Claims Prediction Model and the Simulation of Health Savings Account (HSA) Performance

Abstract: Using data from the Health & Retirement Study (HRS), a two-part medical claim prediction model is estimated for a cohort of survey respondents approaching Medicare-eligibility age. A High Deductible Health Plan (HDHP) with a companion Health Savings Account (HSA) is applied to simulated claims streams to model the build-up of HSA assets over the near-retirement years. Results show that the HSA is a grossly inadequate savings vehicle to provide for retiree medical care expenses at age 65. Moreover, HSA adequacy worsens exponentially with diminishing health status. Based on this simulation, it is apparent that Baby Boomers cannot adequately provide for the costs of medical care in retirement using HSAs exclusively.

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Summary

The goals of this project are two-fold. First, using data from the University of Michigan's Health & Retirement Study (HRS) for 50 through 65-year-olds, I have estimated a model of claims *inference* to evaluate the total effects of insurance coverage, health status, lifestyle, and other demographic variables on the mean level of total health expenditures. This will provide estimates of the elasticity of expected expenditures with respect to health insurance coverage that will ultimately be used to parameterize a simulation of Health Savings Account (HSA) roll-over account balances at Medicare age. It will also provide insights into the contribution of health status variables in explaining levels of health expenditures. Second, and also to further the simulation model, I have estimated a model of claims *prediction* which will by necessity take into account the high persistence (correlation) of health expenditures over time, the large unexplained residual variance in these claims, and the correlation of key time-invariant predictor variables identified through the model of claims inference. The prediction model is used to simulate HSA performance over the "near-retirement" years for the population included in the HRS survey. This will provide evidence of how successful HSAs may function as retiree medical savings vehicle, and also allow for modeling of changes to key legislated plan provisions (e.g., maximum HSA contribution). The simulation model further demonstrates how sensitive HSA performance is to underlying economic assumptions such as trust investment returns and health care cost trend. Finally, the simulation demonstrates how changes in health status, lifestyle (smoking, drinking, etc), or the number of chronic medical conditions diminishes the viability of HSAs as a health care financing tool for certain populations.

Background and Literature Review

HSAs were legislated into existence under the 2003 Medicare Prescription Drug, Improvement, and Modernization Act (MMA). To this date, available public data for empirical research has been very sparse. CDHPs have been around since 2002, and are typically high deductible plans with a notional employer-funded "Health Reimbursement Arrangement", or HRA, from which covered persons draw down their available balance to cover medical expenses within the deductible corridor. Unused HRA and HSA amounts typically roll over for use in the subsequent policy year, often with interest or investment credit. While HSA assets are "owned"

by the plan member, HRA assets are forfeited to the employer upon termination of employment. HSAs, which are also attached to catastrophic high deductible plans, allow for pre-tax contributions by both the employer *and* employee (within legislated limits), tax-deferred growth of the HSA balance, and tax-exempt distributions for qualified medical expenses. Both CDHP and HSA plans are products of the increasingly prevailing trend of "consumerism", which in short attempts to engage consumers in their health care choices, mitigate moral hazard (thereby decreasing unnecessary utilization of more discretionary and price elastic services), and expose consumers to the true cost of health care.

These plans are increasingly under scrutiny because of their novelty (the newest significant cost-control attempt since managed care) and because President Bush has set out an agenda to expand HSA enrollment and eligibility through further tax subsidies that may cost as much as $156 billion over the next ten years (CBPP 2006) and raise the number of uninsured by an additional 600,000 persons (Gruber, 2006). Empirical research to date in the area of CDHPs and HSAs has attempted to answer the following:

1) What is the nature of employees who have enrolled in these plans? Are they, as many researchers of high-deductible health plans (HDHPs) posit, the "healthy and the wealthy"? What are the take-up elasticities? Would such plans ever be of interest to the chronically ill, who account for the largest proportion of health care expenditures? What is the nature of employers that offer these plans?
2) Do CDHPs really produce medical costs savings through increased cost-sharing and reduced service utilization? Will adverse selection cause a death spiral of traditional HMO/PPO plan costs, leading to increased overall costs?
3) Will these plans (specifically HSAs) increase or reduce the number of uninsured? Will they lead to a halt or reversal of the downward trend in employer insurance offers?
4) Do these plans allow for build-up of HRA or HSA balances that will finance future health care needs, even into retirement?
5) What will be the fiscal impact of tax credits/subsidies to expand coverage, eligibility and maximum contributions to HSAs?

Given the somewhat slow diffusion of CDHP and HSA plans, there is very little credible data with which researchers can answer these questions. Insurance component surveys from the NHIS, MEPS and the CTS "Followback" data sets do not yet include these plans, but will so in the future. Thus the most significant work to date has been performed by researchers that were able to secure micro-data on plan elections, demographic variables and service utilization for

large employers that have recently offered new plans like CDHPs. These analyses typically attempt to answer questions in #1 and #2 above.

For example, Feldman, Parente and Christianson of the University of Minnesota have published prodigiously on CDHPs and HSAs (they even have their own website for this area of research, http://www.ehealthplan.org). In one paper, using a conditional logistic model of health plan choice, the team found that at the University of Minnesota, CDHPs were not chosen disproportionately by the young and healthy, but certainly attracted the wealthy (Parente et al, 2004). Another paper analyzed one year of claims from one employer and found that CDHP enrollees had lower total costs than another cohort of enrollees in a PPO, but higher costs than an HMO cohort (Parente et al, 2004a). This paper also found that, counter to expectations, hospital costs and admission rates were significantly higher for CDHP enrollees compared to HMO and PPO plans. A third paper by the team, specifically focusing on Health Savings Accounts, asserts that the price elasticity of demand for CDHP enrollees is greater in the "donut hole" of the corridor deductible than in the employer-paid HRA portion of the plan (Parente et al, 2005). They also assert that for HSAs, there would be a correspondingly elastic cross-price response to take-up of HSAs, particularly for the wealthy. This analysis also used a conditional logistic plan-choice model using data on three large employers participating in a Robert Wood Johnson study of CDHPs. Finally, using the same employer data, but extrapolating nationally using MEPS data, the team estimates national HSA take-up of 3.2 million contracts, and suggests that subsidies could greatly reduce the number of uninsured in America (Feldman et al, 2005).

Several additional references specific to Humana's "Smart-Suite" of Consumer-Driven Health Plans are also noted in the literature. These are based entirely on survey and micro-data for Humana employees. Fowles, Kind, Braun and Bertko used logistic regression to find that CDHP enrollees were less likely to have chronic health problems and more likely to have no recent medical visits (Fowles et al, 2004). They concluded that chronically ill employees could benefit the most from the educational and communication support attendant with online CDHP plan tools. With the same population, Tollen, Ross and Poor analyzed risk segmentation between the CDHP plans and "traditional" HMO/PPO plans and found little difference in the underlying demographics of the two populations. However, based on claim data and prior utilization of services, CDHP enrollees were clearly "healthier" as measured by consumption, at least for that experience year (Tollen et al, 2004).

While the Humana literature and that promulgated by the team at the University of Minnesota are seemingly "pro-consumerism", additional research by the Commonwealth Fund, Employee Benefit Research Institute, and the Center on Budget and Policy Priorities argues that more research is necessary before expanding tax credits and subsidies to expand HSA enrollment. The research of these organizations typically responds to questions in #3 and # 5 above. Glied and Remler used MEPS & CPS data to evaluate tax savings for HSA enrollees with varying out-of-pocket expenses and concluded that HSAs are not likely to significantly expand coverage among the uninsured, and could even destabilize the small-group market (Glied and Remler 1005). Davis (et al) used the 2003 Commonwealth Fund Biennial Health Insurance Survey and logistic regression techniques to assert that high deductible health plans will have insignificant effects on both costs and coverage, introduce barriers to preventive care and increase exposure to financial hardship (Davis et al 2005).

Results from the "EBRI/Commonwealth Fund Consumerism in Health Survey" also suggest that adults with HSA-eligible high-deductible plans were more likely to respond that they had delayed or avoided care when they were sick, and the effect was higher for those reporting incomes below $50,000 (Fronstin and Collins 2005). Collins, Davis et al, using data from the "Commonwealth Fund Survey of Older Adults", warn that baby-boomers with HSA-eligible high deductible plans will not be able to save adequately for retirement due to the higher out-of-pocket costs of such plans (no empirical evidence), and that tax credits for older adults with higher incidence of chronic conditions will not expand access (Collins et al 2006). To round out the opposing-view, and to further demonstrate why these plans are of immediate interest for public policy research, one only has to read the titles of recent publications from the Center on Budget and Policy Priorities:

> "Latest Enrollment Data Still Fail to Dispel Concerns about HSAs" (1/30/06)
> "President's Health Care Tax Cut Proposals are Likely to Weaken Employer-Based Health Insurance, Primarily Benefit High-Income People, and Worsen Deficits." (1/31/06)
> "Administration Defense of HSAs Rests on Misleading Use of Statistics" (2/16/06)

Gaps in the Literature

There are many gaps in the literature due to the absence of credible micro-data to answer the questions under #1 through #5 above. The most significant gap addressed in this project

regards #4: "Do these plans allow for build-up of HRA or HSA balances that will pay for future health care needs, even into retirement?" Of particular concern is the difference in claim expenditures and HSA adequacy for the chronically ill versus the healthy, which, to my knowledge, has not been addressed empirically. The viability of HSAs will very much depend on whether individuals can adequately fund their own medical expenses over a working lifetime, and even into retirement, using a tax qualified vehicle like an HSA. Fronstin and Salisbury suggest that HSAs will provide inadequate build-up of roll-over balances to provide for medical care in retirement (Fronstin and Salisbury, 2004). However, the calculations do not reflect sophisticated econometric techniques or actual high-deductible health plan data with indicators of health status. The most important reference in this area, and yet worthy of some criticism as outlined below, is the NBER working paper "Insurance or Self-Insurance? Variation, Persistence and Individual Health Accounts." (Eichner, McClellan & Wise, 1996 and heretofore referred to as "EMW"). The paper uses longitudinal claims and demographic data from one large employer to predict the probability of claims, and expected claims given they are positive, using a two-part model. This model is then used to simulate "HSA-like" account balance build-up in catastrophic health plans with individual health accounts ("IHAs", precursors to HSAs). The predicted claims closely matched actual expenditures, although interpretation of individual parameter estimates was somewhat convoluted as the emphasis was on *prediction*, not inference of any causal relationships or associations. Their simulation results showed that 80% of hypothetical 25 year-old workers retained 50% of their IHA plan contributions (employer-paid) after 25 years, and only 5% retained less than 20%. This project attempts to remedy or improve upon certain aspects of the EMW paper, outlined below.

