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**Evaluating Health Care Externality
Costs Generated by Risky Consuption Goods**

by Michael A. Cohen and M. Selini Katsaiti

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University of Connecticut
Department of Agricultural and Resource Economics

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

Michael A. Cohen

University of Connecticut

michael.cohen@uconn.edu

M. Selini Katsaiti

University of Athens

marina-selini.katsaiti@uconn.edu

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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 proneness 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. To model this the paper borrows insight from prospect theory and applies the reference-dependent preference framework to the specification of out utility model. 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 risk associated with consumption of unhealthy goods 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 the less health-conscious are engaged in less healthy consumption 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. This paper introduces the mathematical programming equilibrium constraint (MPEC) computational approach to compute model equilibria; we believe this approach is new to heterogeneous agent OLG model simulation.

1 Introduction

Overeating, smoking, and alcohol consumption have taken center stage the health care cost debate. These risky consumption choices are driven by consumer preference 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 a 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 demonstrates 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. On the production side there are three sectors: one that produces a risky good, one that produces health care, and one that produces the composite non-risky consumption good. 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 view 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 their model 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.

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 "unhealthy" individuals, the healthy 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. 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

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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) estimates 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 significant contributions. 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, and 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 preference 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. The firms belong to one of 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 their health state 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:

$$u(c|r) = m(c) + n(c|r), \tag{1}$$

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,

$$U(F|r) = \int u(c|r)dF(c). \tag{2}$$

When if we assume the reference point r is beliefs about the consumption outcome the reference point is also stochastic and is drawn according to the probability distribution G, then utility is,

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

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 frame-work. 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, D, the risky consumption good, f, their health, h, and the discrepancy between their actual health and their beliefs, r, about what their health state should be given consumption of the risky good. Health care consumption is determined by the 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 state need to consume health care. Individuals are assumed to supply labor inelastically and place no value on leisure.

Individuals maximize their objective function:

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

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:

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

here the consumption bundle consists of food, f, and a composite consumption good, D, as well as total factor health shock, 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 expectations about required health care consumption. 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. 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 the only consumption good an individual potentially has uncertainly about is health care. This assertion simplifies the departure function $m(h) - m(\mathbb{E}[h])$ to be $h - \mathbb{E}[h]$

The distribution function of health shocks is parameterized with a location and dispersion parameter. We assume health shocks are drawn from the 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:

$$\mathbb{E}[h_{t+1}^i] = \mathbb{E}[h_t^i] + ln(1 + \alpha_i)\nu_t^i + ln(1 + \alpha_i f_{t+1}^i).$$

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 used in services and $1 - u$ in the production of food. Capital is split in the two sectors such that there is no arbitrage.

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

$$Y = A K_2^\psi (1 - u)^{1-\psi} \tag{7}$$

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:

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

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 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:

$$HC = G K_3$$

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 weight 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 weight.

In the risk pooling case all agents face the same insurance premium. So health risk is pooled across individuals with different body weight. 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:

$$\sum \overline{P} \propto \sum h_i \tag{9}$$

The amount of the premium is given by the average health care expenditure in the population. In particular:

$$\overline{P} = \frac{\sum h_i}{N} \tag{10}$$

The average individual for whom $hc_i = \overline{P}$ 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 $h_i < \overline{P}$ and those above the margin $h_i > \overline{P}$.

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 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 weight 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:

$$\sum P(h_i) = \varphi h(f_i) \tag{12}$$

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.

2.5   Equilibrium

Given an initial distribution of α_i, a stationary equilibrium is characterized by: 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, a time-invariant distribution of $a_{t+1} \in \Lambda$, $f(a_{t+1})$, time-invariant relative prices of labor and capital in both sectors $(w_t^z, r_t^z, w_t^y, r_t^y, w_{t+1}^z, r_{t+1}^z, w_{t+1}^y, r_{t+1}^y, r_{t+1}^h c)$, and 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 steady 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 and equilibrium in goods markets given zero arbitrage equilibrium conditions in capital markets and labor markets. The two steps are iterated until 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 is 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 are 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. Given these constraints we chose to populate our economy with 148 individuals, $n = 74$ in each generation, who are heterogeneous in 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. If supply is greater than demand then the price decreases and if demand is greater than supply then price goes up. The sizes 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 care consumption 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 reference points for expected health care consumption. 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 more health care results from their understanding that being overweight has health consequences. On the other hand the high reference population (high values of α) fail to accurately calculate the consequence of obesity, an suffer 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 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 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 service sector size increases.

