Determinants of U.S. Personal Health Expenditure

Meraf Haileslassie

December 16, 2023

---

1 Introduction

Among the fiscal challenges facing America, former President Barack Obama highlighted a crucial issue in one of his White House speeches. Contrary to popular notion surrounding Social Security and crisis-related economic investments, he emphasized the most important threat to the nation's financial balance emanates from the soaring costs of healthcare. Substantially greater threat to the nation's fiscal stability surpassing all other concerns by a considerable margin.

Atul Gawande in his famous articles "The Cost Conundrum" and "Over Kill" talks about the widespread of medical care cost. "The Cost Conundrum" gave an interesting look into the inner mechanisms of the American healthcare system. It shows the misalignment between hospital and doctors best interest for their patients and maximizing revenue. Gawande shows this by looking at McAllen (a hospital in Texas) as a case study into what causes ballooning

costs in the healthcare system. He shows that this is not because McAllen's residents are less healthy than comparable areas with lower cost, and neither is it because McAllen's hospitals have more capable technology. Gwande presented the problem that doctors and hospitals spend too much on healthcare and that practitioners are incentives to put finances as a higher priority than patients. Doctors are ordering more tests, prescribing more medicine, or performing more procedures as means to increase revenue. While these tests may not be at all beneficial to the patient, they are a great source of money for the physician. But was McAllen an anomaly or did it represent an emerging norm?

In 2014, the United States witnessed an astounding $3.0 trillion in healthcare expenditures. Rodmin in a collaborative paper titled "Getting the Price Right" mentioned how the rising costs of US health care make affordability for consumers, employers, and governments—an elusive goal. Studies show that these expenditures are higher in the US than other countries not because the volume of service is higher but because prices are higher.

In addition, millions of people are receiving drugs that aren't helping them, operations that aren't going to make them better, and scans and tests that do nothing beneficial for them, and often cause harm. One major problem is the phenomenon of over testing. The United States population annually undergo million CT and MRI scans, and laboratory test. Since nobody is perfectly normal it is highly likely to find abnormality, a lab result that is slightly off. To try to resolve these abnormality comes with a cost. A cardiac catheterization, echocardigram, heart rhythm monitor will soon add a couple of thousands of dollars in costs. Over testing has also created overdiagnosis. A correct diagnosis of a disease that is never going to bother the patient in their lifetime (Gawande, 2009). With the hope of saving lives in advance screening for different cancer types has increased the detection rate. But then again a malpractice suits are often common in a doctors life. The average doctor in a high-risk practice like surgery is sued about once every six years. General surgeons

face a substantial range in malpractice insurance premiums, with annual costs varying from thirty thousand to two hundred thousand dollars. This considerable fluctuation is influenced by the prevailing litigation climate in the state where they practice. States with a higher likelihood of malpractice claims and larger settlements generally result in surgeons paying higher insurance premiums to mitigate potential legal risks.

Gwande talks about Primary care paradox, that explains the benefit of a primary care physician for long-term life and much more cheaper because of early diagnosis and better control of chronic illness. Chronic illness is categorized under high cost patients along with end of life patients, and patients who suffer from complex illness that interact with the social environment. Chronic illness contributes $\frac{3}{4}$ of direct medical care costs , most of these costs come from diabetes, congestive heart failure, asthma, ...etc. Some of these costs are also from obesity and tobacco addiction (Gawande, 2007).

Since preventative care can be applied through combination of personal consumption expenditure as well as engagement with primary care doctors, this research seeks to investigate the personal consumption determinants impact on health expenditure and adapt forecasting model. It would focus on different players in patients health care story such as nutrition, housing and environmental factors. The personal consumption expenditure we will be studying are tobacco, household and utility, and insurance. By understanding the driving force behind health expenditure and accurately predicting future trends it can provide valuable insight to optimize resource allocation and policy formation. The goal of this research is to analyze these determinants and understand the factors steering health expenditure and predict forthcoming patterns, this study offers valuable insights to enhance resource allocation strategies. To estimate the impact of the determinants on health care expenditure, we employ a structural VAR model based on our yearly data for

$$y_t = (\Delta health_t, \Delta insurance_t, \Delta tobacco_t, \Delta purchasedmeals_t)$$

After conducting our VAR model we compute impulse response function and conclude that a 1 % shock in health care expenditure causes tobacco expenditure to decrease for the rest of the time period and stabiliz. With a significant result a 1 % shock in tobacco decreases health care expenditure. In addition to this we see a decrease in insurance expenditure with a 1 % shock in housing and utilities expenditure.

