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An Experimental Investigation of Income, Insurance, and Investments in Health over the Life Course

Comments

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An Experimental Investigation of Income, Insurance, and Investments in Health over the Life Course

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Abstract

We examine the impacts of age, income and insurance plan on behavior in a virtual environment with cash-motivated subjects, who live multi-period lives in which they earn income and spend on enjoyment, insurance, and investments in health. Health shocks increase simulating aging. The 2x2 experimental has high and low income subjects, and offers employer-based or actuarial insurance. We find: 1) subject behavior approximated optimal responses; 2) in all treatments, subjects under-invested in health early in life and over-invested in health late in life; 3) subjects in the employer-based plan purchased insurance at higher rates; 4) the employer-based plan reduced differences due to income and age; 5) subjects in the actuarial plan engaged in more health-promoting behaviors, but still below optimal levels, and did save at the level required, so did realize the full benefits of the plan. Should these results generalize, they have clear implications for the health insurance policy.

JEL-Codes: *I11, I12, I13, I14*

Keywords: *Health insurance, Moral Hazard, Inter-generational, Subsidies, Actuarially fair, Employer-based*

1 Introduction

US health care costs consume 17.5% of the (CDC, 2018), about 3.2 trillion dollars or nearly 10,000 per person, and close to twice that of other developed nations (OECD,

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2017; CMS, 2019a). At the same time, the ranking of the U.S. relative to other OECD nations has decreased with respect to both health outcomes and mortality rates in the last decade (National Research Council, 2010; National Research Council and Committee on Population, 2013). The deteriorating ranking of the U.S. is at least partly due to higher prevalence of risky behaviors and lifestyles, such as obesity, smoking, and lack of physical activity (ibid).

Socioeconomic status (SES) is strongly linked to morbidity and mortality. For example, Bosworth et al. (2015)), using data from the Health and Retirement Study, report that for women (men), 50-74 years of age, mortality risks are 3.0 (2.24) times higher among individuals with less than high school education than those with college degrees. They also report similar relative risks comparing the bottom quartile of career earnings to those in the top quartile. Moreover, SES effects on mortality increased for those cohorts born later in the twentieth century. They also find that smoking, physical activity, and alcohol consumption have larger effect sizes than SES in the multivariate model including both. The relationship between health and SES is complicated and difficult to disentangle. There is reason to believe there is causality, reverse causality, and that many exogenous factors influence both.

Most of the negative health effects of behavior are delayed and accumulate over time; as such, the consequences are not apparent at younger ages. For example, cardiovascular disease (CVD) and diabetes develop over decades and account for more than 1/3 of all deaths (Ritchie and Roser, 2018). Together, the cumulative effects of lifestyle and biological aging itself lead to an accelerating disease burden and corresponding medical costs with age. For example, in 2014, average annual health care spending for persons over aged 65 was \$19,098, about two and a half times as much as working-age persons (\$7,153) and five times higher than children (\$3,749) (CMS, 2019b).

Not only do health care costs increase with age, but they tend to be lumpy in distribution, triggered by symptoms that lead to diagnosis and treatment of specific forms of morbidity. Health care cost ‘shocks’ provide incentives for insurance. Western countries vary considerably in the health insurance available to their populations, but the U.S. is a clear outlier with respect to health insurance policy. Whereas the majority of western countries have some form of single-payer government-sponsored plan, people in the U.S. have had a mix of private and public plans available to them. During the second half of the twentieth century, most people under the age of 65 who did not qualify for public assistance had two options, depending on their employment status. People working for larger firms or institutions had employer -sponsored and -subsidized health insurance available for purchase. People working independently or for firms that did not offer health insurance could purchase insurance in a private market. A principal difference between these insurance options is in the way that heterogeneous expected costs determine premiums paid for the plan. In the private sector, premiums tend to vary by age or other factors, such as behavior, that affect expected health costs; whereas, in employer-based systems, premiums do not depend on individual expected payouts.

Rising health care costs, the effects of previous conditions on insurability in the private sector, and SES differentials in insurance coverage have contributed to on-going debate about insurance policy, the passage of the “Affordable Care Act” (ACA), also known as Obamacare, and more recently, attempts to repeal the ACA in part or whole. As of now, both employer-based insurance and plans available through the exchanges derived from the ACA typically require the insured purchase the insurance at standardized price, rather than a price that (fully) reflects individual risk levels. However, the appropriate structure for healthcare insurance remains fiercely contested, and countless systems have been proposed or implemented that run the gamut from complete personal responsibility (for costs and risks) to complete shared responsibility. Privately purchased insurance prior to the ACA, and health savings accounts are at the extreme of personal responsibility while single-payer plans stand at the opposite end.

Debates about cost sharing weigh relative expected financial costs for society versus relative expected benefits. A cost sharing system can be more expensive because there is potential for moral hazard and adverse selection—the cost structure does not deter people from seeking excessive care nor higher need people from joining. However, these systems can improve social welfare and equality, by providing care to those who could not otherwise afford it, including the poor, elders who fail to plan for rising costs, and people with the misfortune of high care costs.

Our incomplete understanding of how individuals manage decisions regarding investment in health and the purchase of insurance over the long course of their lives hampers an assessment of the costs and benefits of alternative policies. Presumably, obesogenic diets, being sedentary, smoking, alcohol and drug consumption all provide current utility and satisfaction at the cost of expected future shocks to health. We currently lack an adequate understanding of how people manage those trade-offs. We also need a better understanding of how people manage income allocations to saving, current consumption, health regeneration, and health insurance. Given that shocks to health are lumpy and not deterministic in time, a dynamic model that adjusts to realized and expected future shocks is necessary. Allocation decisions are likely to interact with the particular insurance policy options that are available to people. Thus, the model must be capable of shedding light on those complex interactions.

This paper reports the results of a virtual-environment experiment designed to investigate how people make health and consumption decisions dynamically throughout their life course, and how different insurance policies would interact with those decision processes. Our test environment, based on the Grossman (1972) lifecycle model of health investment, is designed to capture the essential elements and consequences of health-related behaviors and expenditures. Subjects live multi-period lives and have a stock of health that naturally deteriorates each period, and declines further if the subject suffers a stochastic illness event, to which we refer as a ‘shock.’ In each period, each subject receives an allocation of virtual currency that depends positively on his individual health; this is to capture the idea that health effects the earnings from work. Subjects must then decide on how to al-

locate their income to current consumption versus savings and health-related investments. Health-related investments include the purchase of health insurance, health recovery from depreciation and shocks, and expenditures on physical fitness or resilience that lowers the size of potential future shocks. The ability to invest in resilience is designed to capture preventative behaviors such as exercise, diet and abstention from smoking, drugs, etc. Shock probability increases in the second half of life to capture the effects of aging. Insurance pays for recovery from shocks. Subjects must decide whether to purchase insurance each period and coverage lasts only for that period.

We conducted a 2x2 experimental design in which subjects were assigned to one of four experimental treatments cells. One treatment dimension varied subject income. The other treatment dimension varied whether insurance policy regimes were actuarial and employer-based. For the actuarial plan, subjects were offered insurance at an actuarially-fair premium rate that depended on the expected future costs of the shocks they were to experience, which, in turn, depended on their investments in fitness, their current health and their age. For the employer-based plan, subjects could purchase insurance at a fixed premium for all periods of life that did not depend on age, health or fitness and that was approximately equivalent to the average lifetime rate in the actuarial treatment. In addition to the 2x2 treatment design, all subjects face a young and an old period during each life with the latter characterized by higher health risks, so our statistical analysis is necessarily 2x2x2.

A controlled laboratory decision-making environment allows us to examine how insurance policy options interact with the endogenous life cycle choices of individuals with different earning potentials over a long life horizon. The insurance policies we test are abstractions meant to inform policy, regardless of the course of political development. The actuarially fair insurance plan through perfect risk-sensitive pricing theoretically eliminates adverse selection and moral hazard problems. The employer-based plan creates potential for moral hazard, but also may generate more equitable health outcomes.

