Evaluating Health Care Costs Generated by Risky Consumption Goods[†]

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Abstract

We present an overlapping-generations (OLG) macroeconomic model that applies a behavioral interpretation of preferences for goods that generate health risks. In this paper being prone to poor health is viewed as a cognitive miscalculation by economic agents between their expected health state over various consumption bundles and the actual health care they require for their health outcome. This paper applies the reference-dependent preference framework of Koszegi and Rabin (2006). In our model of the economy individual preferences are decomposed into intrinsic consumption utility and gain-loss utility associated with the miscalculation. Agents in the economy are stratified in their health states as well as their expected health care consumption according to some probability measure over the population. Heterogeneity introduced in this way generates consumers of varied proneness to obesity because individuals have various marginal valuations of their miscalculation. In such a population, when all agents pay the same insurance premium, health-conscious agents shoulder the health care costs of their less health-conscious counterparts and causes less health-conscious individuals to be less healthy than they would if they paid actuarially fair premia. We demonstrate these effects in simulations by comparing the risk pooling equilibria to the actuarially fair pricing equilibria. The mathematical programming equilibrium constraint (MPEC) computational approach we apply to determine model equilibria is new to heterogeneous agent OLG model simulation.

1 Introduction

Overeating, smoking, and alcohol consumption have taken center stage in the health care cost debate. These risky consumption choices are driven by consumer preferences for the goods as well as a miscalculation pertaining to their health consequences. Since health insurance premia are determined using risk pool pricing, many individuals consume more of the risky good and demand more health care than they would under an actuarially fair pricing arrangement. This paper develops a framework for modeling an economy when consumption choices involve health risks. To demonstrate the applicability of this modeling framework, the paper presents a poignant example that describes and confirms the externality costs caused by overeating that accrue from risk pool pricing of health insurance premia.

In particular this paper builds an Overlapping Generations (OLG) General Equilibrium model where individuals live for two periods, young and old. They consume a risky good, health care, and a composite non-risky consumption good. These goods are produced by three different sectors. We assume perfectly competitive markets where all firms are identical and small compared to the market size. We treat all firms in each sector as one large firm. The conditions of zero profits, homogeneous products, costless transactions, many buyers and sellers hold. Here we have no entry or exit. Zero cost exit could result from zero demand for a particular product. However, this is never an equilibrium condition.

OLG modeling approaches typically employ classical models of preference wherein agents enjoy utility from the intrinsic consumption of a bundle. For example consider nutrition and health. Health conscious agents make healthful diet choices and place a high marginal value on health care. The implication is that these individuals would actually consume more health care than their less health conscious counterparts when such a model is applied. This counterintuitive result demands a new way to model the consumption decision given implicit health risks.

Fundamentally health outcomes pertaining to an individual's choice of some consumption goods are uncertain. Pioneering research by Kahneman and Tversky (1979) details some fallacies of expected utility theory in the presence of risky prospects. In particular, expected utility theory cannot handle risky prospects without inconsistencies, mainly due to three reasons: a) people underweight probable outcomes in comparison with certain ones, b) individuals discard components shared by all prospects under consideration, and c) choices are determined by individual weights as opposed to probabilities, since choices are endogenously affected by individual characteristics. In addition, utility for gains is concave, whereas utility for losses is convex. Experiments have shown that individuals are hurt more by unexpected losses than they benefit from unexpected gains of equal size.

In the model of Kahneman and Tversky (1979) individual preferences play the role of the state of nature. In the context of the nutrition and health example, individuals who form accurate expectations about the health consequences of poor diets make healthier dietary choices and require less health care. On the other hand individuals that underestimate the health consequences of their dietary choices suffer health problems and require more health care. This observation is consistent with economic models that evaluate potential losses and gains associated with an uncertain consumption decision.

On the footsteps of Kahneman and Tversky (1979), Koszegi and Rabin (2006) introduce a model of reference-dependent preferences, where individuals make decisions given own expectations of decision outcomes. The difference between the expectation and the actual decision outcome creates a "gain-loss" element in the utility function and allows consumer choices to be referenced to endogenously determined expectations. Along the same lines, Koszegi and Rabin (2009) develop a model of individual decision-making in which utility depends both on outcomes and anticipation of outcomes or the difference between the two. Koszegi and Rabin (2009) use reference-dependent utility to explain changes in beliefs about current and future consumption plans and argue that this methodology can also be useful in approaching the relationship between decisions and contemplation. Koszegi and Rabin (2007) use reference dependent theory to explain decisions associated with delayed consequences. The gain-loss part of the utility function is an essential feature of prospect theory since "carriers of value are changes in wealth or welfare, rather than final states". That is, negative departures from the current state are perceived to harm utility.

In practice health care coverage is not priced according to individual consumption of risky goods, owing to legal standards outlawing discriminatory pricing. Since the price of coverage does not reflect the costs of providing health care for "risky" individuals, the health-conscious population subsidizes health care. The implicit subsidization of unhealthful consumption afflicts people prone to it. These people may not be ill but for the subsidy. The moral hazard is due to non-discriminatory insurance premia and actually increases economy wide health care costs. The U.S. individual health insurance market, where some states allow price differentiation on health insurance premia, is taken as a special case and is not included in our analysis (Herring and Pauly (2006)).

Bhattacharya and Sood (2005) construct and calibrate a novel microeconomic model of weight loss and health insurance under two regimes. Under regime one, individuals incur insurance premia according to their weight. Under the second regime, everyone pays the same premium and insurance companies cannot discriminate across agents. Their work illustrates the presence of a negative externality imposed by obese persons on non-obese persons.

Bhattacharya and Bundorf (2005) conduct an empirical study that investigates whether the negative effect of obesity on wage is explained by employers expectation of the higher employee medical costs associated with obesity. They find that obese workers, with employer covered health insurance and medical costs, retain lower wages and lower wage increases. Their conclusion is strengthened by the fact that these wage offsets are not found for obese workers with alternative insurance coverage or for other types of fringe benefits not likely to be affected by being overweight. They conclude that health care costs attributable to obesity are high enough to generate such wage discrimination. Their estimate of the wage offset exceeds the estimate of the expected additional health care costs due to obesity but this finding holds only for women.

An empirical analysis by Finkelstein, Fiebelkorn, and Wang (2003) reports that half of the estimated \$78.5 billion in medical care spending in 1998 attributable to excess body weight was financed through private insurance (38%) and patient out of pocket payments (14%). Finkelstein, Ruhm, and Kosa (2005) estimate that the "average taxpayer spends approximately \$175 per year to finance obesity related medical costs for Medicare and Medicaid recipients." Since the health care costs of overeating are borne by the relatively more health conscious, introduction of an actuarially fair health care pricing regime will compensate for the negative externality created by risk pool pricing. This fact begs strong consideration for policies that force individuals to internalize the costs of their risky consumption decisions.

This paper makes three contributions to the literature. First it applies a reference-dependent utility model to the overlapping-generations general-equilibrium macroeconomic modeling framework to account for the uncertainty implicit in individual health outcomes. Second, to the best of our knowledge, this is the fist paper to employ a mathematical programming equilibrium constraint (MPEC) approach to solve a heterogeneous agent OLG macroeconomic model. Third it demonstrates how our modeling approach may be applied to assess external costs due to risk pool pricing of insurance premia in the context of overeating. A comparison of model equilibria that arise under the risk pool pricing to model equilibria that arise under actuarially fair pricing demonstrates the extent of external costs from risk pool pricing.

