The Effect of Newer Drugs on Health Spending: Do They Really Increase the Costs?

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Abstract. We analyze the influence of technological progress on pharmaceuticals on rising health expenditures using US State level panel data. Improvements in medical technology are believed to be partly responsible for rapidly rising health expenditures. Even if the technological progress in medicine improves health outcomes and life quality, it can also increase the expenditure on health care. Our findings suggest that newer drugs increase the spending on prescription drugs since they are usually more expensive than their predecessors. However, they lower the demand for other types of medical services, which causes the total spending to decline. A one-year decrease in the average age of prescribed drugs causes per capita health expenditures to decrease by $31.92. The biggest decline occurs in spending on hospital and home health care due to newer drugs.

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1. Introduction

In most developed countries, there has been a rising trend in health expenditures. The growth rates of the health expenditures are generally higher than the growth of the overall economy. As a result, the ratio of the health expenditure to the GDP has been rising continuously. The percentage of health expenditures in the GDP was 3.8% in 1960 for OECD countries and has been continuously increasing since then.[1]. The trends in US and in most other countries have been similar. In the US, the ratio of health expenditures to the GDP rose from 5.1% in 1960 to 15.3% in 2005. Moreover, there is a significant variation in health expenditures among the relatively homogenous regions like OECD member countries or US states. For example, while the UK devoted only 8.3% of her GDP to the health care in 2005, the US spent almost twice.[2] In the US, average per capita health expenditures for the period 1993-2004 ranged from $2,972 for Idaho to $8,738 for District of Columbia.[3]

This significant variation in health care spending begs an explanation. Different societies might have different demand levels for health services or might have diverse health care "needs" due to the differences in life style, environmental conditions, or genetic characteristics. Alternatively, perhaps health care systems are not managed as efficiently as possible everywhere. Health care markets are poised with numerous problems such as moral hazard, principal-agent problems, and information failures. Any of these problems can cause markets to operate inefficiently. When we look at the details of the health care spending, we see that the inefficient management of health care systems is highly possible. For example, pharmaceutical spending makes up only 9.4% of the total health expenditure in Norway, while the same figure is 29.4% in Poland. Even if the variation in input choice for the health care (production function) does not mean inefficiency per se, the size of this variation raises a question mark. Indeed Baicker and Sandar (2004) and Fisher et al (2003a, 2003b) conclude that higher spending in health care does not improve health outcomes or patient satisfaction level. Thus, academics and policy makers have been analyzing the health care markets and trying to understand the driving factors behind the continuing increase in health expenditures for decades. In this paper, we contribute to the literature by analyzing the influence of technological improvement in pharmaceutical markets on health spending levels using panel data for US States.

[1] The ratios of the health expenditures to the GDP for 1970, 1980, 1990, 2000 and 2004 were 5.0%, 6.7%, 6.9%, 7.9%, and 9.0%, respectively. These numbers are un-weighted averages of current OECD member countries
[2] See OECD Health Data 2007.
[3] See Table 1.

The rest of the paper is organized as follows: In section 2, we discuss some background information and previous literature about the rising health expenditures. Section 3 summarizes the significance of pharmaceuticals on medical markets and on rising health expenditures. Sections 4 and 5 present the data and empirical methodology, respectively. We discuss the results in Section 6 and conclude in section 7.

2. Rise in Health Expenditures and New Technologies

Several explanations for the rising health expenditures have been cited in the health economics literature. Primary explanation is the rising incomes. Wealthier individuals are willing to pay more for their health, i.e. health care is a normal good. An increasing amount of spending on health care is a natural result of economic growth. Almost all studies analyzing the health care costs found a positive relationship between per capita income and health spending.[4] In fact, earlier studies conclude that income differences can explain almost all of the variation in the spending levels. Another reason for rising health spending is the aging societies. Generally old and very old require much more health care than young and middle-aged. Many studies use the percentage of population over 65 as a proxy for this demographic shift. Most studies have concluded that aging societies are spending more on health services[5]. Insurance coverage is another explanation cited in the literature. As it is common in many markets, insurance coverage can cause moral hazard problems. The individuals, who do not pay for the whole costs of the services they get, tend to use more health care than the efficient level. However, insurance firms are also better equipped than individual patients against the health care suppliers. Specifically, they can use their market power to get favorable terms because they can buy health services in bulk. Moreover, they can take much stronger measures than the individual patients against the advantages of the suppliers due to asymmetric information.

However, rising income levels, demographic shift and increased insurance coverage can only explain a relatively small portion of the rise in health expenditures. Slade and Anderson (2001) note that there is nearly a consensus among health economists that a substantial portion of the increase in health care spending is due to diffusion of new medical technologies. According to Newhouse (1992), usual suspects (supplier induced demand, aging population, income growth, increased insurance) can explain approximately half of the rise in the health expenditures. He conjectures that the rest of the increase should be given to

[4] See Gerdtham and Jonsson (2000) for a good review.
[5] See for example Gerdtham and et all (1992)

technological improvement in health services. Cutler et al. (1998) explains the significance of the technological improvement on health spending with the following sentences:

> "Nonetheless, it has now achieved a degree of acceptance, in part because it is difficult to think of another factor that is common across six consecutive decades and across many countries with different health-care financing institutions. Here we accept for the sake of argument that a substantial portion of the spending rise is attributable to the increased capabilities of medicine and ask what the spending increases-and inferentially the increased capabilities-have bought."

