Economic aspects of drug substitution

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One of the major directions of health policy is the attempt to contain expenditures on pharmaceuticals by encouraging substitution of generic for brand name drug products. Yet, a major marketing survey of prescribing and dispensing patterns in California in 1977 found relatively little drug substitution occurring, and in fact substitution of more expensive products occurred more frequently than did substitution of less expensive products.

This article tests alternative models of pharmacy dispensing behavior to better explain substitution patterns and it estimates price functions to measure the extent to which cost savings on generic products are passed on to consumers.

Introduction

Concern over the rising cost of health care services in the United States has encouraged an extensive examination of every sector of the Nation's health care system. Expenditures on drugs and drug sundries reached $22.4 billion in 1982 (Gibson et al., 1983). Although this is a sizeable amount, it is nonetheless small when compared with expenditures for hospital or physician services. However, these expenditures are seen as more amenable to control than some of the larger sectors, and several regulatory and competition-stimulating programs have been instituted at the Federal and State levels of government to reduce drug costs. An important effort to contain the cost of prescription drugs has concentrated on encouraging the substitution of less expensive brands or generic drugs for more expensive brand name drugs. To allow a wider range of substitution to take place, most States have enacted some form of legislation modifying antisubstitution laws which now permit pharmacists to dispense drug products other than those prescribed.

California is one of the States that has amended its antisubstitution law and has actively promoted drug substitution. The purposes of this article are to examine the extent of substitution, the resulting effect on the retail price of drugs, and the degree to which cost savings on less expensive brands or generics are passed on to consumers. In the first section, the origin of prescription drugs and State antisubstitution laws are briefly discussed. In the next section, the observed substitution pattern is examined. The California substitution law requires pharmacists who dispense a different brand or generic drug rather than the brand name version prescribed, to pass on to consumers the resulting cost savings. To evaluate the compliance of pharmacists with the law, econometric models of drug retailing are developed and estimated in the third section of the paper. The findings of the analysis are summarized in the final section of the paper.

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Origin of State antisubstitution laws

In the first 20 years after passage of the Pure Food and Drug Act in 1906, sales of medicinal drugs increased 600 percent. Unlike the situation today, drug marketing was directed primarily at patients rather than the physicians; less than 5 percent of drug advertising was directed at physicians, implying drug product selection was usually made by patients (and perhaps pharmacists) rather than by physicians. Before the Great Depression, about 5 percent of drug sales was obtained directly from physicians and only one-quarter of drug sales from drugstores was prescribed by physicians (Temin, 1979). All nonnarcotic drugs could be purchased without a prescription until 1938, when the Federal Food, Drug, and Cosmetic Act was signed by President Roosevelt. Subsequently, two classes of nonnarcotic drugs—prescription and over the counter—were recognized. The distinction between the two was not precisely made in the 1938 Act but was generally accepted. However, the legality of requiring prescriptions was unsettled until 1951 when the Durham-Humphrey amendment was passed. Since then, physicians have assumed greater responsibility for choosing drug products. This shift has been noted by the pharmaceutical industry which, in 1972, spent $721.8 million promoting drug products (Schwartzman, 1976). New categories of wonder drugs were introduced in the market during the 1940's and 1950's, and the pharmaceutical industry became increasingly concerned about the sale of "bootleg" drugs and counterfeiting. As a result, in 1953 the American Pharmaceutical Association (APhA), the pharmacists' professional association, and the Pharmaceutical Manufacturers Association (PMA) were instrumental in establishing State antisubstitution laws as a means of preventing distribution of drug products that were designed to look like brand-name products but were not, so called, "counterfeiting."

In April of 1970, however, the APhA reversed its stand and advocated repeal of the antisubstitution laws. APhA argued that counterfeiting no longer existed because of stringent Federal control, and that the pricing policies of the drug industry were being designed to take advantage of the antisubstitution laws. Moreover, it was argued, pharmacists were in

Table 1

Drug substitution pattern

Drug category	Substitution in favor of less expensive version		No substitution (dispensed as prescribed)		Substitution in favor of more expensive version	
	Percent	Number	Percent	Number	Percent	Number
All drugs (weighted avg.)	13.5	60	59.0	264	27.5	123
Tranquilizer	21.8	25	47.8	55	30.4	35
Antibiotic	15.7	27	38.4	66	45.9	79
Sulfa-antibiotic	3.6	3	95.1	78	1.3	1
Sulfa-antibiotic, double strength	6.4	5	83.3	65	10.3	8

