Technology Change and Medical Expenditure under Insurance Policy

Meihong JIA*

Abstract

In recent decades, technology innovation in health care industry has contributed to higher quality of life, yet medical spending has surged rapidly in most developed countries. I develop an endogenous technology growth model of product variety expansion, taking patient demand under insurance policy into account, to explain twin growths of technology progress and medical spending. The partial equilibrium achieved by the model captures the interaction of health financing system and R&D to expand medical product varieties: (1) health insurance has increased medical consumption and incentivized the research sector to innovate new varieties of products; (2) the expansion of product variety has given an impetus for increased medical consumption and further research to innovate. Combined together, these results suggest that, through meticulous design of the coinsurance rate based on current technology level of particular types of health care, it is possible to control the medical expenditure and maintain a high level of research for product innovation.

*Graduate School of Economics, University of Tokyo, 7-3-1, Hongo, Bunkyo-ku. Tokyo 113-0033, Japan (Email: meihongjia0122@gmail.com). I would like to express my special thanks to Professor Kosuke Aoki for his kind instruction. I also thank Fangyuan YI and other members of Aoki seminar for their insightful comments.

1 Introduction

In recent dacades, not a day has passed without the coverage of emerging pharmaceutical and surgical treatments one after another, leading to rosy predictions of improved life quality and lengthened life expectancy. Meanwhile, burgeoning medical spending has also featured the health care industry in most developed countries. One of the most extreme cases would be the United States, where total health care expenditures have surged from about 4% in 1948 to 16% national health expenditures (NHE) share of GDP by 2004. Such a climbing health expenditure has triggered off both social and economic concerns: declining insurance coverage, exorbitant taxes and health insurance premiums and even debt degradation. Wether this trend of increasing costs of health care can be halted and how to tame the undesirable growth of medical spending while maintaining technology progress in health care industry, have been in heated debate among politicians and health economists.

Enormous empirical studies have attributed the growth of medical spending to technology growth. Early work by Newhouse (1992) took into account a wide range of factors that could have affected health expenditures, and suggested that only technology progress, rather than spread of health insurance or an aging population for instance, could account for surging health spending. Other studies advocating the role of technology innovation against the influence of health insurance including the Rand Health Insurance Experiment, one of the largest randomized, individual-level social experiments conducted in the U.S., and found that the spread of health insurance was not an important cause of the health spending rise. Such arguments have been revisited recently, empirical study by Finkelstein (2007) for example, suggested that aggregate effects of health insurance would have played a much larger role in the growth of health spending through innovation and diffusion of technology. Based on these empirical findings to revive the role of health insurance, it is no longer advisable to neglect the role of health insurance or simply attach the label of "technology progress" to explain the problem. Thus, the principle of this paper is to better understand how medical spending under insurance contract interacts with technology progress, especially with the expansion of product variety.

I set up a partial equilibrium model to capture the interaction between current

health financing system and technology innovation of product variety expansion. I investigate two main issues related to this interaction between. First, current retrospective insurance payment mechanism has encouraged the rise of medical consumption and pushed the progress of technology. Second, one type of technology progress, expansion of product variety, has influenced the aggregate medical spending and further research to innovate new products.

While there exists a large literature on health, regarding both health insurance issues and medical spending, my work is the first to combine health financing of the demand side and endogenous technology growth of the supply side, in the tradition of Romer (1987) with endogenous innovation-based growth of product variety expansion. Romer's model has been extended in several directions. For example, Acemoglu and Zilibotti (2001) integrated the idea of directed technological change to explain the persistence of productivity differences among countries. What is common to papers in existing literature is that health care industry, especially its unique financing system is absent from the model and consequently, the interaction between health financing system and technology growth is rarely discussed in previous theoretical papers.

In previous literature studying health insurance, Kitao (2009) builds an overlapping generations model where households face idiosyncratic health shocks and studies the effect of tax deduction policy on savings' behavior and fiscal consequences. On the other hand, others including Borger and Rutherford (2007) focuses more on the technology growth to project long term medical spending growth. My model is an improvement in a sense that I absorb both behaviors of demand side and supply side to understand the issue of medical spending growth more thoroughly and comprehensively.

My work has advantages over many existing works that approach the medical spending growth from either demand side or endogenous technology growth alone, in that I absorb health insurance itself as an integral part of medical spending growth and interactively reacts to and exerts influence on technology growth. Taking the effects of partial equilibrium into account, it is possible to design a more sustainable health care system. For example, raising the copayment rate of health insurance will increase premiums but prosper innovations of variety expansion. And this will

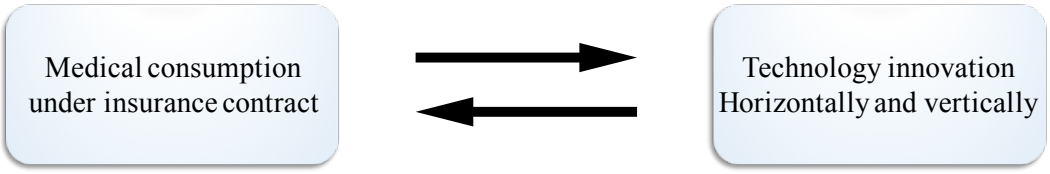

Figure 2.1: Interaction between medical spending and technology progress

potentially mitigate the premium costs. So depending on the current level of technology (number of product variety), setting a proper copayment rate for a particular field of health care is inevitably important for sustainable financing. It's hard to capture their interrelationship from models focusing on just one side of the market.