This paper continues in the next section by explaining the model of individual preferences and the model of the economy. Then it briefly discusses our computational approach, details model calibration, and documents simulation results. Before concluding it conducts a comparative analysis of actuarially fair to risk pool pricing.

2 The Model

In this section we introduce and explain the macroeconomic model of focus in this research. The model of the economy we use is comprised of households and firms. Consumers living in the households have a common utility function, however they differ in tastes for goods and in realized health shocks. Firms belong to one of the two sectors in the economy, the risky good sector and the non-risky composite consumption good sector. A separate third sector supplies health care. Households face uniform prices for health coverage under the risk-pooling pricing regime and actuarially fair prices proportional to health state consumption under the counterfactual pricing regime.

The section begins by introducing the preference model. Next it develops a structural interpretation of the model, introduces it into the overlapping-generations framework, and details the supply side of the model. Then it discusses health care pricing and describes model equilibria.

2.1 A Reference-Dependent Model of Utility

Koszegi and Rabin (2006) explain that a person's utility from consumption is determined by contrast with a reference point as well as the inherent utility from consumption itself. In this view utility is additively separable in intrinsic "consumption utility", corresponding to the classical outcome-based utility, and "gain-loss utility", accruing due to departure from a reference point. The reference dependent utility function can be expressed as:

$$u(c|r) = m(c) + n(c|r), \quad (1)$$

where $m(c)$ is the intrinsic consumption utility and $n(c|r)$ is the gain-loss utility, with r being the individual reference consumption point. Both consumption utility and gain-loss utility are separable across dimensions, such that $m(c) \equiv \sum_k m_k(c_k)$ and $n(c|r) \equiv \sum_k n_k(c_k|r_k)$. Furthermore Koszegi and Rabin (2006) point out that " the sensation of gain or loss due to a departure from the reference point seems closely related to the consumption value attached to the goods in question." Therefore they assume $n_k(c_k|r_k) \equiv \mu(m_k(c_k) - m_k(r_k))$, where $\mu(\cdot)$ satisfies the following properties, as stated by Bowman, Minehart, and Rabin (1999):

1. $\mu(x)$ is continuous for all x, twice differentiable for $x \neq 0$, and $\mu(0) = 0$.

2. $\mu(x)$ is strictly increasing.

3. If $y > x > 0$ then $\mu(y) + \mu(-y) < \mu(x) + \mu(-x)$.

4. $\mu''(x) \leq 0$ for $x > 0$, and $\mu''(x) \geq 0$ for $x < 0$.

5. $\mu'_-(0)/\mu'_+(0) \equiv \lambda > 1$, where $\mu'_+(0) \equiv lim_{x\to 0}\mu'(|x|)$ and $\mu'_-(0) \equiv lim_{x\to 0}\mu'(-|x|)$.

Which are consistent with the value function of Kahneman and Tversky (1979).

This model allows for stochastic consumption outcomes and stochastic reference points. If c is drawn according the the probability distribution F, then utility is,

$$U(F|r) = \int u(c|r)dF(c). \quad (2)$$

If we assume the reference point r is beliefs about the stochastic consumption outcome according to the probability distribution G, then utility becomes,

$$U(F|G) = \int\int u(c|r)dG(r)dF(c). \quad (3)$$

This formulation is particularly well suited to the way individuals make choices about risky consumption goods, given the distribution of health states associated with these choices. For example, intrinsic consumption utility could depend on net calorie consumption and a health shock drawn from the density $f(c|r)$. In our view individuals miscalculate the actual and expected health state associated with a consumption decision. In our application of this preference model, individuals realize a loss or gain in utility proportional to the miscalculation in the amount of health care they require for a given bundle of risky consumption goods. In applying this model to an economy we view individuals as heterogeneous in their preferences. This heterogeneity drives intrinsic marginal utility of consumption and parameterizes the location and dispersion of the density from which health shocks are generated.

2.2 The Household

In our model individuals live for two periods, young and old, under an overlapping-generations framework. Each individual divides their work time between production in the sectors of the economy that produce the riskless and risky goods. The rule that specifies division of labor is exogenous to the model. Individuals derive utility from consumption of a riskless composite consumption good, the risky consumption good, health status, and the discrepancy between the actual and the expected health state. Health care consumption, although not explicitly modeled, is assumed to be proportional to individual health state drawn from the density of health outcomes conditioned on consumption of the risky good and parameters that characterize individual preferences. Agents with negative health status in equilibrium are those who need to consume health care. The lower the individual health state the greater the amount of health care consumed. Last, individuals are assumed to supply labor inelastically and place no value on leisure.

Individuals maximize their objective function:

$$U(c_t, c_{t+1}, r_t, r_{t+1}) = m(c_t) + n(c_t|r_t) + \beta \mathbb{E}[m(c_{t+1}) + n(c_{t+1}|r_{t+1})], \tag{4}$$

where c denotes the entire consumption bundle, r is the reference bundle, and t indexes time. Again $m(c)$ is intrinsic consumption utility and $n(c|r)$ is gain-loss utility. β is the discount factor.

The intrinsic consumption utility function we apply takes the following familiar Cobb-Douglas form:

$$m(f, h(f), D) = \alpha_i ln(f) + (1 - \alpha_i) ln(D) + h$$

where

$$h = -ln(1 + \alpha_i f) + \sqrt{\mathbb{V}[h]}\nu^i$$

here the consumption bundle consists of food, f, and a composite consumption good, D, as well as health status, h. Consumers' preferences, characterized by α_i, are distributed uniformly on $[a, b]$. α_i is a consumer specific parameter that drives consumers' individual tastes for consumption goods as well as actual and expected levels of health. Low values of α_i correspond to health conscious consumers whereas high values of α_i correspond to myopic consumers who are less aware of the health consequences linked with unhealthful consumption bundles. These α_i values also influence individual health status, through h. The intuition behind this assumption is that less health conscious individuals, who consume more of the risky good, not only miscalculate the consequence of their consumption decisions, but also get involved in more risky consumption choices than their more health conscious counterparts, who in turn consume less of the risky good. Thus, less health conscious individuals consume greater quantities of food and also turn out to be more unhealthy, which will result in greater need for health care. So, α_i determines riskiness levels and, through h, their impact on healthiness.

The gain-loss utility function is:

$$n(h|f_r; \alpha) = \mu(m(h) - m(\mathbb{E}[h])), \tag{5}$$

where $\mu(\cdot)$ is:

$$\mu(x) = \begin{cases} \eta x, & for\ x > 0; \\ \eta\lambda x, & for\ x \leq 0. \end{cases}$$

and fulfills the properties of the Kahneman and Tversky (1979) value function enumerated above. Without loss of generality Equation 5 states that individuals potentially have uncertainly about their health status. This assertion simplifies the departure function $m(h) - m(\mathbb{E}[h])$ to be $h - \mathbb{E}[h]$, supporting the argument that "a person's reference point is the probabilistic beliefs she held in the recent past about outcomes" (Koszegi and Rabin (2006)). Expectation, instead of the status-quo, creates the state from which departure is measured. In non-durable consumption, it would be unreasonable to think that the utility of a person who expected to go to the movies and didn't is identical to that of a person who didn't expect to go to the movies and didn't, assuming both are characterized by the same utility function.

