Part II.

Supply:
Firm's Strategies in Listing Products

Chapter 4

Pricing Strategy:
Theoretical Analysis, Data and Case Study

Through interviews with firms and through material research, we identified several problems around the controversies in China's pharmaceutical industry. Of these, we took the following factors to analyze and to discuss: (1) the nature of demand for Giffen Goods under "Feeding Hospitals with Drugs", (2) patent protection and new drug protection, (3) retail price caps and auctions at procurement and (4) the choice of investment in R&D drugs or generic production. Here, we are going to set up simple models and examine the data of a drug class called Statins in China.

1. Literature

1.1 Focus on the Pricing Strategy

Pricing is an important strategic tool firms, although there are government regulations on it for pharmaceutical industries in most economies. A firm's pricing policy is affected substantially by such environments such as (1) competition, (2) bargaining power with buyers, (3) the governments' intervention in pricing, such as a maximum retail price cap, and (4) institutions such as patents or new drug protection in China or auctions. In this chapter, we will analyze how the environment affects a firm's pricing strategy.

Hospitals' deep reliance on the drug price margin, "Feeding Hospitals with Drugs" is a key source of problems that affect the complete medical system in China: patients, medical insurance, hospitals, the health sector, and the pharmaceutical industry. We will not analyze why this phenomenon evolved, but we will analyze what situation will be come as a result of this environment continuing, and we will evaluate the impact of several policies. Hospitals' close dependence on the drug price margin generates an unusual kind of demand in the pharmaceutical industry: industry customers prefer more expensive goods, even when the quality of goods is identical – this is called *Giffen Good*s in economic textbooks. This is not unique in China, however. The Japanese National Medical Insurance system also suffered from this, and overcame the problem by a gradual reform over 20 years from the late 1980s to the 2000s.

1.2 "Feeding Hospitals with Drugs" in Japan

It is often observed around the world, particularly in developing economies where the social medical care system has not been properly established, that physicians are inclined to prescribe high-priced drugs in order to secure their own income. Japan also experienced this problem and subsequently underwent a reform for 20 years.

One direct purchaser of drugs in Japan is the National Health Insurance, which is a compulsory medical insurance system, and the prices of drugs on the insurance catalogue is set by means of the Basic Drug Price Mechanism. As the National Health Insurance covers virtually 100% of the nation including dependents like children and retirees, drugs that are not on the catalogues are see practically no demand, in Japan, or very little. The Basic Drug Price Mechanism has been criticized for a long time as it generates the situation where physicians prescribe high-priced drugs to increase their own income. In the early 1980s, drug expenditure accounted for 40% of Japan's total medical expenditure, which is almost the same level as currently in China.

A reform of the medical system began to reduce drug expenditure by (1) reducing the Basic Drug Price Mechanism (1980-) and changing the price setting formula, and by means of (2) a payment scheme for hospitals: since 2003, reimbursement from insurance to hospitals is fixed by the diagnosis - this induced hospitals to reduce their costs and, in turn, seek cheaper drugs - (3) the separation of hospitals and pharmacies, and (4) by promoting generic drugs (1990-). Through these reforms during the 1990s, drug expenditure's percentage of the total medical expenditure decreased to 8% in 2000.

Anekawa [1999][2001] estimated the demand function to check whether physicians' prescription on how much use which drug prices are increasing or decreasing to prices. In their demand estimation demand for each drugs is explained by wholesale and official retail prices and fixed individual effects. His results show that physicians' prescription policy becomes independent of the drug price when a generic competitor is listed in the same market. He found that when generic competitors were introduced, demand only depends upon wholesale prices and individual effects. In this case, an official retail price reduction does not affect demand, and thus neither sales nor profits by the supplier. On the other hand, demand has negative elasticity to the wholesale price, and in this way suppliers can secure their sales and profits by competing with generic drugs.

Kondo [2006] conducted an empirical test on the impact of the fixed reimbursement policy introduced in 2003. Theoretically, this scheme may induce two opposite results: one is good one, namely accomplishing cost efficiency. The other is the downgrade in quality of medical care. Kondo [2006] showed two opposite results in different fields. In elderly care, the sales price is reduced while the same quality is maintained, but in the dialysis service for outpatients, hospitals started to utilize cheap drugs with stronger side effects, rather than higher-priced ones with fewer side effects. The latter case implies that the quality of service was lower.

1.3 How Do Pharmaceutical Patents and Price Policy Affect Consumer Welfare?

In academics, particularly, in the field of development studies, function of pharmaceutical patents becomes a controversial issue: should pharmaceuticals be patented to private firms or individuals, particularly in developing economies where the general public's ability to afford them is limited? In reality, India refused to provide pharmaceutical firms with patent protection until the WTO forced it to join the international framework on intellectual property rights, Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), in 1996.

One famous story around this problem was the acute conflict over HIV vaccines. Strict patent protection limited access to a newly invented drug for patients in Africa, who were the largest group suffering from this disease. Only rich patients in the US could access this new and effective treatment. Thus, TRIPS also allowed a compulsory removal of patent protection for humanitarian relief. Even for developed economies, pharmaceutical patents are new: Germany did not approve patents on drugs until 1968, and Italy did not do so until 1978 (Chaudhuri, Goldberg and Jia [2006]). In 1980, there were still 50 countries that did not approve patents on pharmaceuticals.

The patent system was originally invented to encourage innovators to transfer their inventions to those affected, particularly those in developing economies. The US and France were the first countries who were developing economies then, introduced the patent system so that they could introduce new technology from the UK, which was the most developed economy in the 19th century. On the other hand, the patent system also has a negative effect on developing economies, such as damaging local firms or industries by pushing up the operating costs (J. Lanjow, A Series of Lectures on "Economic Perspective on Global Patent Law and Pharmaceutical Regulation: R&D and Access to New Treatment." in 2005). Chaudori,S., Goldberg and Jia [2006] estimated how patent protection of pharmaceuticals affects consumer welfare. Their simulation test showed that high retail prices and poor availability of drugs in developing economies because of patent protection for international pharmaceutical firms might reduce consumer welfare.

Lanjouw [2005] analyzed and tested whether patent protection for newly listed drugs and a high price monopoly in the international market (not in a local market we observed) delayed the general publics' access to new treatments. The results showed that the high international price of a new drug will delay access to the new treatment, and the drug price in developed economies has a positive external effect on local prices in developing economies. This implies that patent protection in developed economies that allows a high price monopoly has an external effect over the pricing in developing economies (a negative effect on consumer welfare in developing economies). On the other hand, impact of the patent is mixed: it was not clear whether it was negative or positive. This result implies that the innovation capacity of pharmaceutical firms in developing economies is important for public welfare in those same developing economies.

2. Model Analysis and Data

In this section, lest us consider how firms will set their prices under two different demand properties - Giffen Goods demand and normal demand - and when the bargaining powers for setting prices rests with the firms, the suppliers, or hospitals, the buyers. By investigating the pricing strategy in equilibrium under different demand and bargaining power regimes, we can compare the predicted size of the profits of firms and hospitals, and the volume of drugs supplied in society.

2.1 The Statins' Demand Curve

2.1.1 Data: Statins (or HMG-CoA reductase inhibitors 他汀类) Market

Here, we can consider data on the price, quantity and other characteristics in the Statin drug market in China, which was compiled by IMS Health. The Statin is a class of drugs that lower the cholesterol level in people with, or who are at risk from, cardiovascular disease. Statins and Fibrates are the main two competing drugs for lowering cholesterol, but Statin have a 70% market share in China – they are sold here in the largest amounts in the world as well. In China, the sale of Statins is increasing, which reflects a high ratio of high cholesterol or cardiovascular patients in the country. In particular, after the SARS outbreak calmed down in 2003, drugs for lowering cholesterol were a booming category in China in 2004-2005.

Types of Statins currently on sales are Lovastatin, Simvastatin, Pravastatin, Fluvastatin and Atorvastatin, which are listed in the Chinese market in order of appearance. The first 4 are on the State Basic Medical Insurance Catalogue, and the government caps their retail prices. Patent protections are in effect for Pravastatin, Fluvastatin and Atorvastatin. New drug protection was in effect until 2007 for Pravastatin and Atorvastatin. Cerivastatin, a statin discovered by Bayer, was withdrawn from the market due to risks of serious adverse effects, and 2 Statins, Rousvastatin and Pitavastatin, were discovered to overcome the defects. They are not yet listed in China. Table 1 shows the details.