The paper proceeds as follows. The next section reviews the theoretical and experimental literature relevant to this research, followed by more detailed descriptions of the theoretical model motivating the experiment and the experimental environment and design. The following sections presents the theoretical and empirical results, respectively. The final section concludes with a summary of our main findings and their theoretical implications, an assessment of some of the weaknesses in the current design, and appropriate directions for future research.

2 Literature

Grossman (1972) presents a model in which health naturally declines every period and people invest time and money to restore their health. Grossman notes that resources are limited so investment in health must be traded off against other investments, based

on relative marginal returns. These conditions create an optimal path for the decline of health across life such that it is eventually optimal to die rather than prolong a life that offers minimal enjoyment. However, the heterogeneity of mortality rates and health related behaviors (exercise, diet, vices) empirically observed, indicates that individuals are choosing very different strategies. Our experiment builds directly on this model, but examines that heterogeneity to expand the model.

The term moral hazard has been used in the insurance industry since the 17th century (Hale, 2009). Arrow (1963) introduces it to the medical insurance literature. Arrow however argues that insurance will improve welfare, noting that a physician can help mitigate moral hazard through judging the medical necessity of treatment. Pauly (1968) argues that moral hazard is not easily ameliorated and can be so severe that some care is uninsurable. Rothschild and Stiglitz (1976) contribute to the theory on adverse selection, deriving the conditions necessary for pooling across risk types and for equilibria (stable insurance markets) to exist. For a thorough review of the literature on health insurance see Cutler and Zeckhauser (2000).

A handful of field experiments (Manning et al., 1987) and “natural experiment” policy changes (Weathers and Stegman, 2012; Courtemanche and Zapata, 2014; Finkelstein et al., 2015; Lipton and Decker, 2015; Courtemanche et al., 2018; Ghosh et al., 2019) confirm that health care usage increases in response to more generous insurance benefits (decreased costs to the insured). In general, these studies have found few if any health benefits to increasing access to (decreasing cost of) health services. However, since these studies have short time horizons and cannot rule out long-term benefits or otherwise unmeasured benefits, it remains unclear whether the increased spending is indeed due to moral hazard. In another natural policy experiment, Cutler and Reber (1998) describe an initiative for the employees of Harvard University in which an employee was given a credit (voucher) which paid part of the premium of a selection of insurance plans. The results illustrate the ‘death spiral’ adverse selection can create, the most generous (and most expensive) plan attracted the employees using the most care which necessitated raising premiums, which in turn causes the healthier members to leave the plan. The plan became inviable within a couple of years.

There are few other experiments involving health insurance. (Buckley et al., 2012) report on an experiment in which subjects were asked their willingness to pay for private insurance which had the potential give them priority when medical care was rationed. (Loewenstein et al., 2013) survey representative samples of Americans with private health insurance and find poor comprehension of health insurance a strong preference for simpler plans.¹

We build upon our previous work Bejarano et al. (2014), utilizing lab experiments as a tool for testing the implications of the health investment and how investments in health

¹On average, participant answered 58% of the multiple choice questions correctly and only 11% were able to answer and open ended question. 55% prefer or strongly prefer a simplified plan compared to 14% who prefer or strongly prefer existing plan.

over the life course respond to income streams, retirement, and the social environment. The current experiment includes shocks to health and the possibility of insuring against those shocks through savings or insurance purchase. The interface conveys information about all the factors that a subject must consider when making investments in health, resilience, insurance, savings, and life enjoyment. Through feedback, chat with other subjects, and multiple lives (a surrogate for inter-generational transfer of knowledge), subjects have the opportunity to learn and develop strategies about how to manage a multi-period life.

3 Experimental Design

3.1 Model

In this model, resources are limited and can be allocated between enjoying life and ensuring that it continues. As the subject navigates life period by period (from periods $t = 1, 2, \dots, T$), increasing health allows an individual to be more productive, earn greater income and spend less time attending to ailments; thus, income available to be spent by the subject during each period of the experiment is dependent on health. Any income not spent on health or life enjoyment (ie., current consumption) is deposited into a savings account available for future consumption or investments in health. A final cash payment based on accumulated joy incentivizes experimental subjects to maximize the utility that derived from personal consumption summed across all periods in life. Joy is a concave function of dollars invested in consumption, moderated by health—as being healthy allows one to enjoy life more. Per Grossman (1972), health is in perpetual decline (by a fixed amount of degeneration each period) but investments in health can mitigate the decline and increase health. Health is also subject to stochastic shocks that depend on age and corresponding shock sizes that depend on resilience.

Listed below is the event timeline faced by individual decision makers in our model. Each period, t , is subdivided into the following four stages:

1. Investment allocations are made in health I_t^H , resilience I_t^R , joy I_t^J , and whether or not to buy insurance $D_t^I = \{0, 1\}$. Any remainder S_t becomes savings available for investment in the next period.
2. Intermediate health $H_{t'}$ is determined for the current period considering natural degeneration δ , investment in health I_t^H , and whether an additional health shock Δ_t is received with probability θ_t .
3. Received joy J_t is computed based on investment in joy I_t^J , and intermediate health $H_{t'}$.
4. Income for next period Y_{t+1} is earned based on intermediate health $H_{t'}$.
5. Final health H_t is then determined, based on whether insurance was purchased ($D^I == 1$) if a shock Δ_t occurred.

Here are the corresponding equations that govern the individual's welfare maximization problem:

Maximize:

$$\sum_{t=1, T} J_t$$

Subject to:

$$Y_{t+1} = \Omega^c \times H_{t'}$$

$$I_t^H + I_t^R + I_t^J + D_t^I \times \rho_t^I + S_t = Y_t + S_{t-1}$$

$$H_{t'} = H_t - \delta + \frac{e^{\mu \times I_t^H}}{e^{\mu \times I_t^H} + (1 - H_t)/H_t} - \Delta_t(\theta_t) \times e^{-r \times I_t^R}$$

$$J_t = \frac{I_t^J}{(\gamma + I_t^J)} \times H_{t'}$$

Where:

Ω^c is a constant disposable income available to an individual in perfect health of high or low income.

ρ^I is the current price of insurance, which is constant under employer-based insurance but reflective of current health and age under actuarial insurance.

μ and γ are preset constants that determine the marginal rates of return on investments in health and joy.

θ_t is a binomial $\{0, 1\}$ random variable with age dependent probability of a shock occurring.

Note that in this model, even though insurance provides treatment for shocks, there are still negative consequences from suffering a shock for both the insured and uninsured, as intermediate health $H_{t'}$ remains at a lower level when joy J_t , and the income for next period Y_{t+1} are calculated.

In the experimental environment that is used to implement this model, health is restricted to values from 100 (perfect health) to 0 (death). Life starts with health at 70 ($H_0 = 70$) and depreciates by 8 ($\delta = 8$) each period with certainty. In addition, health declines further if there is a shock in a given period. The shock probability is 3/12 in the first half of life ($\theta_t = .25$ for $t \leq 16$), and 5/12 in the second half ($\theta_t = .4167$ for $t > 16$). The unmitigated shock was set to 25 health points ($\Delta = 25$), but could be reduced to as low as 12 through the purchase of resilience I^R . The reduction in health from either source could be reversed through direct investments in health I^H .

To explore the heterogeneous impacts of insurance plans we create two types of variation in the population. A Subject is either high or low income. Actual income for both types is health multiplied by their type constant. The constant Ω^c for the high-income type was

200, 1.25 times greater than the one for the low-income type, 160. While we refer to the types as high and low, both types had sufficient income to purchase insurance so might be better described as high and middle income. For all levels of health dipped below 35, the subject received the minimum income, the same amount as if she had a health of 35. For both income types we increase the probability of health shocks during the second half of life when the subject becomes old, creating a second type of variation. Our environment is mathematically equivalent to an overlapping generations' model.

The logistic function that governed the cost of health regeneration was cheapest when health was at the middle of possible values (50), and more expensive when the subject was in poor or excellent health. Our intention was to model increasing costs when there are comorbid issues or the patient is otherwise in poor health complicating treatment.