With regard to the two-part claim prediction model, the authors (EMW):

- Used a linear probability model to predict claim incidence which notably suffers from heteroskedasticity of the error terms, and results in predicted probabilities outside the (0,1) range (might have considered probit/logit)
- Do not include any measures of health status or chronic conditions in the claim prediction model
- Do not successfully interpret the parameter estimates, but consider this as secondary to achieving higher accuracy in claim prediction; also, they do not include time trend as an independent variable
- Do not take advantage of the panel nature of the longitudinal claim data (three years of claims)
- Recognize there is large unexplained residual variance in the claim prediction model

- Are unable to estimate a model for a larger, randomly sampled population (beyond this one employer)
- Do not take into account unobserved individual effects that may or may not be correlated with the predictors; assumes that individual random "shocks", along with other unobserved individual effects, are reflected in the residual error (not as much of an issue since prediction is emphasized rather than consistent coefficients)
- Do not cross-validate prediction model within the sample, even though sample size is huge

Regarding the account adequacy simulation, the authors:

- Layer a catastrophic high-deductible medical plan over the projected claims without accounting for changes in utilization due to price elasticity of demand or other behavioral effects
- Do not perform enough sensitivity tests with regard to plan design and IHA contribution amounts
- Significantly overstate personal savings (IHA account balances) due to absence of medical trend in projecting lifetime costs
- Fail to accurately depict total plan costs (including the IHA contributions) from the viewpoint of employer
- Admittedly would like to consider risk aversion and time preferences more formally within a utility framework
- Admittedly would like to consider tax effects since out-of-pocket costs under the deductible could be paid with qualified non-taxable IHA contributions (similar to tax advantages of CDHPs and HSAs)

Without an analysis that addresses some of these potential drawbacks, with particular attention to the adequacy of HSA balances for the chronically ill, policies that expand HSAs on the grounds of long-term viability of the self-funding mechanism, as yet, have no grounding in empirical research. It is my intention to make progress toward changing this, by estimating a claims inference and prediction model as a necessary first step in simulating long-term expenditures. In creating this model, I have made major modifications to the EMW approach which address some of the deficiencies noted above. While EMW focused primarily on matching actual expenditures for one large employer, I have used additional data available through the Health and Retirement Study to look at other health-related factors that would contribute to reducing the unexplained variation of medical expenditures for a more representative cohort of 50 through 65-year-olds nearing Medicare eligibility age. Subsequent to estimating the claims prediction model, I have simulated HSA utilization and build-up by forecasting claims over the years prior to Medicare eligibility. A combination of factors makes

this HRS cohort an important population to focus on. According to the recent Commonwealth Fund Survey of Older Adults (2006),

- Rising out-of-pocket health care costs and sluggish wage growth threaten the Baby Boomer cohort's ability to save adequately for retirement
- This age cohort has medical claims nearly twice as high as "younger adults" and have higher rates of chronic health conditions (62% of 50-64-year-olds reported at least one of six conditions)
- Many have unstable insurance coverage due to termination, early retirement or inability to secure employer-provided or individual health insurance (20% had history of unstable coverage since age 50)

That HSAs have been proposed as a solution to increase the ranks of the insured and allow for greater accountability in health care consumption has led many employers to offer these plans as group medical options, and they have been become the plan du jour in the individual market. Very much in the way employers shifted retirement income risk to employees by moving from defined benefit pensions to defined contribution plans like 401(k)s, they are beginning to move away from first dollar comprehensive medical plans to tax-advantaged high deductible HSAs. For a heterogeneous population, this will of course produce winners and losers based on individual health risks when you consider a) out-of-pocket costs, and b) HSA assets remaining for retirement. While EMW believes that such vehicles will allow for significant build-up of HSA assets to be used for health care costs in retirement, my analysis suggests that they do not. Furthermore, for the chronically ill that may soon be encouraged to enroll in these plans based on newly proposed HSA subsidies, the plans may prove disastrous from a savings adequacy perspective.

Data

The HRS data set, as of 2005, includes several cohorts of respondents interviewed longitudinally from 1992 through 2002. I have extracted the 50-65 year old subset of the population from the data to form a representative sample of respondents and spouses for three waves: 1998, 2000 and 2002. While this cohort of survey respondents pre-dates the current baby-boomers (50-64 year olds as of 2006) by approximately four to eight years, I believe the out-of-pocket expenditures and incidence/prevalence of chronic conditions would be similar to the current baby-boomers (except for medical trend), ceteris paribus. The HRS Cohort was born between 1931 and 1941, giving them an age range of 57-71 over the three wave period. The War

Baby Cohort was born between 1942 and 1947, giving them an age range of 51-60 over the three wave period. The other two cohorts in the HRS, "AHEAD" and "Children of Depression", include respondents whose dates of birth do not bracket the 51-64 age band of interest.

In constructing the data set, I only included persons who responded to all three interview waves, and as such, total expenditures may be biased downward due to the absence of end-of-life costs of care. To make the population as similar as possible to those comprising the potential market for Health Savings Accounts, I have eliminated those covered by Medicaid, Medicare or Champus (VA) for each of the three waves. Also excluded were persons receiving SSDI or living in nursing homes at the time of the interview. Remaining are 5,125 respondents and spouses with quite heterogeneous characteristics: e.g., insured/uninsured, working/unemployed, single/married, rich/poor, college+/no college. In addition, the respondents varied significantly (cross-sectionally, but not over time) with respect to self-reported health status, lifestyle & behaviors (smoking, drinking, etc), the number of chronic medical conditions reported, and the number of activities of daily living (ADLs) presenting difficulty.

The dependent variable in both components of my analysis is "Total medical expenditures", herein referred to as "claims". Claims are gross, including out-of-pocket costs and amounts potentially covered by insurance. If the respondent was unclear about the level of claims, an unfolding bracket technique was employed in conjunction with a RAND imputation algorithm to derive claims (RAND provides the clean HRS data set). This unfortunate aspect of the data creates statistical issues due to the underlying nature of the data generating process, detailed below. As claims are reported over a two year look-back period, all claim amounts and marginal effects reported in this paper are on a biennial basis. The average 2001-2002 claims for the 5,125 subjects are $12,400, or $6,200 annually, which is a reasonable claim level for this age-cohort based on this author's actuarial experience. As claims forecasting for HSA balance simulation will occur over two-year effective policy periods, I have validated my biennial approach using annualized data from Society of Actuaries claim databases, comparing annual versus biennial plan insurance values for a standard HSA plan design. For purposes of calculating out-of-pocket costs under a catastrophic HSA plan, an adjustment was made to the insurer-paid portion of the claims based on the plan value differential gleaned from this analysis (about 9%), discussed below in the simulation section.

Independent variables were chosen based on their likely influence on expected claim levels, and based on the ability to accurately forecast their values over a 15 year simulation horizon. The set of predictors available through the HRS is extremely rich and surpasses the level of micro-data that would typically be available to group insurers (though perhaps not individual insurers). Due to the high persistence of claim shocks over time, I have included lagged claims from prior survey waves in a manner consistent with the EMW approach. Other model specifications were entertained that would reflect the panel nature of the data, and the pros and cons of a panel approach are discussed in the model specification section below. The complete list of independent variables is directly observed from the forthcoming results exhibits.

Model of Inference: Part I

Both the inference and prediction models use a two-part approach to first estimate a "hurdle" component as the probability of having a claim over the current two year period, multiplied by the "level" component as the expected claim amount given that one occurred. The 2001-2002 claim amount is set up as a latent variable Y_i^* such that $Y^* = X\beta + \varepsilon$, for a matrix of predictors X. Assuming ε_i is distributed as Normal $(0,\sigma^2)$, and defining the indicator variable Y for Y^* such that $Y_i = 1$ if $(\beta' x_i + \varepsilon_i) > 0$, then the probability of having a claim (or log claim) may be modeled with Probit as:

$\text{Prob}(Y_i = 1 \mid x_i) = \Phi(\beta' x_i)$ *where Φ is the Normal(0,1) CDF*

Under this specification, marginal effects for predictor x_k are calculated as:

$\frac{\partial}{\partial x_k}[\Phi(X\beta)] = \varphi(X\beta) * \beta_k$ *for continuous real-valued predictors, and*

$\frac{\partial}{\partial x_k}[\Phi(X\beta)] = \Phi(X\beta \mid x_k = 1) - \Phi(X\beta \mid x_k = 0)$ *for categorical indicator variables*

Table 1 below details the estimation results of Part I of the two-part model, where marginal effects have been calculated two ways: first, using the average $\bar{X}\hat{\beta}$ to calculate each effect, and second, by averaging the phi-functions evaluated at each individual $X_i\hat{\beta}$. Also

shown, for comparison, are the parameter coefficients for the Linear Probability Model specification (ala EMW), with heteroskedasticity consistent standard errors.

Table 1: Model of Inference, Part I Probit Specification for Probability of Having a Claim

	Probit Part 1				Linear Probability Model	
Variable	Marginal Effect Average of all	Marginal Effect Using the Avg.	P-Value	Difference in Marg. Eff	Coeff. Est	P-Value
Intercept	N/A	N/A	0.5948	N/A	0.8638	0.0000
Exercises 3X+ Weekly	0.0024	0.0010	0.5903	0.0014	0.0019	0.6973
Ever drinks Alcohol	**0.0091**	**0.0037**	**0.0526**	0.0053	**0.0103**	**0.0400**
Number of Conditions	**0.0189**	**0.0076**	**<.0001**	0.0113	**0.0149**	**0.0000**
Currently Working for $	-0.0043	-0.0017	0.3750	-0.0026	-0.0044	0.4007
50-55 versus 56-60	0.0019	0.0008	0.8511	0.0012	0.0027	0.7363
61-65 versus 56-60	0.0081	0.0033	0.2451	0.0048	0.0084	0.1317
Lives in Northeast vs.South	0.0000	0.0000	0.9996	0.0000	0.0004	0.9488
Lives in Midwest vs. South	0.0085	0.0033	0.1317	0.0052	0.0049	0.3737
Lives in West vs. South	-0.0011	-0.0005	0.8558	-0.0007	-0.0011	0.8769
Some College or Above	**0.0123**	**0.0051**	**0.0148**	0.0072	**0.0127**	**0.0050**
Is Married or Partnered	0.0020	0.0008	0.7146	0.0012	0.0018	0.7923
Health Status (Fair/Poor) vs. Excellent	-0.0022	-0.0009	0.7603	-0.0013	0.0035	0.6830
Health Status Good vs. Excellent	0.0038	0.0015	0.4659	0.0023	0.0036	0.5176
No Claims two waves prior	0.0069	0.0026	0.6314	0.0043	**-0.1357**	**0.0001**
No Claims one wave prior	**-0.0727**	**-0.0453**	**0.0070**	-0.0275	**-0.2586**	**0.0000**
Log Claims two waves prior	**0.0061**	**0.0025**	**0.0021**	0.0037	**0.0034**	**0.0287**
Log Claims one wave prior	0.0009	0.0003	0.6524	0.0005	-0.0015	0.3820
Is Male	**-0.0141**	**-0.0060**	**0.0535**	-0.0081	**-0.0148**	**0.0680**
Is Non-White	-0.0022	-0.0009	0.6987	-0.0013	-0.0030	0.6727
1 ADL problem versus None	0.0081	0.0030	0.5360	0.0051	0.0041	0.6466
2+ ADL problems versus None	0.0103	0.0037	0.5231	0.0066	0.0079	0.4774
Has back problems	-0.0011	-0.0005	0.8350	-0.0007	0.0033	0.5147
HH Income $30-60K vs $0-30K	**0.0113**	**0.0043**	**0.0363**	0.0069	0.0126	0.0932
HH Income $60-100K vs $0-30K	0.0076	0.0029	0.2389	0.0047	0.0080	0.3210
HH Income Over $100K vs $0-30K	**0.0261**	**0.0096**	**0.0004**	0.0165	**0.0232**	**0.0027**
Has Govt. Insurance vs. No Insurance	**0.0222**	**0.0067**	**0.0071**	0.0155	**0.0615**	**0.0018**
Has Indiv. Insurance vs. No Insurance	**0.0183**	**0.0060**	**0.0036**	0.0124	**0.0503**	**0.0009**
Has Employer Insurance vs. No Insurance	**0.0538**	**0.0303**	**<.0001**	0.0235	**0.0705**	**0.0000**
50-55 and Male, versus 56-60 and Male	-0.0041	-0.0017	0.7941	-0.0024	0.0030	0.8462
61-65 and Male, versus 56-60 and Male	-0.0112	-0.0049	0.2649	-0.0063	-0.0073	0.4925
Ever Smokes in Life	-0.0054	-0.0022	0.2386	-0.0032	-0.0051	0.2811

Sample size is 5,125 respondents and spouses aged 50-65 from RAND Health & Retirement Study
Dependent variable is indicator for whether respondent reported claims for period 2001-2002
Names of independent variable specify omitted categorical variable unless obvious
96.6% reported a claim, and this is the basis for marginal effects (e.g., higher education increases Prob(claim) by 1.23% from 96.6% to 97.8%)
First column of marginal effects averages the effect over all individuals; Second column uses the average level of independent variables
Variables significant at or near the 5% level are shaded and boldfaced.
Linear Probability Model p-values reflect heteroskedasticity consistent standard errors

The Probit "hit rate" for 2001-2002 claims is very high, with 96.6% of respondents reporting claims. Thus, over the two years, only 3.4% had zero claims. This is reasonable as it implies an 18.4% probability of having zero claims in any one "policy" year, ceteris paribus, if accepting an unrealistic assumption of independence of claim levels in contiguous periods. Most notable in Table 1 are the large and statistically significant health status, income, education and insurance effects contributing to the probability of having a claim. For example, increasing the number of chronic conditions by one condition increases the probability of having a claim by

almost 2% (using the marginal effects averaged over all persons). Respondents indicating some college or above have a 1.2% higher probability, and those reporting insurance coverage have a 2%-5% higher probability, depending on the insurance type. These are additive effects based on the dependent variable average of 96.6% having non-zero claims, and therefore are not "large" proportional effects on the probability of having claims. Having zero claims in the prior wave is the largest single effect, contributing to a 4%-7% decrease in the probability of having current period claims, depending on the method used to calculate marginal effects.