Table 1: Types of Statins and the Number of Firms in the Market

Derivation	Generic Name	Chinese Name	# of drugs (production document) and firms (document holder)	Global Product Patent Holder	Effective Patent	Effective new drug protection (Latest)	State Basic Medical Insurance Catalogue
1st gen. Fermented	Lovastatin	洛找他汀	51 documents, 36 firms	Merck	X	X	O
	Simvastatin	辛伐他汀	107 documents, 54 firms	Merck	X	X	O
	Pravastatin	普伐他汀	14 documents (3 raw drugs), 6 firms Bristrol-Myers/Sankyo/Huabei/Haizheng/ Shanghai Xiandai/Shanghai Tianwei	Bristol Myers/ Sankyo	O	O	O
1.5 gen: Semi-Synthesis	Fluvastatin	氟伐他汀	Beijing Novartis (2 drugs) and Zhejiang Haizheng (1 raw drugs)	Novartis	O	X	O
2nd gen: Synthesis	Atorvastatin	阿托伐他汀	6 document (1 raw drugs), 3firms Pfizer, Beijing Jialin (Honghui) and Henan Tianfang	Pfizer	O	O	X
	Rosuvastatin	瑞舒伐他汀	Not produced in China	AstraZebecca	-	-	X
3rd gen.	Pitavasatin	-	Not produced, not on sale in China	Kowa	-	-	X

(Source) # of production document holders and effective new drug protection was derived from the Database on Local Production Drugs, at China Medical Drug Webnet. Information on Effective Patents was obtained from the New Horizon Database/State Basic Medical Insurance Catalogue.

2.1.2 Historical Demand Curve in Individual Drugs

What, then, is the relationship between demand quantity and price? We can draw a historical demand curve from our data on quantity and price from 1999 to 2006. For drugs in the Statin markets, we can see the following properties from these drawings: (1) there are three groups in terms of the relationship between quantity and price. One group shows that the price slightly decreases as the volume increases (two drugs in Atorvastatin, two drugs from Pravastatin). The second group's price is almost constant regardless of volume (one drug in Atorvastatin, two drug from Fluvastatin and Simvastatin). The third group's demand volume increases as the price increases (one drug in Pravastatin and Lovastatin). (2) Members of the first group, whose demand volume increases as the price decreases, i.e. a normal case of demand, are all the patented products of foreign pharmaceutical firm. (3) However, that is not always the case as one of the members of the third group, whose demand volume increases as the price goes up, is the patented product of a foreign firm, while the others are domestic manufacturer's generic products.

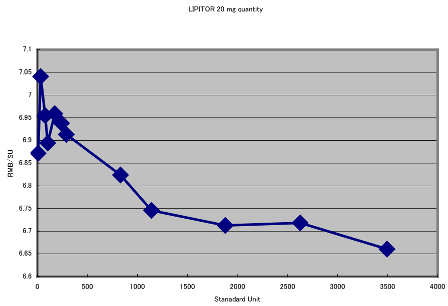
Here, we cannot strongly assert that the demand for drugs in China can be characterized whereby demand increases as price increases. However, we can say that a case of normal demand, where the demand volume increases as the price goes down, is not common in this market either. Furthermore, we miss the interaction between drugs in each type's market or the Statin market as a whole, where there is some product differentiation at work. In any case, precise statistical testing is necessary to capture the nature of the demand in the Chinese drug market.

We will proceed to formally analyzing how the nature of demand will affect the pricing policy of firms and prices at equilibrium by assuming that in the case of "Feeding Hospitals with Drugs," demand increases in relation to price.

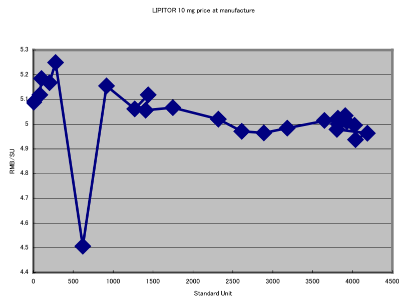
Figure 1: Demand Curve

Atorvastatin

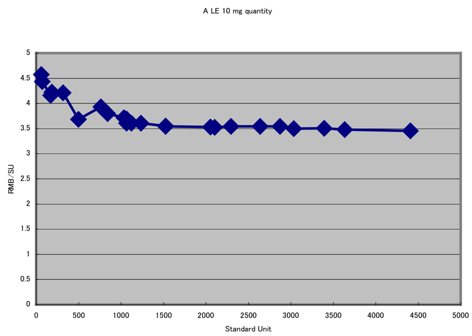
Patent& New Drug Protection: Pfizer



Patent& NDP: Pfizer

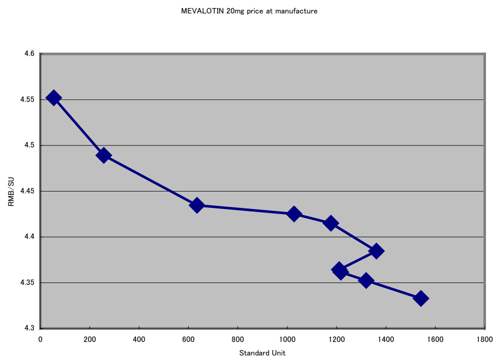


No protection: Beijing Jialin

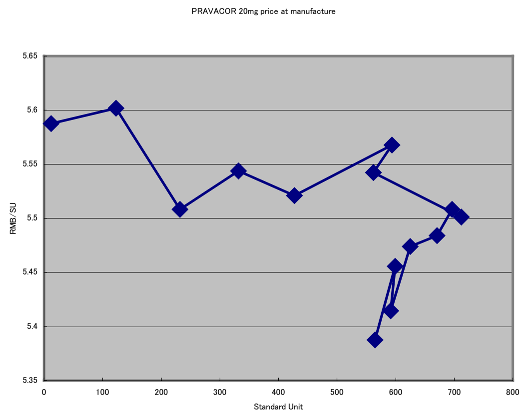


Pravastatin

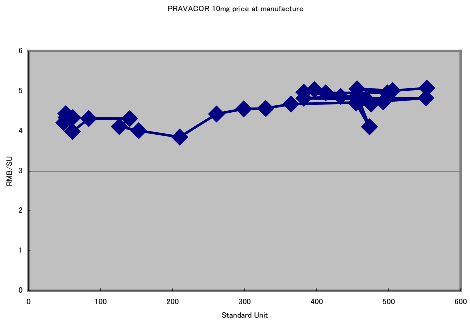
NDP & Patent: Sankyo



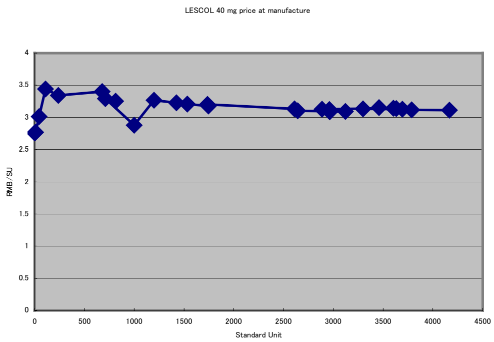
Patent: Bristol Myers-Squibb



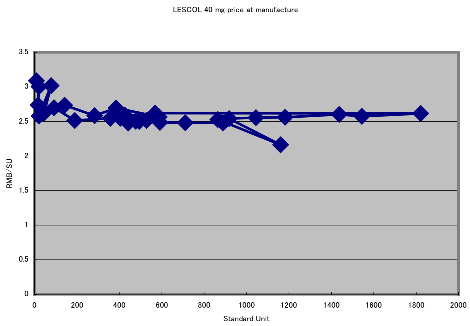
Patent: Bristol Myers-Squibb



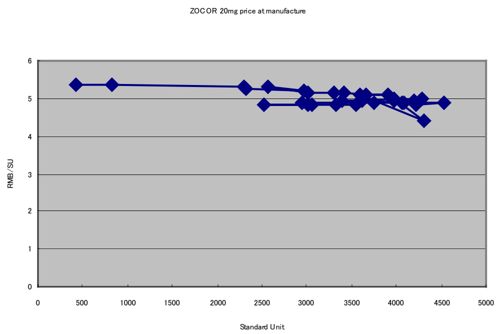
Fluvastatin
Patent: Novartis



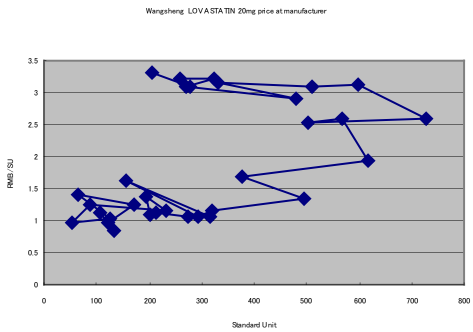
Patent: Novartis



Simvastatin
No protection: Merck



Lovastatin
No protection: Beijing Wangsheng



(Source) IMS Health Data

2.2 Model Prediction for Pricing Strategies

Faced with the unusual demand curve that we have seen above, how do firms set their prices? What factors affect firms' price setting, and what are levels of price and supply volume? Here, we take a look at the results of theoretical analysis. We will compare firms' pricing strategies under several conditions within the "Feeding Hospitals with Drugs" type of demand: (1) where the price is set to maximize the profits of the hospital (buyer), (2) where firms (suppliers) that are competing for quantity set prices in a decentralized way, (3) and the same with regard to price competition. Details of the reduction of these results are set out in the Appendix. Tables 2 and 3 show a summary of the results of our analysis.