the best position to judge the quality of drug products and, as they were in direct contact with the sources of supply, could lower the cost of prescription drugs by selective purchasing and dispensing (Report of the Public Affairs Committee, 1970). The PMA, the American Medical Association (AMA), the National Association of Chain Drug Stores (NACDS), and the National Association of Retail Druggists (NARD) all opposed the APhA position. The APhA then changed its strategy and advocated amending, rather than repealing, State antisubstitution laws. By 1980, nearly every State had amended its antisubstitution law. California's antisubstitution law, for example, was amended in 1975 and states that a "...pharmacist filling a prescription order for a drug product prescribed by its trade name or brand name may select another drug product with the same active chemical ingredients of the same strength, quantity, and dosage ...." (California Business and Professions Code, 1975). The amendment continues, "...In no case shall a selection be made pursuant to this section if the prescriber personally indicates, either orally or in his own handwriting, 'Do not Substitute' or words of similar meaning." And "...the person who selects the drug product to be dispensed pursuant to this section shall assume the same responsibility for selecting the dispensed drug product as would be incurred in filling a prescription for a drug product prescribed by generic name. There shall be no liability on the prescriber for an act or omission by a pharmacist in selecting, preparing, or dispensing a drug product.... In no case shall the pharmacist select a drug product pursuant to this section unless the drug product selected costs the patient less than the prescribed drug product." The amendment became effective May 1, 1976.

In 1977, a marketing survey was conducted for the purpose of determining what products were actually dispensed when different types of prescriptions were presented to pharmacists. Prescriptions were written by cooperating physicians for four major categories of drugs—tranquilizer, antibiotic, sulfa-antibiotic, and double-strength sulfa-antibiotic. For drugs in the first category, prescriptions were written either for a generic or for either of two brands. For the second, three brands were included in addition to the generic product. For the last two categories, only two brands of products (no generics) were available. Within each category, the size of each prescription and the dosage of the drug were the same. Substitution within each of the drug categories was allowed because the respective products were generically equivalent. The survey was done in four metropolitan areas of California: Los Angeles, San Diego, San Francisco, and Sacramento. The actual product that was dispensed and the price charged for it were then noted. In the next section, we look at the observed substitution pattern more closely.

Substitution patterns

A pharmacist's decision to stock and dispense drugs that are available from more than one source of supply depends on many factors. These include the legality of substitution, an assessment of the quality of each manufactured version of the drug, the overall reputation of the manufacturer, the acquisition and inventory cost, the consumer's ability to pay, the third-party reimbursement policy, the degree of competition in the market in which the pharmacy is located, and the consumer's and pharmacist's attitude toward substitution. Therefore, the substitution decision is complex and cannot necessarily be predicted on the basis of a single factor variable.

Table 1 shows the substitution pattern for the four categories of drugs included in the marketing survey. Pharmacists had the opportunity to substitute within each category if they chose to do so.

The data show that the rate of dispensing less expensive brands and generic drugs for more expensive brands is low, below 14 percent of all sampled prescriptions. How can such dispensing patterns be explained, especially in the light of the clear mandate given pharmacists to substitute the less expensive (especially generic) versions of drugs for more expensive brands? In order to better understand this behavior, we hypothesize and test alternative behavioral decisions on the part of pharmacists. We assume that pharmacies (as other firms) optimize some set of profit-enhancing variables, and so in the following section we will examine various hypotheses about possible objective functions. We begin with the hypothesis that pharmacies maximize their profit margin as they decide what to dispense.

Table 2

Price, cost, profit margin, and absolute profit per prescription

Drug category	Cost *(CD)*	Price *(PR)*		Percent of profit margin *PM = (PR-CD)/CD*		Amount of absolute profit *AP = PR-CD*	
		Chain	Independent	Chain	Independent	Chain	Independent
Tranquilizer							
Brand A	$3.53	$6.17	$6.97	75	98	$2.64	$3.44
Brand B	1.90	4.35	5.06	129	166	2.45	3.16
Generic G	0.93	4.03	4.97	333	435	3.10	4.04
Antibiotic							
Brand A	6.23	10.07	10.64	62	71	3.84	4.41
Brand B	6.05	10.72	10.65	77	76	4.67	4.60
Brand C	5.99	9.20	10.39	54	73	3.21	4.40
Generic G	4.20	9.65	9.66	130	130	5.45	5.46
Sulfa-Antibiotic							
Brand A	8.40	12.81	13.34	52	59	4.41	4.94
Brand B	7.80	11.74	13.33	51	71	3.94	5.53
Sulfa-Antibiotic, double strength							
Brand A	7.22	11.09	11.65	54	61	3.87	4.43
Brand B	6.50	9.44	10.88	45	67	2.94	4.38

Maximum profit margin hypothesis

This hypothesis suggests that a pharmacy would dispense the drug product with the highest profit margin *(PM)* whenever possible, within the limits of ethical standards, legal procedure, and generally accepted business practice. Profit margin is defined as:

$PM_i = (PR_i - CD_i)/CD_i$

PR_i = dispensed price of the ith drug

CD_i = acquisition cost of the ith drug dispensed

Price was observed directly in the marketing survey, but the acquisition cost of each drug product was not. In this study we estimate it by the mean drug acquisition cost reported by the Health Care Financing Administration, which administers the Maximum Allowable Cost (MAC) Program for drug reimbursement for the Department of Health and Human Services. The MAC cost estimates are not pharmacy specific, but they are the best available reasonably accurate estimates of wholesale costs that pharmacies face. The use of national average acquisition cost may overstate acquisition cost of chain pharmacies while understating it for independent pharmacies. This bias, to the extent that it exists, should apply to all products, whether low or high cost, generic or brand name, and so differences in estimated profitability between drug products will not be affected. Differences in profitability across pharmacy type, chain versus independent, however, may be affected.

The average price *(PR)*, acquisition cost *(CD)*, and profit margin *(PM)* for the four categories of drugs are reported in Table 2 for chain and independent pharmacies (chain pharmacies refer to the pharmacies that operate in more than one location). The observation of low rates of substitution in favor of less expensive products in Table 1 would seem to contradict the maximum profit margin hypothesis, because the profit margin for less expensive brand versions and especially generic drugs is in fact much higher than that for more expensive brand name drugs. This is generally true even though drug acquisition costs vary from one pharmacy to another.

A test of the significance of the difference between the average profit margin, *PM*, of different drugs, brand versus generic, was made. Because there are more than two versions of the drugs in the first two categories, tranquilizer and antibiotic, more than one comparison had to be made within those categories. Therefore, to test the hypothesis that profit margin of generic drugs was greater than that of brand name versions, a simultaneous multiple technique was used (Dunn and Clark, 1974). The average profit margin of generic drugs is significantly larger than that of each of the brand name drugs (and their average). The differences are statistically significant at the 1-percent level. The *"t"* statistics are reported in Table 3. Therefore the profit margin hypothesis cannot explain the substitution pattern observed in Table 1.

Maximum absolute profit hypothesis

There are two shortcomings with the maximum profit margin hypothesis. First, it assumes that pharmacists face a perfectly inelastic demand for prescription drugs. Second, maximizing the profit margin (profit rate) would maximize total profit if pharmacies could influence the demand for each category of drugs through their dispensing pattern by,

Table 3

Test of significance of profit margin (PM) and absolute profit (AP)

Null hypothesis				"t" Statistics: Chain	"t" Statistics: Independent
Profit margin					
Tranquilizer					
	PM_G	=	PM_A	[1]12.48	[1]14.79
		=	PM_B	[1]4.81	[1]5.40
		=	$\frac{1}{2}PM_A + \frac{1}{2}PM_B$	[1]10.42	[1]12.62
Antibiotics					
	PM_G	=	PM_A	[1]5.68	[1]4.21
		=	PM_B	[1]3.51	[1]4.48
		=	PM_C	[1]5.09	[1]2.82
		=	$\frac{1}{3}PM_A + \frac{1}{3}PM_B + \frac{1}{3}PM_C$	[1]4.83	[1]4.51
Sulfa-antibiotics					
	PM_A	=	PM_B	0.33	1.43
Sulfa-antibiotics, double strength	PM_A	=	PM_B	1.11	0.81
Absolute profit					
Tranquilizer					
	AP_G	=	AP_A	1.15	2.00
		=	AP_B	1.52	1.76
		=	$\frac{1}{2}AP_A + \frac{1}{2}AP_B$	1.30	2.24
Antibiotics					
	AP_G	=	AP_A	[2]2.28	1.49
		=	AP_B	0.88	1.43
		=	AP_C	[2]2.54	1.06
		=	$\frac{1}{3}AP_A + \frac{1}{3}AP_B + \frac{1}{3}AP_C$	1.87	1.62
Sulfa-antiblotic					
	AP_A	=	AP_B	0.96	0.87
Sulfa-antiblotic, double strength					
	AP_A	=	AP_B	1.79	0.09

[1]Significant at 1 percent level.
[2]Significant at 5 percent level.

for example, increasing the total number of prescriptions written for each category of drug. But physicians determine the total number of prescriptions written for each category of drug, and so it is the absolute profit, AP, instead, which might be maximized with AP defined as $AP_i = PR_i - CD_i$.