The paper proceeds as follows. Section 2 introduces the background. Section 3 specifies the model. Section 4 defines and characterizes the partial equilibrium. Section 5 details the parameterizations of the model, and shows the main results of calibration. Section 6 concludes.

2 Background

As figure 2.1 shows, the major question I want to explore in this paper is the interaction between technology change and medical spending under current insurance policy.

1. *Effects of R&D on Medical Spending under Insurance Coverage*

   Advances in medical technology has been a key driving force behind the health spending growth. But the mechanism through which it works is not well understood. Some economists pointed it out that, much of growth in health care expenditures during post World War II period is a result of increased price for new technologies rather than that of existing ones. Thus it's common to attribute the majority growth of medical spending to expanding product varieties since newly developed technologies have pushed the costs upward while also expanded the range of services covered by health financing system. For example, if a previously untreatable disease becomes treatable, it's possible that

the individual will incur a larger health care expense compared to the previous case.

Moreover, some technologies can also prolong our lives, which may potentially increase the costs of health care per capita over his life time. It is likely that the health care system has to sustain an increasing proportion of older population thanks to life-extending technologies. This population structure itself can be costly, taking lower productivity of an aging society and higher risk to fall sick into consideration.

Based on the conjectures above, one branch of technology progress, expansion of product variety is an important factor affecting health financing system. Wether or not the technology change to extend varieties is the desirable for health financing system, and how the medical spending reacts to the expansion of product varieties is one of the principle focuses of my paper.

2. *Effects of the Insurance System on R&D*

   Theory suggests the probable direction of health care finance system's influence on R&D. Depending on the adoption of new technology, which is largely influenced by insurance payment mechanism, the R&D sector will face different incentives towards the level and direction of innovation. There are two types of insurance payment mechanisms: retrospective and prospective. According to classic paper by Weisbrod (1991), under current "retrospective" insurance payment mechanism, which pays the provider depending on his "costs", R&D sector is likely to develop new technologies that enhance quality, regardless of the costs. Whereas the alternative payment mechanism, prospective approach, is said to imply a profoundly different incentive for the R&D.

   Putting away quality innovation for the moment for simplicity, this paper explores wether current health financing system provides incentives for R&D to expand the varieties. Since the costs of health care brought by product innovation are unpredictable, wether the expansion of variety also react to the retrospective payment mechanism and if so, what the process of their interplay is, are another focus of this paper.

3 A Static Model of Product Variety Expansion

This section employs a simple model of product variety expansion that illustrates the the impact of current insurance payment mechanism on medical spending and product innovation in health care industry.

The traditional introduction to health economics usually starts with the discussion of how health care differs from other commodities. Since health care involves preservation of life, a fundamental concern for the suffering of other human being, and a high financial risk once sick, which in turn breeds prevailing insurance systems to finance the health care industry. As health care became more expensive, insurance can insure patients against high financial risk and secure the payment for health care providers. However, widespread of health insurance also brings problems of moral hazard and adverse selection. Moral hazard occurs because it is the insurance company who pay for most cost of transactions between the health care providers and patients. This results in a common phenomenon that patients tend to be less cautious for prevention of diseases, and even more commonly, both patients and health care producers, affected by health insurance system, consume and provide "more than necessary" health care (Wagstaff and Lindelow, 2008).

The other problem, adverse selection can also occur on both sides of market. On one hand, individuals with poor health conditions are more prone to sign a long insurance contract to benefit from reimbursements for anticipatory high costs; On the other hand, insurance companies usually design contracts in a way to attract healthy people to get enrolled (Finkelstein and McGarry, 2006). A third issue is that health care is a technically complicated commodity abounding with principle-agent problem-information asymmetries, that is, physicians are making decision for consumers, inducing "supplier-induced demand". And as a result of these characteristics, governmental and non profit suppliers of health care like hospitals, as the bridge between consumers and R&D sectors, are largely influencing the interaction of medical spending and technology innovation.

Admittedly, adverse selection is important for health care policy, yet it does not play a equally important role as moral hazard and information asymmetry when it comes to explaining the twin growths of medical spending and technology progress.