Here, we can see the following nature:

(1) When the price set according the monopolizing behavior of a hospital (buyer), the price being at equilibrium is an increasing function of the "official price cap on the retail price". Firms' profits are also increasing the function of the official price cap. If prices are set via competition over quantity or price among suppliers, the price being at equilibrium and the profit of the firms are increasing functions of the marginal costs of suppliers (see Table 1). If the former case is an actual mechanism that currently works in China, then retail price reduction by the government would seriously damage the firms' profits.

(2) Volume of drugs supplied also follows a similar course: when equilibrium price is set according to a hospital's monopolistic behavior, the sales volume of the drug is an increasing function of the "official price cap on the retail price." On the contrary, if suppliers are competing over setting the prices, then the sales volume of the drug is an increasing function of the marginal costs of suppliers. Thus, if the former case is an actual mechanism in China, then retail price reduction by the government would, again, reduce the production of drugs. This is not expected by current policy makers.

Table 2: Prices at Factories and Firms' Profits by Pricing Strategy

Demand Type	Price Setting Regime	Price at Factory	Rank	Profit of Firm	Rank

1	"Feeding Hospitals with Drugs"	Hospital's monopolized pricing	$p = (v^{max} - \theta)/2$	1	$(v^{max} + \theta)(v^{max} + \theta - 2c)/4 > 0$	1
2	"Feeding Hospitals with Drugs"	Quantity competition	$p = c - (\theta + c)(n+1)$	4	$-(c+\theta)^2/(1+n)^2 < 0$	6
3	"Feeding Hospitals with Drugs"	Price competition	c_2	3	$(\theta + c_2)(c_2 - c_1)/2$	3
4	Normal	Hospital's monopolized pricing	$p = c$	3	0	5
5	Normal	Quantity competition	$p = c_i + (\theta - c_i)/(n+1)$	2	$(\theta - c)^2/(1+n)^2 > 0$	2
6	Normal	Price competition	c_2	3	$(\theta - c_2)(c_2 - c_1)/2$	4

(Source) Author

(Note) c_1 and c_2 in price competition (columns 3 and 6) represent the marginal costs of supplier 1 and supplier 2. In the analysis here, supplier 1 is more cost efficient than supplier 2, that is, $c_1 < c_2$.

Table 3: Price at Patient, Hospital's Profits, and Supply Volume of Drugs

	Demand Type	Price Setting Regime	Price at Patient	Hospital's Profit	Rank	Total Supply of Drug	Rank
1	"Feeding Hospitals with Drugs"	Hospital's monopolized pricing	v^{max}	$(v^{max} + \theta)^2/4$	1	$(\theta + v)/2$	3
2	"Feeding Hospitals with Drugs"	Quantity competition	v^{max}	$\frac{(\theta+c)}{(n+1)}(v^{max} - c + \frac{\theta+c}{n+1})$	3	$n(c+\theta)/(1+n)$	5
3	"Feeding Hospitals with Drugs"	Price competition	v^{max}	$(\theta + c_2)(v^{max} - c_1)/2$	4	$(\theta + c_2)$	4
4	Normal	Hospital's monopolized pricing	v^{max}	$(\theta - c)(v^{max} - c)$	2	$\theta - c$	1
5	Normal	Quantity competition	v^{max}	$\frac{(\theta+c)}{(n+1)}(v^{max} - c - \frac{\theta-c}{n+1})$	6	$n(\theta - c_i)/(1+n)$	2
6	Normal	Price competition	v^{max}	$(\theta - c_2)(v^{max} - c_1)/2$	5	$(\theta - c_2)$	1

(Source) Author

We also analyzed the impact of non-price (quality) competition on the pricing and volume of drug sales in the Appendix. The results show that when the price in equilibrium is set by monopolistic hospitals, the prices at factories are an increasing function of the “official retail price cap” for all drugs listed in the same market. In other words, for patented drugs and generics of the same drug, prices move in an interacted way, even though suppliers are not competing on price.

3. Case Study

3.1 Pricing Policies of Firms That Were Interviewed

In order to understand what factors actually affect firms’ price setting behavior, we conducted a series of interviews with firms in May and June of 2007. Decisions regarding the choice of which drugs to list, as well as pricing and related investments are all important issues for pharmaceutical management. The final outcome of all these considerations will be the company’s price setting strategy. In this section, we simply summarize the information about (1) who has the power to decide which drugs to list, and (2) what the factors are that determine price setting. We were able to interview members of the decision makers in each of the firms, and they were able to explain what factors actually matter with regard to decision-making.

Table 4: Title of Interviewees

	Firms	Title of Interviewees
1	A	Head of Intellectual Property
2	B	CEO, Chief Scientist
3	C	Head of Research and Development
4	D	General Manager
5	E	General manager
6	F	General Manager
7	G	Chairman
8	H	Secretary of GM cum Head of Development Planning
9	I	Chairman, General Manager
10	J	General Manager
11	K	Vice General Manager
12	L	Vice General Manager

(Source) Author

In Table 5, we have summarized the nature of the listed drugs by patent, new drug, generics, original innovations, etc. Although these statistics is still imperfect and need to be elaborated on, we can still see some characteristics present. (1) The number of listed patented drugs is small for all the firms, regardless of the size of their sales. (2) The number of drugs documented as new drugs and generics is larger than that of patented drugs. (3) The number of original drugs does not show a systematic difference between sales. However, these original drugs seem to have duplicated meanings: some firms responded with the number of drugs that they really developed, and also have patents for. Others pointed out the drugs that were originally developed by some foreign pharmaceuticals, but which they developed themselves based on published information, as the first generics in China. This follows the criteria of pricing formula of the “retail price cap” by the SDRC.

To summarize, most of drugs that were listed by the interviewed firms are not patented. But they are either protected by new drug protection or favored by official pricing. New drug documents are often issued to several drugs, and a drug documented as a “new drug” does not necessarily means there is a perfect monopoly over the market, but rather they can enjoy an oligopolistic environment. The original drug can enjoy the effect of a higher official retail price cap. Thus, most of drugs listed by the interviewed firms enjoy some favorable terms in China’s official pricing policy, but not patent protection.

Table 5: Structure of Listed Products

		Sales in 2006 (bil. RMB)	Patented Drug	New Drug Documents	Generics	Original Drugs	Listed on Drug Catalogue	OTC
1	E	50	1	5	0	6	3	-
2	L	4.05	1	7,8	many	4,5	many	0
3	I	3.59	0	6	33	0	-	-
4	H	2.7	12 (50 applied)	23 (Class2) + 32 (Class4)	51	-	-	-
5	C	2.69	0 product patents. A few process patents	About 20	-	1 TCM	-	-
6	A	2.4	Applications 688; approved 102	0	1,2	1	0	-
7	B	1.5	Applied 69-70, domestic 7, international	Numerous	1,2	Self innovated 40	two thirds	one tenth

8	F	1.4	0	110 (20-30 including APIs)	-	-	40	-
9	J	1	8,9	0	All western drugs are generics	8,9	2,3	1(flu drug)
10	G	0.85	6	?	-	6	-	-
11	K	0.28	3	About 20		0		80-90
12	D	0.2	0	0	All	0	-	-

(Source) Author

Some firms offered a detailed story on their pricing strategies. Our findings are as follows:

(1) The price is set to cover R&D, including failed research. This implies that current price setting can cover fixed costs, and thus the current price level could be higher than the marginal costs.
(2) Foreign pharmaceuticals' prices are used as a reference, and domestic makers will set a price that is lower than them, as the buyer will not purchase a domestic drug if its price is higher.
(3) Firms prefer to set as high prices that the institutions allow as possible: a higher price will not reduce the demand for most drugs.
(4) However, price elasticity is very high for some drugs, lower prices can induces huge demand to increase as in the case of firm F.

