Income Growth and Technology Advance: the Evolution of the Income Elasticity of Health Expenditure*

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Abstract

This paper constructs new theoretical frameworks to study how income growth and technology advance affect the income elasticity of aggregate health expenditure (HE). We show that, in both purely public and purely private payment systems, income elasticity first rises and then falls as income grows. The value could be above, below, or equal to unity on both the rising and falling sides, and it is affected by the ratio of HE to GDP. The demand for health care is more restricted by income when wealth level is low, so income growth meets large demand. When the wealth level is high, demand for health care has been mostly met so further income growth has less effect on HE increase. These predictions are consistent with extant empirical findings that in developed countries income elasticity decreases as GDP rises, while in developing countries it increases as GDP grows. Moreover, we illustrate that income elasticity is biased upward if the effect of technology advance is not controlled, and the bias is larger for developed countries who adopt more medical technologies. This can explain why a few papers find that richer countries have larger income elasticity.

Keywords: *Health expenditure, Income elasticity, Income growth, Technology*

JEL Classifications: *I10; O30; H42; H51*

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1 Introduction

Since Newhouse (1977), numerous papers have studied the income elasticity of aggregate health expenditure (HE), and estimation techniques have been improved. The first-generation studies made use of cross-sectional data and was criticized for the use of small datasets and unrealistic assumptions regarding the homogeneity across countries (see e.g., Parkin, McGuire, and Yule, 1987; Gerdtham, 1992). As a consequence, the second-generation studies used panel structure to analyze the relationship of HE and GDP (see e.g., the review by Gerdtham and Jonsson, 2000). The most recent studies have included analysis of the existence of cointegrating relationships between HE and GDP. Realizing that the used variables are not stationary, researchers have adopted various techniques to handle these non-staionary variables, such as unit root tests, cointegration and vector error correction models (e.g. Blomqvist and Carter, 1997; Gerdtham and Lothgren, 2000; Narayan, Narayan, and Smyth, 2011). Other improvements include considering the dynamics of HE and other variables (Roberts, 1999) and controlling for the technology effect using time and country dummies (Freeman, 2003; Sen, 2005).

Despite the research efforts, it is still an open debate whether health care is a luxury good or a normal good. In studies on OECD countries, some papers report that income elasticity is larger than unity, i.e., health care is a luxury good (e.g. Okunade and Murthy, 2002; Gerdtham and Lothgren, 2002), while others state that the elasticity is less than unity, i.e., health care is a normal good (e.g. Freeman, 2003; Dreger and Reimers, 2005; Baltagi and Moscone, 2010; Bilgel and Tran, 2013). In studies on developing countries, the results also diverge. For example, Bhat and Jain (2004), Jaunky and Khadaroo (2008) and Mehrara and Musai (2011) report income elasticities larger than one, while Sahn (1992) among others provides evidence that the income elasticity is less than one.

There are some explanations for the above conflicts. For example, it is natural to think that income elasticity changes as income grows, since the contents and attitudes of people's consumption are different at different wealth levels. When people are poor, a lot of things are regarded as luxuries, but when people are rich enough, luxuries may become necessities. This has been noticed by some researchers, but the literature that studies how income elasticity varies as income rises has conflicts too. Di Matteo (2003) as well as Lopez-Casasnovas and Saez (2007) show that income elasticity decreases as income grows, while Chen, Lin, and Chang (2009) and Boungnarasy (2011) conclude that rich countries have larger income elasticity than the poor countries do. It is also unconvincing to attribute these differences and conflicts to different data sets and different techniques used by the researchers.

This paper constructs new theoretical frameworks to analyze income elasticity. The main focus is on the purely public payment case, in which the public hospital makes treatment decesions as a representative person considering the country's wealth level. The public hospital sets health condition criteria for treatments and gives priority to people who are with worse health conditions, and sets health improvment criteria and gives priority to people who will get higher health improvement given the same cost. As the country's wealth level grows, the public hospital will lower both two types of criteria and treat more people. Lowering health condition criteria, that is, treating people whose health conditions were regarded as not bad enough for treatments before, is the force that makes the income elasticity rise. The rising trend will stop and change to a falling trend when the country's wealth reaches a certain level, since which the public hospital will not further lower the health condition criteria but will only lower the health improvement criteria as wealth grows. It is showed that on both the rising and falling trends, the income elasticity of HE could be above, below, or equal to unity, and it is related to the ratio of HE to GDP. This first-rise-then-fall trend of income elasticity fits well with the extant empirical works using data on both developed and developing countries.

In addition, this paper discusses the effect of technology, a supply-side force of HE rise and one of the most important factors that is usually compounded with income elasticity. We argue that income elasticity is biased upward if technology is not controlled and the bias is especially large for developed countries that adopt more new medical technologies. This is why some papers conclude that the income elasticity of HE rises with income.

Based on the results of this paper, it is worth reconsidering the motivations of studying the income elasticity of HE. One of them, started by Newhouse (1977), is to investigate if the HE-GDP ratio will continue to rise, since an larger-than-one income elasticity leads to an increasing HE-GDP ratio. However, the larger-than-one income elasticity is only a sufficient but not necessary condition for the HE-GDP ratio to rise. For many developed countries, although health care is a necessity, other reasons such as technology advance and population aging may raise the HE-GDP ratio.

In the literature, another motivation to study the income elasticity of HE is that, as Culyer (1988) and Di Matteo (2003) suggest, the value of income elasticity of HE has important policy implications. They suggest that if health care is a necessity or has less-than-one elasticity, people should advocate greater public involvement in it, while if health care is a luxury or has larger-than-one elasticity, governments should leave it to the market. This argument is not appropriate as well according to our conclusion: Larger-than-one income elasticity mostly occures in less developed societies due to restricted demand, and health care as a luxury good only shows that the level of the health care provided is relatively low, so governments in this case should be involved to provide more health care. Since health care, like many other goods, could be a luxury for poor people but a necessity for rich people, there is no reason for governments to protect the "necessity" of rich people but discourage poor people to enjoy their "luxury".

From our point, the significance of studying income elasticity is to understand the inherent relationship between HE and GDP, which has important policy implications. For example, given the first-rise-then-fall pattern of income elasticity, a rising HE-GDP ratio in less developed countries is more acceptable, since additional HE comes along with substantial improvement on people's health. In developed countries, although income growth alone has diminishing returns, the main driving force of HE-GDP ratio is not income growth but new medical technologies. Even if new technologies do not keep improving health levels in terms of life expectancy etc., they improve people's life quality by providing less painful and less risky treatments. In this sense, a rising HE-GDP ratio comes with higher well-being in developed countries too.

The paper is organized as below. Section 2 is the model setting. It derives the treatment threshold curves and explains how HE is expressed in the cases of pay-out-of-pocket, private insurance and public insurance. Section 3 proves that, in both purely public and purely private payment cases, income elasticity of HE first rises then falls as income grows. Section 4 considers public payment and private payment simultanously and uses the first-rise-then-fall pattern to explain some existing empirical results from rich societies, poor societies, and societies with payment structure change. Section 5 discusses the effect of technology advance on income elasticity. Section 6 concludes.

2 The Model

2.1 Basic Model Setting

Assume all people have the same utility function, $u(w, h)$, where h indicates health level, and w indicates the wealth that can be used to meet necessary demands. For a person to live, both w and h need to be positive, so there are $w > 0$ and $0 < h \leq H$. Notation H is the health level of being perfectly healthy.

The utility function $u(w, h)$ satisfies the following conditions: For all people, including those who have health problems and those who are perfectly healthy, the utility increase caused by wealth growth is strictly rising and concave, i.e., $u_1^{'}(w, h) > 0$ and $u_{11}^{''}(w, h) < 0$, where $0 < h \leq H$. The utility increase caused by health improvement is strictly rising and concave only for people who have health problems, i.e., $u_2^{'}(w, h) > 0$ and $u_{22}^{''}(w, h) < 0$, where $w > 0$ and $0 < h < H$. For people who are perfectly healthy, their utility can not be increased by further health improvement, that is, $u_2^{'}(w, H) = 0$ for all $w > 0$. There is also $u_{12}^{''} > 0$, which implies that neither health nor wealth is substitutable and life quality is based on both wealth and health. This assumption is common in the previous literature (e.g. Viscusi and Evans, 1990).

Notation h measures a general health level but does not specify which disease or diseases a person is suffering from. Since there are many different diseases in the real world, even for people who have the same pre-treatment health h, their health loss $H - h$ probably are caused by different diseases. So, the prices of people's treatments are different and the health improvements from these treatments are different too.[1] In this model, to simplify the calculation, we assume there exists only one treatment and the treatment price is unique, but from this treatment patients have different health improvements. This assumption reflects price-adjusted quality of the treatments in the real world are different, and makes it more convenient to test empirical findings in the literature - in the papers that study the effects of income growth and technology advance on HE, most of them, if not all, control prices. We let p_0 denote the unique price of the treatment and q denote the health improvement from the treatment. People have different q values even if they have the same pre-treatemnt health h.

If there exists no medical insurance and people pay medical treatments out of their pockets, a person with pre-treatment health h will pay for the treatment if and only if

$$u(w, h) < u(w - p_0, h + q). \tag{1}$$

Because u is continuous and monotonic in both arguments, for every wealth level w, there

[1]Even when patients with the same health level take the same treatment, they often achieve different health improvements. Imagine in a case where two patients are at the same pre-treatment health level h. One patient is an athlete. He is perfectly healthy except he has a broken knee from an accident. The other patient's health loss is caused by a trivial knee problem and other diseases. The athlete will take knee-replacement surgery since otherwise he will lose the ability to walk. The other patient might not take the same surgery because his health improvement from it will be quite limited. But if he decides to take the surgery, he has to pay the same price as the athlete does.

exists a unique $\underline{q}$ satisfying

$$u(w,h) = u(w - p_0, h + \underline{q}). \tag{2}$$

People identified by $\underline{q}$ in (2) are indifferent between taking the treatment and not taking. Hence they are the *marginal consumers* with pre-treatment health h. We call $\underline{q}$ the *treatment threshold* because it is the minimal health improvement that induces patients with (w,h) to buy the treatment. Patients who are with (w,h) and have q values that are larger than $\underline{q}$ will pay for the treatment. Obviously, there are $w > p_0$ and $0 < \underline{q} \leq H - h$.

2.2 Threshold Curves in the case of Pay-out-of-pocket

Among a group of people who have the same pre-treatment health h, people may be different only in w and q. From (2), we know that the one-to-one mapping from w to $\underline{q}$ forms a *threshold curve*, $\underline{q}(w,h)$. This curve has all marginal consumers with the pre-treatment health h.[2] People who are located above the threshold curve will for sure pay for the treatments since their utilities of taking treatments are higher than not taking. Suppose these people are evenly distributed in a $q - w$ panel, then the area above the treatment threshold represents the HE of patients who have pre-treatment health h. The total HE of people at all h levels can be achieved by calculating the weighted sum of these areas. When the threshold curves are shifted, the area changed reflects the HE change. Therefore, to study the shape and position of the threshold curves helps to analyze how HE changes. It is started from studying the partical derivates.