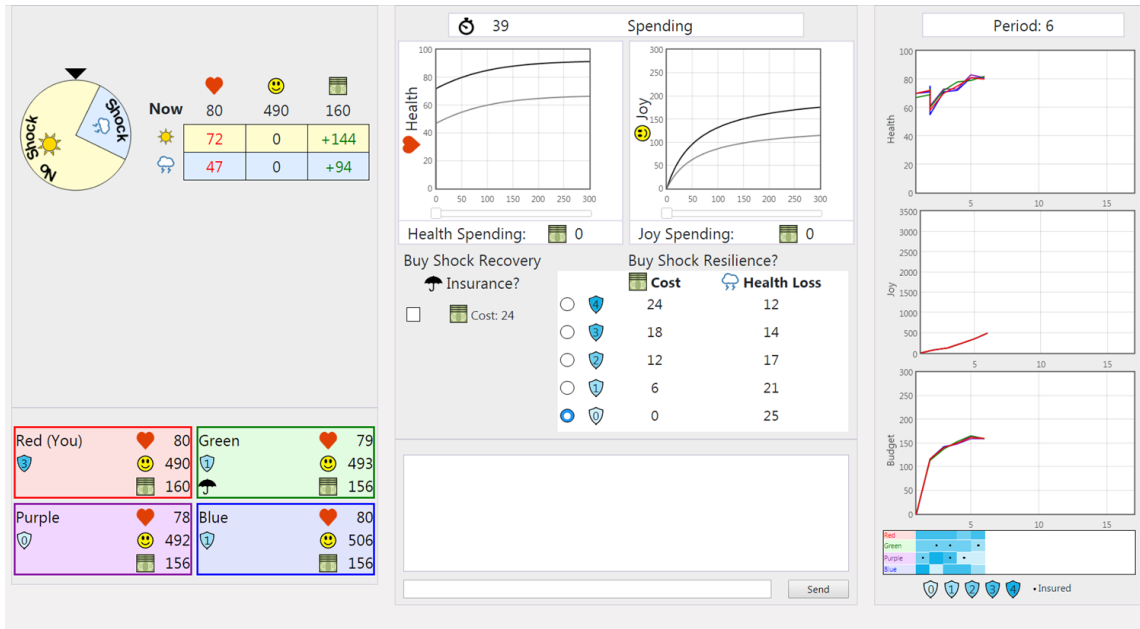
The employer paid 75% of the premium cost, subsidized by wage reductions that were universally imposed on all employees, regardless of whether the individual chose to purchase the insurance. The employee was offered the opportunity to purchase insurance at a cost that was approximately 25% of the real cost of insuring the average person in the pool. The constant deduction rate across incomes (18%) meant the system transferred from high to low income. The constant premium cost across age transferred from young to old. Calculations of exact amounts are in Table A.1.

This environment is very complex and an optimal path through life is not clear. The combination of stochastic shocks and dynamic interdependence across multiple investments, some with nonlinear profiles, make a closed form solution intractable. Instead, we employ a customized software algorithm to solve the associated stochastic dynamic program (DP). It calculates expected joy for every possible vector of investments given the thousands of potential states a subject could be in at any age, and then works backward from the last period to find the paths that optimize expected joy given any sequence of shocks that are incurred. We do not expect human subjects to achieve this optimality, however, distance from the DP's computed optimal path will serve as useful metric.

3.2 Experimental interface

Figure 1 shows the experimental interface seen and manipulated by the subjects. The heart icon represents health. The happy face denotes joy. Each shows the present value, and the resulting values next period with and without a shock. Income is in the top left and is the first number under the money icon. Money can be allocated to health or joy by moving the respective sliders below the graphs in the top center. The graphs allow the subject to see the diminishing marginal returns of both. Subjects make insurance and resilience decisions by checking boxes below the graphs. Remaining budget and potential outcomes update dynamically with each decision. Any unallocated money is saved, and added to income next period. Saving is possible for any number of periods but not across lives. Subjects were paid based on the sum their received joy across all periods and lives. Savings held at the end of life were lost.

Figure 1: Subject Interface



In the shock stage, the wheel in the upper left corner spins. If the pointer lands on the section with the storm cloud icon, the subject receives a shock. The shocks are pseudo-random. We use pre-generated sequences that rule out low probability sequences and reduce variation. The shock section of the wheel is proportionately larger during the second stage of life to convey the increased probability of a shock. Subjects could see what health and joy would be with a shock on the middle line in the upper left corner; the lower lines in the graphs represent values when shocked. The outcome stage is when the subjects receive joy and income. It was a separate stage to make it clear that both were based on the subjects' health, including reductions from any shock received that period. In the final stage, if the subject had bought insurance that period, health was restored to its pre-shock level. If the subject was uninsured or self-insuring through savings, they could pay to restore their health in the first stage of the next period. Income and savings in the experiment had no direct impact on subject payments.

Subjects are organized into groups of four individuals with the same income type. The right side of the screen shows the group history for the present life. There are graphs for health, cumulative joy, and budget. Each graph has a colored line for each group member that corresponded with the member's tile color and label. The bottom right corner displays each member's fitness history in a heatmap style graph, with dots indicating insurance purchase decisions. The numbers in the shield indicate resilience levels. The umbrellas indicate being insured. These icons correspond to ones used in spending decisions.

Table 1: Subjects per treatment cell

	Treatment	
	Actuarial	Employer
Low-Income	64	68
High-Income	64	64

Subjects can chose whether to chat with other group members through text. The bottom center is the chat section. Chat is available at all times including in pauses between lives. Even though subjects can chat, subject payouts from the experiment depend solely on individual performance. There is no financial reward to sharing information, nor is there any incentivized competition giving reason to withhold information.

After thorough on screen and audio instructions, subjects participate in three practice lives of 4, 16 and 16 periods, before engaging in the two longer 32 period lives that we analyze. All periods for all lives are paid. Subject who dies (i.e. Health = 0) in a particular life must waits until all the other subjects in the experimental session complete that life, but can chat with other group members and observe all their actions.

3.3 Procedures

We ran 12 experimental sessions at the Economic Science Institute (ESI) Lab at Chapman University between April 24th and May 16th, 2018. Eight sessions had 24 subjects, two had 20, one had 16 and one had 12.² Subjects were recruited via email through a database of subject volunteers ESI maintains. Table shows the 2x2 treatment design and number of subjects in each cell. Sessions lasted 120 minutes. Average subject earnings were \$36.79, including the \$7 show-up fee.

Table 2 lists insurer details by treatment, including insurance premiums charged, insurer profit and profit rate. Note that subject income was 19% lower under the employer treatment to cover the employer’s cost of insurance subsidies for all employees. Insurer revenue is defined as the sum of all premiums paid (in both treatments) plus all income reductions to subjects (in the employer treatment). Profit is defined as revenue minus the total amount paid to the subjects to recover from insured shocks. The profit rate is the profit divided by the revenue. The actuarial treatment had a slightly lower profit rate (6.3%) than the designed (10%), because, by chance, the stochastic shock rate on the periods when subjects did not buy insurance was lower than the rate during periods when insurance was purchased. The profit rate in the employer treatment (5.7%) was lower than in the actuarial treatment just as in the DP results due to the integral fixed premium

²When there were fewer than 24 subjects, the number of subjects was a multiple of four so that all subjects had equal-sized groups. The subjects, who remained after the maximum number of groups of four was formed, were paid a show-up fee and allowed to depart.

Table 2: Treatment Details

	Actuarial	Employer
Premium	1.1 * E(Cost)	\$9
Subject Income	100%	81%
Insurer Profit	\$675	\$1091
Profit Rate	6.3%	5.7%

charged to the subjects. However, the employer revenue stream was larger due to much increased subscription, so overall the insurer made more profit under the employer plan (\$1,091) than the actuarial plan (\$675) where self-insurance was more frequent. The table demonstrates that the subsidies to poor and old subjects under the employer plan were completely funded, and no ‘external’ resources were required.

3.4 Regression models

The regression on insurance purchase and survival use a panel data probit model:

$$Y_{it} = \Pi(\phi_i + \tau_i + \nu_i + \varepsilon_{it})$$

where ϕ_i is a vector of binary variables indicating the the subjects’ age {young, old} and income type {low, high} combination, sub-population; τ_i is vector of binary variables both indicating belong to a particular sub-population and being in the employer-based insurance treatment; ν_i is an individual error term; and ε_{it} is period specific error term. Errors are clustered at level of which shock sequence the subject experienced.