Cutler and Mcgellan (2001) classify the effects of new technologies into two groups: They use the term "treatment substitution effects" to indicate that new technologies often substitute for older technologies. The treatment costs of these new technologies maybe higher or lower than old technologies. However, new technologies in medicine also make treatment possible for patients who were not able to get treatment with old technologies. For example, new surgical techniques made it possible to operate on very old patients. Cutler and Mcgellan call this "treatment expansion effect". They note that the diagnosis rates for depression doubled after Prozac-like drugs became available, and cataract surgery was performed much more frequently as the procedure improved. When the new treatment is effective, making it available for more people is beneficial, but this would almost certainly increase the health care spending.[6] It is believed that the treatment expansion effect is a major factor in both the benefits of technological innovation and cost-increase.

Health economists usually presume that new technologies increase health expenditures, because they are usually more expensive than the older technologies they replace and they also expand the relevant market size, but the benefits are worth the extra expense. Even posing the question of whether the new technologies are worth the extra cost would be peculiar for other markets. Interactions of utility maximizing individuals and profit maximizing firms would result in an equilibrium at which all questions are answered automatically. However, even the most free-markets oriented economist would not claim that the markets would make efficient allocation of resources in medical care.

[6] However, it is also possible that a new technology might lower the overall health spending by substantially reducing other types of medical spending. For example Garber (2006) notes that the introduction of polio vaccine made iron lung obsolete and eliminated all relevant medical expenses.

The problems like moral hazard (patients pay only a fraction of the whole medical bill, so they tend to overuse the medical services), supplier induced demand (suppliers have the incentive and *ability* to increase the utilization of health services), principal-agent problem (the interests of decision makers [generally doctors] do not coincide 100% with the principles [hospitals, patients or insurance companies]), and asymmetric information (patients know much less about their conditions and what would happen if they don't listen to the doctor's recommendation) make it necessary to study the potential benefits and costs of new technologies very carefully.

Hedonic methods have been used to measure the valuation of the new products and technologies in many markets. However, usually customers of new technologies in health care markets (patients) have insufficient information (one might say ignorant) about the effects of new technologies. This makes it almost impossible to use hedonic techniques. Therefore, most studies focus on the cost of new technologies in terms of higher spending and compare these costs to the quantifiable health effects of the technologies, such as declines in mortality. For example, Cutler and Mcgellan (2001) analyze new technologies in the treatment of five conditions: heart attacks, low-birth weight infants, depression, cataracts and breast cancer. They conclude that the estimated benefits of new technologies are much greater than the costs for all conditions except breast cancer. The costs and benefits of the technological change in breast cancer are approximately of equal magnitude.

3. Pharmaceuticals

Pharmaceuticals have been getting more attention than other types of medical services for a number of reasons. First, the share of pharmaceutical spending on the total health expenditures has been rising in the US and in many other OECD countries since 1980s. In the US, the share of pharmaceutical drugs increased from historical lows of 8.7% in 1982 to 12.4% in 2005. Similarly, the share of pharmaceuticals on public agencies' budgets has been increasing. Duggan and Evans (2007) note that between 1995 and 2004, the fraction of Medicaid costs on prescription drugs nearly doubled, from 7.4% to 13.7%. Most of this increase was due to expensive new treatments. Average Medicaid prescription cost has risen by 90% since 1995. Lichtenberg (2000) cites the Barents Group study for National Institute for Health care Management (1999) which estimates that 42% of the drug costs between 1993 and 1998 were due to newer drugs costing more than older drugs. According to that study, the average 1998 price for drugs introduced in 1992 or later was $71.49 per prescription,

compared to $30.47 for previously existing drugs. Naturally, the policymakers who are desperate to implement cost-containment strategies have focused on pharmaceuticals. Moreover, pharmaceutical drugs market is relatively concentrated with small number of large multinational firms. So politically it is easier to focus on relatively few and very visible firms than focusing on neighborhood doctors and hospitals.

Pharmaceutical companies have been very active on pushing "technological improvement" on medical care. The pharmaceutical sector is one of the leading industries in terms of R&D investment to revenue ratios. Drug companies use patents very effectively to recover the fixed R&D costs. However, "monopolistic"[7] structure of the market due to patents creates the perception that pharmaceutical companies are making excessive profits.[8] Moreover, they make exaggerated claims about the merits of the new drugs for marketing purposes. These claims coupled with the "insider stories" of "dirty secrets" of pharmaceutical companies have created doubts about the value of the new drugs.

Like other types of technological improvements in the health care markets, newer drugs can have ambiguous effects on the total health spending. Generally, newer drugs are substantially more expensive than their predecessors and possibly, they would increase overall spending. On the other hand, improvements in health outcomes due to their effective use could reduce the need (or demand) for other types of medical care, such as hospital visits and nursing home care, which could decrease the total spending on medical care.

Numerous studies have been published about the value of the new drugs. Most studies focused on the effects of specific drugs on health outcomes and health expenditures. Hudson et al (2003) surveys the papers studying the effect of the use of second-generation antipsychotic medications health care costs. The majority of surveyed studies found that second–generation antipsychotic drugs are either cost-neutral or reducing costs.

Duggan and Evans (2007) used the administrative data of Medicaid to estimate the effect of antiretroviral drugs for HIV on health care spending and health outcomes. They exploited the differential take-up of antiretroviral drugs at individual level. Their results suggest that new drugs not only lower the mortality rate by 68% but they also decrease the short-term health care spending by reducing expenditures on other categories of medical care. The average lifetime Medicaid spending on AIDS patients has increased from $89,000 to

[7] We do not claim that the drug companies are monopolies in technical sense. We mean that there is such a perception.
[8] Grabowski and et. all (2002) showed that is not the case.

$234,000, however, because AIDS patients live longer and require more medical care in the long run.