Model of Inference: Part II

Part II of the model is to calculate the expected level of claims, Y_i^*, conditional on positive reported claims for 2001-2002 and the same set of independent variables X. Two methods were employed to handle Part II of the model. The first method uses a "smearing factor" (Duan, 1983; Duan et al. 1983) in retransformation of the logged claims variable, described below and subsequently rejected in favor of the second method based on the Exponential Conditional Mean (ECM) using a generalized linear model. I will present both in order to illustrate the potential bias in calculating marginal effects when the "smearing", or retransformation factor, is heavily dependent on the predictor variables.

Part II: Retransformation using the Smearing Factor to estimate E[$Y_i^* \mid x_i, Y_i^* > 0$]

Due to the extremely skewed distribution of claims on the dollar scale, I employed a log linear model of expected claims set up as $Log(Y^*) = X\gamma + \mu$ where retransformation of the logged dependent variable results in $E[Y_i^* \mid x_i, Y_i^* > 0] = \exp(\gamma' x_i) * E[\exp(\mu_i) \mid Y_i^* > 0, X]$. The initial assumption is not necessarily that of a normally distributed error term μ_i, as it is possible to consistently estimate $E[\exp(\mu_i) \mid Y_i^* > 0, X]$ using a constant non-parametric smearing factor $S = \sum \exp(\hat{\mu}_i)$ where the summation is over non-zero claimants (Duan, 1983). The regression may be performed using OLS on the logged dependent variable with heteroskedasticity consistent standard errors. The assumption is that the log-scale residuals are i.i.d., symmetric about zero and most importantly, *homoskedastic*. Under the assumption of homoskedastic errors, parameters, marginal effects, and $E[Y_i^* \mid x_i, Y_i^* > 0]$ may be consistently estimated with zero bias. In this case, marginal effects are calculated as:

$$\frac{\partial}{\partial x_k} \mathrm{E}[Y_i^* \mid x_i, Y_i^* > 0] = \exp(X\gamma) * \gamma_k * S \qquad \textit{for continuous real-valued predictors, and}$$

$$\frac{\partial}{\partial x_k} \mathrm{E}[Y_i^* \mid x_i, Y_i^* > 0] = S * [\exp(X\gamma \mid x_k = 1) - \exp(X\gamma \mid x_k = 0)] \qquad \textit{for indicator variables}$$

Note that under a general specification of the smearing factor, where $\rho(x) = \mathrm{E}[\exp(\mu_i) \mid Y_i^* > 0, X]$, it is clear that differentiation of $\mathrm{E}[Y_i^* \mid x_i, Y_i^* > 0] = \exp(\gamma' x_i) * \rho(x)$ would lead to additional terms due to indirect effect of x on Y_i^* through $\rho(x)$. This leads to bias in the estimation of marginal effects and expected mean claims when Duan's homoskedastic smearing factor is used in the presence of heteroskedastic log-scale residuals (Mullahy, 1998). Let us assume this away for the moment.

Under the assumption of homoskedastic errors, Table II below presents Part II marginal effects using an estimated smearing factor $S = 2.74$. The mean biennial claim (unlogged) is about $12,860 for those with non-zero claims. As with Part I of the model, marginal effects have been computed both using the average $\overline{X}\hat{\gamma}$ to calculate each effect, and second, by averaging the exponentials evaluated at each individual $X_i\hat{\gamma}$. Saving interpretation of these effects for the *preferred* specification below, I now turn to tests of the homoskedastic errors that permit unbiased estimation of these effects.

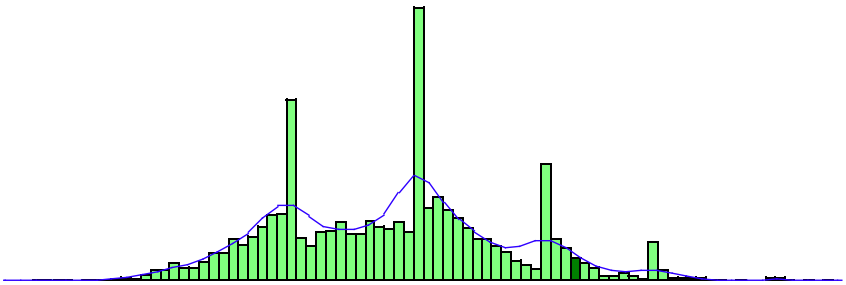
As noted above, an unsettling aspect of the claims data reported in the HRS is that the underlying data-generating process is not random, and certainly not normal. While this will not impact the Part I Probit model significantly (but does argue for potential re-specification), it will make for especially challenging estimation of the Part II claims model. Figure 1 below shows the distribution of biennial claims on the log-scale. Respondents were allowed to report actual claim amounts, or select an amount based on guided responses from an unfolding bracket. As such, while there were about 4,200 responses that were "real" or otherwise imputed continuously by RAND's algorithm, there were about 900 additional discrete responses creating spikes at the values $1000 (count=276), $5,000 (count=405), $25,000 (count=159), $100,000 (count=52) and $500,000 (count=6). Figure 1 below clearly shows these response spikes. The Kolmogorov-Smirnov-Lilliefors test rejects normality of logged claims.

Table 2: Model of Inference, Part II Log-Linear OLS with Smearing Factor

	Log-Linear Model Part 2			
Variable	E(Y/X,Y>0) Average of all	E(Y/X,Y>0) Using the Avg.	P-Value	Difference in Marg. Eff
Intercept	N/A	N/A	0.0000	N/A
Exercises 3X+ Weekly	($329)	($264)	0.5157	($65)
Ever drinks Alcohol	($774)	($623)	0.1495	($152)
Number of Conditions	**$3,065**	**$2,458**	**0.0000**	$607
Currently Working for $	**($1,472)**	**($1,189)**	**0.0101**	($282)
50-55 versus 56-60	($623)	($500)	0.5376	($123)
61-65 versus 56-60	($556)	($446)	0.4276	($110)
Lives in Northeast vs.South	($418)	($335)	0.5763	($83)
Lives in Midwest vs. South	($109)	($88)	0.8632	($22)
Lives in West vs. South	($464)	($372)	0.5065	($92)
Some College or Above	**$1,952**	**$1,565**	**0.0004**	$388
Is Married or Partnered	($48)	($39)	0.9421	($10)
Health Status (Fair/Poor) vs. Excellent	**$8,407**	**$7,162**	**0.0000**	$1,245
Health Status Good vs. Excellent	**$3,341**	**$2,669**	**0.0000**	$672
No Claims two waves prior	$2,605	$2,083	0.2830	$522
No Claims one wave prior	**$16,677**	**$13,219**	**0.0000**	$3,458
Log Claims two waves prior	**$884**	**$709**	**0.0000**	$175
Log Claims one wave prior	**$1,872**	**$1,501**	**0.0000**	$371
Is Male	$739	$592	0.3596	$147
Is Non-White	**($2,472)**	**($1,982)**	**0.0002**	($490)
1 ADL problem versus None	$514	$413	0.7064	$101
2+ ADL problems versus None	**$5,812**	**$4,742**	**0.0064**	$1,070
Has back problems	$1,024	$827	0.0788	$197
HH Income $30-60K vs $0-30K	$641	$514	0.3896	$127
HH Income $60-100K vs $0-30K	$1,606	$1,285	0.0622	$321
HH Income Over $100K vs $0-30K	**$3,372**	**$2,691**	**0.0006**	$681
Has Govt. Insurance vs. No Insurance	**$5,018**	**$4,042**	**0.0136**	$976
Has Indiv. Insurance vs. No Insurance	**$5,301**	**$4,225**	**0.0001**	$1,076
Has Employer Insurance vs. No Insurance	**$4,764**	**$3,781**	**0.0000**	$982
50-55 and Male, versus 56-60 and Male	$196	$158	0.9078	$39
61-65 and Male, versus 56-60 and Male	($930)	($746)	0.3741	($185)
Ever Smokes in Life	$619	$497	0.2278	$122

Sample size is 4,950 respondents and spouses aged 50-65 from RAND Health & Retirement Study
Dependent variable is biennial logged medical expenditures reported for period 2001-2002, given a non-zero claim
Names of independent variable specify omitted categorical variable unless obvious
Average biennial claim amount is $12,860, and this is the basis for marginal effects shown on the unlogged (dollar) scale
First column of marginal effects averages the effect over all individuals; Second column uses the average level of independent variables
Variables significant at or near the 5% level are shaded and boldfaced.
P-Values are based on heteroskedasticity consistent standard errors

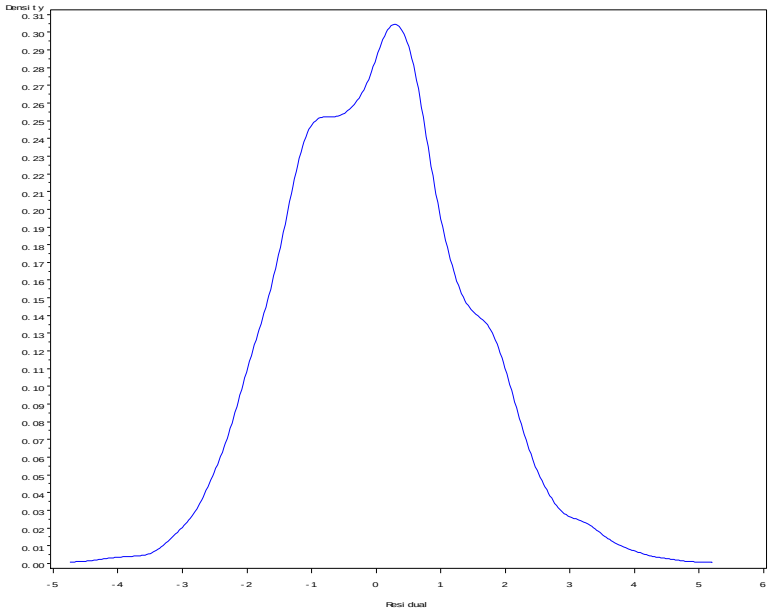
Fig. 1: Distribution of Logged Medical Claims for 2001-2002



However, these response spikes are not necessarily the deal-breaker for the homoskedastic smearing factor. Turning to the log-scale residuals from the OLS log-linear

regression, Figure 2 below illustrates a Kernel density estimation of the distribution of residuals, which depicts a disproportionate share of studentized residuals with absolute value greater than 2 (thick tails) due to expected systematic over-prediction of *low* actual claims and under-prediction of *high* actual claims (spiked responses are also visible here). However, the residuals are i.i.d. to the extent respondent and spouse claims are independent, and the signed rank test of the distributional center failed to reject $E(\mu) = 0$ with a p-value of .27. Thus all that is left to check is whether the errors are homoskedastic, and the smearing retransformation factor will be adequate for unbiased inference.

