Reference Dependent Decisions on Noncommunicable Diseases*  
Prevention, Treatment and Optimal Health Insurance  

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Abstract  
This paper uses the reference dependent model to analyze individuals’ preventive and treatment decisions on noncommunicable diseases. Individuals are assumed to initially differ only in income levels, and to have preferences defined over the changes with respect to a reference point, in the dimensions of health and wealth. Patients are predicted to go bankrupt if the preferred treatment level exceeds their income. Under some conditions, poorer patients may rationally choose to live more unhealthily ex-ante, admitting their correct anticipation of future bankruptcy if sick. The paper then investigates how individuals respond to various forms of social health insurance. It shows that health insurance can either encourage or discourage prevention, even when preventive efforts are not observable to the insurance provider. Deductible insurance is found to be financially unfeasible with ex-post moral hazard, which contradicts Arrow (1963). Finally, this paper derives the analytical results of optimal social health insurance with reference dependent agents, in the presence of ex-ante and ex-post moral hazard.  

JEL classification: D81, D91, I1, H21, H51.  
Keywords: Noncommunicable diseases, moral hazard, reference dependence, prevention, treatment, medical demand, health insurance.  

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1 Introduction

Noncommunicable diseases (or chronic diseases, NCDs henceforth) “are of long duration and generally slow progression,” and they do not transmit among people through infectious ways (WHO, 2015c). NCDs are the leading cause of death globally, and they have been largely the result of inadequate preventive efforts, such as smoking, physical inactivity and unhealthy diets. Once diagnosed, people’s demand for treatment is often desperate, and the financial burden is remarkably substantial. For example, the likelihood to go bankruptcy for cancer patients is 2.65 times higher than that for people without cancer (Ramsey, Blough, & Kirchhoff, 2013). In addition, NCD patients also suffer from deprivation of their health and productivity (Abegunde & Stanciole, 2006).

NCDs have become one of the major challenges to global development. Given the rising concerns over their prevention and treatment, there remains a paucity of theories in explaining how people make relevant decisions. Studies with the von Neumann-Morgenstern utility function do not give valid predictions of what people actually behave when they make decisions related to health. For example, the desperate medical demand often drives people with ordinary income to impoverishment, and in countries such as US and China, medical bankruptcies are quite common (e.g. Himmelstein, Thorne, Warren, & Woolhandler, 2009; Magan, 2013). However, such phenomenon cannot be explained under the expected utility framework, unless with special assumptions on the utility function. Furthermore, although the desperate medical demand demonstrates the vital importance of health, many people engage themselves in unhealthy lifestyles (e.g. WHO, 2015b; Chaloupka & Warner, 2000) which significantly increase the risk of NCDs. The coexistence of ex-post desperate medical demand and ex-ante risky health behaviors also seems inexplicable to standard expected utility theory (EUT). Motivated by the limitations of EUT, this paper uses the reference dependence model to better model people’s preventive and treatment behavior with regard to NCDs. More accurately, “prevention” or “preventive efforts” in this paper refer to actions that are taken before the occurrence of NCDs, aiming to reduce the likelihood, which is also known as primary prevention (Kenkel, 2000).

In this paper, individuals initially differ only in income (exogenously endowed), and are assumed to live for 2 periods. In the first period, people choose their level of prevention, which affects the probability distribution according to which two states, either healthy or sick, will realize in the second period. A sick state means the individual is diagnosed with NCDs in the second period, and he must choose the treatment level for survival. Preferences in each period are defined over changes in health and wealth with respect to some reference points, which are assumed to be
the status quo in each period.

Results suggest that if NCDs occur, people will prefer the same level of treatment, regardless of their income. Therefore, those whose income is insufficient to afford the preferred level will spend all their income on treatment and go bankrupt, and thus patients in the low-income group will be under-treated. The ex-post income constraint on future treatment will be considered when people make prevention decisions ex-ante, and it is possible that poorer people rationally decide to exert less preventive efforts.

This paper also investigates moral hazard associated with different forms of social health insurance. Moral hazard refers to the changes in behaviors either before or after a disease occurs. In health economics, since it is often difficult or impossible for the insurance provider to observe the preventive behaviors, health status or reasons for health-care utilization of the insured (Arrow, 1963), consumers’ incentives can consequently be altered via two channels. On the one hand, as health insurance makes potential treatments cheaper, people may decrease their preventive efforts, which aim to reduce the likelihood of future diseases, known as “ex-ante moral hazard” (Ehrlich & Becker, 1972); on the other hand, ex-post moral hazard arises when lower price of health-care increases medical demand (Pauly, 1968, 1974). Compared with what EUT predicts, individuals with reference dependent preferences respond differently to social health insurance. Specifically, the paper shows that under certain conditions, there exists some coinsurance policy which copays the cost of medical treatment, and at the same time encouraging ex-ante health behaviors, even when preventive efforts is not observable by the insurance provider. In addition, deductible insurance or any stop-loss insurance is found to be financially unfeasible with ex-post moral hazard.

Finally, this paper provides analytical results of optimal social health insurance in the presence of ex-ante and ex-post moral hazard, when losses in health cannot be compensated. Since both prevention and treatment decisions will respond to insurance policies, policy makers should take the impacts on government spending as well as NCD prevalence into consideration. The inverse relationship between income and unhealthy behaviors adds to an extra justification of public intervention, necessitating a redistributive social health insurance.

The contributions of this paper include three aspects. First, reference dependent model is found to be better fitted to people’s decision patterns. Second, it elaborates how monetary incentives can influence health decisions of people with different income levels, even when they face non-monetary health losses. Such mechanism also underlies the coexistence of medical bankruptcy and unhealthy lifestyles, especially for people with low income. In this way, inequality in wealth leads to inequality in health. The third contribution is that it provides important new rationales for
government intervention. In this paper, when there is inverse relationship between income and unhealthy behaviors, namely when poorer people live more unhealthily, a society with redistributive social insurance Pareto dominates the one without it. Associated ex-post moral hazard could be further welfare-improving, since it can protect the poor from medical bankruptcies. The elimination of the difference of preventive effort levels across income groups also underlies the redistributive concerns of social insurance. Theories using EUT predicts that health insurance will discourage prevention, as long as preventive efforts are unobservable (e.g. Ehrlich & Becker, 1972; Ellis & Manning, 2007). This paper, in contrast, shows that even when preventive efforts are unobservable, a more generous insurance plan could encourage ex-ante preventive efforts, and thus further improves social welfare.

The rest of the paper proceeds as follows. Section 2 reviews the conventional theoretical approaches towards prevention and treatment behaviors, and introduces the reference dependent model as well as its empirical evidence in health economics. Section 3 elaborates the application of reference dependent model in prevention and treatment, and contrast the results with the predictions of standard utility theory. Section 4 studies the welfare impact of health insurance, and Section 5 concludes.

2 Literature Review

2.1 Unhealthy behaviors and ex-ante moral hazard

The prevalence of NCDs, partly because of the increased life expectancy, is an important factor that contributes to the size and rapid growth of the health-care cost (Deloitte, 2016). Major types of NCDs include heart disease, stroke, cancer, diabetes and chronic lung disease (WHO, 2015a). The long duration of NCDs make people suffer from expensive treatment regimens and prolonged individual cares, which accounts for a considerable share of the global health-care expenditure. In the review of Muka et al. (2015), health-care spending for cardiovascular diseases ranges from 12-16.5%, and other NCDs accounts between 0.7 and 7.4%. As a rule, ex-ante moral hazard is more likely to occur for diseases where preventive efforts are difficult to implement, such as following a strict diet, regular exercise, or keeping away from smoking (Yilma, van Kempen, & de Hoop, 2012). The control of ex-ante moral hazard is thus crucial, in that the most cost-efficient and effective form of intervention for NCDs is prevention, i.e. “to lower the prevalence of the major risk factors through population-wide methods directed at everyone, and to target treatment to people at high risk of NCDs” (Beaglehole et al., 2011). One estimation suggest that were all the risk factors eliminated, there would be a drastic decrease of NCD prevalence (International Federation of Pharmaceutical Manufac-
Economists have developed different approaches to study people’s unhealthy behaviors, including insufficient information, rational addiction, health capital investment, and time-inconsistent preferences.

Insufficient information refers to the possible scenario that people are neither aware enough of the health consequences involved in consumption choices, nor fully informed about the harmful, or addictive feature of some unhealthy products. Knowledge about health is believed to be positively correlated to preventive behaviors (Kenkel, 1991; Cutler & Lleras-Muney, 2006), but the direction of causality is unclear (Brunello, Fort, Schneeweis, & Winter-Ebmer, 2016), and some findings even deny the effect of health knowledge (e.g. Juerges & Meyer, 2016; Clark & Royer, 2013; Braakmann, 2011; Arendt, 2005). In reality, people engage themselves in unhealthy lifestyles, while knowing what they do is harmful. Due to mass media campaign implemented in many countries, people become more aware of the health consequences of risk factors, at least they know that unhealthy consumptions are “unhealthy” to them (e.g. Meiro-Lorenzo, Villafana, & Harrit, 2011; Peretti-Watel et al., 2007; Beaudoin & Hong, 2011; Kahlert, 2015; Peretti-Watel et al., 2014). Thus, the lack of preventive efforts becomes harder to explain using only insufficient information. For example, it is impossible to understand why some well-informed people adopt unhealthy lifestyles. A typical phenomenon is the attitudes towards smoking among physicians and health-care professionals: more than 25% doctors smoke in developed countries such as France, Italy and Spain; and over 50% developing countries such as India, China, and Turkey (Arif, Assad, & Sulehria, 2016). If instead, people are assumed to be fully aware of the long term effects of inadequate prevention, then their unhealthy behaviors are often thought as “irrational,” either due to time-inconsistent preferences (O’Donoghue & Rabin, 1999) or inability to correctly judge the risks related to their health (Weinstein, 1987, 2005). Becker and Murphy (1988) prosed the theory of rational addiction, where the decision to be unhealthy is the outcome of utility maximization by forward looking, rational consumers. The model captures the addictive features that are usually associated with consumptions of unhealthy products. The consumption of unhealthy products increases the current utility as well as the future marginal utility of unhealthy consumption, and decreases the future utility level due to the increased stock level. The rational addiction model is able to explain many features of addictive consumptions, however, one of the key variables that determines whether a consumer will become addicted, the initial consumption level, is assumed to be exogenous. Therefore, the model well illustrates the path towards addiction, but it does not disclose why rational, forward looking consumers begin to live unhealthily, which will be elucidated.

1 Confirmatory examples include Brunello, Fabbri, and Fort (2013); Kemptner, Jürges, and Reinhold (2011).
in this paper.

Theoretical literature that examines the tradeoff between prevention and health insurance includes Ehrlich and Becker (1972); Barigozzi (2004) and Ellis and Manning (2007). In the EUT framework, all show that when the insurance provider cannot observe preventive efforts, health insurance reduces prevention. Empirically, health insurance generally encourages the use of “preventive care,” such as vaccinations and the screening or detection of breast cancer (Pagán, Puig, & Soldo, 2007; Courbage & de Coulon, 2004), but decrease the primary prevention efforts, such as physical exercise and abstention from smoking (Klick & Stratmann, 2007; Stanciole, 2008). However, not all evidence confirms the existence of ex-ante moral hazard. Courbage and de Coulon (2004) failed to detect any ex-ante moral hazard; Dave and Kaestner (2009) found ex-ante moral hazard effect for men only, and in the ongoing Oregon Health Insurance Experiment with real monetary coverages, no ex-ante moral hazard is detected (Finkelstein, Taubman, & Wright, 2011).

2.2 Demand for treatment and ex-post moral hazard

Ex-post moral hazard contributes to the rapid growth of health-care expenditure, which imposes tremendous pressure on the fiscal sustainability of the health-care system, in both developed and developing countries (OECD, 2015; Collins, Doty, & Davis, 2004; Jakovljevic & Getzen, 2016). Among the theoretical works that explore people’s treatment decisions, the dominating theoretical model for health-care demand is proposed by Grossman (1972). It has brought considerable insights into both the determinants of health and decision of time and money allocation in health production. There are two arguments in the utility function, health and wealth that are interrelated. Better health not only increases utility directly (Consumption effects), but also enables agents to consume more by reducing sick time in which they cannot work (Investment effects). The Grossman Model predicts that the medical demand depends on variables such as wage rate, price of medical service, income, education, etc. Theoretical research efforts have extended the Grossman Model in the directions of uncertainty and endogeneity of variables such as the depreciation rate of health capital, wage rate, education, etc (see Grossman, 2000, for a review).