Lichtenberg has published a series of articles on the values of new drugs using various data sources and methodologies. His studies confirm the proposition that new drugs are not only useful in terms of better health outcomes but they also lower the health expenditures. Lichtenberg (1996) uses US data at disease level. He compares the health outcomes, health expenditures and utilization of different health inputs (such as hospital admissions, physician visits etc…) between 1980 and 1991. In addition, he analyzes the effects of using relatively new drugs for different diseases on health outcomes and health expenditures. He concludes that a $1 increase in pharmaceutical expenditure reduces total health care expenditures by $2.65. In Lichtenberg (2001), he uses person-, condition-, and event-level data to study the effect of drug age on total medical expenditure and mortality. Lichtenberg updates this study using person condition level data in Lichtenberg (2002) which gives very similar results.

Lichtenberg (2006) focuses on HIV treatments using US national data for the period 1982-2001. He estimates that the increased utilization of HIV drugs increases the medical care expenditures by $3,530 per AIDS patient, but it also increases the life expectancy of AIDS patients by 13.6 years. Thus, the medical cost per additional life-year due to increased utilization of HIV drugs is $17,175.[9] However, this method does not allow for differential effectiveness of old and new HIV drugs. Presumably, the newer drugs are more effective on lowering mortality and keeping patients out of hospitals. Thus, he concludes that $17,175 per saved life-year is the upper bound for HIV drugs. However, in another study Duggan (2005) finds that newer antipsychotic drugs have not reduced health spending. According to his estimates, 610% increase in Medicaid spending on antipsychotic drugs has not reduced spending on other types of medical care during 1993-2001 period. Thus, newer drugs have increased total health costs.

The conclusions of the studies on the value of technological improvement and new drugs have significant policy implications. If the new drugs are cost effective per saved life-years, the policies that would reduce the pharmaceutical R&D should be evaluated very carefully. Price regulations, allowing drug importations, putting restrictions on intellectual property rights and other similar regulations are shown to be affecting pharmaceutical companies' R&D and marketing decisions[10].

[9] Lichtenberg (2006) notes that according to Murphy and Topel (2003), average value of US life-year is on the order of $150,000.

[10] See Civan and Maloney (2006), Acemoglu and Linn(2004) and Danzon et all (2005) for specific examples.

Generally, patient/event/disease level data are used in the previous studies. These studies try to control for the endogeneity of the drug use. Generally, newer drugs are first prescribed and used on the patients who are relatively sicker than the average patient. Therefore, their health care spending is higher than the average patient. Even though there have been several approaches to consider this problem, we believe that the individual level patient characteristics are very difficult to control. Thus in this study we are using state level aggregate health spending data.[11] More importantly using aggregate state level data allows us to analyze the treatment expansion effects of newer drugs. Studies that use disease level data also encounter with spillover effects of the diseases. Certain diseases make the patients vulnerable to other ones. Therefore, treatment of a disease might have extra benefits due to spillover effects to other diseases. One should not overlook those crossover effects. Moreover, we use a general proxy to determine the technological level of drugs: the number of years passed since it was first approved by FDA. Most other studies selected specific drugs and analyzed the effects of prescription patterns of these drugs on health spending[12]. Even if the choice of those drugs is far from arbitrary, relatively ad hoc character of this methodology makes it harder to generalize the conclusions. Finally, we use US State level panel data unlike most other studies on the health expenditure issue that use international (usually OECD) data. As Wang and Rettenmaier (2006) point out, one advantage of US State data over international data is that the US states are less heterogeneous in terms of health industry structure, government policy, consumer preferences and payment mechanisms.

4. Data

We use annual data from 1993 to 2004 for 51 states in our estimations. Health Care Expenditures (HCE) and Gross State Products (GSP) are from the webpage of the Center for Medicare and Medicaid Services.[13] We analyze the effect of technology on each of the following 11 categories reported by the Center for Medicare and Medicaid Services: Personal health care, hospital care, physician and clinical services, other professional services, dental services, home health care, prescription drugs, other non-durable medical products, durable medical products, nursing home care, and other personal health care.[14] We obtain state

[11] One other advantage of the aggregate health spending data is that, it is less skewed than the patient level spending.
[12] Lichtenberg uses the same proxy in Lichtenberg (2001)
[13] http://www.cms.hhs.gov/
[14] See Appendix A for the definitions of these categories.

populations and GDP implicit price deflators to calculate the real per capita variables as well as the percentage of the population over age 65 from the websites of the U.S. Census Bureau and Bureau of Economic Analysis, respectively. We obtain insurance coverage data from U.S. Census Bureau website. As stated there "private health insurance is coverage by a health plan provided through an employer or union or purchased by an individual from a private health insurance company, and the government health insurance includes plans funded by governments as the federal, state, or local level. The major categories of government health insurance are Medicare, Medicaid, the State Children's Health Insurance Program (SCHIP), military health care, state plans, and the Indian Health Service." We make use of "Ambulatory Health Care Data" from National Center for Health Statistics' web site[15] to calculate the annual drug mentions for the period above.