Health status is 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. This fact means that the most health conscious pay the largest share of the tab while the least health conscious are subsidized to the largest extent. Since individuals weigh more in their latter generation they actually consume more obesity related health care in their old age than their younger counterparts. So for both young and old, regardless of their reference point, greater food consumption translates worse health status and greater need for health care. Figures 5 and 6 show health state for young individuals in the two regimes and Figures 7 and 8 show the same results for the old generation. Our findings clearly show that individuals characterized by greater values of α are less healthy in equilibrium. The model is structured such that agents with negative values of health status need health care. Healthy individuals, with health status level positive are assumed not to need health care. Thus negative health status is equivalent to positive health care consumption.

Second Result: Less health conscious individuals have lower health status and consequently consume more health care compared to their more health conscious counterparts

in equilibrium, ceteris paribus.

The first two results might seem obvious to the reader. These results should provide the reader with more confidence in the model presented and therefore more confidence in the following less trivial results.

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.

Thus policies that want to reduce obesity and the health care costs associated with diseases that could be prevented through behavioral change should focus on enforcing measures to make individuals worry more about their health status.

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 are thus expected to weigh more in equilibrium. This is also verified in the data. In the first chapter we showed, using data from 128 countries, that the unconditional expectation of obesity given service sector size is strictly increasing in the service sector size. This result agrees to a large extent with the findings of this paper. In particular, regarding health status, our results show that it is strictly decreasing in service sector size (Figures 5 and 6). However, this results are reversed for old agents under both insurance regimes (Figures 7 and 8). Thus, there is no single one conclusion regarding the effect of service sector size on individual health status, ceteris paribus.

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. That is, under the risk pool insurance policy, where health care cost is shared 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 find themselves with bad health status (negative values) whereas under the actuarially fair insurance policy the graph is more balances 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 care consumption 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 population. 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. The results regarding the impact of the size of the service sector again do not agree on a single 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 the agents health status.

Table 1: Simulation Results for Health Status Under Both Regimes

Service Sector Size									

Risk Pool: Health Status Young

u	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

u	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

u	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

u	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

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

3.5 The Externality

Our simulation results clearly indicate the presence of externalities in the case of risk pool insurance premia. In particular the population lower health status, caused by risky behavior and/or negative health shock, need more health care on which the individual cost is higher than the common premium they pay. Table 2 presents the number of individuals that receive and give 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 generation, 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 according to the risk pool case. For the old generation, aggregate health care consumption under actuarially fair pricing is reduced to 1/2 of its height when risk pooling insurance premia are enforced.

