Experts' Agency Problems:

Evidence from the Prescription Drug Market in Japan*

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Abstract

This paper examines an agency problem in an "expert-client" relationship. An incentive problem exists in such a market because the appropriateness of the expert's action cannot be observed costlessly. Furthermore, since the expert often provides both diagnosis and service, the expert has an incentive to *create* demand for his service against his clients' interests. We investigate this issue in the prescription drug market in Japan, where a doctor can make profits by dispensing drugs to his patients. An immediate concern is the physician's agency problem: a doctor may choose drugs based not on efficacy, safety or cost, but on the extent of the profit margin he obtains. Excessive prescriptions may also result simply because the physician earns more profits by dispensing more drugs. Exploiting the advantages of Japanese data, where we observe the physician's margin for each drug, we show that the physician's choices are indeed significantly affected by the margin he obtains. Moreover, counterfactual experiments show that the economic impact of the physician's margin is not trivial: if the physician's margin on prescriptions was eliminated, demand for and expenditure of prescription drugs decrease as much as 14% and 21%, respectively, *ceteris paribus*. In addition, we show that the physician behaves differently depending on the insurance status of the patients. The findings suggest that polices that improve both demand and supply side incentives may be useful to improve efficiency in this market.

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1. Introduction

This paper empirically examines an expert's agency problem. An "expert-client" relationship emerges when clients do not possess sufficient expertise to solve a problem. An expert instead acts as the client's agent. An incentive problem arises in such a relationship because clients cannot observe without cost whether the agent's actions are in their best interests.[1] Moreover, vertical integration between diagnosis and service, which often exist in expert service, may exacerbate the problem since the expert faces a further incentive to create demand for his services. For example, an auto repairer may try to replace brake shoes even when he knows it is not necessary, and a salesperson in a wine shop may recommend a high-margin wine even though it may not be in the customer's best interest. Agency problems of this kind are likely to exist wherever an expert-agent provides both diagnosis and service, whether a taxi driver or a lawyer. This is a common economic phenomenon.

Theoretical models of agency problems generally agree on two conclusions. First, the agent's decision will deviate from the first best, but this is optimal given the informational structure. Second, various arrangements and market responses exist that may mitigate the agency problem. For example, the expert service literature—which focuses on "hidden information" cases—shows that market conditions such as repeat sales, specialization and capacity constraints may mitigate the agency problem (Darby and Karni, 1973; Dranove, 1988; Wolinsky, 1993; Emons, 1997). Similarly, classic agency theory literature—which mostly discusses "hidden action" cases—suggests that agency costs may be reduced by monitoring, bonding activities and reputation, while not being eliminated completely (Jensen and Meckling, 1976; Holmstrom, 1982). It remains to be seen empirically, therefore, how important the agency problem is in specific sectors of the economy.

The main objective of this paper is to shed light on the economic significance of the agency problem by examining the prescription drug market in Japan. A striking feature of the Japanese prescription drug market is that, unlike in many other countries, doctors not only prescribe drugs but also purchase and dispense them. Furthermore, physicians can make profits by dispensing drugs. There are two specific concerns under this condition. First, a doctor may choose drugs based not on efficacy, safety, or cost, but on the extent of the profit margin he obtains. Second, over prescribing may result as well because the physician can earn more profits by dispensing more drugs. The agency problem is a real concern in this market because it may be difficult for patients to judge whether or not the drug dispensed was in her best interests. Anecdotal evidence and high per-capita consumption of pharmaceuticals in Japan is consistent with such a concern.[2]

An advantage of the data used for this study is that we can observe the physician's margin for each drug on the market.[3] Thus, using drug specific data, it becomes possible to test directly whether the physician's margin distorts the expert's decision. Furthermore, we can measure the size of deviation

[1] Of course, other types of information asymmetries exist in this market, including the expert's effort and ability, which may also lead to an agency problem.
[2] See section 2-1 for more discussion.
[3] As we discuss very shortly, previous literature did not have good measures of this kind.

of the prescription choice caused by the physician's margin in the sense of "residual loss" as defined in Jensen and Meckling (1976).[4] Measuring the size of deviation is important since possible remedies of the expert's agency problem may also be costly. For example, one could eliminate the link between diagnosis and service and remove the physician's incentive to create demand or to choose drugs. However, this remedy may be costly since there is usually an economy related to the joint provision of diagnosis and service by an expert. Thus, unless the benefits from the separation appear to exceed the additional costs, policy makers may not wish to take such a drastic measure. The estimates in this paper provide us with a clue as to whether or not potential remedies of the expert's agency problem may be economically justifiable.

We start our investigation by estimating the demand for prescription drugs using a structural econometric model. Hypertension drugs are chosen for study because of repeated use by chronic patients. Since we focus our attention on a case where repeat interactions may mitigate the agency problems, our results are likely to underestimate the overall significance of the problem. Physicians are assumed to choose a drug from more than 40 brands to maximize their own utility, which is allowed to be a function of the physician's margin and the patients' utility associated with each drug. A utility based discrete choice model is introduced to allow for parsimonious estimation of differentiated products with many alternatives. The framework includes random coefficients to allow for important heterogeneity among patients due to insurance status. In addition, in order to compensate for the relatively small data set we have, additional information is combined as a moment restriction in the Generalized Method of Moments (GMM) estimation to estimate parameters efficiently. Finally, using the estimated parameters, we conduct counterfactual experiments that allow us to assess the magnitude of some of the distortions in this market.

Empirical results suggest that a doctor's decisions are indeed significantly affected by the physician's margin. Holding other factors constant, the demand for hypertension drugs increases significantly as the physician's margin increases. This implies that the physician does not represent his or her patients perfectly and instead takes advantage of the profit making opportunity. Interestingly, however, the physician still appears to care about patients' welfare. Holding other factors constant, the physician prefers to dispense lower price, higher quality drugs. This suggests that there exist some forces that encourage the physician to honor patients' interest, albeit partially. Estimated parameter values show that in equilibrium the physician is willing to impose additional 79 cents to non-elderly patients in order to increase his profits by one dollar.

To understand the impact of the physician's profit margin, we conduct counterfactual experiments. We show that if the physician's profit margin is eliminated demand and prescription drug expenditures decrease as much as 14% and 21%, respectively, holding price and other factors constant. This implies that current expenditures on hypertension drugs may be inflated by substitution into high-price, high-margin drugs by 7% and overuse of drugs by 14%. Thus, economic impact of the

[4] To be more specific, the loss of value due to the deviation of prescription choice compared to the case when the decision is made without a reference to the physician's margin.

physician’s margin appears to be not trivial even though transactions take place repeatedly in this market.

Another finding is that the physician appears to choose drugs by taking into account the insurance status of his patients. Estimates show that the price coefficient for non-elderly patients is significantly larger (in absolute terms) than for elderly patients whose co-payments are fixed per visit rather than being proportional to the cost of the treatment. This suggests that the strength of demand side incentives to monitor and to switch physicians may be important to discipline doctors. Indeed, additional counterfactual simulations show that if elderly patients had to bear the same cost of medication as non-elderly patients, demand and prescription drug expenditures would decrease by 13% and by 17%, respectively, *ceteris paribus.* This indicates that the market outcome is significantly affected not just because of the incentives of the physician, but also because of the moral hazard on the part of patients. Thus, policies that may improve *both* demand and supply side incentives may be useful in improving efficiency in this market.

Previous empirical literature on the expert’s agency problems has predominantly focused on examining medical services. Indeed, whether or not physicians use their knowledge to influence demand has been one of the central issues in health economics and it is called "supplier-induced demand" literature.[5] Traditionally, an empirical goal of the literature has been to show either a negative correlation between price changes and utilization of medical service (e.g. Rice, 1983; Rice and Labelle, 1989) or a positive correlation between availability of physicians and utilization (e.g. Grytten, Holst and Laake, 1990; Rossiter and Wilensky, 1983). More recently, Gruber and Owings (1996) document a negative correlation between birth rate and cesarean section delivery. In all cases, the correlation is interpreted as the result of physicians' incentive to compensate for the lost income due to exogenous shocks. While important progress has been made to improve our understanding of the issue, these studies share some weaknesses. First of all, the literature does not directly test if the physician's decisions are affected by the financial incentive (or shift demand), and instead shows the correlation implied by inducement behavior (as discussed above). Thus, it invites various alternative explanations for the empirical pattern. In addition, physicians are often assumed to behave "dishonestly" only if exogenous shocks affect their income. In other words, the equilibrium behavior of physicians is not usually analyzed. Further, little is known about the economic impact of the agency problem since "financial incentives" generally do not appear in these empirical models. To be sure, these difficulties come from the fact that evidence of the physicians' financial incentives has been very scarce. This paper extends the literature by exploiting the drug specific data, especially the physicians' margin, which widely vary across a number of drugs over several years.

This paper is also related to recent papers by Hellerstein (1998), Stern and Trajtenberg (1998) and Coscelli (2000), who examined the importance of physician in the choice of prescription drugs. In particular, they focused their attention on the role of physician "habit" or "authority" in

[5] See the summary of the literature in Folland et al. (1997) and Gruber and Owings (1996). Theoretical models include Evans (1973), Dranove (1988) and McGuire and Pauly (1991).

determining prescription. They showed that these factors are indeed important in explaining market shares in the US and Italy.

As noted above, outside of health-care services, very few papers have looked at the expert's agency problem empirically. However, in recent papers, Hubbard (1997) shows that the "reputation" mechanism exists in the vehicle inspection market by showing that consumers are likely to return if they pass the previous inspection. In another paper, Hubbard (1998) finds that auto repairers conduct inspections differently depending on whether the vehicles are on warranty or not, a similar finding to this paper. Another interesting exception is Chevalier and Ellison (1997). They examine the agency relationship between mutual fund investors and mutual fund companies and find that an agency conflict exists between these players.

Finally, regardless of the importance of the issue, very few empirical studies have examined the Japanese prescription drug market. Anegawa's (1999) is one of the very few studies that look at the market. He estimates the demand for cardiovascular drugs using a log-linear demand system. IHEP (1996) examines prescription choice by taking into account the physician's margin. However, among many other differences, these studies pay little attention to the role of physician as an agent for their patients, a main focus of this paper.

The remainder of the paper is organized as follows: In section 2, we describe the prescription drug market in Japan and show how an incentive problem arises in this market. In section 3, after setting up a behavioral model to guide the empirical work, an econometric model is introduced. In section 4, we discuss the estimation strategy. Section 5 describes the data used in the analysis. Estimated results are shown in section 6. Counterfactual experiments are conducted in section 7. Section 8 concludes the paper.

2. The Prescription Drug Market in Japan

2-1. Price Control and Incentive Problem

This section discusses how current regulation creates an incentive problem in the Japanese market. First, we describe the market, and then discuss the potential incentive problem. Finally, we review briefly how such a government policy emerged in this market.

Two unique features are important in order to understand the potential agency problem in the prescription drug market in Japan. The first is the historic *non-separation* between prescribing and dispensing prescription drugs. Unlike many other countries, doctors in Japan not only prescribe drugs but also purchase and dispense them to their patients. It is a tradition of Oriental medicine that patients receive drugs directly from their physicians. Even though the government tried to enforce the separation after WW II, this effort did not succeed because of strong opposition by the physicians' association. As a result, 80 percent of drugs were still dispensed by physicians in 1995.[6] In fact, even

[6] We wish to examine the difference in the physician's behavior depending on whether the drug is dispensed in-house or at a pharmacy. Unfortunately, however, our data does not distinguish these factors.

when the separation appears to take place, prescriptions have often been filled by a pharmacy located in front of the clinic, which is often connected financially with the prescribing physician through ownership or rebate.[7] Thus, the degree of separation between prescription and distribution has been quite weak in the Japanese market.