We will review prior studies and conduct a critical analysis of existing research and literature examining the correlation between health expenditure and the three determinants. The subsequent sections will cover data, empirical models, and results, providing an overview of the analytical framework and empirical findings.

2 Literature Review

According to the World Health Organization (WHO), tobacco causes 1 in 10 adult deaths worldwide and is the leading preventable cause of death in the world. In 2005, tobacco caused 5.4 million deaths. Exposure to secondhand tobacco smoke is also a major health concern, as it can cause cancer, and other chronic diseases (Lightwood, 2008). The congressional Budget office (2012) estimated that 7% of the nation's total annual health care spending is attributed to smoking (Hoffer, 2018).

Lightwood's paper on the effect of California's large scale tobacco control program on aggre-

gate personal health care expenditures looks into the statistical approach of co-integrating regressions, modeling the relationship between capita tobacco control expenditures, per capita cigarette consumption, and health expenditure. They analyzed data from 1980 and 2004. They found that $ 86 billion was saved in personal health care expenditure between 1989 the start of the program and 2004. Gradually grew to 7.6 % of the total in 2003-2004 (Lightwood, 2008).

Now, turning our attention to a related topic housing, one of the social determinants of health has a range outcome on respiratory impact depending on the types of housing the individual is living in(Gan, 2017). Data from 1999-2006 was collected in the form of a survey for analysis. Characteristics of the participants were compared by types of housing using Rao-scott x^2 for categorical variables. They used multiple logistic regression to calculate odds ratio and 95 % confidence interval of each respiratory outcome for participants living in the different type of houses. The type of housing examined included townhouses, apartments, and mobile homes. Respiratory diseases included asthma, chronic bronchitis and chronic obstructive pulmonary disease (COPD).

According to the 2011 American Housing Survey, there are 132 million homes in the US where 63 % are detached single- family homes, 30 % are attached family homes including duplexes and apartments, and 7 % are mobile homes. The result of this research shows that compared with those living in single family houses, participants living in mobile homes were more likely to have respiratory symptoms and diseases. The difference was statistically significant for wheezing (OR, 1.38; 95 % CI, 1.13–1.69), and dyspnea (OR, 1.49; 95 % CI, 1.25–1.78).

Another environmental determinant for health care expenditure is access to clean water. In 2015, 21 million people living in the United states were served by public water systems that

incurred violations of health based quality standards of the SDWA. While not all violations cause immediate health problems, it has been estimated that contaminated drinking water is responsible for between 16.4 to 19.5 million cases of acute gastroenteritis every year in the united states (Fahad, 2019). A paper that explores the relationship between episodes of contaminated drinking water and health expenditure in the united states conclude that there is a positive and statistically significant relationship between drinking water violations and state's per captia health care expenditure(Fahad, 2019). The result was extrapolated from a spatial durbin model, which indicates that a 1 % decrease in the percentage of population exposed to drinking water quality violation is associated with reductions in in state and regional of 0.005 % and 0.035 %of per capita health care expenditures respectively. The exposure to contaminated water has been demonstrated to increase the consumption of health care services due to its deleterious impacts on human health and in turn health care expenditures are bound to increase as well.

Martin's paper on National Health Spending concludes that the rise in economic growth and the larger portion of GDP in 2014 were mainly driven by the expanded coverage initiatives introduced by the Affordable Care Act. After this enactment health insurance expanded through private insurers(Martin, 2015). The expansion of insurance coverage, particularly through private health insurance, fueled a 5.3 percent increase in total national health care expenditures in 2014. Compared to growth from 2009 to 2013, which averaged only 3.7 % . The way the health sector responds to the evolving access and incentive determines the future trajectory of health expenditure.

3 Descriptive Statistics

To investigate the impact of insurance, tobacco, and housing and utilities personal consumer expenditure on health care PCE we utilize an annual data from 1959 to 2022. Bureau of Economic Analysis measures consumer spending for the United States and is broken down by state and the District of Columbia. While it releases monthly report, supplementary details are provided on an annual basis. Data is obtained from the BEA website at . The BEA reports the total value of PCE collectively every month. Like most economic breakdowns, personal consumption expenditure is split between consumer goods and services. Durable goods and nondurable goods are components of consumer goods. Total yearly observation that was used was 64 with a frequency of 1.