With health insurance, the medical demand or medical services is in general different, compared with what would have happened without it. Empirical evidence consistently confirms the ex-post moral hazard effect of health insurance. The revolutionary and pioneer research is the RAND health insurance experiment between 1974 and 1981 by Manning, Newhouse, and Duan (1987), who gave a robust result rejecting the null hypothesis that health spending does not respond to the

\[2\text{ However, it requires specific functional forms of utility functions and the health production function, and thus incurring some loss of generality (Zweifel, Breyer, & Kifmann, 2009).} \]
out-of-pocket price (Aron-Dine, Einav, & Finkelstein, 2013). Studies with natural experiments also confirm it (e.g. van Dijk et al., 2013; Nolan, 2007; Voorde, 2001). Standard economic theories of health insurance and moral hazard deal with the trade-off between the cost of moral hazard and the benefit of risk sharing. Ex-post moral hazard is predominantly viewed as welfare-reducing, since the additional spending generated by health insurance is inefficient (Feldstein, 1973; Feldman & Dowd, 1991). In the absence of moral hazard, Arrow (1963) first showed that the optimal health insurance contract takes the form of full insurance above a deductible, if insurance is not actuarially fair. Later, Arrow’s theorem of the deductible remains at work in a setup with ex-post moral hazard (Drèze & Schokkaert, 2013). In the framework of EUT, expected utility maximization requires equalizations of marginal utilities (of either health or wealth) across states, which induces a universal stop-loss if the insurance premium is not actuarially fair.

2.3 Reference Dependent Preferences and Its Empirical Supports

2.3.1 The model

In psychology, people’s perceptions and decisions exhibit dependence on reference points. Kahneman and Tversky (1979) transferred this phenomenon into economics, motivated by the compelling and replicable violations of the von Neumann-Morgenstern expected utility theory (EUT henceforth) (e.g. Starmer, 2000, for a review). Reference dependent model captures the three fundamental features of human cognition: framing, loss aversion and diminishing sensitivity. And these features underly much of the empirically observations in decision making. It then became the most influential alternative theory on decisions under uncertainty (see the review of Barberis, 2013). Reference dependence means that people do not evaluate outcomes in absolute terms, but instead, they frame each outcome as gains or losses in contrast with a reference point. The decisions largely depend on the position of reference points, which may be updated based on new informations. Besides the so called framing effect, there are two other important characteristics in the reference dependent model, loss aversion and diminishing sensitivity. Loss aversion has been consistently identified as an “important aspect of human choice behavior” (Rabin, 1998; Camerer, 2005, cited in Weber & Johnson, 2008). It means that people are more averse to losses than their appreciation to gains of the same size, and is identified in decisions over health outcomes (Bleichrodt & Pinto, 2002; A. E. Attema, Brouwer, & I’Haridon, 2013). Regarding diminishing sensitivity, it characterizes the fact that people are more sensitive to changes near the reference point than those that are remote. Schmidt (2012) provided many empirical studies in various decision
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scenarios that confirm framing, loss aversion and diminishing sensitivity. Although originally developed to understand decisions under uncertainty, the key tenets of reference dependent model are later proved to be relevant in deterministic frameworks (Tversky & Kahneman, 1991). And Loewenstein (1988) further demonstrated the applicability of the model in intertemporal choices.

Kahneman and Tversky (1979) proposed the following value function

\[
V(x) = \begin{cases} 
  v(x) & \text{if } x \geq 0 \\
  -\lambda v(-x) & \text{if } x < 0 
\end{cases}
\]  

(2.1)

where \( x > 0 \) are gains and \( x < 0 \) are losses perceived with respect to a reference point, \( v : \mathbb{R}_+ \rightarrow \mathbb{R}_+ \) is a weakly concave, twice differentiable increasing function. The value at the reference point is normalized to 0 (\( v(0) = 0 \)), and \( \lambda > 1 \) is the parameter of the degree of loss aversion. Figure 2.1 depicts its shape.

The function is able to explain “diminishing sensitivity”. If gains or losses move further away from the reference, the valuation will change slower than if they are closer; and “loss aversion” is implied by \( \lambda > 1 \)

\[ V(x) < -V(-x), \forall x > 0. \]

Diminishing sensitivity implies that people are risk-averse over gains and risk seeking over losses.

2.3.2 Empirical evidence in health economics

The descriptive deficiency of EUT in health domain is widely acknowledged. As Bleichrodt, Abellan-Perpiñan, Pinto-Prades, and Mendez-Martinez (2007) pointed
out, “using expected utility to analyze responses to utility measurement tasks in spite of its poor descriptive standing can lead to biased utilities, and decision analyses based on these biased utilities may result in incorrect recommendations (p.469).” Violations of EUT in the field of health economics have been extensively observed in the process of health utility measurement (e.g. Llewellyn-Thomas et al., 1982; Mölken, 1995; Stalmeier & Bezembinder, 1999; Pinto-Prades & Abellán-Perpiñán, 2005). The problem is, under EUT, theoretically equivalent assessment procedures produce systematically different utilities. Bleichrodt, Pinto, and Wakker (2001) argued that loss aversion were one of the key factors that caused the inconsistencies in the valuation of different health state, and Oliver (2003) confirmed this by studying the choices of life durations (see also Doctor, Bleichrodt, & Miyamoto, 2004).

There are attempts using reference dependence to correct the biases in health utility measurement based on EUT. For example, after adjusting for loss aversion, Bleichrodt et al. (2001) showed that the health valuation methods lead to higher internal consistency, in the sense that theoretically equivalent methods give similar results. The adjustments based on reference dependent model are further supported by Osch (2004); van Osch, van den Hout, and Stiggelbou (2006); Bleichrodt et al. (2007).

In addition to loss aversion, framing effects are also well recognized in medical decision making. People exhibit patterns of reference dependent preference when valuing health states and life durations (Verhoef, De Haan, & Van Daal, 1994; Bleichrodt & Pinto, 2005; Happich, Moock, & Lengerke, 2009), and patients’ treatment choices are found to be influenced by the position of reference point (Stiggelbou, Kiebert, & Kievit, 1994; Prosser & Kuntz, 2002; Winter & Parker, 2007). For example, Winter and Parker (2007) discovered that variations in the accessibility of life-prolonging treatments among people are explained by the different reference points. Patients with lower reference point expressed stronger preferences for life-prolonging treatments, especially in the worse-health scenarios. Furthermore, in the context of chronic diseases, the utility function also exhibits diminishing sensitivity, it is concave in gain and convex in loss domains (Bernstein, 1999). Several public health intervention studies have demonstrated how the frame of the outcome would in practice influence the choice of individuals, such as in the preference for becoming pregnant (Pauker, Pauker, & McNeil, 1980), lung cancer treatment methods (McNeil & Pauker, 1982), vaccinations (Slovic, Fischhoff, & Lichtenstein, 1982), breast cancer (Hughes, 1993; Siminoff & Fetting, 1989), and chemotherapy (A. O’Connor & Boyd, 1985; A. M. O’Connor, 1989). In their study of preferences over treatments for a hypothetical lung cancer, McNeil and Pauker (1982) interviewed outpatients, radiologists, and business major students to choose between surgery or radiation therapy. Surgery is assumed to have a 10% chance of perioperative death, but pro-
vides higher life expectancy upon survival. The outcome data was presented in terms of survival rates to some subjects, and in terms of mortality rates to some others. Loss aversion implies that surgery will seem less attractive if the risk is presented in terms of death. Indeed, the authors find that all the three groups selected radiation more frequently when the outcomes of each therapy were presented in terms of mortality (45% v.s. 25%). And framing strategies are widely used in health message conveyance to improve its persuasiveness (Rothman, Bartels, Wlaschin, & Salovey, 2006).

There are direct comparisons of the performances between EUT and reference dependent model. Abellan-Perpiñan, Bleichrodt, and Pinto-Prades (2009) investigated the potential of reference dependent model to lead to better health evaluations. They calculated the utility values based on the two models, and compared the predictions with the directly elicited rankings. Results indicate that reference dependent model outperforms EUT when considering preferences over risky prospects: “The consistency of prospect theory with directly elicited choices and rankings is much higher than that of expected utility.” (p.1046) However, it did not provide better performance when predicting intertemporal decisions. In the context of health insurance decisions, Marquis and Holmer (1996) also claimed reference dependent model provides better fit than EUT with RAND study data. Their results suggest that enrollment in a hypothetical insurance does not depend on household income and premium levels, but rather on the expected payoff that the subjects will receive when sick. When facing risky prospects in people’s decisions of insurance demand, it is found that “prospects are evaluated as gains and losses from a reference point rather than as final wealth states, that the evaluation of gains and losses is asymmetric, and that individuals exhibit risk-seeking behavior in the domain of losses” (p.426).

2.3.3 Reference point in health, and its adaptation

Location and determinants In the reference dependent model, the reference point plays an essential role in decision making. In their first paper that introduces reference dependence, Kahneman and Tversky (1979) pointed out several determinants of reference points, such as status quo, social norms, and aspiration levels. However, in decisions about health, there are no consensus about the location of reference point. Findings suggest that it is reasonable to assume the goal of the individual (Heath, Larrick, & Wu, 1999; van Osch et al., 2006), or the “aspiration level of survival” (Miyamoto & Eraker, 1989), to be the reference point;³ current

³van Osch et al. (2006) explores the reference point by detecting the point of inflection of preferences, and Miyamoto and Eraker (1989) directly asked the subjects whether they view a certain amount of years as gains or losses.
health status is often used as well (Lenert, Treadwell, & Schwartz, 1999). One can also take the lowest outcome (A. Attema, 2012; Bleichrodt et al., 2001), or the sure outcome (Osch, 2004; Osch & Stiggelbout, 2008) as the reference point.4

Evidence shows that the health status is one of the key determinants of the location of the reference point. Froberg and Kane (1989) studied patients’ valuations, and find that “patients with a particular condition often assign it higher utility than do persons without the condition. (p.681)” Dolan (1996) further confirmed that people with poorer health generally give higher valuations to the same health states, which suggests that the current health status has important effects. In general, healthy people have higher reference points, and regard any sickness as losses; whereas sick people, with lower reference point, perceive to have less losses (see Treadwell & Lenert, 1999, for a comprehensive review). Lenert et al. (1999) demonstrated how reference dependent value function could explain the differences in the preferences for health conditions between patients and the general public.

For example, consider two 50-year-old individuals. One is healthy, expecting to live up to 80; whereas the other is diagnosed with cancer, and told by his oncologist that he is left with 10 years or so. Figure 2.2 illustrates their value functions. The reference point of the healthy individual is his remaining life expectancy, i.e. 30 yrs; whereas the individual with cancer is likely to have a lower reference point. Thus, for the same outcome, the cancer patient always have higher valuation than the healthy individual.

\[\text{Figure 2.2: Example of different valuations}\]

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4In finance, different assumptions are used to model reference adaptation. Bowman, Minehart, and Rabin (1999) studied the effect of loss aversion on the consumption and saving behavior, assuming people adjust their reference points according to recent consumptions. Similar adjustment is also assumed in the domain of security trading. Chen and Rao (2002) suggested that people’s reference points react to stimulus, but insufficiently; Gneezy (2005), using real market data, found out that people are most likely to use historical peaks as the reference point; Arkes, Hirshleifer, Jiang, and Lim (2008) tested the magnitude of reference point adaptation, they note faster adaptation of the reference point to gains than losses of equivalent sizes.
**Dynamic inconsistency and reference point adaptation**  Adaptation helps to explain the differences in valuations (Adang, 2001). There is a recalibration of reference point in response to the changes of the health. The cancer patient in Figure 2.2 will have a lower reference point, if he has adapted to his post-diagnosis health (Weinfurt, 2007). The evolution of reference point both over time and with respect to new information about health, is called “reference point adaptation,” and was first recognized in experiments using monetary gambles (Tversky & Shafir, 1992; Barkan & Busemeyer, 2003). In sequential monetary gambles, there is a tendency that people prefer riskier gambles after financial losses, and choose safer options after a monetary gain, and it explains why a gambler keeps gambling in the face of mounting losses, believing the imminent return of their “luck” after series of losses (Sharpe & Tarrier, 1993). Such chasing-loss patterns are commonly observed not only in monetary gambles (Barkan & Busemeyer, 2003; Tversky & Shafir, 1992), but also in many decision scenarios, such as securities trading (Brown, Harlow, & Starks, 1996; Seo, Goldfarb, & Barrett, 2010) and horse race betting (Hausch, Ziemba, & Rubinstein, 1981). Such findings are also corroborated by fMRI records (Campbell-Meiklejohn, Woolrich, Passingham, & Rogers, 2008; Xue, Lu, Levin, & Bechara, 2011; Hytönens et al., 2014).

