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Daniel Lee April 16, 2013

The Rising Price of Anticancer Medicine Based on Social Norm

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Abstract

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By Daniel Lee

The price of cancer drugs have been rising rapidly. Current research suggests that pharmaceutical drug companies increase prices of new drugs not only based on improvements in survival benefits but also based on social norm where a company marks up the price of the new drug by comparing the price of an already existing similar drug. Through empirical analysis, the results show that with survival benefits being equal, the more recent a cancer drug has been FDA-approved, the higher the price. The results contribute evidence that pricing mechanism is influenced by social norm. Concerning the fact that Medicare spending on cancer drugs has been expanding expeditiously and is expected to continuously grow, the results also open discussion on how to prevent the rapid rise in cancer drug prices in order to keep Medicare effective and sustainable.

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I. Introduction

The anticancer pharmaceutical industry periodically introduces drugs that are either completely novel or that are newer versions of previously marketed drugs. The new drugs are improvements on previously available medication, because they are either more potent or effective in extending patients' longevity, act through a different bio-physiological mechanism, or reduce the side effects of treatment. Not surprisingly, these new drugs tend to be sold at higher prices than the older drugs.

However, current research suggests that the prices of cancer drugs rise for other reasons than just the improvement in treatment. The pricing mechanism of newer drugs possibly seems affected by social norms in the sense that companies appear to significantly rely on the prices of existing alternative drugs than either the cost of producing the drug or the improvement of survival that the new drug offers. For example, the recently approved drug Zaltrap offers similar survival benefits of Avastin, a drug already available for the treatment of advanced colorectal cancer. Although both chemicals work through similar mechanisms and prolong patient lives by a median of 1.4 months, the Zaltrap's price, which is $11,063 per month, is more than twice the price of Avastin, which costs roughly $5,000 per month[1]. Major institutions such as the National Comprehensive Cancer Network agree that Zaltrap is no better than Avastin[2]. The price difference is part of a trend of increasing treatment cost in the anticancer market.

Anticancer pharmaceutical companies are able to market similar quality drugs for higher

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[1,2] "In Cancer Care, Cost Matters."

cost without experiencing significant resistance due to the unique characteristics of the cancer market and the current institutional and legislative framework involved with cancer drugs. Facing possible imminent death, cancer patients do not behave in an economically optimal manner; patients have inelastic demands for medication, behave with moral hazard, and are indifferent to rises in prices. The institutional infrastructure of the medical system blind patients from perfect information and prohibits consumers from immediately recognizing and responding to rises in costs. The current legislative framework of Medicare and the Federal Drug Administration (FDA) only scrutinizes drugs' safety and effectiveness and does not provide effective safety nets and competition among drug companies to prevent increases in cancer treatment costs.

A large amount of public funds, most prominently Medicare, provide financial support toward FDA-approved anticancer medicine, so the rise in cancer treatment costs poses a greater problem to the entire population. Most cancer patients are heavily insured, and a large portion of these cancer patients are supported through Medicare. Both the number of cancer patients insured through Medicare and the cost of cancer treatment have been rising dramatically. If prices continue to increase, Medicare ultimately will not be able to be kept efficient and sustainable in the long-run.

This paper seeks to expand upon explaining the factors that enable the rising costs of anticancer treatment drugs and to quantitatively validate the trend. Section II provides background information and previous literature review on the increasing price of cancer medication, the market, institutional, and legislative characteristics that allow this trend to persist, and its economic impact on Medicare. Section III presents the dataset, hypothesis, and

empirical model used to test the hypothesis. Section IV states the results, and Section V offers my conclusion and suggestions for further research.

II. Background and Literature Review

The Social Norm in Rising Cancer Drug Prices

The increase in cost despite similar survival benefits shown through Zaltrap and Avastin is not an isolated case in the anti-cancer medication market. Sipuleucel-T and Avastin are anticancer treatment medicine that target terminal prostate cancer and extend survival by 3 to 5 months (Howard, 2011). Similar to Zaltrap and Avastin, these two prostate cancer treatments produce similar clinical results, but Sipuleucel-T is much more expensive than Avastin due to its comparatively recent debut to the chemotherapeutic market. When observing the aggregate of the market, almost a decade ago, a typical new cancer drug was introduced to the market for about $4,500 per month compared to $10,000 per month (adjusted to 2012 dollars), which was the median price of cancer drugs since 2010[3].

