

Drug utilization: consequences and causes

Frank R. Lichtenberg

Columbia University and
National Bureau of Economic Research

frank.lichtenberg@columbia.edu

Presented at
Centre for Strategic Economic Studies, Victoria University
Melbourne, March 2007

Drug utilization: consequences and causes

Consequences of using (newer) drugs

- impact on longevity and medical expenditure of Americans
- impact on longevity of Australians

Causes of drug utilization (in the U.S.)

- Medicare Part D
- Patent expiration

**The impact of new drugs on
U.S. longevity and medical
expenditure, 1990-2003:
evidence from longitudinal, disease-level data**

forthcoming,
American Economic Association Papers and Proceedings,
May 2007

Equipment-embodied technical progress

- A number of econometric studies (Charles R. Hulten (1992), Byong-Hong Bahk and Michael Gort (1993), Plutarchos Sakellaris and Daniel J. Wilson (2004)) have investigated the hypothesis that capital equipment employed by U.S. manufacturing firms embodies technological change, i.e. that each successive vintage of investment is more productive than the last.
- Equipment is expected to embody significant technical progress due to the relatively high R&D-intensity of equipment manufacturers.
- The method that has been used to test the equipment-embodied technical change hypothesis is to estimate manufacturing production functions, including (mean) vintage of equipment as well as quantities of capital and labor.
- These studies have concluded that technical progress embodied in equipment is a major source of manufacturing productivity growth.

Pharmaceutical-embodied technical progress

- Embodied technical progress may also be an important source of economic growth in health care.
- One important input in the production of health—pharmaceuticals—is even more R&D-intensive than equipment.
- According to the NSF, the R&D intensity of drugs and medicines manufacturing is 74% higher than the R&D intensity of machinery and equipment manufacturing.
- Therefore, it is quite plausible that there is also a high rate of pharmaceutical-embodied technical progress.
- This study examines the effect of changes in the vintage distribution of prescription drugs on U.S. longevity and medical expenditure during 1990-2003.

Econometric model

Estimate the following model, using longitudinal disease-level data:

$$(1) \quad \ln Y_{it} = \beta X_{it} + \alpha_i + \delta_t + \varepsilon_{it}$$

Y_{it} is a measure of mortality or healthcare utilization, for medical condition (disease) i in year t

X_{it} is a measure of prescription drug vintage

Difference-in-differences model

- Since the model includes condition and year fixed effects, it is a difference-in-differences model.
- Negative and significant estimates of β would indicate that conditions with above-average increases in prescription drug vintage had above-average declines (or below-average increases) in mortality and hospitalization.

Weighted least-squares

Eq. (1) will be estimated via weighted least-squares (WLS), where the weight is equal to

$$Y_i = (1 / T) \sum_t Y_{it}$$

Since the dependent variable is $\ln Y_{it}$, and the model includes fixed condition effects, we are in effect analyzing percentage deviations from condition means.

Low-mean conditions exhibit much more volatility (noise) than high-mean conditions, so it is appropriate to give more weight to the percentage deviations from high-mean conditions.

Sample period

- We will use data on mortality during the period 1990-2002, and data on healthcare utilization (hospital discharges) during the period 1993-2003.
- We have prescription drug data for the years 1996-2003, but can impute values of prescription drug vintage in earlier years (1990 and 1993).

Two estimation methods

- There are two different ways to estimate eq (1).
- One is to use data for all available years (1990 and 1996-2002 for mortality, 1993 and 1996-2003 for healthcare utilization).
- However, since the disturbances of eq. (1) are likely to exhibit serial correlation, the standard errors of WLS estimates based on (nearly) annual data are likely to be underestimated.

Long-difference model

The second approach is to estimate eq. (1) just using data for the first and last years of the sample period ($t = 1$ and $t = T$, respectively). This is equivalent to estimating the “long-difference” model:

$$\ln Y_{iT} - \ln Y_{i1} = \beta (X_{iT} - X_{i1}) + (\delta_T - \delta_1) + (\varepsilon_{iT} - \varepsilon_{i1})$$

Measures of mortality & healthcare utilization

Y_{it} is one of the following measures of mortality or healthcare utilization:

- $LYL65_{it}$: Years of potential life lost before age 65 due to condition i in year t
- $LYL75_{it}$: Years of potential life lost before age 75 due to condition i in year t
- $HOSP_TOT_{it}$: Number of hospital admissions (or discharges) due to condition i in year t
- $HOSP_LTC_{it}$: Number of hospital discharges to other institutions (nursing homes, rehab facilities) due to condition i in year t
- $HOSP_DEAD_{it}$: Number of hospital stays in which the patient died due to condition i in year t

Measures of prescription drug vintage

X_{it} is one of the following measures of prescription drug vintage:

- $POST1990_{it}$: the percent of prescriptions used to treat condition i in year t that contained active ingredients approved by the FDA after 1990
- $POST1993_{it}$: the percent of prescriptions used to treat condition i in year t that contained active ingredients approved by the FDA after 1993

Disease classification

- The disease classification we use is the International Classification of Diseases 10th Revision 113 Cause-of-Death classification (<http://www.nber.org/mortality/2002/docs/113cause.txt>).
- Some of the 113 causes are subtotals of other causes. We excluded these subtotals; the classification we used contained 92 non-overlapping diseases.

Mortality data

- Data on LYL65 and LYL75 were computed from the [Multiple Cause-of-Death Mortality Data](#) from the [National Vital Statistics System](#) of the [National Center for Health Statistics](#).
- Each record in the microdata is based on information abstracted from death certificates filed in vital statistics offices of each State and District of Columbia.
- Causes of death were coded according to the International Classification of Diseases, Ninth Revision 1991-1998 and the Tenth Revision 1999 on.
- The average number of records (deaths) per year is about 2.3 million.

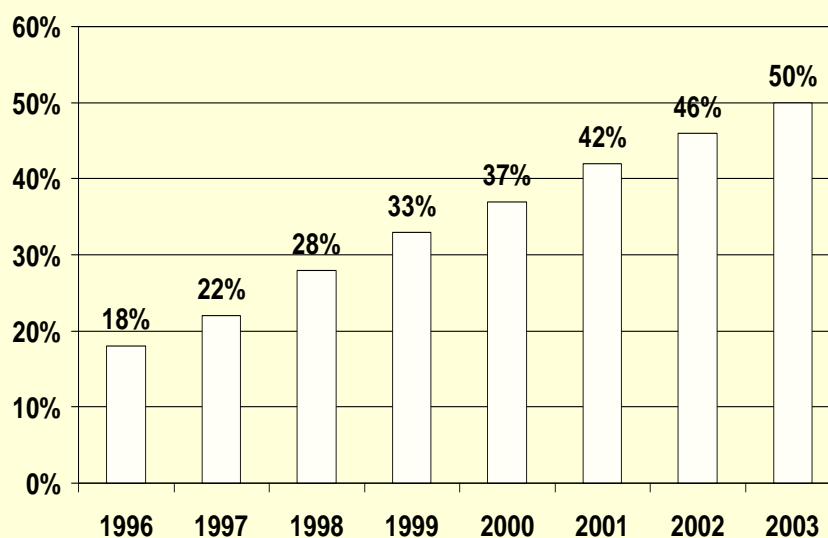
Hospital discharge data

- Annual data on hospital discharges, by cause, 1993-2002, were obtained from HCUPnet (<http://www.ahrq.gov/HCUPnet/>).
- HCUPnet reports the total number of discharges, as well as the number of patients discharged to nursing homes and the number discharged dead.
- We obtained data on the number of discharges by *principal* diagnosis—the condition that is the chief reason for the hospital stay, as determined after evaluation during the stay—rather than by *all-listed* diagnoses, which include all diagnoses that coexist at the time of admission and that develop during the stay.
- Discharge status (e.g. whether the patient was discharged to a nursing home) cannot be determined for all-listed diagnoses from HCUPnet.

Prescription drug data

- Data on prescribed medicines used to treat condition i in year t ($t = 1996-2003$) were obtained from the Medical Expenditure Panel Survey (<http://www.meps.ahrq.gov/>) Prescribed Medicines Files.
- Each record in these files contains a National Drug Code (NDC) and the total amount paid for the prescription by all payers.
- It also contains up to three (self-reported) diagnosis (ICD9) codes. The second and third are usually blank, so we used just the first diagnosis code.
- We used the Veterans Administration Pharmacy Benefits Management National Formulary to determine the active ingredient(s) associated with each NDC.
- We used data from Drugs@FDA to determine the year in which the FDA first approved each active ingredient.