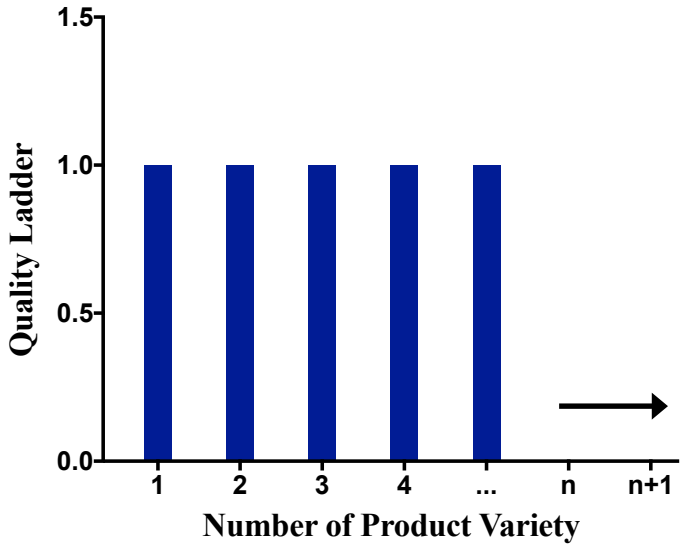

Figure 3.1: Product variety models

In this paper, adverse selection is paid less attention, since even in universal health insurance programs with no discrimination against personal health conditions, in programs like Medicare, we still observe rapid medical spending growth. Instead, in effort of explaining twin growths of medical spending and technology, I propose moral hazard and information asymmetry have provided a fertile ground. The key focus of this paper is to study how moral hazard is affecting health care market and medical technology innovation. And vice versa, how the outcome of technology innovation will potentially influence medical spending and future research in health care industry. Notably, the other issue of information asymmetry is an interesting extension of my model, and will be discussed in my future work.

To capture the effect of health insurance on technology progress, particularly on product innovation, I construct the supply side model building on the idea that medical technology growth comes from expanding variety of specialized intermediate goods. The expansion of product variety takes place gradually because discovering a new treatment or developing new drugs take real resources, including time. As illustrated in figure 3.1, the model takes its inspiration from product-variety model of Romer(1990), according to which productivity growth results from product inno-

vation, not necessarily involving quality improvement. To create a new variety of product, such as a new drug or surgical machine, there is a sunk cost of product innovation that must be incurred just once, when this product is first introduced, and never again. This sunk costs can be interpreted as costs of research, an activity that yields innovations that accumulate the stock of technological knowledge. Here, technological knowledge is comprised of a list of blueprints, each containing description of how to produce a different product, and every innovation adds one more blueprint to the list. Such setting of fixed costs to innovate makes product (pharmaceutical or medical apparatus) markets monopolistically competitive instead of a perfect competition. Such an imperfect competitive market creates positive profits, which can be thought of as a reward for product innovation. This rewarding process allows compensation for the research and development (R&D) sector, and in turn drives medical technology progress. The medical technology progress, or the expansion of medical product variety, will be both potentially affected by and affecting medical spending under health insurance contract.

From ideas above, I formulate the model as follows. Consider a small economy allowing for a representative household, living for two periods. The representative household consumes two types of goods in this economy. First, there is a basic good, which can be consumed or used for production of other goods. Second, there is final health care, which is reimbursed by insurance system and can be consumed to lengthen her life expectancy to further enjoy the world or improve quality of her late stage life.

Besides households, there are three types of agents critical to health care market: final health care producers like hospitals and clinics who directly provide medical treatments to patients; intermediate medical goods firms, such as pharmaceutical companies or medical apparatus manufacturers, who specialize in producing some particular type of medical goods; and finally, research and development (R&D) sector who innovate new blueprints to expand the variety of medical products.

The capital flow among these agents is illustrated in the figure 3.2. In this economy, household maximizes her utility by choosing consumption of both basic goods and medical care, with the latter one covered by universal health insurance. Hospitals and clinics, faced with a competitive market, use different types of intermediate

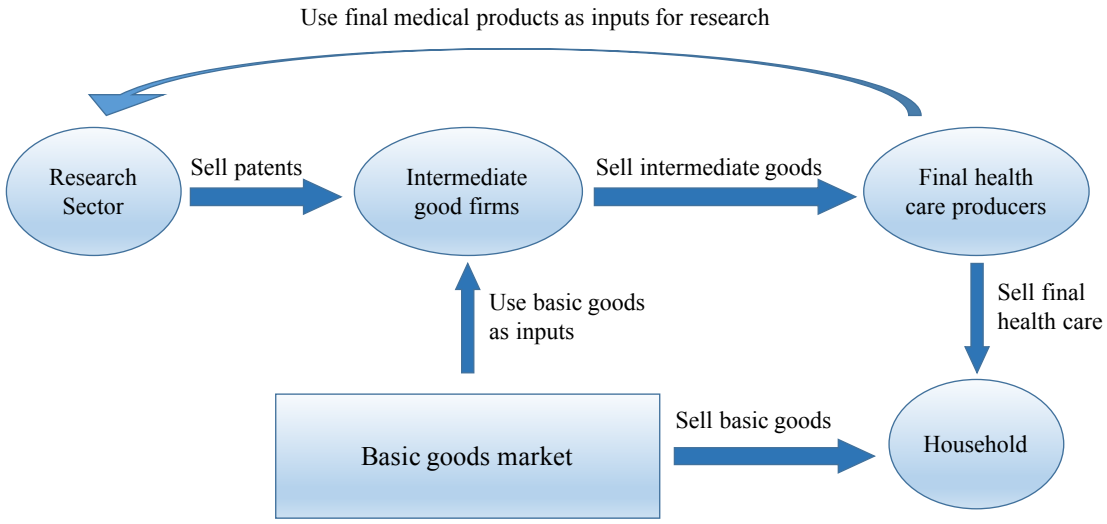

Figure 3.2: Capital flow among agents

goods as input to produce final health care to consumers and investment for R&D. Meanwhile, pharmaceutical companies and medical apparatus manufacturers use basic goods like oil and minerals for production and sell their specialized goods in a monopolistically competitive market at a monopoly price. Finally, research sector use products of final health care producers as input to invest in research and development of new blueprints, obtain a perpetual patents and sell these blueprints to intermediate goods firms.