Regression on resilience, health, savings and joy use a panel data model:

$$Y_{it} = \phi_i + \tau_i + \nu_i + \varepsilon_{it}$$

where the variables have the same specifications, only there is no link function.

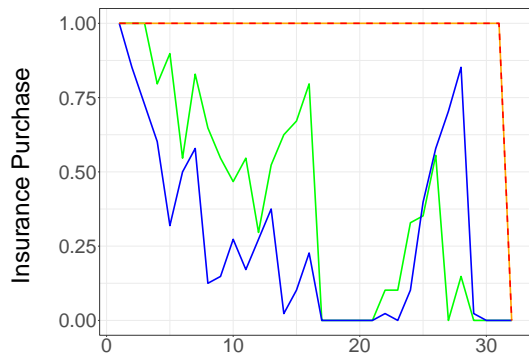
4 Results

4.1 Theoretical results from dynamic program

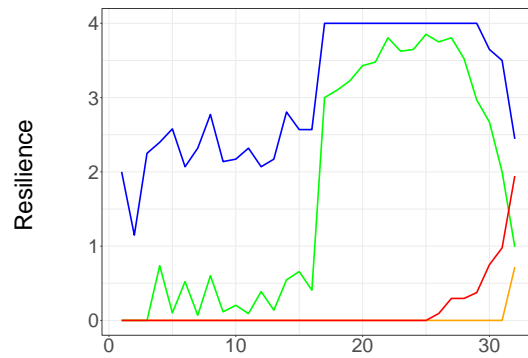
Figure 2 shows DP results for the four treatment groups, based on the limited number of shock patterns to which experimental subjects were exposed. Red and orange plot the welfare maximizing strategy (i.e. maximizing expected lifetime joy) in the employer treatment for high and low income, respectively, and blue and green do so for the actuarial for high and low income, respectively.

Panel 2a shows the proportion of simulated subjects purchasing insurance in each period. The DP predicts insurance purchase for all subjects in the employer treatment,

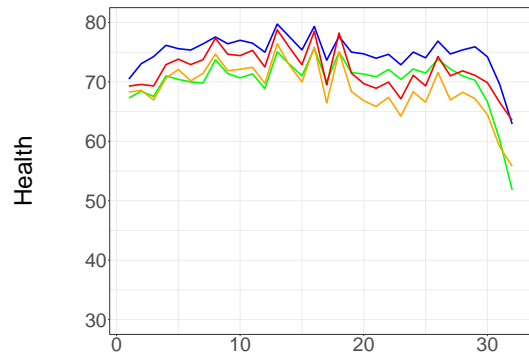
Figure 2: Results from Dynamic Program



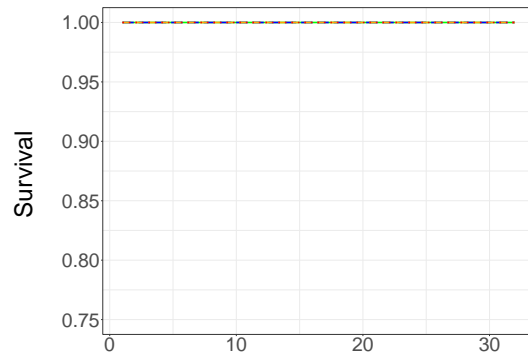
(a) Insurance Purchase Rates



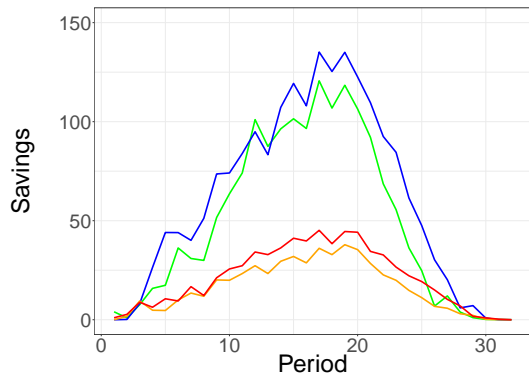
(b) Resilience Levels



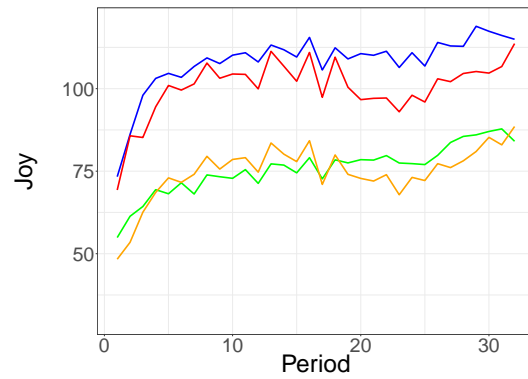
(c) Insurance Purchase Rates



(d) Resilience Levels



(e) Insurance Purchase Rates



(f) Resilience Levels

Population Act Poor Act Rich Emp Poor Emp Rich

regardless of income, whereas in the actuarial treatment, the proportion purchasing insurance is about 50%, generally decreasing across life. In the actuarial treatment, a greater proportion purchase insurance in the low than the high-income treatment. Panel 2b shows investments in resilience to shocks. In the employer treatment, both income types make no fitness purchase until starting the endgame whereas in the actuarial treatment, both high and low-income subjects invest in resilience. In the actuarial treatment, investments in resilience increase when shock probabilities increase in the second half of life, but to a lesser extent among the lower income subjects. Panel 2c shows that the DP predicts relatively small differences in health levels between treatment groups. Panel 2d shows that given the model parameters, it is not optimally to die before period 32 in any of the four treatments.

For all treatment groups, Panel 2e reveals that the DP predicts savings will increase through the first half of life and then decrease in the second half of life, but that savings will be about four times as high in the actuarial than in the employer treatments. The effects of income on savings are much smaller in comparison. DP predictions in Panel 2f indicate that more joy is obtained in the actuarial than in the employer treatment. However, there is an interaction between insurance treatment and income with larger differences between insurance treatments among the higher income groups.

Together, the theoretical results reveal that optimal strategies depend on both insurance plan and income, and change dynamically through life. The decreased premium costs in the employer treatment through the enforced subsidy result in the universal purchase of insurance and reduced savings, and resilience. Reduced investments in resilience reflect moral hazard in that at the individual level, premiums do not change with respect to expected insurer costs. The actuarial plan with greater individual responsibility requires a complex dynamic mix of savings, resilience and investments in health. However, since it is unconstrained by imposed employer subsidy, it results in greater total welfare, especially for the high income group. Interestingly, the DP also predicts greater insurance purchase in the low income treatment, since there is less ability to buffer shocks through savings or investments in resilience.

4.2 Subject results

Table 3 presents the descriptive statistics regarding subject decisions and outcomes for the four experimental treatments in the first and second halves of life, only including the two 32 period lives and none of the practice lives. Figure 3 presents plots of subject data akin to the plots of DP data in Figure 2.

Insurance purchase - Qualitatively, the subject decisions match the DP, including the endgame effect (Panel a). More subjects purchase insurance in the employer than in the actuarial treatment. In the employer treatment, nearly all subjects of both income groups in the employer treatment purchase insurance every period, except the last, as predicted by the DP. Low-income subjects purchase insurance at greater rates than high-

Table 3: Summary Statistics

	Low Income				High Income			
	Actuarial		Employer		Actuarial		Employer	
	Young	Old	Young	Old	Young	Old	Young	Old
Insurance Purchase	0.61	0.57	0.94	0.94	0.40	0.49	0.88	0.89
Resilience	0.78	1.48	0.07	0.15	0.86	1.48	0.15	0.33
Health	63.91	56.16	64.42	57.61	65.36	60.05	63.79	60.13
Savings	15.92	12.46	9.91	6.11	21.04	16.29	5.51	5.00
Joy	79.75	82.16	79.75	82.16	79.75	82.16	79.75	82.16
Income	102.31	94.79	83.33	78.09	129.52	124.64	103.33	100.63
Average Lifetime	29.4		31.9		31.4		31.1	
Premature Deaths	26		5		9		7	

income subjects. The principal difference between the DP predictions and subject behavior is with the actuarial treatment. Subjects purchase less insurance than is optimal in the first quarter of life and then more than is optimal in the second and third quarter of life. In addition, in contrast to the DP, the subject purchase rate does not decline across life. Compared to the DP, subjects tend to undervalue then overvalue health as life progresses.