Share of rx's for post-1990 active ingredients



Estimates based on all available years

Column	1	2	3	4	5
dependent variable	ln LYL65	ln LYL75	ln DISCH_TOT	ln DISCH_LTC	ln DISCH_DEAD
vintage variable	POST1990	POST1990	POST1993	POST1993	POST1993
years	1990, 1996-2002	1990, 1996-2002	1993, 1996-2003	1993, 1996-2003	1993, 1996-2003
No. of observations	550	552	595	594	592
β	-0.349	-0.210	-0.310	-0.314	-0.051
std. err.	0.057	0.050	0.084	0.081	0.061
t-stat	-6.13	-4.24	-3.67	-3.88	-0.83
p-value	<0.0001	<.0001	0.0003	0.0001	0.4078

Mortality estimates

- There appears to be a highly significant inverse relationship between ln LYL65 and POST1990, which suggests that conditions experiencing greater pharmaceutical innovation tended to have greater declines in mortality before age 65. However, as noted above, the standard error of β is likely to be underestimated due to serial correlation, so the statistical significance of this estimate is not guaranteed. We should reserve judgment on this until we examine the long-difference estimate.
- There also appears to be a highly significant inverse relationship between ln LYL75 and POST1990, but the point estimate is 40% smaller than the point estimate in the LYL65 equation.

Hospital discharge estimates

- Estimates of the regression of \ln DISCH_TOT on POST1993 indicate that conditions with larger increases in the fraction of prescriptions for post-1993 drugs had smaller increases, or larger declines, in the total number of hospital admissions.
- Conditions with larger increases in the fraction of prescriptions for post-1993 drugs had smaller increases, or larger declines, in the number of hospital discharges to nursing homes.
- More rapid pharmaceutical innovation was *not* associated with a decline in the number of in-hospital deaths. Indeed, more rapid pharmaceutical innovation was associated with an *increase* in the probability of dying in the hospital, conditional on being admitted. However, the estimates in column 1 and 2 suggest that pharmaceutical innovation reduced overall mortality before age 75 and especially before age 65.

Estimates based on first and last years only

Column	1	2	3	4	5
dependent variable	\ln LYL65	\ln LYL75	\ln DISCH_TOT	\ln DISCH_LTC	\ln DISCH_DEAD
vintage variable	POST1990	POST1990	POST1993	POST1993	POST1993
years	1990, 2002	1990, 2002	1993, 2003	1993, 2003	1993, 2003
No. of observations	149	150	146	145	144
β	-1.125	-0.788	-0.980	-0.652	-0.060
std. err.	0.189	0.196	0.300	0.315	0.245
t-stat	-5.96	-4.01	-3.26	-2.07	-0.25
p-value	<0.0001	0.0002	0.0019	0.0431	0.8069

Long-difference estimates

- Not surprisingly, the standard errors of the long-difference estimates are larger than the standard errors of the corresponding annual estimates.
- However, the long-difference *point estimates* are also larger than the annual point estimates.
- Therefore, the long-difference point estimates are also highly statistically significant.
- The difference in point estimates may be attributable to the fact that mortality is more responsive to long-run changes in the vintage distribution of prescription drugs than it is to short-run changes.

Costs vs. benefits of increasing use of new drugs

The estimates imply that, in the absence of any pharmaceutical innovation during the sample period, mortality, hospital admissions, and hospital discharges to nursing homes would have been higher at the end of the period (2002 or 2003) than they actually were.

The implied (absolute) increases in these variables that would have occurred, absent any innovation, may be calculated as follows:

$$Y_PRED_T - Y_T = Y_T (\exp(\beta (X_T - X_1)) - 1)$$

where

Y_PRED_T = the predicted (counterfactual) value of Y in period T

Y_T = the actual value of Y in period T

X_T = the value of X in period T

X_1 = the value of X in period 1

Estimated effects of new drug use on mortality in 2002 and medical expenditure in 2003

Column	1	2	3	4
Variable	LYL65 in 2002	LYL75 in 2002	Hospital Care expend in 2003	Nursing Home expend in 2003
Y_T	8,229,329	15,418,775	\$515,900,000,000	\$110,800,000,000
$(X_T - X_1)$	0.499	0.499	0.344	0.344
A: Estimates based on data for all available years				
$-\beta (X_T - X_1)$	0.174	0.105	0.107	0.108
$Y_PRED_T - Y_T$	1,566,673	1,701,974	\$58,050,711,511	\$12,629,163,198
B: Estimates based on data for first and last years only				
$-\beta (X_T - X_1)$	0.561	0.393	0.337	0.224
$Y_PRED_T - Y_T$	6,198,015	7,432,321	\$206,577,401,177	\$27,842,189,879

Estimates based on data for all available years

- use of post-1990 drugs in 2002 reduced the number of life-years lost before age 65 by 1.56 million, and the number of life-years lost before age 75 by about 1.70 million in that year
- use of post-1993 drugs in 2003 reduced hospital expenditure by \$58 billion and nursing home expenditure by \$9.5 billion

Expenditure on new drugs

- CMS reports that U.S. expenditure on prescription drugs was \$162 billion in 2002 and \$179 billion in 2003.
- I estimate that just over half of Rx expenditure in 2003 was on post-1993 drugs.
 - Medicaid data for 2003 indicate that between 46% and 56% of Medicaid drug expenditure in 2003 was expenditure on post-1993 drugs.
 - Data reported by NDCHealth indicate that 53% of expenditure on the top 100 drugs in 2004 was accounted for by drugs approved after 1994.
- It is therefore reasonable to assume that 53% of 2003 drug expenditure was on post-1993 drugs. This implies that \$95 billion ($= 53\% * \179 billion) was spent on post-1993 drugs in 2003.

Net cost per life-year saved before age 75

- Since the more conservative estimates imply that the use of post-1993 drugs reduced hospital expenditure by \$58 billion and nursing home expenditure by \$9.5 billion in 2003, they imply that the net cost of these drugs was \$27 billion ($= \$95 \text{ b.} - \$58 \text{ b.} - \9.5 b.).
- The net cost per life-year saved before age 75 was \$15,974 ($= \$27 \text{ billion} / 1.7 \text{ million life-years}$). Treatments that cost this amount are generally considered to be quite cost-effective.

True net cost per life-year gained could be much lower

The true net cost per life-year gained could be much lower, for several reasons.

- This calculation does not account for the likely reduction in years of potential life lost after age 75.
- It does not account for other benefits of pharmaceutical innovation, such as the reduction in work-loss days and illness-induced withdrawal from the labor market.
- Since this estimate is based on data for all available years, it may reflect only the short-run benefits of new drugs. Estimates based on data for the first and last years only may capture the long run benefits. These estimates indicate that the net cost of new drugs was *negative*: the reduction in the sum of hospital and nursing home costs was 2.4 times as great as the cost of the drugs. They also indicate that new drugs reduced the number of years of potential life lost before age 75 in 2003 by 7.4 million.

Other issues

- Use of newer drugs may have cross-disease spillover effects: using newer drugs for one disease may either increase or decrease mortality from other diseases (in part due to “competing risks”). Such spillovers could be either negative or positive. For example, using a newer drug to treat cardiovascular disease might reduce cardiovascular mortality but increase life-years lost due to cancer. On the other hand, using a newer drug to treat depression and other mental disorders might lead to better management of cardiovascular disease.
- The models we have estimated control (via year fixed effects) for non-drug (device/procedure) innovation that is common to all diseases, but not for disease-specific device/procedure innovation, which is difficult to measure. Since device/procedure innovation may either substitute for or complement drug innovation, controlling for disease-specific device/procedure innovation could either decrease or increase our estimate of the cost per life-year gained from using newer drugs. This issue merits further research.

Pharmaceutical innovation and the longevity of Australians: a first look

Superior data quality

- We examine the impact of pharmaceutical innovation on the longevity of Australians during the period 1995-2003.
- Due to the government's Pharmaceutical Benefits Scheme, Australia has much better data on drug utilization than most other countries.