As for health-related decisions, reference point adaptations are consistently documented. For example, women’s reference point shifts in their decisions of anesthesia use during childbirth. They prefer to avoid using anesthesia during childbirth when asked one month before labor and during early labor; however, during active labor their preferences suddenly shift toward avoiding pain. Their preferences shift again toward avoiding the use of anesthesia when evaluated at one month postpartum (Christensen-Szalanski, 1984). People also become risk-seeking as their health declines (A. M. O’Connor, 1989), and may even prefer aggressive Phase I trials⁷ that their physicians themselves report not to participate (Meropol et al., 2003; Gaskin et al., 2004).

The aggressiveness of terminally ill patients is well explained by prospect theory with an evolving reference point determined by pre- and post-diagnosis life expectancies (Rasiel, Weinfurt, & Schulman, 2005). Figure 2.3 depicts the value functions of two previously healthy patients who are diagnosed with life-threatening conditions. For a recently diagnosed patient, since adaptation takes time, his prognosis reference point is likely to remain close to his pre-diagnosis life expectancy (30 yrs), so he will

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⁵Abbrev. for functional magnetic resonance imaging

⁶However, there are also experiments revealing the opposite result, people are loss averse after losses, and risk seeking after gains, also known as “the house money effect” (e.g. Thaler & Johnson, 1990).

perceive all other prognoses as losses, and his risk-seeking behavior is explained by the convexity of his value function, as the left panel depicts. By comparison, for the patient who has already recalibrated his reference point to a more realistic level, he will appear to be risk-averse, as shown by the right panel. The authors also noted that how much the reference point will shift in response to the new conditions depends on many factors, such as how recently the patient was diagnosed, his health before the recent diagnosis, etc. It sometimes happens that the patient has to choose treatments for his life-threatening condition when he has not yet adapted to his post-diagnosis prognosis, then he is willing to take a considerable amount of risks, similar to what problem gamblers will do to win back their money after losses (Page, Savage, & Torgler, 2013; Genesove & Mayer, 2001; Odean, 1998).

3 The Model

Assume initially healthy economic agents are homogeneous in every aspect except for their levels of income. Each agent lives for two periods, young \((t = t_0)\) and old \((t = t_1)\). In each period, they use the status quo as reference points. Assume further that they are rational, and seek to maximize their reference-dependent utilities.

The timing of prevention, treatment and insurance is shown in Figure 3.1. In \(t_0\), the government sets an insurance scheme with \(P\), which may vary with different income levels \(Y\). A negative \(P\) indicates the government transfers money to the agent. People pay \(P\) for the compulsory insurance scheme, and choose their lifestyles, measured by the level of preventive efforts \(e \in \mathbb{R}_+\). In \(t_1\), The health status of each agent will be realized according to \(e\) previously chosen, the probability of illness

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8This reference point may or may not equal actual life expectancy.
9The impact of insurance premium to the labor supply is beyond the scope of this paper.
occurrence is $\pi(e)$, and that of healthy longevity is $1 - \pi(e)$. For the ones with the sick state realized, they will decide how much treatment to receive, measured by medical spendings $M$, and get reimbursed accordingly. This paper studies the case of compulsory insurance, as will be explained later, $P$ does not enter into agents’ perceived changes of wealth.

### 3.1 The reference dependent utility function for NCDs

Individuals derive utility from various goods and services, including health and wealth. In most studies, health insurance are modeled merely as a protection against uncertain medical expenses, and the insurance demand or regulations are studied using a utility function with income as its unique argument. It works for curable diseases, after which people get fully recovered if they pay for treatment. The impact of such diseases can be treated as shocks to income only. In this paper, nevertheless, since risky health behaviors ($e$) will affect the likelihood of chronic diseases that are non-curable, the occurrence of such illness will cause not only income losses, but irrevocable health damages as well. The irreparable damage in health could be measured in terms of reduced productivity, pains and sufferings, and loss of life span (Abegunde & Stanciole, 2006). Taking the premature deaths caused by NCDs into account (Suhrcke, Nugent, Stuckler, & Rocco, 2006), this paper uses quality adjusted life expectancy (detailed elaborations in the next section) as the measure in health dimension, and the wealth dimension is measured in monetary units as usual. On that account, people are imperfectly insured, the insurance could only protect the agent from financial shocks, if NCDs occur; except for prevention, there are no ex-ante instruments for the agent to hedge the risks in the dimension of health.

For decisions that consist of more than one attributes, the first step is to determine whether an attribute yields a gain or a loss. One way is to compress the multi-attribute outcome into a single dimension, and see if it is a gain or a loss as a whole. Such approach is used by Zank (2001) and Bleichrodt and Miyamoto (2003).
The alternative method is to assume a reference point for each attribute, and evaluate the alternative as gains or losses on each dimension. This “attribute-specific evaluation (Bleichrodt, Schmidt, & Zank, 2009)” is commonly assumed in empirical studies (e.g. Payne, Laughhunn, & Crum, 1984; Fischer & Kamlet, 1986), and its descriptive accuracy is generally acknowledged (Tversky & Kahneman, 1991; Bateman, Munro, Rhodes, Starmer, & Sugden, 1997; Bleichrodt & Pinto, 2002). Because the consequences of NCDs involve in both health dimension and wealth dimension, and it is difficult to compensate health across dimensions, this paper adopts the attribute-specific evaluation method to analyze the decisions related to NCDs.

For the notations, let $S$ denote the set of states of nature. Then $S = \{\text{sick, healthy}\}$, only two states are possible, either sick with NCDs, or perfectly healthy. Agents face uncertainty in the first period only. Let $C_h, C_w \subset \mathbb{R}_+$ denote the set of outcomes in the dimensions of health and wealth respectively, and an outcome is denoted by $C^s = (C^s_h, C^s_w) \in C_h \times C_w, s \in S$. It can be immediately deduced that $C^\text{sick}_h < C^\text{healthy}_h$, since the occurrence of NCDs reduces life years; and $C^\text{sick}_w \leq C^\text{healthy}_w$, because of the medical expenses $M$. More specifically, $M$ is defined in the way that, without insurance protection

$$C^\text{healthy}_w = Y, \quad C^\text{sick}_w = Y - M.$$  

And if insured,

$$C^\text{healthy}_{w,I} = Y - P, \quad C^\text{sick}_{w,I} = Y - P - M_I.$$  

where $M_I$ stands for the out-of-pocket payment made by patients. Here the assumption is that NCDs affect one’s wealth level via only one channel, the medical expenses. Other consequences associated with NCDs, such as reduced earnings, medical leave, etc., are not considered in this paper.

The adaptation of reference points implies that reference points will be different across periods, whereas the outcome in each dimension, $C^s$ is absolute and objective. In each period, the status quo of the decision maker serves as the reference point, denoted by $r^{t,s} = (r^{t,s}_h, r^{t,s}_w) \in C_h \times C_w, t \in \{t_0, t_1\}, s \in S$. The outcomes $C^s$ are then evaluated as gains or losses, compared with $r^{t,s}$. Mathematically, $C^i_s > r^{t,s}_i$ will be perceived as gains in that dimension, and $C^i_s < r^{t,s}_i$ as losses, $s \in S, i \in \{h, w\}, t \in \{t_0, t_1\}$. The reference dependent utility function in each period, $U(C^s, r^{t,s}) : C_h \times C_w \rightarrow \mathbb{R}$, represents the preference relations: $\forall \ x, \ y \in C_h \times C_w$, given a fixed reference point $r^{t,s}$, $x \succ_{r^{t,s}} y$ $\iff$ $U(x, r^{t,s}) \geq U(y, r^{t,s})$. This paper decomposes the utility function into a two-dimensional value function shown below,

$$U(C^s, r^{t,s}) := \mathcal{V}(C^s_h - r^{t,s}_h, C^s_w - r^{t,s}_w), \forall s \in S, \forall t \in \{t_0, t_1\}. \quad (3.1)$$
where $\mathcal{V} : \mathbb{R}^2 \to \mathbb{R}$, and increases with respect to both its arguments.

The outcome in healthy state, $C^\text{healthy}$, is assumed to be invariant with $e$ or $M$. The agent will live the rest of his life without diseases, with his income free from medical spendings. In the sick state, the agent is facing his reduced life expectancy $h$, and his disposable income $Y$. Outcome $C^\text{sick}$ will be determined by $M$. In the health dimension, $M$ makes the agent live additional years, measured by the increasing function $H(M)$; and the rest of his income goes in the wealth dimension. Figure 3.2 depicts the positions of $C^s$, $s \in S$.

\begin{align*}
C^\text{healthy}_h &= \bar{h} \\
C^\text{healthy}_w &= Y \\
C^\text{sick}_h &= \bar{h} + H(M), \\
C^\text{sick}_w &= Y - M
\end{align*}

where $\bar{h}$ denotes the maximum living years one could have.

Reference points and adaptation In this paper, the status quo in each period serves as the reference point. In $t_0$, the agent forms his expectation about his future health and wealth according to $\pi(e)$, and uses it as his reference point $r^0 = (r^0_h, r^0_w)$. The expectation in health will be his life expectancy adjusted by the effort costs, and in wealth dimension, the expectation equals to his income endowment $Y$ net of the expected medical expenses $\pi(e)M$.

\begin{equation}
r^0_w(e) = Y - \pi(e)M.
\end{equation}
In the first period, as shown in Figure 3.2, when outcomes are evaluated with respect to $r^0$, $C_{\text{healthy}}$ brings gains in both health and wealth, and $C_{\text{sick}}$ is framed as losses in the two dimensions.

In $t_1$, the outcomes $C^s$ will be realized and the reference point will be adjusted to the new status quo in each state. If $s = \text{healthy}$, then the status quo is exactly $C_{\text{healthy}}$, with $h$ in health and $Y$ in wealth.

$$r^{1,\text{healthy}} = C_{\text{healthy}}.$$ (3.7)

In this state, no further decisions have to be made. If instead, $s = \text{sick}$, then the status quo is the reduced, pre-treatment prognosis $h$ in health, and disposable income $Y$ in wealth, i.e.

$$r^{1,\text{sick}}_h = h$$
$$r^{1,\text{sick}}_w = Y$$ (3.9)

and $C_{\text{sick}}$ locates southeast of $r^{1,\text{sick}}$, representing gains in health and losses in wealth. Since $M$ pins down $C_{\text{sick}}$, the agent has to anticipate his future medical spending when he evaluates $C_{\text{sick}}$ in $t_0$. Therefore, the demand for treatment will be analyzed first, followed by the preventive decision.

### 3.2 Treatment: Demand for medical care

#### 3.2.1 Assumptions

Assume the agent’s reference points has been fully adapted to the post-diagnosis prognosis,

$$C_{r_h}^s(M) = r^1_h + H(M), \quad C_{r_w}^s(M) = Y - M.$$ 

In the case of treatment, the gain of health is the life years preserved by treatment, $H(M)$, assume that $H' > 0, H'' < 0$. And $M$ will be framed as losses in wealth. If insured, the loss would be the net amount paid by the patient.