Table 4 reports regression results that provide statistical tests of the differences the graphs visualize. The columns (regression estimation) correspond to the panels in Figures 2 and 3. For all columns, estimates are reported for seven binary indicator variables. The first three variables represent the four sub-populations resulting from interacting age and income (low-income young is the omitted sub-population), so each variable provides an estimate impact of belonging to that sub-population (relative to the omitted one). The remaining variables indicate both belonging to a particular sub-population and being in the employer-insurance treatment, so estimate specific effects for each of the four sub-populations. Column (a) of Table 4 presents estimated marginal effects of a probit regression on insurance purchase. The difference between the purchase rate and each of the other three sub-populations is statistically significant, as is reported in the first three rows. Subjects in all sub-populations are statistically significantly more likely to purchase insurance. The estimates of effect size ranges from 35% for high-Income Old to 41% for high-Income Young. However, those differences are not statistically significant.

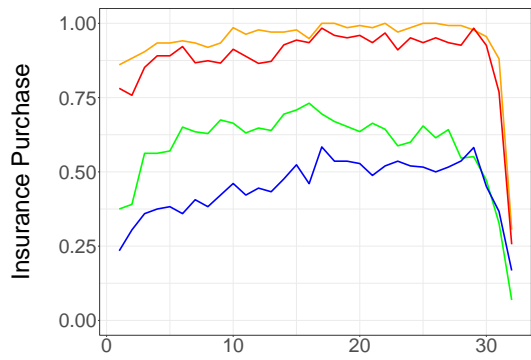
Resilience – As predicted by the DP, subjects invest more in resilience in the actuarial than the employer treatment (the moral hazard effect), and investments in resilience increase in the second half of life when the shock rate increases (Panel b). Again, however, subjects in the actuarial treatment diverge more from the predictions of the DP by underinvesting. Whereas the DP predicts an increase to a resilience level of almost four for both low and high income subjects, their observed resilience levels are less than 1 for the first half of life and only increase to about 1.25 in the second half of life.

Table 4: Regression estimates for baseline differences and treatment effects

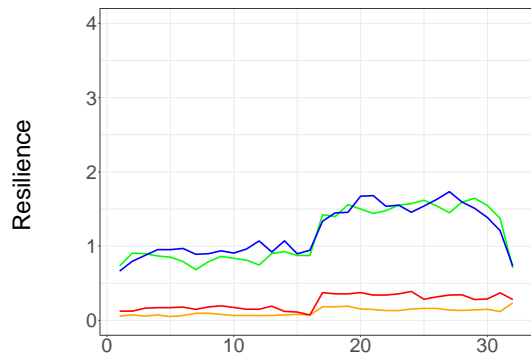
VARIABLES	(a) Ins. Purchase	(b) Resilience	(c) Health	(d) Survival	(e) Savings	(f) Joy
Low Income Old	-0.0760*** (0.0201)	0.532*** (0.0886)	-13.14*** (1.669)		-1.542 (3.169)	-22.10*** (2.788)
High Income Young	-0.150*** (0.0364)	0.0991 (0.0950)	3.132* (1.656)		5.692*** (2.649)	25.93*** (2.006)
High Income Old	-0.0852*** (0.0262)	0.676*** (0.0966)	-4.008 (2.591)	0.117** (0.0527)	1.373 (2.881)	10.15** (4.136)
Emp * Low Young	0.372*** (0.0362)	-0.692*** (0.0496)	2.410 (1.797)		-5.645 (3.739)	-3.016 (2.303)
Emp * Low Old	0.408*** (0.0340)	-1.144*** (0.0716)	8.401*** (2.579)	0.127*** (0.0244)	-7.906*** (2.897)	11.62*** (2.743)
Emp * High Young	0.414*** (0.0293)	-0.711*** (0.0863)	-2.103* (1.267)		-15.61*** (1.925)	-8.239*** (2.336)
Emp * High Old	0.352*** (0.0258)	-1.124*** (0.0847)	-0.481 (2.138)	0.0224 (0.0686)	-10.81*** (1.619)	0.252 (3.803)
Observations	16,640	16,640	16,640	455	16,640	16,640
Sequence Controls	Yes	Yes	Yes	Yes	Yes	Yes
Log Likelihood	-6139			-127.9		
Rho	0.513	0.467	0.461	0.0949	0.612	0.220
P-value		<.001	<.001		<.001	<.001
Number of Subj. Lives		520	520		520	520

Clustered (on Shock Sequence) standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

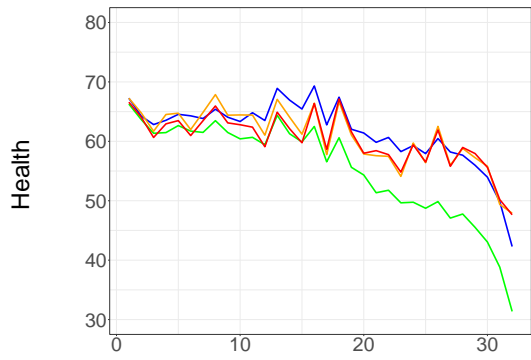
Figure 3: Results from subjects



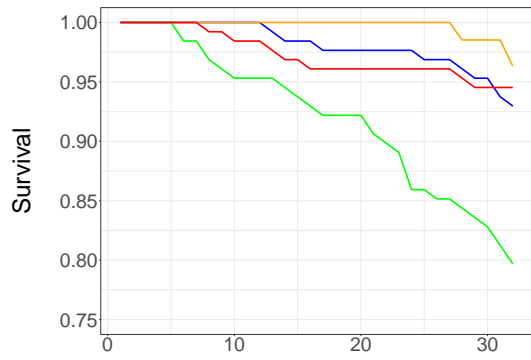
(a) Insurance Purchase Rates



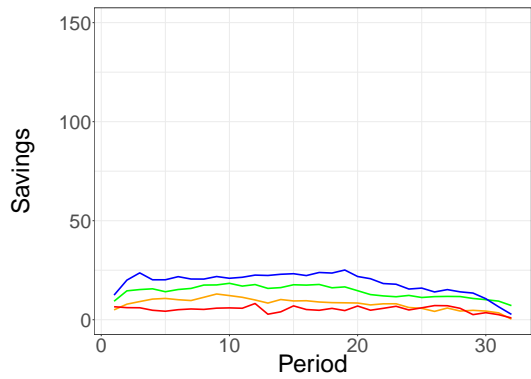
(b) Resilience Levels



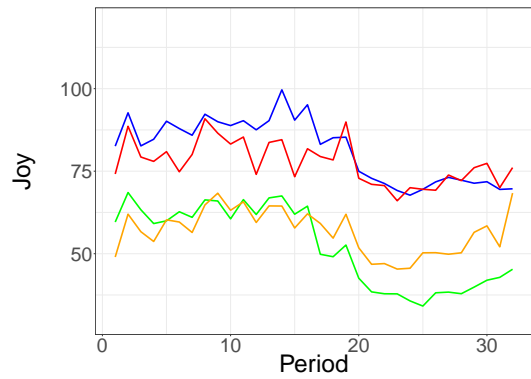
(c) Insurance Purchase Rates



(d) Resilience Levels



(e) Insurance Purchase Rates



(f) Resilience Levels

Population Act Poor Act Rich Emp Poor Emp Rich

Column (b) of Table 4 reports coefficient estimates from a linear regression on resilience (ordered probit results are in the Appendices). Subjects maintain higher resilience during the old half of life, as can be seen in, row 1 and 3. Consistent with moral hazard, the difference across insurance treatments is statistically significant for all four sub-populations, and the difference is larger for the second half of life.