From (2), we get the the partial derivates of $\underline{q}(w,h)$ with respect to the two arguments w and h.

$$\underline{q}_1^{'}(w,h) = \frac{u_1^{'}(w,h) - u_1^{'}(w - p_0, h + \underline{q})}{u_2^{'}(w - p_0, h + \underline{q})} < 0. \tag{3}$$

[2]Note that the threshold curve is not an indifference curve because the marginal consumers on the curve have different utility levels. People with higher w have higher utility because all people have the same pre-treatment health.

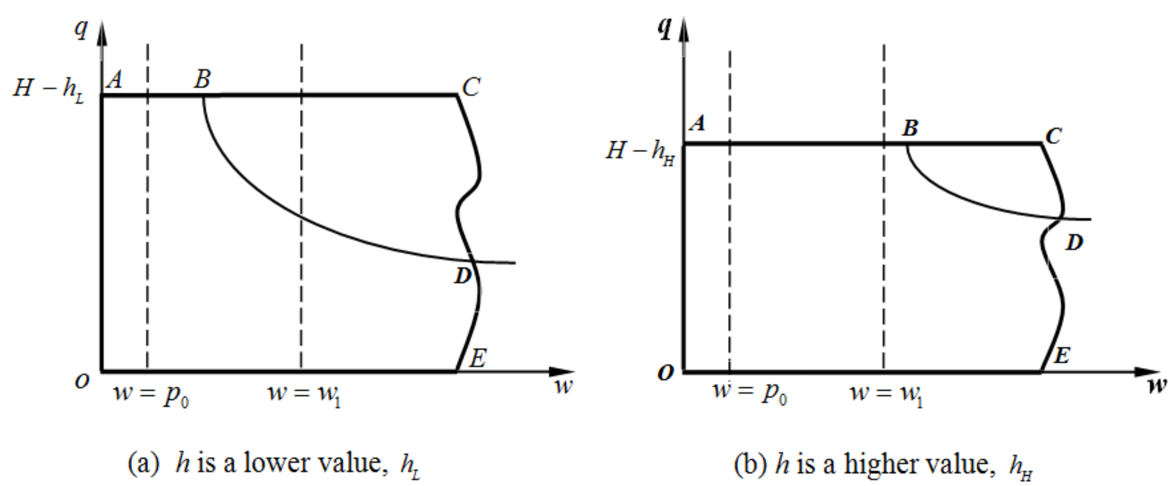
$$\underline{q}_2^{'}(w,h) = \frac{u_2^{'}(w,h) - u_2^{'}(w-p_0, h+\underline{q})}{u_2^{'}(w-p_0, h+\underline{q})} > 0. \tag{4}$$

The first partial derivative, (3), gives the slopes of the threshold curve of people with pre-treatment health h. The slopes are always negative becasue $u_1^{'}(w,h) < u_1^{'}(w-p_0,h) < u_1^{'}(w-p_0,h+\underline{q})$. The negative slope means that the treatment threshold given h decreases as wealth increases. Intuitively, rich people are less sensitive to wealth loss, so their health improvement requirements for paying for the treatments are smaller than the poors'. Notice with $\underline{q} = H - h$, (3) becomes (5), and the slope is negative infinity.

$$\underline{q}_1^{'}(w,h) = \frac{u_1^{'}(w,h) - u_1^{'}(w-p_0, H)}{u_2^{'}(w-p_0, H)} = -\infty. \tag{5}$$

Figure 1 (a) illustrates the threshold curve when pre-treatment health is h_L. The horizontal axis is wealth and the vertical axis is the health improvement a person can get from the treatment. All people with h_L are located in area $OACE$. Patients who can completely recover and get the maximal possible health improvement from the treatments are on segment AC, and on segment OE are located people who do not benefit anything from the treatments. All marginal consumers are located on the threshold curve, curve BD.

Figure 1: Treatment Thresholds of the Case of Pay-out-of-pocket



Since $w > p_0$, curve BD must intersect with AC, and people on point B have least wealth and highest health improvement among all marginal consumers. In particular, they might get treated only when they can fully recover from the treatments ($\underline{q} = H - h$). The slope at B, as in (5), is negative and infinite. This confirms that marginal consumers located at point B are the least rich among all marginal consumers, and therefore the least rich among all people with pre-treatment health h. For patients who are even less rich, the condition for them to buy the treatments is that the treatments improve their health by infinity. In other words, these people will not buy the treatments.

The threshold curve decreases as wealth grows. It will not intersect with the horizontal axis since $\underline{q} > 0$. It intersects with curve CE, on which are located the richest people of each group that has the same health improvement q. The intersection point D represents those, among all marginal consumers, who are the richest and have the lowest treatment threshold. If the marginal consumers represented by D are rich enough, the slope of D will be close to zero.[3] This, together with the negative infinity slope at point B, suggests that the threshold curve in general has decreasing and convex shape. If we use the Cobb-Douglas utility function as some of the previous papers did (see e.g., Jofre-Bonet, 2000; Clemente, Marcuello, Montanes, and Pueyo, 2004), we can prove the threshold curve is strictly convex everywhere.[4]

Equation (4) is the partial derivative with respect to the pre-treatment health level, h. It shows the relative positions of the threshold curves with different h-values. If $\underline{q} < H - h$, there must be $\underline{q}_2'(w, h) > 0$ since both denominator and numerator are positive.[5] This can be applied to all points on curve BD except point B. For each of such points, it means that

[3]This is because of the concavity assumption with respect to wealth w.

[4]Consider the Cobb-Douglas utility, $u(w, h) = w^\alpha h^\beta$. For the marginal consumers, there is $w^\alpha h^\beta = (w - p_0)^\alpha (h + \underline{q})^\beta$. The threshold curve's first-order and second-order derivatives with respect to wealth are respectively

$$\underline{q}_1'(w, h) = \frac{\alpha}{\beta} \cdot \frac{w^{\alpha-1} h^\beta - (w - p_0)^{\alpha-1} (h + \underline{q})^\beta}{(w - p_0)^\alpha (h + \underline{q})^{\beta-1}} = -\frac{\alpha}{\beta} \cdot \frac{p_0 (h + \underline{q})}{w(w - p_0)} < 0,$$

$$\underline{q}_{11}''(w, h) = \frac{\alpha}{\beta} \cdot \frac{p_0 (h + \underline{q})[2w - p_0 + \frac{\alpha}{\beta} p_0]}{w^2 (w - p_0)^2} > 0.$$

[5]The numerator is positive because $u_2'(w, h) > u_2'(w - p_0, h) > u_2'(w - p_0, h + \underline{q})$.

at a given wealth level w, the treatment threshold will become higher when pre-treatment health h is higher. This makes sense, since a person is more eager to get treated when his pre-treatment health is low. If his pre-treatment health level is high, the treatment is as attractive as when his pre-treatment health level is low only if the treatment quality is better for the same price, i.e., his health improvement q from the treatment is higher. Figure 1 (b) gives the threshold curve of h_H, $h_H > h_L$. We see that for the same wealth level, its treatment threshold is higher than the one for h_L.

$$\underline{q}_2'(w,h) = \frac{u_2'(w,h) - u_2'(w-p_0,H)}{u_2'(w-p_0,H)} = \infty. \tag{6}$$

For patients who are located on point B, there is $\underline{q} = H - h$, and equation (4) becomes (6). The partial derivative with respect to h is positive infinity at point B. This means that, given the wealth level of patients at B, who are the poorest (marginal) customers with pre-treatment health h_L, if the pre-treatment health is higher than h_L, the treatment threshold will become infinitely high, in other words, people at this wealth level will not get treated if their pre-treatment health is better.

2.3 Threshold Curves and Health Expenditure with Insurances

The treatment threshold curves in the last subsection were derived in the context that people pay out of pocket for the medical treatments. However, these threshold curves can also be used as analysis bases when it comes to private and public medical insurances. In this subsection it is explained that private insurance essentially is the same as the case of pay-out-of-pocket, so we combine them as “private payment”; for the analysis of public insurance, the derived threshold curves need to be interpreted in a slightly different way.

2.3.1 Private Medical Insurance

The case of private insurance is essentially the same as the case of pay-out-of-pocket. It is true that in the latter case it is the patients who decide to get treated or not after being sick, while in the former insurers decide whether to reimburse treatment costs. But, insurers' decisions are made according to insurance contracts, and it is the customers, based on the expected utilities, who decide which insurance contract to buy. As Blomqvist and Carter (1997) argued, if the higher income enables rich people to buy more generous insurance plans than what the poor buy, there is no reason why spending patterns across rich and poor would look any different from the pattern in the case of pay-out-of-pocket. Rich people buy contracts that are more expensive but have better coverage and payment policies. This leads to rich people having lower treatment thresholds than poor people. In a market with limited private insurance contracts, insurance companies act as intermediates and they use insurance contracts to group people with similar wealth levels. People have the same treatment levels within their groups, but differences still exist between groups. Actually, if there are many contracts, so many that there is one contract for each wealth level, we will get exactly the same threshold curve as in the pay-out-of-pocket case. Therefore, for convenience, in the remaining analysis of this paper we use *private payment* to represent the case of pay-out-of-pocket and the case of private insurance.

2.3.2 Public Medical Insurance

Governments Act as a Representative Person

A most important character of public medical insurance systems is that people are not rationed according to their ability to pay, but according to their health conditons. Patients pay little for treatments so they want to get treated as long as there is any improvement. Public hospitals decide the criteria for treatments, and the criteria apply to all patients. Evidences show that patients who are with lower pre-treatment health (lower h) have priority, and patients who are likely benefit more given the cost (higher q) have priority.

General Practitioners (GPs)' referrals and waiting time are familiar tools to implement cost control. Actually, they are also the tools of implementing the treatment criteria. GPs in some sense play the role of "gatekeepers", and their referrals are necessary for further examinations and treatments. If they believe a kind of treatment is not "suitable" for a patient, which means the patient's problem is trivial or the health improvement that could be achieved from the treatment is small considering the treatment cost, they would not give the patient a referral. On the contrary, if they think a patient's situation is serious they would give him priority and put his name on the top of the waiting list.

Public insurance systems use longer waiting time to deter more patients' coming. As Docteur, Suppanz, and Woo (2003) writes, while the U.S. health system provides ready access to latest clinically effective treatments for those with adequate insurance or ability to pay, many other OECD countries, where public insurance is dominating, have waiting time. Some other papers, for example, Blendon, Schoen, DesRoches, Osborn, Zapert, and Raleigh (1994) and Hurst and Siciliani (2003), also provide evidence that public systems have much longer waiting time. Long waiting time can be regarded as a partial rejection to treatment requests. Considering that people might need to get treated every several years (for different diseases), months of or even longer waiting for one treatment is substantial. During the waiting time, people might recover, or might pay out of pocket to get treated in private hospitals. Some patients do not go to public hospitals in the first place because they know they will be at the end of the long queue.