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 decision. 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 cost 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 condition 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 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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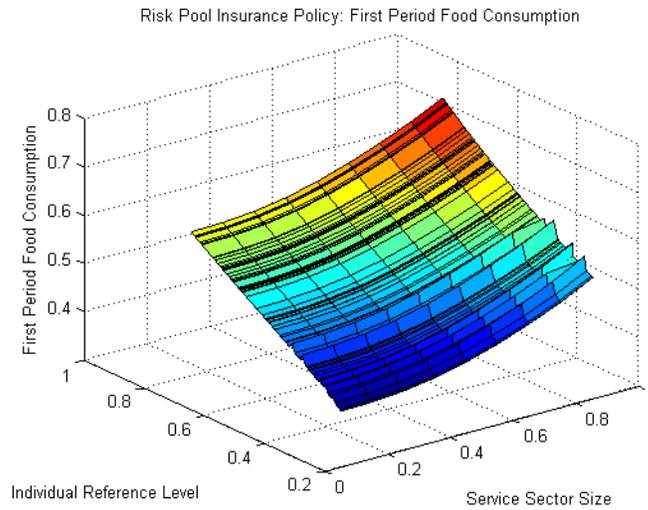
Figure 1: The impact of health consciousness and service sector size on first period food consumption under risk pool regime
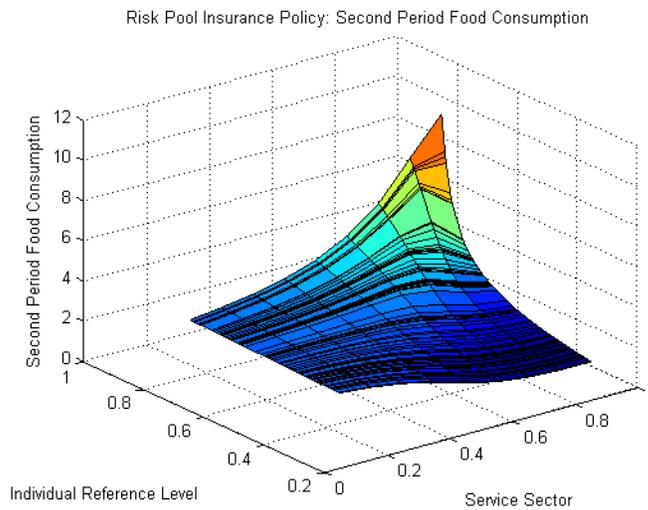
Figure 2: The impact of health consciousness and service sector size on second period food consumption under risk pool regime
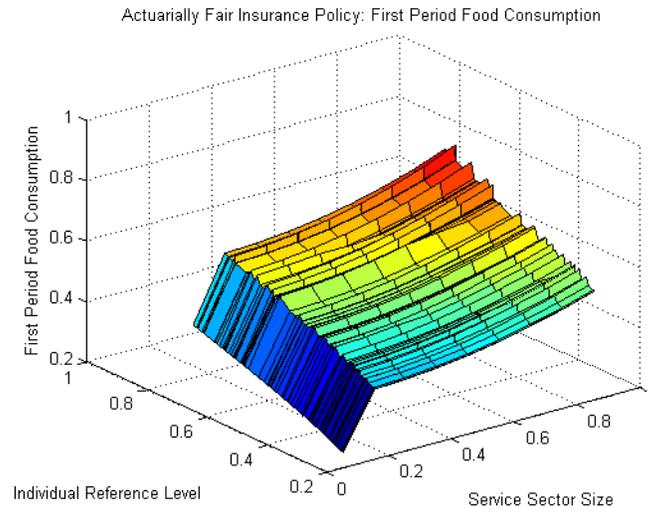
Figure 3: The impact of health consciousness and service sector size on first period food consumption under actuarially fair regime
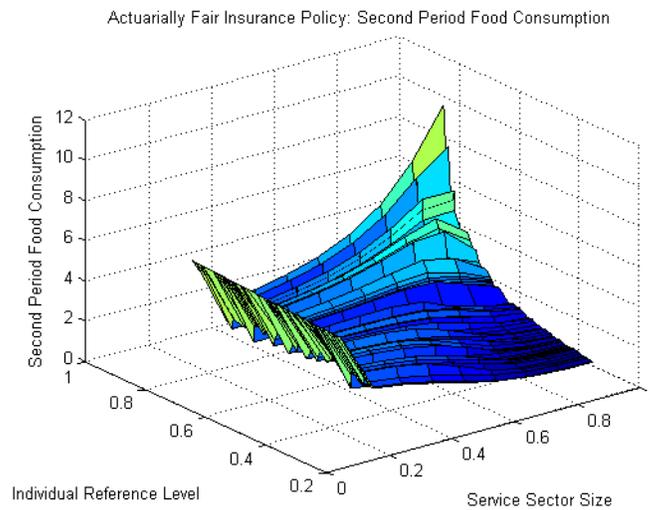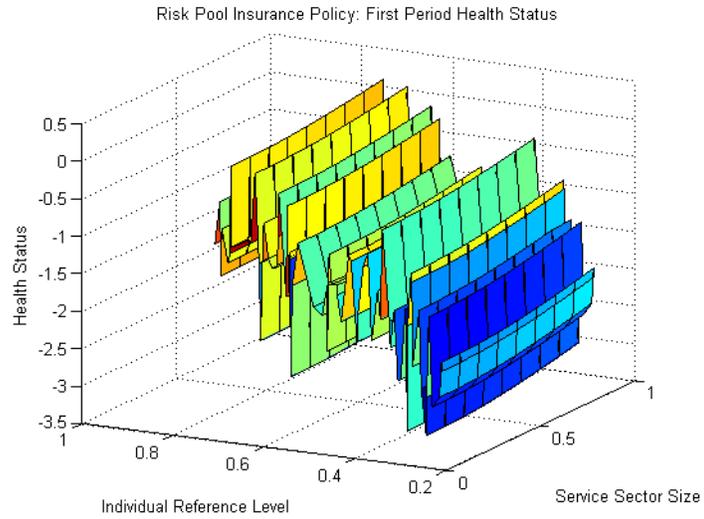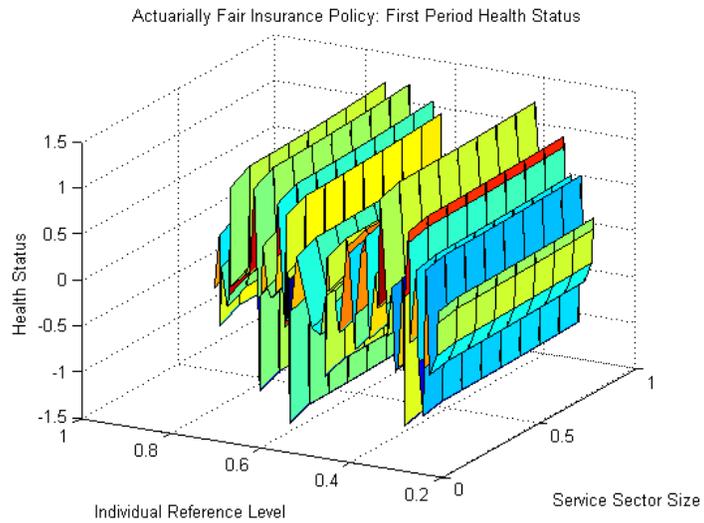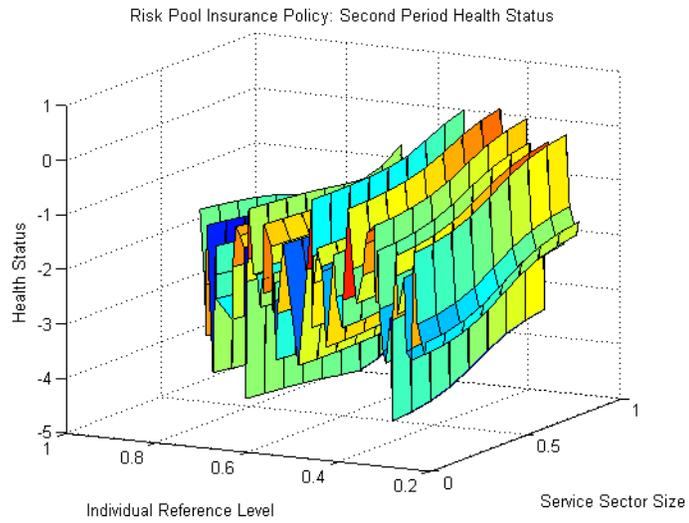