Linking drugs to diseases

ATC Drug Group(s)	ICD-10 Cause of Death Chapter(s)
Alimentary tract and metabolism (A) + systemic hormonal preparations, excluding sex hormones and insulins (H)	Diseases of the digestive system (XI) + endocrine, nutritional and metabolic diseases (IV)
Blood and blood forming organs (B)	Diseases of the blood and blood-forming organs (III)
Cardiovascular system (C)	Diseases of the circulatory system (IX)
Dermatologicals (D)	Diseases of the skin and subcutaneous tissue (XII)
Genito-urinary system and sex hormones (G)	Diseases of the genitourinary system (XIV)
Anti-infectives for systemic use (J) + antiparasitic products, insecticides and repellents (P)	Certain infectious and parasitic diseases (I)
Antineoplastic and immunomodulating agents (L)	Neoplasms (II)
Musculo-skeletal system (M)	Diseases of the musculoskeletal system and connective tissue (XIII)
Nervous system (N)	Diseases of the nervous system (VI) + mental and behavioural disorders (V)
Respiratory system (R)	Diseases of the respiratory system (X)
Sensory organs (S)	Diseases of the eye and adnexa (VII) + diseases of the ear and mastoid process (VIII)

The top 10 cardiovascular system drugs, ranked by number of PBS prescriptions in 2004

Drug	Number of PBS rx's in 2004
atorvastatin	7,207,717
simvastatin	5,756,278
irbesartan	3,278,440
atenolol	2,952,209
irbesartan with hydrochlorothiazide	2,807,419
ramipril	2,663,857
perindopril	2,578,733
amlodipine	2,201,328
pravastatin	1,978,913
perindopril and diuretics	1,522,659

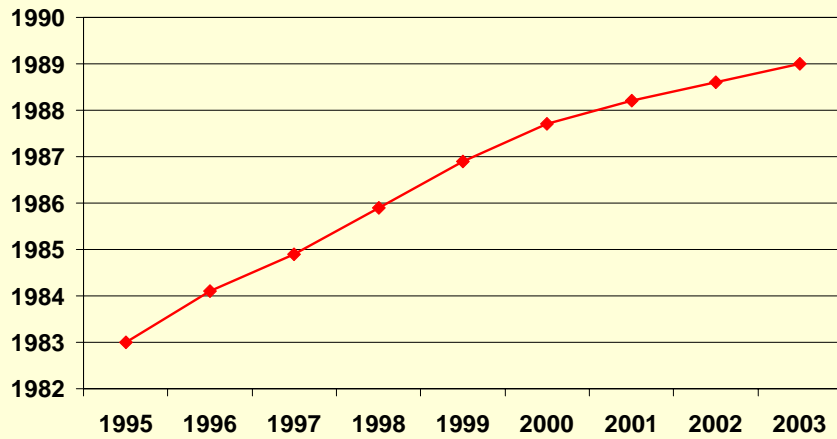
The top 10 antineoplastic and immunomodulating agents,
ranked by number of PBS prescriptions in 2004

Drug	Number of PBS rx's in 2004
tamoxifen	193,340
methotrexate	149,107
leflunomide	108,144
azathioprine	104,236
goserelin	53,556
letrozole	36,837
anastrozole	36,268
cyclophosphamide	35,232
interferon beta-1b	32,282
fluorouracil	29,160

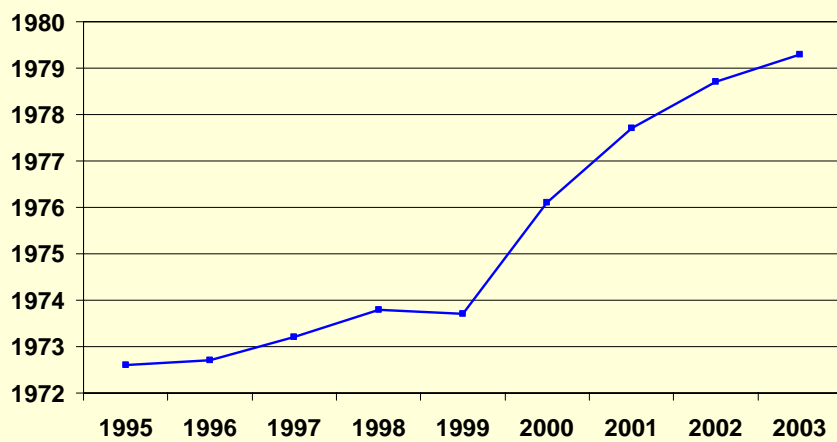
Variation in vintage increase

- The level and growth rate of vintage varies considerably across ATC groups.
- Cardiovascular drugs tend to be much newer than antineoplastic and immunomodulating agents; in 2003 the vintage of the latter was almost 10 years lower.
- The mean vintage of cardiovascular system drugs increased almost twice as much during the first half of this period (1995-1999) as it did during the second half (1999-2003).
- In contrast, the mean vintage of antineoplastic and immunomodulating agents increased over four times as much in the second half as it did in the first half.

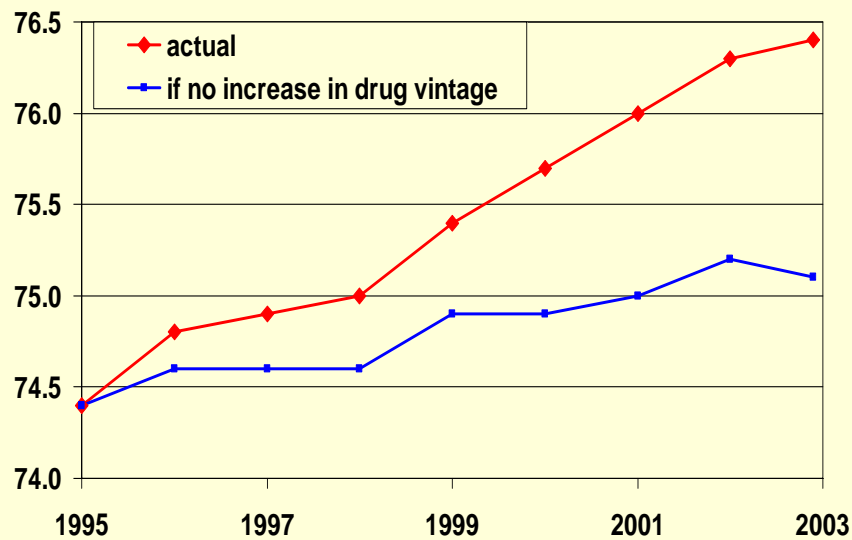
Mean vintage of cardiovascular system drugs, 1995-2003



Mean vintage of antineoplastic and immunomodulating agents, 1995-2003



Comparison of actual increase in mean age at death to the increase that would have occurred in the absence of any increase in drug vintage



- Mean age at death increased more for diseases with larger increases in mean drug vintage.
- The estimates indicate that increasing the mean vintage of drugs by 5 years would increase mean age at death by almost 11 months.
- The estimates also indicate that using newer drugs reduced the number of years of potential life lost before the ages of 65 and 70 (but not before age 75).

- During the period 1995-2003, mean age at death increased by about 2.0 years, from 74.4 to 76.4.
- The estimates imply that, in the absence of any increase in drug vintage, mean age at death would have increased by only 0.7 years.
- The increase in drug vintage accounts for about 65% of the total increase in mean age at death.

- We obtain a rough estimate of the cost per life-year gained from using newer drugs.
- Under our assumptions, using newer drugs (increasing drug vintage) increased life expectancy by 1.23 years and increased lifetime drug expenditure by \$12,976; the cost per life-year gained from using newer drugs is \$10,585.
- An estimate made by other investigators of the value of a statistical Australian life-year (\$70,618) is 6.7 times as large as our estimate of the cost per life-year gained from using newer drugs.
- We discuss several reasons why our estimate of the cost per life-year gained from using newer drugs could be too high or too low.

**The impact of Medicare Part D on
prescription drug use by the elderly:
evidence from a large retail pharmacy chain**

Frank R. Lichtenberg, PhD
Columbia University and
National Bureau of Economic
Research

frank.lichtenberg@columbia.edu

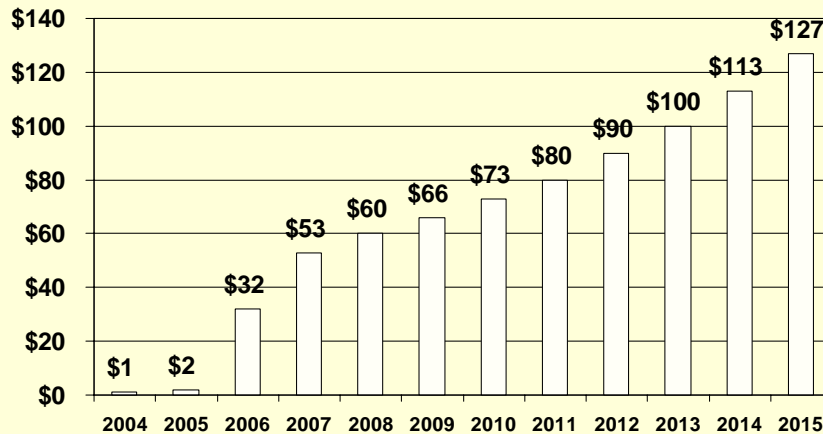
Shawn X. Sun, PhD
Walgreens Health Services

Shawn.Sun@walgreens.com

Medicare Part D

- The Medicare Prescription Drug, Improvement, and Modernization Act (Public Law No. 108-173, 117 Stat. 2066), which was enacted in 2003, produced the largest overhaul of Medicare in its 38-year history.
- The most important provision of the Act was the establishment on January 1, 2006 of a federal entitlement benefit for prescription drugs for Medicare beneficiaries (Medicare Part D), through tax breaks and subsidies.
- The Congressional Budget Office estimates that net Medicare Part D outlays were \$32 billion in 2006, and that cumulative outlays through 2015 will be \$797 billion.