The adequacy and the necessity of the gain-loss part of the utility function is essentially based on the theory by Koszegi and Rabin (2006) and supports the common view "that the "endowment effect" found in the laboratory, whereby random owners value an object more than nonowners, is due to loss aversion-since an owner's loss of the object looms larger than a nonowner's gain of the object". Thus, the convexity of the loss part of the utility function in contrast with the concavity of the gain part, handles this difference in the departure from the reference point, in that loss departures are received and evaluated differently than gain departures.

The distribution function of health shocks is parameterized with a location and dispersion parameter. We assume health shocks are drawn from a normal distribution. The mean parameter is given by the expectation function, $\mathbb{E}[h] = -ln(1 + \alpha_i f_i)$. In addition the distribution's variance is, $\mathbb{V}[h] = [ln(1 + \alpha_i)]^2$. Thus health status depends on food consumption choice, on personal characteristics expressed through the level of α_i, and on an individual shock $\nu^i \sim N(0, 1)$. It is important to note that the scedastic function for the distribution from which the health shock is generated is not determined by consumption of the risky consumption good, rather it is inherited by the consumers draw of α_i. One might argue that this reflects a genetic predisposition to health shock magnitude. For example less health conscious individuals are prone to suffer from larger health problems. Additionally individuals set expectations about their health state according to a first order Markov process, in other words they set their beliefs about period $t+1$ health conditional on their health state in period t, which may be expressed as:

$$\mathbb{E}[h^i_{t+1}] = \mathbb{E}[h^i_t] + ln(1 + \alpha_i)\nu^i_t + ln(1 + \alpha_i f^i_{t+1}).$$

Individual health care consumption is determined through the following rule. Individuals with negative health status are assumed to need health care. Those with zero or positive health status on the other hand are assumed not to. In addition, for people with negative health status, going to the doctor is not a matter of choice. If they require health care, they consume it. The amount of health care consumed is equal to the absolute value of their health status. So, individuals with worse health state consume more health care.

2.3 The Firms

There are three sectors in this economy, the food sector, the service sector, and the health care sector. We first describe the first two sectors, services and agriculture. Firms have Cobb-Douglas production functions but use different technologies. In particular, food and service sectors share the labor force and use capital held by individuals. A fraction u of labor is employed in services and $1-u$ in the production of food. Capital is split in the two sectors such that there is no arbitrage.

$$Z = \gamma K_1^{\varphi}(u)^{1-\varphi} \tag{6}$$

$$Y = AK_2^{\psi}(1-u)^{1-\psi} \tag{7}$$

Z denotes the total production of services and Y the production of food. Firms behave competitively, maximize profits, and take prices as given. From the first period to the second, capital stock fully depreciates, hence new capital is created through investment. Factors of production are paid their marginal products:

$$r^z = \gamma\varphi(\frac{u}{K_1})^{1-\varphi}$$
$$w^z = \gamma(1-\varphi)(\frac{K_1}{u})^{\varphi}$$
$$r^y = A\psi(\frac{1-u}{K_2})^{1-\psi}$$
$$w^y = A(1-\psi)[\frac{K_2}{1-u}]^{\psi}$$

The health sector is assumed to be slightly different. Production of health services depends on technology and capital, K_3. This capital is health services specific and is assumed to be different than the capital used in the other two sectors, K_1 and K_2. In addition we assume that the health care provider buys health care specific capital from outside the economy and that individuals do not have access to capital stock of this type. This assumption is made in order to facilitate our calculations.

Hence, production of health care is described by:

$$HC = GK_3$$

Health care is also provided in a perfectly competitive market where factors of production earn their marginal product. Market clears, whereas supply and demand forces in this sector do not interact through fluctuations in price. On the contrary, demand for health care is a consequence of health condition and supply exactly covers demand.

2.4 Insurance Policy Pricing

Today insurance policies do not discriminate based on individual health riskiness levels. Non discriminatory pricing induces risky behavior with regards to health and consumption of health services and creates an externality towards healthier weight individuals who consume less medical care. In our attempt to identify the existence of externality we divide our analysis in two cases of health insurance policies: (i) health insurance pools risk across individuals with heterogeneous α, so premia do not account for heterogeneity and are constant across people, and (ii) individuals pay an actuarially fair insurance premium incurring a medical cost proportional to their food consumption, or otherwise health status.

In the risk pooling case all agents face the same insurance premium. So health risk is pooled across individuals with different health status. Hence, health insurance premia enter the budget constraint in the form of a lump sum tax:

$$I_t + \frac{I_{t+1}}{1+r} = pf_t + \frac{pf_{t+1}}{1+r} + D_t + \frac{D_{t+1}}{1+r} + \overline{P} + \frac{\overline{P}}{1+r} \tag{8}$$

Here I denotes income, p is the relative price of food with respect to D, and $\overline{P}$ is the insurance premium.

The insurance market is in competitive equilibrium and as a result:

$$\sum \overline{P} \propto \sum |h_i|, \quad for\ h_i < 0; \tag{9}$$

As indicated above, only individuals with negative levels of h, i.e. bad health status, in equilibrium require health care. The amount of the premium is given by the average health care expenditure in the population. In particular:

$$\overline{P} = \frac{\sum |h_i|}{N}, \quad for\ h_i < 0; \tag{10}$$

The average individual for whom $|h_i| = \overline{P}$ is at the margin, borrowing the terminology of Bhattacharya and Sood (2005), since he receives no ex ante subsidy. All individuals below the margin are characterized by either $|h_i| < \overline{P}$ or $h_i \geq 0$ in the case where no health care is required, and those above the margin $|h_i| > \overline{P}$. Thus, the first category of individuals is subsidizing the later.

The average person plays the role of the cut off point between the two categories. Individuals who pay the subsidy are inframarginal and individuals who receive the subsidy are supramarginal (Bhattacharya and Sood (2005)). An inframarginal individual is thin compared to the average and a supramarginal individual is fatter than average. Under the current insurance policy, consumers are fully insured against medical expenses and there is no incentive for lower food consumption and consequently lower weight. Hence, insured people will tend to eat more than would be optimal, were they obliged to pay the full cost of their actions.

Lets now assume that health insurance premia are determined according to individual health care needs and thus are actuarially fair. In the case of public insurance this scheme will take the form of a tax, whereas for employer provided insurance it can be achieved through wage differentiation. Under the actuarially fair policy the individual budget constraint becomes:

$$I_t + \frac{I_{t+1}}{1+r} = pf_t + \frac{pf_{t+1}}{1+r} + D_t + \frac{D_{t+1}}{1+r} + P_t(h_i) + \frac{P_{t+1}(h_i)}{1+r} \tag{11}$$

$P(h_i)$ is the insurance premium for individual i with health state h_i. The health insurance market competitive equilibrium implies that:

$$\sum P(h_i) = \sum |h_i|, for\ h_i < 0; \tag{12}$$

Under this policy each individual pays the full cost of their health care consumption. Thus no subsidies are being received or paid by any individual in the population, implying

$$P(h_i) = |h_i|, for\ h_i < 0; for\ h_i \geq 0, P(h_i) = 0. \tag{13}$$

2.5 Equilibrium

Given an initial distribution of α_i, a stationary equilibrium is characterized by: *a)* individual policy rules f_t, D_t, f_{t+1}, and D_{t+1} for consumption of food and services in both periods, and a_{t+1} capital holdings for the second period, *b)* a time-invariant distribution of $a_{t+1}\ \epsilon\ \Lambda$, $f(a_{t+1})$, *c)* time-invariant relative prices of labor and capital in both sectors (w_t^z, r_t^z, w_t^y, r_t^y, w_{t+1}^z, r_{t+1}^z, w_{t+1}^y, r_{t+1}^y, r_{t+1}^{hc}), and *d)* a vector of aggregates K, L, Z, HC and Y such that:

a)Factor inputs, consumption of food and consumption of health care are obtained by aggregating over individuals.

b)f_t, D_t, f_{t+1}, and D_{t+1} are optimal decision rules and solve the individual decision problem.

c) Factor prices are equal to the factors' marginal productivities.

d) The goods market clears.

e) The distribution of the individual state variable a is stationary.