Personal consumer spending plays a crucial role in driving the U.S. economy and serves as a key component of the Gross Domestic Product (GDP). It is a leading economic indicator. Consumer spending data offers estimates of aggregate expenditures on a wide range of commodities acquired for consumption by households or on their behalf (BEA, website). Our data classification includes both durable and non-durable goods, as well as services. The tobacco variable is situated within the non-durable goods category. Conversely, health care expenditure, housing and utility, and insurance fall under the services category. The insurance compartment covers various aspects, including life insurance, net household insurance, net health insurance, and insurance related to motor vehicles and other transportation. Housing and utilities include expenditures related to housing (mobile homes,stationary homes, nonfarm housing), utilities (water supply and sanitation, and electricity and gas). Health care expenditure is subsumed under household consumption expenditure and comprises expenses associated with outpatient services, hospital services, and nursing home services.

The first step for this research involves the deflation process, where each consumer expenditure is adjusted using its respective price index for each consecutive time period. This deflation process is achieved by dividing the nominal expenditure by its corresponding price index. This division serves to eliminate the impact of changing prices, providing a measure of the purchasing power of the money in constant (inflation-adjusted) dollars.As a result of this deflation process, all variables (insurance, tobacco, housing and utilities and healthcare), are expressed in real terms. These real values facilitate a more accurate comparison of consumer spending across different time periods, as they account for changes in the general price level.

3.1 Personal Health care expenditure

From Figure 1 1 we can see the drop in health care expenditure in 2020. In a paper titled "Tracking the U.S. Health Sector: The Impact of the COVID-19 Pandemic" Rhyan compares the first nine months of 2020 to the corresponding period during of the "Great Recession" from 2007 to 2009. The study reveals that the current pandemic-induced recession is affecting the health sector in unprecedented ways compared to previous economic downturns. The authors categorized spending based on the type of goods or services (such as hospital care, physician and clinical services, and retail spending on prescription drugs) and by the source of funds for each type (private health insurance, Medicare, Medicaid, and out-of-pocket spending). The year-over-year change in national health spending started to decline in March 2020, plummeted to over 20 % below the previous year's level in April, and then began a recover. By August 2020, health spending had essentially rebounded to match or exceed its August 2019 numbers . Spending on hospital care and physician and clinical services experienced significant declines in March and April, gradually recovering by August but still lagging slightly below their February 2020 levels. Dental services exhibited a comparable yet more pronounced pattern, with a nearly 65 % drop in April and sustained

levels below February readings by August. Home health care spending saw a modest decrease in March and April but rebounded to exhibit growth in August. Nursing home spending, on the other hand, initiated a decline in April (a month later than most other categories) and continued to decrease through August. Prescription drug spending exhibited a slight spike in March, potentially due to medication stockpiling, then experienced a small decline, ultimately recovering to be 1.8 % higher in August compared to February (Mohsin,2023).

These variations in spending patterns appear linked to differences in the perceived relative risk associated with seeking or providing care in the pandemic environment. What distinguishes the COVID-19 recession from other contemporary recessions, is that it originated from a health crisis. Consequently, many individuals avoided healthcare services due to infection concerns (Mohsin, 2023).

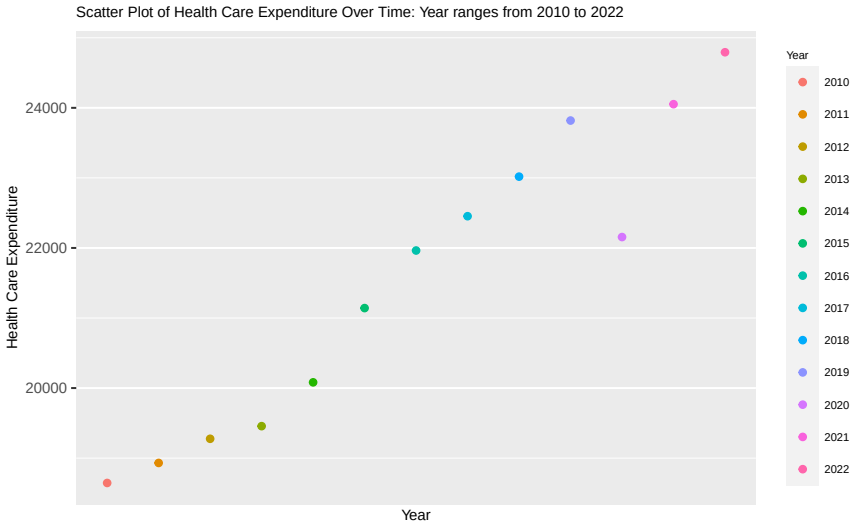


Figure 1: Scatter plot of year against personal health care expenditure.