Table 6: Pricing Policy and its Formula

	Firms	**Pricing Policy**
6	F	In order to take over your foreign rivals' market share, set prices as low as 1/6 of your competition's. You can expect large volumes, and so you can set lower prices. the price is set to cover the cost of any failed R&D.
11	K	Set a price lower than foreign firms' products by considering (1) cost, (2) market volume, and (3) rivalry.
12	L	First, refer to the official price, and try to get a sole price. Then, study the market to decided whether to follow the "high price principle" or "low price principle."

(Source) Author

3.2: Voices in the Field on Pricing

In the interviews with pharmaceuticals, there were many opinions on pricing policy.

- Aggressive price reduction is not effective at reducing the retail market drug price for the patient, and hurts pharmaceuticals regarding investing in R&D and new drugs.
- Production documents are now issued by each firm and are not permitted to be transferred even within a corporate group. This does not allow big corporations to utilize their economies of scale and scope, and this management philosophy is advantageous towards small firms.

On auctions:

- The transactions of hospital and pharmaceuticals should be liberalized, and should not be controlled by the central tendering auctions.
- The auction method is too complicated, and there is no transparent process.
- The rules of auctions are not transparent, particularly the negotiation process.
- Seeing the results of auctions, we have the impression that there was some manipulation against the auction organizer, particularly by small and notorious pharmaceutical firms.
- Categorization by quality is irrational: for drugs priced according to market adjustment, there are (1) patented drugs, (2) original drugs without patents any more, (3) GMP-licensed generic drugs. The second category is irrational, as the patent has already expired but the protection is still effective.

On the retail price cap:

- Aggressive price reductions by the SDRC are irrational as the manufacturers cannot survive.
- Price regulations should be more simple: just set a "reimbursement price on the medical insurance drug catalogues." Other price regulations are ineffective and just duplicate one another.

4. Analysis of the Impacts of Policies

Based on the above, we have attempted to analyze the impact of such government policies as the retail price cap on official pricing, patent and new drug protection, and the centralized tendering scheme by auction.

4.1 Maximum Retail Price

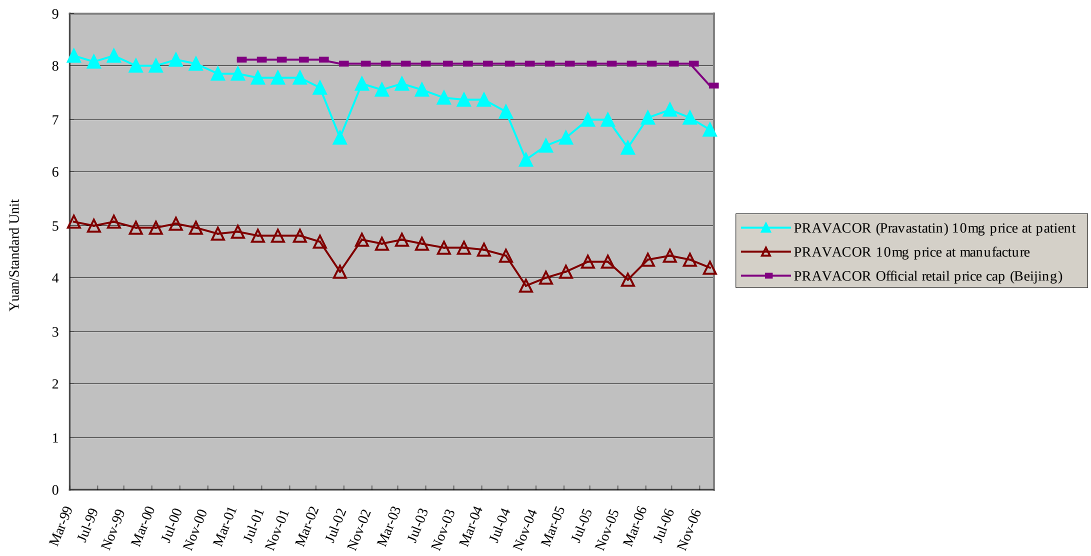
As we saw in Part I, there is price regulation in China's pharmaceutical industry – the State Development and Reform Committee (SDRC) sets a price cap over drugs listed on the State Basic Medical Insurance Drug Catalogue. In 2006, the SDRC aggressively reduced this official price cap and completed price reductions on around 1500 kinds of drugs until March 2007. Several firms complained about this policy, and asked for a rational and accountable pricing mechanism.

According to our model analysis on the price setting strategy above, firms' price setting strategies are a function of retail prices. Hospitals set their retail prices as high as possible, and thus the retail price cap substantially affects hospitals' retail prices and the firms' price setting at the factories. We can confirm this in the Statin market data. Figure 7 shows the movement of the official retail price and market prices of Pravachor, a product of Bristol Myers-Squibb, a British pharmaceutical, in a Pravastatin market. Pravastatin is listed on the State Basic Medial Insurance Drug Catalogue, and Bristol Myers Squibb holds global market exclusivity except in Japan, where an innovator Sankyo holds market exclusivity.

In Figure 7[1], we can observe that market prices at the patient level and at the factory are both decreasing gradually, but basically follow the official price cap, although a statistical test is necessary to more clearly confirm this. What is interesting is that following a reduction of the official retail price cap in 2006, not only the retail price set by the hospital, but also the price at the factory set by the firms, decreased by maintaining almost the same level of margins. This development supports our hypothesis on the price setting mechanism: that hospitals set a monopolized price, and firms accept this level. Thus, firms' profits depend heavily on the official price margin, and as a result they are opposed to this policy.

[1] In IMS Health data, the price that was actually surveyed is the price at the trading company. The price at the factory and price at the patient level are derived by multiplying their "expanding coefficient." Thus, these prices virtually move together by this definition. But here, we show these two prices together so that we can see the relationship between them and the official retail price cap.

Figure 2: Official Retail Price Cap: Pravastatin, Bristol Myers-Squibb



So, is the reduction of the official retail price policy good for social welfare? If we define social welfare as consisting not only of low prices, but also of the availability of drugs, we must also care about whether firms can continue to operate in the market as well as the benefits consumers see from low prices. If the official price reduction is too large, so hospitals offer drugs at a price lower than the firm's marginal costs, the firm will halt production, and subsequently the availability of the drugs will decrease. This is what domestic pharmaceuticals are currently complaining at.

This result – the reduced availability of drugs – can be avoided if the government knows accurately the exact marginal costs for each drug. The SDRC seems be trying their best to ascertain this information and have visited many firms and ordered them to disclose their information on production costs[2]. But the information on the costs is asymmetrical between firms and the regulatory agent by nature, and the cost of disclosing this information is very high. As a result, some irrational setting on official prices are happening: for example, firms will set a price that covers not only their production costs but also their R&D cost, and sometimes they may include expenditure on failed R&D. However, the SDRC only considers R&D cost for succeeded case. Pricing is a key element in a firm's corporate strategy, and so it is not reasonable for a regulatory agent to directly control this variable.

[2] Interviews with pharmaceutical firms in May and June, 2007.

You can expect to allow firms to keep operating by change the environments of both firms and the hospitals. If we can change hospital's demand to a normal property, that is, where the hospital prefers a lower priced drug of the same quality, then hospital will offer the buyer the minimum price that firms can accept, which is equal to their marginal costs, and this allows the firms to keep operating. The regulatory agent then does not have to make efforts to acquire cost information. If demand becomes normal, then the official retail price reduction only affects the hospitals' profits, and does not affect firms' decisions to enter the market. In this way we can achieve both a "lower price" and "high availability of drugs". Of course, the cost of changing a hospital's demand to normal in not nothing, but includes public subsidies to hospitals or equity investment, etc.. It is important to study which cost is higher between a sufficient subsidy that changes a hospital's revenue structure and the cost of a search to get firms to disclose their rational costs. This author presumes that the latter is far higher, particularly taking into consideration the side effect that intervention on pricing has on the incentive to invest in R &D. Furthermore, we must note that firms' prices and profits might be suppressed to the marginal costs, and that they have lost rent that they enjoyed during the "Feeding Hospitals with Drugs" type demand.

4.2 "Patents" and "New Drug Protection"

Patent protection was motivated to provide a certain profit those who have invested a massive amount on the discovery of new drugs with innovators in exchange for disclosing their invention. The power of that protection is evaluated by the size of benefit from market exclusivity that reduces pressure in competition.