Another important feature of the market is that the government regulates prescription drug prices using a pricing formula called *yakka kijyun*, renewed in 1992. The pricing rule can be summarized in the following way. First, at the time of entry, the government determines the *retail price* of the drug in comparison to similar drugs already on the market. If the new drug exhibits significantly higher quality than existing ones, it gets a higher initial retail price than the incumbents. This is designed to encourage innovation in pharmaceuticals. Following entry into the market, the retail price of the drug will be revised every two years based on the following dynamic formula:[8]

$$P^R_t = P^W_{t-1} + P^R_{t-1} * R_t \qquad (1)$$

where, P^R_t is the retail price at time t, P^W_{t-1} is the wholesale price at time $t-1$, and R_t is called "*Reasonable-zone (R-zone),"* set by the government, which is designed to cover technical fees and transaction costs to dispense drugs. The government learns the (average) wholesale price based on extensive surveys and uses them to update the retail price. The "*R-zone"* was set at 15% when it was first introduced in 1992, but was reduced gradually to 10% in 1997 in the hope of reducing the discrepancies between the retail price and the wholesale price.

A crucial point of the price control rule is that the government sets *only* the retail price based on the formula while the wholesale price is determined freely by the seller. How firms set their wholesale prices optimally under the constraints is certainly an interesting question. However, it is beyond the scope of this paper and I explore the issue in a separate paper (see the Appendix for a further discussion). A key fact for this paper is, however, that we know from our data that firms set their wholesale prices almost always *below* the retail prices. This means physicians can pocket the difference between the wholesale price (their purchasing price) and the retail price. The size of the physician margin has been quite a large: in 1996, physician margin accounted for 14% of the total medical expenditure and amounted to $43,000 per physician.

Note that fees for medical services (including prescription drugs) are standardized by the government. Thus, all physicians get the same reimbursement for the same treatment, and doctors have to charge the same price for all patients, given insurance status and treatment. Wholesale prices may vary, however, depending on the bargaining power between medical institutions and sellers. Unfortunately, however, there is no systematic data available which show the extent of heterogeneity of wholesale prices. Thus we rely on average wholesale prices across institutions in our empirical

[7] These explicit forms of financial connections became illegal in 1996, but the practice appears to have lasted at least for a while. See Yomiuri Shinbun (1998).

[8] Retail prices were also revised in 1997 to reflect changes in the sales tax.

model. Available information indicates, however, that the difference in the profit margins may not be too large across different types of medical institutions.[9]

The fact that physicians can make profits by dispensing drugs raises an immediate concern that the physician's choice of prescription may be distorted. Physicians may choose a drug based not on efficacy, safety or cost effectiveness of the drug but rather on the extent of the profit margin they obtain. Overuse of drugs may result as well, since physicians can make more money by dispensing more. In fact, it is possible that some of the patients are taking sub-optimal drugs for their health conditions or even taking drugs when none are necessary. These are realistic concerns since it may be difficult for a patient (or a third party) to verify the appropriateness of the prescription and legally penalize such a practice.[10] Such an agency problem, if it exists, may not only affect each patient's welfare because drugs have side effects and high margin drugs are usually more expensive to patients, but also significantly increase medical expenditure since prescription drugs are commonly covered by insurance in Japan.[11]

Some anecdotal evidence exists that is consistent with the presence of the agency problem in this market. One often cited piece of data is that the consumption of pharmaceuticals appears to be high in Japan. According to the United Nations Industrial and Development Organization (UNIDO), per-capita consumption of pharmaceuticals (including over-the-counter [OTC] drugs) was significantly higher in Japan at $277 in 1990 compared to the US at $128 (Ballance et al. 1992). Similarly, more recent data show that the pharmaceutical share in GDP was higher in Japan with 1.6% of GDP in 1994 compared to 1.3% in the US in 1996. While these numbers are large enough to make one take notice, one may not yet conclude that they are due to the agency problem. Among possible reasons, international comparisons in pharmaceutical markets are difficult (Danzon 1996). For example, there is the difference in the definition of the prescription drug market and price levels, and exchange rate fluctuations. Furthermore, high per-capita consumption of pharmaceuticals in Japan may be due to preferences unrelated to the agency problem. In fact, interestingly, overall medical expenditure is much *smaller* in Japan with 7% of GDP in 1997 compared to 14% in the US (JPMA 2000). A possible reason for this is that physicians in Japan (and in Asia perhaps) tend to treat patients by medicines rather than resort to "western style" surgeries.

Price control policy by the government dates back to the WW II when the supply of prescription drugs was limited (MOHW 1998). Later, prescription drug prices were standardized by the government, just as all other medical services, so as to be reimbursed by the Insurance Association. In the 1980s, concerns were raised that the physician's margin might be causing serious over-prescribing. Responding to the criticism, the government introduced the new formula in 1992, which we discussed above, to reduce the physician's margin and set "appropriate" prices for prescription

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[9] For instance, in 1995, margin to retail-price ratio (i.e. M/P^R) is 0.227 in small hospitals (with fewer than 100 beds) and is 0.211 in large hospitals (with more than 500 beds). The corresponding number is also slightly higher for private hospitals with 0.219 compared to municipal hospitals with 0.215 (Association of Public and Private Hospitals (*zenkoku koushi byo-in renmei),* 1995).
[10] To my knowledge, there has been no lawsuit of this kind.
[11] We will discuss more about the insurance system in the next section.

drugs (MOHW 1998). Obviously, however, a potential agency problem still exists with the current pricing policy.

It is not clear why the government has maintained the pricing scheme that allows physicians to make profits by dispensing drugs. A stated objective of the pricing policy is to achieve "appropriate" prices as well as to encourage innovation. However, the government does not appear to evaluate the potential problems due to the current system. We do not attempt to provide an explanation in this paper, but some arguments have been advanced for the maintenance of the current system. First, both doctors and pharmaceutical manufacturers strongly supported the current system. The doctors' association has resisted any fundamental changes unless the physician's margin is compensated elsewhere, claiming that physicians are underpaid under the current reimbursement schedule. Pharmaceutical manufacturers have supported current pricing policy, which indeed is very close to their own proposal of 1982. In contrast, insurance organizations, which should represent consumers' interests, have not been accountable. Second, the government might have viewed the pricing policy as a tool to reduce prescription drug expenditures. While the government does not so state, outsiders, including academics, generally view that an objective of the policy is to reduce medical expenditures by lowering retail prices (e.g. Aegawa 1999). Indeed, the government reports that the reduction of retail prices lowered prescription drug expenditures by 8.3 % between 1992 and 1997 (MOHW 1998). This potential benefit of lowering prescription drug expenditures might have urged the government to maintain the current policy.

2-2. The Health Insurance System

The Japanese health insurance system may also have important effects on the physician's behavior. Currently, most of the population is covered by some health insurance scheme under universal health coverage. Prescription drugs are covered by the health insurance and patients pay co-payments for their treatment. As we see below, patients have few financial incentives to monitor and to switch physicians because of the high insurance coverage in this market.

One important distinction exists on the amount of co-payments that patients have to pay. Specifically, while elderly people (over age 70) pay fixed co-payments *per visit* (about $5) regardless of the cost of prescription, non-elderly people pay a *proportion* of the cost, which ranges between 10% and 30% depending on eligibility.[12] We expect this to have an important effect on patient's incentive to monitor physicians. Since the marginal cost of receiving additional care is zero for elderly people but positive for non-elderly people, the incentive for elderly patients to monitor the physician's actions is expected to be weak. In our empirical model, we will exploit this distinction of the insurance status to examine how the strength of the demand side incentive to monitor doctors affects the physician's behavior in this market.

[12] Of course, many other differences exist across different types of health insurance schemes. However, we believe this is the simplest and the most important distinction that affects the physician's behavior.

While the patients have generally weak incentive to monitor physicians, it is still possible that insurers discipline the physician's behavior on behalf of enrollees. However, this route does not seem to work effectively either, due to the following reasons. First, it is costly for insurers to monitor the appropriateness of the physician's behavior; thus they will not try to discipline the physician completely. Second, insurers do not have strong incentives to cut costs since there is no competition among health insurance and cost pass-through is not difficult.[13] Furthermore, insurers are not allowed to set prices for medical services or direct their members to specific physicians and drugs (e.g. generics) to reduce costs. Since insurers have neither a strong incentive nor the necessary discretion to discipline physicians, agency problem could be a big concern in this market.

2-3. Hypertension Drug Market

We use hypertension drugs as an example to examine the physician's agency problem in the prescription drug market. Hypertension drugs are appropriate for our purpose for at least four reasons: first, hypertension drugs are used repeatedly for chronic patients and agency problems are presumably limited by the repeat transactions. Thus, we can provide the lower-bound estimate of the economic impact created by the physician's profit margin. Second, since there are more than 40 alternative brands to choose from with different prices and margins but similar product characteristics, there is room for the physician's margin to affect the choice of prescription. Third, the large number of drugs allows us to estimate a discrete choice model with the market level data we have. Finally, the market is important in itself given the size of patients and importance of health expenditure. Hypertension is the most common reason for a physician visit and it is the most important risk factor for stroke. The hypertension drug market is one of the largest markets in prescription drugs with sales of 424 billion yen (approximately $3.5 billion) in 1997.[14]

There are five major therapeutic classes of the drugs used to treat hypertension. They are angiotensin converting enzyme (ACE) inhibitors, calcium-blockers, α-blockers, β-blockers and diuretics. These drugs are differentiated in various ways. Most importantly, the mechanisms of actions to reduce hypertension are distinctively different across these five therapeutic classes, and drugs in each class share similar mechanisms of actions and have similar chemical structures. For example, while diuretics reduce high blood pressure by eliminating excess fluid from the body, ACE inhibitors do so by preventing the conversion of angiotensin I into angiotensin II which increases blood pressure. Calcium blockers, on the other hand, reduce hypertension by inhibiting the movement of calcium ions across cell membranes. This grouping is commonly used in a number of medical studies. We exploit this prior knowledge of the segmentation to set up our econometric model.

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[13] Insurers are monopolists: individuals automatically belong to a health insurance set up by their employer or the government. Employer and employee share the cost of insurance premium. However, if the insurer goes bankrupt then the government steps in to bail out.

[14] The number is based on our sample.

Hypertension drugs are also differentiated in other dimensions even within each therapeutic class. The number of indications to treat patients approved by the government, contra-indications, and the extent of adverse reactions are important attributes that differentiate products. Pharmacokinetic attributes such as half-life period also vary from drug to drug. Frequency of dosage per day is another attribute that varies across hypertension drugs. In the econometric model, we treat hypertension drugs as differentiated products in these dimensions. Product characteristics used in the analysis and their definitions are listed in Table 1.

About 39 million Japanese, approximately one out of three people, were estimated to have elevated brood pressure in 1993.[15] Table 2 shows the distribution by age group. It is clear from the table that hypertension is most common in the elderly population. Strikingly, more than 80% of the people at age 70 or above suffer hypertension and this consists of one fourth of the total hypertensive population. Not all of these people are, however, treated by physicians with hypertension drugs. For one reason, all of these people do not go to see a doctor. For another reason, doctors may treat these people by non-drug therapies first as is recommended in guidelines (e.g. JNC V, 1993).[16] In the data section, we compute "potential" market size to find out the number of people who are "at risk" of taking hypertension drugs.

3. The Model

3-1. Physician's Decision

The theoretical literature on the expert's service emphasizes the role of repeat transactions or future profit opportunities in mitigating the expert's shirking (e.g. Darby and Karni 1973; Dranove 1988). The central trade off pointed out in the literature is that an expert who tries to shirk today is likely to suffer negative consequences in the future through the reduction of demand and profits. These negative effects may arise because current (and potential) patients may learn that the expert does not work in their best interest; thus clients choose not to return to the expert in the future. Of course, detecting the expert's shirking may not be an easy task for the clients. However, it is still plausible that the clients can judge the appropriateness of the expert's action to some extent through personal experience and communications with others (including other experts). Thus, concerns for his reputation may encourage the expert to be an honest agent of his clients.