The reference dependent utility function is then $u(H(M), M)$ where $\partial u/\partial H > 0$, $\partial u/\partial M < 0$. Here, the losses and gains here are measured in incomparable dimensions, and thus loss aversion is irrelevant when making treatment decisions. To capture diminishing sensitivity, assume $\partial^2 u/\partial H^2 < 0$, $\partial^2 u/\partial M^2 < 0$. Assume further, $\lim_{H \to 0} \partial u/\partial H = +\infty$, $\lim_{M \to 0} |\partial u/\partial M| < +\infty$, so that the patient always finds it optimal to spend some positive amounts. Denoted the optimal spending by $M^* > 0$. Also note that the choice of treatments is beyond the scope of this paper. It focuses on the demand of medical resources, therefore, assume there is only one treatment method available, and the ex-post decision is made without uncertainty.
3.2.2 Desperate medical demand

The problem of medical care demand is

$$\max_{M \leq Y} u(H(M), M)$$  \hspace{1cm} (3.10)$$

If the budget constraint is not binding, then the first order condition holds

$$\frac{du}{dM} = \frac{\partial u}{\partial H}(H(M), M)H'(M) + \frac{\partial u}{\partial M}(H(M), M) = 0 \implies \frac{\partial u}{\partial H} \cdot H'(M) = -\frac{\partial u}{\partial M}$$  \hspace{1cm} (3.11)$$

The LHS is the marginal gain of health from the additional medical expenses, and the RHS is the marginal cost. And $M^*$ is the optimal solution to Equation 3.11.

**Proposition 3.1** (Existence and uniqueness of interior solution). If $\frac{\partial^2 u}{\partial H \partial M} < 0$, then there will be a unique, interior solution to the maximization problem 3.10.

**Proof.** The second order condition then

$$\frac{d^2 u}{dM^2} = \left[ \frac{\partial^2 u}{\partial H^2}H'(M) + 2\frac{\partial^2 u}{\partial H \partial M} \right]H'(M) + \frac{\partial u}{\partial H}H''(M) + \frac{\partial^2 u}{\partial M^2} < 0$$  \hspace{1cm} (3.12)$$

is satisfied, guaranteeing the existence and the uniqueness of the interior solution.  

The cross derivative, $\frac{\partial^2 u}{\partial H \partial M}$ denotes the relationship between the marginal utility of medical expenses and health states. If it is negative, then a healthier patients would be hurt more by additional medical expenses, and thus he has a lower willingness to pay further for treatment. Under the assumption of negative cross derivative, it can be easily checked that LHS of Equation 3.11 is decreasing, and the RHS is increasing with respect to $M$. The marginal benefit of medical expenses is thus decreasing, and the marginal cost is increasing, which implies that the agent will stop spending on medical treatments beyond $M^*$.

Notice that when $r^1_w = 0$, the problem goes back to the EUT framework. Let $U(h, y)$ denote the conventional utility function defined over the absolute level of health and wealth, then its arguments will be $C_h(M)$ and $C_w(M)$ respectively, and Problem 3.10 rewrites as

$$\max_{M \leq Y} U(r^1_h + H(M), Y - M)$$  \hspace{1cm} (3.13)$$

The medical demand, denoted by $M^*_{EU}$ satisfies the first order condition

$$\frac{\partial U}{\partial h} H'(M) - \frac{\partial U}{\partial y} = 0$$  \hspace{1cm} (3.14)$$
where $\frac{\partial U}{\partial y}$ denotes the marginal utility of income. An expected-utility-maximizer will choose the level of medical spending where the marginal utility of health and wealth are equal. Unless the utility function has the shape such that $H'(M)\frac{\partial U(\cdot,0)}{\partial y} - \frac{\partial U(\cdot,0)}{\partial y} \geq 0$, there should be no medical bankruptcies. With the ordinary assumption that $\lim_{y \to 0} \frac{\partial U}{\partial y} = +\infty$, people will stop spending when $M$ is close to $Y$, due to the rapid increase of marginal utility of wealth. Therefore, Equation 3.14 defines the medical demand as $M^*_{EU}(Y)$, and income effect is

$$\frac{dM^*_{EU}}{dY} = -\frac{\frac{\partial^2 U}{\partial h \partial y} H'(M) - \frac{\partial^2 U}{\partial h^2}}{H'(M) \left[ \frac{\partial^2 U}{\partial h^2} - \frac{\partial^2 U}{\partial h \partial y} \right] + \frac{\partial U}{\partial h} H''(M) + \frac{\partial U}{\partial y} \frac{\partial^2 U}{\partial y^2}}$$  \hspace{1cm} (3.15)

**Proposition 3.2** (Income effect in EU). If marginal utility of wealth is increasing with respect to health, namely $\frac{\partial^2 U}{\partial h \partial y} \geq 0$, then $0 \leq \frac{dM^*_{EU}}{dY} < 1$, $\forall Y$, and the equality holds only when $\frac{\partial^2 U}{\partial h \partial y} = \frac{\partial^2 U}{\partial y^2} = 0$.

**Proof.** EU assumes all the second order derivatives in Equation 3.15 are all negative, with $H''(M) < 0 < H'(M)$, it is obvious that Equation 3.15 is positive. It is strictly smaller than 1 because of the strict negativity of $H''(M)$.

It worth noting that, the assumption of the cross derivative in Proposition 3.2 coincides with that in Proposition 3.1. Since $\partial(Y - M) = -\partial M$, $\frac{\partial^2 U}{\partial h \partial y} = \frac{\partial}{\partial (Y - M)} \left( \frac{\partial U}{\partial h} \right) = -\frac{\partial^2 U}{\partial h \partial M}$. Unlike EU, Equation 3.11 indicates that the preferred level of medical spending is independent of the wealth level. $M^*$ is determined by the shape of the utility function and the health production function $H(M)$, and agents with different income endowments are predicted to have the same medical demand. However, due to the limited amount of income they own, some will not be unable to reach the stopping point. For those whose budget constraint in Problem 3.10 is binding, an insurance policy that enables the agent to purchase more medical service is welfare-improving. Such effect is also raised by Nyman (1999) labeled as the “access value”. As long as the LHS of Equation 3.11 is greater than the RHS, the agent will not stop spending on treatments until they become unaffordable, engendering the problem of medical bankruptcy.

**Proposition 3.3** (Desperate demand). Agents with homogeneous preferences prefer the same amount of medical treatment, determined by Equation 3.11, despite the difference in their incomes. For people whose budget constraint is binding, i.e. $Y \leq M^*$, there will be a corner solution that $M = Y$, and they are led to bankruptcy by medical bills.

Proposition 3.3 denies the existence of income effect in the problem of treatment. Indeed, empirical research suggests that income elasticity of medical demand is
relatively small (Liu, Chollet, Liu, & Chollet, 2006). Based on the results of Keeler and Rolph (1988), Phelps and Phelps (1997) calculated the income elasticity to be 0.2 or less. Some studies also find income elasticity insignificantly different from 0 (e.g. Reschovsky, 1998). Getzen (2000) found that income elasticities at individual level are typically close to 0, while at regional or national level, income elasticities are greater. Proposition 3.3 also implies different income elasticities among people with different income levels. For the rich whose budget constraint is not binding, their optimal health-care spending is $M^*$, which is insensitive to the income; whereas the bankrupt ones have positive income elasticities, because additional income would allow them to consume at a point closer to $M^*$. The prediction is consistent with empirical findings, that income elasticities among people at low income levels are higher (Di Matteo, 2003; Freeman, 2003).

**Definition 3.1.** In what follows, agents who cannot afford their treatment in the second period if they are ill, will be called “poor,” and the ones whose income level is high enough for the treatment, will be labeled as “rich”.

**Definition 3.2.** Call the medical spending of the rich the “preferred” level of treatment, which is the solution of the unconstrained optimization problem of patients. It is needed but unaffordable to the poor.

### 3.3 Prevention: Choice of lifestyles

Prevention in health and investment in finance is a classical analogy in health economic literature. However, in the context of NCDs, preventive efforts differ from financial investments in several aspects. First, the future realization of health outcomes is largely out of individual control. There are many factors that jointly determines the risks of NCDs besides preventive efforts, such as genes, environment, mental states, etc. The effect of prevention is also controversial. For instance, a recently published research in Science finds out that two thirds of the cancer incidences in US is caused by “bad luck”, that is, “random mutations arising during DNA replication in normal, noncancerous stem cells” (Tomasetti & Vogelstein, 2015). It imposes a tough challenge on how successful prevention can reduce cancer deaths. Second, there is no risk-free options to invest in health. No matter how much preventive efforts are carried out, the risks to have NCDs persist. To the best of my knowledge, there is no literature taking such uncertainty into consideration. In health, products to hedge the risks are not available—the loss in health can neither be compensated nor insured. As a result, given his future medical expenses, either $M^*$ of the rich or $Y$ of the poor, when the agent makes decisions about his lifestyle in early life, he has to take the his future health into consideration as well.
3.3.1 Assumptions

The decision variable in the first period is the level of preventive efforts, $e$. It first determines the likelihood of the sick state in the next period ($\pi(e)$). As mentioned above, there are many other factors than $e$ that can affect the likelihood of NCDs, therefore, even by exerting a high effort level, one cannot completely eliminate the risks of NCDs’ future occurrence. Thus $0 < \pi(0) < \pi(e) < 1$, and $\pi'(e) < 0$. The efforts are costly too. Compared with no efforts, empirical evidence shows that a positive $e$ is costly, denote the cost by $\alpha(e) \geq 0$. It is arguable that, for some people with special preferences, preventive efforts may happen to be enjoyable ($\alpha(e) < 0$), such as for vegetarians and sports fans. However, the widespread NCDs strongly demonstrate the difficulties of preventive efforts for the majority of human beings. For a formal proof of $\alpha(e) \geq 0$, see Proposition A.1 in Appendix A. Furthermore, assume $\alpha'(e) > 0$ and $\alpha''(e) > 0$. The cost of effort is increasing with respect to the level, and it becomes more difficult to maintain when $e$ is high.

Figure 3.3 illustrates the framing in wealth, with $Y - \pi(e)M$ being the reference point. The gain is $\pi(e)M$, i.e. the saved expected expenses; and the loss (in size) is $[1 - \pi(e)]M$, the medical expenses “in surprise”. As explained in Section 3.2, one’s medical spending $M$ depends on $Y$,

$$M(Y) = \begin{cases} Y & \text{if } Y \leq M^* \\ M^* & \text{if } Y > M^* \end{cases} \tag{3.16}$$

Therefore people with different income levels have different gain/loss payoffs in the dimension of wealth. Note here that $P$ changes the payoffs in neither states, and is thus irrelevant.

In the dimension of health, gains or losses are jointly determined by one’s effort level $e$ and his medical spending, $M(Y)$. The reference point is the expectation of future health

$$r^0_h(e, M) = \pi(e)(\bar{h} + H(M)) + (1 - \pi(e))\bar{h} \tag{3.17}$$

How he frames their payoffs in health is illustrated in the picture below:

Given one’s medical spending, his $r^0_h$ will shift to the right if he has a healthier lifestyle, because people with a higher chance of longevity have a higher expectation about his health. Let $h^+ > 0$ denote the size of gains if $s = \text{healthy}$. Then
Reference Dependent Decisions on Noncommunicable Diseases

Figure 3.4: Graphical Illustration of framing in health

\[ h^+(e, M) = C_h^{\text{healthy}} - r_h^0(e, M) = \pi(e)(\bar{h} - b - H(M)), \]

which is decreasing with respect to \( e \). It implies that longevity brings a larger amount of gain to indulgent agents. This prediction could be interpreted in the way that the agent wins longevity without paying extra efforts. The following thought experiment can help readers understand the intuition:

Thought Experiment 1: Longevity

Imagine that before born, you are guaranteed that you will live a healthy life, and will die peacefully without NCDs at the age of 100. Moreover, you are free to choose whether to live ascetically or live with indulgence, ceteris paribus. Which lifestyle do you prefer?

Most probably, you will choose the indulgent life. The “price” for living healthily and ascetically is a high effort level, such as regular exercise, healthy diet, and abstention from alcohol and tobacco, and they are associated with discomforts.