If we look into the waiting time data within a country, we will see clearly that public hospitals give priority to patients with lower h and higher q. According to Hurst and Siciliani (2003), in all the 12 OECD countries where public insurance dominates, there are obvious evidences showing that more "important" treatment has shorter waiting time. For example, the waiting time for Percutaneous transluminal coronary angioplasty (PTCA) is, if not the shortest, much shorter than other treatments', while the waiting time of knee replacement surgery is much longer than other surgeries.

To sum up the above, public hospitals decide treatment criteria and the treatment criteria apply to all patients, and patients with lower h and higher q have priority to get treated. Then, what makes public hospitals, for example, decide less strict treatment criteria and to provide treatments to more people? The (main) cause is larger budget. To ask further, how does a government decide public hospitals' budget? It is of course related to merits like sympathy, etc., but at macro level, it is more accurate to say that it is decided by the society's utility function on wealth and health and the society's wealth level.

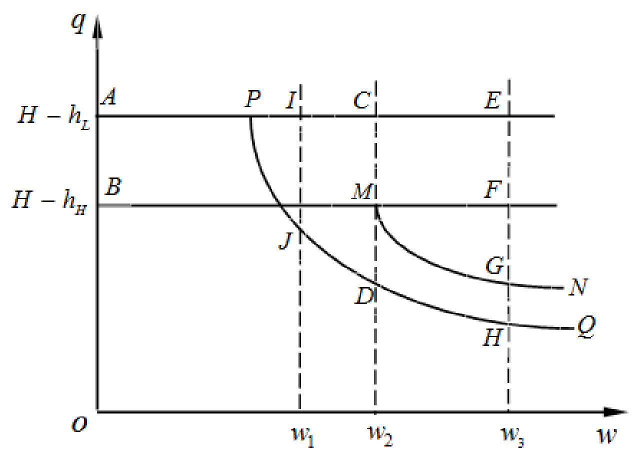
A government acts as a representative person and she decides treatment thresholds according to her utility function and wealth level. The government's decision should be the same as the decision of a person in the case of pay-out-of-pocket. In other words, the government provides insurance to her people, but the government herself does not have any insurance. She may have different wealth levels at different time. At a given wealth level, she gives one treatment threshold for each h, and people with the pre-treatment health h will be treated if and only their q values are above this treatment threshold.

The Health Expenditure of Public Insurance

Figure 2 gives an illustration of the treated patients in a purely public insurance society. Two pre-treatment health levels h_L and h_H are considered. The maximal possible health improvements for people who are with these health levels are $H - h_L$ and $H - h_H$, and curves PQ and MN are their threshold curves respectively. As proved early, curve MN is above curve PQ. When the society is less rich and has wealth w_1, only patients with h_L may get treated. We say that h_L is in the *treatment pool* while h_H is not. In particular, patients who are with h_L and are located on segment IJ will be treated. When the society's wealth grows to w_2, patients who are with h_L and are located on segment CD will be treated, and patients who are with h_H and are located on point M become marginal consumers. We say at w_2, h_H starts entering the treatment pool. At even higher wealth level w_3, both h_L and

h_H are in the treatment pool and people located on segments EH and FG are treated. The lengths of the segments represent the numbers of treated patients as long as people with the same h are evenly distributed across q. Let $\rho(h)$ denote the percentage of patients with h and we will get the weighted sum of these segments, which represents the total HE of people at all h levels.

Figure 2: Treatment Thresholds of Public Payment



If we generalize the case with two h levels to a case where h is continous, when the society's wealth grows, h will also enter the treatment pool from low value to high value. [6] When h stops entering the treatment pool depends on the society's wealth w. Let $\widehat{h}(w)$ denote the highest h in the treatment pool. At $\widehat{h}(w)$ marginal consumers are patients who can completely recover. Given public's values on wealth and health, a higher $\widehat{h}(w)$ comes along with a higher w. It is not possible for h to continue entering the treatment pool until H. Suppose it will stop at $\overline{h}$, which is the sufficiently high health level even if treatment cost is not a consideration. Health loss $H - \overline{h}$ is small and it does not affect people's normal life.

The HE spent on patients with h is represented by $H - h - \underline{q}(w, h)$, which is the difference between the maximal possible health improvement $H - h$ and the treatment threshold $\underline{q}(w, h)$.

[6]Technically, this is because the threshold curve with higher h is at a higher position and it is right to the ones with lower h. Intuitively, this is consistent with the rationale that it is more urgent for patients with bad health conditions to be treated so the decision maker gives them priority.

This corresponds to, for example, the length of segment IJ at w_1 in Figure 2. When the decision maker's wealth w is not high enough to let $\overline{h}$ be in the treatment pool, i.e., new h levels will enter the treatment pool when w is higher, the total HE is the integral of $H-h-\underline{q}(w,h)$ from zero to $\widehat{h}(w)$. When the decision maker's wealth is high enough to have $\overline{h}$ in the treatment pool, which means the government will not consider giving treatments to any people whose h is higher than $\overline{h}$ even when the society's wealth further grows, the total HE is the integral of $H-h-\underline{q}(w,h)$ from zero to $\overline{h}$. The HE, denoted as $\Pi(w)$, is expressed in (7).

$$\Pi(w) = \begin{cases} \int_0^{\widehat{h}(w)} [H - h - \underline{q}(w,h)] \cdot \rho(h)\, dh, & \text{(before } \overline{h}\text{)} \\ \int_0^{\overline{h}} [H - h - \underline{q}(w,h)] \cdot \rho(h)\, dh, & \text{(after } \overline{h}\text{)} \end{cases} \tag{7}$$

3 Income Growth Effect on Income Elasticity

This section studies how wealth growth affects the income elasticity of HE in the cases with purely public and purely private payment. For both cases, the idea is to first find how wealth growth affects the increase speed of HE. It is the technical core of the analysis about income elasticity. Based on it, we need only a little more algebra to get the wealth effect on the income elasticity of HE. We give a strict proof for the case of purely public payment and a simple illustration for the case of purely private payment. In the public case, based on the analysis about wealth effect on the increase speed of HE, it is also easy to see how the public HE as a share of GDP changes when wealth grows.

3.1 Public Medical Insurance

3.1.1 The Increase Speed of Public Health Expenditure

The first order derivative of $\Pi(w)$, (8), measures the change in HE when wealth grows. It is positive both when pre-treatment health level $\overline{h}$ is in the treatment pool and when it is not, which means the HE always increases with wealth regardless of the wealth level.

$$\Pi'(w) = \begin{cases} \widehat{h}'(w)\big[H - \widehat{h}(w) - \underline{q}\big(w, \widehat{h}(w)\big)\big]\rho(\widehat{h}(w)) - \int_0^{\widehat{h}(w)} \underline{q}_1'(w,h)\rho(h)\,dh, & (\overline{h} \text{ not in pool}) \\ -\int_0^{\overline{h}} \underline{q}_1'(w,h)\rho(h)\,dh, & (\overline{h} \text{ in pool}) \end{cases} \tag{8}$$

In the first row, which represents the change in HE when $\overline{h}$ is not in the treatment pool, we can use the condition $H - \widehat{h}(w) = \underline{q}\big(w, \widehat{h}(w)\big)$. It is directly from our defination that at $\widehat{h}(w)$ only patients who can completely recover are marginal consumers. Equation(8) can be simplied as

$$\Pi'(w) = \begin{cases} -\int_0^{\widehat{h}(w)} \underline{q}_1'(w,h)\rho(h)\,dh, & (\overline{h} \text{ not in pool}) \\ -\int_0^{\overline{h}} \underline{q}_1'(w,h)\rho(h)\,dh, & (\overline{h} \text{ in pool}) \end{cases} \tag{9}$$

Equations in (10) are the second order derivatives with respect to w when $\overline{h}$ is in the treatment pool and when it is not. They are denoted as $\Pi''(w)$, and reflect the speed variation of the HE increase.

$$\Pi''(w) = \begin{cases} -\int_0^{\widehat{h}(w)} \underline{q}_{11}''(w,h)\rho(h)\,dh - \widehat{h}'(w)\underline{q}_1'\big(w, \widehat{h}(w)\big)\rho(\widehat{h}(w)), & (\overline{h} \text{ not in pool}) \\ -\int_0^{\overline{h}} \underline{q}_{11}''(w,h)\rho(h)\,dh, & (\overline{h} \text{ in pool}) \end{cases} \tag{10}$$

As explained earlier, based on the assumptions $u_1' > 0$, $u_2' > 0$, $u_{11}'' < 0$, $u_{22}'' < 0$ and $u_{12}'' > 0$, we have a general convex shape for the threshold curve $\underline{q}(w,h)$, i.e. $\underline{q}_{11}''(w,h) > 0$. Therefore, from the second equation in (10), which for the situation where wealth is so high that $\overline{h}$ is already in the treatment pool, we can have the general trend that the HE increases slower and slower as wealth rises.

The sign of first equation in (10) is less straightforward. The first term indicates how wealth growth affects the increase speed of the HE spent on patient groups that are already in the treatment pool. It corresponds to the h_L type at w_2 in Figure 2. Because of the convexity of the threshlold curve, it is also negative. The second term measures the effect of the new pre-treatment health h entering the treatment pool, represented by the h_H type at w_2 in Figure 2. The latter effect is the product of the percentage of people with $\widehat{h}(w)$, $\rho(\widehat{h}(w))$, the speed at which the new threshold curve enters, $\widehat{h}'(w)$, and the threshold value change of this new curve, $\underline{q}_1'\big(w,\widehat{h}(w)\big)$. From $H-\widehat{h}(w)=\underline{q}\big(w,\widehat{h}(w)\big)$, we have

$$\widehat{h}'(w)=\frac{-\underline{q}_1'\big(w,\widehat{h}(w)\big)}{\underline{q}_2'\big(w,\widehat{h}(w)\big)+1}=\frac{u_1'(w-p_0,H)-u_1'\big(w,\widehat{h}(w)\big)}{u_2'\big(w,\widehat{h}(w)\big)} \tag{11}$$