Previous literature and research confirms the upward trend in the cost of cancer medication. Both Meropol and Schulman (Meropol, 2007) and Schrag (Schrag, 2004) have indicated the diminishing returns of metastatic colorectal cancer treatments. Furthermore, nitrogen mustard, which has been used since 1949 to treat cancer, has increased in price by 13 fold in the year 2006 alone from $33 to $420[4].

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[3] "In Cancer Care, Cost Matters."

[4] "A cancer drug's big price rise is cause for concern."

The increase in price does not seem to solely reflect the improvement of cancer drugs, but rather, pharmaceutical companies seem to be raising prices in comparison to already existing similar drugs. Rather than following the standard economic models, new chemotherapeutics seem to follow social norms rather than market forces when dictating prices. For example, a company may introduce "a drug that costs $30,000. Insurers complain but still cover the drug. The next company to introduce a drug, seeing that the first was able to charge $30,000, sets its price at $40,000, and the cycle continues. (Howard, 2011)" Although the effectiveness of drugs remain similar, the cost-effectiveness of drugs are diminishing with introductions of newer, more expensive cancer medicine.

Market, Institutional, and Legislative Characteristics of Anticancer Medication

Pharmaceutical companies are able to raise cancer drug prices without substantial resistance due to the unique characteristics of the cancer treatment market. The phenomenon cannot be explained by simply examining a single facet of the cancer pharmaceutical market, because various attributes combine in order for the rising trend in prices to persist. The issue needs a multidimensional examination where reasons can be categorized most broadly through the market, institutional, and legislative characteristics.

First, market behaviors are unusual due to consumer attributes that lead to economically inefficient market behaviors. Cancer patients are at the last moments of their lives and need medical treatment in order to prolong imminent death. Thus, the patients' demand for medication is inelastic; patients are willing to purchase medication regardless of cost or the increase of cost. According to 2006 *Nation Survey of Households Affected by Cancer,* among 980 adults who either personally experienced or had a family member experience

cancer, 71 percent reported receiving some kind of treatment[5]. While 56 percent of the responders agreed that the prices prescription drugs for cancer has gone up, 91 percent never decided to delay or not get care or chose one treatment over another because of cost[6]. When faced with either life or death, cost no longer becomes a factor among patients and their family members.

The rise in cost does not falter patients from receiving medication not only due to their price inelasticity but also because cancer patients do not experience heavy financial burden. Most cancer patients are heavily insured either privately or publicly and pay low amounts through out-of-pocket methods. From the same survey, 92 percent of members reported being covered by some form of health insurance or health plan during the entire time of the cancer treatment with a large portion of 34 percent being covered by Medicare[7]. 52 percent reported that the medical care was not a financial burden while 29 percent considered care only a minor burden[8]. Patients are heavily insured in one form or another, so they are less sensitive to the rises in cancer treatment costs. Moreover, even in the case that treatment imposes significant financial burden, cancer patients in fatal conditions passively experience moral hazard. If a cancer patient does not recover and passes away, the patient would not incur the cost of paying back the money used for receiving expensive treatments. Therefore, patients are more willing to take financial risks by consuming medication regardless of extravagant costs.

[5, 6, 7, 8] *USA Today/Kaiser Family Foundation/Harvard School of Public Health National Survey of Households Affected by Cancer*

Second, the institutional infrastructure of medicine is designed in a way for patients to not have access to perfect information and to be dependent on intermediary agents when purchasing treatments. Even if patients desired to analyze the cost-effectiveness of drugs, the information is extremely difficult to procure. The cost of treatment is not openly accessible, which inhibits consumers from comparing the prices of similar drugs. Also, instead of buying cancer drugs directly through pharmaceutical companies, patients purchase treatment through physician recommendations and insurance policies. As patients interact through these intermediary agents, the increase in drug prices is not immediately detectable by patients.

Third, cancer drugs are protected from the legislative and regulatory framework designed to hold down the utilization and costs of health goods. The FDA and Medicare are two large federal agencies involved with cancer drugs. When approving drugs, the FDA only focuses on the safety and effectiveness of the medication. Thus Medicare is solely responsible in placing cost control methods to most effectively and efficiently expend public funds. However, in terms of cancer drugs, Medicare has been legislated to cover virtually every type of cancer drug that the FDA approves[9].