Our key variable is the average drug age, which is a measure for the technological progress in the market for drugs. To be more precise, we use the age of the active ingredients of the drugs. A relatively lower average active ingredient age indicates newer technology. We proceed as follows to calculate the average active ingredient age: First, we calculate the annual drug mentions for each drug for our data period. Then, we calculate the total annual mentions of each active ingredient. An active ingredient can appear more than once in different drugs because of the combination drugs. Next, we match the names of these active ingredients with the names of the active ingredients in FDA.[16] FDA database has the first approval dates of the active ingredients, which we use to determine the ages of the active ingredients. Once we have ages of the active ingredients, we calculate the weighted average drug age as follows:

$$Drug\ Age\ = \frac{\sum_{i=1}^{n} f_i \cdot (Active\ Ingredient\ Age)_i}{\sum_{i=1}^{n} f_i}$$

where f_i is the total number of mentions and $(Active\ Ingredient\ Age)_i$ is the age of the ith active ingredient. Unfortunately, Ambulatory Health Care Data does not have the zip codes for the drug mentions. Therefore, we were able to calculate the average drug age for

[15] http://www.cdc.gov/nchs/about/major/ahcd/ahcd1.htm
[16] This database is located at http://www.fda.gov/cder/drugsatfda/datafiles/

four US regions: Northeast, Midwest, South, and West.[17] Accordingly, we assume that the average drug age is same for all states in the same region.

Table 1 reports the summary statistics for our data. Per capita health care expenditure is $4024 while $382 of this amount is spent on prescription drugs. Average drug age varies between 22.71 years and 23.80 years. Alaska is the youngest state and Florida is the oldest in terms of the percentage of population over 65. Only 6% of Alaska residents are older than 65 while 18% of Floridians are older than 65. Insurance coverage also varies between states. New Mexico has the lowest private insurance coverage with 57% and Iowa has the highest with 82%. Average of government insurance coverage in US States is 26%.

5. Empirical Methodology

We estimate the following panel-data models:

$$HCE_{it} = \beta_1 DrugAge_{it} + \beta_2 GSP_{it} + \beta_3 GovIns_{it} + \beta_4 PrivIns_{it} + \beta_5 Over65_{it} + \beta_6 t + \alpha_i + \varepsilon_{it} \quad (1)$$

$$\Delta HCE_{it} = \beta_1 \Delta DrugAge_{it} + \beta_2 \Delta GSP_{it} + \beta_3 \Delta GovIns_{it} + \beta_4 \Delta PrivIns_{it} + \beta_5 \Delta Over65_{it} + \alpha_i + \varepsilon_{it} \quad (2)$$

where $i = 1,...,51$ and $t = 1,...,12$; HCE_{it} is per capita real health care expenditure for each category mentioned in the previous section; *Drug age* is the weighted average age of the active ingredients as described in the previous section; *GSP* is the per capita real gross state product; *GovIns* and *PrivIns* are the government and private insurance coverage, respectively; *Over65* is the percentage of the population over age 65; α_i is the unobserved state effect and ε_{it} is the error term. Allowing for the time trend explicitly recognizes that HCE may be changing over time for reasons unrelated to the exogenous variables that we use. Our purpose is to analyze the long- and short-term effects of the new technology on HCE by estimating equations 1 and 2, respectively.

As is well known, nonstationarity may be a problem for panel data especially when the time dimension is long. Many papers in the earlier literature have found that the HCE and GSP have unit-roots.[18] We applied Levin-Lin-Chu[19] test with time trend to HCE and GSP in

[17] The states in each region are as follows. **Northeast:** Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont; **Midwest:** Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin; **South:** Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia; **West:** Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming, Alaska, Hawaii

[18] See for example, Gerdtham and Lothgren(2000), and Wang and Rettenmaier(2006)

equation (1). The method described in Ng and Perron (2001) produces optimal lag lengths of 0, 1, or 2, and accordingly, we have employed unit-root test for lags 0, 1, and 2. Appendix B, Panel A reports Levin-Lin-Chu unit-root test results. For almost all our variables, unit-root is rejected at the 1% level. Karlson and Löthgren (2000) states that "panel unit root tests can have high power when a small fraction of the series is stationary and may lack power when a large fraction is stationary. The acceptance or rejection of the null is thus not sufficient evidence to conclude that all series have a unit root or that all are stationary." Therefore, we also employed *individual* unit-root test for each state. Since unit-root tests are shown to have low power,[20] to support the results of Levin-Lin-Chu test, we employed KPSS test in which the null hypothesis is that the series is stationary. Appendix B, Panel B presents the percentage of states for which the variable's stationarity is not rejected. At the 5% level, on average, stationarity of 85% of the states (i.e., 43 states) is not rejected. Stationarity is not a problem for equation 2, as the first differences of the HCE and GSP are stationary.

We estimate equations (1) and (2) by using the fixed effects regression methods and report the heteroskedasticity-robust standard errors obtained by using the Huber-White sandwich estimator. Using AR1 or panel-specific AR1 autocorrelation structure produces qualitatively and quantitatively similar results.

6. Results and Discussion

The focus of this study is the influence of innovation in pharmaceutical sector on health spending. As we have discussed earlier, we use the *average drug age* prescribed in each region as a proxy for the diffusion of new technologies. The presumption is that the smaller the value of "*drug age"* the higher the technological level of the pharmaceutical products.

First column of Table 2 reports the estimation results for the effect of drug age on per capita total health expenditures. The positive and statistically significant coefficient of the variable "drug age" suggests that the newer the drugs prescribed in a state are, the lower the total per capita health spending in that state. This implies that newer drugs not only increase the quality of medical care but also actually lower the total health expenditures. Usually newer drugs have lower side effects, thus patients would be willing to pay more for them. Moreover, due to treatment expansion effects, newer drugs would expand the potential patient

[19] Levin, Lin, and Chu (2002)
[20] This is especially a problem for our data set that has 12 time series observations.

pool. Naturally, as the number of patients to be treated increases, the total treatment costs also increases. However, similar to the results found in the literature that we have discussed earlier, our findings imply that the newer medicines are so effective that even if there are more patients to be treated and each patient is willing to pay more for the lower side effects, the total spending decreases. However, earlier studies generally use individual and/or event level data; therefore, they do not consider the treatment expansion effects. Since we use aggregate state level data, our results are stronger. As an example, a one-year decrease in the average age of prescribed drugs causes per capita health expenditures to decrease by $31.92. This amounts to a significant reduction of $171,974,723 for an average state population of 5,387,038 for our sample period.