This model setup helps us to recognize the important role of health insurance in financing surging medical spending through technology innovation in health care industry. Instead of only focusing on demand side of health care to study traditional moral hazard problem tied with insurance payment mechanism, I also combine innovation based growth of supply side, to explain twin growths of medical spending and technology progress. This view is based on both empirical and theoretical studies concerning health care up to date, and profoundly inspired by the classic article "the health care quadrilemma" by Weisbrod (1991). Weisbrod argued in this article that the long run growth of medical spending is a by-product of interacting R&D process and health insurance system, with a straightforward intuition behind: they will

create it, if you pay for it. In the spirit of Weisbrod's work, I develop the following model to capture this interaction.

3.1 The demand for Health care under Insurance Policy

Inspired by the Amitabh and Jonathan (2011), I develop a two period demand side model, where a household derives utility from basic goods consumption in both first and second periods. The probability to survive to the post retirement period, $s(M)$, is a function of medical spending M. The utility function of household is written as

$$U(C_1) + \beta s(M) U(C_2) \tag{3.1}$$

where C_1 is basic goods consumption in period one, β is the discount rate, M is medical spending, or health care inputs. The survival probability function is defined as $s(M) = 1 - e^{-M}$, a concave function of medical spending with $s'(M) \geq 0$ and $s''(M) < 0$. More generally, $s(M)$ can be interpreted as an augmenting factor on post retirement utility. Alternatively speaking, more health care inputs will improve "quality of life" in a broad sense, not necessarily extend life expectancy. This setting is essential to assess the productivity of new medical innovations. For instance, myopia laser operation will improve quality of life instead of quantity of life years.

Household maximizes her utility subject to her budget constraint:

$$w - \widetilde{P} = C_1 + (1 - \tau) pM + \frac{C_2}{1 + r} \tag{3.2}$$

where w is income earned in the first period, $\widetilde{P}$ is the premium for health insurance. Here we suppose no earning after retirement, household in turn make post retirement consumption through savings. p is price of health care before reimbursement, with price of one unit of basic good normalized to 1. And τ is coinsurance rate reimbursed by health insurance, r is the interest rate. The optimal conditions for individual include optimal choices between basic goods and medical consumption:

$$(1 - \tau) p U'(C_1) = \beta s'(M) U(C_2) \tag{3.3}$$

intuition behind this condition is that optimal medical spending is determined when $(1-\tau)p$ dollars of basic goods consumption for first period is given up for an improved quality of life after retirement.

Another optimal condition is Euler Equation:

$$\frac{U'(C_1)}{1+r} = \beta s(M) U'(C_2) \tag{3.4}$$

this condition captures the idea that, for a given chance to survive into second period, one unit of basic good consumption in first period is given up for $(1+r)$ units of basic goods consumption in second period, taking discount rate β into account.

A major concern with the framework above is the assumption of a representative household. Health care financing, in reality, involves participation of the government and large amounts of redistribution from the healthy to the sick, the young to the old. Adopting a collective view to model the demand of health care has its limitation in showing the income transfer process of health insurance system and different demands of health care due to idiosyncratic health condition status. Nevertheless, even without benefits from income transfer, this framework can still capture the essence: medical spending depends largely on how health care is financed.

3.2 Final Health Care Producers (Hospitals)

Final health care is produced under perfect competition. Final medical care producers like hospitals and clinics, use intermediate goods, such as drugs or medical instruments to produce outputs. Here for simplicity, I suppose final health care does not take labor as input for production.And the final health care products are used for both consumption and investment (in research and development of new blueprints). The production function of final producer is

$$Y = \int_1^{N_2} (z_j)^{\alpha} \tag{3.5}$$

where $0 < \alpha < 1$. Here, N denotes the number of medical product variety available currently, z_j is intermediate goods of type j. Assume $z_j = z$ for all types of

intermediate good j. Then the production function becomes $Y = Nz^{\alpha}$.

Given the price of health care p and intermediate input p_j, the profit maximization of final good producer is

$$\max_{z_j} pY - \int_1^{N_2} p_j z_j$$

where the production function is given as3.5. The hospitals choose the demand for intermediate inputs z_j to maximize its profit:

$$z_j = \left(\frac{\alpha p}{p_j}\right)^{\frac{1}{1-\alpha}} \tag{3.6}$$

this result captures the idea that the demand for intermediate inputs is dependent on the relative price of final output and intermediate input.

A limitation of this framework arises because we can not measure labor demand of hospitals. Admittedly, absorbing the factor of labor into production function is closer to reality since hospitals hire doctors, physicians and nurses to provide services. However, the principle focus of this paper is to capture the collaboration between health financing system and technology progress of product variety expansion, with no intention to touch on health care labor market to perplex the issue. One reason behind the possible perplexity is that wage of doctors can be influenced by the machines they choose to make diagnosis or drugs they use to assist operations. The problem of principle-agent caused by information asymmetry is mostly likely to happen in final health care producers and is an interesting topic worth exploration in future work.