Table 1 shows the number of production document holders, that is the number of firms that have entered the market. Here, we can see that (1) the number of firms who embarked on a drug whose patent protection has expired is far larger than those whose patent or new drug protection is effective: Lovastatin, which is the first of the Statin drugs, and Simvastatin, whose patents have expired already, have respectively 36 and 54 suppliers with production documents. This number is far beyond those who are still protected by patents or new drug protection, such as Pravastatin, Fluvastatin and Atorvastatin: their number of their suppliers is respectively 6, 3 and 3. This implies that once market exclusivity protection is removed, massive (domestic) firms have entered into each drug market. This implies that they can make a profit, even with a substantial number of rivals. This is inconsistent with the result of the model analysis on decentralized competition, which predicts that decentralized competition in quantity leads to a halt in production in market. It seems that a model of decentralized competition faced with Giffen Goods market is not suitable for use in understanding the Chinese pharmaceutical market.

Table 7 shows the number of drugs and firms in a market, and the number of firms protected by new drug documents or patents. The number of drugs in the market is clearly different between a group of Lovastatin and Simvastatin and others. The former group has said that their substantial (product) patents have expired, but a number of patents confirmed in the New Horizon Database shows no big difference. On the contrary, the number of effective new drug documents shows a correlation to the number of drugs in the market. Thus the there are zero effective new drug documents for a group of Lovastatin and Simvastatin, a substantial "patent-expired" group. New drug documents for Pravastatin and Atorvastatin are effective, and the number of drugs and firms are small. In the Fluvastatin market, no firm holds an effective new drug document. Novartis, a global product patent holder, made a component patent application in 2001.[3] IMS health data reported sales of Fluvastatin only by Novaritis. Patent protection could be effective in this case.

Table 7: Market Exclusivity Protection and the Number of Firms in the Statin Market

	# of drug (firms)	New Drug Documents			Patents		
		# of NDD issued*	# of new drug docs currently effective	Firms	# of patents	Earliest patent applied for in:	Firms
Lovastatin	51 (36)	0	0	-	16	1989/7/17	Merck etc.
Simvastatin	107 (54)	17	0	-	14	1989/7/17	Merck etc.
Pravastatin	14 (6)	11	9 docs (3 raw materials), 5 firms until 2007.1.17or 2008.1.23	Xiandai, Huabei, Haizheng, Tianwei, Sankyo	12	1989/3/31	Bristol Myers-Squibb, Sankyo
Fluvastatin	3 (2)	0	0	-	2	1989/3/31	Pfizer, Nova
Atorvastatin	6 (3)	3	3 doc, 1 firm	Pfizer	10	1996/7/8	Pfizer

[3] State Intellectual Property Office website, http://app.sipo.gov.cn:8080/sipo/enzljs/hyjs-yx.jsp?recid=01807914

			until 2007.9.28				(Warner-La mbert)

*(Note) *The number of new drug documents (class 1 to 5), that can be confirmed in the Database on Local Production Drugs at China Medical Drug Webnet in 2007 July.*

How, then, does this market protection affect prices in a market? Take a look at the movements of price and market protection in the Atorvastatin market. In this market, Pfizer holds both new drug protection and patent protection. Beijing Jialin, a local firm, is also operating in this market. Figure 3 shows the price development of Pfizer products, which shows that the price level is high but it kept almost at the same level since listing. On the other hand, Figure 4 shows the price of Jialin's products. This shows that the price has fallen at a relatively high speed. In addition to market protection by new drug documents and patents, there is another factor: the former has brand power, the latter does not. We cannot say exactly what factors affect this difference in price movement here, but we can say that the institution of market exclusivity works in this case.

Figure 3: Patent and New Drug Protection: Atrovastatin, Pfizer

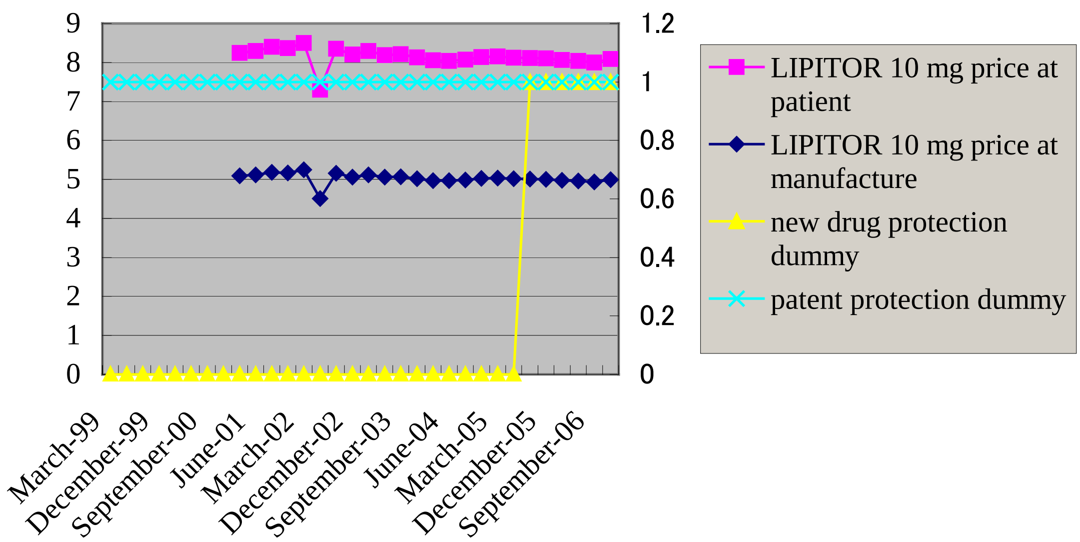
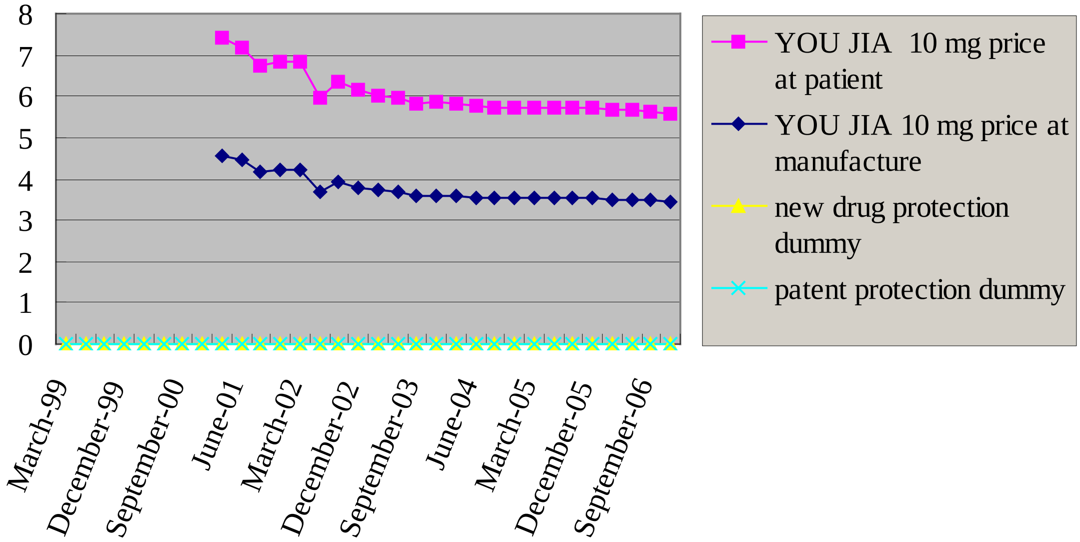


Figure 4: No Patent or New Drug Protection: Atrovastatin, Beijing Jialin



4.3 The Impact of Auctions

The analyses above focus on a one-to-one transaction between hospitals and firms. Auctions, where the buyer invites supplier to bid, are a form of transaction where more than one supplier competes against each other. What will happen when the auction is introduced, and where competition between suppliers evolves? If we do not care about any disclosure of quality, an auction generates a similar result to a decentralized competition case mentioned earlier in this chapter. If buyer demand is normal, the price decreases when the number of competitors increases, but above cost. If the demand follows the model of "Feeding Hospitals with Drugs", the price will be suppressed to be lower than the costs, and thus the firm cannot enter the market. So, the supply of drugs might stop if an auction is introduced without adjusting the nature of demand to prefer a high-priced drug.

Contract theory can be sued to study the impact of an auction as follows: if the contract between buyers and firms specifies the disclosure of the quality of products and requires the incentive that the supplier will see higher profits if they disclose true information, then the higher quality supplier will be contracted with a higher transaction price than lower quality firms under normal demand. Higher quality firms will be able to acquire a rent by disclosing information on their own quality. This is called information rent according to the theory. The introduction of competition by means of an auction will not change this quality level, but can suppress this information rent.

4.4 Pricing Policy and Innovation

So, how does the pricing policy affect innovation in pharmaceutical firms? The pricing policy seriously affects a firm's profits, which is an important source of financing for research and development. Thus, it is not beneficial to innovation to suppress a firm's profit so much that it becomes negative.