Net Medicare Part D Outlays (billions of dollars)



- As of January 1, 2006, all 43 million people on Medicare had access to the new Medicare Part D prescription drug benefit offered by stand-alone prescription drug plans (PDPs) or Medicare Advantage prescription drug (MA-PD) plans.
- The Medicare drug benefit is voluntary; individuals may choose whether or not to enroll in a Part D plan.
- Many beneficiaries already had drug coverage
- By June 2006 about 90% of the 43 million people on Medicare had creditable prescription drug coverage

Debate about Medicare Part D's impact

- The Centers for Medicare and Medicaid Services (CMS) claims that “the MMA legislation provides seniors and people with disabilities with the first comprehensive prescription drug benefit ever offered under the Medicare program, the most significant improvement to senior health care in nearly 40 years.”
- But in a 2004 paper, Mark Pauly argued that “from the viewpoint of improvements in health, national spending on drugs, or pharmaceutical firm revenues, effects [of Medicare drug coverage improvement] are small.”

Pauly's argument

- Pauly predicted that Medicare drug coverage improvement would increase drug utilization by the elderly by only about 6%. This prediction was based on the following reasoning.
- Medicare drug coverage improvement affects drug utilization via its effect on the out-of-pocket cost (or “user cost”) of prescription drugs.
- Pauly estimated that, for people with no previous drug coverage, Medicare drug coverage improvement would reduce user cost by almost 50%.
- However, almost three-fourths of elderly Americans already had some kind of drug coverage; Medicare drug coverage improvement would have almost no effect on their user cost.
- He estimated that overall, Medicare drug coverage improvement would reduce user cost by 14%.
- Previous studies indicated that the price elasticity of demand for prescription drugs is about 0.4.
- The implied impact of Medicare drug coverage improvement on drug utilization by the elderly is about 6% ($\approx 0.4 * 14\%$).

Ex post appraisal

- This study will investigate the effect of Medicare Part D on prescription drug user costs and utilization with data on 585 million prescriptions filled by one of the nation's largest retail pharmacy chains (Walgreens) during the period September 2004-December 2006.
- Walgreens fills about 1.4 million prescriptions per day, on average—about 18% of all prescriptions filled in the U.S.
- As of November 30, 2006, Walgreens had 5580 retail pharmacies throughout the U.S.
- To reduce computing burden, we drew a 50% sample (essentially, every other week) of Walgreens prescription drug claims.

- Each claim includes the following information:
 - The date the prescription was filled
 - The patient's date of birth
 - The number of days of therapy dispensed
 - The amount paid by the patient (e.g. copayment)
 - The amount paid by third parties
- Hence we can compute the patient's age as (prescription date – birth date), and the total amount paid for the prescription (amount paid by the patient + amount paid by third parties).
- By aggregating the data, we can calculate the number of prescriptions, the number of days of therapy dispensed, mean amount paid by the patient, and mean total amount paid, by date and patient age.

Difference-in-differences (DD) research design

- Having these data by date and patient age, before and after 1/1/06, enables us to use a difference-in-differences (DD) research design to evaluate the impact of Medicare Part D.
- In particular, we can calculate pre- vs. post-1/1/06 changes in the ratio of elderly to non-elderly mean user cost and utilization.
- The DD approach controls for the effects of all time-varying determinants of prescription drug use and cost that are common to elderly and non-elderly people.
- Lichtenberg (2002) used a similar approach to evaluate the effects of launching Medicare Parts A and B in the 1960s.

Summary statistics for the approximately 50% sample of Walgreens prescription drug claims during the period September 2004-December 2006

	elderly	non-elderly	total
Number of Rx's	125,168,312	459,341,225	584,509,537
Number of days of therapy	3,970,483,265	11,030,571,174	15,001,054,439
Total amount paid	\$7,032,500,017	\$26,395,283,980	\$33,427,783,997
Amount paid by patient	\$2,422,995,529	\$7,431,808,189	\$9,854,803,718
Amount paid by third parties	\$4,609,504,488	\$18,963,475,792	\$23,572,980,280
Total amount paid per day of therapy	\$1.77	\$2.39	\$2.23
Amount paid by patient per day of therapy	\$0.61	\$0.67	\$0.66
Amount paid by third parties per day of therapy	\$1.16	\$1.72	\$1.57
Amount paid by patient/total amount paid	34%	28%	29%

- Walgreens drug customers tend to be younger than U.S. drug customers in general.
- Twenty-one percent of Walgreens prescriptions were dispensed to elderly customers.
- Data from the Medical Expenditure Panel Survey (MEPS) indicate that, during the period 1996-2003, 33-35% of U.S. prescriptions were dispensed to elderly patients.
- If the difference between the age distribution of Walgreens customers and other drug customers was fairly stable over time, this discrepancy will not bias our estimate of the impact of Medicare Part D on prescription drug use.

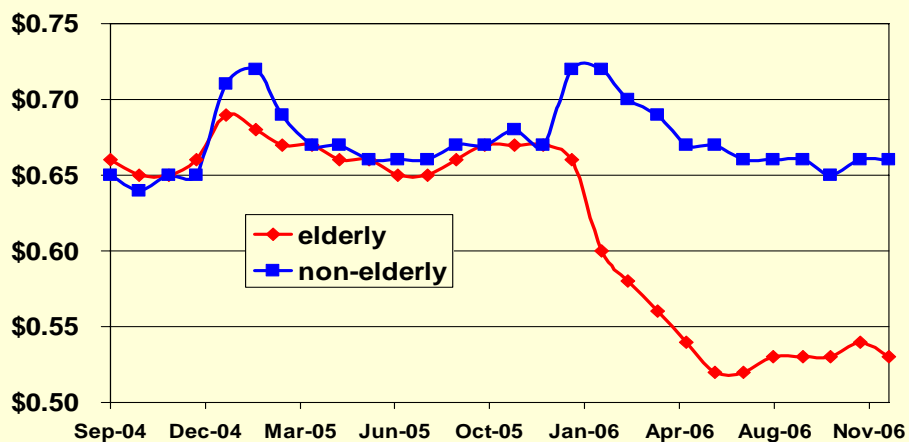
Medical Expenditure Panel Survey estimates of the total number of Rx's dispensed in the U.S., 1996-2003

Year	MEPS estimate of number of Rx's dispensed to elderly patients (millions)	MEPS estimate of total number of Rx's dispensed (millions)	Elderly Rx's/total Rx's
1996	639	1865	34%
1997	644	1874	34%
1998	695	1970	35%
1999	716	2068	35%
2000	722	2167	33%
2001	851	2494	34%
2002	919	2693	34%
2003	974	2802	35%

Amount paid by the patient per day of therapy, by age group

- From September 2004 to December 2005, the amounts paid by elderly and non-elderly patients per day of therapy were quite similar; in December 2005 they differed by less than 1%.
- But from December 2005 to June 2006, the amount paid by elderly patients per day of therapy fell substantially, while the amount paid by non-elderly patients per day of therapy remained essentially unchanged.
- In June 2006 the amount paid by elderly patients per day of therapy was about 24% lower than the amount paid by non-elderly patients per day of therapy.
- The user cost differential narrowed slightly in the last six months of 2006; it was 21% in December 2006. This may be attributable to an increasing number of Medicare patients falling into the Part D coverage gap (“doughnut hole”) in the second half of the year.

Amount paid by the patient per day of therapy, by age group, Sept. 2004-Dec. 2006



Relative (elderly vs. non-elderly) P and relative Q

P: mean amount paid by the patient per day of therapy

Q: number of days of therapy

Analyze log-differences between elderly and non-elderly patients.