3.3 Intermediate Medical Goods Firms

I develop intuition from the supply side models proposed in Borger and Rutherford (2007), that medical sectors take non-medical goods as input for producing medical goods and apply this idea to the process of intermediate goods production. While producing intermediate goods inputs for final health care producers, intermediate medical goods provider uses basic goods to make its own production, given one for one technology. And each intermediate firm is monopolized by the person who

created it. In each period, the monopolist maximizes her profit:

$$\pi_j = p_j z_j - z_j$$

where p_j is the price of intermediate input j.

Because intermediate good firms have the monopoly right, the intermediate good firm j's optimization problem is to choose the monopoly price p_j to maximize its profit

$$\max_{p_j} [p_j - 1] z_j \Rightarrow \max_{p_j} [p_j - 1] \left(\frac{\alpha p}{p_j} \right)^{\frac{1}{1-\alpha}}$$

The price of intermediate good depends on price of final medical care and the same for all types of intermediate goods $p_j = \frac{1}{\alpha}$.

It follows that the equilibrium quantity will be identical across j:

$$z_j = \alpha^{\frac{2}{1-\alpha}} p^{\frac{1}{1-\alpha}}$$

Denote $Z = \int_1^{N_2} z_j = N_2 z_j$.

The equilibrium profit for every firm j at each date then becomes $\pi = \frac{1-\alpha}{\alpha} \alpha^{\frac{2}{1-\alpha}} p^{\frac{1}{1-\alpha}}$.

3.4 Research Sector in Health Care Industry

Product variety grows at a rate dependent on the amount of research and development R. That is, the research sector invests the amount R of final output to produce new blueprints, which allow new products to be developed. Assume the production function of research sector is decreasing return to scale, where research is seen as a form of investment. So we have

$$\Delta N = N_2 - N_1 = \phi R^{\gamma} N_1$$

where $0 < \gamma < 1$ and ϕ is a positive parameter indicating the productivity of research sector. N_1 on the right hand side captures the spillover from stock of existing ideas. The larger N_1 is, the more productive the research on new blueprints is.

The research sector of the economy is perfectly competitive. The revenue of

research sector comes from selling its newly invented blueprints to intermediate firms. Each blueprint is worth $\pi/(1+r)$ to its inventor, the discounted present value of the profit flow. Hence profit maximization problem for research sector is

$$\max_R \pi \Delta N - pR \Rightarrow \max_R \pi \phi N_1 R^\gamma - pR$$

To maximize her profit, marginal revenue of research should equal its marginal cost. Hence optimal R for research sector should satisfy:

$$R = \left[\phi \gamma N_1 \left(\frac{1-\alpha}{\alpha} \cdot \alpha^{\frac{2}{1-\alpha}} \right) p^{\frac{\alpha}{1-\alpha}} \right]^{\frac{1}{1-\gamma}} \tag{3.7}$$

4 Characterization of a Partial Equilibrium

A partial equilibrium for health care market in this closed economy is defined in a straightforward way. Note that this equilibrium is not "competitive," since intermediate goods producers have market power.

Definition 1. A *partial equilibrium for health care market* in this economy is given by

- relative price of health care to basic goods p,
- allocation function consisting of medical spending and basic goods consumption for pre and post retirement $\{M, C_1, C_2\}$,
- universal health insurance premium $\widetilde{P}$ collected by a competitive insurance company,
- relative prices and quantities of intermediate goods (drugs and medical apparatus) for production of health care $\{p_j, z_j\}$,
- aggregate R&D expenditure on health care R,

such that

1. Given wage, interest rate, the health insurance premium, the coinsurance coverage ratio τ, the allocation solve the above described utility maximization problem for representative household.

2. The health insurance company is competitive, that is, it collects health insurance premium $\widetilde{P}$ from its agent that covers precisely the reimbursement of medical expenditure of the insured:

$$\widetilde{P} = \tau pM$$

3. Given relative price of health care, number of product variety available currently, the final health care provider (hospitals and clinics) chooses quantities of intermediate goods to maximize its profit.

4. Given demand for each type of intermediate goods, the monopolist intermediate goods provider chooses price p_j to maximize its profit.

5. Given interest rate, the R&D sector chooses the amount of research to maximize its profit.

6. Market clearing condition for health care products.

$$Y = M + R$$

where $Y = \int_1^N (z_j)^\alpha$.

5 Calibration

In this section, I specify the parameter used in the simulations. Two models are tested to capture the interaction of health financing system and product innovation in health care industry. The first model explores how health care financing system may have incentivized more research and induced a increasing demand for health care. The second model, on the other hand, examined how the current state of technology has risen the medical consumption and pushed further research to expand the product variety. The results of calibration are exhibited respectively as follows.

1. *Effects of the Insurance System on R&D to Expand Product Variety*

   Table 1 summarizes the values and description of the parameters. As shown in the table, interest rate is set at an average level of the United States. Furthermore, wage rate of households is exogenously given around 25, since total GDP per capita is 56,115 in year of 2015 according to World Bank, around five times as much as health care cost per capita of 9403 dollars recorded by World Health Organization (WHO). In this model, I hold the current number of product variety N_1 as a constant, representing the current technology level in health care industry.

   Figure 6.1 shows the main result of this part. By adjusting coinsurance rate of health insurance, τ, from 50% to 90%, my model captures an obvious influence of moral hazard: when copayments for health care rises, the demand for health care increases correspondingly. The increasing demand drives the price of health care to rise. Consequently, household incurs higher health insurance premium and in turn sacrifices basic goods consumption, especially in the first period, to pay for the increased health care demand.