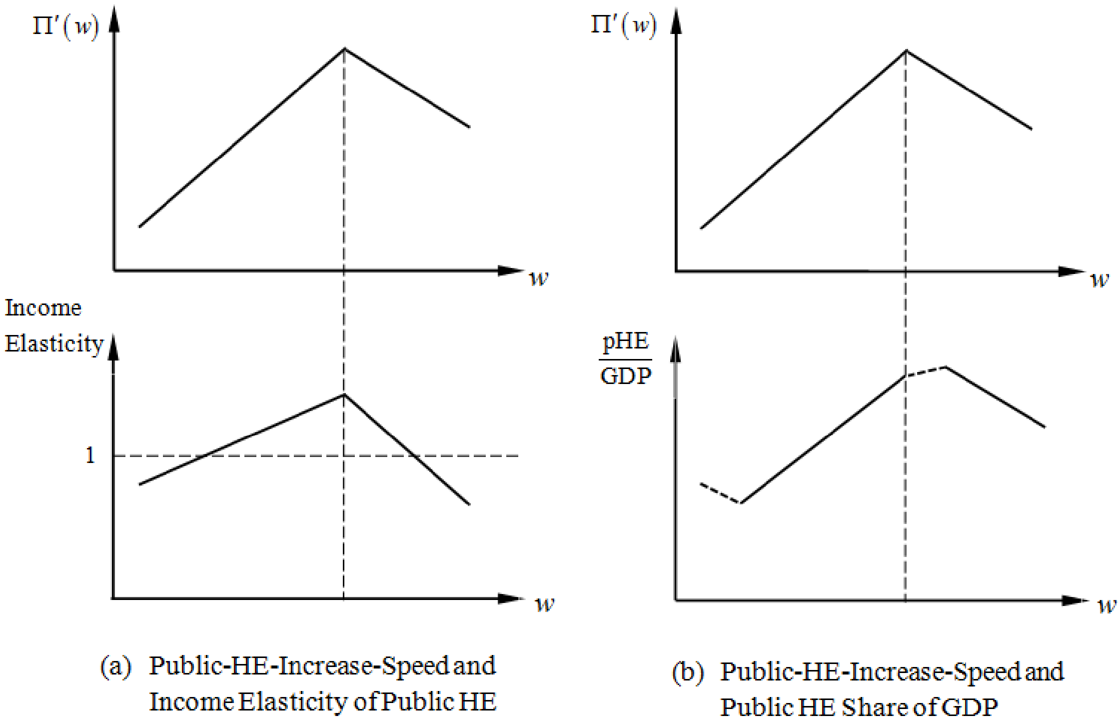
and $\widehat{h}'(w)$ is always positive and finite. Concerning $\underline{q}_1'\big(w,\widehat{h}(w)\big)$, recall (3), $\underline{q}_1'(w,h)$ is negative and infinite at the intersection point of the maximal health improvement line $q=H-h$ and the corresponding threshold curve. This exactly matches $\underline{q}_1'\big(w,\widehat{h}(w)\big)$ in our context, since we defined $\widehat{h}(w)$ as the pre-treatment health level at which those who can completely recover from the treatment (on the horizontal line, $q=H-\widehat{h}(w)$) become marginal consumers (on the threshold curve). Therefore, the second term of $\Pi''(w)$ when $\overline{h}$ is not in the treatment pool is always positively infinite, and therefore we can conclude that $\Pi''(w)$ always has positive values, which means the speed of HE increase is rising with wealth when $\overline{h}$ is not in the treatment pool.

3.1.2 The Income Elasticity of Public Health Expenditure

In the analysis earlier we concluded that as wealth grows the public HE increases faster and faster until the society's wealth reaches a certain level, at which patients with further higher pre-treatment health level will not be considered for treatment even when the society gets richer. After this wealth level the public HE increases slower and slower. This is because at first higher buying power not only meets the demand from the existing groups in the treatment pool but also lets groups of patients with higher pre-treatment health enter the pool; after a certain wealth level there is no new groups entering and the demand from the existing groups increase slower and slower with wealth.

In Figure 3 (a) and (b), the upper panels give the Public-HE-Increase-Speed curve (PHIS curve). The horizontal axis is wealth and the vertical axis is $\Pi'(w)$, the speed of public HE increases. Based on this curve, and with a little additional work, we can know about the

Figure 3: Public-HE-Increase-Speed, Public HE Share of GDP and Income Elasticity



change trends of the income elasticity of public HE and the ratio between public HE and GDP.

Consider the income elasticity at two wealth levels w_1 and w_2, $\epsilon(w_1)$ and $\epsilon(w_1)$, where $w_2 = w_1 + dw_1$ and $\Pi(w_2) = \Pi(w_1) + \Pi'(w_1) \cdot dw_1$. For convenience, let $t_1 = \Pi'(w_1)$ and $t_2 = \Pi'(w_2)$. In addition, define $t_0 = \Pi(w_1)/w_1$. It measures the ratio of the stock values of HE and GDP at w_1. In sum, we have

$$\epsilon(w_1) = \Pi'(w_1) \cdot \frac{w_1}{\Pi(w_1)} = \frac{t_1}{t_0}$$

$$\epsilon(w_2) = \Pi'(w_2) \cdot \frac{w_2}{\Pi(w_2)} = t_2 \cdot \frac{w_1 + dw_1}{t_0 w_1 + t_1 \cdot dw_1}.$$

It follows that

$$\epsilon(w_1) - \epsilon(w_2) = \frac{t_1}{t_0} - \frac{t_2 \cdot (w_1 + dw_1)}{t_0 w_1 + t_1 \cdot dw_1} = \frac{t_0 t_1 \cdot \frac{w_1}{dw_1} + t_1^2 - t_0 t_2 \cdot (\frac{w_1}{dw_1} + 1)}{t_0 \cdot (t_0 \cdot \frac{w_1}{dw_1} + t_1)} \tag{12}$$

In the rising side of the PHIS curve, $t_1 < t_2$. From (12), we can get

$$\epsilon(w_1) - \epsilon(w_2) < \frac{t_0 t_1 \cdot \frac{w_1}{dw_1} + t_1^2 - t_0 t_1 \cdot (\frac{w_1}{dw_1} + 1)}{t_0 \cdot (t_0 \cdot \frac{w_1}{dw_1} + t_1)} = \frac{t_1 \cdot (t_1 - t_0)}{t_0 \cdot (t_0 \cdot \frac{w_1}{dw_1} + t_1)}. \tag{13}$$

There are two cases concerning t_0 and t_1. First, if $t_0 \geq t_1$, (13) shows $\epsilon(w_1) - \epsilon(w_2) \leq 0$. That is, if the elasticity at w_1 is no more than one, the elasticity from w_1 to w_2 will be rising.

Second, if $t_0 < t_1$, (12) can be written as

$$\epsilon(w_1) - \epsilon(w_2) = \frac{t_0 \cdot (t_1 - t_2) \cdot \frac{w_1}{dw_1} + t_1^2 - t_0 t_2}{t_0 \cdot (t_0 \cdot \frac{w_1}{dw_1} + t_1)} \tag{14}$$

In practice, the annual GDP growth rates of in OECD countries are about 2-3%, so we consider only $dw_1 \ll w_1$. Since $t_1 < t_2$ in the rising side of the PHIS curve, (14) implies that $\epsilon(w_1) - \epsilon(w_2) < 0$. To sum up, on the rising side of the PHIS curve, if the income elasticity at w_1 is larger than one, we will also get a rising trend in income elasticity as wealth grows from w_1 to w_2.

Similarly, on the falling side of the PHIS curve where $t_1 > t_2$, there is

$$\epsilon(w_1) - \epsilon(w_2) > \frac{t_0 t_1 \cdot \frac{w_1}{dw_1} + t_1^2 - t_0 t_1 \cdot (\frac{w_1}{dw_1} + 1)}{t_0 \cdot (t_0 \cdot \frac{w_1}{dw_1} + t_1)} = \frac{t_1 \cdot (t_1 - t_0)}{t_0 \cdot (t_0 \cdot \frac{w_1}{dw_1} + t_1)}. \tag{15}$$

There are also two cases concerning t_0 and t_1. In the first case, $t_0 \leq t_1$, we have $\epsilon(w_1) - \epsilon(w_2) > 0$ from (15). That is, if the elasticity at w_1 is no less than one, the changing trend of income elasticity from w_1 to w_2 is falling. In the second case when $t_0 > t_1$, the elasticity at w_1 is less than one. We also have $\epsilon(w_1) - \epsilon(w_2) > 0$, so the changing trend of income elasticity from w_1 to w_2 is falling as well.

To summarize, on the rising side of the PHIS curve, or, before the public HE increase speed reaches the maximal point, the income elasticity may be below, above or equal to unity, but it for sure increases with wealth. On the falling side of the PHIS curve, health care also may be a normal good or a luxury good, but the income elasticity for sure decreases as wealth grows. The lower panel in Figure 3 (a) is an illustration for such evolution of the income elasticity.

3.1.3 Public Heath Expenditure as a Share of GDP

The speed of HE increase is also connected to the change of the public HE (denoted as pHE) share of GDP. Recall $t_0 = \Pi(w_1)/w_1$. We have

$$\begin{aligned} \frac{\Pi(w_2)}{w_2} - \frac{\Pi(w_3)}{w_3} &= \frac{t_0 w_1 + t_1 dw_1}{w_1 + dw_1} - \frac{t_0 w_1 + t_1 dw_1 + t_2 dw_2}{w_1 + dw_1 + dw_2} \\ &= \frac{(t_0 - t_2)w_1 + (t_1 - t_2)dw_1}{(w_1 + dw_1)(w_1 + dw_1 + dw_2)} \cdot dw_2 \end{aligned} \tag{16}$$

As $dw_1 \ll w_1$, the sign of $\frac{\Pi(w_2)}{w_2} - \frac{\Pi(w_3)}{w_3}$ depends on the relative sizes of t_0 and t_2. On the rising side of the PHIS curve, $t_1 < t_2$. As usual we consider two cases concerning the relative size of t_0 and t_1. If $t_0 \leq t_1$, we have $t_0 \leq t_1 < t_2$ and hence $\frac{\Pi(w_2)}{w_2} - \frac{\Pi(w_3)}{w_3} < 0$. However, if $t_0 > t_1$, it is possible that $\frac{\Pi(w_2)}{w_2} - \frac{\Pi(w_3)}{w_3} > 0$ when, relative to the decrease from t_0 to t_1, the increment from t_1 to t_2 is too small. In this case, it takes longer for public HE to increase faster to compensate for the decrease of the ratio. This may happen in a poor country that, for example, has experienced a shock in health sector or received external aid so that it has a relatively high ratio. When the country is on its own and is back to its normal track, there might be a period that the public HE share of GDP decreases, although the share will rise in the long run.

On the falling side of the PHIS curve, $t_1 > t_2$. Similarly, if the public HE share of GDP is on the falling track, i.e. $t_0 \geq t_1$, the share will keep decreasing. But this might not be the case if a country for any reason has $t_0 < t_1$. For example, after the PHIS curve's turning point, there might be a lag for the share to enter the falling track although it will occur sooner or later. Figure 3 (b) gives a comparison of the PHIS curve and the evolution of the pHE-GDP ratio.

The above analysis is based on the assumption that the government acts like a representative person and he does what he thinks is right. Although this is an ideal condition, we do have some evidence supporting our conclusion that there is a maximal level for pHE-GDP ratio: the ratio increases before it reaches the level and decreases after. For example, Hopkins (2010) compares the public HE share of GDP of 31 low, middle and high income countries in 2006, there is a roughly falling trend from the rich countries to the poor countries. Actually we will see the pHE-GDP ratio change clearer from rich countries' historical data. Using the 1975-1996 Canadian data provided by Di Matteo (2000), we have a series of pHE-GDP ratios that first increase with GDP growth then decrease with it. Clemente et al. (2004) explicitly gives a figure of the evolution of the government HE as a fraction of GDP in Sweden (1960-1998), which exhibits a changing trend (the maximal point) in 1980. The author also points out that "this pattern of the behavior is followed by a significant number of countries."