We incorporate the idea in a simple model of a doctor and his patient. In spirit, it is similar to McGuire and Pauly (1991) and Gruber and Owings (1996) who assume shirking provides disutility to a physician and that he will thus limit its amount. In particular, we assume that the physician chooses a drug that maximizes the physician's utility, $U(M, u)$, which is a function of the physician's margin, M,

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[15] Systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg and/or using antihypertensive therapy.

[16] Interventions based on life-style factors, such as a high sodium intake, an excessive consumption of calories, physical inactivity, and excessive alcohol consumption have been emphasized as the first steps to treat hypertension.

and the utility of the patient from the drug, *u*. The physician may consider patient welfare for either of two reasons. First, the physician may be altruistic about the patient's welfare. This view may be better supported in medical care than in other services because it is in line with the medical code of ethics (Folland et al 1997). Second, alternatively, the physician may care about the patient's utility because the doctor cares about his reputation. Again, the idea is that the physician is constrained to consider the welfare of the patient in choosing a drug, since, otherwise, not only the current patient but also her friends and family may never return to the physician's office. This is plausible because drugs have commonly side effects and a high margin drug is generally more costly to the patient, except for elderly patients. Thus, the physician has an incentive to balance his current profit opportunity and the loss of patient's welfare.

Suppose J hypertension drugs (and outside goods) exist, which are differentiated with product characteristics, X, amount of the physician's margin, M, and retail price, P^R. Assuming additive separable utility, the physician's problem is to choose drug j for patient i among the $J+1$ alternatives, which maximizes the following physician's indirect utility:

$$\max_{j \in 0, J} \; U(M, u) = \lambda M_j + \tau u_{ij} (X_j, P^R{}_j, Y_i)$$

where, M_j is the physician's margin from drug j, u_{ij} is patient i's utility from drug j. The physician's margin M is defined as the difference between retail price and wholesale price, i.e., $M_j = P^R{}_j - P^W{}_j$. As discussed previously, X includes various drug characteristics such as efficacy, safety and time trends. Patient's characteristic Y is included in u since the utility that patient i gets from drug j may be different depending on the patient's characteristics such as insurance status and age.

Our primary interest in this paper is to analyze whether or not prescription choices are driven by the physician's margin: i.e., is λ positive? In general, we would expect that both λ and τ to be positive because both M and u are "good" for the physician. The physician trades off profits from drugs with the patient's welfare to maximize the physician’s own utility.

In some extreme cases, however, we may observe λ or τ to be zero. The zero λ may occur when market forces are strong enough to discipline the physician completely or the physician is completely altruistic. In this case, the physician's prescription choice is not affected due to the physician's margin. Note, however, that this would require very high expenditures on the part of the patient or insurers to monitor the doctor. Alternatively, we may find τ to be zero in circumstances where the doctor does not care about the welfare of the patient at all. This may be the case when repeat transactions do not motivate the physician to be an agent for the patient and the physician is not altruistic. Then the physician would choose a drug that would provide the highest margin for him without worrying about its negative effect. In the empirical model, we will examine these testable implications on λ and τ.

The positive λ implies the following two things. First, it suggests that some patients may be taking drugs even when none is necessary. That is, if the positive margin earned by the physician exceeds the negative utility of the patient from the drug, the drug may be prescribed by the physician. Second, it suggests that some patients may be taking sub-optimal drugs since the best drug for the patient may not be chosen by a physician whose decision may be affected by the profit margin from each drug. We will distinguish these two effects later using a counterfactual experiment.

As noted before, an important distinction exists on the insurance coverage in this market, which may affect the physician's prescription behavior (when τ is positive). In particular, elderly patients are covered highly by the insurance than non-elderly patients. Then, *given the retail price of the drug*, we expect that the physician is more price sensitive to the patients with low insurance coverage (i.e., non-elderly). This is so because the low-coverage patients pay higher out-of-pocket expenses for the same drug, thus suffer a higher disutility given the retail price of the drug.

Finally, we would also like to allow λ to vary depending on the type of the physician. In particular, we expect the physician in public or large hospitals to have smaller coefficients because of the "free rider" problem compared to, say, in small private clinics. Unfortunately, however, our data do not have such variation; thus we will look at the average effect of the physician's margin across institutions.

3-2. Econometric Model

In order to identify the effect of the physician's profit margin, we estimate the demand for hypertension drugs, using a utility based random coefficients discrete choice model. Since our empirical model is motivated by our relatively limited data set, we briefly describe the data at the outset (Section 5 discusses the data in detail). We have market-level data for more than 40 hypertension drugs for 1991-1997, which contains retail price, physician's margin, various quality attributes and quantity sold for each drug. We do not have individual level data, however, except limited information on the distribution of the patients by age group, which we use to construct additional moment restrictions. A discrete choice model is particularly useful in our case to account for the high dimensionality since one hypertension drug has to be chosen from more than 40 alternative brands. A simple constant elasticity demand model will face "too many" elasticities to estimate if used in this type of market.

Following the behavioral model described in the previous section, we permit the doctor to choose a drug by taking into account the patient's utility as well as the profit margin obtained from each drug. Specifically, we assume that the doctor chooses drug *j* for patient *i* at time *t* among *J+1* alternatives (including outside goods) that would maximize objective function, V_{ijt}, defined below:

$$\underset{j \in 0,\, J}{Max}\; V_{ijt} = X'_{jt}\beta_i - \alpha_i P^R_{jt} + \xi_{jt} + \gamma M_{jt} + \mu_{ijt} \qquad (2)$$

where, X_{jt} is observed product characteristics of drug *j* at *t*, P^R_{jt} is retail price of drug *j* at *t*, and ξ_{jt} is unobserved product quality of *j* at *t*, M_{jt} ($=P^R_{jt} - P^W_{jt}$) is physician's margin for drug *j* at *t*, and μ_{ijt} is idiosyncratic error term. Parameters to be estimated are α_i β_i γ, and we allow α and β to vary depending on the type of patient.

The structural error term ξ_{jt} represents the unobserved quality level which both physicians and manufacturers observe but we econometricians do not. We include this term since we believe some important quality attributes, such as reputation of drugs and rare but severe adverse reactions, are difficult to quantify. Since the unobserved quality level should be reflected in the level of price and physician's margin, we need to take into account the endogeneity problem in the estimation later.

As we will discuss later in the data section, retail price P^R and physician's margin M are correlated, but the correlation is not very large especially within each therapeutic class. This allows us to identify the two coefficients separately. Observed product characteristics X_{jt} contain a number of quality attributes of each drug, including efficacy, safety, and time trends, which differentiate one drug from another. Table 1 lists the characteristics used in the estimation and the definitions of the variables.

We allow the error term μ_{ijt} to have a group specific component as well as an *i.i.d.* term: $\mu_{ijt} = \zeta_{ig}(\sigma) + (1\text{-}\sigma)\,\varepsilon_{ijt}$, where, ε_{ijt}, is an identically, independently distributed extreme value and ζ_{ig} is a function of σ. As the parameter σ approaches to one, the within group correlation goes to one, and as the parameter σ approaches to zero, the within group correlation goes to zero. Cardel (1997) shows the distributional assumption required for ζ_{ig}. The nested logit error structure fits naturally in the group structure of the hypertension drugs. As discussed previously, drugs in the same therapeutic class (such as ACE inhibitors) share similar mechanisms of actions and have similar chemical structures to treat hypertension. Accordingly, various product characteristics are much more similar within each therapeutic class than across it. Note that, in the estimation, we allow for the group structure rather than impose them *a priori*. Indeed, if σ is estimated to be zero, then we will be back in the multinomial logit model.

Recent empirical literature in industrial organization has shown that allowing heterogeneity among consumers is one of the key elements in estimating consistently the demand parameters with aggregate data. They show that assuming homogeneous tastes, as in the simple logit model, is not only unrealistic but also creates unreasonable substitution patterns across alternatives (Berry 1994; Berry, Levinson and Pakes, henceforth BLP, 1995). In particular, it implies that cross price elasticities are determined solely by the market shares. As a result, conditional on the market shares, observed product characteristics have no role in determining the substitution pattern.

We take the critique into account in a specific way. In particular, we assume there exists two types of patients, namely *elderly* and *non-elderly*, and allow them to have different price (and other) coefficients. We believe that price and other coefficients are systematically different between the two types because of the difference in the insurance coverage as discussed previously. To repeat, briefly, while elderly people pay fixed co-payments *per visit* regardless of the treatment, non-elderly patients pay the co-payments of 10% to 30 % of the cost of treatments. In addition to the difference in insurance status, some of the drug characteristics appear to be more suited to elderly patients. For example, it is often argued in medical literature that the "once-a-day formula" is beneficial especially to elderly patients since they are more likely to forget taking medicines than younger people.

Furthermore, the medical literature suggests that some classes of medicines such as calcium-blockers and diuretics are more suited for the elderly because of their mechanisms of actions (Saruta, 1989).[17] Thus, we expect the two-point distribution may capture important differences in tastes and incentives across each group. Berry, Carnall and Spiller (1996) estimate a similar two-point distribution model for the airline passenger market by drawing a distinction between "business travelers" and "tourists."

Note that our model is different from the most common assumption in the empirical IO literature that random coefficients are distributed *i.i.d.* normal across consumers (BLP 1995; Nevo 1998; Petrin 1999). The main advantage of our model is that we may capture two distinct coefficients corresponding to the different types of population, which allows us to discuss the role of insurance in this market. Obviously, the model can be extended to accommodate more types, for example, by distinguishing 10% payers and 30% payers, and/or to allow normal distribution within each type of patient. We believe, however, that the current model is the simplest form that can capture the important heterogeneity among the patients given the relatively small data set we have.

Based on the distributional assumptions, the market share for drug *j* at *t* for type *i* patient will be given by the standard nested logit share equation (McFadden 1978):

$$S^i_{jt} = \frac{exp((X'_{jt}\beta_i - \alpha_i P^R_{jt} + \gamma_i M_{jt} + \xi_{jt})/(1-\sigma))[\sum_{j\in g} exp((X'_{jt}\beta_i - \alpha_i P^R_{jt} + \gamma_i M_{jt} + \xi_{jt})/(1-\sigma))]^{-\sigma}}{\sum_{g\in G}[\sum_{j\in g} exp((X'_{jt}\beta_i - \alpha_i P^R_{jt} + \gamma_i M_{jt} + \xi_{jt})/(1-\sigma))]^{(1-\sigma)}} \quad (3)$$

where S^i_{jt} is predicted share for drug *j* (in group *g*) at *t* for type *i* patient. In our case, we assume two types of patients, i.e. elderly type (i=1) and non-elderly type (i=2). Total market share can be obtained by the weighted average of the shares for different types:

$$S_{jt} = k\, S^1_{jt} + (1-k)\, S^2_{jt}$$

where, S^1_{jt} is the market share of the drug *j* at time *t* in the elderly market, S^2_{jt} is the share in the non-elderly market, and *k* is the share of the elderly market in the total potential market.

In this paper, the market share of each drug is expressed in terms of the "potential" market size that includes "outside goods."[18] The size of the potential market plays an important role in this application since we conduct counterfactual experiments later to see what happens if the physician's margin is eliminated. If no “outside goods” are allowed to exist, then it is implied that there is no "over prescription." We do not expect, however, the share of “outside goods” to be zero. First, as discussed previously, physicians are encouraged to use non-drug therapies first to control high blood pressure. Second, while we use the standard definition of hypertension, physicians may not necessarily follow

[17] For example, ACE inhibitors may be more suited to young patients because their hypertension tends to be renin related, while the hypertension of elderly patients is less likely to be renin related.
[18] We normalize the utility of the "outside good" to be zero.

the guideline because of the discretion they have to prescribe as they wish.[19] See the data section for actual computation of the "potential" market size.

4. Estimation

4-1. Estimation Strategy

A central issue in the estimation is how to identify the coefficient for the physician's margin, our primary interest of the paper. First of all, physician's margin is likely to be correlated to the quality level of the drugs. We take into account this correlation in our empirical model by including various observed quality attributes (shown as *X* in the previous section) of each drug. Secondly, the price of the drug is also likely to be correlated to the physician's margin since high price drugs may have more room for discounts. This correlation is also controlled in the estimation since both price and physician's margin appear in our empirical model.