Let \( h^- > 0 \) denote the size of losses in health. Analogously, \( h_0^-(e) = r_h^0(e, M) - C_h^{\text{sick}} = (1 - \pi(e))(\bar{h} - b - H(M)) \), and it is increasing with respect to \( e \). Losses under abstention is larger (in size) because the preventive efforts turn out to be in vein. Consider the following thought experiment:

Thought Experiment 2: Early Death

Imagine again about the choice between an ascetic or an indulgent. If instead, before born you are told that at the age of 40 you will die with cancer. Ceteris paribus, which lifestyle do you prefer?

Perhaps to live with indulgence is still preferred. The ascetic agent has taken efforts for a decreased probability of illness, but it does not pay back. Such “default” of health investment makes the occurrence of illness under abstention worse than that under indulgence.

One remark is that the reference point is determined jointly by \( e \) and \( M \). \( e \) reduces the likelihood of future diseases, and \( M \) improves the sick outcome. Other differences associated with different lifestyles, such as appearance, vitality, emotional states, etc., are assumed to be irrelevant with one’s well-being.

To capture loss aversion and diminishing sensitivity, let \( V(C_h - r_h, C_w - r_w) := V(h, w) \), where

\[
V(h, w) = \begin{cases} 
  v(h, w) & \text{if } (h, w)^\top \geq 0 \\
  -\lambda v(-h, -w) & \text{if } (h, w)^\top < 0
\end{cases}
\]  

(3.18)
Choose $e$

$\pi(e)$

$1 - \pi(e)$

\[\text{Sick: } V = -\lambda v(h^-, w^-)\]

\[\text{Health: } h^- = [C_h^{\text{sick}} - r_h^0(e)] = (1 - \pi)(\Delta h - H(M))\]

\[\text{Wealth: } w^- = [C_w^{\text{sick}} - r_w^0(e)] = (1 - \pi)M\]

\[\text{Healthy: } V = v(h^+, w^+)\]

\[\text{Health: } h^+ = C_h^{\text{healthy}} - r_h^0(e) = \pi(\Delta h - H(M))\]

\[\text{Wealth: } w^+ = C_w^{\text{healthy}} - r_w^0(e) = \pi M\]

Figure 3.5: Ex-ante payoffs in health and wealth

where $\frac{\partial v}{\partial h} > 0$, $\frac{\partial v}{\partial w} > 0$, $\frac{\partial^2 v}{\partial h^2} < 0$, $\frac{\partial^2 v}{\partial w^2} < 0$.

As noted above, there are no ex-ante gain-loss trade-offs. Each effort level $e$ defines a gain-loss mixed lottery. There are no cases where the agent has gains in one dimension, and simultaneous losses in the other. Arguments in the function is either both positive or both negative. Figure 3.5 depicts the agent’s utility in different states, with $M$ defined in Equation 3.16, and $\Delta h = \bar{h} - \bar{h}$ denotes the difference of the end points along the health dimension. Table 1 summarizes the mean and variance of such $e$-lottery in the two dimensions, and the covariance is $M(\Delta h - H(M))\pi(1 - \pi)$.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Health</th>
<th>Wealth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain</td>
<td>$\pi(\Delta h - H(M))$</td>
<td>$\pi M$</td>
</tr>
<tr>
<td>Loss (-)</td>
<td>$(1 - \pi)(\Delta h - H(M))$</td>
<td>$(1 - \pi)M$</td>
</tr>
<tr>
<td>Mean</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Variance</td>
<td>$(\Delta h - H(M))^2(1 - \pi)\pi$</td>
<td>$M^2(1 - \pi)\pi$</td>
</tr>
</tbody>
</table>

Table 1: Lottery summary

### 3.3.2 Optimal Prevention

For the optimal preventive efforts level, the problem is described as follows: the agent is considering to choose some $e \in \mathbb{R}_+$, where $\pi(0) > 0$. A positive effort level decreases the gains in the healthy state, and increases the sizes of losses in the unhealthy state, in both dimensions. Given $M$, a decreased probability decreases monetary gains $\pi(e)M$, increases and monetary losses $[1 - \pi(e)]M$. In health dimension, the reference point is shifted up, and thus gains $\pi(e)(\Delta h - H(M))$ are smaller
and losses \((1 - \pi(e))((\Delta h - H(M))\) are larger.

Assume\(^\text{10}\)

\[
v(h, w) = \gamma h + w \tag{3.19}
\]

The choice of \(e\) comes from the maximization of expected payoff adjusted by \(\alpha(e)\), denoted as below

\[
(1 - \pi(e))v[\pi(e)((\Delta h - H(M))], M\pi(e)] - \lambda\pi(e)v[(1 - \pi(e))((\Delta h - H(M))], M(1 - \pi(e))] - \alpha(e),
\]

which reformulates to \(EV_0 - \alpha(e)\), where

\[
EV_0 = -(\lambda - 1)(1 - \pi(e))\pi(e)(\gamma(\Delta h - H(M)) + M),
\]

with the first order condition

\[
(\lambda - 1)(2\pi(e) - 1)\pi'(e)(\gamma(\Delta h - H(M)) + M) = \alpha'(e). \tag{3.22}
\]

Its LHS is \(\frac{\partial EV_0}{\partial e}\), the marginal change of the expected value caused by the change of \(e\), where \(\pi'(e)\) captures the effect of \(e\) on the probability of NCDs, \(2\pi(e) - 1\) captures that of the shifting reference point, and \(\lambda - 1\) captures loss aversion. The RHS is the marginal disutility associated with \(e\). At the optimum, marginal change/increase of \(EV_0\) should be exactly offset by the marginal effort cost \(\alpha'(e)\). Note that \(\alpha'(e)\) is strictly positive, and it could be the case that for certain values of \(M\), the LHS is always smaller than the RHS, as a result there is a corner solution \(e = 0\). The first order condition is necessary but not sufficient for a global maximum. Assumptions for it to be sufficient are

\[
(\lambda - 1)(2\pi(0) - 1)\pi'(0)(\gamma \Delta h - \gamma H(M) + M) > \alpha'(0) \tag{3.23}
\]

\[
(\lambda - 1)(\gamma \Delta h - \gamma H(M) + M)((2\pi(e^*) - 1)\pi''(e^*) + 2\pi'(e^*)^2) < \alpha''(e^*) \tag{3.24}
\]

where \(e^*\) denotes the optimal preventive efforts that solves Equation 3.22. The LHS of the first inequality is \(\frac{\partial EV_0}{\partial e}\) evaluated at \(e = 0\), and the second inequality implies the concavity of \(EV_0 - \alpha(e)\) at \(e^*\).

Figure 3.6 depicts the choice of \(e^*\). First note that if \(\pi(e) < 1/2\), the effect of reduced probability dominates that of framing, \(EV_0\) is always increasing with respect to \(e\). Furthermore, \(EV_0\) is convex in \(e\), as the second order condition \(2\pi'(e)^2 + (2\pi(e) - 1)\pi''(e) \geq 0\) is always positive. Therefore, the two upward sloping curve

---

\(^{10}\)Empirical studies of reference dependent models often assumes power utility function (e.g. Tversky & Kahneman, 1992; Fetherstonhaugh, Paul, Johnson, & Friedrich, 1997; Wakker & Zank, 2002), results and predictions of a power-form bivariate value function makes no qualitative differences than that of a linear, separable value function.
should cross as the picture depicts, and the intersection determines the optimal level of prevention.

![Figure 3.6: Optimal preventive efforts](image)

In contrast, the maximization problem under EUT is

$$\max_{e \in \mathbb{R}_+} (1 - \pi(e)) (\gamma C_{\text{healthy}}^h + C_{\text{healthy}}^w) + \pi(e) (\gamma C_{\text{sick}}^h + C_{\text{sick}}^w)$$

(3.25)

where the final outcomes $C^s$, $s \in S$ are defined in Equation 3.2 to 3.5. The first order condition is then

$$-\pi'(e) (\gamma (\Delta h - H(M)) + M) = \alpha'(e)$$

(3.26)

Compared with Equation 3.22, one can obtain the following proposition

**Proposition 3.4** (Optimal prevention, EUT versus Reference dependence). In the decision making of the expected utility maximizer, the effect of framing and loss aversion is absent. Specifically,

1. When $\lambda > 1 + \frac{1}{1-2\pi(e)}$, then an agent with reference dependent preference will exert a higher level of preventive efforts than the expected utility maximizer;

2. When $\lambda < 1 + \frac{1}{1-2\pi(e)}$, then an agent with reference dependent preference will exert a lower level of preventive efforts than the expected utility maximizer;

3. When $\lambda = 1 + \frac{1}{1-2\pi(e)}$, the two types of agents exert the same level of preventive efforts.

The intuition is straightforward. When $\lambda$ is high, a loss averse agent will be hurt more when a sick state realizes, and thus he is willing to invest on prevention more than an expected utility maximizer in order to further decrease $\pi$. On the other
hand, agents with small $\lambda$ will care more on the gain side, when framing effects dominates, an increase of $e$ will shift the reference point up, making them reluctant to invest in prevention considering the associated decrease in gains.

The effect of income on optimal prevention is then measured by the comparative statics $\partial e^*/\partial Y$ implied by Equation 3.22.

$$\frac{\partial e}{\partial Y} = -M'(Y) \frac{\partial^2 EV_0}{\partial M \partial e} - \alpha''(e)$$  \hspace{1cm} (3.27)

For the rich, $M(Y) = M^*$ and $M'(Y) = 0$, there will be no differences in prevention among people whose income is greater or equals to $M^*$. As for the poor, $M(Y) = Y$, $M'(Y) = 1$, the relationship of $e$ and $Y$ will depend on the size of $\partial^2 V/\partial e \partial M$, given that Equation 3.24 is satisfied. The cross derivative is

$$\frac{\partial^2 EV_0}{\partial M \partial e} = (\lambda - 1)(2\pi(e) - 1)\pi'(e) (1 - \gamma H'(M))$$  \hspace{1cm} (3.28)

**Proposition 3.5** (Prevention across income groups). If the sufficient conditions in Equation 3.23 and 3.24 are satisfied,

1. All the rich choose the same level of prevention.

2. For the poor,

   (a) If $1 - \gamma H'(M) \geq 0$, then $e$ increases with respect to $Y$, people with less income live in a more indulgent lifestyle, there is an inverse relationship between income and health behavior.

   (b) If $1 - \gamma H'(M) < 0$, then $e$ decreases with respect to $Y$, people with less income live in a healthier lifestyle.

For agents with income/medical expenses that cannot equate the LHS and RHS of Equation 3.22, their choice of prevention is a corner solution, $e = 0$.

When the medical expenses of the poor increase, from Table 1 one can conclude that the $e$-lottery becomes less volatile in health, and more volatile in wealth. Magnitudes of both gains and losses in health dimension are reduced, and in wealth dimension magnitudes in both dimensions are increased. With a certain level of $e$, Equation 3.21 shows that the agent dislikes volatility in either dimension. Therefore, the $e$-lottery becomes more attractive in health dimension, and less attractive in wealth. The term $1 - \gamma H'(M)$ thus measures how these mixed changes in volatility are evaluated, as denoted by the LHS of Equation 3.22, it is also the derivative of the last term in the LHS of Equation 3.22 with respect to $M$. When $1 - \gamma H'(M) \geq 0$, the effect of increased wealth volatility outweighs that of decreased health volatility,
marginal gains associated with each level of e decreases as M increase, and agents will find it optimal to reduce the level of preventive efforts. In this case, the unequal distribution of income leads to the unequal distribution of health, there is an inverse relationship between income and unhealthy behaviors. Poorer people, anticipating themselves in potential bankruptcy if sick, will deliberately choose to live less healthier than the rich.

3.4 Moral hazard

3.4.1 Ex-post moral hazard and comparison of insurance forms

The effect of ex-post moral hazard can be either enhancing or deteriorating welfare, ex-post point of view. In the case when $Y < M^*$, an insurance policy that redeems the agents from medical bankruptcy is welfare-improving.