For example, relative user cost is $(\log(\text{USER}_E) - \log(\text{USER}_N))$

where

USER_E = mean amount paid by elderly patients per day of therapy

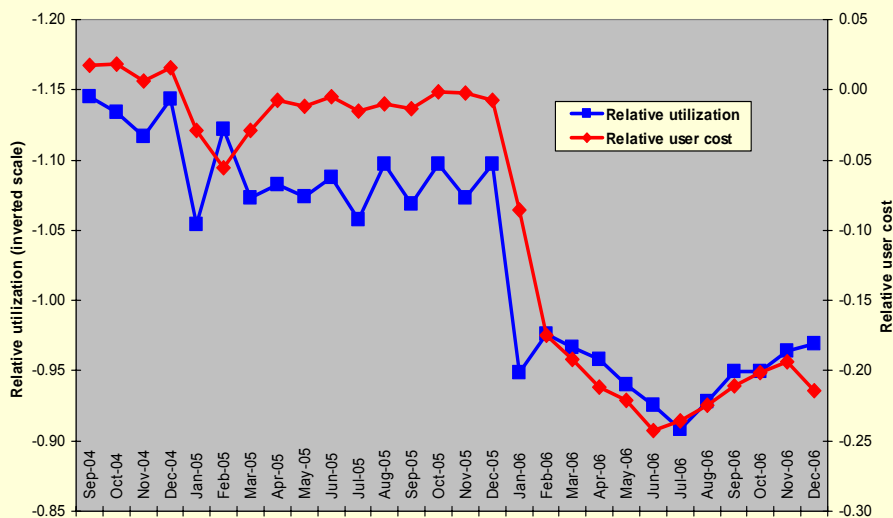
USER_N = mean amount paid by non-elderly patients per day of therapy.

Relative utilization is shown on an inverted scale.

There was a dramatic increase in relative utilization by the elderly between December 2005 and June 2006; relative utilization increased almost 19%.

In the second half of 2006, as relative user cost increased, relative utilization declined by about 6%.

Relative user cost (mean amount paid by the patient per day of therapy) and relative utilization (number of days of therapy) of elderly and non-elderly patients



- Under certain reasonable assumptions, the slope of the simple regression of relative utilization on relative user cost is an estimate of the elasticity of demand for prescription drugs.

Suppose that the demand for prescription drugs by elderly and non-elderly consumers can be represented by the following equations:

$$\begin{aligned}\log(\text{UTIL}_{Et}) &= \alpha_E + \delta_t + \beta \log(\text{USER}_{Et}) + \varepsilon_{Et} \\ \log(\text{UTIL}_{Nt}) &= \alpha_N + \delta_t + \beta \log(\text{USER}_{Nt}) + \varepsilon_{Nt}\end{aligned}$$

where

UTIL = number of days of therapy

USER = mean amount paid by patient per day of therapy

This allows for month-specific demand shocks (δ_t) that are common to elderly (E) and non-elderly (N) consumers.

We also allow for different intercepts in the elderly and non-elderly demand functions (α_E and α_N), but assume a common demand elasticity (β).

Subtracting the second equation from the first,

$$\log(\text{UTIL}_{Et} / \text{UTIL}_{Nt}) = (\alpha_E - \alpha_N) + \beta \log(\text{USER}_{Et} / \text{USER}_{Nt}) + (\varepsilon_{Et} - \varepsilon_{Nt}).$$

The slope of the simple regression of relative utilization on relative user cost is an estimate of the demand elasticity.

Demand elasticity estimate

- The estimate of β , based on 28 monthly observations, is 0.72 (t-stat = 14.1, p-value < .0001).
- This is considerably larger than the estimate (0.4) that Pauly used to make his forecast of the utilization impact of Medicare drug coverage improvement.
- An alternative estimation approach, based on Walgreens data aggregated by drug and month, rather than by age group and month, also indicates a demand elasticity well above 0.4, albeit not as high as 0.72.

Elderly vs. non-elderly difference in the 2005-6 growth rates of key variables

- The mean amount paid by non-elderly patients per day of therapy declined 0.4%, while the mean amount paid by elderly patients per day of therapy declined 18.8%.
- The number of days of non-elderly therapy increased 6.8%, while the number of days of elderly therapy increased 19.5%.
- This suggests that Medicare Part D reduced user cost among the elderly by 18.4%, and increased utilization among them by about 12.8%.
- The ratio of the latter to the former is 0.70, virtually the same as the estimate of the demand elasticity reported above.

Elderly vs. non-elderly difference in the 2005-6 growth rates of key variables

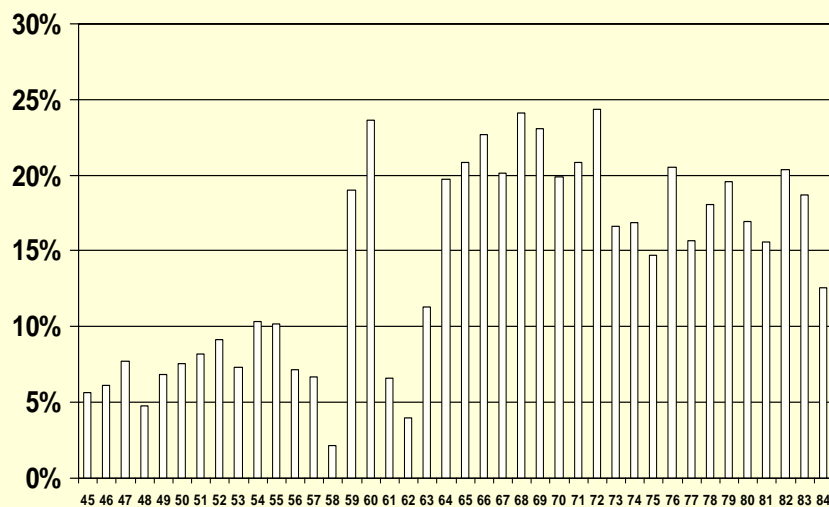
	% change from 2005 to 2006		
	Elderly	Non-elderly	Elderly – non-elderly
Amount paid by patient per prescription	-13.7%	1.9%	-15.6%
Amount paid by patient per day of therapy	-18.8%	-0.4%	-18.4%
Expenditure per prescription	7.1%	4.6%	2.5%
Expenditure per day of therapy	2.0%	2.3%	-0.3%
Number of prescriptions	14.4%	4.5%	10.0%
Number of days of therapy	19.5%	6.8%	12.8%
Days of therapy per prescription	5.1%	2.3%	2.8%
Total amount paid by patients	0.8%	6.4%	-5.6%
Total payments by third parties	32.4%	10.1%	22.3%
Total expenditure	21.5%	9.0%	12.5%

- Due to the increase in utilization, Medicare Part D reduced the total amount paid by patients by only 5.6%.
- It increased the amount paid by third parties by 22.3%.
- Medicare Part D seems to have had a negligible impact on the overall price of prescription drugs (expenditure per day of therapy); the elderly and non-elderly growth rates differ by just 0.3%.

Validity of age partition

- The preceding calculations were based on partitioning Walgreens customers into just two age groups: elderly (65 and over) and non-elderly (under 65).
- Because we have very detailed age data (in principle, age *in days* at the time of the transaction), we can assess the validity of this age partition.
- Analyze the percentage increase between 2005 and 2006 in utilization (number of days of therapy), by single year of age for ages 45-84.
- Three below-65 ages (59, 60, and 64) exhibit large (>19%) growth, which is a bit puzzling.
- However 17 out of the top 40 ages, ranked by 2005-6 utilization growth, are greater than or equal to 65.
- This supports the view that the elderly vs. non-elderly differences we have documented are primarily due to Medicare Part D.

% increase between 2005 and 2006 in number of days of therapy, by single year of age



Crowding out

- Medicare Part D is estimated to have increased drug utilization in the Medicare population by 13.5% in 2006.
- Since about one-third of prescription drugs are used by the Medicare population, this implies that Medicare Part D increased total U.S. drug utilization by 4.5% (= (1/3) * 13.5%) in 2006.
- The projected number of elderly rx's in 2006, in the absence of Medicare Part D, is 1172 million.
- Medicare Part D is estimated to have increased the number of prescriptions by 158 million in 2006.
- The average cost of a prescription was \$57.19 in 2006, so the market value of the 158 million additional prescriptions was \$9.0 billion.
- The CBO estimates that net Medicare Part D outlays were equal to \$32 billion in 2006.
- The cost to the Federal government of increasing drug utilization was 3.5 times as great as the market value of the additional prescriptions.
- In other words, every seven prescriptions paid for by the government crowded out five other prescriptions, and resulted in only two additional prescriptions consumed.