The estimated coefficients of other exogenous variables are generally inline with the prior expectations. The positive coefficient on per capita income suggests that on average, patients of wealthier states spent more on health care because they are willing and *able* to do so. In addition, sickness or death is costlier for them than the residents of lower income states due to working productivity differences. Indeed, the positive relationship between income and health spending is a common result found in the health expenditure literature.

Interestingly, we find a positive (negative) relationship between the percentage of government (private) insurance coverage and the HCE. One possible reason is that the cost containment strategies of private insurance firms are more successful than that of the public agencies. However, it is also possible that the private insurance companies select the relatively low cost patients, and government insurance is generally for the poor and old who have a higher possibility of getting sick and who need more medical care.

The percentage of the population over 65 has a positive relationship with the health expenditures as expected. The older the state population the more higher the average health spending. Time trend is also positive and significant. Even after controlling for income, insurance, demographic effects and the technological improvements in pharmaceuticals, the health expenditures still rise as time passes. Cost increasing technological improvements on other areas of medical care could be a reason for that.[21] Alternatively, modern life style, which does not require physical activity, encourages unhealthy diet, and causes stress could be the cause of health problems and higher health care spending.[22] Finally, there might be more subtle influences of demographic shifts on health spending that are measured poorly by the

[21] See Pammolli et all (2005) for a detailed review of effects of technological progress on health spending.
[22] See McGinnis and Foege (1993) for an analysis of lifestyle on health outcomes.

demographic variable that we employ, which is the percentage of population over 65.

In the second column of the Table 2, the *health expenditures on pharmaceutical drugs* is the dependent variable. As expected, relatively newer drugs cost more. The negative coefficient of "*drug age"* indicates that the states in which relatively newer drugs are prescribed spent more on pharmaceuticals. This result is parallel to the earlier studies. Newer drugs are more expensive than older ones. A one-year decrease in the average age of prescribed drugs causes the per capita health expenditures on pharmaceutical drugs to increase by $6.4.

On the third column of Table 2, non-drug health expenditures is the dependent variable. The hypothesis we test in this regression is that the newer drugs save money since they lower the expenditures on other types of medical services like physician services, hospital stays, and surgical operations. The positive coefficient of drug age implies that the data confirm our hypothesis. Higher technology (newer) drugs are more effective than the relatively older ones, which cause the patients who take them to utilize other types of medical services less.

Table 3 reports the estimated coefficient of "drug age" on each HCE category reported by the Center for Medicare and Medicaid Services, as discussed in Section 4.[23] Technological improvements in pharmaceuticals reduce the hospital care and home health care expenditures the most. Hospital care spending category includes revenues received for all services provided by hospitals to patients. Home health care includes medical care services delivered in the home-by-home health agencies.[24] Probably physicians are both substitutes and complements for prescription drugs. The results also suggest that spending on other non-durable medical products is increasing with the newer drugs. The category of other non-durable medical products includes items such as bandages, surgical and medical instruments and nonprescription drugs. Negative sign of the coefficient is probably due to mechanical reasons since drug age variable also includes the age of nonprescription drugs. Similar to prescription drugs, younger and newer nonprescription drugs are more expensive than the older ones so as the drug age variable gets bigger the expenditure on nonprescription drugs declines.

[23] We only report and discuss the estimated coefficient of the variable "drug age". Full regression results are available from the authors upon request.
[24] See Appendix A for detailed descriptions of the HCE categories.

Table 4 reports the results from estimating equation 2 that employs first differences of all variables. In a way, this technique will indicate the short-run effects of newer drugs on total health spending. The results are similar to the ones from our earlier estimations. Newer drugs decrease the total health spending. Short run estimations also confirm our hypothesis, which states that newer drugs are so effective that they lower the demand for other types of medical care and reduce total health care expenditures. We see similar results when we look at the short run effects of drug age on various categories of health care expenditures, reported in Table 5. Newer drugs reduce hospital care and home health care expenditures while increasing non-durable medical products spending. In addition, newer pharmaceutical products also lower the expenditure on durable medical products in the short run.

7. Conclusion

In this paper, we studied the influence of the technological improvement in pharmaceutical technology on health care spending using US State level panel data. We find that even if newer drugs are more expensive than their predecessors, they are much more effective so that they reduce total health expenditures by lowering the need for other types of medical services.

Earlier studies on the subject have not analyzed the treatment expansion effects, i.e., the ability to treat hitherto untreatable patients, of the new drugs. Treatment expansion effects almost certainly would increase the total health expenditures unlike the treatment substitution effects. Some of the earlier studies found that newer drugs lower the per patient health expenditures. However, many new drugs also expand the potential patient pool. Thus in theory, even if new drugs lower per patient expenditures they could increase the total health expenditures in a state by treating hitherto untreatable patients. However, our results indicate that is not the case for US States. By using aggregate data, we show that the newer drugs lower total health expenditures in a state.