3.2 How PCE of health care respond to the determinants

The three plots in figure 2 1 visually shows the relationship between the determinant variables and PCE of health care. The distribution of points in the graphs shows us that increase in PCE of insruance and housing and utilities corresponds to an increase in PCE of health care while its the converse tobacco. Higher PCE of tobacco coincides with a decrease in PCE of health care.

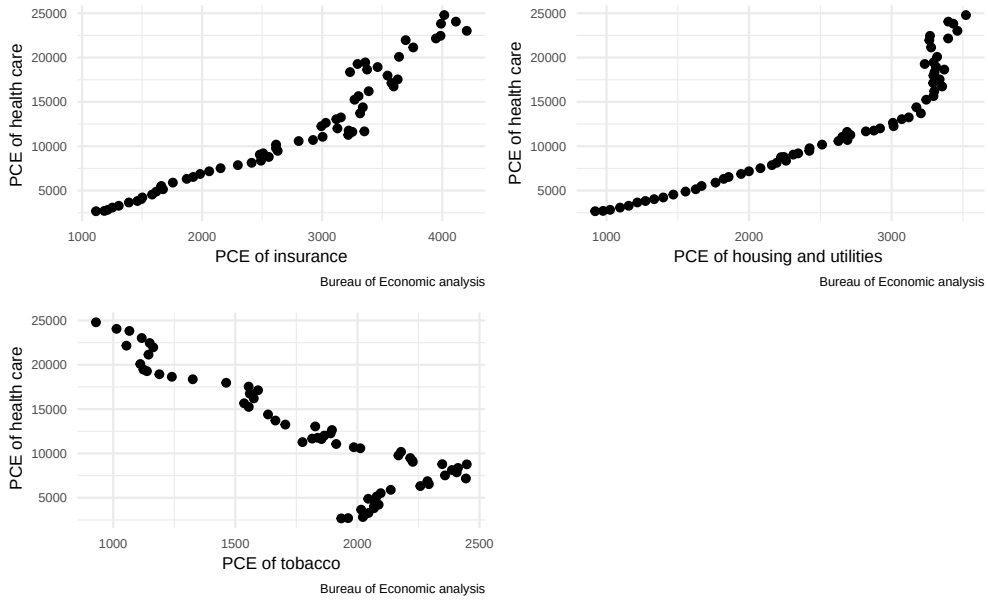


Figure 2: Scatter plot of year against personal health care expenditure.

We can further analyse our data by looking at Table 1 1. It shows us further insight into the distribution of the variables. For instance the mean and median values of PCE of healthcare suggest a central tendency of $11 million dollars. Variability in the variables can be evaluated by looking at the minnimum and maximum. We can see that insurance has the highest expenditure of around $14 million dollars.

Table 2 2 correlation of the variables. Although it doesn't imply causation, it would suggest potential relationships that will be explored later. It will help with identifying patterns and relationships. In addition, since correlation is often used as a preliminary step in Granger

Table 1: Summary Statistics

	health_care	**insurance**	**tobacco**	**hous_util**
Minimum	2672	1116	929.6	4580
1st Quartile	6789	1969	1550.2	9595
Median	11171	2998	1904.6	14776
Mean	11953	2743	1806.1	15144
3rd Quartile	17230	3362	2105.6	21605
Maximum	24794	4204	2447.7	25491

causality testing, it will be useful to examine whether past values of our determinant variables help predict another, providing insights into potential causal relationships.

We can see that our matrix reflects our interpretation result from the scatter plot 1. There is a strong positive correlation between PCE of health care, insurance and housing and utilities. As spending on health care increase so does spending in insurance and housing an utilities.

Table 2: Correlation Matrix

	health_care	insurance	tobacco	hous_util
health_care	1.0000000	0.9511067	-0.8836950	0.9840849
insurance	0.9511067	1.0000000	-0.7578853	0.9674022
tobacco	-0.8836950	-0.7578853	1.0000000	-0.8542985
hous_util	0.9840849	0.9674022	-0.8542985	1.0000000

Fixing for a deterministic trend is necessary when working with a time series data set. It involves removing or accounting for the systematic and predictable movement in the data. This is important because when we regress a non stationary variable on another non stationary variable we might have a spurious regression. That builds a relation between the variables based on correlation rather than causation. For example we might see a strong relationship between health care expenditure and Alcohol but it actually might not exist.