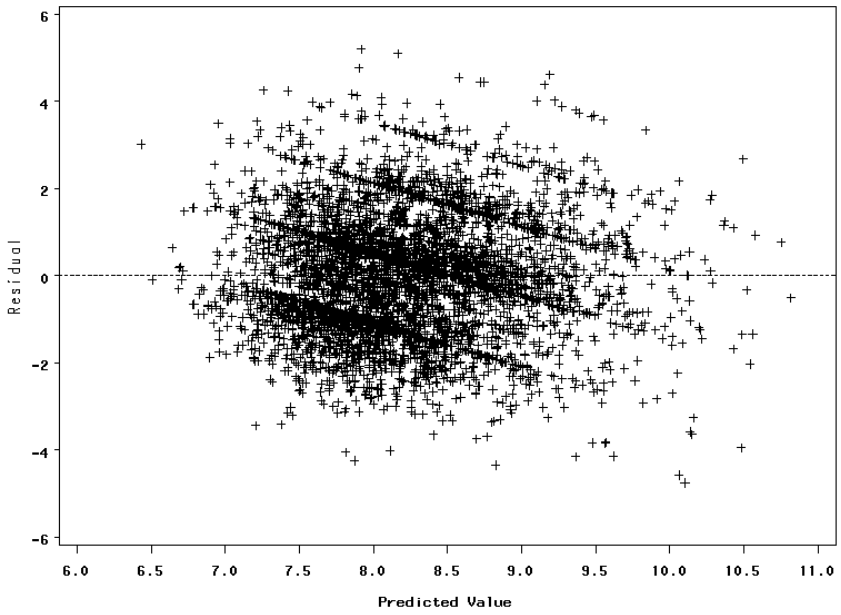
Fig. 2: Kernel Density Estimation of Log-scale Residuals Resulting from Part II Smearing Model



White's test of homoskedastic errors failed to reject the null of homoskedasticity with a p-value of .78, although a SAS warning indicated that the average covariance matrix had been deemed singular, violating an assumption of the test. Moreover, Figure 3 below shows a plot of log-scale residuals versus predicted values. What could be a beautiful cloud of residuals has been corrupted by what appears to be "claw-marks" due to the spiked responses discussed above (colleagues have described them as "grill-marks"). Despite these evident strata of residuals due to clustered responses, homoskedasticity may still be plausible, but an additional test is warranted. Mullahy (1998) suggests a method to determine if the functional form of the

smearing factor, $\rho(x) = \mathrm{E}[\exp(\mu_i) | Y_i^* > 0,\ X\ ]$, is truly dependent on x, in which case Duan's homoskedastic smearing estimate S could lead to bias in the inference of marginal effects unless a functional form of $\rho(x)$ is parameterized and the marginal effects equations expanded to include the indirect effects of x on Y_i^* through $\rho(x)$.

Fig. 3: Plot of Log-scale Residuals versus Predicted Values for Part II Smearing Model



Mullahy posits that a functional form for $\rho(x)$, namely $\rho(x) = \exp(x\lambda)$, can be estimated by a non-linear regression of $\exp(\hat{\mu}_i)$ on $\exp(x\lambda)$. Should the results of this regression show no dependence on the x's, then homoskedastic errors pave the way for Duan's constant smearing factor. Results of this non-linear regression are shown in Table 3, below. Clearly, there is noticeable dependence on many of the x's using this form of the retransformation function. While it would be possible to use the predicted values of $\rho(x) = \exp(x\lambda)$ to derive heteroskedasticity-consistent total marginal effects, the formula is non-trivial due to differentiation of a product of three functions of the x's, and would also be dependent on this specific form of the retransformation function. The researchers of the RAND Health Insurance Experiment (HIE) corrected for a non-constant retransformation function by splitting the sample according to discrete levels of x and estimating separate smearing factors (e.g., based on insurance plan assigned). However, Manning (1998) illustrates that the RAND HIE results are sensitive to such simplified corrections for heteroskedasticity. Additionally, using separate

smearing factors based on distinct vectors of the *x* 's would not be possible in my model specification due to continuous predictor variables on the right-hand side. Thus, we *re-develop* Part II of the claims inference model using a modified log-linear specification, that of the Exponential Conditional Mean (ECM), as suggested by Mullahy (1998).

Table 3: Non-linear Least Squares test of Homoskedastic Smearing Function for Part II Model

Non-Linear Regression to test Duan's Homoskedastic Smearing Factor

	Parameter Estimate	Approx Std Error	Approximate 95% Confidence Limits		Skewness
Intercept	**-1.367**	**0.3867**	**-2.1252**	**-0.6088**	**-0.023**
Is Male	-0.1675	0.1864	-0.533	0.198	-0.1769
Is Non-White	**-0.3037**	**0.128**	**-0.5547**	**-0.0528**	**-0.224**
Lives in Northeast vs.South	0.2432	0.1356	-0.0227	0.5091	-0.0525
Lives in Midwest vs. South	**0.4614**	**0.1097**	**0.2462**	**0.6766**	**0.0891**
Lives in West vs. South	-0.1028	0.1486	-0.3941	0.1885	-0.1236
Some College or Above	**0.5006**	**0.0984**	**0.3078**	**0.6934**	**0.0556**
Is Married or Partnered	-0.1589	0.0965	-0.348	0.0302	0.0173
Health Status (Fair/Poor) vs. Excellent	**-0.4902**	**0.1467**	**-0.7777**	**-0.2027**	**-0.1533**
Health Status Good vs. Excellent	**-0.5048**	**0.1027**	**-0.7062**	**-0.3033**	**-0.1374**
Log Claims two waves prior	-0.014	0.0374	-0.0873	0.0593	-0.0229
Log Claims one wave prior	**0.1186**	**0.0309**	**0.058**	**0.1791**	**-0.0186**
No Claims two waves prior	**1.6955**	**0.299**	**1.1094**	**2.2817**	**0.0368**
No Claims one wave prior	-0.3566	0.4863	-1.31	0.5969	-0.6474
1 ADL problem versus None	-0.1461	0.2439	-0.6243	0.3322	-0.5341
2+ ADL problems versus None	-0.2974	0.3282	-0.9408	0.346	-0.8054
Number of Conditions	0.052	0.0413	-0.029	0.133	-0.0447
Has back problems	**0.5358**	**0.085**	**0.3691**	**0.7024**	**0.024**
Exercises 3X+ Weekly	**-0.518**	**0.0986**	**-0.7114**	**-0.3247**	**-0.1263**
Ever drinks Alcohol	0.1795	0.0919	-0.00076	0.3598	0.0766
Ever Smokes in Life	**0.5904**	**0.1055**	**0.3836**	**0.7971**	**0.1761**
HH Income $30-60K vs $0-30K	**0.3659**	**0.1134**	**0.1435**	**0.5882**	**0.0973**
HH Income $60-100K vs $0-30K	-0.1574	0.1624	-0.4757	0.161	-0.0795
HH Income Over $100K vs $0-30K	-0.1239	0.1752	-0.4674	0.2196	-0.0826
Has Govt. Insurance vs. No Insurance	0.3914	0.2291	-0.0578	0.8406	-0.235
Has Indiv. Insurance vs. No Insurance	**-0.635**	**0.2603**	**-1.1453**	**-0.1247**	**-0.4117**
Has Employer Insurance vs. No Insurance	-0.0938	0.1366	-0.3617	0.1741	0.2136
Currently Working for $	**0.3355**	**0.104**	**0.1317**	**0.5393**	**0.118**
50-55 versus 56-60	0.1174	0.2119	-0.2981	0.5329	-0.3028
61-65 versus 56-60	**0.6432**	**0.1222**	**0.4037**	**0.8827**	**0.181**
50-55 and Male, versus 56-60 and Male	0.3085	0.3369	-0.352	0.969	-0.0518
61-65 and Male, versus 56-60 and Male	**-0.5583**	**0.2247**	**-0.9988**	**-0.1177**	**0.0597**

Confidence intervals are computed using Wald-based formula and are only asymptotically valid
Caution is warranted in interpreting confidence intervals for skewness factors not near zero.
Variables whose confidence intervals do not bracket zero are significant (shaded and boldfaced above)

Part II: The Exponential Conditional Mean estimation of E[$Y_i^* \mid x_i, Y_i^* > 0$]

Under the ECM specification, the Part II expected claims can be estimated directly as E[$Y_i^* \mid x_i, Y_i^* > 0$] = exp($\gamma' x_i$), where the log-link is assumed and the exponential form may be modeled according to a variety of distributions (Normal, Poisson, Gamma, Inverse Gaussian) and solved using maximum likelihood estimation. The generalized linear model is attractive because the log-link function directly specifies how the dependent variable is related to the predictors on the untransformed (dollar) scale, and thus no retransformation factor is necessary. As Mullahy (1998) has observed through simulation, this procedure is more robust to interpretation of marginal effects and estimation of expected claims relative to the homoskedastic smearing factor, particularly in the presence of heteroskedastic log-scale residuals. The trade-off is that estimation of the parameter coefficients *themselves* is not as robust as the smearing factor approach when the residuals truly are homoskedastic. As I am only concerned with total effects for the entire two-part model, not estimates of the coefficients themselves, and have heteroskedastic log-scale residuals under the smearing method, the ECM approach will offer more robust inference of key predictor variables that will parameterize the HSA simulation model (e.g., the total effect of a change in the level of insurance or number of chronic conditions on expected claims).

The mean of the biennial claims data is $12,860, conditional on non-zero claims. The variance is approximately 1.6 billion. Under specifications of the ECM, for the Normal, Poisson, Gamma and Inverse Gaussian distributions, the variance of Y^* takes the respective forms σ^2, μ, μ^2/ν, and $\sigma^2\mu^3$ where μ is the mean claim amount, and σ and ν are scale parameters for the different distributions. This attractive feature allows the variance of claims to increase with the mean level of claims. The ECM distributional specification that best approximates the large variance in our data sample is the Inverse Gaussian distribution, although Quasi-Maximum Likelihood techniques could be used to specify other relationships of the variance with the mean (e.g., Var(Y^*) proportional to $\mu^{2.24}$), without an associated distributional assumption.

A comparison of the Poisson, Gamma and Inverse Gaussian results is shown below in Table 4.

Table 4: Comparison of ECM Estimates by Distribution Specification for Part II Model

Part II with Exponential Conditional Mean
Comparison of parameter estimates

	Poisson Distrn		Gamma Distrn		Inverse Gaussian		Part II with Smearing Factor	
	Coef	Asymptotic P-Value	Coef	Asymptotic P-Value	Coef	Asymptotic P-Value	Coef	Het Cons P-Value
Intercept	**6.788**	<.0001	**6.682**	<.0001	**6.241**	<.0001	**5.575**	0.000
Is Male	**0.023**	<.0001	-0.001	0.992	0.055	0.591	0.058	0.360
Is Non-White	**-0.155**	<.0001	**-0.165**	0.001	**-0.172**	0.050	**-0.208**	0.000
Lives in Northeast vs.South	**0.187**	<.0001	0.066	0.223	0.069	0.473	-0.033	0.576
Lives in Midwest vs. South	**0.123**	<.0001	**0.115**	0.014	0.073	0.386	-0.009	0.863
Lives in West vs. South	**0.147**	<.0001	0.084	0.109	0.014	0.877	-0.037	0.507
Some College or Above	**0.223**	<.0001	**0.244**	<.0001	**0.154**	0.033	**0.153**	0.000
Is Married or Partnered	**-0.025**	<.0001	0.045	0.369	0.086	0.316	-0.004	0.942
Health Status (Fair/Poor) vs. Excellent	**0.714**	<.0001	**0.705**	<.0001	**0.708**	<.0001	**0.574**	0.000
Health Status Good vs. Excellent	**0.391**	<.0001	**0.313**	<.0001	**0.252**	0.002	**0.250**	0.000
Log Claims two waves prior	**0.032**	<.0001	**0.055**	0.000	**0.104**	0.001	**0.070**	0.000
Log Claims one wave prior	**0.154**	<.0001	**0.137**	<.0001	**0.139**	<.0001	**0.147**	0.000
No Claims two waves prior	**0.410**	<.0001	**0.494**	0.003	**0.654**	0.019	0.187	0.283
No Claims one wave prior	**0.622**	<.0001	**0.439**	0.010	0.431	0.091	**0.842**	0.000
1 ADL problem versus None	**-0.108**	<.0001	0.060	0.507	0.422	0.115	0.040	0.706
2+ ADL problems versus None	**0.233**	<.0001	**0.382**	0.001	0.334	0.360	**0.385**	0.006
Number of Conditions	**0.238**	<.0001	**0.249**	<.0001	**0.269**	<.0001	**0.241**	0.000
Has back problems	**0.019**	<.0001	0.051	0.221	0.158	0.052	0.080	0.079
Exercises 3X+ Weekly	**-0.006**	<.0001	-0.035	0.360	-0.039	0.553	-0.026	0.516
Ever drinks Alcohol	**-0.161**	<.0001	**-0.151**	0.000	-0.124	0.080	-0.061	0.149
Ever Smokes in Life	**0.162**	<.0001	**0.174**	<.0001	**0.227**	0.001	0.049	0.228
HH Income $30-60K vs $0-30K	**-0.024**	<.0001	-0.027	0.620	-0.057	0.563	0.050	0.390
HH Income $60-100K vs $0-30K	**-0.156**	<.0001	-0.067	0.274	-0.007	0.947	**0.122**	0.062
HH Income Over $100K vs $0-30K	**0.109**	<.0001	0.047	0.477	0.028	0.824	**0.245**	0.001
Has Govt. Insurance vs. No Insurance	**0.330**	<.0001	**0.320**	0.006	0.137	0.552	**0.337**	0.014
Has Indiv. Insurance vs. No Insurance	**0.255**	<.0001	0.109	0.193	0.053	0.684	**0.356**	0.000
Has Employer Insurance vs. No Insurance	**0.330**	<.0001	**0.376**	<.0001	**0.406**	<.0001	**0.411**	0.000
Currently Working for $	**-0.185**	<.0001	**-0.201**	<.0001	**-0.292**	0.000	**-0.115**	0.010
50-55 versus 56-60	**0.158**	<.0001	0.006	0.942	0.236	0.100	-0.050	0.538
61-65 versus 56-60	**-0.044**	<.0001	0.028	0.588	0.178	0.066	-0.044	0.428
50-55 and Male, versus 56-60 and Male	**0.168**	<.0001	0.132	0.290	-0.223	0.296	0.015	0.908
61-65 and Male, versus 56-60 and Male	**0.081**	<.0001	0.051	0.521	-0.110	0.441	-0.075	0.374
Scale	1.000		0.623		0.024		N/A	