Figure 4: The impact of health consciousness and service sector size on second period food consumption under actuarially fair regime

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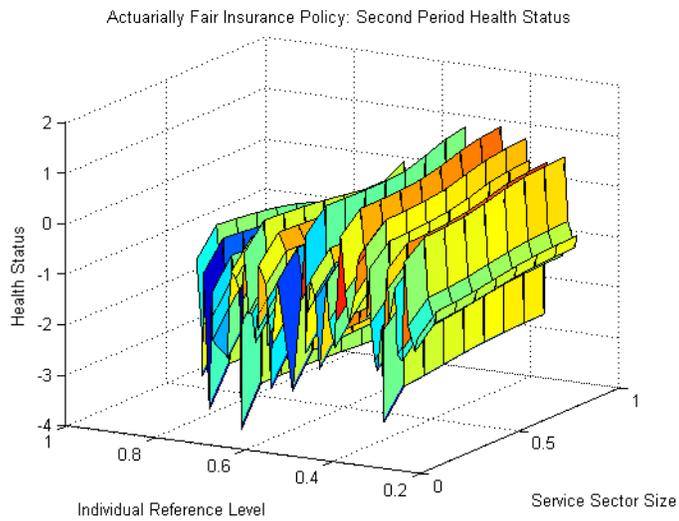

Figure 6: The impact of health consciousness and service sector size on first period health status under actuarially fair regime
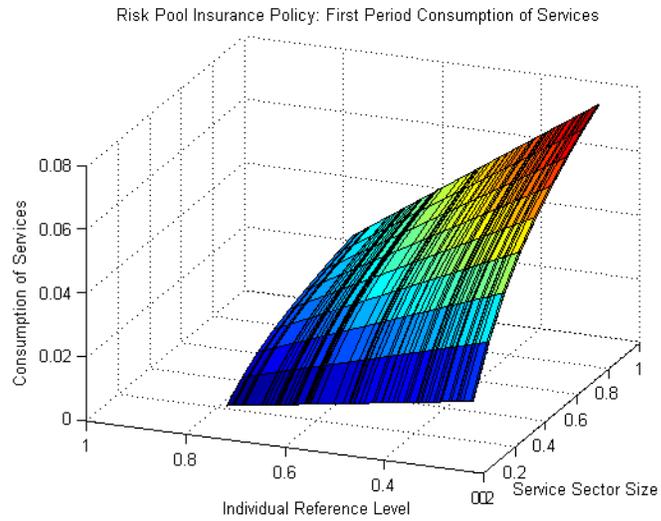
Figure 7: The impact of health consciousness and service sector size on second period health status under risk pool regime