3 Simulation

The model provides a framework for evaluating the impact of heath care premia pricing. This section presents simulations of the model. First, it begins with an explanation of the new computational technique we apply. Second, it provides motivation for the simulation exercise. Third, it investigates the distribution of health consciousness in the economy. Forth, it examines equilibria sensitivity to the model specification. Finally, it examines various permutations of policy instruments to induce new equilibrium results.

3.1 Simulation Method

Previous work employs a nested fixed point approach to evaluate steady state equilibria for OLG models. This approach relies on optimizing the household objective function while holding price signals fixed. In a subsequent step, prices of goods are adjusted to move toward an equilibrium in goods markets given zero arbitrage equilibrium conditions in capital markets and labor markets. The two steps are iterated until goods markets clear to some predetermined level of numerical tolerance. This approach requires a great deal of computational time and allows for a large degree of error. The approach does not rely on information from the gradient or the hessian of the objective or the constraints.

We introduce a new approach that takes advantage of recent computational developments in constrained numerical optimization. We recast the problem as a mathematical programming problem with equilibrium constraints (MPEC). That is we maximize the utility of an empirical distribution of individuals by choosing optimal consumption bundles for each individual as well as prices and wage, with the added constraints that goods markets clear, zero arbitrage conditions hold, and household budget constraint is satisfied. In the current setting for n individuals, this amounts to solving a problem with $4n + 4$ control variables, n first period inequality budget constraints, n second period equality budget constraints, and 4 market equilibrium constraints. Altogether a very large highly non-linear optimization problem.

To achieve this computational feat we employ the help of $KNITRO^{®}$ non-linear optimization software, an industry standard, on the MATLAB platform. Using this optimization tool allows us to take advantage of the numerical gradient and hessian of both the objective function and the constraints to determine locally optimal solutions. This approach vastly improves computational time and precision by orders of magnitude and makes large problems, like the one we solve, more feasible than nested fixed point approaches. The version of the software made available allows us to specify 300 control variables and 300 constraints *(By the time this paper was completed the latest version of the software could handle unlimited number of control variables and constraints).* Given these constraints we chose to populate our economy with 148 individuals, $n = 74$ in each generation, who are heterogeneous in their preferences and their expectations about weight-health education level. These individuals work in both sectors and earn the marginal product of their labor. They also save in the first period and earn interest in the second. Prices are adjusted according to demand and supply of goods, such that markets clear. The size of the two sectors, based on the labor force, is exogenous. However, the wages are equal across sectors so that individuals have no incentive to change jobs. The same holds for savings. Individuals save through purchase of physical capital which is different in the two sectors. In order to avoid any arbitrage opportunities, interest rates in the two sectors are forced to be equal. After individuals make decisions on capital holdings, consumption and savings, production of goods takes place such that markets clear and supply equals demand in both sectors. All capital is destroyed from one period to the next and individuals die in the end of the second period. We assume no bequest motives.

To calibrate parameters from data we estimate a model of health status. We hypothesize starting values for variables endogenous to the model. For variables that are exogenously determined we compute equilibria for a grid of values to determine equilibrium behavior over the grid. The size of service sector u is exogenously set and varies between 0.1 and 0.9 with steps of 0.1. The minimum and maximum value that u takes comes from the min and max in the data for 128 countries (CIA (2008)). α takes values between 0 and 1 and is different for each agent following a random distribution.

The parameters that we need to calibrate with estimates from data are i) the exponent on capital in the Cobb-Douglas production function, φ and ψ, and ii) the discount factor, β. The estimation of φ and ψ, exponents on capital in the two sector's production functions, is simple since we can follow the estimations in the literature and set the Cobb-Douglas coefficient on capital at 0.36 (Prescott (1986)). β is set at 0.95 (Gayle and Khorunzhina (2009)).

3.2 Agent Heterogeneity: Estimates and Equilibria

We introduce heterogeneity to the model by assuming that economic agents vary in their ability to map consumption decisions into health consequences which leads to varied levels of weight and health status levels across the economy. The composition of the levels of health and wellness education throughout the economy are captured by a distribution of αs. These αs may be interpreted as preference characteristics, determinants of riskiness impact on individual health, and as a consequence reference points for expected health states. Individuals that are more in tune with the health consequences of obesity are part of the low reference population (lower values of α). The loss they associate with results from their understanding that being overweight has health consequences. On the other hand the high reference population (high values of α) fails to accurately calculate the consequence of obesity, an suffers in turn.

Figures 1 through 12 show food consumption, health status and composite good consumption for each generation of the seventy four reference types given different service sector size in each economy. Individual heterogeneity is measured on x axis on all 12 figures and is labeled "Individual Reference Level". These graphs include results for both insurance policies. Service sector size, varying from 0.1 to 0.9 is measured on y axis.

In both generations low reference types consume less food than their high reference counterparts. It is clear by comparison of the amounts of food consumption for the same reference type from young to old that there is a difference. Individuals under both insurance policies consume more food when old, compared to young. In detail, Figures 1 through 4 show food consumption patterns across individuals and across economies with different service sector size, under both insurance policies. We observe a common pattern in the results regardless of age and policy regime. Individuals with higher α, representing a higher reference level, consume in equilibrium more food and thus weigh more.

First Result: Less health conscious individuals consume more food in equilibrium, ceteris paribus.

Figure 1 shows that at all different sizes of the service sector under the risk pool regime, agents characterized by larger values of α, eat more food in equilibrium, when young. During the second period of their life, results shown in Figure 2, these differences still exist, but are not of the same magnitude. Across agents of old age the discrepancy becomes more profound as the service sector becomes larger.

Under the actuarially fair regime we observe similar results. In particular, for the young generation (Figure 3), food consumption is increasing in α, ceteris paribus, at all levels of service sector size. For the old generation (Figure 4) food consumption patterns are similar, however, as before, across agents there are larger discrepancies as the service sector size increases. The effect of α on food consumption remains positive, for the young generation under both insurance regimes, even when the "gain-loss" part of the utility function is eliminated, whereas for the old generation the effect of α is negligible (see Figures 13-14). Figures 15-16 show the individual health status levels, that result from the food consumption levels described above, for young and old respectively. It is apparent from these graphs that more health conscious individuals again appear to be more healthy in equilibrium than their less health conscious counterparts. It is crucial to underline the fact that when the "gain-loss" element of the utility function is eliminated, there is no difference between the two insurance regimes. Thus, the preference specific characteristic in the population causes the differentiation in risky consumption patterns across individuals, whereas the discrepancy between the two policies is attributed to the "gain-loss" element.

A significant result shown in Figures 5 through 8 is that health status levels are better for the health minded citizens. Since they each pay the same flat tax for health care this testifies that low reference types pay the bill for the high reference types. Hence, the more health conscious part of the population pays the largest share of the tab while the least health conscious is subsidized to the largest extent. Figures 5 and 6 show health status levels for young individuals in the two regimes, and Figures 7 and 8 show the same results for the old generation. Our findings clearly indicate that individuals characterized by greater values of α are less healthy in equilibrium.