Although most health economists believe that the rising trend in health spending is partly due to improvement in health technologies, many studies including ours conclude that the technological improvement in pharmaceutical products does not rise the health spending but reduces it. This apparent controversy needs an explanation. Many studies have shown that input use in health production is not efficient everywhere. Fisher et al (2003a, 2003b) conclude that high spending differences between states are almost entirely due to greater frequency of physician visits, more frequent use of specialist consultations, more frequent

tests and minor procedures, and greater use of the hospital and intensive care unit. Moreover, they also conclude that the pattern of practice observed in higher-spending regions does not result in improved survival, slower decline in functional status, or improved satisfaction with care. These conclusions imply that high spending regions use wrong types of technologically advanced medical goods and services, since the government officials play a significant role in planning of the medical markets.

Our results suggest that regulatory and reimbursement policies toward technologically better medical goods and services should be reconsidered, and usage of newer drugs should be encouraged more than usage of newer versions of non-pharmaceutical medical goods and services.

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Table 1. Summary Statistics

This table reports summary statistics calculated by using annual data from 1993 to 2004 for 51 US states. HCE and income are the per capita real health care expenditure and income in dollars; Drug Age is the average drug age. The last three columns are the percentage of government insurance, private insurance and percentage of the population over age 65, respectively.

Regions	Total HCE	HCE on Pharmaceuticals	Income	Drug Age	% Govt. Insurance	% Priv. Insurance	% >65
Midwest	4,054	383	31,105	23.30	24.29	77.83	13.40
Northeast	4,500	435	34,631	22.71	25.73	74.65	13.74
South	4,146	414	34,088	22.80	28.37	67.58	12.68
West	3,508	302	32,316	23.80	25.99	69.64	11.15
States							
Alabama	3,836	456	25,378	22.80	27.40	70.21	13.08
Alaska	4,302	307	43,831	23.80	32.30	64.91	5.51
Arizona	3,289	296	28,890	23.80	27.85	63.97	13.16
Arkansas	3,501	375	24,739	22.80	31.52	63.60	14.24
California	3,631	282	34,669	23.80	25.93	62.66	10.81
Colorado	3,661	275	35,983	23.80	20.17	74.25	9.93
Connecticut	4,928	467	43,882	22.71	23.65	78.19	13.99
Delaware	4,463	479	48,730	22.80	25.08	75.07	12.91
D. of Columbia	8,738	322	103,447	22.80	31.23	63.55	13.10
Florida	4,288	431	28,476	22.80	29.93	64.90	17.91
Georgia	3,701	382	32,873	22.80	24.63	68.54	9.79
Hawaii	3,926	327	33,950	23.80	32.12	73.56	13.14
Idaho	2,972	310	25,801	23.80	23.97	72.41	11.41
Illinois	3,926	373	35,490	23.30	22.57	74.88	12.29
Indiana	3,898	431	30,290	23.30	21.67	78.21	12.52
Iowa	3,788	370	29,974	23.30	22.63	81.87	15.02
Kansas	3,818	386	29,576	23.30	27.13	76.40	13.40
Kentucky	3,916	484	27,292	22.80	30.53	69.18	12.55
Louisiana	4,004	416	28,629	22.80	28.73	61.48	11.53
Maine	4,232	409	26,459	22.71	29.38	72.66	14.13
Maryland	4,078	421	32,927	22.80	21.92	76.68	11.38
Massachusetts	5,143	417	39,496	22.71	25.65	74.17	13.79
Michigan	3,766	415	31,261	23.30	24.90	76.78	12.36
Minnesota	4,404	362	35,129	23.30	21.24	81.11	12.27
Mississippi	3,452	396	22,442	22.80	31.05	63.14	12.24
Missouri	4,164	382	30,163	23.30	25.39	76.07	13.67
Montana	3,552	302	23,564	23.80	28.92	69.29	13.38
Nebraska	4,009	393	31,935	23.30	25.51	77.72	13.71
Nevada	3,512	329	36,346	23.80	20.93	71.04	11.29
New Hampshire	4,001	364	33,075	22.71	21.07	79.48	12.01
New Jersey	4,320	472	39,504	22.71	20.98	75.09	13.42
New Mexico	3,203	251	27,841	23.80	31.41	57.36	11.47
New York	4,924	454	39,008	22.71	28.11	66.43	13.15
North Carolina	3,830	428	32,014	22.80	27.79	69.23	12.35
North Dakota	4,567	384	27,541	23.30	26.90	77.32	14.64
Ohio	4,150	404	30,977	23.30	24.20	76.34	13.33
Oklahoma	3,514	367	25,360	22.80	29.51	65.42	13.38
Oregon	3,594	284	30,669	23.80	25.38	72.95	13.15
Pennsylvania	4,528	460	30,765	22.71	25.78	77.47	15.68
Rhode Island	4,602	503	30,979	22.71	28.03	74.90	15.03
South Carolina	3,619	405	26,957	22.80	28.04	69.41	12.13
South Dakota	4,088	314	29,741	23.30	27.04	76.87	14.39
Tennessee	4,281	482	30,125	22.80	32.11	67.96	12.52
Texas	3,640	320	32,781	22.80	22.60	61.87	10.05
Utah	3,022	306	28,292	23.80	18.07	78.75	8.70
Vermont	3,824	367	28,509	22.71	28.96	73.50	12.46
Virginia	3,518	383	34,581	22.80	26.35	73.57	11.22
Washington	3,754	329	34,440	23.80	26.26	73.09	11.44
West Virginia	4,096	487	22,741	22.80	33.93	65.04	15.24
Wisconsin	4,066	382	31,177	23.30	22.27	80.38	13.17
Wyoming	3,190	322	35,839	23.80	24.58	71.05	11.51

Table 2. Effects of Drug Age on Health Expenditure

This table reports results from estimation of equation 1 by using the fixed effects regression. Heteroskedasticity-robust standard errors are reported in parentheses. ***, ** and * denotes significance levels at the 1%, 5% and 10% levels, respectively.