Tables 2 and 3 summarize the impact on price and profits of manufacturers by price setting regimes: for firms, Regime 1 is the best. Under Regime 1, the hospital sets a monopolized policy when demand is increasing respective to price, and thus the profits of the firm are largest as their sales price is the highest.

4.5 Summary: normalization of demand should be the first

So far, we have examined the current phenomena in the Chinese pharmaceutical industry. Tables 3 and 4 summarize the results of the model analysis. Here, we can see that:

(1) as long as a hospital or physician has bargaining power with the patient over the retail price, the retail price of a drug will be set as high as possible. Competition between hospitals or physicians, or other schemes to promote a reduction in the sales price by the hospital, is necessary to resolve the problem of a "high drug price' which is a important target of the current administration. Competition or auctions among firms cannot reduce the retail drug price.

(2) We can compare the size of hospital profits. If the current state of transactions between hospitals and pharmaceutical firms can be assumed to be that the hospital price monopolizes their profit and demand is increasing the price at factories, the profits of hospitals are maximized in the four regimes we studied here.

(3) Total drug supply may represent the size of social welfare in the pharmaceutical industry. This should be also an important policy target for China, and indeed for most developing economies. The model analyses show that the total supply of drugs is larger when a hospital's demand is normal. From this conclusion, it is desirable for policy makers to change hospitals' demand so that it is decreasing in order to accomplish a secure and sufficient supply of drugs for society.

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Appendix   Model Analysis on Price Setting Behavior

A.1 Model 1: Decentralized price setting leads to a halt in production

First, we will see what will happen when firms in competition in a decentralized manner are setting prices for hospitals. We will see what will happen when firms compete in quantity and price under demand characterized as "Feeding Hospitals with Drugs". If the price at the factory is set in a decentralized way, in a first model analysis, we will see how competition among firms affects the price, production volume and both the firm's and hospital's profits.

A.1.1 Competition in quantity under normal and "Feeding Hospitals with Drugs" type demand

The nature of competitions in quantity and price were basic cases in industrial organization textbooks. We also first look at quantitative competition and then price competition under "Feeding Hospitals with Drugs" demand. First, as a reference, we take a look at the normal goods market, where demand is decreasing to price: D= $\theta - p$. D is a total volume of supplied goods by n firms, $D = d_i + \sum_{j \neq i}^{n} d_j$.

A firm i will decide how much to supply their product so as to maximize their profit as described before. As a result, the price in the market is determined following the demand curve above.

$$\max_{d_i} \quad \Pi_i (d_i, d_j) = d_i (p - c_i)$$

$$\text{subject to:} \quad p(D) = \theta - D$$

Then, the first order condition to maximize firm's profit is as follows:

$$\partial \Pi_i / \partial d_i = \theta - d_i D' - D - c_i = \theta - d_i - D - c_i = 0$$

For simplicity, by assuming that production volumes are symmetrical among firms in the market, that is, D=nd_i, we can get $\theta - d_i - nd_i - c_i = 0$.

Then, $d_i = (\theta - c_i)/(1+n)$

$$p = \theta - nd = \theta - n(\theta - c_i)/(1+n) = c_i + (\theta - c_i)/(n+1) .$$

Each firm's profit is,

$$\Pi_i = d_i(p - c_i) = (\theta - c_i)^2/(1+n)^2 > 0.$$

The hospital's profit becomes,

$$\Pi_H = d_i(v - p) = \frac{(\theta + c)}{(n+1)}(v - c - \frac{\theta - c}{n+1}).$$

As profit is increasing in relation to retail price v, thus the hospital will set the retail price as high as possible,

$$v = v^{max}.$$

The firm can earn a positive profit here. In a normal goods market, (1) the firm sets the price based on the cost and number of rivals. The retail price of drugs sold by the hospital to patient does not affect firms' pricing of firms. (2) The firm's profits are positive, though it gets small as the number of rivals increases.

Next, take a look at what will happen when the hospital's demand is increasing in relation to price, D= θ+ p, which is the "Feeding Hospitals with Drugs"-type demand here. A firm i will solve the following problem:

$$\max_{d_i} \quad \Pi_i(d_i, d_j) = d_i(p - c_i)$$

subject to: $p(D) = -\theta + D$[4].

By similar calculation to above, we can get,

$$d_i = (c+\theta)/(1+n) \quad \text{and} \quad D = n(c+\theta)/(1+n)$$

$$p = -\theta + nd = -\theta + (c+\theta)n/(1+n) = c - (\theta + c)(n+1).$$

Here, we find that the firm's profits become negative, as the price is lower than the cost,

$$\Pi_i = d_i(p - c) = -(\theta + c)^2/(1+n)^2 < 0,$$

The hospital's profit becomes,

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[4] The profit of i, Π_i will be maximized if the d_i satisfies the first order condition of Π_i. $\Pi_i(d_i, d_j)$ can be rewritten as follows: $\Pi_i(d_i, d_j) = d_i(p - c_i) = d_i(-\theta + D) - c_i d_i$. Then, the first order condition for maximizing profit is: $\partial\Pi_i/\partial d_i = -\theta + d_i D' + D - c_i = 0$. We again assume that each firms' production volume is symmetrical among firms in the market, that is, $D=nd_i$, we can get, $-\theta + d_i + nd_i - c_i = 0$.

$$\Pi_H = d_i(v - p) = \frac{(\theta + c)}{(n+1)}(v - c + \frac{\theta + c}{n+1}) > 0,$$

Thus hospital will set the retail price as high as possible,

$$v = v^{max}.$$

In a market with the “Feeding Hospitals with Drugs” type of demand, (1) the firm cannot make a profit when supply volumes are determined in a decentralized way. This is in contrast to a case of competition under normal demand, or a case where the hospital has monopolistic power, as we will see below. We can expect no firm to enter a market where demand is not normal and firms are competing against each other in a decentralized way. (2) As the number of firms in competition increase, prices at factories get lower, but the supply of drugs increases. Thus, if patent or new drug protection is effectively enforced, then the number of firms entering is restricted, and the price that the firm sets will be able to remain higher, but the production volume will be suppressed.

A.2.2 Competition in Price

If the firms compete in price, they should not have a deficit, but the price is lowered to level of marginal costs.

Suppose two firms (Firms 1 and 2) with constant marginal costs are competing in a market. We assume that the level of marginal costs are different, $c_1 < c_2$, and all the products are homogenous. Usually, lower marginal cost firms are more efficient, as they can produce the same products at lower costs. The firms face a demand curve D(p) （$= \theta + p$）, and each firm decides their (private) price p_i. If demand is of the Giffen Goods type, or “Feeding Hospitals with Drugs” type, Firm 1 or 2 will face the following demand curve.

		Giffen Goods demand	Normal demand
$d_i(p_i, p_{-i})$	$= D(p_i)$	if $p_i > p_{-i}$	if $p_i < p_{-i}$
	$= D(p)/2$	if $p_i = p_{-i}$	if $p_i = p_{-i}$
	$= 0$	if $p_i < p_{-i}$	if $p_i > p_{-i}$

Consider that Firm1 will set price $p_1 = c_2$, then Firm 2 will also set $p_2 = c_2$. In this case, Firm 1 and Firm 2 will produce $D(c_2)/2$ respectively. The profits for Firm 1 and Firm 2 will become $D(c_2)(c_2 - c1)/2 > 0$ and zero. For Firm 1, if they set price c_1, then they will lose their profits, so they will not change strategy. For Firm 2, by setting price c_1, their profit stays at the same level as zero. Thus, Firm 2 has no incentive to change its strategy. Thus, the first case is equilibrium.

Here the price, production volume and profit of the firm sector and hospital are:

$$p^*=c_2,\ D^*=\theta+c_2\ ,\ \Pi^*_f=(\theta+c_2)(c_2-c_1)/2,\ \Pi^*_H=(\theta+c_2)(v-c_2).$$

Interestingly, when demand is normal, and price in equilibrium stays as c_2, the total demand volume will change to $\theta - c_2$. Thus, if firms in the drug market in China set the price independently and compete in price, prices at factory are set to the marginal cost of a less efficient firm. As firms in a market faces with the same price, anyway, more efficient firms get rent here[5].