After transforming the data set into a time series object. We conduct stationarity test using Phillips Perron and Augmented Dickey Fuller unit root test for the purpose of robustness.

But since ADF provides weak evidence of stationarity by only including information on unit root test, results of this test in not included in the paper.The Z-tau test statistic in the Phillpis Perron test is based on the regression coefficient of the lagged level term in the model. We compare this to the critical value at 5 % significant level.

$$|TestStatistic| < |CriticalValue|$$

$$H_o : \rho = 1$$

$$H_a : \rho \neq 1$$

When equation 1 holds we reject the null hypothesis and conclude that our variable is stationary. Our result from table 3 shows 3 by evaluating the test statistic and critical value (a the 1 % significant value all our variables except for housing and utilities are not in a stationary form.

Variable	**Test Statistic**	**Critical Value (1%)**	**Critical Value (5%)**
Health care	2.842	-3.536092	-2.907667
Tobacco	0.8489	-3.536092	-2.907667
Housing and utilities	-3.6133	-3.536092	-2.907667
Insurance	-1.1989	-3.536092	-2.907667

Table 3: Phillips-Perron Test Statistics and Critical Values

To address this problem we take the first and log difference of the non stationary variables. This will help eliminate inherent trends and systematic patterns. The additional transformation of taking the log difference not only contributes to the elimination of trends but also our interpretations in terms of percentage change (4).

Test	Test Statistic	Critical Value (1%)	Critical Value (5%)
Health care	-6.4182	-3.537867	-2.908436
Tobacco	-5.356	-3.537867	-2.908436
Housing and utilities	-3.6133	-3.536092	-2.907667
Insurance	-6.5899	-3.537867	-2.908436

Table 4: Phillips-Perron Test Statistics and Critical Values

4 Empherical methods

This study adopts estimation technique such as vector autoregressive (VAR) model, which includes impulse response function (IRFs), forecast error variance, and Granger causality test. VAR is suitable for analyzing impact in multivariate system and rich to produce good forecast. It allows us to model the interdependence's between variables that might affect each other.

Estimating a structural VAR model between PCE of health care (Δh_t), tobacco (Δt_t), housing and utilities (Δu_t), and insurance (Δi_t) which takes the following form:

$$\Delta h_t = \alpha_i + \sum_{i=0}^{p} \beta \Delta h_{t-1} + \sum_{i=0}^{p} \gamma \Delta t_{t-1} + \sum_{i=1}^{p} \rho \Delta hu_{t-1} + \sum_{i=1}^{p} \delta \Delta i_{t-1}$$

$$\Delta t_t = \alpha_i + \sum_{i=0}^{p} \beta \Delta h_{t-1} + \sum_{i=0}^{p} \gamma \Delta t_{t-1} + \sum_{i=1}^{p} \rho \Delta hu_{t-1} + \sum_{i=1}^{p} \delta \Delta i_{t-1}$$

$$\Delta hu_t = \alpha_i + \sum_{i=0}^{p} \beta \Delta h_{t-1} + \sum_{i=0}^{p} \gamma \Delta t_{t-1} + \sum_{i=1}^{p} \rho \Delta hu_{t-1} + \sum_{i=1}^{p} \delta \Delta i_{t-1}$$

$$\Delta i_t = \alpha_i + \sum_{i=0}^{p} \beta \Delta h_{t-1} + \sum_{i=0}^{p} \gamma \Delta t_{t-1} + \sum_{i=1}^{p} \rho \Delta hu_{t-1} + \sum_{i=1}^{p} \delta \Delta i_{t-1}$$

Where β, γ, ρ, δ are parameter estimates and p represents optimal lag length. Optimal lag length was selected using Akaike Information Criterion (AIC) and Schwarze Bayesian

Criterion. Since we are estimating a structural VAR model we will impose restriction to avoid feedback loop so that we are not hindered from estimating the causal effect of each shock.