   For the supply side of health care market, the insurance also motivates the technology innovation. Final health care producer reacts to the surging demand by producing and serving more. Due to increased demand from final health care producer, intermediate firms also supply more drugs or medical apparatus to final health care producer and profit more from the increased price of health care. As intermediate firms profit more as a result of higher insurance coverage, their demand for new variety of products goes upwards. In response to the surging demand for new blueprints, research sector invests more to expand product variety.

   This part successfully captures the effects of the insurance system, not only on medical expenditure as a direct outcome of moral hazard, but also on technology innovation. The demand pull inflation of health care gives incentives for final health care producer to provide more services, brings more profits to the intermediate goods firms, and motivates research sector to invest more into expansion of product variety in reaction to the booming health care industry.

Parameter	Description	Values
Preferences		
β	discount factor	0.9
r	interest rate	0.042
w	wage	25
Final health care producer		
N_1	current number of product variety	10
α	intermediate input share for production	0.95
Research sector		
ϕ	productivity of research sector	4
γ	return to scale of research	0.6

Table 1: Parameters of the model with changing coinsurance rate

2. *Effects of R&D on Medical Spending under Insurance Coverage*

   Table 2 summarizes the values and description of the parameters. As shown in the table, wage rate and most other parameters are set identical as previous part except that this time I hold the coinsurance rate τ as a constant. And the current number of product variety N_1, becomes the explanatory variable in this model. Our main goal in this part is to explore how expansion of product variety will influence the medical expenditure and the R&D in health industry.

   Figure 6.2 shows the main result of this part. By adjusting number of product variety, N_1, from 10 to 1000, my model captures an important role of product variety expansion played in the interaction process of health financing system and technology innovation: when medical product variety expands, the productivity of final health care producer increases correspondingly. Hospitals supply more units of health care as productivity increases and this in turn causes the decreased price of health care. The falling price directly hurts the profit of intermediate goods firms and cuts down the production of intermediate goods.

Parameter	Description	Values
Preferences		
β	discount factor	0.9
r	interest rate	0.042
w	wage	25
τ		0.7
Final health care producer		
α	intermediate input share for production	0.95
Research sector		
ϕ	productivity of research sector	4
γ	return to scale of research	0.6

Table 2: Parameters of the model with changing current number of product variety

For the demand side of health care market, the decreased price of health care benefits the consumers tremendously. Since the price of health decreases as a result of product variety expansion, household can afford more health care to elevate quality of life. The health insurance premium actually decreases, because the rise of health care demand is offset by the drop of health care price. The decreased health insurance premium allows household to spend more on basic goods in both periods.

Finally, research sector reacts to the expansion of product variety by investing more into technology innovation. The larger the number of product variety, the more spillover the research sector attains to develop new blueprints. Alternatively speaking, the productivity of research is increased as N_1 rises, and thus, it becomes more profitable to research and develop new blueprints despite the decreased price of health care.

Another feature of the result is the decreasing marginal research with respect to current state of technology. When current number of product variety N_1 expands from a small amount, we can observe a rapid increase in research investment to further develop and innovate. Even though price of health care

declines accordingly with expanding product varieties, it's still highly lucrative for research sector to do research, since the spillover effect far more exceeds the side effect of decreased price of blueprints. However, as N_1 reaches a relatively high amount, it is no longer a wise decision to pour more money into research in this field. That is because, due to a large variety of products in the market, the price of health care decreases to an amount, so low that the spillover effect is totally offset by the decreased price of blueprints. Consequently, the research is reaching an stationary amount and so are the price of health care and medical consumption of households.

This part successfully captures the effects of product variety expansion, on both medical expenditure and on further R&D of medical product. The availability of larger number of product variety decreases the price of health care which consequently increases the consumers' demand for health care, brings more profits to research sector due to increased spillover effect, and gives impetus for further research and development.

Moreover, besides the interaction between consumers and providers of health care affected by expansion of product variety, the result also reflects some facts observed in the pharmaceutical industry. Nowadays, rapidly increasing investment is put into frontier sciences like treatment of cancer and auto immune diseases, where few or even no drugs are effective. In contrary, research in other fields of illnesses remains still or even on decrease, possibly for the reason that it's no longer profitable to invest more into the saturated market occupied by a large number of product variety already.

6 Conclusions

There is no easy solution to the skyrocketing health care expenditures experienced in vast majority of developed countries. On one hand, theoretical economists' concern focuses on problems of health financing systems: moral hazard, information asymmetry and adverse selection issues tied with insurance and inefficiently great utilization brought by current insurance payment mechanism. Yet empirical studies proved lit-

tle influence of insurance policy on medical expenditure, instead, they pointed it out that much of growth in health care expenditures after 1960s resulted from the rapid technology growth in health care industry.

However, simply attaching the label of "technology growth" to explain the surging health care costs is too simplistic and leading us no closer to understand the principle problem: in what process has technology growth driven the increase of medical expenditure, and wether current health financing system has incentivized such inventions to push the health costs. It is clear that substantial proportion of medical expenditure growth is not a result of increased prices of existing technologies, but an outcome of high price for new technologies. Intuitively, newly developed technologies have driven up the both costs of care and range of services covered by insurance. Simultaneously, the expansion of insurance coverage also provides an increased incentive for further innovate new products. Based on these intuition, I develop an product variety expansion model to capture the interaction between the demand side and supply side of health care.