To remedy the later problem a new version of profit maximization hypothesis is developed. According to this version, pharmacies dispense drug products with the highest absolute profit whenever possible in order to maximize their total profit. Absolute profits are reported in Table 2 for the four categories of drugs. Although the absolute profit of generic drugs is higher than that for brand products, the difference was not statistically significant at the 1-percent significance level. The "t" statistics are reported in Table 3. All of the t-statistics for differences in absolute profit, AP, are insignificant at the 1-percent level. The contrast with the t-statistics for the profit margin, PM, is striking. Thus the absolute profit version of the profit maximization hypothesis cannot be rejected and the observed dispensing pattern is shown to be consistent with the absolute profit maximization hypothesis.

Minimizing inventory cost

When a pharmacist dispenses a drug, the choice as to which version of the product is to be dispensed has, in one respect, already been made. What is dispensed is limited to what is in stock. Inventory costs are one of the factors that influence pharmacies' dispensing patterns. In a State with antisubstitution laws, maintaining a large inventory would be mandatory for pharmacies in order to avoid losing sales for multiple-source products, but maintaining an inventory that includes a large number of different versions of the same drug product is costly.

If substitution is allowed, pharmacies have the chance to store fewer versions of products, maybe only one version, and reduce inventory cost substantially. Reduction in inventory costs because of substitution was noted by Coward (1976) in his study of Michigan pharmacies. The average saving to the patient was $2.09 per prescription. The argument

for the existence of economies of scale in storing and dispensing drug products is supported by Cady (1975). The design of the sample in the marketing survey, however, does not allow us to test this hypothesis.

Pricing behavior

It has been widely argued that prescribing and dispensing generics has a vast saving potential for consumers (Borok and Schweitzer, 1979). The Federal Trade Commission (1979) staff estimated that total savings at the wholesale level could have been $817 million in 1977 had subsitution possibilities been fully utilized and the lowest price generic products substituted for all brand name prescriptions written. In a study of drug substitution in Michigan, Goldberg (1978) reported a saving of 65¢ per generic drug written and dispensed. However, when prescriptions were written for brand name products but generic products were dispensed, the saving per prescription was $1.14.

In this section, different pharmacy pricing formulae, or models, are estimated in order to examine the influence of the substitution laws. The pricing formulae are then used to test the hypothesis that pricing is different when a substitute drug is dispensed than when the ordered drug is dispensed. Further, one can use these pricing formulae to examine the extent to which potential savings are passed on to consumers.

We assume that the supply of each and every drug to each and every pharmacy is perfectly elastic, that is, the acquisition cost of all drugs is fixed and is the same for all pharmacies. The total amount of demand, that is, the number of prescriptions written for each and every category of prescribed drug (e.g., antibiotics), is exogenously determined by physicians. Pharmacies can substitute within drug categories, but not across categories. However, consumers are price sensitive and, therefore, there will be competition among pharmacies. The competition among pharmacies, chain versus independent, would influence their pricing behavior and is reflected in the professional fee and the markup.[1]

The difference in acquisition cost *(DAC)* of what was ordered and what was dispensed, could be positive (substitution in favor of a less expensive product), zero (no substitution), or negative (substitution in favor of a more expensive product). *DAC* could also affect the professional fee and the markup.

[1]The professional fee is a flat dispensing fee charged by the pharmacy, regardless of prescription size and/or cost. The markup, on the other hand, is the difference between the cost and sales price of an item, excluding the professional fee, calculated as a percent of the cost.

This leads us to the following model:

$$(1)\ PR_{ijk} = a_0 + a_1 D1 + a_2 D2 + a_3 D3 + a_4 CD_{ik} + a_5 CD_{ik} \cdot D1 + a_6 CD_{ik} \cdot D2 + a_7 CD_{ik} \cdot D3 + u_{ijk}$$

$D1$ = 1 if $DAC > 0$ (substitution in favor of less expensive drug)
= 0 otherwise
$D2$ = 1 if $DAC < 0$ (substitution in favor of more expensive drug)
= 0 otherwise
$D3$ = 1 for independent pharmacy
= 0 for chain
i = drug (as defined earlier)
j = type of pharmacy (chain or independent)
k = observation
$E(u_{ijk})^2 = \sigma_{ij^2}$ and $E(u_{ijk}\, u_{ijk}) = 0$

The coefficients a_0, a_1, a_2, and a_3 define the professional fee under different circumstances, and a_4 through a_7 define the markup. The above model allows us to test several interesting hypotheses. Do pharmacies charge a professional fee and/or markup? Are professional fees and/or markups affected by the decision to substitute? And finally, do independent pharmacies charge higher professional fees and/or markups?