Second Result: Less health conscious individuals have lower health status in equilibrium compared to their more health conscious counterparts, ceteris paribus.

Thus, policies that aim at the reduction of obesity and the health care costs associated with it, should heavily target the alteration of the behaviorally controlled part of individual decision making.

3.3 Estimates using different service sector size

Service sector size points to more or less sedentary lifestyles lead by the structure of the economy. In societies were service sector is large, jobs are more sedentary, individuals expend less calories at work and thus are expected to weigh more in equilibrium. This is also verified in the data. In Katsaiti (2010) it is shown, using data from 128 countries, that the conditional expectation of obesity given service sector size is strictly increasing. This result agrees to a large extent with the findings of this paper, however only for the young generations. In particular, regarding food consumption, our results show that it is strictly increasing in service sector size for young individuals under both policy regimes (Figures 1 and 3). However, these results are reversed for old agents under both insurance regimes (Figures 2 and 4). Thus, there is no single one conclusion regarding the effect of service sector size on individual food consumption, ceteris paribus.

Regarding consumption of services, one observes in Figures 9 through 12 that individuals with lower reference levels, consume more than their "least health conscious" counterparts.

The first two results of our simulation exercise, presented in the previous subsection, might seem obvious to the reader. However, these results should provide the reader with more confidence in the model presented and therefore more confidence in the following less trivial results.

3.4 How Policy Instruments Influence Equilibria: Individual and Aggregate

In order to see how insurance policies induce changes in individual consumption decisions one should observe the differences between equilibrium health status between the young generations as well as between the old generations in the two regimes. The results for the young are shown in Figures 5 and 6 and for the old in Figures 7 and 8. In particular, in Figure 5 individual health status levels for the majority of the population take negative values. As explained above, health state levels under zero imply health care need. So the more unhealthy individuals in our model population are those described by the very bottom values on the graph. That is, under the risk pool insurance policy, where insurance premia are identical in the population, agents make choices without considering the full cost. However, the same agents when faced with the entire cost of individual health care, Figure 6, alter their consumption decisions notably. In detail, it is evident that a large fraction of the population stands on the positively signed part of the graph, indicating good health status and no need for health care. Similarly, there are sizable differences between the two insurance policies for the old generation individuals. This is easily shown by the big difference between Figures 7 and 8. Once again, under the risk pooling regime the majority of the population finds themselves with bad health status (negative values) and greater need for health care, whereas under the actuarially fair insurance policy the graph is more balanced around zero. From this it is obvious that we reach our third result.

Result Three: Actuarially fair insurance premia induce more health conscious behavior, and result in less consumption of health care in equilibrium, ceteris paribus.

Table 1 shows the aggregate results stemming from the change in insurance premia. We report the mean, median, and standard deviation regarding health status in the population, across different sizes of service sector in the economy, for the two policies. The upper part of the Table shows the results for the young population and the lower part of the Table reports our findings for the old generation. Once again, as expected, we see that under the risk pool regime individuals consume on average more health care, in both generations compared to the actuarially fair regime, since they have worse health status. The results regarding the impact of the size of the service sector again do not lead to robust and interesting conclusion. However, one should note that when going from the risk pool case to the actuarially fair one, there is notable difference in the magnitude of the standard deviation in all cases. So the second policy induces much healthier choices in the population, with lower consumption of health care and smaller discrepancies among individuals' choices.

Table 1: Simulation Results for Health Status Under Both Regimes

Health Status									
Risk Pool: Health Status Young									
Service Sector Size	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
mean	-1.4905	-1.48741	-1.47721	-1.4583	-1.43034	-1.39525	-1.35588	-1.31287	-1.26646
median	-1.3766	-1.3738	-1.3642	-1.34625	-1.3195	-1.28465	-1.24565	-1.2031	-1.1562
st deviation	0.698324	0.698117	0.697361	0.695944	0.693834	0.691178	0.688161	0.684785	0.680628
Actuarially Fair: Health Status Young									
Service Sector Size	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
mean	0.089872	0.169217	0.171158	0.174782	0.180112	0.187482	0.196687	0.206711	0.218426
median	0.099713	0.18002	0.181315	0.18393	0.18795	0.19337	0.199605	0.20605	0.217615
st deviation	0.528553	0.533613	0.533887	0.534257	0.534586	0.535145	0.535719	0.536567	0.537533
Risk Pool: Health Status Old									
Service Sector Size	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
mean	-2.06307	-2.06795	-2.05678	-2.0248	-1.9704	-1.89745	-1.81159	-1.71002	-1.58005
median	-1.98165	-2.01935	-2.04625	-2.04005	-2.00085	-1.84245	-1.7117	-1.6107	-1.50845
st deviation	0.847778	0.843615	0.838847	0.835912	0.843579	0.875522	0.922744	0.955864	0.937492
Actuarially Fair: Health Status Old									
Service Sector Size	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
mean	-1.41348	-0.91758	-0.91799	-0.91181	-0.89925	-0.88322	-0.86045	-0.83206	-0.77864
median	-1.4158	-0.94887	-0.94271	-0.91121	-0.88109	-0.83247	-0.77533	-0.75459	-0.72768
st deviation	0.845004	0.78042	0.777474	0.77697	0.784069	0.805981	0.841439	0.873784	0.891118

Table 2: Number of Agents that Receive or Give a Subsidy in Health Care under the Risk Pool Insurance Policy

Young									
u	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Receive	32	32	32	32	32	32	32	32	32
Give	42	42	42	42	42	42	42	42	42
Old									
u	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Receive	34	35	37	38	38	33	35	35	35
Give	40	39	37	36	36	41	39	39	39

At this point it is deemed necessary to underline the sensitivity of our results to the nature of the model chosen, in particular the reference-dependent preferences presented in Section 2. Behavioral adjustments due to price differences stemming from changes in the insurance regime are generated (Figures 5-8) within the model dynamics. However, when the gain-loss part of the utility function is eliminated, we are unable to distinguish between the results of the two regimes. In particular, the results are exactly identical, spotlighting the advantages of the reference-dependent preferences modeling.

3.5 The Externality

Our simulation results clearly indicate the presence of an externality in the case of risk pool insurance regime. In particular the population following risky behavior and/or negative health shock needs more health care for which the individual cost is higher than the common premium they pay. Table 2 presents the number of individuals that pay and receive a subsidy in the health sector for each generation and for all different economies. It is obvious that under all different specifications of the model and for both generations, there is an externality caused by a fraction of the population on the rest of the population. This is exactly what the actuarially fair insurance premia correct for when applied. Since every agent pays exactly the amount of health care he consumes there is no externality (or otherwise subsidy) paid or received.

In addition, the imposition of an actuarially fair health insurance premium results in lower aggregate health care consumption. In particular, for the young generation aggregate health care consumption under the actuarially fair premium is reduced to the 1/10 of its magnitude when premia are priced under the risk pool case. For the old generation, aggregate health care consumption under actuarially fair

Table 3: Deadweight Loss (DWL) Generated by Risk Pooling, for Each Economy

u	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Act Fair	159.0	-286.1	-258.2	-238.0	-221.4	-206.7	-193.0	-180.3	-168.0
Risk Pool	-803.6	-754.8	-724.0	-698.1	-672.8	-647.1	-621.8	-596.9	-572.2
DWL	962.6	468.7	465.8	460.1	451.4	440.5	428.8	416.6	404.2

pricing is reduced to 1/2 of its magnitude under when risk pool insurance premia are enforced. Hence, the actuarially fair insurance policy in this context lowers individual food consumption and health care needs, in addition to correcting for the externality that was present under the risk pool insurance premia.