First, I examined the effect of health insurance on medical consumption and technology progress. The results indicate that, moral hazard brought by insurance payment mechanism will prosper health care industry at the expense of basic goods consumption. As insurance covers more percentage of medical expenditure, both hospitals and intermediate goods firms will benefit from the increased demand. Consequently, research sector will invent more blueprints to get profits. In my model, relative price of health care acts as an indispensable factor to channel effects of health insurance into provider side. As coinsurance rate increases, the health insurance premium climbs up, not only resulting from higher copayment percentage of health care costs, but also increased price of health care itself.

Second, I find the expansion of product variety will encourage medical consumption and further R&D. The results show that, an expansion of product variety will increase the productivity of final health care producers and decrease the relative price of health care. As a result, medical consumption increases whereas the production of intermediate goods shrinks. The research amount, however, increases due to spillover effect, or a rise in productivity of research sector. One of our major concern, health insurance premium actually will decrease as product varieties expands, owing

to decreased relative price of health care.

Combining these two main results together, we can see that though health insurance might have given an impetus for rise of health care costs and technology innovation of expanding product variety, and it may potentially incubate a self healing system. That is, the expansion of product variety further encouraged by health financing system has the potential to pull down the price of health care and in turn decrease the health insurance premium, at the expenses of profit losses of intermediate medical goods firms. My model implies that through meticulous design of the coinsurance rate based on current technology level of particular types of health care, it is possible to control the medical expenditure and maintain a high level of research for product innovation. Another policy implication is that advocating technology innovation that expands varieties of products, unexpectedly, has the potential to decrease the costs of health care. However, intermediate medical goods firms, such as incumbent pharmaceutical companies and medical apparatus manufacturers will lose tremendously from this expansion. Thus, how to tradeoff the health care costs and profits of intermediate goods firms is a major concern to health financing system.

One of interesting extensions of this model is to include both insured and uninsured individuals in the demand side, in order to see how price of health care reacts to changing coinsurance rate or changing insurance coverage of the population. Furthermore, it may yield interesting results to involve health care consumptions in both periods, to examine if a finance in preventative health care will increase efficiency and encourage technology progress at the same time. Another improvement on the supply side is to include labor into production function of final health care producers, taking information asymmetry into consideration. The model needs to be extended to reflect more reality and left for future work.