**Deductible** People generally view a deductible as losses (Johnson, Hershey, Meszaros, & Kunreuther, 1993). With a deductible insurance $(D, P)$, the agent’s value function becomes

$$ u(H(M), D) $$ (3.29)

where $D$ denotes the stop-loss value that is specified in the insurance contract in $t_0$. Thus the utility is strictly increasing with $M$, and the ex-post medical spending of any patient will be $+\infty$, boosting up the premium to infinity. Therefore, any insurance with a stop-loss will be financially unfeasible.

**Fixed Indemnity** A fixed indemnity insurance offers a fixed cash transfer in case of sickness in $t_1$. Denote the transfer by $T$, which is independent of $M$. If the individual treats $T$ as a change of status quo and thereby adjusts his reference point of income to $Y - P + T$, then all spending on treatment will be framed as losses, and the transfer scheme is a pure relaxation of the budget constraint, leaving the medical demand of the rich unaffected. For the poor, their new spending is $Y - P + T$, as $P < T$, the positive ex-post moral hazard $T - P$ allows more access to medical resources.

**Coinsurance** With a coinsurance policy $(c, P)$, the reference point in health dimension remains at $r_{h1}$. The new outcome $C_{i}^{\text{sick}} = (r_{h1} + H(M), Y - P - cM)$, and the new reference point in wealth dimension is $Y - P$. The problem of a patient then

---

11Of course the stop-loss have to be less than the income of the insured.
becomes

$$\max_M u(H(M), cM) \quad (3.30)$$

s.t. \( cM \leq Y - P \)

and the FOC becomes

$$\frac{\partial u}{\partial H} H'(M) = -c \frac{\partial u}{\partial M} \quad (3.31)$$

The LHS of Equation 3.31 is the same as that of Equation 3.11, yet the RHS is smaller in Equation 3.31. Optimal spending of \( M \) increases as LHS is decreasing. The demand for treatment is a function of \( c \), denoted by \( M_I(c) \), and Equation 3.31 with Proposition 3.1 imply that \( \frac{dM_I(c)}{dc} < 0 \):

$$\frac{dM_I}{dc} = -MH'(M)\frac{\partial^2 u}{\partial H \partial M} + \frac{\partial u}{\partial M} + cM \frac{\partial^2 u}{\partial M^2} < 0 \quad (3.32)$$

A smaller \( c \) will correspond to a larger \( M \) in optimum, \( M_I(c) > M^*(= M(1)) \), and the difference \( M^* M_I(c) \) represents the ex-post moral hazard, as Figure 3.7 shows.

![Figure 3.7](image_url)

**Figure 3.7: Optimal Medical Spending when Individuals Differ in Effectiveness**

**Proposition 3.6 (Insurance form comparison).** *Patients with the protection of deductibles will demand infinite amount of medical resources. Therefore, either a coinsurance or fixed indemnity policy is better ex-post.*

**Contrast with EUT** In the framework of EUT, insurance is welfare-improving because agents have risk-averse preferences. With moral hazard, the maximization of ex-post utility leads too much utilization of medical resources, because the premiums that depend on the demand in the second period are paid ex-ante, and thus ex-post, premiums are treated exogenously. Since the preference of EUT are defined over the absolute level of health and wealth (instead of changes in reference dependent model), the demand for medical treatments will not exceed one’s disposable
income, and thereupon, NCDs such as cancers should not increase the risk of medical bankruptcies for a rational expected utility maximizer, contradicts to the findings of Ramsey et al. (2013). Apart from that, neither can the dependence of medical demand on income explain the high market share of imported medical products in China.

Proposition 3.6 denies the optimality of deductible insurance (including full insurance), opposite to the predictions of EUT (e.g. Arrow, 1963; Bardey & Lesur, 2005). At the first glance, the assertion that deductible insurance will induce infinite demand seems implausible, as in practice patients do not spend infinite amount with deductibles. Nevertheless, it does not conflict with the prediction of Equation 3.29. One’s medical spending is certainly bounded, by a country’s GDP for example, and moreover, patients cannot spend without physician’s prescriptions. Equation 3.29 thus serves as a justification for third-party interventions complementary to the deductible insurance, in order to control ex-post moral hazard.

3.4.2 Ex-ante moral hazard

This section studies the effect of coinsurance and fixed-indemnity policy only, as deductible is ruled out by Proposition 3.6. Let $M_I$ denote the new medical demand under insurance.

**Fixed indemnity**  The contingent transfer in $t_1$ offers a downside protection against illness, and thereby shifts the reference point in both dimensions. $C^{\text{sick}} = (h + H(M_I), Y - P - M_I + T)^\top$, where $M_I(Y) = \max\{M^*, Y - P + T\}$. With the new reference point, gains in wealth change to $\pi(e)(M_I - T)$ and losses $(1 - \pi(e))(M_I - T)$. Problem 3.20 becomes

$$
\max_{e \in \mathbb{R}_+} - (\lambda - 1)(1 - \pi(e))\pi(e)(\gamma(\Delta h - H(M)) + M - T) - \alpha(e) \\
(3.33)
$$

**Proposition 3.7.** There is ex-ante moral hazard associated with $T > 0$, both for the rich and the poor will decrease their effort levels.

**Proof.** It is easy to verify that the first order condition for the rich,

$$
(\lambda - 1)(2\pi(e) - 1)\pi'(e)(\gamma(\Delta h - H(M^*)) + M^* - T) - \alpha'(e), \\
(3.34)
$$

evaluated at the original optimal level is negative, given $\pi(e) \leq 1/2$. A positive transfer induces unhealthy behavior to the rich. For the poor, the first order condition is

$$
(\lambda - 1)(2\pi(e) - 1)\pi'(e)(\gamma(\Delta h - H(Y - P + T)) + Y - P) = \alpha'(e) \\
(3.35)
$$
With the assumption that the inequality 3.24 is satisfied, the sign of the comparative static $\frac{\partial e}{\partial T}$ is then determined by

\[
(\lambda - 1)(2\pi(e) - 1)\pi'(e) [\gamma(P'(T) - 1)H'(-P(T) + T + Y) - P'(T)].
\]

As $P'(T) \in [0, 1)$, the expression above is negative.

Note that $T$ decreases $e$ for all income levels, the rich still exerts the same level of $e$. As for the poor, the sign of $\frac{\partial e}{\partial Y}$ is determined by

\[
\left(1 - \frac{\partial P}{\partial Y}\right)(1 - \gamma H').
\]

It is therefore possible to alter the relationship between income and health behavior among the poor, through the premium schedule $P$. A social insurance usually sets $\frac{\partial P}{\partial Y} \geq 0$, i.e. the poor will pay less to be insured in $t_0$; and $P$ could even be negative.

**Coinsurance** With coinsurance, the agent pays $cM_I$; the gains and losses in the wealth dimension becomes $\pi(e)cM_I$ and $(1 - \pi(e))cM_I$ respectively.

\[
\begin{array}{c|c|c}
\text{Loss} & r_{w,I}^0(e) & \text{Gain} \\
Y - P - cM_I & Y - P - \pi(e)cM_I & Y - P \\
\end{array}
\]

Figure 3.8: Framing in wealth with health insurance

Compared with Figure 3.3, $C_{w}^{healthy}$, $C_{w}^{sick}$ and $r_{w}^0(e)$ will be shifted to the left by the amount of the premium $P$, which does not change wealth payoffs. It worth mentioning that, $M_I$ differs according to the income levels. The maximum amount that one can spend on medical treatment is $Y - P$, indicating that the maximum treatment they can get is $\tilde{M} := Y - P/c$. For the ones whose $\tilde{M} \geq M_I(c)$ where $M_I(c)$ is the solution of the problem in Equation 3.4.1, their after-insurance medical spending will be $M_I(c)$. However, if the income level is so low that $\tilde{M} < M_I(c)$, then these agents will remain in bankrupt even after insurance. It summarizes below

**Lemma 3.8** (Medical spending under coinsurance). The amount of after-insurance spending on medical treatment depends on one’s income level,

\[
M_I(Y) = \begin{cases} 
M_I(c) & \text{if } Y \geq cM_I(c) + P \\
\tilde{M} & \text{if } Y < cM_I(c) + P 
\end{cases}
\]

With the out-of-pocket payment of the poor is $Y - P$, and that of the rich is $cM_I(c)$.
In health, sick outcome becomes $h + H(M_I)$, and reference point will also adjust accordingly. The new prevention problem is

$$\max_{c \in \mathbb{R}^+} -(\lambda - 1)(1 - \pi(e))\pi(e)(\gamma(\Delta h - H(M_I)) + cM_I) - \alpha(e),$$

where $M_I$ is defined in Lemma 3.8. When making preventive decisions, both $c$ and $P$ will be taken as given, therefore, $M_I(Y)$ does not change with respect to $e$, for all income levels. The new first order condition is

$$(\lambda - 1)(2\pi(e) - 1)\pi'(e)(\gamma(\Delta h - H(M_I)) + cM_I) = \alpha'(e)$$

(3.40)

The sign of $\partial e / \partial c$ is determined by $M'(c)(c - \gamma H'(M_I)) + M(c)$, which is not clear. The ex-ante moral hazard could be measured by an alternative term $\partial e / \partial c M_I$, and the following result is obtained.

**Proposition 3.9** (Ex-ante moral hazard with coinsurance). Assume that for the poor, $\partial M_I / \partial c = \partial Y - P(c) c / \partial c \leq 0$, and moreover, if $M_I + c \partial M_I / \partial c \geq 0$, then optimal $e$ increases with respect to the out-of-pocket payment $cM_I$.

**Proof.** See Appendix B.

**Corollary 3.10** (Ex-ante moral hazard of the poor). If $P'(c) = 0$, then the optimal $e$ of the poor increases with respect to $c$. A more generous coinsurance plan induces less healthy lifestyles for the poor.

**Proof.** The first order condition then becomes

$$(\lambda - 1)(2\pi(e) - 1)\pi'(e) \left[\gamma \left[\Delta h - H\left(\frac{Y - P}{c}\right)\right] + Y - P\right] = \alpha'(e),$$

(3.41)

and the sign of $\partial e / \partial c$ is determined by $\gamma(Y - P)H'\left(\frac{Y-P}{c}\right)/c^2 \geq 0$.

Ex-ante moral hazard is not linked with ex-post moral hazard directly. Proposition 3.7 and 3.9 imply that optimal $e$ is positively related to patients’ out-of-pocket payment, instead of the amount of treatment they receive with insurance. From the ex-post point of view, insurance should allow access to patients as much as possible, but ex-ante, the risks of NCDs may rise associate with deceased out-of-pocket payment. It also worth noticing that, a coinsurance itself does not necessarily reduce healthy behaviors, since the out-of-pocket payment $cM_I(c)$ does not always decrease with respect to $c$. It is therefore possible that, there exists some $c < 1$, which copays the cost of medical treatment, and at the same time encouraging health behaviors of the insurees.
Equation 3.41 implies that the sign of $\frac{\partial e}{\partial y}$ of the poor is determined by

$$
\left(1 - \frac{\partial P}{\partial y}\right)(c - \gamma H')
$$

(3.42)

Again the government can alter the relationship between health behavior and wealth by manipulating $P$. It worth noticing that, although by setting $\frac{\partial P}{\partial y}$ will eliminate the difference in health behavior among the poor, there is still difference in prevention between rich and poor, because the first order conditions of their decision problems are different.

4 Optimal Health Insurance

When agents are not standard expected utility maximizers, normative welfare and policy analysis become challenging. There are a variety of models in behavioral welfare evaluation, and no consensus has yet emerged (Bernheim & Rangel, 2007). In this paper, due to the shift of the reference point, individual preference evolve across periods. Consequently, for a given policy, welfare measured ex-ante differs from that evaluated ex-post. In this paper, individual preferences are assumed to be respected by the government, and optimal policy is chosen such that ex-post welfare is maximized. In ex-ante, when people employ the value function defined in Equation 3.18 to evaluate different lifestyles, there is no distinction between healthy people and patients. In addition, the optimal level of preventive efforts does not affect the well-being of an agent in the sick state. Therefore, concerning both the healthy and the sick, the policy maker should maximize welfare which is measured after the realization of the states. Moreover, the primary focus of the government should be the poor, who have greater need for money to pay for treatment.