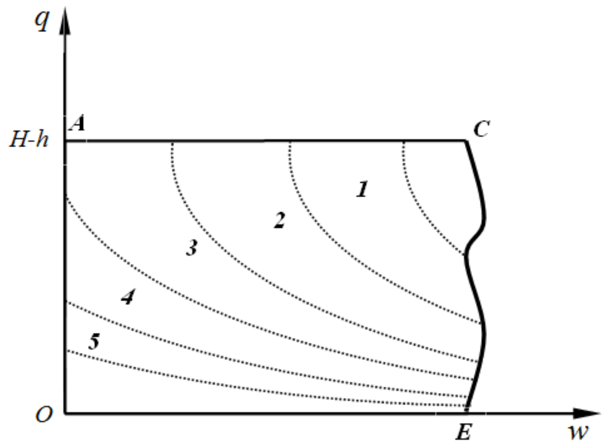
3.2 Private Medical Insurance

Private payment includes pay-out-of-pocket and payment with private insurance. The private insurance case is essentially the same as the pay-out-of-pocket case. It is true that in the latter case it is the patients who decide to get treated or not after being sick, while in the former insurers decide whether to reimburse treatment costs. But, insurers' decisions are made according to insurance contracts, and it is the customers, based on the expected utilities, who decide which insurance contract to buy. As Blomqvist and Carter (1997) argued, if the higher income enables rich people to buy more generous insurance plans than what the poor buy, there is no reason why spending patterns across rich and poor would look any different from the pattern in the pay-out-of-pocket case. Rich people buy contracts that are more expensive but have better coverage and payment policies. This leads to rich people having lower treatment thresholds than poor people. In a market with limited private insurance contracts, insurance companies act as intermediates and they use insurance contracts to group people with similar wealth levels. People have the same treatment levels within their groups, but differences still exist between groups. Actually, if there are many contracts, so many that there is one contract for each wealth level, then we will get exactly the same threshold curve as in the case of pay-out-of-pocket. Therefore, for convenience, in the remaining analysis of this paper we use private payment to represent the case of pay-out-of-pocket and the case of private insurance .

In the case of private payment, customers make treatment decisions under the background of their h and w levels. For a given h, there is one treatment threshold curve in the $q-w$ panel. People who are located right to the curve will get treated. When a person's wealth grows by a certain amount, for example, α, he will move rightwards by α unit but keep the vertical height unchanged. His new position relative to the threshold curve is the same as when he does not move but the threshold curve is shifted leftwards by α unit. This can be applied to anyone. If we assume the wealth amounts of all people in the society are increased by α unit, the new treated population can be achieved by left shifting the threshold curve by α unit, and the people located in the enlarged area are new consumers after the wealth growth.

Figure 4 illustrates the idea when wealth is increased by the same unit for five times for a given h level. At first, when wealth is at a very low level, only people who are located in the right-upper corner of panel $OACE$ will get treated. As wealth grows, the threshold curve is shifted leftwards. People located in areas 1, 2, 3, 4 and 5 are respectively the new consumers of five continuous wealth growths. Area 1 corresponds to the new consumers from wealth growth when the society is the poorest and Area 5 corresponds to the new consumers when the society is the richest. We see that although increasing wealth always lets more patients buy the treatment, the share of the increments of the treated population among people with h are different. When wealth is at very low level, a further wealth increase leads to more

Figure 4: Private Payment: Increments in HE are Different at Different Wealth Levels



and more additional patients being treated, therefore, larger and larger increased HE at h. When wealth is at very high level, so high that even the poorest patients have already bought treatments as long as their q values are high, increasing wealth further leads to smaller and smaller HE increase at h. This is because of the decreasing shape of the threshold curve.[7] Wealth growth always makes people have bigger buying power but it is more effective when people are poor, since when people are rich most people's demand have already been met and to lift the wealth limitation is less likely to create a lot of new business.

The situations of HE increment for different h levels are similar. By summing up the increments at all h levels we get the total increment in HE. It has the character that, wealth growth always leads to higher HE, but in a very poor society further wealth growth leads to larger and larger HE increments, while in a very rich society the same amount of further wealth growth has smaller and smaller impact on it. If we draw a HE increase speed curve for the private payment case, maybe it will be obscure where wealth is at middle levels, but, in general, it still has an increasing-when-poor-and-decreasing-when-rich shape. Therefore, based on it, the income effect on the income elasticity of private HE and the income effect

[7]If we assume all people's wealth are increased by the same percentage, the rich people, compared with the less rich people, will be moved rightwards more. Then the curves in Figure 4 will have a little change. In particular, the lower parts of the curves are steeper than illustrated in Figure 4. But this does not affect our conclusion because the changed curves still have the decreasing shape.

on the private HE as a share of GDP are similar to in the purely public payment situation, at least it is the case when the society is very poor and very rich.

At last, it is worth mentioning that this conclusion is drawn under the assumption that the society wealth growth means everyone's wealth grows by the same amount. Not like in the case of public payment where governments believe all people should have the same treatment thresholds and they can actually realize this belief, it is not realistic to make all people in a society to increase their wealth at the same pace. Nevertheless, this assumption is less strong for local analysis where people's wealth levels are similar. Figure 4 and the conclusions above are still meaningful in sense of illustrating the differences existed between rich people and poor people. The changes occur in Area 4 and 5 can be used to explain the behavior of rich people whose medical needs had mostly been met before. The changes of Area 1 and 2, on the other hand, reflect the wealth growth effects on those poor people. Their treatment decisions have been more restricted by wealth so income growth has larger effects. There are more in Section 4.

4 Explaining Income Elasticity of Health Expenditure

In the last section, we studied how HE's income elasticity changes along with GDP growth in the purely public payment case and the purely private payment case. However, in reality, there are very few countries that use purely public or purely private payment in health sector. According to Poullier, Hernandez, Kawabata, and Savedoff (2002) that studies the global HE pattern using data from 191 countries, most countries have a public-private mix in their health sectors. Moreover, there should be that people whose wealth is less than a certain level use the service provided by public hospitals and have the same threshold for given h, while people who are richer use private payment and enjoy better services, or, in our context, have lower treatment threshold. This coincides with empirical evidence. For example, Hopkins (2010) found from 31 high, middle and low income countries' data that public HE is more prevalent for funding of curative care. Such distribution not only is prevalent in the real world but also is proved to be the best choice considering both social welfare and cost. In Jofre-Bonet (2000)'s theoretical work, the author finds in the equilibrium that the private provider serves the high quality demand and the public suppliers servers the low quality demand, and such provision results in a welfare improvement compared to the purely private regime and is less costly than a purely public one.

Figure 5: Treatment Thresholds in a System with Public-Private Mix

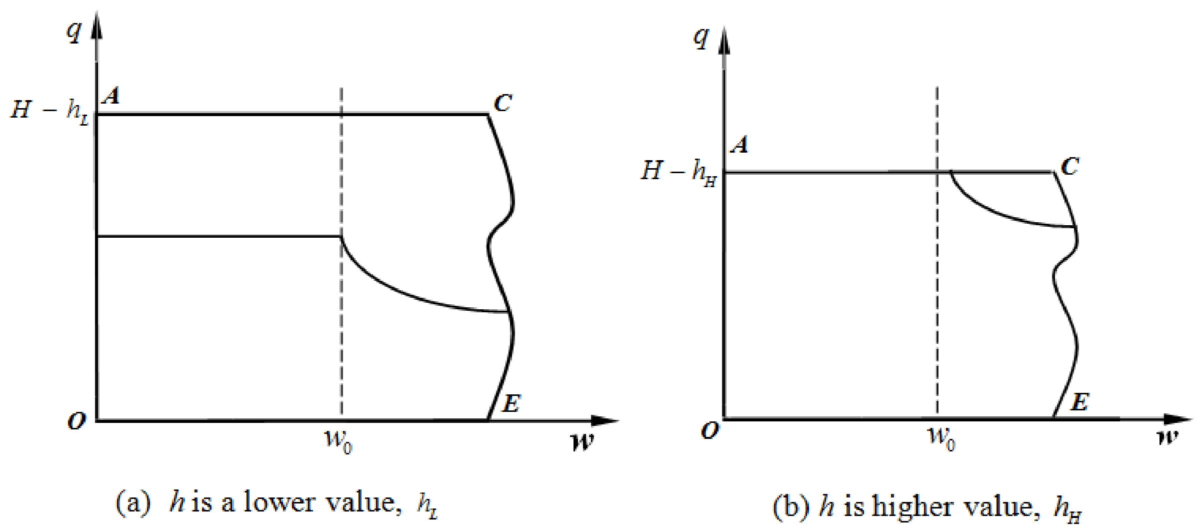


Figure 5 (a) and (b) illustrate the treatment thresholds when h is low and high. Patients with different w and q levels are located in panel $OACE$. As illustrated in Figure 5 (a), when h is low, patients with all levels of wealth may get treated. The difference is that those who have less than w_0 use public service. If their q values are above the public hospital's treatment threshold, they will get free treatment. People who have more than w_0 use private payment and their treatment thresholds are lower. The situation when h is high is illustrated in Figure 5 (b). Public hospital doctors will not give treatment to any of such patients, while with private payment rich patients might get treated.

The HE is reflected by the sum of the areas above the treatment thresholds at all h levels, and the change of the areas denotes the change in HE. The analysis about income elasticity for total HE is the same as in the purely public case and the purely private case. The core is to find how income growth affects the speed of HE increase and which stage the wealth level is at.

4.1 Rich Societies with Little Public-private Structure Change

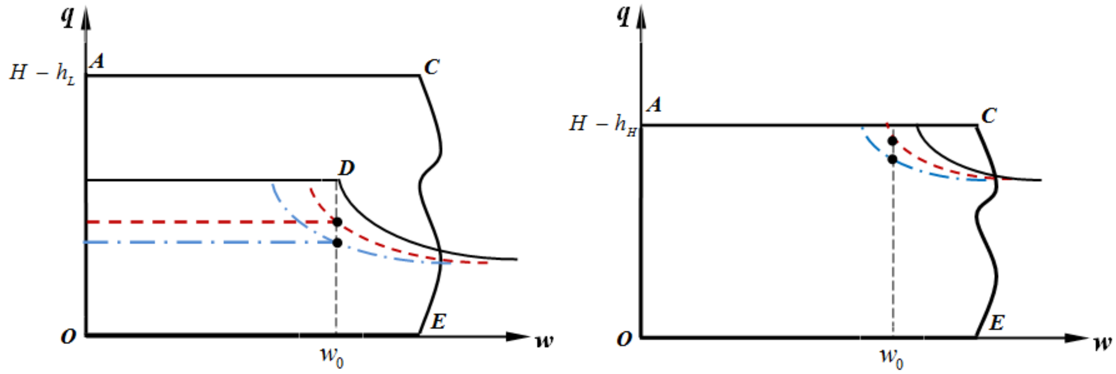
A rich society in our context is where the wealth is higher than the turning point's wealth level in Figure 3, that is, the society's wealth is high enough to let $\overline{h}$ be in the treatment pool. In reality, such rich society corresponds to the developed countries because in these countries public hospitals provide patients (almost) all of important curative services and products at very low even zero price.