It is still plausible, however, that some of the important quality attributes, such as severe adverse reactions or reputation, are unobservable to us or difficult to measure. If these unobserved quality attributes are important in the choice of prescription drugs, the endogeneity problem arises again since both producers and consumers are aware of the unobserved quality level ξ_{jt}; thus, price and physician's margin should be correlated to them. In this case, estimated coefficients for both physician's margin and price tend to be biased towards zero. We will deal with this potential endogeneity problem by constructing exogenous instruments, which will be discussed shortly. Given the exogenous instruments, we estimate the model using a generalized method of moments (GMM).

The estimation strategy follows recent advances in empirical IO literature due to Berry (1994) and BLP (1995). GMM can handle the endogeneity of price and physician's margin very easily and can incorporate additional moment conditions we can obtain from different data sources. As discussed above, we suspect that the price and the physician's margin for product *j* reflect the level of unobserved quality level, ξ_{jt}, and thus bias the estimates. The highly non-linear form of Equation (3), however, makes it difficult to use linear instruments. Berry’s (1994) suggestion was to solve this problem in two-steps. First, we "invert" the demand equation with respect to "mean valuation", δ_{jt}, which would equalize predicted market share to observed market share conditional on random coefficients θ_2.

$$S_{jt}(\delta_{jt}\,;\,\theta_2) = s_{jt}$$

where S_{jt} is predicted market share and s_{jt} is observed market share. Mean valuation is given by:

$$\delta_{jt} = X'_{jt}\beta - \alpha P_{jt} + \gamma M_{jt} + \xi_{jt} \qquad (4)$$

[19] Hypertension is defined as systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg.

Once we get the mean value, the structural error term, ξ_{jt}, can be obtained simply by taking the difference between the mean valuation and observed part of the model, i.e. $\xi_{jt} = \delta_{jt} - (X'_{jt}\beta - \alpha P_{jt} + \gamma M_{jt})$. Then, we can construct moment restrictions by interacting the structural error with relevant instruments, Z. The moment restriction is given by:

$$E(\xi' Z)=0 \qquad (5)$$

Closed form expressions exist for δ_{jt} for simple models such as the logit model or the nested logit model. However, once we include random coefficients in the model, we no longer have an analytic formula for the inversion. Thus, we need to solve for δ_{jt} numerically. BLP (1995) proves that a contraction mapping finds unique value for δ_{jt}. In our case the contraction mapping is slightly different from BLP (1995) because of the nested logit structure of the error term:

$$\delta^{h+1}_{t} = \delta^{h}_{t} + (1-\sigma)(\log(s_t) - \log(S_t))$$

Given that the structural error term represents the unobserved quality level of each drug, we suspect that ξ_{jt} may be correlated over time. To account for this, following BLP (1995), moment restrictions for the same drugs are treated as one sample moment condition. This produces the standard errors of the parameter estimates that allow for arbitrary correlation across years.

We utilize additional moment restrictions to estimate the model efficiently in a similar way as in Imbens and Lancaster (1994) and Petrin (1999). In particular, from the government health statistics, we know the number of hypertension patients treated by doctors by age group in 1996. Although we do not know the distribution of patients for each drug, we can still incorporate the aggregate information as an additional moment restriction. Specifically, we ask the model to set predicted total market share for elderly patients in 1996 equal to the observed market share as closely as possible:

$$E(\Sigma_j S_{j,1996}|elderly)^{model} = (\Sigma_j s_{j,1996}|elderly)^{observed} \qquad (6)$$
$$E(\Sigma_j S_{j,1996}|non\text{-}elderly)^{model} = (\Sigma_j s_{j,1996}|non\text{-}elderly)^{observed}$$

Finally, a GMM estimator can be defined by combining the moment restrictions discussed above:

$$\hat{\theta}_{GMM} = argmin_{\theta}\, (E(\psi))'\, C\, (E(\psi))$$

where, ψ represents the moment restrictions discussed above, and C is an optimal weight matrix defined by Hansen (1982).

4-2. Identification and Instruments

A natural starting point to construct exogenous instruments is to look for cost shifters that may be correlated to the price and the physician's margin, but not to ξ_{jt}. The strategy is, however, less likely to be successful in the case of pharmaceuticals because the production cost is generally quite small relative to the prices, and cost data for each brand is hard to obtain. Instead, we use instruments that capture the extent of competition within and across therapeutic classes, similar to the ones used in recent literature (BLP 1995; Stern 1996; Bresnahan, Stern and Trajtenberg 1997). In particular, we rely on the orthogonality assumption between observed characteristics, X, and unobserved quality level, ξ, to construct instruments.

Although the orthogonality assumption between observed and unobserved product characteristics has been frequently used in the recent literature, it is a strong assumption in general, and the validity must be examined carefully. Recall that unobserved quality, ξ_{jt}, contains the quality information that both physicians and manufacturers observe but we (econometricians) don't. If a profit-maximizing firm chooses these characteristics jointly, the orthogonality condition is likely to be violated. In fact, in order that the assumption hold, the unobserved part has to be "unanticipated" or "not known" by producers when they determine product characteristics.

We believe the orthogonality assumption is less severe in our case, although we may not rule out correlation completely. First of all, we include many product characteristics in the estimation that represent various quality aspects including safety, efficacy and age of drugs. Thus, we believe that the major component of ξ_{jt} is such as "reputation" of the drug and/or "adverse reaction" that is severe but very infrequent. Obviously, they may significantly affect the price and the physician's margin, but we do not believe that they are known *ex-ante* while the drugs are developed. In such a case, observed product characteristics X is not necessarily correlated with ξ; thus we are less concerned about using X as instruments in our particular case. Given the assumption, we need excluded instruments to be at least as many as the number of endogenous variables, which is two in our case.

We construct the instruments by utilizing the nature of oligopoly pricing. First, price and physician's margin should reflect the extent of competition each product faces, assuming entry is exogenous. As shown in Table 4, the prescription drug market is oligopolistic with a limited number of drugs especially within a therapeutic class (such as ACE inhibitors). If the number of close substitutes increases, the drug should have a lower mark-up, thus a lower price relative to cost. Therefore, the number of competing products should be correlated with the price and the physician's margin but not with the unobserved quality level, assuming entry is exogenous to ξ_{jt}. (Please see the Appendix for a formal argument on why the instrument reflects the level of the physician's margin.)

Again, the exogenous entry assumption may be strong in general, but we believe our case is much less severe due to the nature of drug discovery process. Note that brand name drugs dominate the market and it takes ten to fifteen years to develop a new drug. The decision to develop a drug is made long before the drug is actually marketed. Moreover, the drug discovery process faces a number of uncertainties through its development, trial and FDA review process, which creates a lot of noise around the arrival rate of new drugs. In addition, once the drug is developed the firm has few incentives not to launch the drug because major costs of development, i.e., R&D and clinical trial, are sunk at this stage. This makes the exogenous entry assumption more plausible in this market than others.

The second set of instruments reflects price setting behavior by multi-product firms that maximize joint profits over their own products. In order to maximize joint profits from all products, multi-product firms set different prices depending on whether the close substitutes are produced by their own firm or by competitors. If, for example, all products in a category are produced by the same firm, the firm would set higher prices for all products to maximize joint profits across products. Thus, the degree of multi-product ownership should be correlated to the price and the physician's margin.

In addition to the simple count of close substitutes, we also use the sum of the product characteristics as instruments that would also reflect the extent of competition (as in the previous literature). Finally, by taking into account the group structure of the market, we use the following set of instruments, similar to the ones previously used in Stern (1996) and Bresnahan, Stern and Trajtenberg (1997):

1) *the number of drugs and the sum of product characteristics for other products sharing the same therapeutic class at t*
2) *the number of drugs and the sum of product characteristics for other products sold by the firm selling product j at t*
3) *the number of drugs and the sum of product characteristics for other products sharing both therapeutic class and seller at t*

4-3. Identification of Random Coefficients

How the data identify the coefficients of the model is always an important question. In our case, we can identify price and other coefficients for the two types of population, although we do not have individual level data. First, recall that this is a special case of the random coefficients model used in BLP (1995) and other studies.[20] As in this literature, the identification strategy relies on the changes in choice sets over time. Suppose, in the initial period, there exists two drugs, *A* and *B1*, which are identical except for prices. We assume the price of *A* is lower than that of *B1*. In the second period, drug *B2* enters the market, which is exactly the same as *B1*, including the price. If there is no difference in tastes on price across the population, we would expect *B2* gains its market share by drawing the share both from *A* and *B1*, proportional to the previous market share. If, however, there is a difference in taste across two types, we would expect that the share of *A* changes little and *B2's* share comes predominantly from *B1*. This is due to the fact that the price sensitive consumers who used to choose *A* are less likely to switch to *B2* upon entry. On the other hand, those who prefer the high price drug are more likely to switch to *B2*. As will be discussed later in the data section (and shown in Table

[20] See Petrin (1999) for a similar discussion.

4), we observe a number of entries in the hypertension drug market during the 1990s and this allows us to identify the random coefficients in this manner.

It is still unclear, however, how one can be sure that the price sensitive type corresponds to non-elderly patients, given the data we have. In fact, we are likely to have two local minimums in the GMM objective function, especially when we identify the two types successfully; thus we may have two different coefficient estimates, depending on the starting value. Without additional information, we may not be confident about assigning one type of the population to either α_1 or α_2 in our estimates. The additional moment restriction introduced in Equation (6) helps in solving this problem. Recall that from the additional data source we know that a higher percentage of the elderly are receiving medicine than the non-elderly with respect to their potential market. This suggests that it is likely that the price coefficient for the elderly is smaller (in absolute value) than for the non-elderly. The GMM estimator takes into account this information in a precise manner as a moment restriction and assigns a correct value for each type.

5. Data

5-1. Data Construction

To estimate the discrete choice model described above, we need retail price, physician's margin, market share and product characteristic for each drug. For this paper, we constructed a new market level unbalanced panel data set covering more than 40 products between 1991-1997. The data set contains 258 observations.[21] In addition, as discussed previously, we have limited information, taken from government health statistics, on the distribution of the patients.

Among the required data, retail prices and product attributes can be obtained relatively easily. Retail prices are announced by the government when they are revised and can be found in various publications. We draw the data from various issues of *Prescription Drug Directory (Hokenyaku Jiten).* Most of the product characteristics are taken from *Today's Prescription Drug* (*Kyo-no Chiryo Yaku).* In addition, detailed drug safety information, such as the extent of adverse reactions and pharmacokinetic attributes, were supplemented by the manufacturers' data provided by UMIN (University Hospital Medical Information Network) and The Organization for Pharmaceutical Safety and Research.[22]

While the retail prices are publicly available, the government does not disclose the data for the wholesale price and the physician's margin. We construct the average wholesale price and the

[21] Getting detailed price and quantity data for prescription drugs is, however, a major challenge in the Japanese market. Although the government has data on detailed price and quantity based on their extensive surveys, it is not readily available. Wholesale level quantity data that includes essentially all wholesalers does exist but again is not available for public study. Accordingly, we have to rely on aggregate estimates in some parts of the analysis.

[22] http://www.pharmasys.gr.jp/

physician's margin for our estimation by exploiting the nature of the dynamic pricing policy by the government. Recall that the government uses the following formula to determine the retail price:

$$P^R_t = P^W_{t-1} + P^R_{t-1} * R_t \qquad (1)$$

Since we know both the retail price at time *t*, P^R_t, and *t-1*, P^R_{t-1}, and *"R-zone"* at *t*, R_t, it is easy to compute the wholesale price at *t-1*, P^W_{t-1}. Then the physician's margin is simply given by the difference between the retail price and the wholesale price. Free samples and rebates that distort the pricing mechanism are prohibited.[23] Thus the physician’s margin should reflect the physician’s profit from each drug very well. All prices are deflated by the CPI and expressed in constant 1995 prices.