To compute impulse response function, we identified the PCE of health care shock through cholesky factorization, in which health care shock is ordered first followed by tobacco, housing utilities and insurance. This scheme assumes that shocks in health care affects other variables contemporaneously, but other shocks don't affect health care.

$$e_t = \begin{vmatrix} e_t^h \\ e_t^t \\ e_t^h u \\ e_t^i \end{vmatrix} = \begin{vmatrix} 1 & 0 & 0 & 0 & e_t^h \\ b_{21} & 1 & 0 & 0 & e_t^h \\ b_{31} & b_{32} & 1 & 0 & e_t^h \\ b_{41} & b_{42} & b_{43} & 1 & e_t^h \end{vmatrix}$$

The next stage of analysis was a Granger causality testing. This test provides information of the direction and strength of causality between PCE of health care, tobacco, housing utility and insurance. To establish whether these variables drive each other. For p-value ¡ 0.05 we reject our hypothesis that our variable granger causes the remaining variables. Finally to understand the importance of each variable in driving future shocks we employ forecast error variance decomposition. By looking at the contemporaneous effect in addition to 5 periods ahead.

5 Emperical results

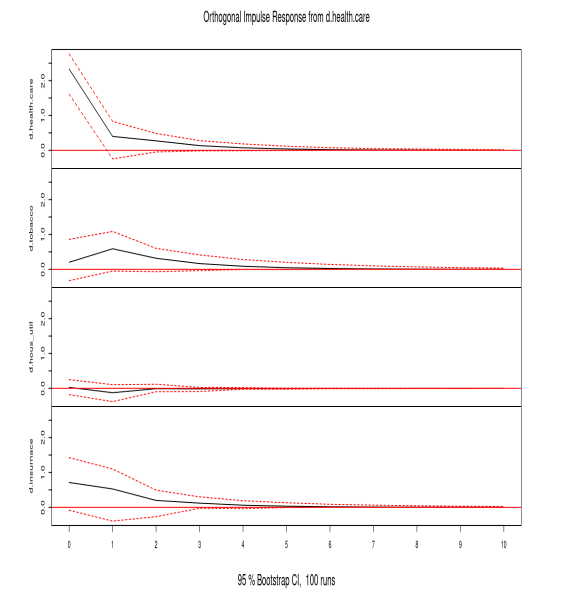
Testing for a maximum of 6 lags, optimal lag from AIC and Schwarze Bayesian criterion gave out a 1 lag estimated coefficients. The impulse response function of the four consumption are shown in figure 3. Although the results are not significant 1 % shock in health care

expenditure causes tobacco expenditure to decrease for the rest of the time period and stabilizes. With a significant result a 1 % shock in tobacco decreases health care expenditure. In addition to this we see a decrease in insurance expenditure with a 1 % shock in housing and utilities expenditure.

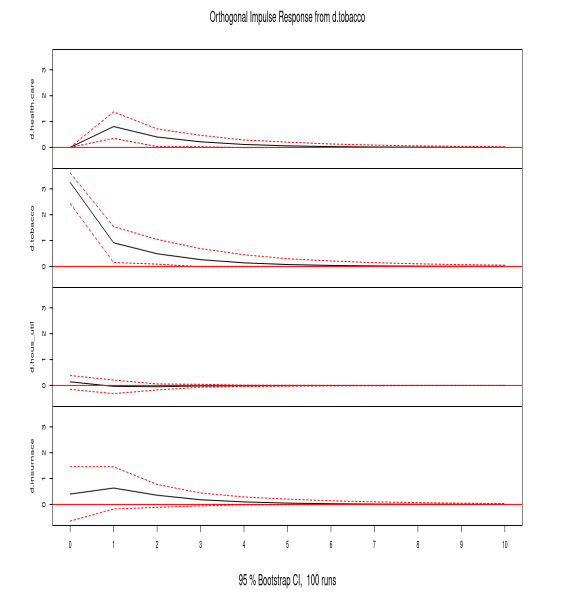
From our granger causality results show that with a p-value of 0.03 we reject the null hypothesis that there is no instantaneous causality between housing utility and health care, tobacco expenditure and insurance. With a p value of 0.020 there is no instantaneous causality between insurance and health care, tobacco, and housing utility. In addition, with a p-value of 0.403 we fail to reject our null hypothesis that health care granger cause tobacco, housing utility and insurance expenditure.

Figure 4 shows us the forecast error variance decomposition of 5 years ahead. We can see that after 4 years 12 % variation in health care is driven by tobacco expenditure shocks. After 4 years we can also see that 6 % of variation in health care is driven by insurance expenditure shocks.