The developed countries have large HE and relatively mature health care systems, so the changes in public-private structure of the health sector, or, the changes of wealth division line between the groups using public payment and the private payment, if there is any, are relatively small. Figure 6 (a) describes, with the public-private structure unchanged, how the treatment threshold changes when this society's wealth grows for a smaller h value. The black solid curve is the original treatment threshold. The red broken curve is the one after the wealth is increased by the first Δw, and the blue dot dash curve is what is achieved after the wealth is increased by the second Δw. We see that in the public sector the amount of the free treatment threshold decreases is smaller in the second time than in the first time.[8] In the private payment part, the enlarged area of the second time is smaller than in the first time too.

Also with the public-private structure unchanged, Figure 6 (b) is for when h is a large value, so large that public hospital doctors think that it is not necessary for these people to take any treatment even if they can completely recover with the treatment. With the same h, people who use private payment can be treated as long as they are rich enough. We see that

[8]The sum of the treatment threshold at all h levels decreases slower and slower too, because it is on the falling side of the PHIS curve.

Figure 6: Rich Societies with Little Public-private Structure Change



(a) *h* is a lower value, h_L (b) *h* is a higher value, h_H

the enlarged area in (b) will eventually become smaller and smaller as wealth rises. Actually, the situation like in (b) accounts for a small share in rich societies, because in rich societies the public medical service level is not very low compared with the private service level, and for most of pre-treatment health level h that the richest patients get treated, the less rich patients can get treated in public hospitals too.

In sum, the total HE increase speed is decreasing as wealth grows. Hence, unless at special situations like right after a shock, the income elasticity of total HE should be less than one and it decreases when wealth grows. That the income elasticity is less than one shows, as Bilgel and Tran (2013) said, that health care is a necessary good and the delivery of it is dominated by the needs rather than the ability to pay in rich countries.

This conclusion coincides with empirical findings. For example, Lopez-Casasnovas and Saez (2007) study the income elasticities of HE of eight OECD countries, Australia, Canada, France, Germany, Italy, Spain, Sweden and United Kindom. It is found that all the elasticity values are between 0.2 and 0.3, and the ranking of the elasticity is exactly the opposite to the ranking of per capita GDP of these countries. Di Matteo (2000) works on the United States state level data (1980-1997), Canadian province level data (1965-2000) and 16 OECD countries' data (1960-1997). The paper finds that income elasticities are higher at low-income levels and lower at higher income levels. Roberts (1999) studies 20 OECD countries' data from 1960 to 1993 and finds the correlation coefficient between the estimated income elasticity and the level of income in a country is -0.27.

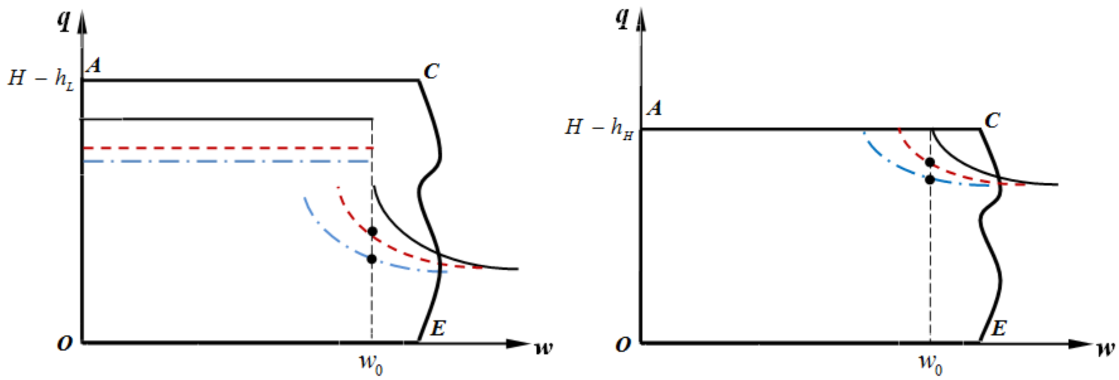
4.2 Poor Societies with Very Few Rich People

It is not uncommon in very poor countries that there is a small share of population controlling a disproportionately large share of wealth of the country. In such countries, it is even less likely for the public-private structure to change. Rich people never want to access what is provided by public hospitals and poor people do not have hope to afford the good quality medical services or products with private payment.

Figure 7 (a) and (b) illustrate the idea. When wealth grows, what happens in the public part is exactly the same as on the rising side of the curve in Figure 7 (a), that is, the sum of the enlarged areas (representing the increased public HE) becomes larger and larger as wealth rises. The private HE part for sure increases slower and slower when h is small; when h is relatively big, it might increases fast at the beginning but will become slower and slower in the long run. Anyway, as a whole, if the rich people are only a very small share of the total population, the public HE gets to dominate the trend, and the income elasticity of the total HE should be rising.

Jaunky and Khadaroo (2008) study 28 African countries' HE data over 1991-2000 and found that in both short-run and long-run, public HE is found to be luxury while private HE a necessity. This is not surprising to the authors because in these countries "public sector has to strive hard to provide basic health care to the poor majority but a rich minority can easily afford hi-tech private health care". Sahn (1992) uses the 1974-1987 data of 23 sub-Saharan African countries to evaluate the central governments and social services spending to changes of GDP. It is reported that both before and after these countries' structural adjustment programs (SAP), the elasticities of total HE in low-income countries are lower than that of the middle-income countries (pre-SAP 0.63 in low-income to 0.83 in the middle-

Figure 7: Poor Societies with Very Few Rich People



(a) h is a lower value, h_L (b) h is a higher value, h_H

income countries; post-SAP 0.93 in low-income to 1.13 in the middle-income countries). Another finding relevant to our study is that the reported elasticities of government HE are 1.17 for 1974-1979, 1.06 for 1980-1984 and 1.17 for 1985-1989, while the elasticities of total HE for the three periods are respectively 0.67, 0.67 and 0.96. This means that the HE with private payment increased relatively slowly and it dragged down the elasticities of total HE.

Okunade (1985) constructed Engel expenditure models using select of African nations data covering 1960-1972 to estimate the elasticities for 'basic needs' expenditures. The following are within country income elasticities of HE: 0.24 (Ghana-urban), 0.25(Ghana-rural), 1.58(Kenya-Nairobi), 1.33 (Kenya-Mombasa), 1.25 (Kenya-Kisumu), 0.61 (Malawi-urban), 0.51(Malawi, other areas), 0.83 (Sudan-urban), 0.72 (Sudan-semi-urban), 0.85(Sudan-rural), 1.70 (Tanzania-urban), and 0.34 (Tanzania-mainland). The estimated results support his conjecture of HE rising faster with incomes in urban than in rural areas.

4.3 Societies with Public-private Structure Change

Things will be complicated if the public-private structure changes as wealth grows. Because the total HE increase speed depends on the wealth level, the relative size of public and private HE and the magnitude of the structure change relative to the stock sizes of public and private

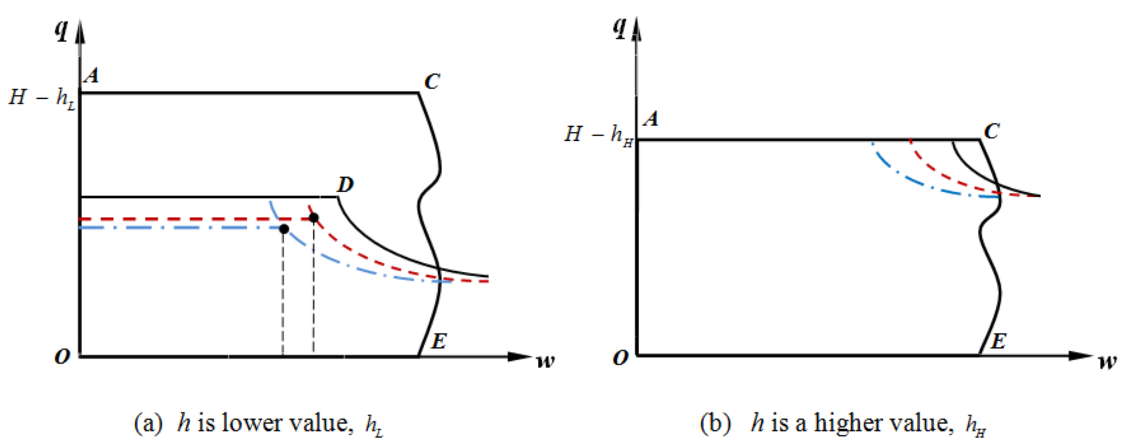
HE. For example, there are papers reporting private payment expansion in both low-income and high-income countries, but the extents of the expansion are very different and have very different effects on total HE. Besley and Gouveia (1994) and Zweifel and Breyer (1997) observed a shift from publicly financed health care systems to mixed ones in industrialized countries. According to Di Matteo (2000), both Canadian public and private HE has been steadily increasing since 1975 but the public HE stopped rising since 1991. As a whole, the total HE increase speed is slowed down since 1991. Clemente, Marcuello, Montanes, and Pueyo (2004) show the evolutions of government HE as a share of GDP and private HE as a share of GDP of Sweden (1960-1998), which "is followed by a significant number of countries". The figures show that the former decreases from 1980s, but the latter increases even more since 1990 so the total HE as a share of GDP still rises. Jowett (1999) examines the period from 1990-1995 in 44 low income countries and found that private HE was substituted for public HE due to structural adjustment and privatization policies. Actually, the public HE decreased too much compared with the increment of private HE so the total HE decreased in these counties. In India the private health expenditure was 2.4% of GDP in 1960 and this has risen to 5.8% in 2003. In nominal terms it has grown at the rate of 11.3% since 1960 and during 1990's the growth rate is 18% per annum. As a result, Bhat and Jain (2004) find that income elasticity of private HE in India is 1.95.

Here we have a closer look at the example of Turkey because its information is available. Sulku and Caner (2011) examine Turkey HE data (1984-2006) and conclude that the income elasticities for public HE and total HE are less than one (0.75 and 0.87 respectively) while the elasticity for private HE is greater than one (1.81). From their introduction of some major events of Turkey's health sector, we know that there were (stricter) restrictions of medical service usage. For example, in 2003, Health Transformation Program was launched to increase access ability. Performance-based wage scheme was introduced in public hospitals and led to an increase in the volume of services provided. Private health providers were allowed to charge up to 100% above the prices set by Social Security Institute (SSI). Consequently, HE increased rapidly, with private sector payment growing fastest. Such facts give U.S. reason to believe that there are restrictions to access medical services in Turkey and the restriction to public hospitals is tighter than to the private hospitals.