An examination of the data provided by the survey suggested the presence of heteroskedasticity in the model with the variances of the error term u_{ijk} not being equal across all settings and drugs. Use of Bartlett's test (Intriligator, 1978) confirmed our suspicion, because the value of chi-square was 78.46 which is significant at the 1-percent level. Bartlett's test for nonhomogeneity of variances, Q/L, has a chi-square distribution with P-1 degree of freedom.

$$Q = n \log \sum_{i=1}^{P} \frac{n_{ij}}{n} S_{ij}^2 - \sum_{i=1}^{P} n_{ij} \log S_{ij}^2$$

$$L = 1 + \frac{1}{3(P-1)} \left(\sum_{i=1}^{P} \frac{1}{n_{ij}} - \frac{1}{n} \right)$$

n = total sample size
n_{ij} = sample size of ith drug and jth type of pharmacy
S_{ij}^2 = estimated variances of ith drug and jth type of pharmacy
P = number of variances compared.

This implies that the use of ordinary least squares yields inefficient estimators. To estimate equation 1 in the presence of heteroskedasticity, the residuals obtained from the first round of ordinary least squares estimates (column 1 in Table 4) are used to estimate variances, σ_{ij}^2. The estimate of variances is then used as weights to estimate equation 1 in a second round using weighted least squares (Kmenta, 1971). The iterative procedure was discontinued

when the estimates converged after the seventh round of estimation. The final round estimates are reported in the second column of Table 4.

The final results of equation 1, when simplified, are presented in Table 5 (Part A). These results confirmed several hypotheses. First, pharmacies do charge a professional fee ($2.28) as well as a markup, and the professional fee is 81¢ higher for independent pharmacies ($3.09) than for chains. This could be attributed to a wider range of services generally provided by independent pharmacies or to economies of scale enjoyed by chains. The markup charged by independent pharmacies is 4 percent lower than that charged by chains, however, the difference in the markup is not statistically significant. If the common acquisition cost assumption introduces a bias, as discussed earlier, the observed difference in markup between pharmacy types will be understated, and the difference between professional fees will be overstated. These biases, however, will be small. Second, the professional fee and the markup are both affected by the decision to substitute. The professional fee and the markup increase by 73¢ and 2 percent respectively, as pharmacies substitute in favor of less expensive drugs, e.g., generics. The finding is consistent with the findings of Schwartzman (1976) who reported higher markups for generic dispensing. When pharmacies substitute in favor of more expensive drugs the professional fee drops by 88¢ but the markup increases by 18 percent. As long as the difference in price of what is ordered and what is dispensed is less than $4.90, the net effect is a reduction in price of drug dispensed.

Table 4

Estimates of equation 1

Coefficient	(1) Ordinary least squares	(2) Weighted least squares	(3) Ordinary least squares	(4) Weighted least squares
a_0	[1]2.48 (0.40)	[1]2.28 (0.18)	[1]2.19 (0.37)	[1]2.01 (0.15)
a_1	0.78 (0.50)	[2]0.73 (0.34)	[2]1.04 (0.48)	[1]0.96 (0.34)
a_2	[1]-1.40 (0.67)	[1]-0.88 (0.30)		
a_3	0.62 (0.46)	[1]0.81 (0.29)	0.67 (0.46)	[1]0.86 (0.29)
a_4	[1]1.20 (0.06)	[1]1.23 (0.04)	[2]1.24 (0.06)	[1]1.27 (0.03)
a_5	0.02 (0.10)	0.02 (0.08)	-0.02 (0.10)	-0.02 (0.08)
a_6	[2]0.26 (0.12)	[1]0.18 (0.06)		
a_7	0.01 (0.08)	-0.04 (0.06)	0.01 (0.08)	-0.04 (0.06)
F	160	387	222	515
R^2	0.712	0.861	0.716	0.854

[1]Significant at 1 percent level.
[2]Significant at 5 percent level.
Note: Numbers in parentheses are standard errors.

It might be argued that the only legitimate form of substition is the substitution of less expensive drugs for more expensive ones. To investigate this, Equation 1 is reestimated using the same technique as before, with all the cases for which substitution was in favor of more expensive drugs treated as no substitution. The results are reported in Columns 3 and 4 of Table 4 and are summarized in part B of Table 5.

The findings do not change, as the professional fee is observed to be 86¢ higher in independent pharmacies than in chain pharmacies, and is 96¢ higher when pharmacies substitute in favor of less expensive drugs. The markup is 4 percent lower for independent pharmacies than for chains and is 2 percent lower when substitution takes place. However, these differences are not statistically significant.

Now we turn to the question of potential savings to consumers. The California substitution law states "... the pharmacist shall pass on to the purchaser the difference in the acquisition cost between the drug product prescribed and the drug product dispensed, exclusive of the pharmacist's professional fee. The pharmacist may not charge a higher or different professional fee for the generic drug product dispensed than that charged for the brand name product prescribed" (California Business and Professions Code, 1975). Although the law is specific about the professional fee, it does not mention anything about the markup. Therefore, pricing of the drugs, in case of substitution, and the amount of "saving" that should be passed on to the purchaser are left unspecified.