Calculation of the net cost to the government per additional prescription

Line	Description	Estimate	Source
1	Elderly vs. non-elderly difference in 2005-6 % change in number of days of therapy	12.8%	Table 3
2	Estimated ratio of (Medicare vs. non-Medicare difference) to (Elderly vs. non-elderly difference)	105.3%	fn. 4
3	Medicare vs. non-Medicare difference in 2005-6 % change in number of days of therapy	13.5%	(1) * (2)
4	Projected number of elderly rx's in 2006, based on 1996-2003 trend (millions)	1172	Table 2
5	Est. absolute increase in senior rx's in 2006 due to Medicare Part D (millions)	158	(3) * (4)
6	Mean cost of Rx	\$57.19	Table 1
7	Est. market value of increase in senior rx's in 2006 due to Medicare Part D (millions)	\$9,034	(5) * (6)
8	Cost of Medicare Part D in 2006	\$32,000	Figure 1

- “Crowd out”: the substitution of public programs for private arrangements
- “Crowd out” occurs to some extent in every public program.
- Several studies have tried to determine the extent to which substitution occurred when Medicaid expanded coverage for pregnant women and children up to 133 percent of poverty (and, in some states, up to 185 percent of poverty for pregnant women and infants).
- One study found that for every two people who enrolled in Medicaid, one person dropped private insurance.
- However, other researchers have criticized the methodology of this study and have come to different conclusions.
- Recent studies have shown that either there was no crowd out over the expansion period or that, at most, for every five people who enrolled in Medicaid, only one person dropped private coverage.
- Clearly, our estimate of the extent of Medicare Part D crowd-out is much higher than even the highest estimate of the extent of Medicaid expansion crowd-out.

Summary

- This study has investigated the effect of Medicare Part D on prescription drug user costs and utilization with data on 585 million prescriptions filled by one of the nation’s largest retail pharmacy chains (Walgreens) during the period September 2004-December 2006.
- We used a difference-in-differences research design to evaluate the impact of Medicare Part D. In particular, we calculated pre- vs. post-1/1/06 changes in the ratio of elderly to non-elderly mean user cost and utilization.

Summary

- Our ex post estimate of the user cost reduction is 31% larger than Pauly's forecast, and our estimate of the elasticity of demand is 62% larger, so our estimate of the utilization increase in the Medicare population is over twice as large as Pauly's forecast.
- We estimate that Medicare Part D reduced user cost among the elderly by 18.4%, increased utilization among them by about 12.8%, and increased total U.S. drug utilization by 4.5% in 2006.

Summary

- Although our estimate of the utilization increase in the Medicare population is over twice as large as Pauly's forecast, our estimate of the market value of the increased utilization is considerably smaller than CBO estimates of net Medicare Part D outlays.
- The cost to the Federal government of increasing drug utilization was 3.5 times as great as the market value of the additional prescriptions.
- This suggests that every seven prescriptions paid for by the government crowded out five other prescriptions, and resulted in only two additional prescriptions consumed.
- While "crowd out"—the substitution of public programs for private arrangements—occurs to some extent in every public program, Medicare Part D appears to be subject to an unusually high rate of crowd out.

The impact of patent expiration on U.S. drug prices, marketing, and utilization

Frank R. Lichtenberg
Columbia University and
National Bureau of Economic
Research
frank.lichtenberg@columbia.edu

Gautier Duflos
University of Paris
Gautier.Duflos@univ-paris1.fr

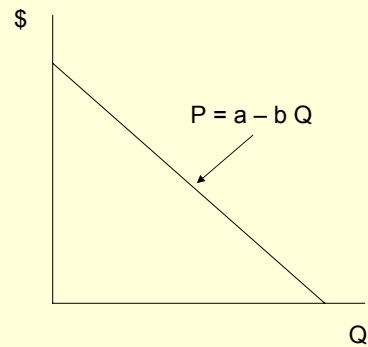
- Conventional view: monopolies restrict output.
- Entry by additional suppliers will expand total industry output.

Demand for drug

Demand for drug:

$$P = a - bQ$$

P = price per pill
Q = number of pills



Cost of producing drug

Total cost of producing drug:

$$C = F + cQ$$

F = fixed cost (\approx \$800 million?)
c = (constant) marginal cost

Pharma firm's decision problem: determine whether or not to develop drug, and if so, how much to produce and sell

Assume that the firm's objective is to maximize its profits, and that it will have a monopoly on the drug (due to patent protection)

Profit maximization

$$\text{Profit} = \text{revenue} - \text{cost}$$
$$\Pi = R - C$$

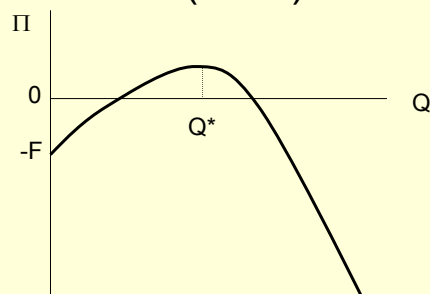
$$\Delta\Pi = \Delta R - \Delta C$$

Profit maximizing Q:

$$\frac{\Delta\Pi}{\Delta Q} = \frac{\Delta R}{\Delta Q} - \frac{\Delta C}{\Delta Q} = 0 \rightarrow MR = MC$$

Profit function

$$\begin{aligned}\Pi &= QP - C \\ &= Q(a - bQ) - (F + cQ) \\ &= -F + (a - c)Q - bQ^2\end{aligned}$$



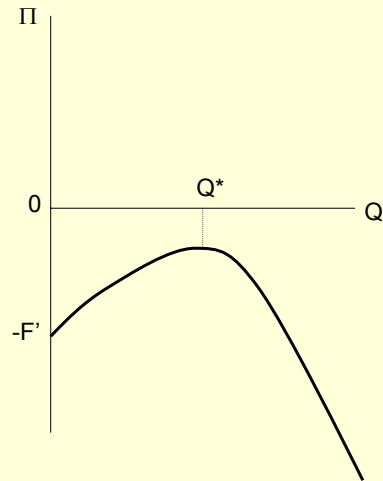
Equilibrium Q

$$MR = MC \rightarrow$$

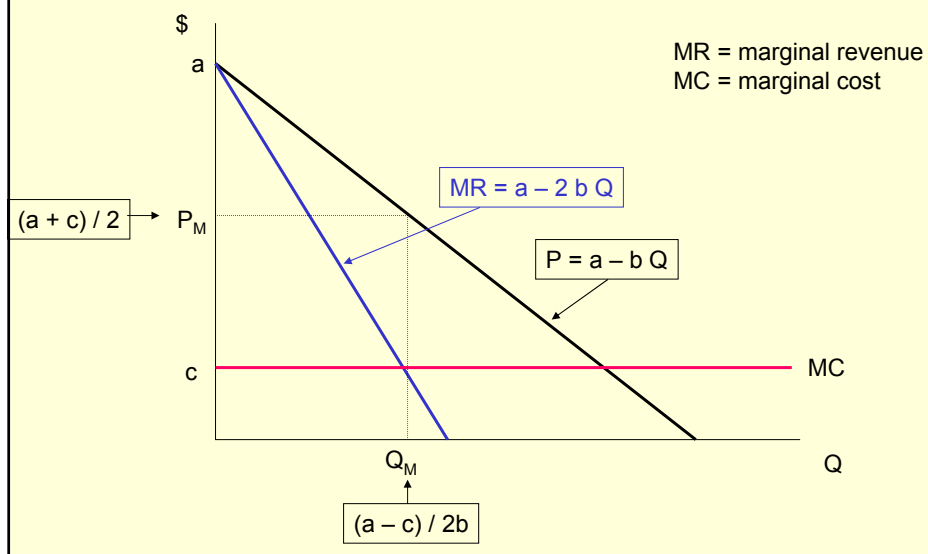
$$a - 2bQ = c$$

$$Q^* = (a - c) / 2b$$

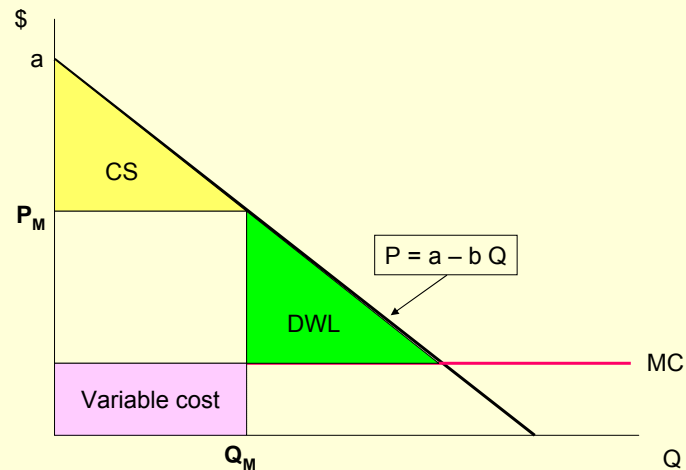
However, $\Pi(Q^*)$ will be *negative* when F is large; in this case, do not develop the drug



Monopoly equilibrium



Monopoly equilibrium



Inefficiencies

- Firm “restricts output” below the socially optimal amount ($P_M > MC$)
 - But charging “too high” a price may help offset the tendency of insured consumers to consume “too much” of the good
- Due to fixed costs, firm may not develop the drug even though it would be socially desirable to do so (total benefits > total costs), because the firm pays all of the costs, but does not capture all of the benefits (consumer surplus)
 - If $(a^2 / 4 b) < F < (3 a^2 / 8 b)$, firm will not develop a socially desirable innovation.
 - The government can increase social welfare by granting production subsidies. But inappropriate subsidies could reduce social welfare.