Our understanding of the magnitude of the health care cost related externality stemming from the moral hazard the risk pool insurance regimes can create, becomes more accurate by estimating the deadweight loss (DWL), measured as the change in individual utility resulting from pooling. Food consumption, and consequently health care consumption, are at socially optimal levels in the actuarially fair case. So the difference in food consumption Δf will reflect the degree to which food consumption choice differs from socially optimal when pooling pertains.

Following the methodology of Bhattacharya and Sood (2005) DWL is:

$$DWL = U^{**} - U^{*} \tag{14}$$

where U** is utility under actuarially fair regime and U* is utility under pooling.

Table 3 presents the obesity externality caused by pooling. This externality is a result of higher food consumption and greater health care needs under the risk pooling regime. Our finding, regarding the presence of obesity externality, is in agreement with the theoretical finding of Bhattacharya and Sood (2005).

The implications of the above results provide support of the argument that obese populations, characterized by risky behavior consist an economic burden to society, mainly through their health care cost. It is evident that the above results are taken seriously into account when it comes to policy formation regarding health insurance, private and public.

4 Conclusion

This essay introduced a new macroeconomic model that offers an explanation about how economies arrive at inefficient and non-equitable consumption plans when the individuals that live in them miscalculate consequences of their consumption decisions. The introduction of a reference-dependent theory of preference to the overlapping-generations general-equilibrium macroeconomic modeling framework develops an understanding about how behavioral rigidities in an economy effect equilibrium outcomes. Simulations illustrate how a particular rendition of the model determines equilibrium macroeconomic aggregates. The comparative analysis conducted sheds light upon consumption and production plans under two health care pricing policies. This comparison allowed us to identify externality costs accruing to the health conscious portion of the economy under the risk pooling pricing regime.

In brief we find i) that health conscious individuals consume less food and are on average in better health than less health conscious agents, ii) individual food consumption patters and health conditions change when agents have to incur the full cost of their choices, iii) the results do not point to a conclusion regarding the effect of the (exogenously set) service sector size on consumption patters and health care needs, and iv) that the externality induced by the obese to the non-obese is attributable to the risk pool insurance premia.

We believe that our application of a behavioral macroeconomic model is just the tip of the iceberg. Future research might apply such a model to any economy wide behavioral phenomena that follows from a cognitive explanation of behavior.

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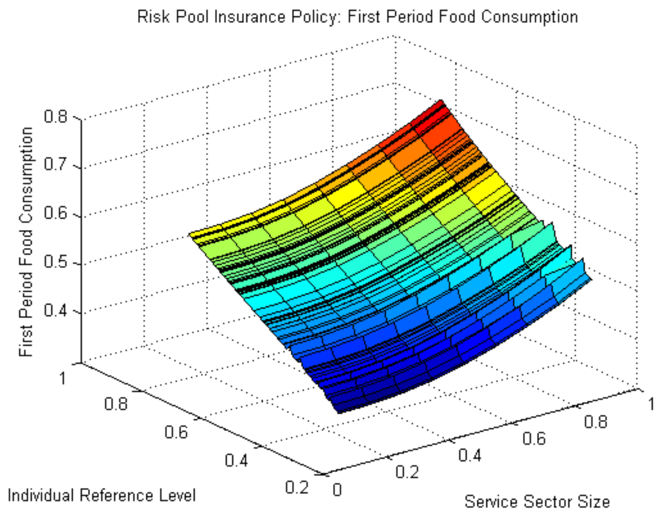

Figure 1: The impact of health consciousness and service sector size on first period food consumption under risk pool regime

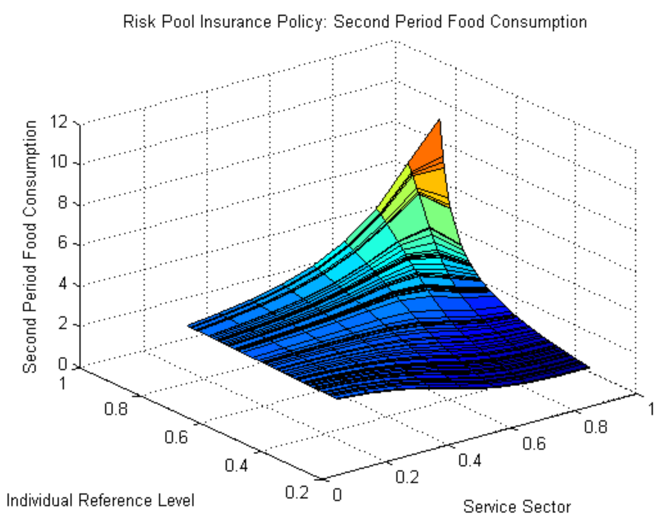

Figure 2: The impact of health consciousness and service sector size on second period food consumption under risk pool regime

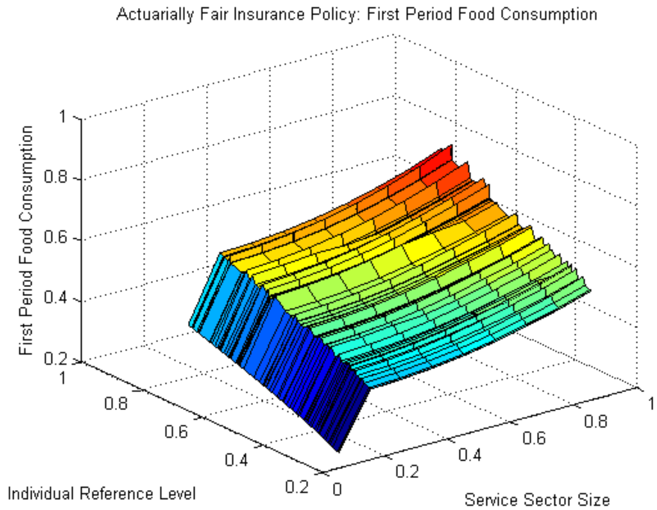

Figure 3: The impact of health consciousness and service sector size on first period food consumption under actuarially fair regime

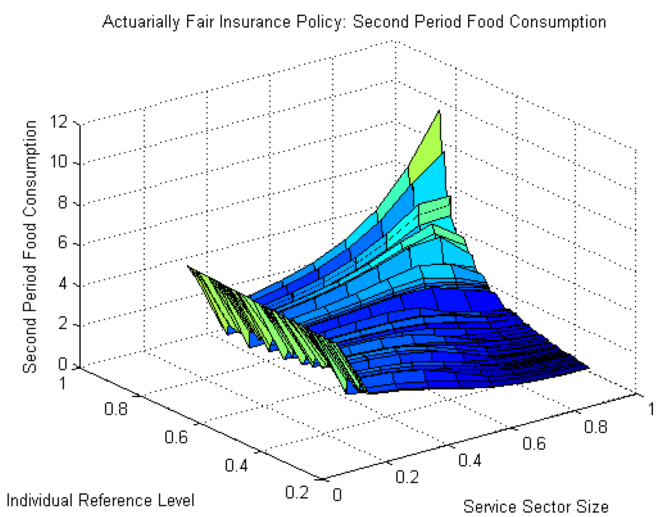

Figure 4: The impact of health consciousness and service sector size on second period food consumption under actuarially fair regime