In order to compare different drugs with various dosages per day, we need to standardize the prices and the margins obtained above. For this purpose, patient-day prices and margins for each drug are calculated based on the maximum volume of the recommended dosage listed in the standard physician reference, *Today’s Prescription Drug* (*Kyo-no Chiryo Yaku)*. As explained below, unlike the price data, the sales data do not distinguish the strength/form for each drug. Thus, when patient-day prices and margins are different across strength/form for each drug, we took the average of these to represent the drug. Furthermore, when an extended release formula became available for a drug, we used these prices and margins to represent the drug. This simplification is due mainly to the tractability of the data. However, we believe that it is a reasonable approximation since, as seen in the US market, extended release formulas tend to dominate the market due to the high compliance of patients. In addition, physicians may prefer to use these drugs since they provide higher margins for physicians in general.

Market share for each drug is based on the data generously provided by Pharma Marketing Survey Institute, a pharmaceutical consulting firm in Japan.[24] Pharma Marketing Survey Institute publishes *“Management Strategy Dictionary (Keiei senryaku jiten)”* which lists estimated annual sales for major drugs based on annual reports of the pharmaceutical companies and other industry sources. We calculate the volume for each drug using the annual sales and the patient-day wholesale prices. As discussed previously, the market share for each drug has to be expressed relative to the potential market size. This is done by dividing the estimated patient-day volume by the potential market size.

The potential market size was computed using government health statistics. Recall that we are modeling the decision of a physician facing a patient with high blood pressure.[25] Thus, we need to compute the number of patients who are “at risk” of getting hypertension drugs. First, using "*Patient Survey (Kanja chosa),"* a detailed health statistics survey by the government, we get the number of

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[23] Several drugs that violated this rule have been excluded from the government’s list of drugs that are covered by insurance.
[24] We are grateful to *Pharma Marketing Survey Institute* for providing the data for this research.
[25] Thus, if we treat all of the people with high blood pressure as in Table 2 then it will overstate the potential market size since not everyone with high blood pressure go to see a doctor. On the other hand, however, we need to include patients with high blood pressure who *saw* doctors for one reason or another, i.e. not necessarily because of hypertension, who could prescribe hypertension drugs.

patients by age group who saw a doctor who could prescribe hypertension drugs.[26] Then, we obtained the potential market size by multiplying this number by the distribution of hypertension by age group given in Table 2. As shown in Table 3, the potential market size is estimated to be about twice as large as that of those who are treated by physicians. We believe that this is a reasonable approximation of the potential market size, but the results may be sensitive to the potential market size. We will check the robustness of the results later by changing the assumption of the potential market size.

One potential concern is that the data do not cover minor drugs with small sales, including generics. We are confident, however, that the data cover the vast majority of the hypertension drugs on the market. The share of generics is estimated to be no more than 8 % of the total market value in Japan.[27] While the inclusion of the generics would make the research more interesting and probably enhance the results, we believe the current data set represents the market sufficiently well to understand the physician's behavior. Also, it should be noted that we do not have detailing advertising data in the pharmaceutical market. Unfortunately, such data are not disclosed for public in Japan. However, detailing advertising is typically high at entry and decreases over time. Thus, it is likely that the time trend variables largely capture the effects of advertising. Beyond this, I assume that instruments discussed in the previous section are orthogonal to the error term.

5-2. Data Overview

Table 4 shows the 44 drugs included in the analysis for 1997. Calcium blockers are the most popular hypertension drugs with the largest number of brands on the market as well as sales and volume dispensed. ACE inhibitors are the second largest class among the five, followed by beta-blockers. The hypertension drug market has observed a number of entries during the 1990s. As shown in the last column of the Table 4, the entry was most frequent in the newer therapeutic classes such as ACE inhibitors and calcium blockers. For example, there were only nine drugs in the calcium blockers class in 1991, but the number increased to 16 in 1997. As we discuss in section 5-3, this large change in the choice set over time helps us identify the parameter values.

Patient-day retail prices vary across therapeutic classes but range mostly between 100 yen to 250 yen. (Roughly speaking, 1 yen equals 1 cent.) Physicians, in turn, make profits around 10 yen to 30 yen per patient-day by dispensing a drug. That is, doctors make approximately 3,600 yen to 10,800 yen per patient-year if the patient suffers chronic hypertension. Note also that the physician's margins vary widely across products. Price differentials across therapeutic class exist as well: ACE inhibitors are the highest among those and calcium blockers are priced second to the lowest.

In Fig. 1, we plot the physician's margin and the market share in 1997 to find casual "evidence" of the agency problem. A first look at the figure, however, does not support our concern

[26] The data provides the estimate of patients for more than 60 disease categories.
[27] Generics are not often prescribed due to their lower safety records. In addition, unlike in the US, there is no mandatory substitution law in Japan. The physician's margin is also generally lower for generics since the initial retail price for generics is set lower by the government.

over the agency problem. On the contrary, it appears that market share is higher for the drugs that provide *lower* margins for the physicians.[28] Obviously, however, without controlling for other important attributes including quality and price of the drugs, as well as time trends, it is hard to conclude anything at this point.

Fig. 2 cuts the data from a different angle and shows the correlation between the retail price and the physician's margin for all observations in our data set. Three observations are noteworthy. First, note that both price and margin vary over a wide range of values, thanks to the dynamic pricing policy. This is what identifies the coefficients of our main interests, the retail price and the physician's margin, separately. Second, we observe a general pattern that the higher the retail price, the higher the physician's margin. If physicians choose a drug by looking at the margin they get, the correlation may lead to an explosion of prescription drug expenditure that policy makers would wish to avoid. Third, drugs in the same therapeutic class are clustered in the retail price-margin space. This is particularly clear for calcium blockers and ACE inhibitors. This appears to suggest that drugs within each class are close substitutes. Table 5 provides summary statistics for all variables used in this paper.

5-3. Price Regression

To better understand our data, we ran a simple regression of the retail price on various product characteristics. Table 6 shows the results. The objective of the exercise was only to summarize the data. First, we find that most of the estimated coefficients are significant with expected signs. Drug prices are higher if observed quality levels are higher. This suggests that, although the government uses the pricing formula, market mechanism appears to be working at least in the sense that high quality goods are priced higher. Second, time trend variables show a clear downward trend in "quality adjusted" prices during the 1990s. The negative coefficient for *"Time from entry"* and positive coefficient for *"Time from entry squared"* is intuitive: on average, retail price drops rapidly at the entry but to a lesser extent over time. Combined together, the price reduction is substantial. The average price of a drug introduced in 1991 fell by 52.3 yen by 1997, approximately 25.7% of the average price in 1991. Finally, the therapeutic class "fixed effect" is relatively large. In particular, diuretics and calcium blockers are priced lower than other drugs**,** controlling for other quality measures.

[28] After a closer look, however, it appears that the market share is higher for the drugs whose margins are in the middle of each therapeutic class. Then the graph may be picking up a spurious correlation with respect to time: market share increases at the beginning but declines over time, and the physician's margin also tends to decline over time.

6. Results

6-1. Main Results

Table 7 shows the estimation results of the model described in the previous section. The first and the second column show the results for the nested logit model without and with instruments for the retail price and the physician's margin. The third column shows the results when we allow the coefficient for the retail price to take two different values. We will discuss the coefficients of our main interests, the physician's margin and the retail price, across the models first, and delay the discussions of other variables.

Let us begin by looking at the result from the nested logit model with instruments shown in the second column of Table 7. First, and most importantly, physicians appear to be sensitive to the extent of the margin in choosing among hypertension drugs. The significantly positive coefficient for the physician's margin suggests that demand for a drug increases significantly as the physician's margin goes up. Thus, we find a support for the agency problem caused by the physician's profit margin. The result suggests that market forces are not strong enough to completely discipline experts from taking advantage of their clients. Interestingly, however, we find that physicians are also sensitive to what patients have to pay. Holding other factors constant, demand for drugs decreases significantly as the retail price goes up. This appears to indicate that patients, to some extent, succeed in providing incentives for physicians to act on their behalf probably through costly monitoring and/or switching doctors. Overall, the physician's behavior was as expected: while physicians do not represent patients perfectly, they are still encouraged to remain as agents for their patients, albeit partially.

The first column in Table 7 shows the result when we treat the retail price and the physician's margin as exogeneous. Note that qualitative results are very similar to the previous case. In particular, the coefficients for the physician's margin and the retail price are both significant with the same signs as above. We find, however, that these coefficients are larger (in absolute values) in column 2 compared to column 1. This is as expected because, holding observed quality attributes constant, unobserved quality level and price (margin) should be positively (negatively) correlated. Therefore, without instruments, the price (margin) coefficient should be biased upwards (downwards). The estimation results may also be viewed as weak evidence of the endogeneity problem.

The third column in Table 7 shows the result when we allow the price coefficient to vary across two types of patients, i.e. elderly and non-elderly. Note that the coefficients of mean value for retail price and physician's margin are significant with the same signs as before. Now, the random coefficient associated with elderly patients is significant and positive, suggesting *lower* price sensitivity for elderly patients given the retail price. In addition, the price coefficient for elderly patients is very close to zero. This appears to suggest that physicians choose drugs by taking into account the insurance status of the patients. As discussed before, this may be a direct consequence of the current insurance system. Physicians may be less price sensitive for *elderly* patients because elderly patients, with the same fixed payment *per visit*, do not have strong incentives to monitor the physician's behavior and discipline them. In contrast, *non-elderly* patients have stronger incentives to monitor their physician, which may make the physician more sensitive to prices.

Additional parameters were also allowed to vary across the two types of patients (not reported). However, the model does not pick up significant differences between the two types of patients for those variables. This is probably because most of the product characteristics do not change over time. This appears to show the limitation of our relatively small data set.

Table 7-b presents additional estimation results from the fixed effect model, which include drug specific dummies. In this specification, both observed and unobserved quality attributes that are time invariant are controlled for by the drug specific dummies. The same qualitative results hold in this specification, which provides us additional confidence on the robustness of the results regardless of the specification of different models.

6-2. Implications of the Estimates

An examination of the estimated coefficients reveals the physician's trade-off (or marginal rate of substitution) between his current profits and his patients' welfare in choosing a drug. Specifically, I ask the following question: "By how much would the physician be willing to see the patient's out of pocket expense increase to garner an additional dollar of profit from drug?" Table 8 summarizes the results. For the non-elderly group, assuming patients pay 20% of the cost of the medication on average,[29] we find that the physician is willing to impose 79 cents of additional expense borne by patients in order to increase the physician's profit by one dollar.[30] For some readers, the agency problem between the physician and patients may look benign because of this small number. The comparison becomes more striking, however, if we consider the implicit trade-off between the physician's profits and the cost of medication. In this case the physician is willing to impose an additional $3.9 in medical expenditure for non-elderly patients, and $40.2 for elderly patients to collect an additional one dollar of his own profit margin. This striking difference is due to the high insurance coverage, particularly for elderly patients. This simple analysis reveals that, while the physician may not exploit individual patients "too much," combined with the high insurance coverage, medical expenditure may be increased significantly. We will discuss this issue further in Section 7, using various counterfactual simulations.

6-3. Other Parameter Values

Many other parameter values in Table 7 are also quite interesting on their own to understand the demand for pharmaceuticals in this market. We discuss the results briefly, however, since they are

[29] This is obviously a simplified assumption, given that most patients pay either 10% or 30% of the cost of medication.