Table 5

Estimates of professional fees and markups: Equation 1

Substitution pattern	Amount professional fee		Percent markup	
	Chain	Independent	Chain	Independent
Part A				
No substitution	$2.28	$3.09	23	19
Substitution in favor of less expensive drugs	3.01	3.82	25	21
Substitution in favor of more expensive drugs	1.40	2.21	41	37
Part B				
No substitution	2.01	2.87	27	23
Substitution in favor of less expensive drugs	2.97	3.83	25	21

Note: Markup is the related coefficient minus 1.

The first interpretation of the law is that pharmacies should maintain the same pricing formula regardless of whether or not substitution is made. In such case $D1$ and $D2$, substitution dummy variables, are discarded from equation 1. Thus, if a generic drug is substituted for a brand name product, the pharmacist should price that generic product at

Figure 1
Pricing formula: Equation 1

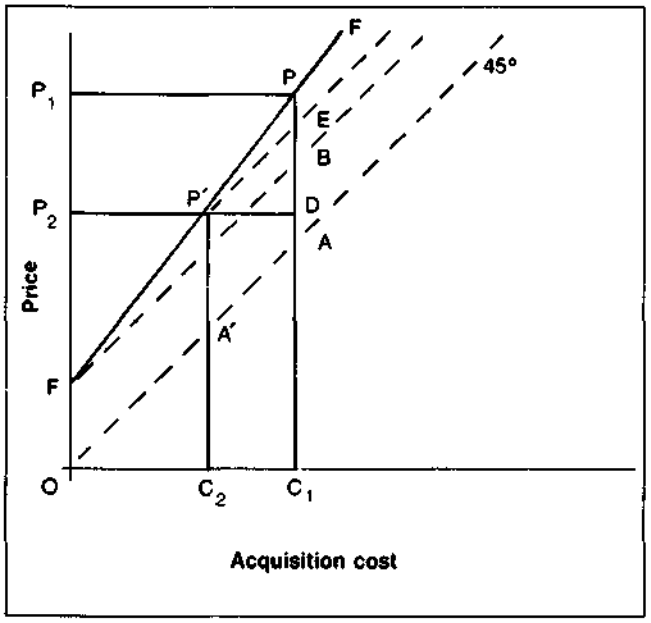
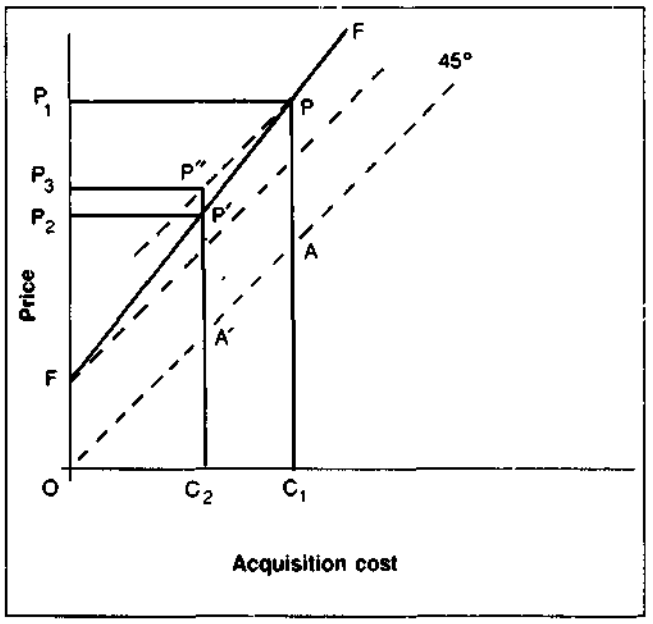


Figure 2
Pricing formula: Equation 2



the same cost as if it were a brand name product. This is shown in Figure 1. *FF* represents the single pricing formula used by a pharmacist to price drug products regardless of the kind of drug dispensed, brand or generic, and the nature of substitution made. For example, a drug that costs the pharmacists OC_1 will be priced OP_1. The price charged has two components $C_1A(=OC_1)$ the acquisition cost and *AP* the absolute profit made by pharmacists. *AP* in turn has two components, $AB(=OF)$ the professional fee and *BP* the amount of markup. However, if pharmacists substitute a different product, say a generic product, that costs only OC_2, then its price would be OP_2, using the same pricing formula *FF*. The saving that will be passed on to the consumer from substitution is P_1P_2 which is equal to sum of *DE* ($=P'D=C_2C_1$), the difference in acquisition cost, and *EP*, a part of markup that now is passed on to the consumer. The absolute profit made by pharmacists will be *AP*, which is smaller than *AP* as shown in Figure 1. In terms of equation 1, the price, *PR*; the savings that should be passed on to consumer, *S*; and absolute profit made per prescription, *AP*, will be:

$$PR = a_0 + a_3D3 + a_4CD + a_7CD \cdot D3$$

$$S = (a_4 + a_7D3)DAC$$

$$AP = a_0 + a_3D3 + (a_4 + a_7D3 - 1)CD$$

where *CD* is the acquisition cost of the drug dispensed.