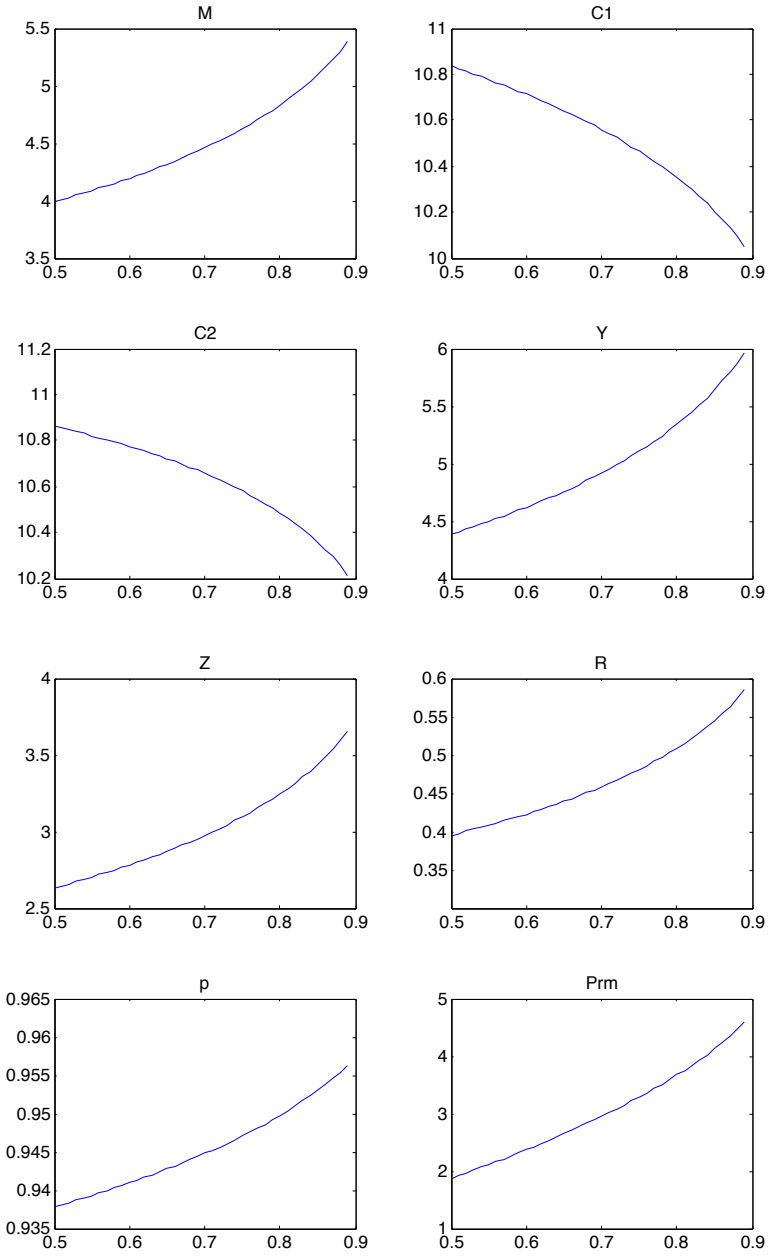

Figure 6.1: The model with changing coinsurance rate

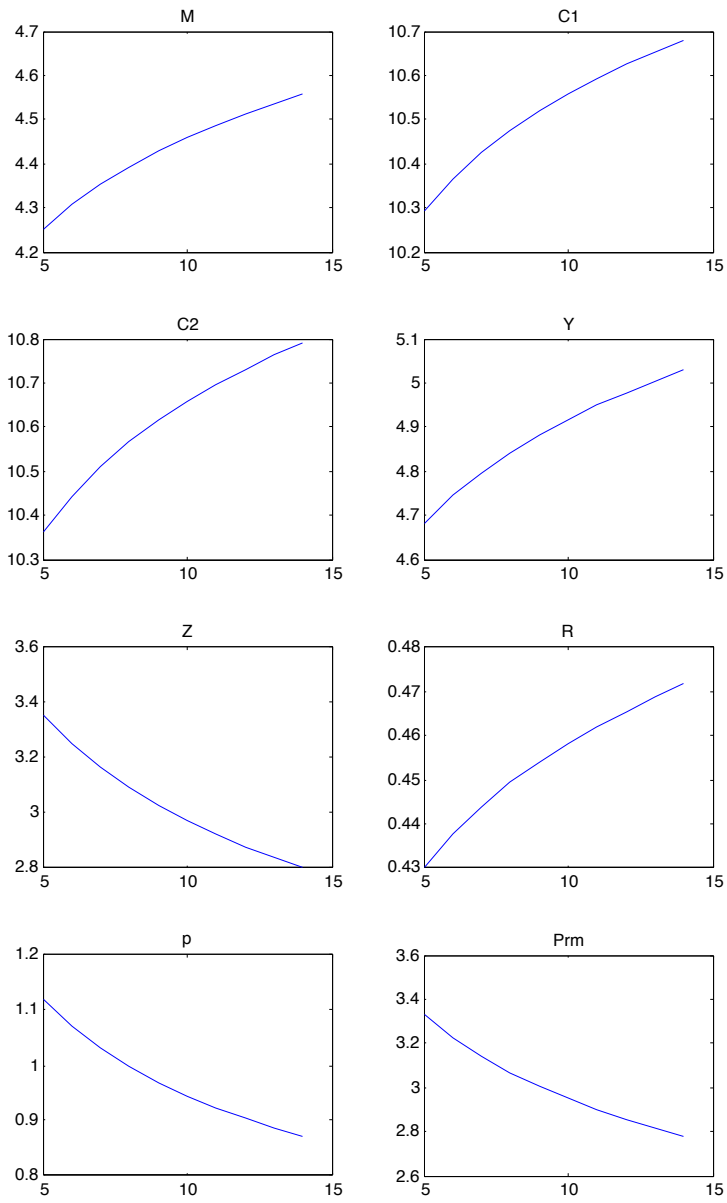

Figure 6.2: The model with changing current number of product variety

References

[1] Newhouse, Joseph P. "Medical care costs: how much welfare loss?." The Journal of Economic Perspectives 6.3 (1992): 3-21.

[2] Joseph P. Newhouse, and Rand Corporation. Insurance Experiment Group. Free for all?: lessons from the RAND health insurance experiment. Harvard University Press, 1993.

[3] Finkelstein, Amy. "The aggregate effects of health insurance: evidence from the introduction of Medicare." The quarterly journal of economics 122.1 (2007): 1-37.

[4] Romer, Paul M. "Growth based on increasing returns due to specialization." The American Economic Review 77.2 (1987): 56-62.

[5] Acemoglu, Daron, and Fabrizio Zilibotti. "Productivity differences." The Quarterly Journal of Economics 116.2 (2001): 563-606.

[6] Jeske, Karsten, and Sagiri Kitao. "US tax policy and health insurance demand: Can a regressive policy improve welfare?." Journal of Monetary Economics 56.2 (2009): 210-221.

[7] Borger, Christine, Thomas F. Rutherford, and Gregory Y. Won. "Projecting long term medical spending growth." Journal of Health Economics 27.1 (2008): 69-88.

[8] Weisbrod, Burton A. "The health care quadrilemma: an essay on technological change, insurance, quality of care, and cost containment." Journal of economic literature 29.2 (1991): 523-552.

[9] Wagstaff, Adam, and Magnus Lindelow. "Can insurance increase financial risk?: The curious case of health insurance in China." Journal of health economics 27.4 (2008): 990-1005.

[10] Finkelstein, Amy, and Kathleen McGarry. "Multiple dimensions of private information: evidence from the long-term care insurance market." The American economic review 96.4 (2006): 938-958.

[11] Chandra, Amitabh, and Jonathan Skinner. "Technology growth and expenditure growth in health care." Journal of Economic Literature 50.3 (2012): 645-680.