	Dependent Variables		
Exogenous Variables	**Total Health Expenditures Per Capita**	**Per Capita Health Expenditures on Pharmaceuticals**	**Per Capita Health Expenditures on Non-Drug Medical Care**
Intercept	1220.1712*	552.3330***	667.8369
	(635.3003)	(133.0223)	(573.5077)
Real Income	0.0123**	-0.0023**	0.0146***
	(0.0054)	(0.001)	(0.0052)
Drug age	31.9238***	-6.3962***	38.3200***
	(9.3561)	(1.8677)	(8.5216)
Government Insurance	18.3551***	4.4657***	13.8895***
	(4.1664)	(0.7790)	(3.85)
Private Insurance	-16.2455***	-0.1093	-16.1361***
	(3.612)	(0.8611)	(3.2764)
Over 65	122.7671***	-24.9576***	147.7248***
	(36.5091)	(6.7061)	(32.9765)
Time	121.4497***	39.8055***	81.6442***
	(5.8745)	(1.0623)	(5.5571)
# of Obs.	612	612	612
R^2	91.77%	92.83%	88.60%

Table 3. Effects of Drug Age on Various Health Expenditure Categories

This table reports the estimated coefficient of the variable *Drug Age* for each health care category from estimation of equation 1 by using the fixed effects regression. Heteroskedasticity-robust standard errors are reported in parentheses. ***, ** and * denotes significance levels at the 1%, 5% and 10% levels, respectively.

Exogenous Variables	Estimated Coefficient of Drug Age	Adjusted R^2
Total Health Care	31.9238***	91.77%
	(9.3561)	
Hospital Care	25.8320***	75.57%
	(5.0935)	
Physician and Clinical Services	4.9157	80.35%
	(4.1335)	
Other Professional Services	0.1057	79.69%
	(0.651)	
Dental Services	1.1630	89.88%
	(0.5972)	
Home Health Care	11.9530***	21.17%
	(1.2058)	
Prescription Drugs	-6.3962***	92.83%
	(1.8677)	
Other Non-Durable Medical Products	-1.0233**	5.81%
	(0.5135)	
Durable Medical Products	0.2498	54.54%
	(0.2258)	
Nursing Home Care	-1.8216	43.11%
	(1.6460)	
Other Personal Health Care	-3.0655	66.81%
	(1.6265)	

Table 4. Short Run Effects of Drug Age on Health Expenditure

This table reports results from estimation of equation 2 by using the fixed effects regression. Heteroskedasticity-robust standard errors are reported in parentheses. ***, ** and * denotes significance levels at the 1%, 5% and 10% levels, respectively.

	Dependent Variables		
Exogenous Variables	**Δ(Total Health Expenditures Per Capita)**	**Δ(Per Capita Health Expenditures on Pharmaceuticals)**	**Δ(Per Capita Health Expenditures on Non-Drug Medical Care)**
Intercept	122.0779***	34.1757	87.9022***
	(8.5622)	(1.0583)	(8.0828)
Δ(Real Income)	0.0207**	-0.0007	0.0214**
	(0.0091)	(0.0008)	(0.0085)
Δ(Drug age)	23.7627***	-1.0592	24.8219***
	(5.5652)	(1.0984)	(5.1682)
Δ(Government Insurance)	3.0362	0.1489	2.8873
	(2.1535)	(0.3830)	(1.9763)
Δ(Private Insurance)	-6.0151***	-0.5812	-5.4339***
	(1.7518)	(0.3593)	(1.6130)
Δ(Over 65)	308.8451***	-8.5133***	317.3583***
	(103.6278)	(10.0655)	(95.5956)
# of Obs.	612	612	612
R^2	27.08%	0.87%	31.19%

Table 5. Short run Effects of Drug Age on Various Health Expenditure Categories

This table reports the estimated coefficient of the variable *Δ(Drug Age)* for each health care category from estimation of equation 2 by using the fixed effects regression. Heteroskedasticity-robust standard errors are reported in parentheses. ***, ** and * denotes significance levels at the 1%, 5% and 10% levels, respectively.

Exogenous Variables	Estimated Coefficient of Δ(Drug Age)	Adjusted R^2
Δ(Total Health Care)	23.7627***	27.08%
	(5.5652)	
Δ(Hospital Care)	14.8053***	24.74%
	(3.3580)	
Δ(Physician and Clinical Services)	1.0508	1.63%
	(2.8826)	
Δ(Other Professional Services)	-0.1574	5.98%
	(0.5303)	
Δ(Dental Services)	1.1927**	2.78%
	(0.6386)	
Δ(Home Health Care)	6.3186***	17.48%
	(0.8170)	
Δ(Prescription Drugs)	-1.0592*	0.87%
	(1.0984)	
Δ(Other Non-Durable Medical Products)	-0.4411***	15.75%
	(0.2032)	
Δ(Durable Medical Products)	0.5777***	22.72%
	(0.1456)	
Δ(Nursing Home Care)	0.2531	7.91%
	(1.0056)	
Δ(Other Personal Health Care)	1.2366**	2.53%
	(0.6689)	

Appendix A. Definitions of Health Care Expenditure Categories Reported by the Center for Medicare and Medicaid Services

Following definitions of the categories of the health care expenditures are extracted from the links below:

- http://www.cms.hhs.gov/NationalHealthExpendData/downloads/prov-methodology2004.pdf
- http://www.cms.hhs.gov/NationalHealthExpendData/downloads/dsm-04.pdf.