Figure 2: Production and Profit matrix in the Price Competition Game

Production Volume

		Firm2	
		c_1	c_2
Firm1	c_1	$(D(c_1)/2, D(c_1)/2)$	$(0, D(c_2))$
	c_2	$(D(c_2), 0)$	$(D(c_2)/2, D(c_2)/2)$

Profit

		Firm2	
		c_1	c_2
Firm1	c_1	$(0, D(c_1)(c_1-c_2)/2<0)$	$(0, 0)$
	c_2	$(D(c_2)(c_2-c1)>0, 0)$	**$(D(c_2)(c_2-c_1)/2>0, 0)$**

(Note) (Outcome of Firm 1, Outcome of Firm2)

The quantity competition model shows that no firm will enter a market with a Giffen Good demand, as they lose money. Table 1 shows that a huge number of firms entered the markets, and thus firms are not competing on quantity. The price competition model

[5] However, if the quality of products is not sufficiently observable for buyers, and difference of the marginal cost indicates a cost reduction by quality reduction, manufacturers of poor quality products secure a rent.

indicates that their prices at the factory in the drug market are a function of the marginal cost. We compare the movement of price in the body of this chapter.

A.2 Model 2: Monopolistic Hospital Sets the Price

According to the quantity competition model, decentralized competition in quantity may lead to a negative profit for a firm and they will exit the market. However, in reality, several firms are operating in the market, and a shortage of drugs is hardly heard of in China. On the other hand, if firms are competing in price, equilibrium prices are function of marginal cost. Theoretically speaking, the government's pricing policy does not affect firm's pricing and profit. However, so many firms are complaining at the government's official price reduction. How is the price set in reality? An alternative hypothesis on the pricing mechanism is that buyer has monopolistic bargaining power, offering a price such that the buyer can maximize their profits and the supplier can accept this, and thus the supplier accepts the price.

We will consider the model of a transaction between a hospital (H) and pharmaceutical firm (P). We assume that the hospital has 100 % bargaining power and thus can set the price of purchasing from the pharmaceutical firms. The hospital will set the purchasing price to maximize their profit, $\Pi_H = d\,(v - p)$, where d is the transaction volume of the drug, v is the retail price of the drug from the hospital to the patient, whereas p is the purchasing price from the pharmaceutical firms by the hospital. Furthermore, in China's pharmaceutical industry, the SDRC has set the maximum price as v^{max}. Here we assume that the consumer, the patient, benefits more as the retail price is lowered. Furthermore, the transaction will not take place if the pharmaceutical firms do not accept the transaction offer. We assume that pharmaceutical firms will take this offer as long as their profit is not less than zero, that is, $d(p - c) \geqq 0$, c is the marginal cost of production to guarantee a certain level of quality.

A.2.1 The Normal Goods Market

When hospital demand is normal, that is the hospital prefers a cheaper price for the same quality goods, demand for the drug decreases in relation to the price. Here, we describe this demand nature as follows: $d = \theta - p$. Thus, the hospital will solve the following problem so as to maximize their profit.

$$\text{Max} \quad \Pi_H = (\theta - p)\,(v - p)$$

p,v

subject to: $v^{max} \geqq v$

$d(p - c) \geqq 0.$

In this setting, there is no unique solution to maximize the hospital's profit, but the solution is get at the maximum of v and minimum of p within a range $p \leqq (\theta + v)/2$[6]. Thus, the transaction price between the hospital and pharmaceutical industry, and the retail price between the patient and hospital, and production volume of drugs in equilibrium are:

$$p^*=c,\ v^*= v^{max},\ d^*=\theta - c.$$

Here, profits of the hospital and firms are:

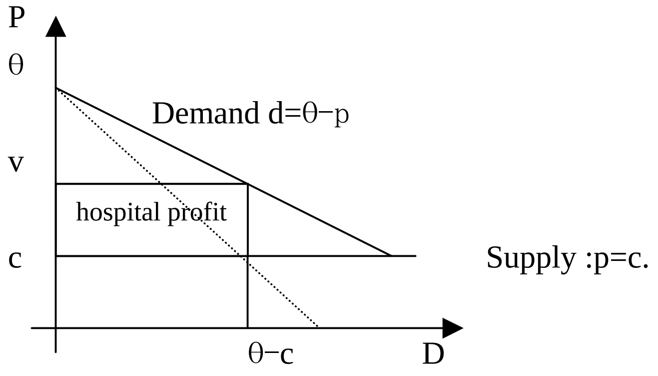
$$\Pi_H{}^* = (\theta - c)(v^{max} - c), \text{ and } \Pi_F{}^* = 0 .$$

In this result, we can see the following properties: (1) the transaction price between the hospital and pharmaceuticals is set at the minimum level of cost for the firms[7]. Here, no rent is left for the pharmaceutical firms and their profit is independent of the maximum retail official price. Thus, a reduction of the official price does not affect the profit of the pharmaceutical firm, so they are neutral regarding the retail price reduction if hospital's drug demand is normal. But its profit is smaller than the case under a "Feeding Hospitals with Drugs" scenario, as we see below. (2) The hospital will set the retail price as high as the retail price cap permits. The retail price cap set by the government is effective in terms of securing a consumer's welfare by keeping the retail price lower, rather than as high as possible, when the hospital has monopolistic power over pricing.

Figure 1: Normal goods demand.

[6] As the hospital profit function is concave to p, or the second derivative is positive, the first order condition of the profit is a minimizer of the profit. p will not take the value larger than $(\theta + v)/2$ as it c cannot be larger than $(\theta + v)/2$, as $c<\theta$, $c<v$.

[7] Here, we assume that marginal costs among firms are identical, different from the price competition model above.



A.2.2 "Feeding Hospital with Drug" or Giffen goods market.

Next, we will consider a case when demand is increasing to price, or "Feeding Hospital with Drug" type demand. We just replace a setting on demand with d = θ + p. Here, Hospital under the "Feeding Hospital with Drug" will solve the following problem:

$$\max_{p,v,} \Pi_H = (\theta + p)(v - p)$$
$$\text{subject to:} \quad v^{max} \geqq v$$
$$d(p - c) \geqq 0.$$

Here, there exist an unique solution to maximize hospital's profit: p= (v- θ)/2if (v-θ)/2≧c which maximizes the marginal revenue of hospital. $v = v^{max}$. Thus, transaction price between hospital and pharmaceutical industry and production volume in equilibrium are

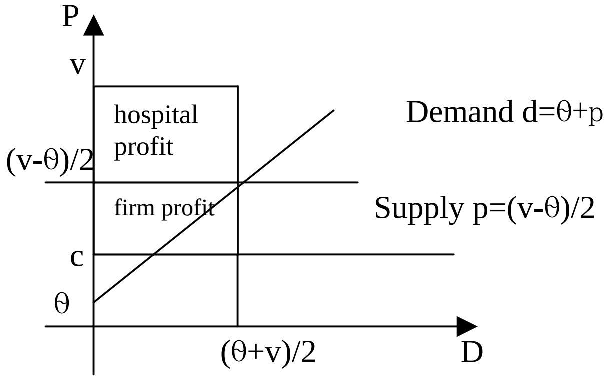
$$p^* = (v^{max} - \theta)/2,\ v^* = v^{max,},\ d^* = (\theta + v)/2\ .$$

Profits of hospital and firms at equilibrium are,

$$\Pi_H = (v^{max} + \theta)^2/4, \text{ and } \Pi_F^* = (v^{max} + \theta)(v^{max} + \theta - 2c)/4.$$

A result here have following properties: (1) hospital's price setting will generate a rent of the pharmaceutical firms, as transaction price p is higher than marginal cost of firms. Pharmaceutical firms can share rent of transaction, in contrast to a case under a normal demand when their profit are zero. The hospitals and firms share rent from high retail price, not constrained to a demand of hospital, as we can see in Figure 2. (2) This transaction price p is a function of retail price v, thus reduction of official retail price reduced profit of the pharmaceutical firms. Therefore, firms are very negative to the policy. (3) Hospital will set retail price as much as high that retail price cap permits. The retail price cap set by the government is effective, again, in terms of securing a certain consumer's welfare by keeping the retail price restraining lower than highest as possible when hospital has monopolistic power in setting price.

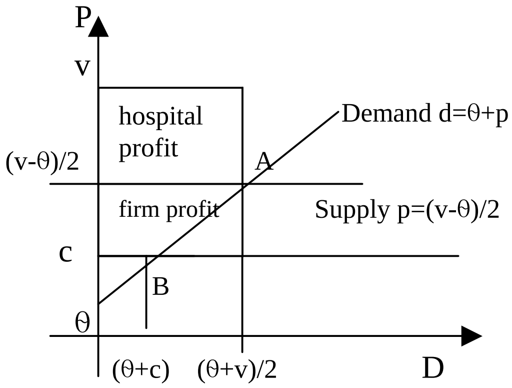
Figure 2: Feeding Hospital with Drug.