Not like in the African countries we discussed, where there is polarization in wealth and the poor majority has no hope to afford private payment medical services, Turkey has much bigger potential buying power for private medical services. This gives the possibility of large expansion of private HE. On the other hand, Turkey is not like the other OECD countries either, where public hospitals provide relatively high standard medical services. In 2004, average HE per capita of OECD countries was \$2550 but the number of Turkey was \$580, the least among all OECD countries (OECD, 2006). This shows that there exists a necessity of increasing the demand for higher quality private medical services. Therefore, Turkish had a faster expansion in private HE when the restrictions were lifted a little.

At last, public HE has a dominating position in Turkey as in most of OECD countries. In 2004, the public resources covered 72% of total HE while private resources covered 28% (OECD, 2006). This explains why in Sulku and Caner (2011), the income elasticity of total HE (0.87) gets little effect from the private HE elasticity (1.81) but is much closer to the public one (0.75). Figure 8 is an illustration of the case where there is an expansion in private payment.

Figure 8: Societies with Private Payment Expansion



5 The Influence from Technology Advance

5.1 New Medical Technologies Create Demand

For HE increase, if income growth is a demand side force then technology advance is a supply side force. Medical technology advance makes better treatments available therefore creates new demands. In our model, we assumed that patients are evenly distributed across wealth w, pre-treatment health h and health improvement from the treatment q. Technology advance means this distribution is changed. In particular, there will be more patients with higher q along with new technologies coming to the market.

This is because, first of all, with technology advance some previously untreatable diseases at any cost become treatable (e.g. Weisbrod, 1991; Freeman, 2003). For example, before the establishment of organ transplant procedure, a person with serious liver malfunction simply died. Now with a high cost, patients can undergo liver transplants. In our figures, this means some people who were located on the horizontal axis jump vertically to higher places in the panel $OACE$.

The other aspect of technology advance is the *treatment expansion effect*, named by Cutler and McCellan (2001). It means that technology advance induces more patients, including those who could not afford, who were too sick to get treated, and whose symptoms were mild, to buy the medical products. Treatment expansion might be very significant. For example, prescriptions for antidepressants have grown from 40 million in 1988, when the first selective serotonin reuptake inhibitors (SSRIs), Prozac, was introduced, to 120 million in 1998 (IMS, 1999). Improved safety of SSRIs has been a key reason to the rapid diffusion. Actually, improved quality, which in the context of our model is health improvement q, is the most important reason of treatment expansion. New medical products tend to be more expensive than the old ones that they substitute for Blomqvist and Carter (1997). Even occasionally there is cost saving at per patient level, the great elasticity of demand for the medical products offsets it, and renders increasing HE in the aggregate (Gelijns and Rosenberg, 1994). For example, data shows the diffusion of percutaneous transluminal coronary angioplasty (PTCA), a treatment for coronary artery disease, led to higher total costs despite its lower unit cost after two decades of its introductory (Cutler and Huckman, 2003).

To sum up, technology advance creates new demand in the market. In our figures, this is done by moving the dots representing these affected patients upwards. Then, the density of the area with higher q is larger, and the integrated value above the threshold curve is lager. Therefore the total HE, HE per capita increases even when income does not grow.

5.2 Income Elasticity is Up-biased without Controlling Technology

Since new medical technologies create demand and increase HE, the income elasticity estimated will be biased upward if technology advance effect is not controlled. This problem is especially important for the studies on industrialized countries since the adoption of new medical technology in these countries are more and faster. There are a few papers with such a view (Blomqvist and Carter, 1997; Freeman, 2003; Sen, 2005). Blomqvist and Carter (1997) believe that omitting country-specific factors and time factors confounds the effect from new technology and real income effects. They studied 18 OECD countries data (1960-1991) and showed that the income elasticity is substantially lower than typically obtained in earlier work and it is below one by considering technology. Freeman (2003) argued that the estimates of HE's income elasticity will be biased unless controlling the role of technology: except the effect from time trend, between group variation accounts for at least some of the higher elasticity estimates. Sen (2005) suggested both year and country effects should be controlled. In his paper using OECD data (1990-1998), OLS estimates drop by more than 50% (0.21-0.51) with the use of two-way fixed effects and the inclusion of various variables. The author found many earlier papers precludes the use of either country or year fixed effects or linear trends, and this is the reason why these papers report the common finding of the income elasticity equal to or exceeding one.

What the above papers emphasize is to control technology advance in the income elasticity estimation. Because it is not easy to get an instrument variable to measure technology level, and the new technology adoption paces are different in different countries and at different time, including time and country specific factors play the role of controlling technology advance. There are more papers using this method besides those mentioned in the above works, such as Jaunky and Khadaroo (2008), Smith, Newhouse, and Freeland (2009) and Chakroun (2009). They all conclude that by controlling technology, the income elasticity of HE is decreased.[9] Related papers using other variables to proxy technology are rare. Dreger and Reimers (2005) use variables like life expectancy, infant mortality and the share of the elderly as proxies. They found income elasticity is not different from one by studying the data of 21 OECD countries (1975-2001). Moscone and Tosetti (2010), using a panel of 49 U.S. States in 1980-2004, adopted a method to explicitly control for cross-section dependence and unobserved heterogeneity (time dummy is also included). The estimated results, like most of the works that have controlled technology, show that health care is a necessity rather than a luxury.

Since the estimated income elasticity will be biased upward if technology effect is not controlled, we can understand why some studies found income elasticity grows with a country's wealth level. World Bank (1993) reported richer countries have higher income elasticity. Chen, Lin, and Chang (2009) investigated the local relationship between HE per capita and GDP per capita of 154 countries in year 2001 using local quantile regressions. In all 25, 50 and 75% quantile regressions, they found income elasticity increases with country's GDP per capita. Boungnarasy (2011) studied 11 Asian countries using balanced panel data for the period of 1975-2006. The estimates show that the income elasticities of rich countries or regions, for example, Australia, Hong Kong, Japan and NewZealand, are above one while

[9] An exception is Roberts (1999), which used a method that allows for parameter heterogeneity across the 20 OECD countries. The author found that the long-run elasticity estimates are sensitive to the exclusion of the time trend. With a time term, the elasticity of HE is greater than one, but without it is approximately unity. Okunade and Murthy (2002) is another exception. They use health R&D or total R&D to proxy technology but still find high income elasticities for USA. Van Elk, Mot, and Franses (2009) think that this is because they omit the relative price.

the elasticities of poor countries like Bangladesh, Indonesia, Malaysia and Nepal are below one. In the cross section study of Africa income elasticity, Gbesemete and Gerdtham (1992) compared their estimated result, 1.07, with the income elasticity achieved from a similar exercise by Gerdtham, Sogaard, Andersson, and Jonsson (1992), 1.33. The latter paper works on 19 OECD countries' data of 1987.

One thing common of the above examples is that the data sets used have large income spans. They do not study, for example, OECD countries alone, or African countries alone, but cover both the poorest countries and the richest ones. In such studies, bias caused by compounding technology effect and income effect is even more misleading, since the estimate income elasticity is not only biased but also unevenly biased. Rich countries every year adopt much more new medical technologies than the poor countries do, so the technology effect compounded to the income elasticity is much larger for the rich countries than for the poor countries. However, with the first-rising-then-falling income elasticity route we suggested, people can still get a monotonic rising trend when allowing technology effect being included.

5.3 Technology's Influence on HE: the U.S.

The U.S. has similar income growth rate as other OECD countries but much higher HE growth rate than them. A natural thought is that the prosperous characters in the U.S. health sector are the key reasons that lead to this difference. Papers describing the U.S. health sectors are far from rare. Here we only provide a sketch from the angle of technology.

The U.S. has the technologically oriented medical culture. Americans are more interested in (medical) technology and have higher demand for it, so the U.S. uses more latest medical technologies in treatment than other industrialized countries do (Gelijns et al., 1994; Kim et al., 2001). This notion is confirmed by findings from various studies. For example a study comparing care for heart attack patients in 17 countries over the past decade shows that the U.S. had a pattern of early adoption of new technologies and fast diffusion, while other countries either had late start and fast diffusion pattern, or had late start and late diffusion pattern (TECH Research Network, 2001). The more interesting thing of the study is that the pattern of diffusion for new, very high cost drugs were similar to those for intensive procedures, but no such patterns were observed for low-cost, easy-to-use medications.

Higher price is another character of the U.S. medical sector. For example, in 1996, Americans got 27 percent fewer prescriptions than the average level of OECD, but the drug expenditure per person was 41 percent higher. As a whole, the U.S. prices for medical care commodities and services are more than 35 percent higher than weighted average level of OECD Docteur, Suppanz, and Woo (2003). The reasons of higher price are said to be that the U.S. has many pharmaceutical firms, and financing system of the health sector is disorganized so their ability to negotiate price with providers is low. Another important reason is related to new technologies. Americans consume more new medical technologies, so averagely one prescription or one hour medical service contain more technology 'ingredient'. Since new treatments/ medicines are normally more expensive, the U.S. patients face higher prices.

The difference in the insurance system development is sometimes used to explain the high HE-GDP ratio of the US. The U.S. insurance coverage started to expand later than other countries. Only 65 percent of health spending was covered in the U.S. in 1970, and the share rose to 86 percent in 2002. However, the insurance story can't explain why the HE-GDP ratio keeps rising after 2002, when the insurance coverage stopped expanding. On the other hand, new technology is often associated with insurance expansion. When studying the introduction of Medicare in 1965, Finkelstein (2007) finds that the impact of insurance on hospital spending is mainly by altering the incentives of hospitals to incur the fixed costs of entering the market or adopting new practice styles, which means new medical technologies in our context. As Weisbrod (1991) says, the development of insurance system induces technology advances faster, and then more money is spent on new medical technologies.

Actually, if inducement accounts, income growth may be an even more important factor that induces medical technology advance. Woodward and Wang (2011) plotted the log of

U.S. national HE per capita against the log of the U.S. GDP per capita and found curve is remarkably straight. They estimated from this curve that the income elasticity of HE is 1.388 under the assumption that technology advance is endogenous and mostly decided by GDP per capita. However, the endogeneity story is not suitable for our study. The authors regard technology as endogenous because, for many of them, the introduction is determined by their expected market. First, there are many new technologies, might be even more, are created because relevant researches enter new stages. Even if being guided by the market, research itself is full of uncertainty. Second, it is possible to regard medical technology as endogenous only in the study of the US, because only the U.S. has both big market and big medical research ability (biggest in the world). The consumption of new medical technology in every other country in the world is a small share and it is not enough to induce new technology innovations. For all of these countries, technology advance is rather an exogenous variable.

Some people may say that what is influenced by a country's income growth is the adoption of new technology but not the emergence of new technology. This argument is not convincing either, since income growth (and insurance coverage increase) is a demand side force that represents the consumption concept and the ability to pay, while new medical technologies drive up HE from the supply side by providing better products and services. They are different in nature.