[30] We cannot do the same excise for elderly patients because they pay fixed amount per visit.

used primarily as controls in this paper. First, frequency of *"Dosage per day"* affects the demand significantly: the less frequent the dosage per day is, the higher is the demand. This is probably because the patients' compliance improves substantially if the drug is prescribed once-a-day rather than three times a day. A similar measure,*"Half-life,"* one of the important pharmacokinetic attributes that determine the frequency of dosage, also affects the demand significantly. We included both "*Dosage per day*" and "*Half-life*" because they are not perfectly correlated. The coefficient for *"Number of approved indications"* is positive as expected but not statistically significant. *"Number of contraindications"* does not have much explanatory power, given the data we have. The coefficient for the dummy variable for *"Foreign drug"* is not significantly different from zero, suggesting the drugs developed by foreign firms are equally favored in the market. The coefficient for *"Frequency of adverse reaction" (%Adv.Effects*), interacting with a dummy variable indicating we have the information, shows that adverse reactions negatively affect the demand as expected but it is not statistically significant. *"First mover advantage" (Move1st)* appears to exist in this market when more than one firm produces brand name drugs of the same molecule. Finally, *"Time from entry"* has been one of the key variables to explain the demand for pharmaceuticals in the previous papers.[31] We confirm the previous findings: it appears that it takes some time for a prescription drug to pick up its demand and that demand gradually declines over time. In addition, all of the time trend variables and therapeutic class dummies are statistically significant with expected signs. The upward trend of the coefficients for year dummies confirms that demand for hypertension drugs increased during the 1990s.

7. Counterfactual Experiments

7-1. Eliminate Physician's Profit Margin

In the previous section, we find that the physician's margin affects the choice of prescription significantly. It may not be a serious issue, however, if the impact of the problem is not very large. The objective of this section is to shed further light on the economic significance of the physician's margin. For this purpose, we conduct counterfactual experiments using the estimated parameters.

Consider a hypothetical case in which the physician no longer makes profits by dispensing drugs. This corresponds to the case in which, as in the US, the government enforces vertical separation between prescribing and dispensing drugs. Then there will be no room for the physician's margin to affect prescription choice.[32] Operationally, we simulate this hypothetical vertical separation by removing the margin from the physician's objective function, holding other factors (including price) constant. New market share and expenditure for each drug are calculated using the share equation (3) with the estimated parameters. By comparing these to the current outcome, we can assess the impact of the physician's margin on pharmaceutical demand and prescription drug expenditure.

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[31] For example, see Mortimer (1997) and Stern (1996).

[32] Thus, the physician will only write prescriptions and independent pharmacies will fill the prescriptions.

Note that the objective of the counterfactual experiment is not to predict the outcome, but to understand the economic impact of the physician's margin. Of course, players—including the government, physicians, manufacturers and patients—may act differently if the physician's margin is eliminated, especially in the long run.[33] Since we do not model supply side (and other players), we cannot account for these changes. Therefore, the results of counterfactual experiments have to be viewed with great caution. Nonetheless, we believe the experiments are very useful to understand the potential magnitude of the problem at hand.

Another concern on this drastic measure is that estimated coefficients may not be relevant in the "zero-margin" region. This is true in a strict sense but it turns out that the data provide a good support for a wide range of the physician's margin between 4 yen and 70 yen as shown in Fig. 2. Thus, we believe the estimates may be viwed as reasonable approximations, if not ideal.

First, we simulate a *"Base Case"* in which prices are assumed fixed at the current retail prices.[34] The physician is facing exactly the same retail price as in the observed data, but now the physician does not gain any money from choosing drugs since he is no longer dispensing them. Thus, we can isolate the effect of the physician's margin on demand from other changes that may also affect prescription choices.

We expect two important changes to occur as a consequence of the elimination of the physician's margin. First, some of the previously dispensed drugs may be substituted by outside goods. That is, over prescribing due to the physician's margin may be eliminated. Second, substitution among hypertension drugs may occur. That is, once the physician's margin is removed from the calculation of the physician, he may choose an alternative drug that would reflect the patients' welfare more closely.

Fig. 3 shows the changes in market shares due to the elimination of the physician's margin, using the estimates from the third column in Table 7. The horizontal axis shows the size of the margin that the physician obtained previously, and the vertical axis shows the changes in market shares due to the elimination. Three changes are noteworthy. First, the number of drugs losing share is higher than those gaining share, suggesting that the total market size for hypertension drugs decreases. Second, the drugs with higher margins are more likely to lose market share. This is reasonable because previously favored high-margin drugs lost their attraction. Third, market shares appear to shift from high-margin drugs to low-margin drugs *within* each therapeutic class. This is also intuitive because drugs within the same class are close substitutes.

Table 9, model 2 (*Base Case A*) shows the outcome due to the elimination of the physician's margin. Current outcome is shown in model 1 for comparison. First of all, demand for prescription drugs (in terms of patient-day volume) decreases by 13.7%, suggesting that over prescription due to

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[33] For example, a physician's price sensitivity may change once he is no longer involved in purchasing drugs. Manufacturers may put more resources into advertisement and try to affect the physician's prescription choice. Obviously, if the government changes its pricing policy, the drug prices may change dramatically. In addition, vertical separation might create an unintended consequence in the treatment of heart diseases in general since the physician may substitute more expensive but more profitable "surgeries" rather than writing prescriptions.

[34] We also simulated a variation of the *Base Case* by setting the price at current wholesale levels. Qualitative results are similar as in the *Base Case* and not reported here.

the physician's margin is not trivial. Second, compared to the current outcome, expenditures for hypertension drugs decrease by 21.0%. This is due to the combination of two effects: reduction in total demand and substitution into alternative, probably cheaper, drugs. Given that the demand decreased by 13.7%, the substitution into cheaper drugs accounts for the reduction of total expenditure by 7.2%. Given the large size of the prescription drug market, the potential economic effect of the physician's margin does not appear to be negligible. The estimates suggest that policies that mitigate physician incentive to choose drugs for profits may be important.

It is also interesting to see how the elimination of the physician's margin affects pharmaceutical manufacturers. First, it is not difficult to see that the supply side as a whole will lose if the physician's margin is eliminated holding retail price constant. If we further assume that the wholesale prices are also fixed at current levels—which implies that the physician's margin is transferred to pharmacists who now provide technical advice and bear inventory costs—then manufacturers revenue goes down by 20.7%. This may partially explain why Japan's pharmaceutical manufacturers' association has long supported the current policy. Secondly, however, the payoffs of the firms may be different depending on the products they have. In particular, we expect that firms with high-margin**,** high-retail price drugs tend to lose from this change because the demand is likely to shift to low-margin, low-price drugs.

As discussed before, the results may be sensitive to the estimated size of the potential market. To see the robustness of the results, we did the same exercise in Table 9, model 3 (*Base Case B*) by reducing the potential market size by 20%. The results are as expected: demand decreases by 11% with the elimination of the margin, which is smaller than in the *Base Case A* since the size of "outside goods" is now smaller. On the other hand, however, the extent of the substitution into cheaper drugs changes very little. Thus, the exercise confirms that the qualitative results are likely to be robust unless the potential market size is reduced drastically.

7-2. Increase Out-of-Pocket Expenses

The second set of counterfactual experiments examines how demand-side incentive to monitor and switch doctors affects the size of demand and prescription drug expenditure. Recall that we found a significant difference in the price coefficients between elderly and non-elderly patients. This is presumably due to the difference in patients' incentive to monitor the physician's behavior. Because elderly patients pay fixed co-payments regardless of the cost of medication, they have little financial incentive to check the physician's behavior. This suggests that if elderly patients have to pay a proportion of the costs, then this may significantly affect the market outcome.

In order to examine the effects of insurance, we analyze the case where elderly patients bear approximately the same out-of-pocket expenses as non-elderly patients. We further assume that, as a result, the physician becomes as price sensitive to elderly patients as to non-elderly patients.[35] Again,

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[35] Of course, it is possible that the physician's price sensitivity for elderly patients can be different from non-elderly patients by reasons other than their insurance status. For example, elderly patients may exhibit more

for simplicity, we ignore the responses of agents who face the policy change.[36] Thus, the experiment does not predict the outcome of the policy change but, instead, provides a sense of economic impact caused by the insurance coverage. We note, however, this exercise is in line with the Japanese government party's plan which asks elderly people to pay 10% of co-payments instead of the current fixed fees per visit (Japan Economic Journal, July 30, 1999).

Table 9, model 4 shows the result when we assume the physician becomes as equally price sensitive to elderly patients as to non-elderly patients. Here, we assume that the physician's margin still exists. Thus, the difference in the result compared to the current outcome is due solely to the change in the price coefficients for elderly patients. The result is striking. Demand of and prescription drug expenditure for hypertension drugs decrease as much as 13.4 % and 17.2%, respectively, *ceteris paribus*. This suggests that the generous insurance coverage for elderly has significant impact in this market. Physicians tend to prescribe high-price, high-margin drugs to elderly patients because elderly patients may not care about the cost of medications. If the elderly patients were to bear some portion of the cost of medication, it may significantly affect the size of demand and prescription drug expenditure.

Table 9, model 5 shows the results when the physician's margin is eliminated in addition to the change in the price coefficient for elderly patients. As we expect, the changes are even greater here. Demand of and prescription drug expenditure for hypertension drugs decrease by 25.7% and by 38.4%, respectively. Overall, the results suggest that both supply side incentive (i.e., physician's incentive to prescribe high-margin drugs) and demand side incentive (i.e., patients' incentive to monitor and to switch doctors) substantially affect the outcome in this market. It is important for policy makers to take into account these two forces to implement policy measures.

8. Conclusion

We examined the physician's agency problem in the prescription drug market in Japan, where the physician has an incentive to choose drugs to increase his profits. Estimated results show that the physician's decision is indeed significantly affected by the profit margin he obtains. Two implications are likely to follow from the results: first, some patients may be taking drugs even when none is necessary. That is, over prescribing may exist. Second, some patients may be taking sub-optimal drugs because the physician’s choice may be affected by the extent of the margin each drug provides. These should raise concerns not only from public health viewpoints but also form public finance perspectives.

Interestingly, however, the physician still appears to care about the patients' welfare, albeit partially. We found that physicians tend to dispense low price, high-quality drugs, *ceteris paribus.*

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elastic demand than the non-elderly because of their generally lower income level. In this case, the simulation results will understate the impact of the current insurance policy. On the other hand, however, demand for elderly patients may be more inelastic if, for example, they are too sick to be treated by alternative treatments.

[36] For example, the change in the insurance policy may reduce elderly people's office visits.

This implies that some force still exist in this market, which encourage the physician to work on behalf of the patients. Overall, the results are as predicted by agency theories: an agency problem exists to the extent that information asymmetry exists. However, experts are still encouraged to remain as agents for their clients, albeit partially.

A counterfactual experiment showed that the impact of the physician's profit margin may not be trivial. If the physician's margin were eliminated, demand of and expenditure for prescription drugs would decrease as much as 14% and 21%, respectively, holding current prices and other factors constant. This suggests that even though transactions may be repeated over time, the physician's profit margin appears to affect prescription choice quite substantially.

We also found that the level of insurance coverage for the patients affect the market outcome significantly. Currently, the patients (especially elderly) pay very little for prescription drugs. Thus, they have few financial incentives to monitor and to switch doctors even with the physician's shirking. If the patients were to pay more of the marginal cost of treatment, the physician would be more likely to prescribe less expensive drugs, and this would reduce overall prescription drug expenditure. Thus, economic polices that improve *both* demand and supply side incentives may be useful in order to improve efficiency in this market.

While the analysis holds primarily for the unique market environment in the prescription drug market in Japan, nonetheless, we believe the results have important policy implications for many economic activities where the "expert-client" relationship exists. First, a straightforward implication may apply to injectable drugs, which are directly purchased and used by medical institutions even in the US. No vertical separation exists in this class of drugs; thus, similar problems may be important. Many other medical services may also face similar problems when diagnosis and service are closely connected. Even in other industries, similar implications may hold, albeit to a different extent, where clients cannot fully observe the appropriateness of the expert's action and diagnosis and service are closely tied. We showed that the economic impact of the agency problem could be quite significant in such a market. Room for government intervention may exist in these markets.

Appendix: How Should Firms Set Physician's Margin?