Patent expiration

Patent expiration → generic entry → perfect competition

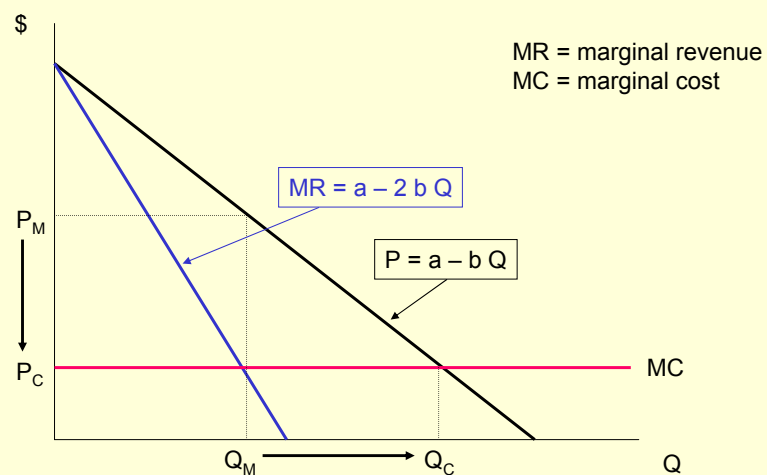
Perfect competition: each producer is small relative to the market, and thinks that his output level has no effect on market price

$$MR = P$$

Profit maximization requires that $MR = MC$

Hence $P = MC$

Effect of generic entry



Assuming factors influencing the demand curve do not change

Objective

- Assess the impact of changes in market structure (changes in generic drug market share) on U.S. drug prices and utilization, using comprehensive data on almost all drugs
- Many studies have examined the effect of patent expiration/generic entry on drug prices, but we are aware of only one study that examined the effect on marketing and utilization. Moreover, this study examined data on just two drugs (cimetidine and ranitidine).

Data

- A large retail pharmacy chain (Walgreens) has given us confidential data on all prescription drug claims from Sept. 2004-Dec. 2006.
- Walgreens dispenses 1.4 million prescriptions per day (about 18% of all U.S. prescriptions). The dataset has 1.2 billion observations!
- Five things we know about each prescription (Rx) are:
 - The date the Rx was dispensed
 - The number of days of therapy (e.g. 30-day supply)
 - The generic name of the drug dispensed (e.g. simvastatin)
 - Whether the drug dispensed was a brand-name or a generic drug
 - The amount paid by the consumer for the Rx
- We have performed a preliminary analysis of a small (approximately 5%) subset of the data (one week in each of these 5 months: SEP2004, APR2005, OCT2005, APR2006, SEP2006).
- Data on 2225 drugs in each of these 5 months (N \approx 11,000)

Three key variables

Q_{it} = quantity of drug i consumed in month t
(number of days of therapy)

G_{it} = generic market share (generic
days/total days)

P_{it} = average cost to consumer (co-payment)

Effect of market structure on price

$$\begin{aligned}\ln P_{it} &= \beta_1 G_{it} + \alpha_i + \delta_t + \varepsilon_{it} \\ &= -.571 G_{it} + \alpha_i + \delta_t + \varepsilon_{it} \\ &\quad (t = 61.1)\end{aligned}$$

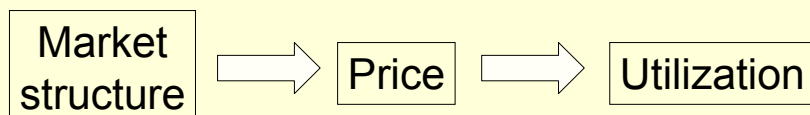
Increase in generic market share sharply
reduces average cost of a drug

Effect of price on utilization

$$\begin{aligned}\ln Q_{it} &= \beta_2 \ln P_{it} + \alpha_i + \delta_t + \varepsilon_{it} \\ &= -.401 \ln P_{it} + \alpha_i + \delta_t + \varepsilon_{it} \\ &(t = 16.6)\end{aligned}$$

Reduction in price increases utilization of drug;
apparent demand elasticity = 0.4.

Since increase in generic market share sharply
reduces average cost of a drug, and reduction in
price increases utilization, one might expect
increase in generic market share to increase
utilization



Effect of market structure on utilization

However, this is not the case!

$$\begin{aligned}\ln Q_{it} &= \beta_3 G_{it} + \alpha_i + \delta_t + \varepsilon_{it} \\ &= -.011 G_{it} + \alpha_i + \delta_t + \varepsilon_{it} \\ &\quad (t = 0.41)\end{aligned}$$

Increase in generic market share has no effect on utilization of a drug!

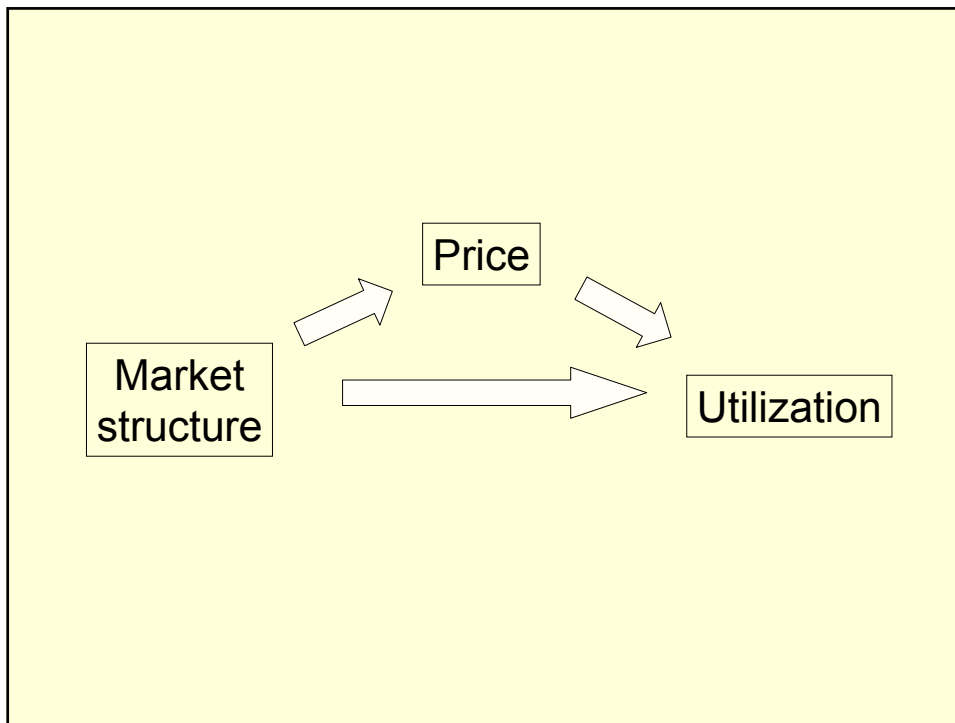
There seems to be a paradox.