Our findings are inconsistent with such an interpretation of the law by pharmacies. Our estimates of equation 1 indicate that both the professional fee and the markup are significantly affected by the decision to substitute (column 2 of Table 4). When substitution is defined as substitution in favor of less expensive drugs (column 4 of Table 4), then only the professional fee is significantly affected by the decision to substitute.

The second interpretation of the law is that pharmacies are allowed to keep constant the amount of absolute profit they make (presumably at the brand name level), and pass on to the consumer only the difference in acquisition cost.

In this case, the difference in acquisition cost of what is ordered and what is dispensed, *DAC*, enters directly into the pricing formula. We continue to make the same assumption about the pricing formula as in the case of equation 1. This leads to the following pricing formula.

$$(2)\ PR_{ijk} = b_0 + b_1CD_{ik} + b_2DAC_k + b_3D3 + b_4\,CD_{ik} \cdot D3 + b_5DAC_k \cdot D3 + u_{ijk}$$

$$E(u_{ijk})^2 = \sigma_{ij}^2$$

$$E(u_{i'j'k'}) = 0$$

DAC, a continuous variable measured in dollars, is used instead of *D*1 and *D*2, the two dummy variables in model 1, in order to take into account the substitution decision and to facilitate the test of the hypothesis concerning our second interpretation of the law. This case is shown in Figure 2. *FF* represents

Table 6

Estimates of equation 2

Coefficient	(1) Ordinary least squares	(2) Weighted least squares	(3) Ordinary least squares	(4) Weighted least squares
b_0	[1]2.62	[1]2.17	[1]2.32	[1]2.04
	(0.35)	(0.13)	(0.38)	(0.16)
b_1	[1]1.20	[1]1.27	[1]1.23	[1]1.27
	(0.06)	(0.03)	(0.06)	(0.03)
b_2	0.30	[1]0.32	0.35	[2]0.42
	(0.13)	(0.09)	(0.34)	(0.21)
b_3	0.69	[1]1.11	0.45	[2]0.79
	(0.46)	(0.26)	(0.51)	(0.31)
b_4	0.01	-0.07	0.04	-0.02
	(0.08)	(0.05)	(0.08)	(0.06)
b_5	-0.05	-0.10	0.37	0.18
	(0.16)	(0.12)	(0.40)	(0.28)
F	219	594	220	514
R^2	0.714	0.871	0.714	0.854

[1]Significant at 1 percent level.
[2]Significant at 5 percent level.
Note: Numbers in parentheses are standard errors.

the pricing formula used by a pharmacist when drug products are dispensed as ordered. As in the previous case, a drug product that is dispensed as ordered and which costs the pharmacist OC_1 will be priced OP_1. However, if a substitution is made to a generic product that costs the pharmacy OC_2, the generic product dispensed would be priced in such a way that the absolute profit made by the pharmacist remains constant, and so the generic drug will be priced OP_3. The absolute profit made by a pharmacist will be $A'P''$, equal to AP, the absolute profit made by a pharmacist if the brand name product ordered had been dispensed.

The savings that will be passed on to the consumer will be P_1P_3, which is less than P_1P_2, the savings that would have been passed on to the consumer if the pharmacist had used the same pricing formula, FF.

In terms of equation 2, price PR; the savings that should be passed on to the consumer, S; and the absolute profit made per prescription, AP, will be

$$PR = b_0 + b_1CD + b_2DAC + b_3D3 + b_4CD \cdot D3 + b_5DAC \cdot D3$$

$$S = (b_1 - b_2)\, DAC + (b_4 - b_5)DAC \cdot D3$$

$$AP = b_0 + b_3D3 + (b_1 - b_2 + b_4D3 - b_5D3 - 1)CD + (b_2 + b_5D3)\, CO$$

when CO is the acquisition cost of the drug ordered.

The constant profit hypothesis, our second interpretation of the law, requires that $(b_1\text{-}b_2 + b_4D_3\text{-}b_5D3\text{-}1) = 0$.

Equation 2 is estimated using weighted least squares, as in equation 1. The results are reported in columns 1 and 2 of Table 6 and are summarized in part A of Table 7.