Medicare has several strategies to keep the public program's cost down by controlling utilization. In order to limit utilization, Medicare, either through a single national or a local coverage decision, actively decides strict circumstances when a drug's usage is reasonable

[9] "In Cancer Care, Cost Matters."

and necessary. For example, in 2007, with efforts to narrow down the coverage of erythropoiesis-stimulating agents (ESAs), Medicare restricted both the types of patients who are eligible to receive ESAs and the clinical circumstances when they can be utilized (Bach, 2009). That year in August, Amgen reported to their investors that the changes in coverage made by the Centers for Medicare and Medicaid Services (CMS) would reduce the company's annual sales of Aranesp, a version of ESAs, from approximately $1 billion to $200 million among Medicare patients (Bach, 2009).

Another way that Medicare keeps cost down is by controlling prices by categorizing several health goods as clinically interchangeable. Subsequently, Medicare can obtain lower prices by encouraging price competition among manufacturers. One strategy to engage in price competition is through the least-costly-alternative (LCA) reimbursement, where Medicare reimburses healthcare providers at the price of the least costly drug among the interchangeable alternatives. Manufacturers respond by lowering drug prices so that treatment costs are not higher than the amount health providers would be reimbursed after administering their drug. The LCA reimbursement has been implemented by many local contractors to the Medicare program for clinically interchangeable prostate-cancer drugs Lupron and Zoladex. In 2002, Zoladex's price was 27 percent less than the Lupron, and the Office of the Inspector General estimated that Medicare would have saved approximately $40 million with the application of the LCA reimbursement plan[10].

[10] Medicare Reimbursement for Lupron

Although Medicare has several cost containing mechanisms for health goods, cancer drugs are shielded from the legislative and regulative framework. The restrictions to limit utilization are invalidated for cancer medication, because numerous provisions of the law addressing Medicare's coverage of cancer drugs have been traditionally interpreted to provide flexible coverage. Medicare part B covers cancer drugs that are generally administered in the doctor's office, and Medicare is legally required to cover practically all cancer drugs that are used in an anticancer chemotherapeutic regiment as long as the medication is used for a "medically accepted indication". The indication standard is defined in a broad manner to include drug usage approved by the FDA, usage listed in one of several drug compendia, and usage supported in peer-reviewed medical literature (Bach, 2009). Drugs covered by Medicare's part D are generally oral drugs that are obtained from a pharmacy, and Medicare-contracted private plans are required to include virtually all cancer drugs that were made available when the program was first administered in 2006 (Bowman, 2006). In 2008, Congress included all oral cancer drugs that come on to the market after 2006 to be included under the Plan D's coverage, and as of 2010, Part D plans are required to include all drugs that treat "major" or "life-threatening" conditions, which summarily encompasses all drugs used in the treatment of cancer (Bach, 2009).

Cancer drugs also evade Medicare's control on price, because a complex set of laws prevent Medicare from combining similar related cancer drugs as being interchangeable. The laws have two prominent and related effects by classifying nearly all new cancer drugs as "sole-source" drugs and by requiring Medicare to give each sole-source drug a unique payment rate and billing code (Bach, 2009). For drugs to be classified as multiple-source, law states multiple

drugs need to be pharmaceutically, therapeutically, and biologically equivalent as classified in the FDA's Orange Book of approved drugs(Bach, 2009). Standards are strict enough to prevent new cancer drugs from being adequately similar to existing compounds, and new cancer drugs do not get classified as a multiple-source drug or interchangeable. Unable to classify cancer drugs as interchangeable, Medicare is cannot invoke competition through methods such as the LCA reimbursement plan and lower drug prices.

Rising Cancer Prices and Medicare's Sustainability

Historically, the spending on cancer drugs has been one of the most rapidly increasing sections compared to many other areas of healthcare spending. While Medicare spending increased by 47 percent from $210 billion to $309 billion between 1997 and 2004, in the same time, spending on Medicare's Part B drugs, which is dominated by cancer medication, has alarmingly risen by 267 percent from $3 billion to $11 billion (Bach, 2009). One estimation suggests that the direct medical costs of cancer increased from $27 billion in 1990 to more than $90 billion in the 2008 (Elkin, 2010), which is nearly a three-fold increase within less than two decades.