Health – Like the DP, subjects maintained relatively high levels of health throughout life (Panel c). However, compared to the DP, subjects in all treatments under-invest in health in the early periods of life, resulting in lowering income throughout life and less joy realized in later periods of life. Again, subjects in the actuarial treatment, especially lower income subjects, differ more from the DP than those in the employer treatment.

Column (c) of Table 4 reports coefficient estimates from a linear regression on Health. Health is lower for low-income old subjects. This age effect is marginally significant. The employer treatment increases the health of the low-income, old subjects significantly and decreases the health of high-income young subjects marginally significantly. Other health impacts are not significant.

Survival – 91% all of subjects survived through both lifetimes, similar to the DP, which had perfect survival. However, some subjects did die due to under-investments in health and resilience, especially in the low income actuarial treatment in which 20% died.

Column (d) of Table 4 reports probit estimates on whether the subject was alive at the end of the 32 period life, so there are no estimates for young subjects. Sixty-five subject lives were dropped from the regression because their innocuous shock sequences perfectly predicted survival. Under actuarial insurance, being rich increases a subject’s chance of survival by 11.7%. Employer insurance closes this gap.

Savings - As predicted by the DP, subjects in the actuarial treatment save more than those in the employer treatment, and high income subject save more than low income subjects (Panel e). However, compared to the DP, subjects in all treatment groups under-invested in savings, on average, and none of the treatment groups supported the DP prediction of a dramatic increase in savings during the first half of life followed by a decrease in savings in the second half of life. Again, the divergence between DP predictions was greatest for the actuarial treatment - only 20 out of 256 subjects in the actuarial plan had savings of 75 or more at midlife (period 16).

Column (e) of Table 4 shows regression estimates of how savings differed by sub-population. Only the high-income young had a statistically significant difference in savings. The employer treatment reduced savings for all four sub-populations, but the reduction in low-income young was not statistically significant. However, the relatively small magnitude estimates highlight the fact that the subjects did not optimize savings in any of the treatments. The largest savings estimate is only 16, whereas optimal behavior would have produced a regression estimate of about 80, half the peak savings.

Joy – Subjects in all four treatment groups experience less joy than predicted by the DP, cumulatively earning between 67 and 77 percent as much as the optimal, depending on the treatment (Panel f). This is due mostly to the under-investments in health, savings

Table 5: Obtained Mean Joy

	Low Income			High Income			Low/High	
	Subj	DP	Subj/DP	Subj	DP	Subj/DP	Subj	DP
Employer	1816	2391	0.76	2482	3213	0.77	0.73	0.74
Actuarial	1679	2423	0.69	2609	3462	0.75	0.64	0.7
Emp/Act	1.08	0.99		0.95	0.93			

Table 6: Coefficient estimates from regressing cumulative Joy on insurance type

VARIABLES	(1)	(2)	(3)
	Low Income	High Income	All
Employer	137.7*	-127.8	-5.127
	(72.75)	(90.03)	(76.43)
Observations	264	256	520
# of Subjects	132	128	260

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

and resilience early in life. The results also reveal an interaction between the income and insurance treatments. As predicted by the DP, joy is higher in the actuarial than in the employer treatment for higher income subjects, especially in the first half of life. In contrast to the predictions of the DP, joy realized is less in the actuarial than in the employer treatment for lower income subjects, particularly in the second half of life.

Table 5 below compares mean joy earned in the Actuarial and Employer treatments by DP maximizers and human subjects. The results confirm significant interaction between income and insurance treatment in obtaining joy. In the high-income treatment, subjects obtained considerably more under the actuarial than the employer treatment, as predicted by the DP. However, contrary to DP predictions, low-income subjects did absolutely better in the employer than the actuarial treatment. As such, differences between lower and higher earning subjects were significantly greater (Table 6) in the actuarial than in the employer treatment, with higher income subjects obtaining 55% and 36% more joy cumulatively than lower income subjects for the actuarial and employer treatments, respectively. It underscores the transfers of welfare that occurred in our test environment (see sections A.1 and 2 of the appendices for a detailed economic breakdown of the transfer and moral hazard effects).

Figure ?? illustrates the differential complexity of the decision space between the insurance treatments. For each subject in each period, the DP was employed to determine, given the current situation the subject faced in that period, what would be optimal action

(the one that maximized expected cumulative joy for the rest of life). The DP was also used to determine a pessimal decision for that period (the currently worst decision that would minimize expected cumulative joy for the rest of life, even if in all future periods expected joy would be correctly maximized). Figure ?? plots the difference band between optimal and pessimal decisions for each treatment. The actuarial band is blue and the employer is red. The top of the band shows the expected remaining optimal lifetime joy from making the currently optimal decision, and bottom of the band shows expected remaining optimal lifetime joy from making the currently pessimal decision. The height of the band gives the potential efficiency cost of the worst decision. The dotted lines (only in the red employer band) show the expected lifetime joys for optimal and pessimal decisions assuming the subject buys insurance. The dark line is the average mean expected joy given observed subject decisions, assuming the subject would make optimal decisions in all subsequent rounds. Subjects' average realized cumulative joy for all previous periods is added to current optimal and pessimal values.³

1. Average subject performance is much closer to the optimal than the pessimal decision.
2. The width of the band is greater for the actuarial treatment than for the employer treatment for both income levels.
3. For lower income subjects, pessimal performance is worse in the actuarial than in the employer treatment.

In summary, the figures and tables above indicate that most of the qualitative predictions from the DP were supported by subject behavior (see Tables A.3 and A.4 for a complete summary of our results):

1. Subjects invested in health, insurance, and resilience in ways that kept 91% of them alive throughout their 32 period lifetimes, with sufficient patience and forethought to smooth consumption throughout life.
2. Subjects dis-invested in health as the endgame approached.
3. Subjects in the employer treatment purchased more insurance but invested less in resilience than in the actuarial treatment.
4. Low-income subjects purchased more insurance than high-income subjects, particularly in the actuarial treatment.
5. High-income subjects earned more in the actuarial than in the employer treatment.

³For example: in period 1, cumulative joy is zero and all the expected values are for all 32 periods. However, in period expected values are only for the remaining 31 periods, because period 1 has been realized, so we add that realized value from period 1. This way, every period graphed accounts for joy across the whole life. As periods are realized and the subjects do not optimize, the maximum potential score (the top of the band) falls because non-optimal decisions they have made have reduced it.

However, there were some important deviations from the welfare maximizing investment patterns suggested by the DP:

1. Subjects under-invested in health at the beginning of life in all treatments, and under-invested in resilience throughout life in all treatments. Subjects undervalued the marginal effects of resilience in reducing the size of a health shock.
2. Subjects in the actuarial treatment deviated from the predictions of the DP more than subjects in the employer treatment, especially with respect to savings and resilience.
3. Lower-income subjects fared worse in the actuarial treatment than in the employer treatment, even though the DP predicted they would earn more if they invested well dynamically.

5 Discussion

Our findings have several important implications. First, while there are several laboratory experiments in which individuals must make dynamic decisions in multi-period lives (Ballinger et al., 2003; Gillet et al., 2009; Carbone and Infante, 2014, 2015), our environment presented the additional complication of multi-variate, allocations. Yet, subjects are still able to engage in arbitrage between present and future utility gains, and they are able to buffer against risk through savings, resilience and the purchase of insurance. Second, endogenous investments in health interact with the institutional and economic environment in ways suggested by the DP's welfare maximizing agents. An actuarial insurance premium environment creates incentives for greater investments in resilience and savings. In contrast, an employer-subsidized insurance premium environment creates incentives to purchase insurance and disincentives for investments in resilience to health shocks (moral hazard), resulting in greater total insurance payouts. Third, transfers in the employer treatment from young to old and from higher to lower income subjects result in greater smoothing of joy realized throughout life, and reduced differences between higher and lower income subjects. Fourth, subjects deviated from theoretical predictions in systematic ways: a) they under-invested in health in the beginning of life and over-invested at the end of life; and b) they under-invested savings and resilience, compared to the optima, particularly in the actuarial treatment. These findings are in line with previous findings Ballinger and Gillet in particular.