Effect of market structure and price on utilization

Resolution of the apparent paradox: utilization depends on market structure, conditional on price

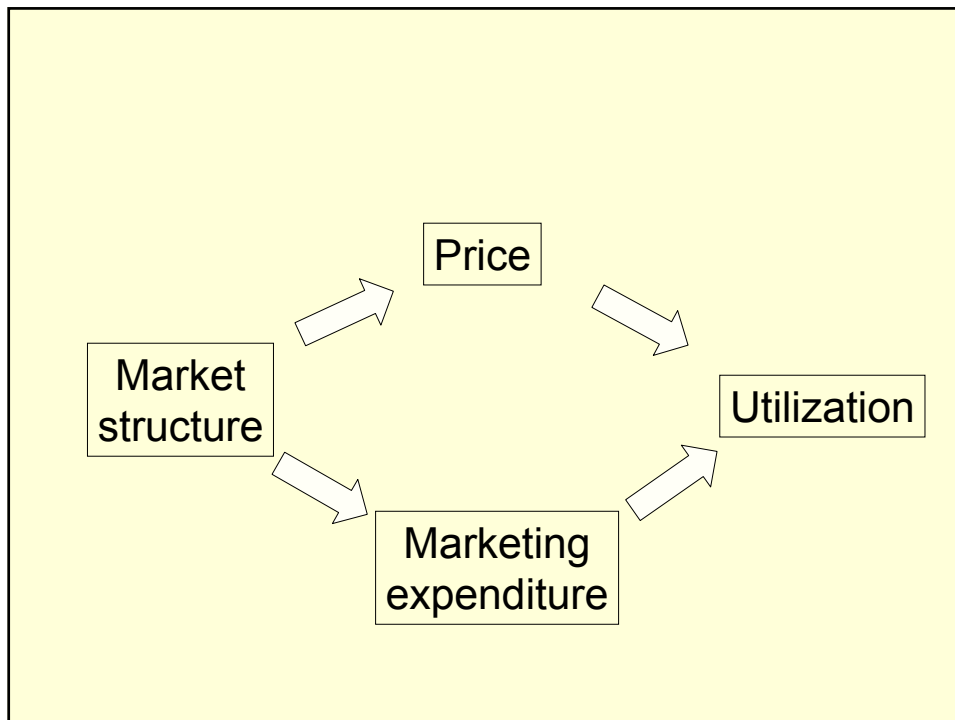
$$\begin{aligned}\ln Q_{it} &= \beta_4 G_{it} + \beta_5 \ln P_{it} + \alpha_i + \delta_t + \varepsilon_{it} \\ &= -.371 G_{it} - .623 \ln P_{it} + \alpha_i + \delta_t + \varepsilon_{it} \\ &\quad (t = 12.9) \quad (t = 21.1)\end{aligned}$$

- Increase in generic market share reduces utilization, conditional on price.
- Generic market share has a direct (negative) effect on utilization, as well as an indirect (positive) effect, via price; these effects almost exactly offset one another, so net effect is zero.
- Controlling for direct effect increases the estimate of the price elasticity of demand by over 50%.



Role of marketing

- Why does utilization depend on market structure, conditional on price?
- Hypothesize that utilization depends on intensity of marketing (“detailing”), as well as on price, and that, due to the existence of marketing spillovers, marketing intensity depends on market structure.



Effect of marketing on utilization

- Demand equation: $Q = M^\beta$
(For simplicity, ignore the effect of price on utilization)
- Q = quantity of drug consumed (number of days of therapy)
- M = quantity of marketing (minutes of detailing)
- $0 < \beta < 1$: diminishing marginal productivity of marketing

Detailing spillovers

- It is reasonable to assume that there are detailing spillovers, whereby the detailing of a drug by a manufacturer affects the total number of prescriptions for that drug and not just those of the marketer.
- Prior to patent expiration, the branded firm's share (S_{brand}) is 100 percent, but after the patent expires, the share falls rapidly perhaps reaching 20 percent after a couple of years.

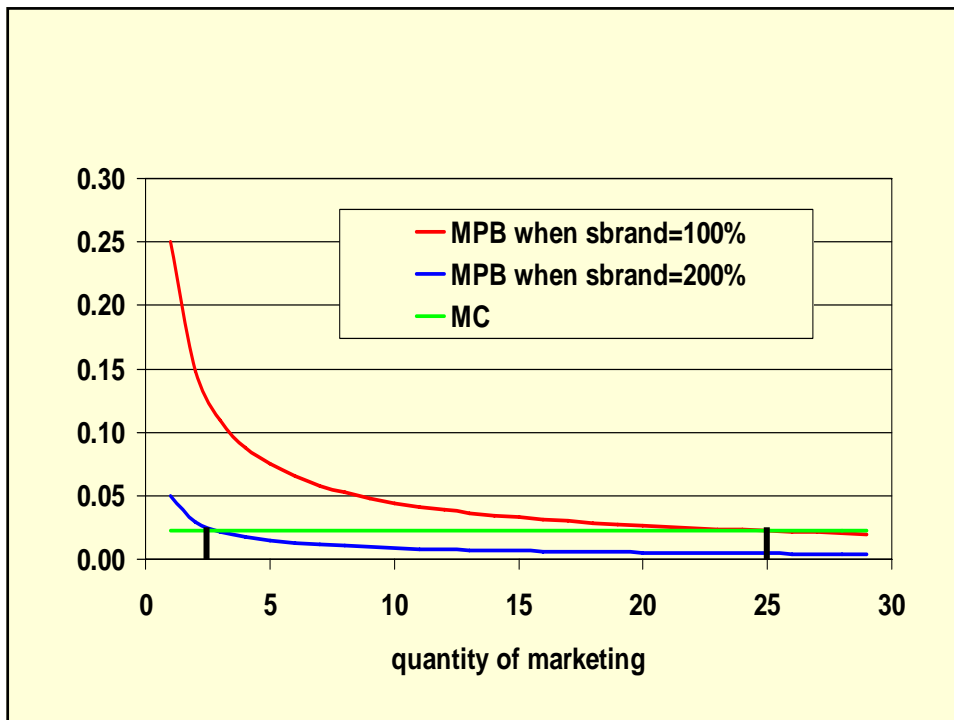
Profit maximization implies the branded firm will increase marketing up to the point where the marginal return is equal to the marginal cost of marketing (c).

If marketing costs are directly proportional to the amount of marketing, then

$$S_{\text{brand}} \beta M^{\beta-1} = c$$

which can be rearranged as

$$\ln M = \text{constant} + (1 / (1 - \beta)) \ln S_{\text{brand}}$$



- The greater the elasticity of total sales with respect to marketing, the more responsive the equilibrium stock of marketing will be to exogenous changes in the branded firm's market share (due e.g. to patent expiration).
- Suppose that patent expiration causes the branded firm's market share to decline from 100 percent to 20 percent.
- If $\beta = 0.1$, the firm's detailing stock will decline by 83 percent.
- Alternatively, if the branded market share declines to 20 percent and the firm's detailing stock declines 88 percent, then we can infer that the marketing elasticity is $a = 0.25$.

Instrumental variables estimation

OLS estimation of the equation

$$\ln M = \text{constant} + (1 / (1 - \beta)) \ln S_{\text{brand}}$$

may yield a biased estimate of β , due to possible reverse causality.

Therefore, we adopt an instrumental variables approach. The instrument for $\ln S_{\text{brand}}$ is `any_generic`, defined as follows:

`any_generic` = 1 if there have ever been any generic sales of a drug

`any_generic` = 0 if there have never been any generic sales of a drug

Consider the following two reduced-form regressions:

$$\ln M = \text{constant} + \pi_1 \text{any_generic}$$

$$\ln S_{\text{brand}} = \text{constant} + \pi_2 \text{any_generic}$$

$$\pi_1 = \frac{d \ln M / d \text{any_generic}}{d \ln S_{\text{brand}} / d \text{any_generic}} = 1 / (1 - \beta)$$

$$\pi_2 = d \ln S_{\text{brand}} / d \text{any_generic}$$

$$\rightarrow \beta = 1 - (\pi_2 / \pi_1)$$

Estimate using panel data from IMS Health on hundreds of drugs

$$\ln M_{it} = \pi_1 \text{any_generic}_{it} + \alpha_i + \delta_t + \varepsilon_{it}$$

$$\ln S_{\text{brand},it} = \pi_2 \text{any_generic}_{it} + \alpha_i + \delta_t + \varepsilon_{it}$$

Parameter	Estimate	s.e.
π_1	-1.08	.0429
π_2	-0.79	.0175
$\beta = 1 - \pi_2 / \pi_1$	0.28	

$$\ln Q = \beta \ln M = .28 \ln M$$

$$\ln M = \pi_1 \text{ any_generic} = -1.08 \text{ any_generic}$$

$$\frac{d \ln Q}{d \text{ any_generic}} = \frac{d \ln Q}{d \ln M} * \frac{d \ln M}{d \text{ any_generic}} = .28 * (-1.08) = -.30$$

Generic entry reduces utilization, via its effect on marketing, by about 30%.

This estimate is fairly consistent with our estimate of β_4 (= -.371)

Summary

- In general, entry by additional suppliers is expected to reduce price and increase total production and consumption of a good
- While expiration of a drug's patent sharply reduces its price in the U.S., it does not increase utilization of the drug
- Generic market share has a direct (negative) effect on utilization, as well as an indirect (positive) effect, via price; these effects almost exactly offset one another, so net effect is zero.

Summary

- Much of the direct effect of generic market share on utilization may be attributable to the role of marketing:
 - Utilization depends on marketing intensity as well as on price
 - Due to the existence of marketing spillovers, marketing intensity depends on market structure
- The elasticity of utilization with respect to marketing expenditure is estimated to be 0.28
- The price elasticity of demand for drugs is estimated to be 0.63; failure to control for the direct effect of generic market share on utilization results in substantial underestimation of the price elasticity