The previous rise in spending for Medicare on cancer drugs and overall cancer care is due in both in part by increasing costs and quantity of care. One study found that both the chemotherapy treatment costs and the proportion of breast cancer patients receiving chemotherapy treatment both doubled between 1991 and 2002; the average chemotherapy costs increased from $6,642 to $12,802 in 2003 US dollars and the proportion of breast cancer patients receiving the treatment increased from 11 percent to 24 percent (Warren, 2008).

The number of cancer patients insured by Medicare is expected to continue to rise with the growing cancer population. The increase in cancer patients will largely reflect the shift in the aging demographics of the baby boomer generation. Mariotto et. al. estimates that, between 2010 and 2020, cancer survivors will increase from 13.8 to 18.1 million and costs of cancer care will increase by 27 percent from 124.57 to 157.77 billion in 2010 US dollars (Mariotto, 2011).

As a significant portion of the population is expected to receive medical treatment in the near future, the rising cost in cancer care is a major concern regarding the sustainability of Medicare. In 2013 alone, spending on health care has been estimated to be close to $3 trillion[11], which is an amount that is already excessively high reflecting about 17.6 percent of the U.S. Gross Domestic Product. According to CMS's projection, between 2010 and 2020, the average annual growth in the overall economy is expected to be 4.7 percent, which is 1.1 percent outpaced by the expected annual growth in health spending of 5.8 percent [12]. By 2020, national health spending is projected to be $4.6 trillion with 50 percent being a government-sponsored, which is a 5 percent increase from 2010[13]. Thus, without proper implementation of cost control for cancer drugs, cancer medication will significantly contribute to towards preventing Medicare from being sustainable in the long run.

[11, 12, 13] *National Health Expenditure Projections 2010-2020*.

III. Dataset, Hypothesis, and Empirical Strategy

Dataset

Data has been collected on 48 anticancer treatment medicines that have been FDA-approved between 1996 and 2012. Most of the information was procured through the drugs' package inserts, which is also known as the structured product labeling (SPL). This document is a markup standard adopted by the FDA as an instrument to exchange drug and facility information. The SPL is a publicly available through the FDA Online Label Repository and is submitted by pharmaceutical companies to the FDA regarding detailed information of their drug such as usage directions, warnings, clinical trials, and potential adverse and side effects. Not all information, especially those regarding price and the drug's usage cycle, was available through the SPLs. Thus, through the guidance of Dr. Howard, these data were consulted through other sources, which included numerous journal articles, nonprofit organizations such as the Medical Letter, and managed healthcare companies such as Medco and the All Wales Medicines Strategy Group.

The dataset includes the following variables for each cancer drug: target disease, FDA approval month, FDA approval year, gain in survival time, average whole sale price adjusted to 2012 dollars, drug quantity per whole sale, dose per person, dosing schedule, doses per cycle, number of cycles, treatment received by control group in clinical trial, and the rate of vomit, diarrhea, nausea, neutropenia, and anemia of both the treatment and control group in the clinical trial. Price, lnPrice, and time were additional variables created using the dataset. Price is the expected cost of treatment adjusted to 2012 dollars, and this was calculated by finding the dosage amount per treatment and cost of dosage using the variables whole sale price, drug

quantity per whole sale, dose per person, dosing schedule, doses per cycle, and number of cycles. lnPrice was calculated by finding the log of price. Time indicates the years between the FDA-approval date and January 1, 1996. Not all entries were complete across the variables especially for side effect rates of the treatment and control groups in clinical trials. Thus, dummy variables were created in order to indicate whether a side effect existed for a treatment or control group in the clinical trial results. The generated dummy variables were diarrheaTreatmentGroup, diarrheaControlGroup, vomitTreatmentGroup, vomitControlGroup, nauseaTreatmentGroup, nauseaControlGroup, neutropeniaTreatmentGroup, neutropeniaControlGroup, anemiaTreatmentGroup, and anemiaControlGroup. See Table 1 on page 20 for the summary statistics of the variables used in the study.

Hypothesis

This study aims to identify the factors that play a role in the pricing decisions made by pharmaceutical companies in the cancer drug market. In particular, the investigation seeks to understand drug pricing behavior that is based on the social norm of marking up novel drug prices in comparison to previously available similar drugs. By observing and testing the data, this study attempts to show the relationship between price, survival benefits, and the time that a drug has been approved by the FDA.