People can be divided according to their “luck” after the realization of health states. Those with good luck do not have NCDs at elder age, and enjoy their longevity for the rest of their lives, whereas the unlucky ones have to face reduced life years caused by NCDs and spend their wealth on treatment. The utility of the unlucky patients are defined by Problem 3.10. And the lemma below describes the well-being of agents whose $s = \text{healthy}$.

**Lemma 4.1** (Well-being of the longevous). For the people whose health state realization is good, the value of their utilities is 0 after reference point adaptation.

After the realization of health states, the ones with good luck will update their reference points to the status quo, which is the remaining long life years and their disposable income. Note that utility is defined over changes of health or wealth,
and there is nothing to gain or lose if \( s = \) healthy, therefore, their utility is 0 by definition. Only the well-being of the patients will be relevant therefrom.

**Corollary 4.2** (Well-being of the sick). *Utility of the sick in \( t_1 \) is negative.*

\[
  u(H(M), M) \leq 0, \ \forall M \in \mathbb{R}_+.
\]

Lemma 4.1 states that the subjective well-being is the same across income groups. At the same time, the well-being of agents with \( s = \) sick should be lower than that of the longevous, both subjectively and objectively, as Corollary 4.2 states. Suppose \( Y \sim F(\cdot) \), and \( Y \in [\bar{Y}, \tilde{Y}] \), then \( Y < M^* \leq \bar{Y} \), considering the long duration and non-curable feature of NCDs.

The utilitarian welfare function is then

\[
  W = \int_{Y}^{\bar{Y}} (1 - \pi(e(Y))) \times 0 dF(Y) + \int_{Y}^{\bar{Y}} \pi(e(Y)) u(H(M_1(Y)), \zeta(Y)) dF(Y), \quad (4.1)
\]

where \( e(Y) \) stands for the after-insurance optimal prevention of each agent, and \( \zeta(Y) \) stands for the after-insurance loss in income. Since \( u < 0 \), \( W \) is increasing and concave in \( e \). Therefore the government prefers a uniform level of preventive efforts ceteris paribus.

### 4.1 Purely redistributive insurance: A benchmark

In the basic model, to eliminate medical bankruptcies, the government can simply induce a transfer by setting

\[
  P(Y) = Y - M^*, \text{ for } Y \leq M^*, \quad (4.2)
\]

and the negative \( P \) means a positive subsidy for financing the health-care for poor people. In this case, the government sets \( c = 1 \), and only pays the difference for those who cannot afford their treatment, and who can afford the treatment will not be taken care of by the government. It worth noticing the difference between the ex-ante transfer and the ex-post reimbursement. It is neither optimal nor financially feasible to fully reimburse the poor ex-post, as long as they behave in accordance with the tenets of reference dependent preference. People would otherwise demand infinite amount of treatment otherwise. If the payment is made ex-ante, treatment decisions will not be made with a new budget constraint that is not binding, and consequently, medical bankruptcies are eliminated. Such policy makes everyone able to receive \( M^* \) when sick, and since \( \partial P / \partial Y = 1 \), there is a uniform level of preventive effort across income groups. Let \( e_0 \) denote the uniform level, which satisfies Equation 3.22 with \( M = M^* \), then there will be a proportion of \( \pi(e_0) \) of people in all income groups that
will get sick in the second period $t = t_1$. Therefore, how much government spends on health is determined solely by how much each patient will spend after insurance. As the premium is transferred in the first period, i.e. before the realization of health states, therefore, the fund that the governments need for such redistribution, $G$ is

\[ G = \int_Y^{M^*} M^* - YdF(Y) \]  

(4.3)

and the available income for financing this is

\[ A = \int_{M^*}^{Y} Y - M^*dF(Y) \]  

(4.4)

As long as $E[Y] \geq M^*$ so that $A \geq G$, then the redistributive policy is financially feasible.

**Definition 4.1.** Assume $E[Y] \geq M^*$, then a purely redistributive insurance scheme that eliminates medical bankruptcies is characterized by the following equations:

\[ c(Y) = 1, \ \forall Y; \]  

(4.5)

\[ P(Y) = Y - M^*, \ \text{if } Y \leq M^*; \]  

(4.6)

\[ \int_{M^*}^{Y} P(Y)dF(Y) \geq \int_{Y}^{M^*} M^* - YdF(Y), \ \text{if } Y \geq M^*. \]  

(4.7)

The transfer through insurance premium should be made in $t_0$.

Assume there are always consumers of mass 1, given the insurance policy, the welfare in $t_1$ is

\[ W^I = (1 - \pi(e_0)) \cdot 0 + \pi(e_0) \int_Y^{Y} u(H(M^*), M^*)dF(Y) = \pi(e_0)u(H(M^*), M^*). \]  

(4.8)

In the reference dependent model, the ex-post utility level is assumed to be independent of one’s income level, unless the budget constraint in Problem 3.10 is binding. It indicates that a patient spending $M^*$ on his treatments is equally happy with one who has the same level of medical spending but is richer. Reference dependence underlies the intuition behind this: the subjective happiness of human beings is defined over changes with respect to the reference points. What matters is “What we gain and lose,” rather than “What we have”. In consequence, people with the same level of medical spending are equally happy, because they have different reference points in wealth.
**Proposition 4.3** (Welfare-improving redistributive insurance).

\[ 1 - \gamma H'(M) \geq 0 \implies W^I \geq W. \]

*Proof.* First note that by definition, \( u(H(Y), Y) \leq u(H(M^*), M^*) \) for \( Y \leq M^* \). Corollary 4.2 further implies that for \( Y \leq M^* \), \( u(H(Y), Y) \leq u(H(M^*), M^*) \leq 0 \). By Proposition 3.5, \( 1 - \gamma H'(M) \geq 0 \) implies that \( \partial e / \partial Y \geq 0 \), \( \pi(e(Y)) \geq \pi(e_0) > 0 \), then \( W^I \geq W \). \hfill \blacksquare

Proposition 4.3 provides a sufficient condition for the redistributive insurance policy to be welfare-improving. It serves as a justification of government intervention. In each period, the gain-loss payoff of the rich is not affected by the policy, hence it creates ex-ante and ex-post moral hazard only to the poor. As long as there is an inverse relationship between income and unhealthy behavior, an ex-ante payment to the poor will encourage preventive efforts, meanwhile protecting them from medical bankruptcies.

### 4.2 Fixed indemnity

Fixed indemnity insurance should be offered to the poor only, in that Proposition 3.7 predicts it does nothing but induces unhealthy behavior of the rich. Assume the government sets \( \partial P / \partial Y = 1 \) for \( Y \leq M^* \), so that the difference of prevention within the poor is eliminated. In particular, let

\[ P(Y) = Y - Z, \quad Z \in \mathbb{R}. \]  \hspace{1cm} (4.9)

Then the disposable income of the poor is \( Y - P = Z \). For the fixed indemnity, first note that \( T \leq M^* - Z \), since more transfer will not increase the patients’ utilization of medical care. To guarantee that the preferred medical treatment is affordable to everyone, the government should set

\[ T = \max\{M^* - Z, 0\} \]  \hspace{1cm} (4.10)

Then for \( Z = M^* \), it goes back to the insurance in Definition 4.1. Let \( e(Z) \) denotes the optimal level of prevention, from Proposition 3.7 one can deduce that \( e'(Z) \geq 0 \). With such policy, patients’ reference points become \( Y - P + T = M^* \), after paying \( M^* \) for treatment, his income is 0, and thus his after-insurance loss in income becomes
Government spending on insurance is
\begin{align}
G(Z) &= \int_Y^M \pi(e(Z)) (M^* - Z) dF(Y) + \int_Y^M Y - Z dF(Y) \\
&= \pi(e(Z)) (M^* - Z) F(M^*) + \mathbb{E}[Y | Y \leq M^*] - Z F(M^*). \tag{4.11}
\end{align}

The rich serves as the source of financing health-care for the poor
\begin{equation}
A = \int_Y^\bar{Y} Y - M^* dF(Y) \tag{4.12}
\end{equation}

As income is observable, the government can levy lump sum taxes on the rich. Then the optimal fixed indemnity insurance solves
\begin{align}
\max_{Z \leq M^*} \pi(e(Z)) u(H(M^*), M^*) \\
\text{s.t. } G(Z) \leq A \tag{4.13} \tag{4.14}
\end{align}

Optimal $Z$ is characterized by the following first order condition
\begin{equation}
\pi'(e) e'(Z) u(H(M^*), M^*) = \mu_T G'(Z), \tag{4.15}
\end{equation}

where $\mu_T$ is the Lagrangian multiplier of the budget constraint. The LHS of Equation 4.15 represents the marginal gain in welfare if $Z$ increases, which is the result of decreased $\pi$. The RHS measures government’s marginal cost to financing its expenditure. If the constraint in 4.14 is not binding, as $W'(Z) \geq 0$, there is a corner solution that $Z^* = M^*$, which becomes the purely redistributive insurance described in Definition 4.1.

### 4.3 Linear coinsurance

A linear coinsurance policy could improve the well-beings of both the rich and the poor, therefore all the people should be included. By setting $c < 1$, the preferred level of treatment becomes $M_I(c) > M^*$, and the additional medical spending represents ex-post moral hazard. People whose $Y < cM_I(c)$ will declare bankrupt, hence a premium $P(Y) = Y - cM_I(c)$ for $Y \leq cM_I(c)$ is needed. Government’s health-care expenditure, denoted by $G(c)$ is
\begin{equation}
G(c) = \int_Y^{cM_I(c)} cM_I(c) - Y dF(Y) + \pi(e(c))(1-c) \int_Y^{\bar{Y}} M_I(c) dF(Y) \tag{4.16}
\end{equation}

where the first term represents the transfer payment to the poor in $t_0$, and the second term is the payment for treatment in $t_1$. The available resource for financing
\( G(c) \), denoted by \( A(c) \) becomes
\[
A(c) = \int_{c M_I(c)}^{\bar{Y}} Y - c M_I(c) d F(Y). \tag{4.17}
\]

Compared with \( c = 1 \), the government has to pay partly for the treatment costs in \( t_1 \) in addition; while on the other hand, the effect of such coinsurance scheme on the redistribution in the first period is unclear. More specifically, it depends on the threshold of income that will go bankrupt after insurance, \( c M_I(c) \). First note that, the first term in Equation 4.16 is increasing, and \( A(c) \) is decreasing with respect to \( q = c M_I(c) \), with the first order derivatives
\[
\frac{\partial}{\partial q} \int_{c M_I(c)}^{\bar{Y}} c M_I(c) - Y d F(Y) = \int_{c M_I(c)}^{c M_I(c)} d F(Y) = F(q) > 0 \tag{4.18}
\]
\[
\frac{\partial}{\partial q} A(c) = - \int_{c M_I(c)}^{\bar{Y}} d F(Y) = F(q) - 1 < 0 \tag{4.19}
\]

The derivative of \( c M_I(c) \) with respect to \( c \) is \( M_I(c) + c \frac{\partial M_I(c)}{\partial c} \), where \( \frac{\partial M_I(c)}{\partial c} \) is negative, as expressed in Equation 3.32. The derivative evaluated at \( c = 1 \) is \( M^* + \frac{\partial M_I(1)}{\partial c} \), which could possibly be negative. Thereupon, if there exists a \( c < 1 \) such that \( c M_I(c) < M^* \), and \( G(c) \leq A(c) \), then the after-insurance welfare in \( t_1 \) becomes
\[
W_I(c) = \pi(e(c)) u(H(M_I(c), c M_I(c))), \tag{4.20}
\]

where \( e(c) \) solves Equation 3.39 when \( M_I = M_I(c) \). As \( c \) affects both \( e \) and \( M_I \), when making policy, the government has to consider both the ex-ante and ex-post moral hazard associated with \( c \). Proposition 3.9 states that without bankruptcies, \( e \) is decreasing with respect to the out-of-pocket payments \( c M_I \), as the relationship between \( c \) and \( c M_I \) is one-to-one, setting a welfare maximizing \( c \) is equivalent as setting an optimal out-of-pocket payment \( c M_I \). Therefore, optimal \( q = c M_I(c) \) should solve
\[
\max_q \pi(e(q)) u \left( H \left( \frac{q}{e(q)} \right), q \right) \tag{4.21}
\]
\[
s.t. \ A(q) \geq G(q) \tag{4.22}
\]
where $A(q) = \int_{q}^{\bar{Y}} Y - cM_l(c) dF(Y)$ and $G(q) = \int_{q}^{\bar{Y}} q - Y dF(Y) + \pi(e(c(q)))(1 - c(q)) \int_{Y}^{\bar{Y}} \frac{q}{c(q)} dF(Y)$. The first order condition

$$\mu_q \left[ (c'(q)\pi + (c(q) - 1)e(q)c'(e)) \frac{q}{c(q)} + (c(q) - 1)\pi \frac{(c(q) - qc'(q))}{c(q)^2} - 1 \right]$$

$$+ \pi'(e)c'(q)u + \pi \frac{du}{dq} = 0 \quad (4.23)$$

**Theorem 4.4** (Optimal linear coinsurance rate with redistributive premiums). Let $c^*$ denote the optimal linear coinsurance rate, then

$$c^* = \frac{\pi[M_I\mu_q(1 - \varepsilon_q) + \varepsilon_{\pi}\varepsilon_q(u - \mu_q)]}{(1 - \pi)M_I\mu_q\varepsilon_q - \pi(M_Iu_M + \varepsilon_{\pi}\varepsilon_q\mu_q)} \quad (4.24)$$

where $\varepsilon_\pi := \frac{d\pi/\pi}{dq/q}$ measures how $\pi$ change with respect to $q$, and $\varepsilon_q := \frac{dq/q}{dc/c}$ measures how the out of pocket payment $q$ changes with respect to $c$, and $u_M := \frac{du}{dM}$. Together with a premium schedule such that for $Y \leq cM_I$, $P = Y - c^*M_I(c^*)$, the coinsurance schedule is welfare-maximizing.