6 Conclusion

This paper studies how income growth and technology advance affect income elasticity of aggregate health expenditure. It starts with the studies of purely public payment and purely private payment situations, and shows that in both situations there is a general trend for the income elasticity first to rise with income, then to fall with it. On both the rising and falling sides, the size of the income elasticity could be above, below, or equal to unity, and it is related to the size of HE-GDP ratio. In both the purely public and private payment situations, the form of the rising side is because the demand for health care has been more restricted by income so income growth meets larger demand, while on the falling side, demand for health care has been mostly met so further income growth has less effect on HE increase. Applying such evolution routes to the real world where both public and private payment exist, they seem to fit well with the existing income elasticity estimations of developed and developing countries, although it should be interpreted with care when it comes to the situations with public-private structure change in the health sector.

This paper also discusses the effect of technology on income elasticity. If we say income growth increases HE from the demand side, the technology advance increases HE from the supply side. However medical technology advance is often compounded with income growth. Technology level rises with time and wealth and additional demand is created by new medical technologies, so income elasticity is biased upward if technology effect is not controlled. This paper points out that the bias is especially large for developed countries who adopt more new medical technologies. With this idea, we can explain why some studies concluded that richer countries have larger income elasticity.

At last, we emphasize that the income elasticity we are discussing about is at aggregate level but not at individual (or household) level. A most important difference between the aggregate level and the individual level analysis is that there is no insurance available for countries, so countries pay out of their pockets. Existing literature using recent years' data show that the income elasticity at individual level is much smaller than the one at aggregate level. For example, in summary of Getzen (2000), the insured individual level elasticity is close to zero. This is because, as Blomqvist and Carter (1997) and Freeman (2003) argue, people covered by insurance have little income restriction on their HE. Even for those covered by private insurance plans which have deduction and copayment, the income restriction is mostly reduced compared with when they have no insurance. If we draw threshold curves for the insurance cases, they should be horizontal segments, and each segment is for a group of people who have similar wealth. If the income growth is not big enough for people to buy more expensive insurance contracts, or, go to treatment thresholds at lower positions, their HE will not be affected and their income elasticity of HE will be zero.

References

Baltagi, B. H., F. Moscone, 2010. Health care expenditure and income in the OECD reconsidered: Evidence from panel data. Economic Modelling 27, 804–811.

Besley, T., B. Gouveia, 1994. Alternative Systems of Health Care Provision. Economic Policy Oct., 203–258.

Bhat, R., N. Jain, 2004. Time Series Analysis of Private Health Care Expenditures and GDP: Cointegration Results with Structural Breaks. Indian Institute of Management Working Paper.

Bilgel, F., K. Tran, 2013. The Determinants of Canadian Provincial Health Expenditures: Evidence from a Dynamic Panel. Applied Economics 45, 201–212.

Blendon, R. J., C. Schoen, C. M. DesRoches, R. Osborn, K. Zapert, E. Raleigh, 1994. Confronting Competing Demands to Improve Quality: A Five-Country Hospital Survey. Health Affairs 23, 119–135.

Blomqvist, A. G., R. Carter, 1997. Is Health Care Really a Luxury?. Journal of Health Economics 16, 207–229.

Boungnarasy, M., 2011. Health Care Expenditures in Asia Countries: Panel Data Analysis. Economics Bulletin 31, 3169–3178.

Chakroun, M., 2009. Health Care Expenditure and GDP: An International Panel Smooth Transition Approach. Munich Personal RePEc Archive Paper No. 14322.

Chen, M. Y., F. L. Lin, C. K. Chang, 2009. Relations between Health Care Expenditure and Income: An Application of Local Quantile Regressions. Applied Economics Letters 16, 177–181.

Clemente, J., C. Marcuello, A. Montanes, F. Pueyo, 2004. On the International Stability of Health Care Expenditure Functions: Are Government and Private Functions Similar?. Journal of Health Economics 23, 589–613.

Culyer, A. J., 1988. Health Care Expenditure in Canada: Myth and Reality; Past and Future. Canadian Tax Paper No. 82. Canadian Tax Foundation: Toronto.

Cutler, D. M., R. S. Huckman, 2003. Technological Development and Medical Productivity: The Diffusion of Angioplasty in New York State. Journal of Health Economics 22, 187–217.

Cutler, D. M., M. McCellan, 2001. Is Technological Change In Medicine Worth It?. Health Affairs 20, 11–29.

Di Matteo, L., 2000. The Determinants of the Public-private Mix in Canadian Health Care Expenditures: 1975-1996. Health Policy 52, 87–112.

——— , 2003. The Income Elasticity of Health Care spending, A Comparison of Parametric and Nonparametric Approaches. European Journal of Health Economics 4, 20–29.

Docteur, E., H. Suppanz, J. Woo, 2003. The US Health System, An assessment and prospective directions for reform. OECD Economics Departement Working Papers. No.350.

Dreger, C., H. Reimers, 2005. Health Care Expenditure in OECD Countries: A Panel Unit Root and Cointegration Analysis. IZA DP No. 1469. Institute for the Study of Labor, Germany.

Finkelstein, A., 2007. The Aggregate Effects of Health Insurance: Evidence from the Introduction of Medicare. Quarterly Journal of Economics.

Freeman, D. G., 2003. Is Health Care a Necessity or a Luxury? Pooled Estimates of Income Elasticity from US State-level Data. Applied Economics 35, 495–502.

Gbesemete, K., U. G. Gerdtham, 1992. Determinants of Health Care Expenditure in Africa: A Cross-Sectional Study. World Development 20, 303–308.

Gelijns, A., N. Rosenberg, 1994. The Dynamics of Technological Change in Medicine. Health affair pp. 28–46.

Gerdtham, U.-G., 1992. Pooling International Health Care Expenditure Data. Health Economics 1, 217–231.

Gerdtham, U.-G., B. Jonsson, 2000. The International Comparison of Health Expenditure: Theory Data and Econometric Analysis. The chapter 1 of Handbook of Health Economic, published by North Holland, Edited by Culyer A. J. and J. P. Newhouse.

Gerdtham, U.-G., D. G. Lothgren, 2002. New Panel Results on Cointegration of International Health Expenditure and GDP. Applied Economics 34, 1679–1686.

Gerdtham, U.-G., M. Lothgren, 2000. On Stationary and Cointegration of International Health Expenditure and GDP. Journal of Health Economics 19, 461–475.

Gerdtham, U.-G., J. Sogaard, F. Andersson, B. Jonsson, 1992. An Econometric Analysis of Health Care Expenditure: A Cross-Section Study of the OECD Countries. Journal of Health Economics 11, 63–84.

Getzen, T. E., 2000. Health Care is an Individual Necessity and a National Luxury: Applying Multilevel Decision Models to the Analysis of Health Care Expenditure,. Journal of Health Economics 19, 259–270.

Hopkins, S., 2010. Health Expenditure Comparisons: Low, Middle and High Income Countries. The Open Services and Policy Journal 3, 117–117.

Hurst, J., L. Siciliani, 2003. Tackling Excessive Waiting Times for Elective Surgery: A Comparison of Policies in Twelve OECD Countries, Annexes 1, 2, 3. OECD Working Papers.

Jaunky, V. C., A. J. Khadaroo, 2008. Health Care Expenditure and GDP: An African Perspective. Applied Econometrics and International Development 8, 131–146.

Jofre-Bonet, M., 2000. Health Care: Private and/or Public Provision. The European Journal of Political Economy 16, 469–489.

Jowett, M., 1999. Bucking the Trend? Health Care Expenditures in Low-income Countries 1990-1995. International Journal of Health Planning and Management 14, 269–285.

Lopez-Casasnovas, G., M. Saez, 2007. A multilevel Analysis on the Determinants of Regional Health Care Expenditure: A Note. The European Journal of Political Economy 8, 59–65.

Mehrara, M., M. Musai, 2011. The Causality between Health Expenditure and Economic Growth in Iran. International Journal of Economics and Research 2, 13–19.

Moscone, F., E. Tosetti, 2010. Health Expenditure and Income in the United States. Health Economics 19, 1385–1403.

Narayan, P. K., S. Narayan, R. Smyth, 2011. Is Health Care Really a Luxury in OECD Countries? Evidence from Alternative Price Deflators. Applied Economics 43, 3631–3643.

Newhouse, J. P., 1977. Medical Care Expenditure: A Cross-national Survey. Journal of Human Resources 12, 115–125.

OECD, 2006. OECD Health Data 2006: How Does Turkey Compare. `http://www.oecd.org/dataoecd/29/54/36959956.pdf`.

Okunade, A. A., 1985. Engel Curve for Developing Nations: The Case of Africa. Eastern Africa Economic Review New Series 1 pp. 13–22.

Okunade, A. A., V. N. R. Murthy, 2002. Technology as a major driver of health care costs: a cointegration analysis of the Newhouse conjecture. Journal of Health Economics 21, 147–159.

Parkin, D., A. McGuire, B. Yule, 1987. Aggregate Health Care Expenditures and National Income: Is Health Care a Luxury Good?. Journal of Health Economics 6, 109–127.

Poullier, J. P., P. Hernandez, K. Kawabata, W. Savedoff, 2002. Patterns of Global Health Expenditures: Results for 191 Countries. EIP/HFS/FAR, Discussion Paper No. 51, World Health Organization.

Roberts, J., 1999. Sensitivity of Elasticity Estimates for OECD Health Care Spending: Analysis of a Dynamic Heterogeneous Data Field. Health Economics 8, 459–472.

Sahn, D. E., 1992. Public Expenditures in Sub-Saharan Africa during a Period of Economic Reforms. World Development 20, 673–693.

Sen, A., 2005. Is Health Care a Luxury? New Evidence from OECD Data. International Journal of Health Care Finance and Economics 5, 147–164.

Smith, S., J. Newhouse, M. Freeland, 2009. Income, Insurance, and Technology: Why does Health Spending Outpace Economic Growth?. Health Affairs 28, 1276–1284.

Sulku, S., A. Caner, 2011. Health Care Expenditures and Gross Domestic Product: The Turkish Case. The European Journal of Health Economics 12, 29–38.

Van Elk, R., E. Mot, P. H. Franses, 2009. Modelling Health Care Expenditure-Overview of the Literature and Evidence from a Panel Time Series. CPB Discussion Paper, No. 121, CPB Netherlands Bureau for Economic Policy Analysis.

Viscusi, W. K., W. N. Evans, 1990. Utility Functions That Depend on Health Status: Estimates and Economic Implications. American Economic Review 80, 353–374.

Weisbrod, B., 1991. The Health Care Quadrilemma: An Essay on Technological Change,Insurance Quality of Care, and Cost-Containment. Journal of Economic Literature XXIX, 523–552.

Woodward, R. S., L. Wang, 2011. The Oh-So Straight and Narrow Path: Can the Health Care Expenditure Curve be bent?. Health Economics.

Zweifel, P., F. Breyer, 1997. Health Economics. Oxford University Press, Oxford, .