A fifth and significant implication of our results is that the increased complexity of the decision environment in the actuarial treatment reduces subjects' abilities to optimize their choices dynamically. Although the actuarial environment is associated with higher potential maximum joy because choices are not constrained by an obligatory employer tax to subsidize health insurance premiums, subjects in the actuarial environment performed relatively worse, compared to their DP optimum, than those in the employer environment. The employer plan charged the same premium and tax rate across life; however, it pays

out more in claims to the old than to the young because the old have more frequent health shocks. Effectively, the employer plan eliminates the subject's need to implement his own inter-temporal transfers: consumption (spending on joy) varies less across the two stages in life (young and old) in the employer treatment, and given the diminishing marginal utility of consumption, this help subjects increase their welfare. In previous studies, subjects had more difficulty optimizing when lives were longer and the optimal decision varied more across life.

Several findings raise questions that should be addressed in future research. One question concerns health insurance purchase. It is interesting to observe that subjects in the low-income actuarial treatment purchase more insurance than those with higher income, as predicted by the DP. This apparently reflects a greater gain from buffering risk as income decreases in our environment. The experimental result seems somewhat contrary to observational data findings in which low-income individuals are less likely to be insured (Berchick et al., 2018). We first note that subject decisions qualitatively match DP decision; subjects in the low-income treatment insured at higher rates, but had lower resilience relative to high-income subjects, so were correctly allocating given the variation in marginal benefits. However, an even lower income treatment might have reversed this effect. A second point is low income individuals in the world outside the laboratory may be more risk sensitive than higher income individuals. However, due to income constraints and incomplete markets, they may often insure through informal mechanisms, even at considerable expense, to prevent the extremely harsh consequences a negative shock would cause them (Banerjee and Duflo, 2007).

This raises the concern that our model does not implement the real reasons why minority status, lower education and unemployment are associated with the probability of not purchasing health insurance. Since most periods of time during which people lack health insurance are temporary, obstacles such as income interruption, under-forecasted expenditures, and difficulties interacting with governmental agencies, may play a larger role than insensitivity to risk in explaining individuals' uninsured episodes. This issue deserves further experimental investigation.

Another issue raised by our results is the interpretation of moral hazard. While subjects invested more in resilience in the actuarial than the employer treatment, as predicted by moral hazard, they still invested much less than DP predicted. This finding suggests that providing premium discounts for subjects to engage in healthier behavior that lowers the expected cost of health shocks would have some effect on their behavior, but it would be a smaller effect than would be predicted by DP maximizer behavior. Given that less than 3% of Americans follow four major guidelines for healthy behavior Loprinzi et al. (2016), our findings are consistent with empirical patterns observed in the real world. This raises the question of why direct economic incentives produce smaller than expected effects on health maintenance. More importantly, it also raises the question of what other incentives might produce larger effects.

A final question provoked by our results concerns whether a hybrid insurance system,

combining elements of the Actuarial and Employer systems might produce the greatest social welfare. The eEmployer-based system aims to increase social welfare by decreasing the complexity of the decision space and by seamlessly implementing the transfer from the young to the old and from higher to lower income individuals. The Actuarial system incentivizes health investments, and therefore aims to increase social welfare by decreasing average premium costs and the actual burden from repairing health shocks. Might an Employer-based system with premium incentives for health behavior outperform the two systems we investigate here?

The limitations of our study should be considered in interpreting these results. First, virtual ‘health’ in an experimental environment may be experienced very differently than real-world health. Behaviors, such as diet, exercise, and tobacco, alcohol and drug use, may be experienced and motivated differently than moving levers to pay for improved health in an economics laboratory. What is very encouraging, however, is that our subject behavior matched most of the qualitative predictions of the DP welfare maximizers, and deviations from maximizer behavior, such as under-investment in health and resilience, are commonly observed in the real world.

While it was employed to enhance treatment effects, a design limitation might be that all subjects were endowed an initial health stock of 70/100 at the beginning of the experiment. Many subjects tended to maintain this stock with small deviations (+/- 5) from period to period until the endgame in which they allowed it to deteriorate. It is unclear whether they would have maintained a higher, ‘near optimal’ level of 75-80 if that were their initial allocation, or whether and how quickly they would have allowed their health to deteriorate if they were blessed with an initially even higher than optimal stock. However, the experiment had three training lives and chat groups with complete public information on like-subjects’ behavioral choices. This allowed the subjects to jointly explore their strategy space, prior to the 32 period lifetimes. This suggests that the behavioral proclivities observed are not the results of anchoring effects.

Finally, the disposable income differences between the treatment groups were relatively small ($80 \Leftrightarrow 100$), compared to potential income differences in the real world. It is possible that the effects we found are limited to small differences in income and that expanding the difference might lead to non-monotonic relationships. For example, the greater likelihood of purchasing insurance by the lower income group might be reversed if their disposable income were decreased even further.

To conclude, we find that the actuarial plan did not outperform the employer plan in our experiments. At the population level, there was not a statistically significant difference in aggregate social welfare between the plans. Employer plan transfers from high to low-income subjects and from ‘young’ to ‘old’ subjects brought significant enough benefits in a difficult to optimize decision environment to justify the costs of social subsidization. Health levels were similar across the two plans, except for low-income old subjects who in the actuarial treatment had significantly lower health, and higher death rates. As expected, there was considerably higher insurance uptake for the employer plan, and moral

Table A.1: Transfer Calculations

Group	Payout	Withheld	Premium	$\pi/period$	Sum Zero
Low Inc. Young	21.54	19.43	8.46	-6.34	-4.74
Low Inc. Old	36.51	17.73	8.46	10.32	11.93
High Inc. Young	19.43	23.7	7.9	-12.17	-10.56
High Inc. Old	32.26	22.45	8.05	1.76	3.37
Total	109.75	83.31	32.87	-6.43	0

hazard was exhibited by those insured. However, the employer plan relieved subjects of the responsibility of saving for increased health care costs when they became old, substantially improving their welfare, especially for low-income subjects. Subjects were also better able to navigate the simpler decision space provided by Employer insurance as they forfeited proportionately less of their potential joy through less-than optimal decisions than they did under the actuarial plan. Our environment provides an effective test bed for examining investment in health preservation and insurance consumption as many of the behavioral proclivities observed in the real world surface in our test results. Future experiments will examine additional plan variations including ‘hybrid’ plans that take advantage of the relative strengths of both plans. Our results suggest that behavioral economic insights derived from controlled laboratory experiments may be helpful in designing insurance policy.

A Appendices

A.1 Transfers

Table A.1 provides calculations of the transfers in the employer based insurance. Profit (π) per period for each group of subjects is the Insurer’s “Payout” less Withheld (from subjects’ income) and Premium paid. Sum-zero subtract one quarter of \$6.43 of insurer profit from each group. This column sums to zero and is the inter-group transfers. Mean transfers from young to old are \$7.65, and \$3.60 from high to low income.

A.2 Supplemental regressions

Table A.2 report coefficient estimates and level cut points from ordered probit regressing Resilience on insurance type, as robustness check to the regression on resilience as continuous variable, reported in the main text. Estimates are consistent with the continuous version. In all cases employer insurance reduces resilience.

Table A.2: Estimates from ordered probit regressing Resilience on insurance type

	(1) Young Low Income	(2) Young High Income	(3) Old Low Income	(4) Old High Income
Employer	-1.217*** (0.0971)	-1.283*** (0.100)	-1.090*** (0.110)	-1.154*** (0.0861)
/cut1	0.408*** (0.0579)	0.0527 (0.0770)	0.181* (0.0940)	-0.216*** (0.0799)
/cut2	0.708*** (0.0617)	0.259*** (0.0764)	0.638*** (0.0856)	0.0874 (0.0579)
/cut3	1.232*** (0.0853)	0.662*** (0.0518)	1.148*** (0.0905)	0.606*** (0.0786)
/cut4	1.647*** (0.0954)	1.094*** (0.0575)	1.850*** (0.136)	1.286*** (0.110)
Observations	4,224	4,224	4,096	4,096

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

A.3 Results Summary

All treatment effects, for both optimally computed (DP maximizers) and observed (human subjects), are summarized in the following tables: In both tables, sign denotes direction of effect, number of signs denotes size of mean effect relative to its range and variation. Blank cells indicate no meaningful effect. Survival is calculated only for the old. Table A.3 reports difference between DP joy maximizers and the human subjects.