Let us compare results on different pricing policies under (1) decentralized price competition (2) contract with monopolistic hospital in both (3) normal and (4) Giffen goods demand market. In Figure 3, we compare pairs of production volume and prices for a case when hospital has 100 per cent bargaining power (Point A), and the other case is price competition (Point B). When firm compete in price in a decentralized way, revenue of firm is smaller than cost of production, thus firm will stop and exit from the market.

This difference mainly comes from that of allocation of decision power: in the former case, hospital, buyer has a monopolistic power to decide volume and price, there is no influence of interaction between suppliers. On the other hand, in the latter case, decision right on entry of market and production was given to the firms, competitive interaction among supplier drastically shrinks production volume, and price is also lowered due to special feature of demand "Feeding Hospital with Drug," thus, supplier cannot help stopping production. It is natural that if number of firms is large, price and production will shrink further, though the model analysis indicates that even only 1 supplier exists in the market, its revenue is smaller than cost.

Figure 3: Decentralized decision under Feeding Hospital with Drug.



A.3 Model 3: Product differentiation under "Feeding Hospital with Drug"

In actual world in the pharmaceutical industry in China, several firms coexist in a market; e.g., foreign R&D base pharmaceuticals and domestic manufacturers, under hospital's monopolistic power. If only price is the factor that determines that market demand, and higher price is preferred to lower one by buyer, monopoly by the highest price supply appears. It is presumable that product differentiation may exist here; quality is also an important factor to determine demand.

Here, we consider a case when the buyer values quality of goods, s, as well as price p. We again assume that buyer prefers higher price (Utility of buyer is higher for higher price of drugs).

$u_i = \theta_i s_j + p_j > 0$ Buy Drug j with quality s_j and price p_j.
$= 0$ Not buy.

When we take quality into consideration, we can see that several products with different price coexist in the market, as we experiences in actual life. We consider a case that there are two buyers: Buyer 1 values higher price for their drug price margin, but do not much care about quality. On the other hand, Buyer 2 values both high quality for medical reason and high price for high drug price margin. There are also 2 kinds of products: $Drug^H$ is high quality and high price, and $Drug^L$ is low quality and high price. In this case, Buyer 2 will definitely buy high-quality-high price drug. However, Buyer 1, who cares less about quality will buy drug under some condition, may buy $Drug^L$ if price is high enough to compensate low evaluation to quality (See Figure 4).

Demand for each drug will become as follows: Buyer will buy drug if its utility

$\theta_i s_j + p_j$ is higher than zero. In the other word, if $\theta_i \geqq -p_j/s_j$ is hold, that is, hospital j whose type index or a taste on price and quality θ_i is larger than a price-quality ratio, $-p_j/s_j$ of Drug j will buy this drug. If we know a ratio of those whose type index is larger than a price-quality ratio of Goods j, we can know size of demand for Goods j by multiplying this ratio to total sales of the market interested. We assume that type θ_i is distributed uniformly between 0 to 1[8], one hospital buy one unit of drug and total number of hospital as D.

Here, we have size of demand for drug j in the total population become

$$D\{ 1-(- p_j/s_j)\}$$ [9].

When demand for a high quality, Drug H, and a low quality Drug L coexist in a market, ratio of demand for these two drugs in a market can be described following in a way above. Demand for two drug in one drug market coexist when $\theta_i s_H + p_H > \theta_i s_L + p_L > 0$. In the other word, a high quality drug H and is demanded by a type group who are in $\theta_i \geqq -(p_H - p_L)/(s_H - s_L)$, lower type of drug is demanded by a type group within $-(p_H - p_L)/(s_H - s_L) \geqq \theta_i \geqq -p_L/s_L$. Here, demand for drug H and drug L become;

$$d_H = D\{ 1- (p_H - p_L)/(s_L - s_H) \} = D\{(p_H - p_L) + \Delta s\}/\Delta s, \quad \text{Demand for Drug H,}$$
$$d_L = D\{ - (p_H - p_L)/(s_L - s_H) - (-p_L/s_L)\} = D(p_L s_H - s_L p_H)/s_L \Delta s, \quad \text{Demand for Drug L.}$$
$$\text{where } \Delta s \equiv s_H - s_L.$$

Total volume of this drug in this market is,

$$d_H + d_L = D(s_L + p_L)/s_L.$$

Figure 5: Different quality goods coexist in a market under "Feeding Hospital with

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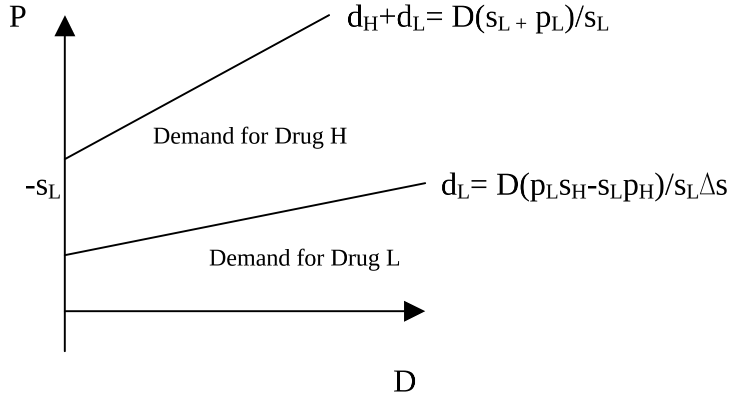
[8] We define s as quality index in a range of $[-\infty, -p]$, then type index is distributed in $0 \leqq \theta_i \leqq 1$ and θ_I is increasing to quality index s. For simplicity to derive solution in this theoretical model, we assume type index θ_I is distributed uniformly. In empirical investigation, this could be a restrictive assumption. In empirics, logistic function, or logit model, is often employed to describe distribution of preference or tasted of buyers.

[9] Type index of those who will buy drug j ranges $-p_j/s_j \leqq \theta_i \leqq 1$. Ratio of population whose taste type is larger than $-p_j/s_j$, $1-F(-p_j/s_j)$, $F(\cdot)$ is a cumulative density function of type index θ. We assumed the type index is distributed uniformly, this ratio of population $1-F(-p_j/s_j) = 1-(-p_j/s_j)$. Total demand for drug j is derived by multiplying this ratio to total population N.

Drug.”



The hospital, a monopolistic buyer we assume again, will solve the following problems and determine prices to purchase[10].

For drug H,

$$\max_{p,v} \quad \Pi_H = D\{ 1- (p_H- p_L)/(s_H - s_L) \}(v_H - p_H)$$

$$\text{subject to:} \quad v_H^{max} \geqq v_H$$

$$d(p_H - c_H) \geqq 0.$$

For drug L,

$$\max_{p,v} \quad \Pi_H = D\{ - (p_H- p_L)/(s_H - s_L)-(-p_L/s_L) \}(v_H - p_H)$$

$$\text{subject to} \quad v_L^{max} \geqq v_L$$

$$d(p_L - c_L) \geqq 0.$$

Prices to maximize the profits of the hospitals[11] are,

$$p_H = \{v_H + p_L -(s_H -s_L) \}/2,$$
$$p_L = \{v_L + p_H s_L /s_H\} \}/2.$$

For suppliers, it is rational to accept the prices offered by the hospital, as they can earn higher profits than by setting the price in a decentralized competition way[12]. Taking into consideration interaction between drug H and drug L in price and demand, price and

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[10] Supplier firms will not compete in price or quantity, but accept the offered price by monopolizing hospital, as they will fall into deficit if the firms compete each other.
[11] Reaction functions of respective firms.
[12] Cournot-type quantity competition.

demand in equilibrium are increasing functions of the cap on the official retail price as follows:

$$p_H^* = (2v_H s_H + v_L s_H - 2s_H \Delta s)/(4s_H - s_L) = p_H(\overset{+}{vH}, \overset{+}{vL}, \overset{+}{sH}, \overset{-}{sL}),$$

$$p_L^* = (2v_L s_H + v_H s_L - s_L \Delta s)/(4s_H - s_L) = p_L(\overset{+}{vH}, \overset{+}{vL}, \overset{+}{sH}, \overset{-}{sL}).$$

Prices of both high-quality and low-quality drugs are increasing functions of retail prices of all products in a market. The larger the differences of taste for quality, the lower the sales prices of high- and low-quality drugs.

Here, the hospital will set as high a retail price as possible,

$$v_H = v_H^{max} \quad \text{and } v_L = v_L^{max}.$$

The total volume of this drug in this market is,

$$d_H + d_L = D(s_L + p_L)/s_L = D\{s_L + (2v_L s_H + v_H s_L - s_L \Delta s)/(4s_H - s_L)\}/s_L.$$