1. **Personal Health Care:** "Personal health care" is comprised of therapeutic goods or services rendered to treat or prevent a specific disease or condition in a specific person.
2. **Hospital Care:** Hospital care spending is defined to cover revenues received for all services provided by hospitals to patients. Thus, expenditures include revenues received to cover room and board, ancillary services such as operating room fees, services of resident physicians, inpatient pharmacy, hospital-based nursing home care, hospital-based home health care and fees for any other services billed by the hospital.
3. **Physician and Clinical Services:** The expenditures for physician services are estimated in three pieces: (1) expenditures in private physician offices and clinics and specialty clinics that include family planning centers, outpatient mental health and substance abuse centers, all other outpatient care facilities, and kidney dialysis centers. ; (2) fees of independently billing laboratories; and (3) clinics operated by the U.S. Department of Veterans Affairs (DVA) and the U.S. Indian Health Service.
4. **Other Professional Services:** "Other professional services" covers spending for services provided by health practitioners other than physicians and dentists. Professional services include those provided by private-duty nurses, chiropractors, podiatrists, optometrists and physical, occupational and speech therapists, among others.
5. **Dental Services:** Expenditures in Offices and Clinics of Dentists (NAICS 6212) are based on State distributions of business receipts from taxable establishments reported in the 1977, 1982, 1987, 1992, 1997, and 2002 CSI (U.S. Bureau of the Census, 2005).
6. **Home Health Care:** The home health component of the NHEA measures annual expenditures for medical care services delivered in the home by freestanding home health agencies (HHAs). NAICS 6216 defines home health care providers as private sector establishments primarily engaged in providing skilled nursing services in the home, along with a range of the following: personal care services; homemaker and companion

services; physical therapy; medical social services; medications; medical equipment and supplies; counseling; 24-hour home care; occupation and vocational therapy; dietary and nutritional services; speech therapy; audiology; and high-tech care, such as intravenous therapy.

7. **Prescription Drugs:** The category of prescription drugs includes retail sales of human-use dosage-form drugs, biologicals and diagnostic products. The transactions to purchase prescription drugs occur in community pharmacies, grocery store pharmacies, mail-order establishments, and mass-merchandising establishments.
8. **Other Non-Durable Medical Products:** The category of other non-durable medical products includes such items as rubber medical sundries, heating pads, bandages, and nonprescription drugs and analgesics. Nonprescription drugs sold over the counter include those marketed to the general public and those promoted to the medical professions and comprise products such as analgesics, and cough and allergy medications. Finally, medical sundries primarily include such items as surgical and medical instruments, surgical dressings, and diagnostic products such as needles and thermometers.
9. **Durable Medical Products:** Expenditures in this category represent retail sales of items such as contact lenses, eyeglasses and other ophthalmic products, surgical and orthopedic products, equipment rental, oxygen and hearing aids. Durable products generally have a useful life of over three years whereas non-durable products last less than three years.
10. **Nursing Home Care:** Expenditures reported in this category are for services provided by freestanding nursing homes. These facilities are defined in the 1997 NAICS as private sector establishments primarily engaged in providing inpatient nursing and rehabilitative services and continuous personal care services to persons requiring nursing care (NAICS 6231) and continuing care retirement communities with on-site nursing care facilities (NAICS 623311).
11. **Other Personal Health Care:** Privately funded other personal health care consists of industrial in-plant services provided by employers for the health care needs of their employees.

Appendix B. Unit Root tests

Panel A reports t-statistics from Levin-Lin-Chu unit-root test for the optimal lag lengths of 0, 1, or 2, produced by the method described in Ng and Perron (2001). The null hypothesis is that the variable has a unit root.***,**, and * indicate that unit-root is rejected at the 1%, 5%, and 10% levels, respectively. Panel B reports the % of states for which the variable's stationary is not rejected by a KPSS test in which the null hypothesis is that the variable is stationary.

Panel A. Levin-Lin-Chu test

	Lags		
Variable	**0**	**1**	**2**
realhcepercap_1	-6.9535***	-5.0735***	-6.3099***
realhcepercap_2	-7.3137***	-6.8123***	1.3565
realhcepercap_3	-7.7661***	-5.2772***	-3.0045***
realhcepercap_4	-6.8513***	-8.0869***	-7.2043***
realhcepercap_5	-10.5225***	-4.2779***	-1.7984**
realhcepercap_6	-5.6311***	-8.7841***	-2.3944***
realhcepercap_7	-1.4149*	-2.0435**	-7.4251***
realhcepercap_8	-5.4724***	-8.9696***	-14.6721***
realhcepercap_9	-6.3982***	-11.7145***	-15.3161***
realhcepercap_10	-8.5772***	-9.3637***	-7.2259***
realhcepercap_11	-5.1288***	-12.4175***	-3.6509***
realhcepercap_1_7	-7.5224***	-5.5610***	-5.6627***
percaprealinc	-3.9461***	-4.2670***	-1.4060*

Panel B. KPSS test

Variable	**5%:**	**2.5%:**	**1%:**
RealHCEperCap_1	82.35	100	100
RealHCEperCap_2	78.43	100	100
RealHCEperCap_3	74.51	100	100
RealHCEperCap_4	58.82	58.82	58.82
RealHCEperCap_5	92.16	98.04	98.04
RealHCEperCap_6	98.04	98.04	98.04
RealHCEperCap_7	86.27	100	100
RealHCEperCap_8	90.2	100	100
RealHCEperCap_9	100	100	100
RealHCEperCap_10	90.2	98.04	98.04
RealHCEperCap_11	84.31	96.08	100
RealHCEperCap_1_7	88.24	100	100
PerCapRealInc	90.2	96.08	98.04