Normal distribution failed to converge due to observational values out of limits
P-values are based on asymptotic standard errors
Coefficient estimates that are significant at 5% have been boldfaced

As seen in Table 4, the maximum likelihood function under the Normal assumption could not be maximized as the mean value was beyond an acceptable range due to large claim observations. Parameter estimates that were significant under the Part II smearing factor approach also tend to be significant under the ECM Inverse Gaussian method, with the notable exception of high income, individual insurance, government insurance, and having difficulty with 2+ ADLs. The estimate associated with smoking is highly significant (and properly signed) under ECM IG, where it was not significant under the smearing method. The majority of the parameter estimates across all three ECM specifications are in the same range. One exception is the lagged predictors related to having zero claims in prior waves, whose estimates tend to shift

significantly depending on the approach. As will be discussed later, these non-linear variables appear to be highly leveraged in the sense that there is a large hit rate (96.6% with claims), and *possibly*, the cyclical nature of claims for those with zero claims in a particular wave could lead to high current wave marginal effects. However, not much inference should be made on these prior wave variables as estimates are highly sensitive depending on the estimation approach employed.

Notwithstanding this, parameters for the lagged claims of prior waves is consistently estimated across all model specifications, and will be significant in claims prediction as they capture the high persistence (correlation) of claim shocks over time. Note that under the ECM Poisson model, all predictors are wildly significant. It is worth noting that when running goodness-of-fit tests on the logged claims distribution, the only functional form that "liked" this distribution (as shown in Figure 1) was the Poisson. Strangely enough, this may be because the test, in addition to the ECM Poisson specification, has treated the spiked responses as the *real data* and the real data (between the spikes) as *noise*. It is also possible that the data is over-dispersed under the Poisson model, and a weighting procedure is necessary to adjust the asymptotic variance-covariance matrix (however, the parameter estimates are fine). As such, at least for this HRS data set, the Poisson model may be the best for simulating the claims as generated by this particular survey method. However, when more randomized claims are obtained from this researcher, a more likely candidate for forecasting will be the Gamma, Inverse Gaussian, or a QMLE specification that allows the variance to increase as a power function of the expected mean claim.

For purposes of *inference* of the Part II model of expected claims, I have elected to go with the Inverse Gaussian as the variance-mean relationship is most reasonable, and roughly the same set of predictors are significant in comparison to the smearing approach. As the Gamma and Inverse Gaussian are not nested models, I cannot compare the two specifications using the difference in $-2\log(l)$, although the Gamma may ultimately be preferred (the variance is a power of 2.24 over the mean, which is "closer" to the Gamma than the Inverse Gaussian). Nonetheless, marginal effects for the Part II ECM IG model are shown below in Table 5. Marginal effects have been calculated using the same formula as in the Part II smearing

approach, where S , the smearing factors, is set to 1.0. P-values are based on asymptotic standard errors.

Table 5: Model of Inference, Part II ECM Model with Inverse Gaussian Distribution

	Exponential Conditional Mean Model Part 2: Inverse Gaussian			
Variable	E(Y/X,Y>0) Average of all	E(Y/X,Y>0) Using the Avg.	P-Value	Difference in Marg. Eff
Intercept	N/A	N/A	<.0001	N/A
Exercises 3X+ Weekly	($584)	($409)	0.5531	($175)
Ever drinks Alcohol	($1,833)	($1,291)	0.0802	($542)
Number of Conditions	**$4,004**	**$2,793**	**<.0001**	$1,211
Currently Working for $	**($4,365)**	**($3,155)**	**0.0002**	($1,211)
50-55 versus 56-60	$3,873	$2,688	0.1002	$1,185
61-65 versus 56-60	$2,634	$1,847	0.0662	$787
Lives in Northeast vs.South	$1,057	$738	0.4725	$320
Lives in Midwest vs. South	$1,107	$772	0.3859	$335
Lives in West vs. South	$212	$148	0.8766	$64
Some College or Above	**$2,327**	**$1,612**	**0.0331**	$715
Is Married or Partnered	$1,255	$875	0.3160	$380
Health Status (Fair/Poor) vs. Excellent	**$12,071**	**$9,464**	**<.0001**	$2,607
Health Status Good vs. Excellent	**$3,982**	**$2,750**	**0.0021**	$1,232
No Claims two waves prior	**$13,647**	**$9,414**	**0.0187**	$4,233
No Claims one wave prior	$8,001	$5,545	0.0913	$2,456
Log Claims two waves prior	**$1,550**	**$1,081**	**0.0005**	$469
Log Claims one wave prior	**$2,063**	**$1,439**	**<.0001**	$624
Is Male	$826	$575	0.5914	$251
Is Non-White	**($2,431)**	**($1,691)**	**0.0496**	($740)
1 ADL problem versus None	$7,464	$5,340	0.1152	$2,124
2+ ADL problems versus None	$5,740	$4,081	0.3596	$1,659
Has back problems	**$2,380**	**$1,693**	**0.0515**	$687
HH Income $30-60K vs $0-30K	($838)	($584)	0.5631	($254)
HH Income $60-100K vs $0-30K	($110)	($77)	0.9474	($33)
HH Income Over $100K vs $0-30K	$413	$288	0.8236	$125
Has Govt. Insurance vs. No Insurance	$2,174	$1,521	0.5517	$653
Has Indiv. Insurance vs. No Insurance	$809	$564	0.6844	$245
Has Employer Insurance vs. No Insurance	**$5,519**	**$3,810**	**<.0001**	$1,710
50-55 and Male, versus 56-60 and Male	($2,999)	($2,095)	0.2958	($903)
61-65 and Male, versus 56-60 and Male	($1,588)	($1,105)	0.4407	($483)
Ever Smokes in Life	**$3,276**	**$2,312**	**0.0009**	$965

Sample size is 4,950 respondents and spouses aged 50-65 from RAND Health & Retirement Study
Dependent variable is biennial logged medical expenditures reported for period 2001-2002, given a non-zero claim
Names of independent variable specify omitted categorical variable unless obvious
Average biennial claim amount is $12,860, and this is the basis for marginal effects shown on the unlogged (dollar) scale
First column of marginal effects averages the effect over all individuals; Second column uses the average level of independent variables
Variables significant at or near the 5% level are shaded and boldfaced.
P-Values are based on asymptotic standard errors

Worthy of note in Table 5 are the highly significant and large biennial marginal effects (relative to a mean claim of $12,860) associated with poor self-reported health status (increase of $9,500 - $12,100), an additional chronic condition (increase of $2,800 - $4,000), higher education (increase of $1,600 - $2,300), current employment (decrease of $3,200 - $4,400), having employer insurance (increase of $3,800 - $5,500) and having ever smoked (increase of $2,300 - $3,300). Ranges are provided above based on the method used to calculate marginal

effects ($*using the average* – $*average of all*). Note that lagged claims are also highly significant. With a unit increase on the log-scale, translating into a departure from the mean claim of about $3,000 two waves prior and $3,500 one wave prior, there is an increase in current claims of $1,000 and $1,400 respectively (using marginal effects based on the average). One can infer from this that an average claim shock persists about 33% from two waves prior and 40% from one wave prior. This is consistent with log-scale Pearson correlations of .30 and .34 for two waves prior and one wave prior, respectively. As discussed above, effects for having zero claims in prior waves should be interpreted with caution.

Putting the Two-Part Model Together

Combining the Part I Probit model and the Part II ECM Inverse Gaussian (IG) model, one can estimate expected biennial claims on the unlogged (dollar) scale as:

$$E[Y_i^* \mid x_i] = \text{Prob}(Y_i = 1 \mid x_i) * E[Y_i^* \mid x_i, Y_i^* > 0] = \Phi(\beta' x_i) * \exp(\gamma' x_i)$$

Total marginal effects, taking into account the impact of x_k on both parts of the model, are estimated as:

$$\frac{\partial}{\partial x_k} E[Y_i^* \mid x_i] = \frac{\partial}{\partial x_k} [\Phi(\beta' x_i)] * \exp(\gamma' x_i) + \frac{\partial}{\partial x_k} [\exp(\gamma' x_i)] * \Phi(\beta' x_i)$$

$$= [\text{Part 1 Marginal Effect}] * \exp(\gamma' x_i) + [\text{Part 2 Marginal Effect}] * \Phi(\beta' x_i)$$

Again, the exponential and Normal CDF in the total effects equation have been calculated first by using the average $\bar{X}\hat{\gamma}$ and $\bar{X}\hat{\beta}$ to calculate each effect, and second, by averaging the functions evaluated at each individual $X_i\hat{\gamma}$ and $X_i\hat{\beta}$.

Table 6, on the next page, presents the final total effects combining the Part I and Part II models. The average biennial claim (including zeroes) is about $12,400, and the total effects have been added to the mean claim under the columns "Effect on Mean". Percentage effects on the mean claim are shown in the last two columns. Predictor variables that were significant in both parts of the model are *darkly* shaded and include the number of chronic conditions (increase of $2,900 - $4,200 from the mean), higher education (increase of $1,700 - $2,400), having employer-provided health insurance ($4,100 - $6,100), and claims from two waves prior (increase of $1,100 for each additional $3,000 in lagged claims).