In this Appendix, we show why the proposed instruments in section 4-3 reflect the level of physician's margin in multi-product oligopoly. We consider a static case for simplicity. Assuming Nash-in-price equilibrium, a multi-product firm *f* with several products maximizes profits by choosing a vector of physician's margin ***M*,** conditional on product characteristics:

$$Max_M \; \pi_f = \sum_{k \in f} (P^R_k - M_k - MC_k)\, Q_k$$

where, P^R_k is the retail price of drug *k*, M_k is the physician's margin for drug *k*, MC_k is the marginal cost of drug *k*, and Q_k is the quantity of drug *k*. The first order condition for drug $j \in f$ is given by the following:

$$\frac{\partial \pi_f}{\partial M_j} = -Q_j + (P^R_j - M_j - MC_j)\frac{\partial Q_j}{\partial M_j} + \sum_{k \in f\; k \neq j} (P^R_k - M_k - MC_k)\frac{\partial Q_k}{\partial M_j} = 0$$

By rearranging this, we get:

$$(1 + \frac{1}{\eta_{jj}})\, M_j = (P^R_j - MC_j) - \sum_{k \in f\; k \neq j} (P^R_k - M_k - MC_k)\frac{-\eta_{kj}}{\eta_{jj}}\frac{Q_k}{Q_j} \qquad (1)$$

where, η_{jj} and η_{jj} are own and cross elasticity of margin, i.e. $\eta_{jj} = \frac{\partial Q_j}{\partial M_j}\frac{M_j}{Q_j}$, $\eta_{kj} = \frac{\partial Q_k}{\partial M_j}\frac{M_j}{Q_k}$, and $\eta_{jj} > 0$, $\eta_{kj} < 0$.

<u>1) The effect of "multi-product"</u>

First, the firm *f* sets M_j *lower* if the firm owns more products in the relevant market. This can be easily seen by the second part of the right-hand side in Equation (1) because as *k* increases this part will decrease. (Note that $\eta_{kj} < 0$.) Thus the number of products owned by the firm should reflect the extent of the physician's margin. This is easiest to see when the firm has two products.

<u>2) The effect of competition</u>

Second, increasing competition makes the firm *f* sets M_j *higher*. We expect that the elasticity of margin, η_{jj}, to be larger as competition increases since there are more close substitutes in the market. This means that the coefficient of the left-hand side becomes smaller, and the right-hand side becomes larger, both of which imply M_j to be set higher. Thus, the extent of competition should affect the extent of the physician's margin.

The dynamic pricing rule of the government should not change the signs of the results. Instead, the physician's margin is expected to be set smaller since the discount today would negatively affect future profits by reducing the room for future discounts.

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Table 1: Definition of the Variables

Price and Margin	
Retail price	Reimbursement price officially determined by the government
Wholesale price	Average purchase price by physicians
Physician's margin	Average margin physicians obtain by dispensing the drug
Product Characteristics	
Dosage per day	Recommended frequency of dosage per day
Half life	Time required for a drug concentration to be reduced by 50%
# of Indications	Number of approved indications
# of Contraindications	Number of contraindicated conditions
Foreign drug	Dummy = 1 if the drug is developed in foreign
D (Adv_react.)	Dummy =1 if the drug does not have detailed information on adverse reactions
Adv_react.	Percentage of patients who experienced adverse reactions in clinical trials and re-evaluation (%)
Move1st	Dummy = 1 if the drug is the one first marketed in Japan in its molecule
Time from entry	Number of months from entry
Time from entry sq.	Number of months from entry squared

Table 2: Distribution of Hypertension[37] by Age Group (1993)

	Hypertension Patients (1000)	Total Population (1000)	(1)/(2) %
15-19	291	9,265	3.1%
20-29	1,557	18,302	8.5%
30-39	2,842	15,847	17.9%
40-49	7,333	19,735	37.2%
50-59	9,329	16,657	56.0%
60-69	8,882	13,220	67.2%
70 & up	8,815	10,908	80.8%
Total	39,042	103,934	37.6%

(Source: Horibe, 1996)

Table 3: Potential vs. Actual Market Size in 1996

	Hypertension Patients (A)	Potential Market (B)	Patients Treated (C)	(C)/(B) (%)
Elderly (above 70)	10,071	8,696	4,113	47.3
Non-elderly	30,891	10,562	4,595	43.5
Total	40,962	19,158	8,708	45.5

(A): Estimated hypertension population with systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg. Computed based on Horibe (1996) by taking into account the demographic changes.
(B): Estimated number of hypertension patients who saw doctors, who could potentially prescribe hypertension drugs, by various disease conditions (not necessarily by hypertension.)
(C): The number of patients who were treated by physicians for their hypertension in 1996.

Moment restriction: ex.

$$E(\Sigma_j S_{j,1996} | \, elderly)^{model} = (\Sigma_j s_{j,1996} | \, elderly)^{observed} = 4113/8696 = 0.473$$

[37] Systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg.

Table 4: Hypertension Drugs Included in the Analysis (1997)

(Prices are constant 1995 prices)

Brand Name	Generic Name	Firm Name	Retail price (yen)	Wholesale Price (patient-day) (yen)	Physician's Margin (yen)	Volume (patient-day) (million)	Sales (bil. yen)	Entry
ACE inhibitors								
Acecol	temocapril HCL	Sankyo	250	222	27	49	11.0	Aug-94
Adecut	delapril HCL	Takeda	223	197	25	27	5.4	Apr-89
Captoril	captopril	Sankyo	229	195	33	36	7.0	Feb-83
Captoril	captopril	BMS	229	195	33	15	2.9	Jan-91
Cetapril	alacepril	Dainippon	190	169	20	47	8.1	Jun-88
Cibacen	benazepril HCL	Novartis	230	196	32	20	4.0	Jan-93
Conan	quinapril HCL	Yoshitomi	215	181	33	16	3.0	Sep-95
Inhibace	cilazapril	Eisai	239	210	28	32	6.9	Dec-90
Longes	lisinopril	Shionogi	235	209	25	37	7.9	Aug-91
Renivace	enalapril maleate	Banyu	245	218	25	140	30.8	Jul-86
Tanatril	imidapril HCL	Tanabe	235	204	29	77	16.0	Dec-93
Zestril	lisinopril	Zeneca	221	190	29	20	3.9	Aug-91
Calcium Blockers								
Adalat	nifedipine	Bayer	109	95	13	357	34.5	Jul-85
Amlodin	amlodipine besilate	Sumitomo	119	103	15	155	16.2	Dec-93
Atelec	cilnidipine	Mochida	118	102	15	7	0.7	Jul-97
Baylotensin	nitrendipine	Yoshitomi	116	99	16	76	7.6	Apr-90
Baymycard	nisoldipine	Bayer	119	105	13	65	6.9	Apr-90
Calslot	manidipine HCL	Takeda	126	111	15	142	16.0	Sep-90
Cinalong	cilnidipine	Fujirebio	115	99	15	11	1.1	Sep-95
Coniel	benidipine HCL	Kyowa Hakko	105	91	13	293	27.0	Nov-91
Herbesser	diltiazem HCL	Tanabe	152	132	19	143	19.1	Feb-74
Hypoca	barnidipine HCL	Yamanouchi	130	114	15	43	5.0	Aug-92
Landel	efonidipine HCL	Zeria	114	101	12	9	0.9	Apr-94
Nivadil	nilvadipine	Fujisawa	117	102	14	150	15.5	Apr-89
Norvasc	amlodipine besilate	Pfizer	119	103	15	430	45.0	Dec-93
Perdipine	nicardipine HCL	Yamanouchi	108	96	11	220	21.5	Sep-81
Sepamit	nifedipine	Kanebo	102	86	15	45	3.9	Sep-81
Siscard	cilnidipine	NBI	118	100	17	15	1.5	Nov-95
Alpha Blockers								
Cardenalin	doxazosin mesilate	Pfizer	222	196	25	101	20.0	Apr-90
Detantol	bunazosin HCL	Eisai	219	190	27	9	1.7	Jul-85
Minipress	prazosin HCL	Pfizer	130	115	15	16	1.8	Sep-81
Beta Blockers								
Almarl	arotinolol HCL	Sumitomo	186	165	20	29	4.9	Dec-85
Artist	carvedilol	Daiichi	233	206	25	13	2.7	May-93
Inderal	propranolol HCL	Zeneka	133	118	14	28	3.3	Oct-66
Kerlong	betaxolol	Yoshitomi	234	206	27	24	5.1	Jan-93
Lopresor	metoprolol tartrate	Novartis	196	172	23	10	1.8	Feb-83
Maintate	bisoprolol fumarte	Tanabe	236	208	27	43	9.1	Dec-90
Mikelan	carteolol HCL	Otsuka	106	94	12	57	5.4	Dec-80
Sadonorm	bopindolol malonate	Novartis	211	186	24	16	3.0	Jun-93
Selectol	celiprolol HCL	Nihonshinyaku	232	204	27	23	4.7	Sep-92
Seloken	metoprolol tartrate	Fujisawa	196	172	23	22	3.9	Feb-83
Tenormin	atenolol	ICI	175	155	19	87	13.7	Mar-84
Diuretics								
Aldactone A	spironolactone	Dainippon	127	111	15	43	4.8	Nov-63
Lasix	furosemide	HMR	48	42	5	198	8.5	May-65

Table 5: Summary Statistics

	Mean	St.D.	Min	Max
Price and Margin				
Retail price	189.58	62.11	47.68	308.68
Wholesale price	157.90	51.45	42.38	241.52
Physician's margin	30.69	12.10	4.39	69.58
Product Characteristics				
Dosage per day	1.40	0.59	1.00	3.00
Half life	8.46	8.70	0.35	36.35
# of Indications	2.71	1.62	1.00	9.00
# of Contraindications	5.40	3.95	1.00	15.00
Foreign drug	0.59	0.49	0.00	1.00
D (Info on Adv. Effects)	0.86	0.34	0.00	1.00
% of Adv. effects	5.30	2.18	2.10	12.50
Move 1st	0.87	0.34	0.00	1.00
Time from entry	8.88	7.85	0.33	34.19
Time from entry sq.	140.24	244.48	0.11	1168.89
Therapeutic Class Dummies				
ACE inhibitors	0.27	0.44	0	1
Calcium blocker	0.33	0.47	0	1
Alpha-blocker	0.08	0.27	0	1
Beta-blocker	0.27	0.44	0	1
Time Dummies				
y97	0.17	0.38	0	1
y96	0.17	0.37	0	1
y95	0.16	0.36	0	1
y94	0.16	0.36	0	1
y93	0.13	0.34	0	1
y92	0.12	0.33	0	1

Table 6: Regression of Retail Price on Product Characteristics

	Dependent variable = Retail price		
	Coef.	**Std. Err**	**t**
Const.	111.62	15.52	7.19
Quality Varialbes			
Dosage per day	-6.85	2.80	-2.44
Half life	0.42	0.16	2.67
# of indications	3.63	1.34	2.71
# of contraindications	-4.86	1.12	-4.36
Foreign drug	2.12	2.75	0.77
D (Info on Adv_effects)	75.20	7.08	10.62
D* % Adv_effects	-4.59	0.71	-6.48
Move1st	9.69	3.90	2.49
Time from entry	-38.75	6.64	-5.84
Time from entry sq.	11.67	2.27	5.14
Therapeutic Class Dummies			
ACE-inhibitors	141.60	13.27	10.67
Calcium-blockers	5.98	12.30	0.49
Alpha-blockers	89.26	13.05	6.84
Beta-blockers	136.34	15.39	8.86
(Diuretics omitted)			
Year Dummies			
Year 97	-33.21	5.29	-6.28
Year 96	-26.76	5.18	-5.16
Year 95	-16.69	5.10	-3.27
Year 94	-19.10	5.02	-3.81
Year 93	-10.34	5.09	-2.03
Year 92	-14.30	5.10	-2.81
Adj. R-squared	0.898		