**Proof.** See Appendix B.

Technically, Equation 4.24 is not a closed-from solution of optimal $c$, since parameters such as $M_I$, $\varepsilon_\pi$, $\varepsilon_q$ and $\pi$ are functions of $c$ as well. However, it facilitates some intuition of optimal linear health insurance. As $\mu_q$ denotes the shadow price of public fund, when $c$ decreases, term $M_I\mu_q(1 - \varepsilon_q)$ measures the additional cost to the government for raising the fund, and the term $\varepsilon_{\pi}\varepsilon_q(u - \mu_q)$ measures the corresponding marginal change of patients, and both terms in the numerator are scaled by the NCD prevalence parameter $\pi$. In the denominator, the term $M_I\mu_q\varepsilon_q$ represents change of patients’ out-of-pocket payments, scaled by $1 - \pi$, it measures the aggregate impact of the change of $\pi$. And $-\pi M_Iu_M$ measures the dollar value of welfare impact of the change of $\pi$, and $\pi\varepsilon_{\pi}\varepsilon_q\mu_q$ measures the cost of ex-ante moral hazard to the government.

## 5 Conclusion and Discussions

In this article, a new decision model has been established based on reference dependent model. In this framework, medical bankruptcy is commonly observed among the poor, and it is possible that it coexists with low preventive effort level “rationally”. Such coexistence also serves as a justification for redistributive social insurance.

In the treatment problem, when there is no insurance, interior solutions only apply to the rich, and the corner solutions of the poor indicate that medical demand is
not always perfectly income inelastic. Therefore, medical bankruptcy is a strong evidence against the argument that ex-post moral hazard is inefficient. Policy makers should allow insurance coverage to be generous enough to make sure all can afford their preferred level of treatment after insurance. Concurrently, the result suggests that patients’ out-of-pocket payment should be strictly increasing with respect to the amount of treatment, since effective stop-loss policies will boost up the medical demand to infinity, causing fiscal problems to the insurance provider. This prediction is quite strong, and it is arguable that medical demand must be bounded, for example, by a country’s GDP. In addition, physicians’ decisions are at least equally important in determining a patient’s level of treatment. It therefore needs to be interpreted with caution. The prediction does not vehemently disapprove stop-loss policies, but instead, it shows concerns about the potential over-utilization of healthcare induced by such policy. A stop loss insurance policy necessitates third-party supervisions such as gate keepers. Another remark is that if the treatment level is not continuous, deductible insurance might then become feasible.

For preventive behavior, the model evinces that monetary incentives can influence one’s prevention decision, since the decision maker is assumed to fully anticipate his treatment outcome which is a function of treatment. Either the poor exert more preventive efforts or they live more unhealthily. However, the latter is of particular interest, because it makes redistribution desirable. The “income effect” of prevention makes the preventive effort levels differ across income levels, and thus when income is assumed to be observable to the government, it makes effort levels observable as well. It is therefore possible to use monetary payoffs to incentivize preventive decisions. Ex-post cost sharing would also influence ex-ante decisions, furthermore, in contrast to early findings, cost sharing insurance could even encourage the poor increase their effort level. Ex-ante distribution also acts as a useful tool to eliminate both ex-ante inverse relationship between income and unhealthy behavior, as well as ex-post medical bankruptcy. Note that payment in different periods are not perfect substitutes, they may have the same effect on medical demand; however, optimal prevention reacts differently.

In terms of optimal health insurance, due to the associated ex-ante and ex-post moral hazard, policy makers should consider both effects when designing insurance policies. Optimal health insurance policy should make people exert more efforts ex-ante and pay less once ill. Besides, the timing of monetary transfers matters. For example, given the inverse relationship between income and unhealthy behavior, ex-ante redistribution will increase the effort levels of the poor, whereas the same amount of transfer made ex-post has the exactly opposite effect. Such difference comes from the different ways of altering the reference point ex-ante. It is also worth taking in to consideration that an increase of insurance generosity does not
necessarily increase the health expenditure. If a more generous insurance effectively lowers the NCD prevalence, it could be the case that it helps to reduce health expenditure as well.

Reference point is essential in the model. As mentioned before, people’s reference point could be influenced by different factors, and status quo is one of the possible candidates that better fit the experimental data. It is possible that people take alternative reference points, such as parental rearing and the community atmosphere. Correspondingly, reference dependent model helps to understand the inter-generation transmissions of NCDs as well as its cross-regional epidemics. It will be interesting to see what are the predictions for people who are initially unhealthy, and what is the optimal redistribution if people initially differ in both health and wealth. Policy makers might also want to consider other forms of policies which can shift people’s reference points. This is an important issue for future work. Furthermore, it is worth asking how will the reference point change in the presence of both private and public health insurance.

A number of additional caveats need to be noted regarding the assumptions and limitations of this study. Ex-post uncertainty is assumed away, and there is only one treatment. The welfare impact of ex-post moral hazard may change if there is uncertainty in the second period, or treatments are diversified. There are no physicians in the treatment problem, inasmuch as the paper is focusing on the health decisions made by the general public. Similarly, there is no adverse selection issue in this paper. Agents are assumed to have the same genetic dispositions, to live in the same environment with the same background risks, and to be initially healthy. People originally differ only in income, and the correlation between prevention (or NCD risks) is endogenous. As for welfare analysis, it is perplexing to define a paternalistic government, due to the difficulties to find a “first best” benchmark, as what is often done in standard welfare analysis. The ex-ante utility is effectively treated as the “decision utility”, and the ex-post utility is the experienced utility, which constitutes the welfare function.

This paper has thrown up plenty of questions in need of further investigation. More empirical work on the determinant of reference point would help to establish a greater degree of accuracy in understanding people’s choices over health. Although reference dependent model has been incorporated by a large body of theoretical research in various fields, it has not been applied to health economics very extensively. This paper demonstrates its potential, and extends our knowledge of people’s health decisions. The author hereby appeals for more research efforts devoted to the application of reference dependent model in health economics.
Appendices

A Cost of prevention

Proposition A.1. Assume the lifestyle will not shape the preference of the agent, then healthy lifestyle (abstention) is more costly than indulgence, i.e. \( \alpha(e) \geq 0 \).

Proof. The utility maximization problem of the indulgent person is

\[
\max_{x \in X} u(x) \quad (A.1)
\]

subject to a budget constraint. Where \( x \) is the consumption bundle chosen from the feasible set \( X \), and \( u : X \rightarrow \mathbb{R} \) is the utility function.

Mathematically, exerting preventive efforts refers to keeping away from the unhealthy consumptions in the broadly defined commodity set \( X \), such as tobacco, drugs, fat foods, and even time lying in the couch watching TV. Denote the consumption set of the ascetic agent as \( X_A \), then the problem of the ascetic agent is

\[
\max_{x \in X_A} u(x)
\]

Since \( X_A \subsetneq X \), one has \( \max_{x \in X} u(x) \geq \max_{x \in X_A} u(x) \). Thus, denote the difference by \( \alpha \), one has \( \alpha \geq 0 \).

For most of the people, given the prevalence of NCDs, their \( \alpha \) would be strictly positive. For the minority, who enjoys a healthy lifestyle, they will not choose the unhealthy commodities in \( X \), their \( \alpha = 0 \).

B Omitted proofs

Proof of Proposition 3.9 Let \( cM_I = q \), first note that \( dq = d(cM_I(c)) = (M_I + c\partial M_I/c)dc \), thus

\[
\frac{dc}{dq} = \frac{1}{M_I + c\partial M_I/c}.
\]
With $\pi(e) \leq 1/2$, Equation 3.40 implies that the comparative statics $\partial e/\partial q$ is determined by

$$
\frac{d}{dq} \left( \gamma \Delta h - \gamma H \left( \frac{q}{c} \right) + q \right) = \gamma \left( \Delta h - H'(M_I) \frac{d}{dq} \left( \frac{q}{c(q)} \right) \right) + 1
$$

$$
= \gamma \left( \Delta h - H'(M_I) \frac{c - cM_I}{c^2 c} \left( \frac{1}{M_I + c \frac{\partial M_I}{\partial c}} \right) \right) + 1
$$

$$
= \gamma \left( \Delta h - \frac{1}{c} H'(M_I) \left( 1 - \frac{M_I}{M_I + c \frac{\partial M_I}{\partial c}} \right) \right) + 1.
$$

Since

$$
0 \leq M_I + c \frac{\partial M_I}{\partial c} \leq 1 \implies 1 - \frac{M_I}{M_I + c \frac{\partial M_I}{\partial c}} \leq 0,
$$

therefore the term above is positive, i.e. $\partial e/\partial q \geq 0$.

**Proof of Theorem 4.4** Equation 3.31 implies that $\frac{du}{dc} = \frac{\partial u}{\partial c} = M_I \frac{\partial u}{\partial M}$, hence $\frac{du}{dq} = \frac{du}{dc} \frac{dc}{dq} = \frac{q}{c} \frac{\partial u}{\partial M} c'(q)$. Therefore Equation 4.23 becomes

$$
\pi'(e)e'(q)u + \pi \frac{q}{c} \frac{\partial u}{\partial M} c'(q) = \mu_q \left[ 1 + \pi \cdot (1 - c) \left( \frac{c - q c'(q)}{c^2} \right) + (1 - c) \pi'(e)e'(q) - \frac{1}{e} \pi q c'(q) \right] \quad (B.1)
$$

Thus one gets

$$
\frac{u_M}{\varepsilon_q} + \frac{u_{e\pi}}{q} = \mu_q \left( \frac{(1 - c)\varepsilon_{\pi}}{q} + \frac{(1 - c) \left( 1 - \frac{1}{\varepsilon_q} \right)}{c} + \frac{1}{p} - \frac{1}{\varepsilon_q} \right) \quad (B.2)
$$

Since $c$ should be strictly positive, Equation B.2 can be reformulated to a quadratic form of $c$,

$$
\frac{\varepsilon_{\pi} \mu_q}{q} c^2 + \left[ \frac{u_M}{\varepsilon_q} + \frac{u_{e\pi}}{q} - \frac{\mu_q}{p} - \frac{\varepsilon_{\pi} \mu_q}{q} + \mu_q \right] c - \mu_q \left[ 1 - \frac{1}{\varepsilon_q} \right] = 0 \quad (B.3)
$$

Substitute $q$ with $cM_I$, one gets Equation 4.24.
References