Table 6: Model of Inference, Part I Probit and Part II ECM Model *Total Effects*

	Total Effects				*2001-2002 Claims* **$12,423** Effect on Mean		% Effect from Mean	
Variable	Average of all	Using the Avg.	P-Val Part 1	P-Val Part 2	Average of all	Using the Avg.	Average of all	Using the Avg.
Intercept	N/A	N/A	0.5948	<.0001	N/A	N/A	N/A	N/A
Exercises 3X+ Weekly	($528)	($396)	0.5903	0.5531	$11,894	$12,027	-4.3%	-3.2%
Ever drinks Alcohol	**($1,636)**	**($1,243)**	0.0526	0.0802	$10,786	$11,180	-13.2%	-10.0%
Number of Conditions	**$4,151**	**$2,852**	**<.0001**	**<.0001**	$16,573	$15,274	33.4%	23.0%
Currently Working for $	**($4,282)**	**($3,149)**	0.3750	**0.0002**	$8,141	$9,273	-34.5%	-25.4%
50-55 versus 56-60	$3,772	$2,677	0.8511	0.1002	$16,194	$15,099	30.4%	21.5%
61-65 versus 56-60	$2,666	$1,868	0.2451	0.0662	$15,089	$14,290	21.5%	15.0%
Lives in Northeast vs.South	$1,022	$732	0.9996	0.4725	$13,444	$13,155	8.2%	5.9%
Lives in Midwest vs. South	$1,196	$800	0.1317	0.3859	$13,618	$13,223	9.6%	6.4%
Lives in West vs. South	$189	$142	0.8558	0.8766	$12,611	$12,565	1.5%	1.1%
Some College or Above	**$2,431**	**$1,653**	**0.0148**	**0.0331**	$14,854	$14,076	19.6%	13.3%
Is Married or Partnered	$1,242	$877	0.7146	0.3160	$13,665	$13,300	10.0%	7.1%
Health Status (Fair/Poor) vs. Excellent	**$11,630**	**$9,385**	0.7603	**<.0001**	$24,053	$21,808	93.6%	75.5%
Health Status Good vs. Excellent	**$3,904**	**$2,746**	0.4659	**0.0021**	$16,327	$15,168	31.4%	22.1%
No Claims two waves prior	**$13,289**	**$9,372**	0.6314	**0.0187**	$25,712	$21,794	107.0%	75.4%
No Claims one wave prior	**$6,648**	**$5,034**	**0.0070**	0.0913	$19,071	$17,457	53.5%	40.5%
Log Claims two waves prior	**$1,589**	**$1,099**	**0.0021**	**0.0005**	$14,011	$13,521	12.8%	8.8%
Log Claims one wave prior	**$2,006**	**$1,432**	0.6524	**<.0001**	$14,429	$13,855	16.2%	11.5%
Is Male	**$589**	**$509**	**0.0535**	0.5914	$13,011	$12,931	4.7%	4.1%
Is Non-White	**($2,382)**	**($1,688)**	0.6987	**0.0496**	$10,041	$10,735	-19.2%	-13.6%
1 ADL problem versus None	$7,333	$5,333	0.5360	0.1152	$19,756	$17,755	59.0%	42.9%
2+ ADL problems versus None	$5,700	$4,090	0.5231	0.3596	$18,122	$16,512	45.9%	32.9%
Has back problems	**$2,283**	**$1,676**	0.8350	**0.0515**	$14,705	$14,098	18.4%	13.5%
HH Income $30-60K vs $0-30K	**($642)**	**($535)**	**0.0363**	0.5631	$11,781	$11,888	-5.2%	-4.3%
HH Income $60-100K vs $0-30K	$7	($46)	0.2389	0.9474	$12,430	$12,377	0.1%	-0.4%
HH Income Over $100K vs $0-30K	**$788**	**$385**	**0.0004**	0.8236	$13,210	$12,808	6.3%	3.1%
Has Govt. Insurance vs. No Insurance	**$2,431**	**$1,579**	**0.0071**	0.5517	$14,853	$14,002	19.6%	12.7%
Has Indiv. Insurance vs. No Insurance	**$1,054**	**$621**	**0.0036**	0.6844	$13,477	$13,044	8.5%	5.0%
Has Employer Insurance vs. No Insurance	**$6,133**	**$4,096**	**<.0001**	**<.0001**	$18,556	$16,519	49.4%	33.0%
50-55 and Male, versus 56-60 and Male	($2,959)	($2,098)	0.7941	0.2958	$9,464	$10,325	-23.8%	-16.9%
61-65 and Male, versus 56-60 and Male	($1,701)	($1,147)	0.2649	0.4407	$10,721	$11,275	-13.7%	-9.2%
Ever Smokes in Life	**$3,086**	**$2,272**	0.2386	**0.0009**	$15,508	$14,695	24.8%	18.3%

Sample size is 5,125 respondents and spouses aged 50-65 from RAND Health & Retirement Study
Dependent variable is biennial logged medical expenditures reported for period 2001-2002
Names of independent variable specify omitted categorical variable unless obvious
Average biennial claim amount is $12,423, and this is the basis for total marginal effects shown on the unlogged (dollar) scale
First column of marginal effects averages the effect over all individuals; Second column uses the average level of independent variables
Variables significant at or near the 5% level in both parts of the model are boldfaced and darkly shaded.
Variables significant at or near the 5% only one of the parts are boldfaced and lightly shaded
P-Values for Part 2 are based on asymptotic standard errors

A number of additional predictors were large and significant in predicting either the probability of a claim (incidence), or the level of the claim (severity), but not both. These are *lightly* shaded in the table above. Having "good" and "poor" health status, relative to "excellent" status, increases the expected claims by about $3,300 and $10,500 respectively (averaging the two marginal effects methods). Reporting back problems increases expected claims by about $2,000. Reporting income over $100,000 increases expected claims by about $600, although other income variables suggest this effect is negative at lower salaries and then increases (*U*-shaped). Demographic variables related to age and gender are insignificant, for reasons discussed below. Although insignificant, drinking alcohol decreases the average claim by about $1,400, while smoking significantly increases expected claims by about $2,700. Engaging in rigorous physical activity three or more times a week contributes a statistically insignificant and modest $500 decrease in claims.

Of special interest are the parameters on health insurance variables which will be useful in simulation. For example, averaging the marginal effects methods, having employer-provided health insurance increases expected claims by about 40%. In the sample, the proportion with employer-provided insurance is 82%. For a 100% increase in the quantity of coverage (going from none to having insurance), there is a 40% increase in expected costs. From this we can associate a .40 elasticity of expenditures with respect to insurance coverage (RAND HIE reports a .17 - .22 elasticity using smearing factor approach). If one were to model the combined behavioral effects due to adverse selection and moral hazard due to implementation of a high deductible health plan (HDHP) attached to an HSA, one could estimate the decrease in insurance coverage due to the "doughnut hole" and apply the .40 elasticity to reduce claims. For example, if a $1000 deductible decreased the insurance value by 10%, then one would expect a 4% decrease in expected claims.

Alternative Model Specifications

In the model of inference, are we adequately modeling the serial correlation of claims over time? I would argue that the Two-Part model with lagged claims does allow for valuable inference on key predictor variables. The three waves of data span a time period of 6 years. If the current period claims are from period (t-1) and (t), then it is clear from the significant marginal effects for claims from two waves prior, that is periods (t-5) and (t-6), that persistence of health care shocks is high for this age cohort, and may very well go back to periods before (t-6). I am not convinced that more meaningful estimates of key predictors could be gleaned using a random effects approach. What's more, given the panel data would be short (only 3 biennial periods long), I do not believe that significantly more accurate inference would result. It is also difficult to implement such a model with serially correlated error terms embedded in the likelihood function. Fixed effects would not be useful for inference as many of the model predictors have very little "within variation" over time, which *does* make them excellent for forecasting and simulation purposes. However, if I were interested in more accurately estimating variables that do change somewhat over time (e.g., lifestyle variables, the number of ADLs posing difficulty, or chronic conditions by *type*), then fixed effects may prove valuable as unobserved individual heterogeneity would be eliminated. I believe, though, that compared to the high unexplained residual variance, the effect of any unobserved heterogeneity is de minimis

and the two-part lagged model is sufficient for my purposes, particularly for parameterizing the simulation model.

There are two other models that could be implemented to estimate the expected claims. One would be the Heckman sample selection approach and the Inverse Mills Ratio. However, Duan et al. (1983) argue that the censored data approach requires restrictive assumptions that are not testable, that we are dealing with "true zeroes", and the sample selection approach has "poor numerical and statistical properties". What's more, with the same set of predictors X for both parts of the model, there would be possible heteroskedasticity due to high correlation between X and the Inverse Mills Ratio. I am also willing to assume independence of the errors terms ε and μ, while the sample selection approach allows these to be correlated. To the extent health care events are stochastic and not planned, and that people do not seek medical advice based on the severity of a current condition (debatable), then an assumption of independence between the probability of a claim and the subsequent level of the claim is not unreasonable. The second model one could consider is a one-step estimation of $E[Y_i^* \mid x_i]$ using the entire sample. Mullahy (1998) points out that one-step ECM specification is possible using instrumental variables to get consistent coefficient estimates should some elements of X be correlated with unobservable determinants of the conditional mean (using a "GMM-type IV estimator"). While this method provides for simple interpretation of marginal effects, it is intractable to implement. Mullahy's simulation shows that the "1-part" approach provides results close to the 2-part ECM approach, although the 2-part ECM approach has lower mean squared error, making it the preferred model for prediction and simulation purposes.

As far as modifying the two-part model of inference ultimately chosen (Part I Probit and Part II ECM with Inverse Gaussian distribution), there are some additional considerations. The thick tails evident in Figure 2 may be remedied by using a Part 1 logistic specification since the logistic distribution has higher kurtosis and allows for more of the variance to be due to infrequent or extreme observations. For future consideration under Part II estimation, I would entertain the use of QMLE procedures with the ECM and log link, specifying a non-integer power of variance related to the mean claim. This may further both causal inference and claim prediction, and will be explored in future research.

Claims Prediction Model for Simulation Forecast Period

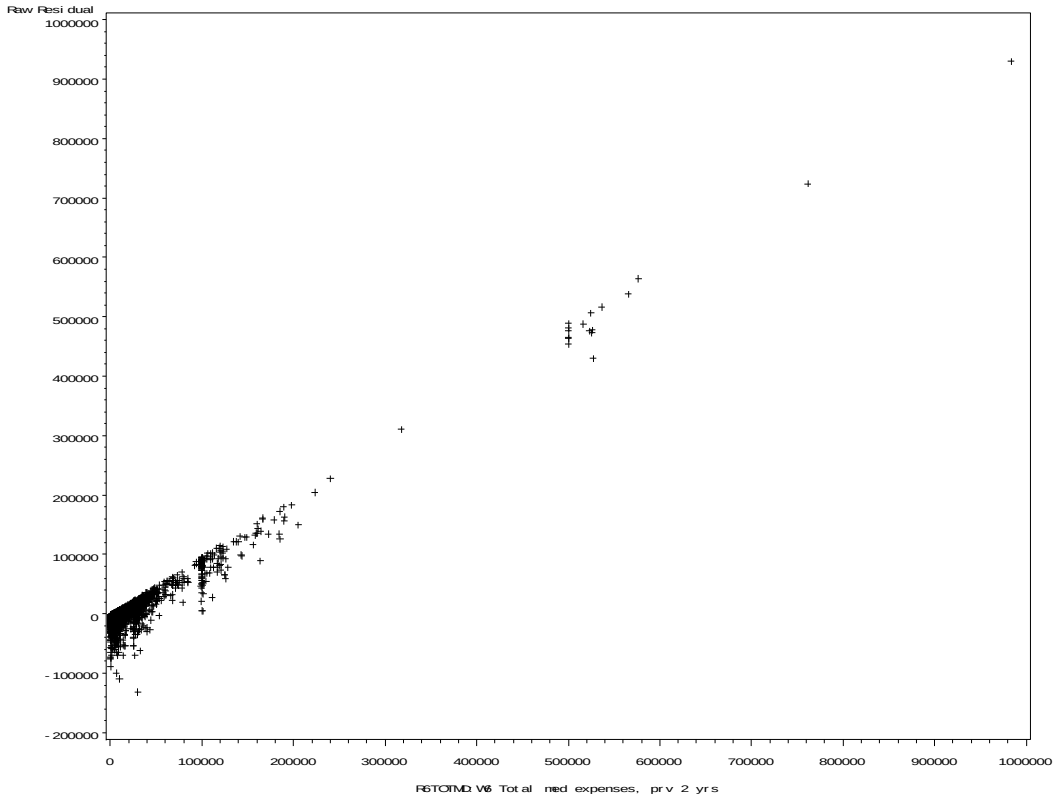
In the log-linear OLS regression of E[$Y_i^* \mid x_i, Y_i^* > 0$], the proportion of variance explained by the model was $R^2 = .17$. This is not atypical given the highly skewed distribution of claims (largest claim was $984,000). Even when adding a full set of utilization variables to the model (e.g., having seen a doctor, staying at the hospital, using prescription drugs, having surgery), the R^2 only increases to .32. The utilization variables are of course highly correlated with other predictors already in the model, and are useless for forecasting purposes over a 15 year horizon, and so have been excluded from candidate models. Also, variables that have traditionally been highly correlated with claims, namely age, gender, and interactions thereof, are not significant and offer very little additional explanatory power in a model that includes variables like "health status" and "number of conditions". However, in a model that predicts the "number of conditions", these demographic variables are highly significant.

For prediction purposes over a simulation horizon, one has the option of *1)* predicting the number of conditions based on a second regression and including the predicted value in the two-part model, or alternatively, *2)* initializing the hypothetical HSA members with a chronic health care profile (including number of conditions), and maintaining that profile over the short simulation horizon. The latter approach is more plausible as the number of conditions changes very little over time for this cohort, and the *true* number of chronic health conditions is highly significant in both parts of the model. Initializing the HSA members with the number of chronic conditions (and other health status variables) will be the preferred approach for simulation purposes.