Table A.4 has three sections. In each section, there is a column for the within DP joy maximizer comparison and a column for the within human subject (HS) comparison. The top section reports the differences between the employer and actuarial treatments. The middle section reports the differences between old and young. The bottom section reports the difference between high and low income.

A.4 Decomposition

Moral Hazard and Joy Transfers – Subjects under the Employer treatment (especially Low-income) were able to perform relatively better, compared to maximizers, than their actuarial counterparts. This indicates that the subsidies and implicit transfers provided under the employer plan, from high to low-Income and from young to old subjects, are having a marked effect even though all subjects tend to underinvest in resilience. Because actuarial insurance bases its premiums on individual subject resilience and health, there

Table A.3: Effect Size, (DP Maximizers - Human Subject)

Income Type	Ins. Type Age	Insurance Purchase	Resilience Investment	Health Investment	Survival to period 32	Total Savings	Total Joy Consumed
Low	Act/Yng	+	-	+		+++	+++
	Act/Old	--	++	++	+++	+++	+++
	Emp/Yng			+		+	++
	Emp/Old			++	+	+	++
High	Act/Yng		++	+		+++	++
	Act/Old	--	+++	++	+	+++	++
	Emp/Yng	-				++	++
	Emp/Old				+	++	++

Legend: sign notes direction. -/+ small but meaningful, -/- moderate, - - - / + + + large difference

Table A.4: Effect Size for all Treatment Comparison

Compare	Subgroup	Insurance Purchase		Resilience		Health		Survival		Savings		Joy	
		DP	HS	DP	HS	DP	HS	DP	HS	DP	HS	DP	HS
Emp-Act	Yng Low	++	++	-	-	+	-	-	-	-	-	-	+
	Old Low	+++	++	-	-	++	-	-	-	-	-	-	-
	Yng High	+++	++	-	-	-	-	-	-	-	-	-	-
	Old High	+++	++	-	-	-	-	-	-	-	-	-	-
Old-Yng	Act Low	---		++	+	-	-	-	-	-	-	++	++
	Act High	--	+	++	+	-	-	-	-	-	-	+	+
	Emp Low			++		-	-	-	-	-	-	+	+
	Emp High			++	+	-	-	-	-	-	-	+	+
High-Low	Act Yng	--	--	+++	+	+	+	+	+	+	+	+++	+++
	Act Old		-	++	+	+	++	+	+	+	+	+++	+++
	Emp Yng		-		+	+	+	+	+	+	+	+++	+++
	Emp Old		-	+	+	+	+	-	-	+	+	+++	+++

Legend: sign notes direction. -/+ small but meaningful, -/- ++ moderate, - - - / + + + large difference

is by definition no moral hazard and no welfare transfers between categories of actuarial subjects. But considering the degree to which the actuarial subjects fall ‘behaviorally’ short of optimal resilience investment, we can assume that that employer subjects underinvesting to any greater extent are falling subject to moral hazard.

The mean percentage by which actuarial subjects underinvest in resilience was 54%. Premiums in the employer insurance treatment were pre-calibrated to be profitable despite anticipated underinvestment in resilience. To measure subject-induced moral hazard under the employer treatment, we simply calculated the insurer’s expected profit and the subjects’ expected joy for every level of health and resilience the subject could have had. We then calculated how much the insurance company could have transferred to the maximizer/subject conditional on her investing in each resilience level in order for the insurer to have the same expected profit as it does when subjects have a fitness of 0. Finally, we calculated how much more expected joy the subject could have earned with the conditional transfer. We defined potential moral hazard costs as the gain in expected joy between a subject’s optimal resilience level and observed (mean) levels in actuarial subjects. We then calculated how high expected joy level would have been if there were transfers and the subjects maintained the fitness level that actuarial subjects maintained, which was 46% of the potential moral hazard cost. The balance, 54% of the transfer benefits, can be attributed to the behavioral proclivity to underinvest in resilience, even when there are incentives to invest, as in the actuarial treatment.

Using this information and mean expenditures on the various possible investments, Table A.5 below decomposes the mean components of joy obtained under the employer treatment, relative to the actuarial treatment, by considering the insurance subsidies provided and received.

The first line of Table A.5 shows the mean joy amounts at the end of life for the each income group in the actuarial Treatment. The last line shows the corresponding means in the employer treatment. Each intermediary line is the estimated impact of one difference between treatments. We saw no selection bias in the employer treatment, neither in the DP nor human subjects, meaning young and old purchase insurance at near identical rates. The third line reports estimates for the benefit of consumption smoothing from the transfers from young to old netted across life. The human subjects benefit mildly from these. The DP is actually hurt by the transfers. The DP has the foresight to save to smooth consumption, so the imposed transfers constrain its ability to adjust savings according to the stochastic shock pattern experienced. The fourth line reports the estimated impact of the transfers from rich to poor: the effects are strong and all in the correct direction. The administration fee line is the estimation of the cost in joy to the employer subjects of the profit the insurer extracts. Moral hazard is the estimated impact on joy of maintaining resilience at a lower level, which may be individually optimal but socially costly. The Health Modified Joy line is the estimate of how much higher health in the Employer versus actuarial treatment benefits subjects by increasing their joy: DP maximizers do not display this effect. The Death Prevention Joy line is the estimate of how much extended life in

Table A.5: Employer Subjects' Decomposition of Joy Obtained

	Low Income		High Income	
	DP	Subjects	DP	Subjects
Actuarial Joy	2423	1679	3462	2609
Selection Bias	0	0	0	0
Transfer Young → Old	-31	4	-25	1
Transfer High → Low	99	66	-75	-112
Admin Fees	-27	-21	-37	-14
Moral Hazard	-80	-57	-96	-63
Health Modified Joy	0	27	0	23
Death Prevention Joy	0	173	0	11
Total Adjustments	-39	193	-233	-154
(% Actuarial Joy Obtained)	(-1.6%)	(+11.5%)	(-6.7%)	(-5.9%)
Residual Joy	-21	-56	-16	27
(% Actuarial Joy Obtained)	(0.3%)	(-8.2%)	(-0.5%)	(+4.9%)
Employer Joy	2391	1816	3213	2482

the employer versus actuarial treatment benefits subjects by increasing their joy: again, DP maximizers do not display this effect. The Residual Joy is the unexplained difference between observed joy in the actuarial and employer treatments after accounting for the Total Adjustments.

Subjects The young to old transfer was estimated by averaging the consumption across the young and old periods, and taking the difference between the smoothed and unsmoothed consumption. Admittedly, this is only part of the benefit of the transfer—the amount applied to consumption. The other part is the benefit gained by applying some of the transfer to increasing health. This is the health modify joy line, which is the difference in the amount of joy actuarial consumption would have resulted in between employer treatment levels of health and the level in the actuarial treatment. The rich to poor transfer was calculated by taking the difference between consumption if was increased by $(\text{transfer} + \text{mean income})/\text{mean income}$. Admin was found by the same method as the previous transfer but with the amount of the increase in profit in the employer treatment relative to the actuarial. Prevent death is the difference in expected mean joy at the end of life including or not including subjects who died early.

DP We calculated for the employer subjects net payments to the insurer, summing withholdings and premium paid less health regenerated from insurance, for each age and income combination. The administration cost is the adjustment required for the employer plan to have the same profit as the actuarial plan, \$-0.53 per subject per period. For the

administration line we reran the DP adjusting the income each period by this amount. The young to old and low to high transfer lines follow the same logic. After adjusting for the difference in administration costs, we found the mean for age or income and used that amount to adjust the DP's income. We report the difference in Joy earned with adjusted and unadjusted income. The Joy Modified income line is not calculated for the DP, because using method above the DP increases its income so this is already included. The prevent death line is not calculated because there were no lives under either treatment in which the DP died prematurely.

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