Economic theory suggests that prices of cancer drugs should increase with the improvement of survival benefits. This study considers the extension in survival time and the rate of side effects to be the prime indicators of survival benefits. Thus, a drug's price should rise as it becomes more effective in extending a patient's life and by having less side effects. Furthermore, more recently FDA-approved drugs are expected to be priced higher compared to

previously available similar drugs. The following hypotheses indicate the predicted outcomes of the empirical testing for the relationship between price and other factors.

H_1. Price increases as gain in survival time increases.

H_3. Price increases when a drug has less side effects.

H_2. Price increases as time increases.

Empirical Strategy

The empirical model for this project seeks to determine the relationship between price, survival benefits, and the novelty of a drug in order to observe if these factors could have an effect on pharmaceutical companies' pricing strategies. For the model, the variables are studied in relation to price, which is the expected cost per treatment. The model follows the following expression:

Model

$$lnPrice = \beta_0 + \beta_1 gain\ in\ survival\ time + \beta_2 time + \beta_3 diarrheaTreatmentGroup + \beta_4 diarrheaControlGroup + \beta_5 vomitTreatmentGroup + \beta_6 vomitControlGroup + \beta_7 nauseaTreatmentGroup + \beta_8 nauseaControlGroup + \beta_9 neutropeniaTreatmentGroup + \beta_{10} neutropeniaControlGroup + \beta_{11} anemiaTreatmentGroup + \beta_{12} anemiaControlGroup$$

Due to the small sample size of 48 observations, the regression is executed using the aggregate dataset. Moreover, since information regarding improvements in side effects and quality of life is not equally available for all drugs, the model uses dummy variables, which show if drugs have certain side effects, alongside with gain in survival time as indicators for survival benefits.

In order to gain more insight on survival benefits, direct statistical analysis is used for the side effects. The statistical analysis of the aggregate data is not ideal concerning the discrepancies in the number of observations between the treatment and control group for the five side effects. Thus, a direct statistical analysis is conducted only on entries where the rate of side effects for both treatment and control groups is available.

IV. Results

Using the regression model on the aggregate data, the study was able to find the relationship between price, survival benefits, and time. Price was shown to have a positive relationship with gain in survival time, which was expected. Price was also shown to have a positive relationship to time, which was expected. Both coefficients of time and survival time were significant with time having a higher coefficient value of 0.077 compared to gain in survival time's coefficient of 0.051. The R-squared value indicated that the model explained about 60 percent of the data, which is statistically significant.

The dummy variables also provided evidence that improvements in side effects have a positive relationship with price. The coefficient values for diarrheaTreatmentGroup, vomitTreatmentGroup, and neutropeniaTreatmentGroup had negative values, which means that if these side effects are prevalent after treatment, then the treatment prices go down. In other words, if these side effects do not exist after treatment, the drug's price is higher. NauseaTreatmentGroup and anemiaTreatmentGroup had positive values, but these coefficients had significantly high t-values, which suggest that the results are statistically insignificant. The overall results regarding the dummy variables confirm that improvement in survival benefits is related to rise in price of cancer drugs. See Table 3 on page 22 for details.

Graphs were also produced to visually confirm the expected positive trends of survival time and FDA-approved time on price. In Figure 1 (page 23), lnPrice was graphed with time, and an overall increasing positive trend was observed. Figure 2 (page 24), which is the graph of lnPrice and gain in survival time of breast cancer, shows that although gain in survival time has remains similar between 1.5 and 2.5 months, price increases as time increases.

Direct statistical analysis also provided insight on the drugs. On average, the prominence of diarrhea, vomit, nausea, neutropenia, and anemia was higher for the treatment group compared to the control group. Control groups were either administered a placebo or other available treatments. The fact that the treatment group's average rate of side effect was higher for all five side effects provides insight that newer drugs do not necessarily provide treatment with improved survival benefits. Rather, in this case, the results seem to indicate the opposite. See Table 2 on page 21 for more details.