The Part II expected claims model with smearing factor tends to over-predict claims on the low end of the actual claim distribution and under-predict claims on the high end of this distribution. The residuals on the dollar scale clearly increase with actual claims. The same effect occurs under all the Part II specifications using the ECM. However, based on root mean square prediction error, the predictive power (within sample) may be judged. In order of increasing prediction error, the models are ranked as: ECM Poisson < Log-Linear OLS^1 < ECM Gamma < Log-Linear OLS^2 < ECM IG where the Log-Linear OLS^1 model uses a uniform smearing factor and the Log-Linear OLS^2 uses a person specific predicted smearing factor based on the non-linear least squares regression to estimate $\rho(x)$. It is evident from this ranking that

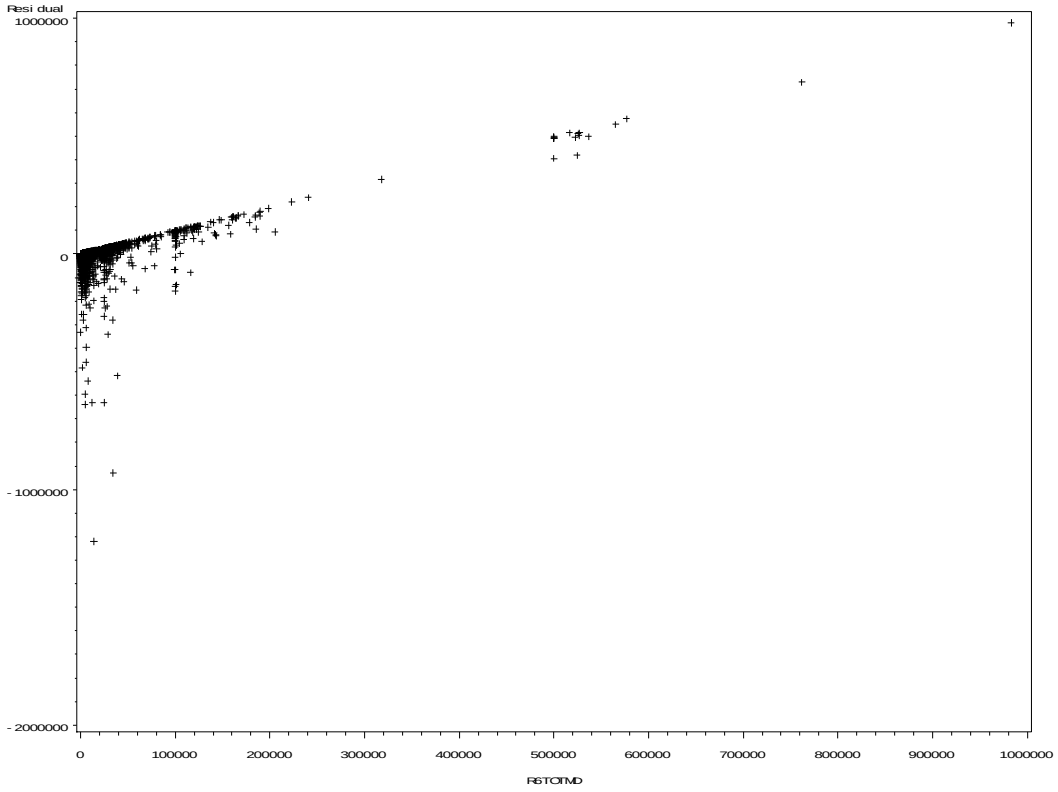
the ECM IG model selected for inference does the worst in replicating actual claim amounts, suggesting an apparent trade-off between predictive power and inference of marginal effects. Figure 4, below, shows a plot of dollar-scale residuals versus actual claims for the ECM Poisson specification. Even this specification is seemingly incapable of predicting outlier claims, as is expected. Nonetheless, as it produces the lowest prediction error for this data set, the ECM Poisson model will be preferred for simulation purposes.

Fig. 4: Dollar-scale Residuals versus Actual Values for Part II ECM Poisson Model



To remedy the over- and under-prediction, I have developed a method to sample log-scale residuals from the prediction model for use as random shocks in claims forecasting. That is, for Part II of the model, I first predict $\gamma' x_i$. Then, based on the range of the predicted values and the corresponding distribution of log-scale residuals conditional on that predicted range (there are seven such conditional distributions), a shock residual is randomly sampled, added to $\gamma' x_i$, and exponentiated back to the dollar scale. This was accomplished for the Poisson specification, with results shown in Figure 5 below.

Fig. 5: Dollar-scale Residuals based on Random Shock Draw for Part II ECM Poisson Model



Note that there is still systematic under-prediction and over-prediction noticeable in Figure 5. Using this shock residual sampling approach, the root mean square prediction error is about 40% higher. However, using this sampling approach, the median of the predicted claims has been stabilized at a value closer to the actual claims median of $4,300 (median was $9,400 for predicted values before shocks and $3,900 after shocks). In forecasting claims for simulation purposes, the shocks are sampled during each biennial forecast period, with the claim variance naturally increasing with the trended expected mean claim. For all of the simulation runs, claim trend is added in logarithmic form prior to exponentiating back to the dollar scale. Trend assumptions are modeled from the 2005 Kaiser Family Foundation Annual Survey of Employer Health Benefits. This is a noticeable improvement over the EMW approach, which did not account for health care cost increases over time, thereby making the Individual Health Accounts appear more viable than they actually would be with assumed trend. In order to avoid over-trending due to the inclusion of lagged claims from the prior two forecast periods, the lagged

claim amounts are de-trended so that their impact on claim estimation is only through the persistence of claim shocks as inferred from the coefficients of the prediction model. Trend assumptions are disclosed further below, and may be varied with sensitivity tests.

The above sections explain how Part II of the claims prediction model is used in the claim cost simulation. Part I of the claims prediction model is employed to determine if there will be a non-zero claim for the HSA member in each of the biennial forecast periods. This is much more straightforward. The Part I Probit estimation from the prediction model is used to calculate the probability of having a non-zero claim. Then, a random draw from the Uniform(0,1) distribution is selected. If the random draw exceeds the probability of having a claim (e.g., exceeds .96), then the individual will have zero claims for that period. Total claims are estimated as the Part II claim amount unless zeroed out by the Part I hurdle component. It remains to validate this claims prediction approach using holdout sample cross-validation techniques, which will be considered in future research.

An additional modification to the total claim amount is employed to model decreased utilization as a result of the demand-mitigating effects of moral hazard due to the large HSA plan deductible. Using data from the Society of Actuaries claim database for about 60,000 insured lives age 50 through 65, I calculated insurance plan values as the ratio of the insurer payment over the gross claim amount under two separate plan designs. The first plan (PPO) allowed for $150 deductible, 90% coinsurance and $5,000 out-of-pocket (OOP) maximum. The second "HSA-style" plan allowed for a $1,000 deductible, 80% coinsurance and $5,000 OOP max. The decrease in insurance value is approximately 10% (robust to a limited range of initial PPO plan provisions). I am making a strong assumption that all individuals covered by insurance had such a generous plan with a modest $150 deductible. As CDHP and HSA plans were not in existence at the time data was collected, one might expect only small-employer groups and individual insureds to have such large-deductible plans already. As it is not possible to glean this from the data, I am assuming an across the board *decrease* in expenditures of 4% for all forecast years consistent with the 40% elasticity of expenditures with respect to insurance coverage and a 10% decrease in insurance plan value. A small percentage (11%) of HRS survey respondents in the sample reported having no insurance coverage. One would plausibly expect, for these persons, an increase in expenditures even upon entry into a catastrophic health plan. It is my intent for

future research to segment out the differently insured populations and apply separate demand adjustments, particularly for those lacking initial insurance coverage.

Types of Simulations That May Be Performed

For purposes of simulating hypothetical HSA balance build-up for near-retirement years, *three* different types of simulations have been performed based on the claims prediction model using Microsoft Excel and the Visual Basic programming language:

1) **"*Total Population*"***:*** Under this scenario, I assume that all 5,125 individuals included in the claims inference and prediction models are immediately enrolled in an HSA at their current attained age between 50 and 65. For each individual, biennial claim amounts are forecasted for the duration of the simulation horizon until attained age 65 (when the HSA plan ceases to accrue value and enters "withdrawal mode" for purposes of financing retiree medical expenses). Each member is initialized with stationary levels of all time-invariant predictor values (such as health status and the number of chronic conditions). Claims forecasting is "seeded" with the lagged values of prior period expenditures (1997-1998 and 1999-2000 actual claims) as the prediction model requires these initial values for prediction beginning with the 2001-2002 period. As the simulation runs, the prediction algorithm keeps track of the forecasted claims (and whether they were non-zero) for the two lagged biennial periods. The member's age is also tracked to update the age group and age-gender interaction variables. Medical trend may be applied over the forecast period, as noted above. For this simulation, 100 runs of the entire population take approximately 13.0 hours on an IBM ThinkPad T42 with a 1.70GHz microprocessor. The primary reason for this long run-time is the use of Visual Basic programming and the calculation intensive HSA module described below. To achieve high statistical precision, using this platform would require over 50 days to simulate the 5,125 person file 10,000 times. I am obviously investigating alternative programming environments to conduct this simulation. Despite the statistical imprecision underlying results derived from only 100 runs of the population file, I have nonetheless provided the valuation output in the results section below. This allows for at least an introductory analysis of the *entire* population in the study group, while this researcher pursues a more efficient computing interface.

2) ***"Average Respondent"***: Second, using substantively the same approach described above, I have simulated the HSA performance for an *average* individual by entering the average

values of the predictor variables and generating 10,000 claim forecasts using the claim prediction model. Based on the simulation for an average respondent, key significant predictor variables can be turned on and off (one at a time) to determine how sensitive HSA performance is to changes in health status, lifestyle behaviors or other indicator variables, with greater statistical precision. For example, I may simulate 10,000 "poor health status" and 10,000 "excellent health status" respondents, with all other predictors held at their average values, in order to gauge the impact of health status on the distribution of HSA outcomes. Or, I may evaluate the impact of increasing the number of chronic conditions from two to three, or the impact of smoking or regular exercise. The impact on HSA balances is illustrated in the forthcoming results section for several key predictors.

3) ***"Hypothetical Respondent"***: Lastly, and again using the same claims forecasting approach discussed above, I have simulated HSA performance for *hypothetical* individuals of varying health status, where each run is for 10,000 randomly drawn claims forecasts using the claim prediction model. That is, instead of using the average predictor values in the simulation, I only run the simulation for uniquely specified individuals. For example, I may run 10,000 fifty-year-old males in excellent health with no chronic conditions or problems with ADLs, versus 10,000 fifty-year-old males with three chronic conditions and at least one ADL posing difficulty. In this case, values must be chosen to initialize the claim history and *all levels* of predictor variables for the unique hypothetical respondent. Several examples are illustrated in the results section below.

Health Savings Account Module and Simulation Parameters

The HSA Module is shown in the Appendix as Exhibit 1. Inputs to the process include the stream of biennial claim amounts derived from the stochastic claims prediction model. Initial household salary and non-housing wealth are also used in the module (this data is available in the HRS). Economic assumptions include a 4% rate of HSA interest credited to the remaining HSA balance at the end of each period, salary scale of 3%, discount rate of 5% for accumulating claims and Out-of-Pocket (OOP) expenses, and wealth accumulator of 0% (may be varied, although it does not impact output measures of primary interest). These economic assumptions are compounded to reflect biennial policy periods. Baseline medical trend is drawn from the 2005 Kaiser Annual Survey of Employee Health Benefits. Actual insurance premium trend of

10.9/12.9%, 13.0/11.2% and 9.2/9.2% was used as a proxy for 2001/2002, 2003/2004, and 2005/2006 HSA claim increases respectively. Annual trends were compounded to create effective biennial health trends. Future trends used in simulation were graded down to 8/8%, 7/7% and 6% for 2007/2008, 2009/2010 and 2011 and beyond. Trend sensitivity tests were performed, as discussed below. A standard single member catastrophic plan design was used to model HSA performance. The plan has a $1,000 deductible, 20% coinsurance, and $5,000 OOP maximum. Using Society of Actuaries claim databases, I estimated a 9% reduction factor to the insurance claim payment due to the use of biennial policy periods. The OOP maximum is hit with greater frequency when applying plan provisions to biennial claim amounts, as opposed to separately calculating the insurance payment over two annual periods, and combining. Without the 9% correction, insurer payments and the percentage of remaining HSA contributions would be overstated. In any given policy period, OOP costs in excess of the HSA balance are paid from the store of initial wealth with a 35% tax adjustment to OOP costs to reflect after-tax spending. Average accumulated wealth does *not* reflect payment of HSA premiums or annual HSA contributions. HSA contributions occur at the beginning of each biennial policy period, while claims and HSA withdrawals occur at the end of each biennial policy period. The annual HSA contribution formula funds the smaller of 5% of household income or the entire high-deductible ($1,000), with a minimum contribution of $500. This contribution may be over-ridden to reflect changes in the maximum HSA contribution, catch-up provisions after age 55, or certain other rules to sustain HSA balances. For example, it is possible to model HSA balance build-up with a rule that no more than 50% of the current HSA balance will be withdrawn in any policy period, with the balance of that period's OOP costs paid as tax adjusted withdrawals from the initial store of wealth. Finally, no employer contributions to the HSA are assumed in this simulation.