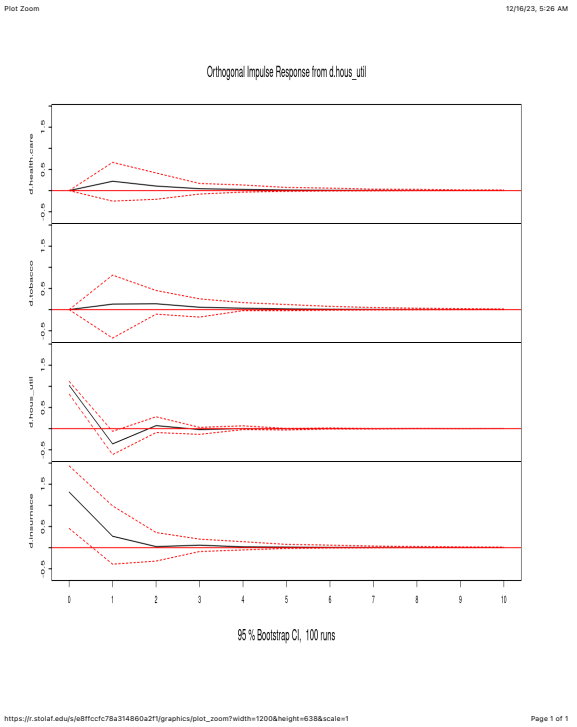
The observed decrease in tobacco expenditure following a 1% shock in health care expenditure may suggest a trade-off between health care and tobacco consumption. This could have positive implications for public health if individuals are reallocating funds from tobacco to health care. The decrease in insurance expenditure following a 1% shock in housing and utilities expenditure implies a sensitivity or connection between housing costs and insurance spending. This could have implications for risk management behaviors of consumers.