The results confirm the previous findings about the existence of a professional fee as well as a markup and that independent pharmacies charge a higher professional fee, $1.11. Although the markup by independent pharmacies is 1 percent lower than that of chain pharmacies, their indirect markup, the coefficient of DAC in equation 2, is 10 percent higher. But neither of these differences in the markup are statistically significant. Therefore, it is indeterminant as to which type of pharmacies pass on a greater portion of acquisition cost savings when substitution takes place.

Our second interpretation of the law, the constant profit hypothesis, as discussed earlier, implies $b_1\text{-}b_2 = 1$ for chains and $(b_1 + b_4) - (b_2 + b_5) = 1$ for independent pharmacies. To test this hypothesis we used an F test for the difference of coefficients estimated from weighted least squares. The results indicate that the constant profit hypothesis could be maintained for both chain and independent pharmacies because the values of the F statistics were 0.44 and 0.04, respectively. The hypothesis that the difference in the markup and indirect markup is equal to 1 was not rejected.

In short, estimates of the pricing formula suggest that pharmacies do price drugs differently when a substitution is made and that pricing aims to maintain a constant absolute profit. It appears that differences in acquisition cost of drug products ordered and dispensed are passed on to consumer.

As we did for equation 1, we next estimated equation 2 setting all differences in acquisition costs for cases in which substitution in favor of a more expensive drug was made to zero. Results are reported in columns 3 and 4 of Table 6 and summarized in part B of Table 7. Our conclusions about the professional fee and markup do not change. However, the F statistics to test the constant profit hypothesis becomes significant, at a 1-percent level, 4.02 and 4.62 for chain and independent pharmacies respectively, suggesting that the constant profit hypothesis should be rejected. The relative size of the coefficients indicate that pharmacies pass on to consumers an amount less than the difference in the acquisition costs of drug product ordered and drug product dispensed, when "substitution" is defined as dispensing only lower cost products.

Table 7

Estimates of professional fees and markups: Equation 2

Substitution pattern	Amount professional fee		Percent markup		Percent indirect markup	
	Chain	Independent	Chain	Independent	Chain	Independent
Part A						
No substitution	$2.17	$3.28	27	26	0.00	0.00
Substitution	2.17	3.28	27	26	0.32	0.22
Part B						
No substitution	2.04	2.83	27	25	0.00	0.00
Substitution	2.04	2.83	27	25	0.42	0.60

Note: Markup is the related coefficient minus 1.

Conclusions

Attempts to contain the costs of prescribed drugs have taken many forms, one of which is the stimulation of market competition for drugs on which protection has expired. Actual savings realized by this policy have been far less than initially expected for a number of reasons, including the relatively low rate of substitution.

In an attempt to explain low rates of substitution for a sample of drugs frequently used among California pharmacies, alternative models of economic behavior and profit maximization were tested. The drug substitition issue is complex, involving not only physician preferences for different brands or generic products, but pharmacist cooperation in an area that threatens professional prerogatives and economic performance. A frequently cited reason for the reluctance of both physicians and pharmacists to prescribe and dispense generic drugs is the concern over lack of appropriate safeguards on the quality and efficacy of different products. This concern must be addressed in order for drug substitution to expand to the point of offering substantial cost savings in the health system.

This complexity led us to examine a number of economic models in an attempt to explain observed substitution patterns. If pharmacies sought to maximize the profit margin, they would have substituted more than observations indicated. Observed patterns of dispensing do appear consistent with the hypothesis that pharmacies attempt to maximize absolute profit per prescription, which may be consistent with overall profit maximization under the assumption that the demand for the product is determined exogeneously by the physician rather than by the pharmacy itself. Consistent with this notion is the recognition that inventory costs may play an important role in pharmacist decisionmaking because multiple-source drugs are generally available in a large number of forms, making a full inventory of all available versions of the same drug impractical.

Our analysis of the pricing formula gives useful insights into the pricing decision of pharmacists, with regard to the use of a professional fee, as opposed to an ordinary percentage markup, and the relationship between profit margin and acquisition cost. The professional fee tends to be higher in independent pharmacies than in chain pharmacies, but the markup is the same across pharmacy type. Both the professional fee and the markup are higher when a substitution is made in favor of a less expensive product, so that the absolute profit produced by dispensing a brand-name or generic drug is the same. The highest fee appears to be charged by independent pharmacies when they substitute, and the lowest by chain pharmacies dispensing as ordered.

Whether or not savings as a result of substitution are passed on to consumers is a more difficult question than might be presumed because there are many definitions of "savings." Our finding indicates that pharmacists do price drugs differently when substitution is made. Furthermore, we observe that the professional dispensing fee associated with substitution in favor of less expensive products in general, and generic products in particular, exceeds that for brand-name drugs. What does appear to be the case, however, is that substitute drugs are priced so as to yield approximately the same absolute profit, and so the cost differentials associated with the substitute drugs are largely passed on to consumers.

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