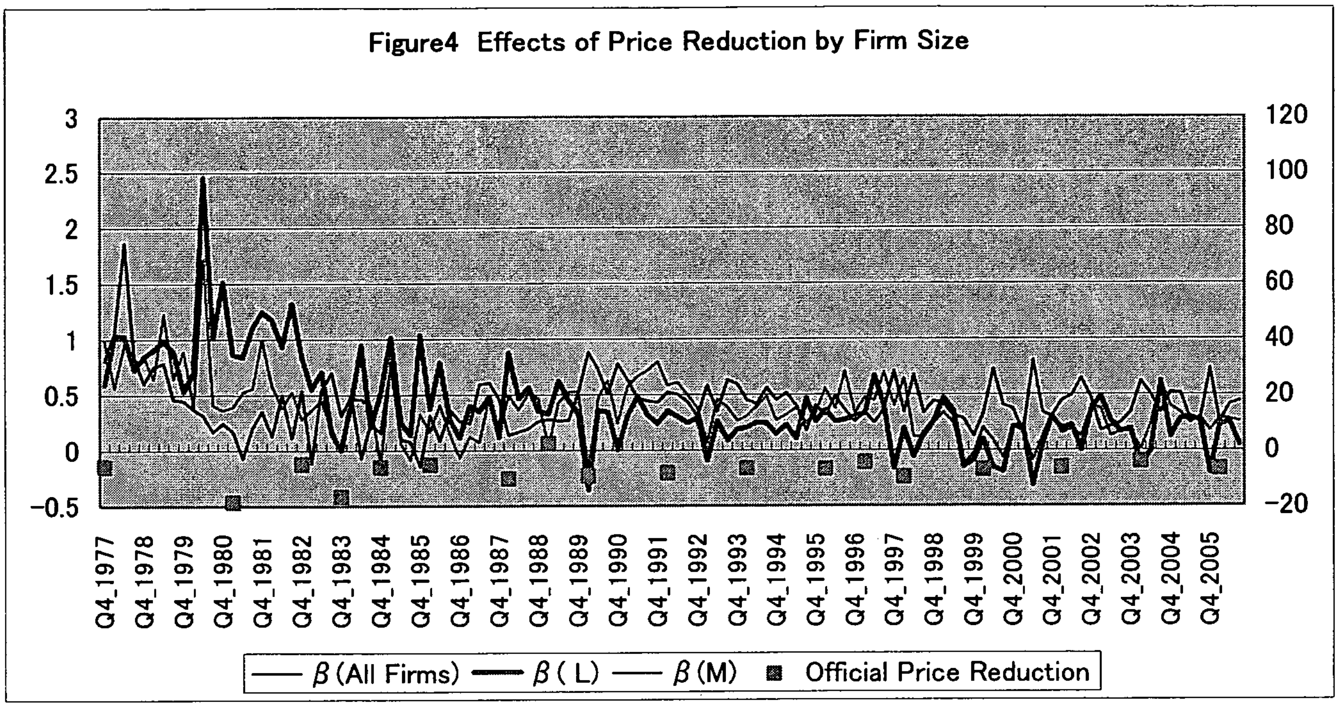
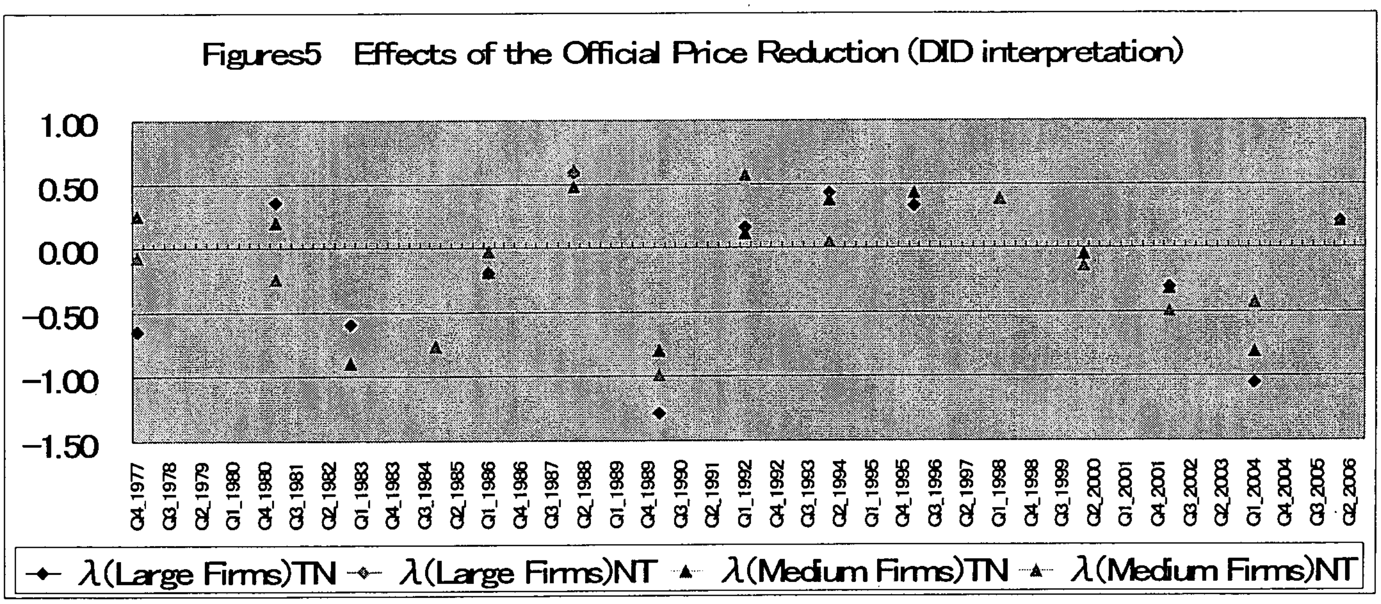