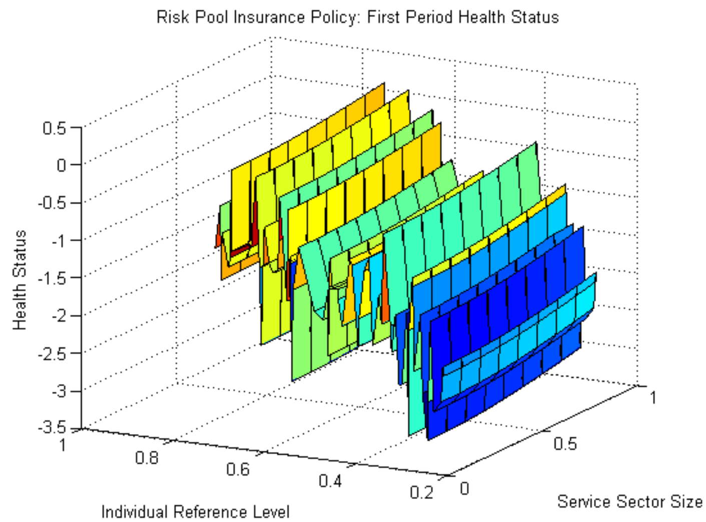

Figure 5: The impact of health consciousness and service sector size on first period health status under risk pool regime

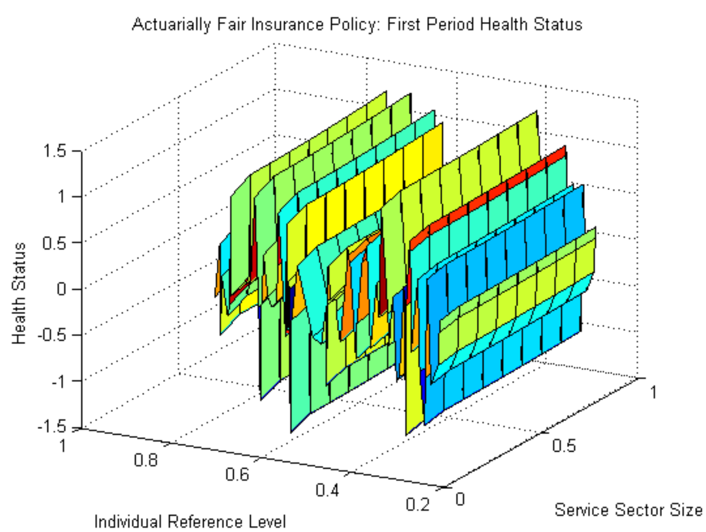

Figure 6: The impact of health consciousness and service sector size on first period health status under actuarially fair regime

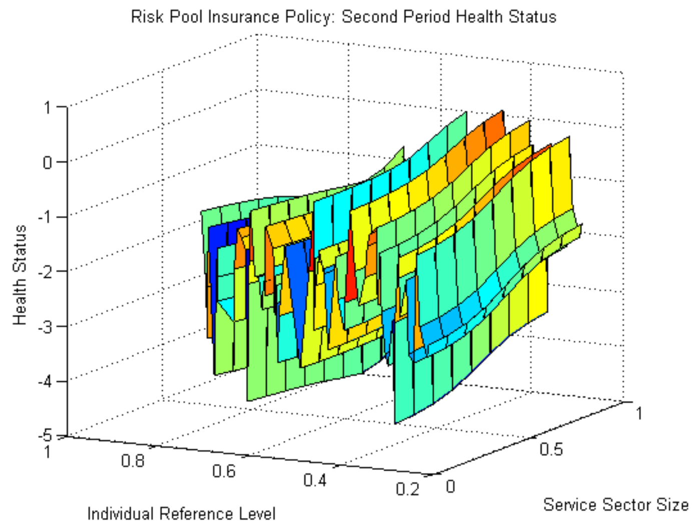

Figure 7: The impact of health consciousness and service sector size on second period health status under risk pool regime

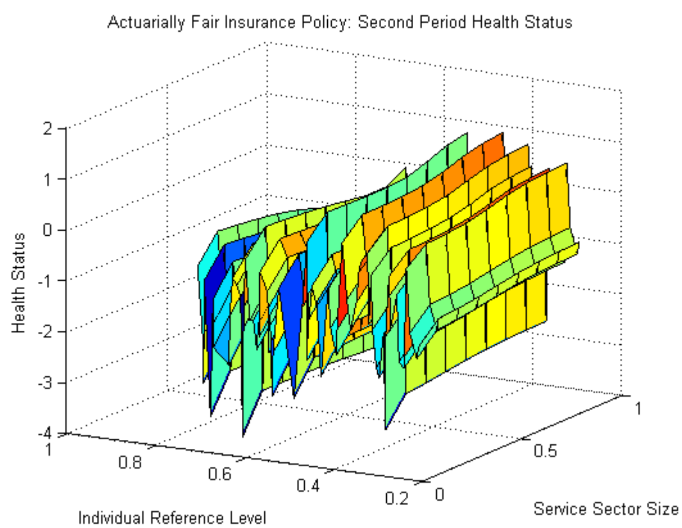

Figure 8: The impact of health consciousness and service sector size on second period health status under actuarially fair regime

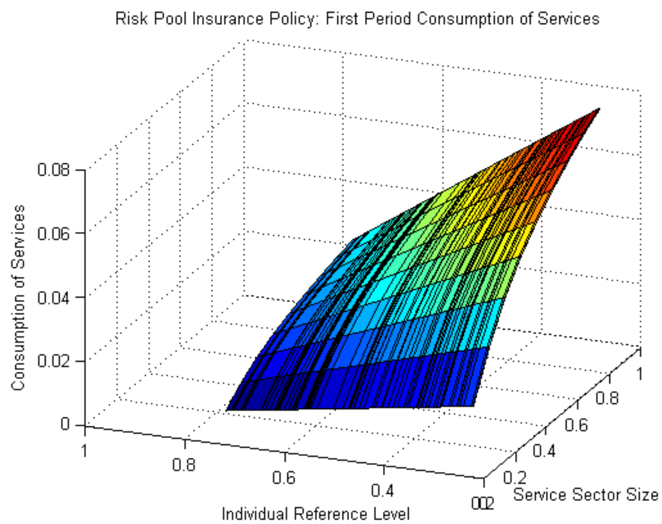

Figure 9: The impact of health consciousness and service sector size on first period consumption of services under risk pool regime

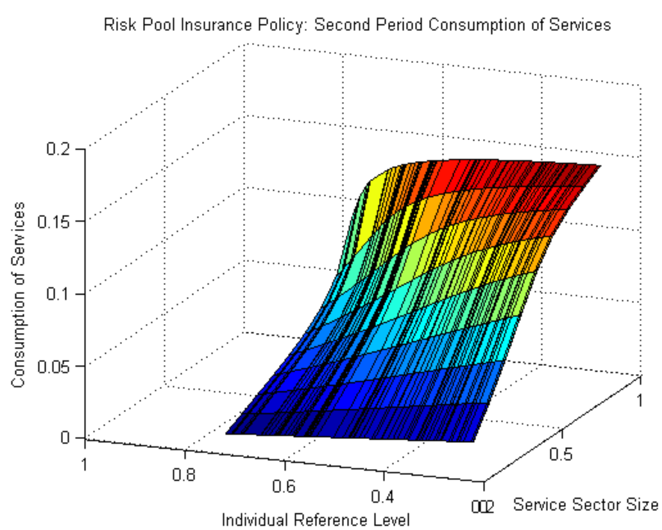

Figure 10: The impact of health consciousness and service sector size on second period consumption of services risk pool regime