V. Discussion and Conclusion

Cancer drug prices are expected to increase with improved survival benefits, but the pricing mechanism of pharmaceutical companies seem to also rely on other factors. This study suggested that aside from improvements in survival benefits, companies mark up prices of new drugs based on already existing similar drugs. Therefore, a new drug may have similar survival benefits to an already existing drug, but the price of treatment may be higher simply due to its novelty in the cancer drug market. The results of the aggregate regression not only showed that improved survival benefits increases drug price but also that the time the drug was FDA-approved has a significant influence in the rise in price; with survival benefits being equal, the later the drug is FDA-approved, the higher the price of treatment. In fact, the coefficient of the

FDA-approved time had a higher value than the coefficient of gain in survival time, suggesting that time might have more influence on the pricing mechanism than survival benefits. Moreover, the direct statistical analysis also provided insight that side effects are not necessarily improved for newer drugs, which provides further evidence that prices may be rising without substantial improvements in survival benefits. Overall, the study's result supports the suggestion that pharmaceutical companies may be increasing novel drug prices based on social norms.

The results of this study lay a foundation for further investigation of the cancer drug pricing mechanism. With a larger and more complete dataset, the regression model can incorporate more observations and variables involving other survival benefits to provide powerful evidence towards rising prices due to social norm.

Procuring the dataset shed light towards how pharmaceutical companies are able to raise prices while experiencing little resistance. Prices were extremely difficult to find and required one to seek through various sources. Some of the information was obtained through journal articles and managed health care companies where one needs some type of subscription in order to access the information. For an average person, this may not be obvious or practical, and making a comparison of similar drugs could be tremendously difficult. The challenge in accessing information on price and similar drugs eliminates the competitive element in the cancer drug market allowing pharmaceutical companies to continue to raise prices based on social norms.

Concerning the rise in cancer patients in the near future, several legislative and institutional changes should be made in order to prevent cancer treatment prices from

uncontrollably rising according and to keep Medicare sustainable. The main remedy would be to reintroduce competition among pharmaceutical companies. Medicare should implement agencies to identify interchangeable cancer drugs with similar survival benefits along with their prices for treatments. By making this information easily accessible to the public, cancer drug consumers can participate in driving costs down toward low and competitive prices. Moreover, in order to lower Medicare spending on cancer treatment, congress could increase the rate of Medicare's co-payment, which has proven to be effective in reducing healthcare spending in the RAND experiment (Lohr, 1986). With higher copayments, patients will either spend less or strive for lower priced alternatives, which would further amplify the competitive element of the cancer drug market.

VI. References

Bach, Peter B., Leonard B. Saltz, and Robert E. Wittes. "In Cancer Care, Cost Matters." *The New York Times*. The New York Times, 14 Oct. 2012. Web. 20 Dec. 2012.

Bach PB. 2009. Limits on Medicare's ability to control rising spending on cancer drugs. *N. Engl. J. Med.* 360:626–33

Berenson A. "A cancer drug's big price rise is cause for concern." New York Times. March 12, 2006:A1

Bowman J, Rousseau A, Silk D, Harrison C. Access to cancer drugs in Medicare Part D: formulary placement and beneficiary cost sharing in 2006. Health Aff (Millwood) 2006;25:1240-1248

Centers for Medicare and Medicaid Services. *National Health Expenditure Projections 2010- 2020*. N.p., n.d. Web. 15 Mar. 2013. <https://www.cms.gov/Research-Statistics-Data- and-Systems/Statistics-Trends-and- Reports/NationalHealthExpendData/downloads/proj2010.pdf>.

Department of Health and Human Services, Office of Inspector General, Office of Evaluation and Inspections. *Medicare reimbursement for Lupron*. January 2004. (Accessed March 16, 2013, at http://oig.hhs.gov/oei/reports/oei-03-03-00250.pdf.)

Elkin EB, Bach PB. Cancer's Next Frontier: Addressing High and Increasing Costs. *JAMA.* 2010;303(11):1086-1087. doi:10.1001/jama.2010.283.

Howard, David, Dr. "Realigning Incentives for Developing and Pricing New Anticancer Treatments." *The Journal of the American Medical Association* 35.22 (2011): 2347-348. Print.