Table 7: Estimated Parameter Values

	Nested Logit w/o IV			Nested Logit w/ IV			Random Coefficient *(price only)*		
	Coef.	Std. Err		Coef.	Std. Err		Coef.	Std. Err	
Price and Margin									
Physician's margin	0.479	0.169	***	1.222	0.355	***	1.730	0.342	***
Retail Price (mean)	-0.116	0.038	***	-0.201	0.060	***	-0.242	0.066	***
Deviation for elderly type							0.199	0.053	***
Implied Price Coefficient for Non-elderly							-0.440		
Implied Price Coefficient for Elderly							-0.043		
Product Characteristics									
Dosage per day	-0.003	0.013		-0.019	0.013		-0.028	0.013	**
Half life	0.002	0.001	***	0.003	0.001	***	0.002	0.001	**
# of Indications	0.004	0.006		0.011	0.006	*	0.009	0.009	
# of Contraindications	-0.007	0.005	*	-0.002	0.005		0.006	0.004	
Foreign drug	0.009	0.012		0.021	0.014		0.021	0.016	
D (Info on Adv_react.)	-0.029	0.037		-0.029	0.050		-0.073	0.044	*
D* % Adv_react.	-0.001	0.003		-0.005	0.003		-0.006	0.004	
Move1st	0.024	0.020		0.082	0.028	***	0.073	0.032	**
Time from entry	0.087	0.036	***	0.213	0.049	***	0.291	0.045	***
Time from entry sq.	-0.029	0.012	***	-0.067	0.016	***	-0.095	0.014	***
Therapeutic Class Dummies									
ACE-inhibitors	0.756	0.069	***	0.649	0.080	***	0.575	0.089	***
Calcium-blockers	1.991	0.055	***	1.917	0.059	***	1.940	0.073	***
α-blockers	-0.873	0.061	***	-0.920	0.064	***	-0.982	0.087	***
β-blockers	0.502	0.077	***	0.365	0.093	***	0.219	0.103	**
(Diuretics omitted)									
Year dummies									
Year 97	0.559	0.034	***	0.649	0.056	***	0.726	0.046	***
Year 96	0.524	0.030	***	0.591	0.045	***	0.657	0.036	***
Year 95	0.351	0.025	***	0.382	0.033	***	0.420	0.023	***
Year 94	0.326	0.025	***	0.360	0.033	***	0.408	0.023	***
Year 93	0.132	0.023	***	0.156	0.029	***	0.184	0.018	***
Year 92	0.091	0.023	***	0.117	0.034	***	0.132	0.015	***
(year 91 omitted)									
Others									
constant	-3.233	0.080	***	-3.482	0.110	***	-3.565	0.123	***
sigma	0.979	0.008	***	0.940	0.015	***	0.934	0.011	***

*** 1% significant level ** 5% significant level * 10% significant level

GMM Obj.							35.68		

[Overidentifying restrictions test: Chi-squared(0.95,49-25)=36.42]

Table 7-b: Estimated Parameter Values (Fixed Effects Model)

	Fixed Effects Nested Logit w/o IV		
	Coef.	Std. Err	
Price and Margin			
Physician's margin	0.828	0.205	***
Retail Price (mean)	-0.197	0.078	***
Deviation for elderly type			
Product Characteristics			
Dosage per day			
Half life			
# of Indications			
# of Contraindications			
Foreign drug			
D (Info on Adv_react.)			
D* % Adv_react.			
Move1st	0.059	0.025	***
Time from entry	0.184	0.063	***
Time from entry sq.	-0.100	0.019	***
Therapeutic Class Dummies			
ACE-inhibitors			
Calcium-blockers	**Molecule Dummies**		
α -blockers	**included**		
β -blockers	**(Mostly significant)**		
(Diuretics omitted)			
Year dummies			
Year 97	0.626	0.046	***
Year 96	0.578	0.038	***
Year 95	0.392	0.029	***
Year 94	0.362	0.027	***
Year 93	0.168	0.023	***
Year 92	0.106	0.022	***
(year 91 omitted)			
Others			
constant	-2.952	0.157	***
sigma	0.952	0.014	***

*** 1% significant level ** 5% significant level * 10% significant level

Table 8: Physician's Trade Off

"By how much would the physician willing to impose additional expense to the patient to garner an additional dollar of profit from drug?"

Estimated Parameter Values		
Physician's Margin		1.730
Retail Price	Elderly	-0.043
	Non-elderly	-0.440
Implied Physician's Trade Off (per additional one dollar of profit)		
Trade off with patients' expenses		($)
	Elderly	NA
	Non-elderly	0.79
	(Note, non-elderly patients are assumed to pay 20% of the cost.)	
Trade off with medical expenditure		
	Elderly	40.23
	Non-elderly	3.93

Table 9: Counterfactual Experiments: Summary Results

	(1) Current (1997)		(2) Base Case A		(3) Base Case B (potential mkt*80%)	
			eliminate margin		*eliminate magin*	
			price=current retail price		*price=current retail price*	
	share (%)		share (%)	% change	share (%)	% change
Share of drugs (within potential market)	47.3		40.8	-13.7	52.6	-11.0 *(see note)*
	bil yen	%	bil yen	% change	bil yen	% change
Drug expenditure	477.6	100	377.5	-21.0	389.3	-18.5
(contribution)						
reduction in demand				-13.7		-11.0
substitution into cheaper drugs				-7.2		-7.5
Suppliers' Revenue	418.3	87.6	331.9	-20.7	342.2	-18.2

	(4) Same co-payments for elderly		(5) Same co-payments for elderly	
	with physician's margin		*eliminate margin*	
	price=current retail price		*price=current retail price*	
	share (%)	% change	share (%)	% change
Share of drugs (within potential market)	41.0	-13.4	35.2	-25.7
	bil yen	% change	bil yen	% change
Drug expenditure	395.3	-17.2	310.8	-38.4
(contribution)				
reduction in demand		-13.4		-25.7
substitution into cheaper drugs		-3.8		-12.7

Note: share of drugs before the separation is 59.1% in this case.

Fig. 1: Physician's Margin vs. Market Share

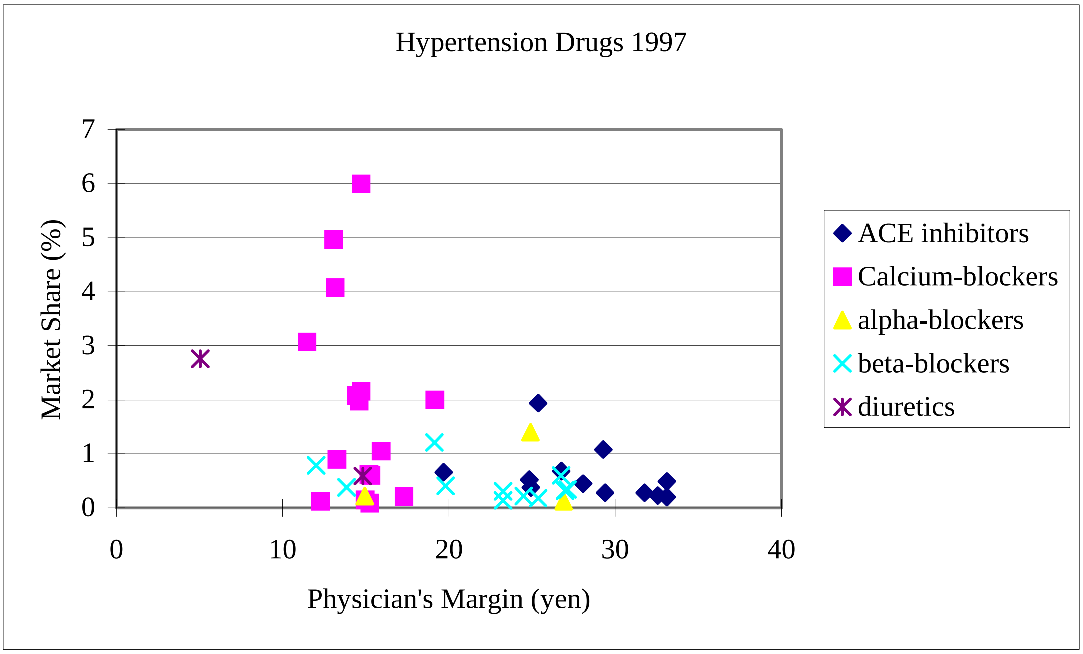

Fig. 2: Retail Price vs. Physician's Margin

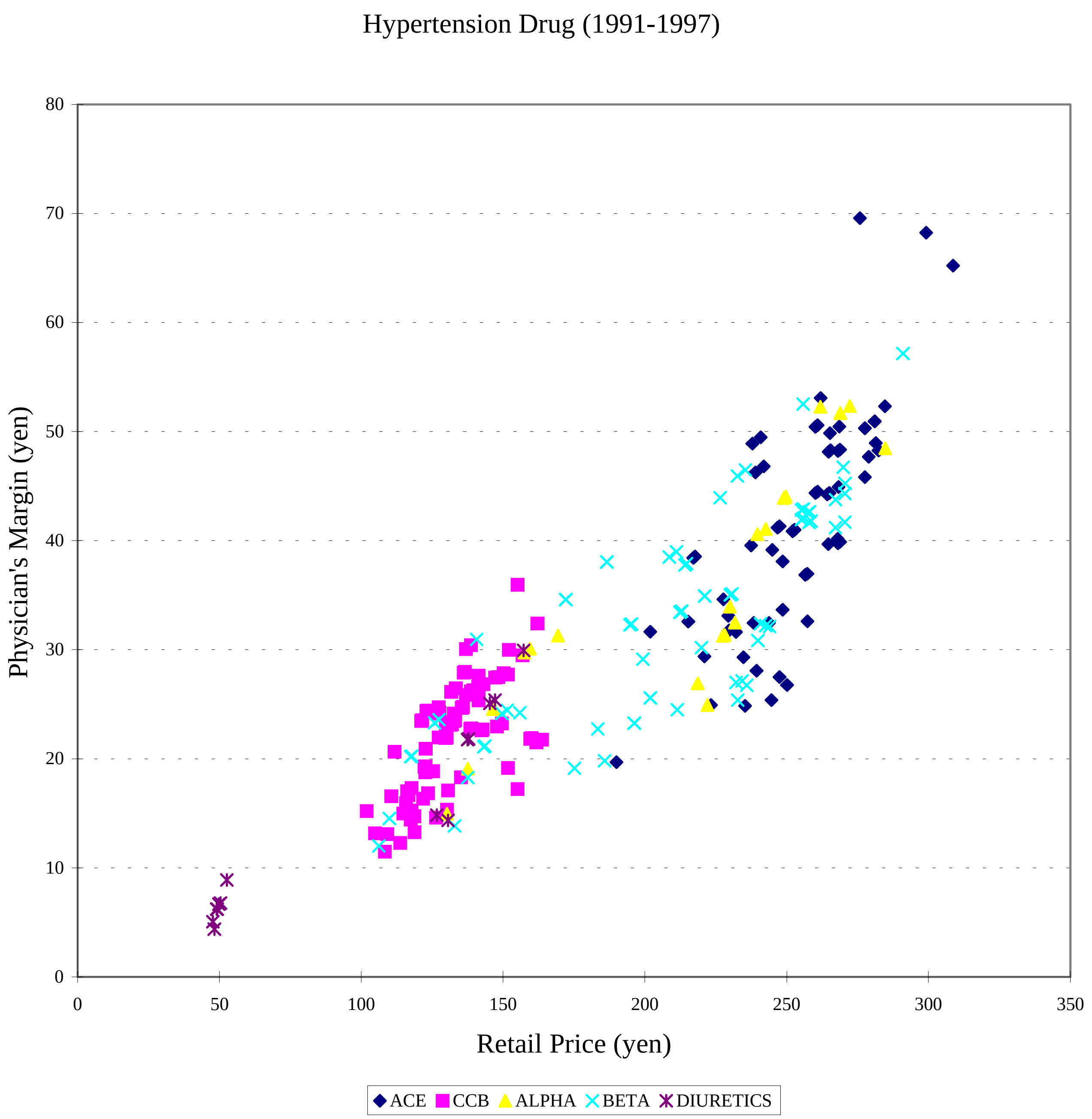

Fig. 3: The Effects of the Vertical Separation