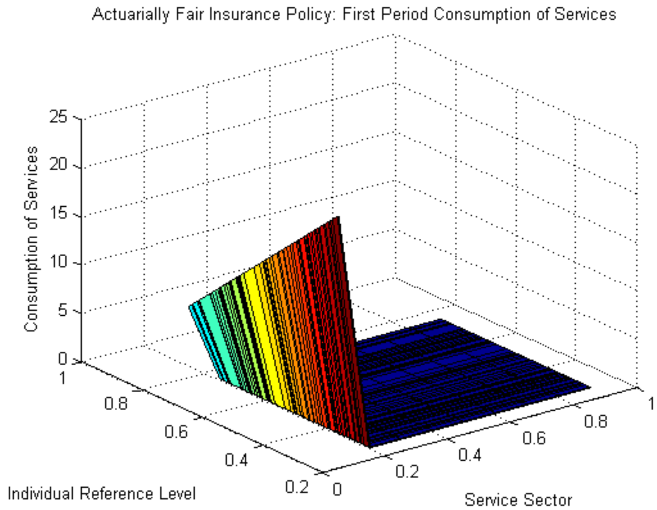

Figure 11: The impact of health consciousness and service sector size on first period consumption of services under actuarially fair regime

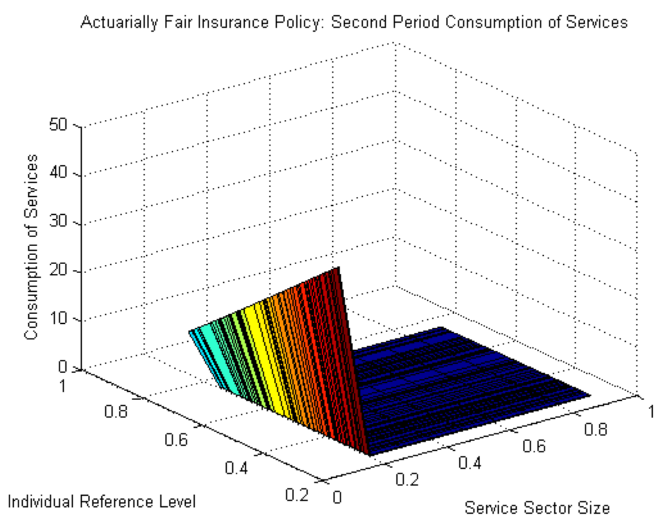

Figure 12: The impact of health consciousness and service sector size on second period consumption of services under actuarially fair regime

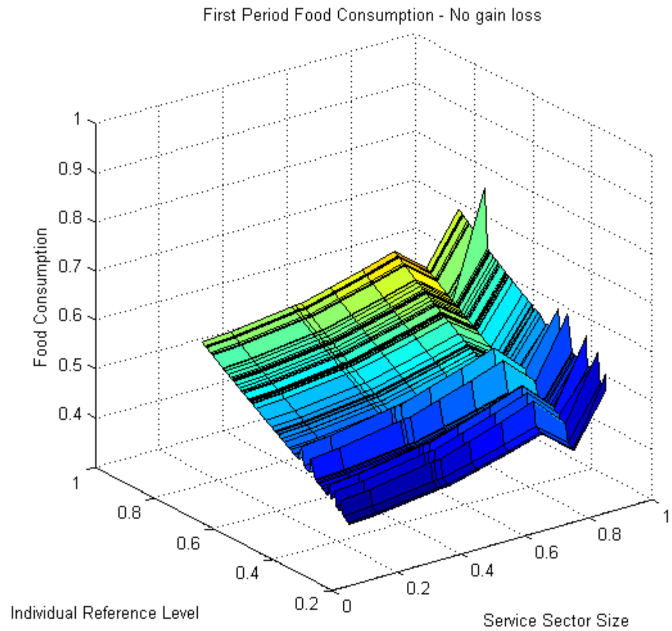

Figure 13: The impact of health consciousness on first period food consumption under both insurance regimes, having eliminated the reference dependent part of the utility function

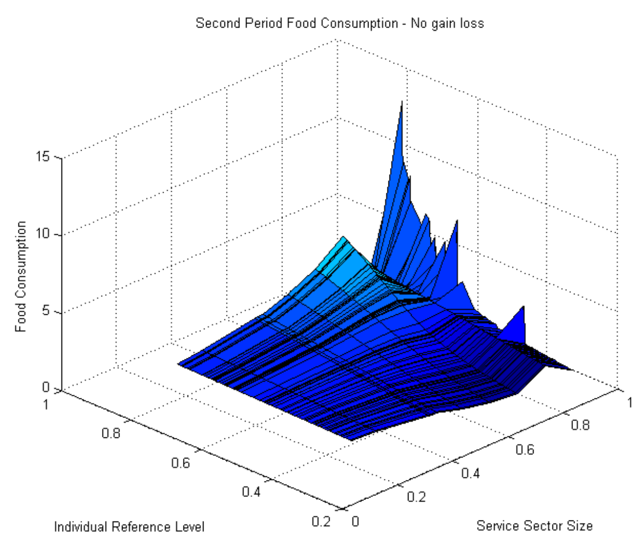

Figure 14: The impact of health consciousness on second period food consumption under both insurance regimes, having eliminated the reference dependent part of the utility function

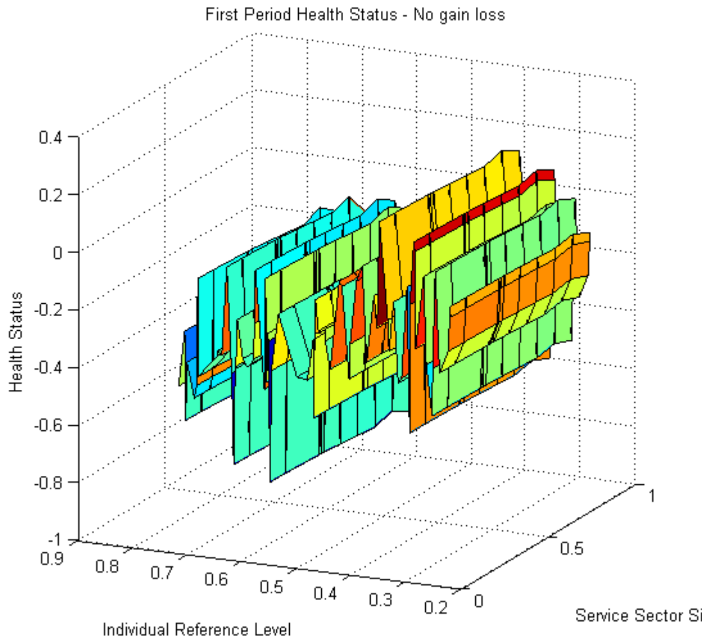

Figure 15: The impact of health consciousness on first period health status under both regimes, having eliminated the reference dependent part of the utility function

Figure 16: The impact of health consciousness on second period health status under both regimes, having eliminated the reference dependent part of the utility function