Lohr KN, Brook RH, Kamberg CJ, et al. Use of medical care in the RAND Health Insurance Experiment: diagnosis- and service-specific analyses in a randomized controlled trial. Med Care 1986;24:Suppl:S1-S87

Mariotto, Angela B., K. Robin Yabroff, Yongwu Shao, Eric J. Feuer, and Martin L. Brown. Projections of the Cost of Cancer Care in the United States: 2010–2020*JNCI J Natl Cancer Inst* (2011) 103(2): 117-128 first published online January 12, 2011doi:10.1093/jnci/djq495

Meropol NJ, Schulman KA. Cost of cancer care: issues and implications. J Clin Oncol 2007;25:180-186

Schrag D. The price tag on progress -- chemotherapy for colorectal cancer. N Engl J Med 2004;351:317-319

The Kaiser Family Foundation. *USA Today/Kaiser Family Foundation/Harvard School of Public Health National Survey of Households Affected by Cancer*. November 20, 2009. *http://www.kff.org/kaiserpolls/pomr112006pkg.cfm.* Accessed February 10, 2010

Warren JL, Yabroff KR, Meekins A, Topor M, Lamont EB, Brown ML. Evaluation of trends in the cost of initial cancer treatment. *J Natl Cancer Inst*. 2008;100(12):888-897

Table 1. Summary Statistics of Variables

Variable	Observation	Mean	Std. Dev	Minimum	Maximum
Average Wholesale Price (in 2012 dollars)	48	1300	5000	5.0	31000
Dose per Person (mg)	48	390	580	0.4	2500
Drug Quantity Priced (mg)	48	140	240	0.1	1000
Dose per Person	48	11	26	1.0	80
Dose per Cycle	48	2.9	5.1	1.0	28
Number of Cycles	48	270	860	1.0	5500
Price (in 2012 dollars)	48	61000	86000	3100	420000
lnPrice	48	10	1.0	8.1	13
Gain in Survival Time (months)	46	5.9	11	0.12	54
Time (years between FDA-approval date and January 1, 1996)	48	9.4	5.3	0.37	17
*Rate of Diarrhea among Treatment Group **	45	0.36	0.19	0.06	0.72
*Rate of Diarrhea among Control Group **	27	0.24	0.17	0.03	0.65
*Rate of Vomit among Treatment Group **	41	0.27	0.13	0.07	0.67
*Rate of Vomit among Control Group**	25	0.21	0.12	0.06	0.52
*Rate of Nausea among Treatment Group**	43	0.38	0.19	0.0	0.86
*Rate of Nausea among Control Group**	25	0.30	0.19	0.0	0.79
*Rate of Neutropenia among Treatment Group**	26	0.46	0.32	0.0	0.94
*Rate of Neutropenia among Control Group**	17	0.31	0.28	0.0	0.87
*Rate of Anemia among Treatment Group**	29	0.46	0.34	0.0	0.99
*Rate of Anemia among Control Group**	18	0.39	0.35	0.0	0.98

* Dummy variables diarrheaTreatmentGroup, diarrheaControlGroup, vomitTreatmentGroup, vomitControlGroup, nauseaTreatmentGroup, nauseaControlGroup, neutropeniaTreatmentGroup, neutropeniaControlGroup, anemiaTreatmentGroup, and anemiaControlGroup were generated using the number of observations of the respective rates of side effects.

Ex. For diarrheaTreatmentGroup, we look at *Rate of Diarrhea among Treatment Group **, which has 45 observations across 48 available entries. Thus, we assign 45 dummy variables with value of 1 and 3 dummy variables with value of 0.

Table 2. Direct Summary Statistics

Variable	Observation	Mean	Std. Dev	Minimum	Maximum
Rate of Diarrhea among Treatment Group	27	0.36	0.19	0.06	0.69
Rate of Diarrhea among Control Group	27	0.24	0.17	0.03	0.65
Rate of Vomit among Treatment Group	25	0.24	0.12	0.07	0.58
Rate of Vomit among Control Group	25	0.21	0.12	0.06	0.52
Rate of Nausea among Treatment Group	25	0.33	0.17	0.0	0.84
Rate of Nausea among Control Group	25	0.30	0.19	0.0	0.79
Rate of Neutropenia among Treatment Group	17	0.45	0.33	0.0	0.94
Rate of Neutropenia among Control Group	17	0.31	0.28	0	0.87
Rate of Anemia among Treatment Group	18	0.43	0.36	0	0.98
Rate of Anemia among Control Group	18	0.39	0.35	0	0.98