Figure 5. Effects of the Official Price Reduction (DID inter)



Figures5 Effects of the Official Price Reduction on Quarterly β

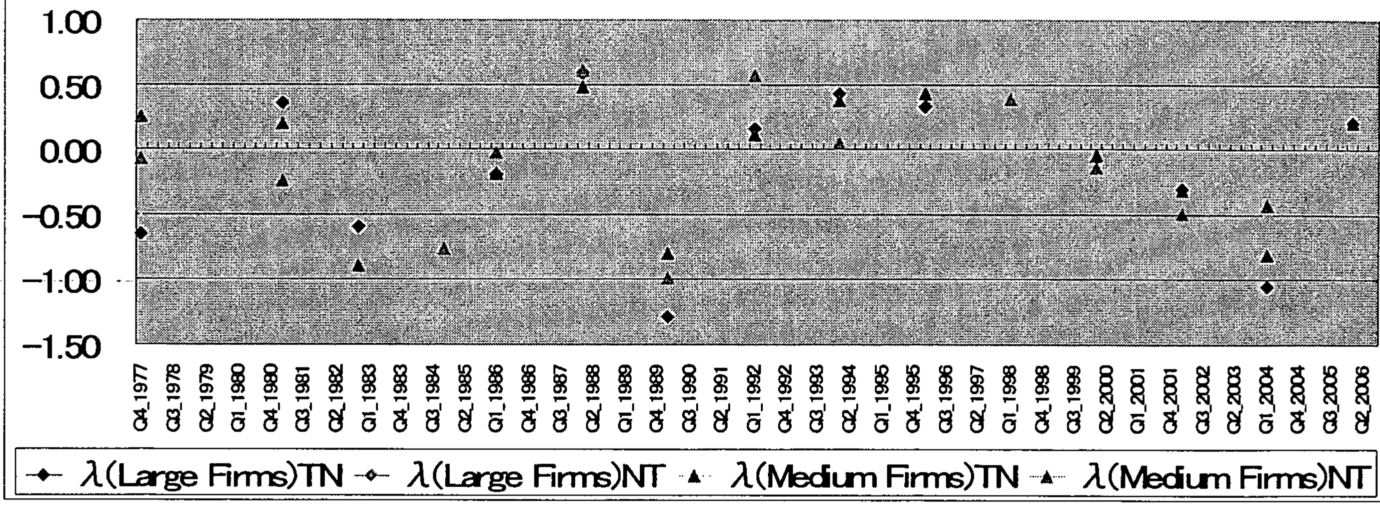


Table 1. Pharmaceutical Transactions and Prices

Pharmaceutical Firms

↓ ··············Manufacturer's Sales Price P^M (listed price)

Wholesalers

↓ ··············Wholesale Price P^W (market price)

Hospitals/Pharmacies

↓ ··············Official Price $\overline{P}$ for the National Health Insurance Purpose

Patients Regulated by the government

Table 2. History of the Official Price Reduction (1978-2006)

Date of Price Reduction	Date of Survey Date	Percentage Change of Total Pharmaceutical Expenditure	Major historic changes
1977/11			(introduction of the official price system based on individual brand)
1978/2/1	1976/2	-5.8%	
1981/6/1	1978/6	-18.6%	
1983/1/1	1981/12	-4.9%	
1984/3/1	1983/4	-16.6%	
1985/3/1	1984/10	-6.0%	
1986/4/1	1985/10	-5.1%	
1988/4/1	1987/6	-10.2%	
1989/4/1		+2.4%	(increase due to newly introduced 3% consumption tax)
1990/4/1	1989/3	-9.2%	
1992/4/1	1991/6	-8.1%	(introduction of new price regulation system)
1994/4/1	1993/6	-6.6%	
1996/4/1	1995/6	-6.8%	(three consecutive years of price reduction)
1997/4/1	1996/8,10	-4.4%	(2% increase in consumption tax and new updates)
1998/4/1	1997/9	-9.7%	
2000/4/1	1999/9	-7.0%	
2002/4/1	2001/09	-6.3%	
2004/4/1	2003/9	-4.2%	
2006/4/1	2005/5,11	-6.7%	

Source: Japanese Ministry of Health and Welfare, Ministry of Health and Labor, *Yakumu Koho,* cited from Yakujinippousya, *Yakkakijyunseido*,2007.