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
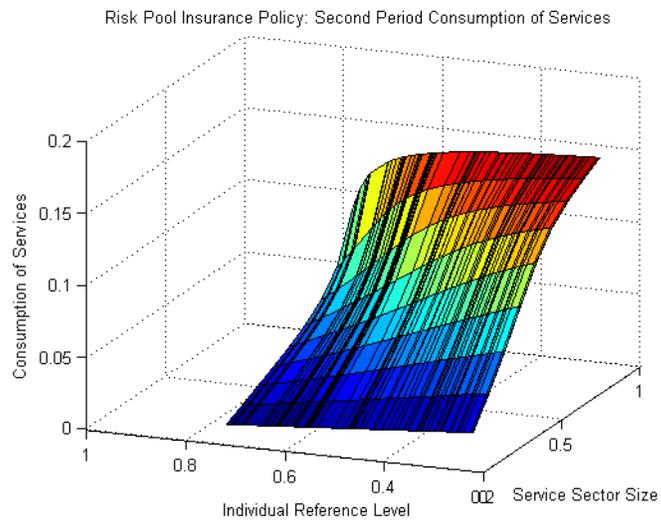

Figure 10: The impact of health consciousness and service sector size on second period consumption of services risk pool regime
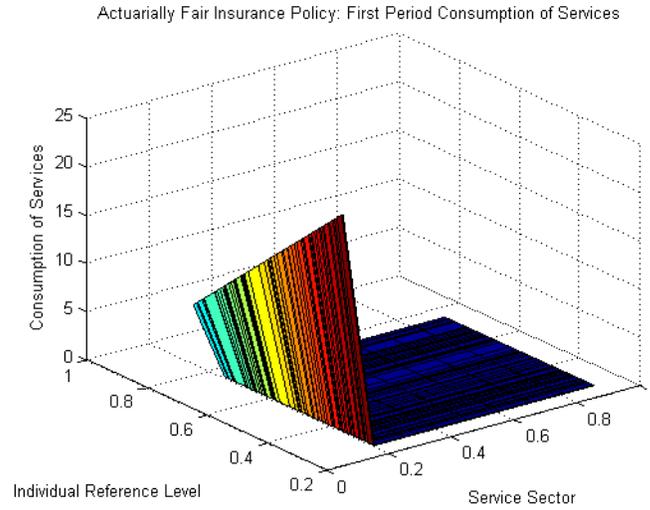
Figure 11: The impact of health consciousness and service sector size on first period consumption of services under actuarially fair regime
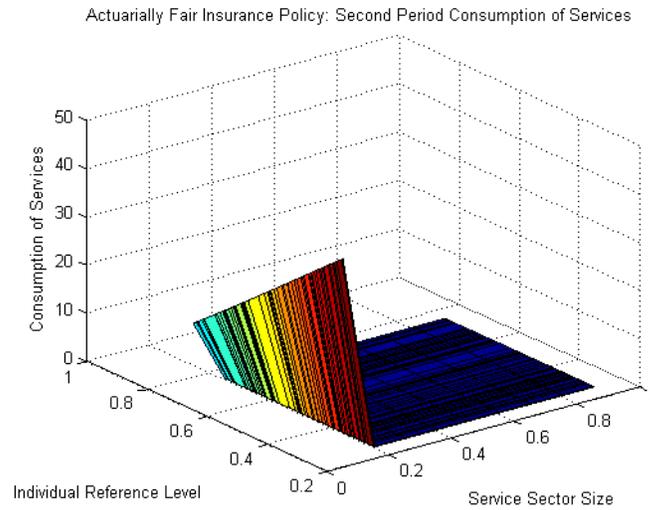

Figure 12: The impact of health consciousness and service sector size on second period consumption of services under actuarially fair regime

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Food Marketing Policy Center
1376 Storrs Road, Unit 4021
University of Connecticut
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