Table 3. Log-linear Regression Model

Dependent Variable: Log of Price	
Variable	Aggregate Regression
Gain in Survival Time	0.051
	(0.001)***
Time	0.077
	(0.004)***
diarrheaTreatmentGroup	-0.27
	(0.76)
diarrheaControlGroup	0.13
	(0.91)
vomitTreatmentGroup	-0.17
	(0.77)
vomitControlGroup	0.79
	(0.29)*
nauseaTreatmentGroup	0.10
	(0.93)
nauseaControlGroup	-0.062
	(0.38)
neutropeniaTreatmentGroup	-0.10
	(0.87)
neutropeniaControlGroup	0.35
	(0.65)
anemiaTreatmentGroup	0.12
	(0.87)
anemiaControlGroup	0.0047
	(0.99)
constant	9.60
R-Squared	0.60
Adjusted R-Squared	0.46

Figure 1. lnPrice and Time

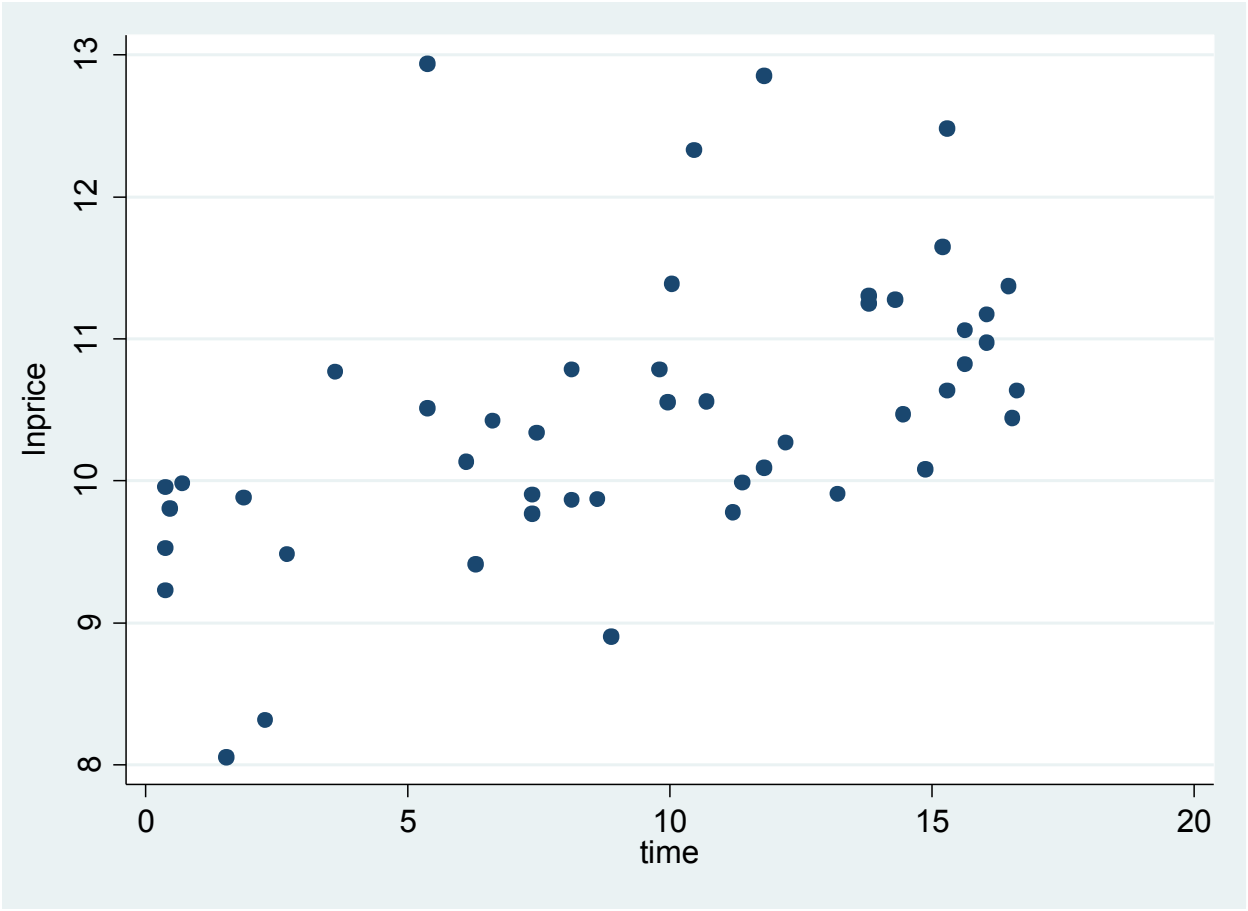

Figure 2. lnPrice and Time for Breast Cancer (plots marked with time)