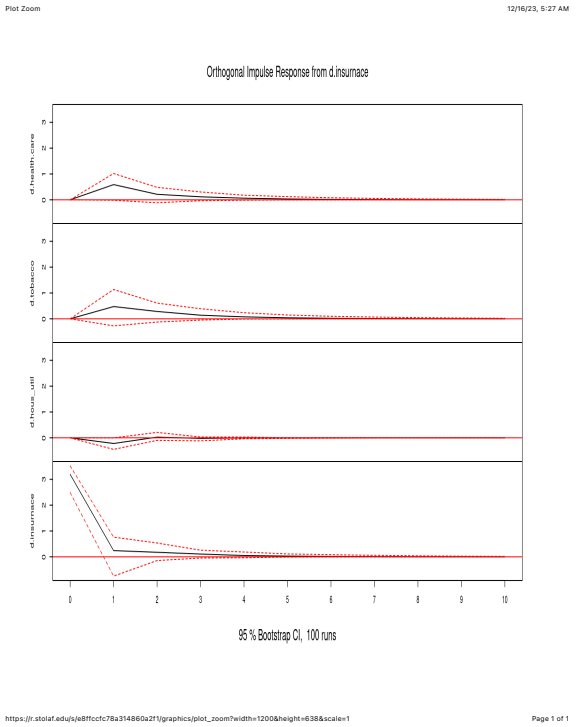
(a) IRF of health care



(b) IRF of tobacco



(c) IRF of housing and utilities



(d) IRF of insurance

Figure 3: IRF

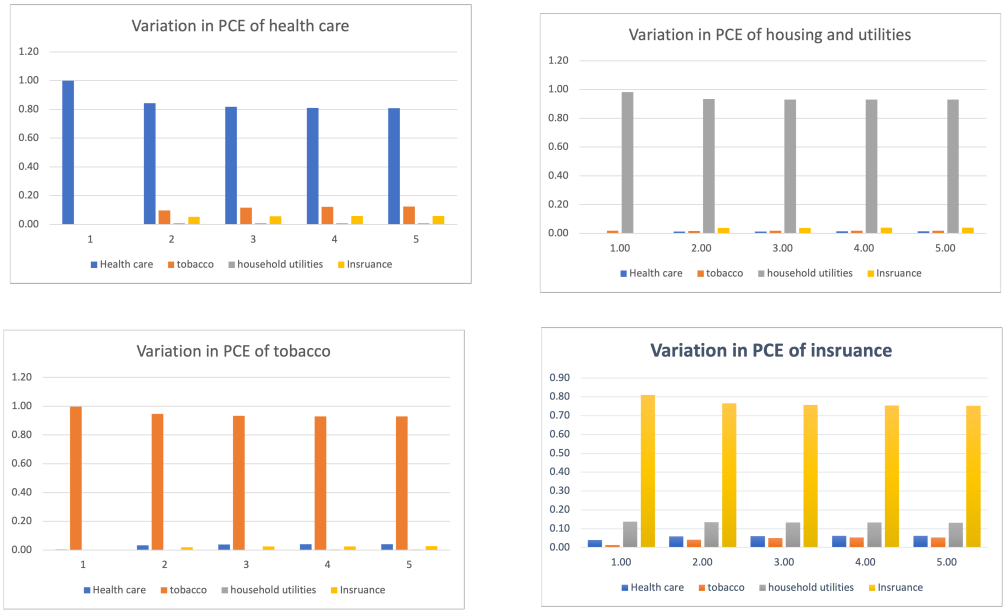


Figure 4: Forecast error variance decomposition

6 Conclusion

Atul Gawande, through articles like "The Cost Conundrum" and "Overkill," investigated the widespread issue of escalating medical care expenses, revealing a misalignment between hospital and doctor interests, prioritizing revenue over patient welfare. Gawande's case study on McAllen, Texas, demonstrated that rising healthcare costs were not attributable to residents' health or advanced technology but were influenced by financial incentives. Rodmin's collaborative paper in 2014 emphasized the challenge of achieving healthcare affordability in the face of soaring U.S. healthcare expenditures. Over-testing and over diagnosis contribute to unnecessary healthcare expenses and potential harm to patients. Gawande's exploration of the Primary Care Paradox highlighted the long-term health benefits and cost-effectiveness of primary care physicians.

Another component of a cost-effective health benefit is looking into personal consumption expenditure, such as tobacco, household, and insurance. By utilizing structural VAR model

we were able to evaluate our impulse response functions, granger causality and forecast error variance decomposition.

Although results from the IRF may not be statistically significant, the observed trends could still be economically meaningful. Policymakers might consider interventions that promote health care spending as a means to potentially reduce tobacco consumption.

7 Citation

Alzahrani, F., Collins, A. R., Erfanian, E. (2020). Drinking Water Quality Impacts on Health Care Expenditures in the United States. Water Resources and Economics, 32. https://www.proquest.com/scholarly-journals/drinking-water-quality-impacts-on-health-care/docview/247 2, doi:https://doi.org/10.1016/j.wre.2020.100162.

Chattopadhyay, S., Pieper, D. R. (2012). Does Spending More on Tobacco Control Programs Make Economic Sense? An Incremental Benefit-Cost Analysis Using Panel Data. Contemporary Economic Policy, 30(3). https://doi.org/info:doi/

Gawande, A. (2009, June 1). The cost conundrum. The New Yorker. Retrieved from https://www.newyorker.com/magazine/2009/06/01/the-cost-conundrum

Gawande, A. (2007, December 10). The checklist. The New Yorker. Retrieved from https://www.newyorker.com/magazine/2007/12/10/the-checklist

Health Affairs. https://www.healthaffairs.org/doi/10.1377/hlthaff.2019.01804

Hoffer, A., Humphreys, B. R., Ruseski, J. E. (2019). State Cigarette Taxes and Health Expenditures: Evidence from Dynamic Spatial Lag Panel Models. Papers in Regional Science, 98(2). https://doi.org/info:doi/

Lightwood, J. M., Dinno, A., Glantz, S. A. (2008). Effect of the California tobacco control program on personal health care expenditures: E178. PLoS Medicine, 5(8), e178. doi:https://doi.org/10.1371/journal.pmed.0050178

Ling, P. M., Neilands, T. B., Glantz, S. A. (2007). The effect of support for action against the tobacco industry on smoking among young adults. American Journal of Public Health, 97(8), 1449-56. Retrieved from https://www.proquest.com/scholarly-journals/effect-support-action-against-tobacco-industry-on/docview/215080043/se-2

Mohsin, A. K. M., Hongzhen Lei, and Far Abid Hossain Syed. 2021. Impact of COVID-19 pandemic on consumer economy: Countermeasures analysis. Sage Open, 11(2) (04), https://www.proquest.com/scholarly-journals/impact-covid-19-pandemic-on-consumer-economy/docview/
2 (accessed December 14, 2023).

Rhyan, Corwin, Ani Turner, and George Miller. 2020. Tracking the U.S. health sector: The impact of the COVID-19 pandemic. Business Economics, 55(4) (10): 267-278, https://www.proquest.com/scholarly-journals/tracking-u-s-health-sector-impact-covid-19/docview/247058
2 (accessed December 14, 2023).

ScienceDirect. https://www.sciencedirect.com/science/article/pii/S2211335517300992: :text=ComparedH

M. N., Potter, L. B. (2015). Emerging Techniques in Applied Demography. Springer Netherlands. https://doi.org/info:doi/