For each claim forecast generated in simulation (10,000 of them in the case of "average" and "hypothetical" enrollees), valuation output is written to a results file for analysis. Output measures include:

Unique ID
Initial Age
Forecast Periods to Age 65
Number of actual years in forecast
Final Average Accumulated HSA Account
Potential Average Accumulated HSA Value
% of HSA Contributions Remaining
Average Annual HSA Contribution
Average Annual Claim
Average Accumulated Claims (all years)
Accumulated Average Out-of-Pocket (OOP)
Accumulated Amounts Paid by Insurance
Final Average Insurance Plan Value
Accumulated Average Paid from HSA
% of OOP Paid from HSA Withdrawals
Average Household Income
Average Intitial Household Wealth Level
Accumulated Average Wealth Reduction
Final Average Accumulated Wealth
Final Average % Wealth Reduction

Simulation Results: Total Population

Table 7, below, summarizes the total population results by biennial age-grouping. As noted above, due to computational limits, the population was only run 100 times in simulation. Thus the convergence properties are not as desirable as in a simulation of 10,000 claim forecasts for each individual. Results are broken out by age cohort as there are more years to accumulate HSA assets based on earlier attained age. An immediate observation is that, contrary to expectations, younger participants have a lower remaining percentage of HSA contributions at the end of the forecast horizon (e.g., 5.7% for age 50-51 and 11.2% for age 56-57). This has very little to do with the impact of age in the claim prediction model, but rather, that those with more years to age 65 have higher exposure to the types of catastrophic claims that could wipe out the entire HSA balance (reaching the $10,000 biennial OOP maximum could eliminate eight years of accumulated contributions). Additionally, the impact of medical trend is more significant for younger participants due to the fact that the plan design is held constant (deductibles and OOP max are satisfied with higher probability as claims increase over time).

This is observed by noting that the average annual claim decreases with duration to Medicare age. HSA insurance plan values increase with worsening average claim experience, as is expected.

Table 7: Simulation Results for Total HRS Population (with medical trend)

HSA Account Performance: Total Population simulated 100 times for each hypothetical HSA enrollee
With Medical Trend

Age Bracket	Age 50-51	Age 52-53	Age 54-55	Age 56-57	Age 58-59	Age 60-61	Total
Count of respondents	591	689	793	1132	1068	852	5125
Forecast Periods to Age 65	8	7	6	5	4	3	5.2
Number of actual years in forecast	15	13	11	9	7	5	9.5
Final Average Accumulated HSA Account	$1,409	$1,570	$1,493	$1,426	$1,396	$1,314	$1,429
Potential Average Accumulated HSA Value	$24,583	$20,219	$16,264	$12,784	$9,627	$6,870	$14,042
Average % of HSA Contributions Remaining	5.7%	7.8%	9.2%	11.2%	14.5%	19.1%	10.2%
Average Annual HSA Contribution	$967	$960	$951	$946	$938	$939	$948
Average Annual Claim	$9,435	$8,763	$7,971	$7,403	$6,461	$4,809	$7,281
Average Accumulated Claims (all years)	$196,716	$152,790	$113,327	$85,393	$57,359	$30,901	$96,713
Accumulated Average Out-of-Pocket (OOP)	$41,635	$33,194	$25,829	$19,834	$14,499	$9,253	$22,201
Accumulated Amounts Paid by Insurance	$155,081	$119,596	$87,498	$65,559	$42,860	$21,648	$74,512
Final Average Insurance Plan Value	78.8%	78.3%	77.2%	76.8%	74.7%	70.1%	77.0%
Accumulated Average Paid from HSA	$23,174	$18,649	$14,772	$11,358	$8,232	$5,556	$12,613
% of OOP Paid from HSA Withdrawals	55.7%	56.2%	57.2%	57.3%	56.8%	60.1%	56.8%
Average Household Income	$89,198	$82,378	$71,487	$81,084	$65,959	$59,890	$74,033
Average Intitial Household Wealth Level	$225,214	$233,931	$282,388	$300,267	$315,356	$294,614	$282,132
Accumulated Average Wealth Reduction	($23,078)	($16,901)	($12,760)	($8,751)	($5,476)	($2,544)	($10,405)
Final Average Accumulated Wealth	$204,019	$216,497	$268,445	$289,182	$306,839	$289,372	$270,092
Final Average % Wealth Reduction	-10.2%	-7.2%	-4.5%	-2.9%	-1.7%	-0.9%	-3.7%

Notes:
HSA single member plan has $1,000 high deductible, 20% coinsurance, and $5,000 OOP max; Unused HSA balances accrue at interest rate of 5%
Assumes full $1,000 deductible is funded with HSA contributions subject to a 5% of salary limit and $500 minimum
Assumes HSA enrollee will draw down entire HSA account balance in any given period if OOP costs exceed current HSA balance
OOP Costs in excess of HSA balance are paid from the store of initial wealth with a 35% tax adjustment to OOP costs to reflect after-tax spending
Results are shown as of the end of the biennial policy period during which age 65 is attained
Individuals are assumed to be enrolled in an HSA plan effective immediately; all 5,125 individuals were simulated from attained age to age 65
Actual claim experience is used for first two biennial periods, followed by simulated claim experience for duration of forecast period to age 65
Medical trend is reflected in claim forecast; 9% biennial insurance plan value adjustment; 4% decrease in expenditures due to HDHP plan
100 simulated runs for each hypothetical HSA enrollee are averaged, and above statistics represent averages over all respondents in age bracket
Average accumulated wealth does not reflect HSA premiums or annual HSA contributions
Average accumulated wealth does not reflect zero-income respondents who would have to pay HSA premiums and contributions out of initial wealth
HSA contributions occur at beginning of each biennial policy period; claims and withdrawals occur at end of biennial policy period.
A discount rate of 5% is used for accumulating claims, out-of-pocket costs, and insurance payments
Initial wealth is not assumed to increase

Overall, participants retain an average of only 10.2% of their HSA contributions, or $1,400 over 9.5 experience years, which is grossly inadequate for financing the costs of future retiree medical services. While the percentage of remaining HSA contributions is variable based on age cohort, the $1,400 HSA balance is fairly consistent across all ages, indicating that claim experience in the last few years before age 65 is the "great equalizer" over so short a simulation horizon (moral of the story: if you are over age 50, the final HSA value is independent of how many years you paid in). On average, 57% of OOP costs were paid from the HSA, with the remainder paid from the household's initial store of wealth. There was an average wealth decrease of $10,000 or 3.7% of initial wealth, with greater losses in wealth accruing to longer duration enrollees.

Table 8, below, illustrates the distribution of remaining HSA balances based on averaging the performance within decile for each age group. It is again apparent that while the percentage of remaining HSA assets varies by age cohort, the dollar amounts are again consistent by decile, although the largest possible remaining amounts are realized by the longest duration enrollees (e.g., the 10th decile for Age 50-51 is $5,609 versus $4,928 for age 56-57). The range of the percentage of HSA contributions remaining declines with duration to age 65, again indicating that very few long-term enrollees would be able to save meaningfully via this financing mechanism over the near-retirement years.

Table 8: Simulation Results for Total HRS Population, Averages within Decile

HSA Account Performance: Total Population simulated 100 times for each hypothetical HSA enrollee
With Medical Trend

Age Bracket	Age 50-51	Age 52-53	Age 54-55	Age 56-57	Age 58-59	Age 60-61	Total
Final Average Accumulated HSA Account							
1st Decile	$48	$59	$57	$73	$71	$76	$64
2nd Decile	$126	$148	$174	$181	$182	$179	$167
3rd Decile	$235	$269	$322	$331	$314	$294	$297
4th Decile	$391	$460	$527	$532	$489	$416	$473
5th Decile	$609	$724	$763	$783	$682	$603	$703
6th Decile	$920	$1,050	$1,087	$1,060	$971	$948	$1,014
7th Decile	$1,361	$1,456	$1,554	$1,468	$1,406	$1,384	$1,442
8th Decile	$1,901	$2,148	$2,160	$2,035	$2,025	$1,986	$2,047
9th Decile	$2,814	$3,061	$3,042	$2,848	$3,049	$3,003	$2,976
10th Decile	$5,609	$6,313	$5,218	$4,928	$4,758	$4,231	$5,101
Potential Average Accumulated HSA Value							
1st Decile	$20,232	$16,934	$13,125	$10,158	$7,002	$5,536	$12,261
2nd Decile	$24,527	$20,542	$16,276	$12,397	$9,283	$6,645	$13,780
3rd Decile	$24,817	$19,669	$16,035	$12,871	$9,697	$6,805	$13,657
4th Decile	$25,015	$20,464	$16,484	$12,726	$9,986	$7,072	$13,657
5th Decile	$25,151	$20,408	$16,712	$13,253	$9,969	$6,939	$14,230
6th Decile	$25,210	$20,458	$16,813	$13,297	$10,079	$7,076	$14,563
7th Decile	$24,972	$20,980	$16,918	$13,438	$9,980	$7,034	$14,499
8th Decile	$25,436	$20,956	$16,904	$13,406	$10,118	$7,176	$14,824
9th Decile	$25,223	$20,883	$16,886	$12,990	$10,011	$7,230	$14,089
10th Decile	$25,236	$20,895	$16,521	$13,323	$10,156	$7,201	$14,857
Average % of HSA Contributions Remaining							
1st Decile	0.2%	0.3%	0.4%	0.7%	1.0%	1.4%	0.5%
2nd Decile	0.5%	0.7%	1.1%	1.5%	2.0%	2.7%	1.2%
3rd Decile	0.9%	1.4%	2.0%	2.6%	3.2%	4.3%	2.2%
4th Decile	1.6%	2.2%	3.2%	4.2%	4.9%	5.9%	3.5%
5th Decile	2.4%	3.5%	4.6%	5.9%	6.8%	8.7%	4.9%
6th Decile	3.6%	5.1%	6.5%	8.0%	9.6%	13.4%	7.0%
7th Decile	5.4%	6.9%	9.2%	10.9%	14.1%	19.7%	9.9%
8th Decile	7.5%	10.2%	12.8%	15.2%	20.0%	27.7%	13.8%
9th Decile	11.2%	14.7%	18.0%	21.9%	30.5%	41.5%	21.1%
10th Decile	22.2%	30.2%	31.6%	37.0%	46.9%	58.7%	34.3%

Shown below in Table 9 are the total population results split by age cohort (to allow comparison) and by self-reported health status. Across all age cohorts, there is a noticeable decline in HSA performance as the increase in morbidity translates into worsening claim experience. Compared to 10.2% for the entire population, those reporting fair/poor health retain a meager 4.4% of contributions, while those reporting excellent health retain a marginally higher

13.4% of contributions. Insurance value is greater for those with lower health status, and OOP amounts and wealth reductions are considerably higher.

Table 9: Simulation Results for Total HRS Population, by Self-Reported Health Status

HSA Account Performance: Total Population simulated 100 times for each hypothetical HSA enrollee

Age Bracket	**Age 50-51**			**Age 52-53**			**Age 54-55**		
Health Status:	Exc/V.Good	Good	Fair/Poor	Exc/V.Good	Good	Fair/Poor	Exc/V.Good	Good	Fair/Poor
Count of respondents	325	179	87	369	222	98	424	231	138
Forecast Periods to Age 65	8	8	8	7	7	7	6	6	6
Number of actual years in forecast	15	15	15	13	13	13	11	11	11
Final Average Accumulated HSA Account	$2,047	$751	$376	$2,115	$1,114	$552	$2,011	$1,179	$427
Potential Average Accumulated HSA Value	$24,974	$24,457	$23,380	$20,503	$20,214	$19,157	$16,639	$16,297	$15,059
Average % of HSA Contributions Remaining	8.2%	3.1%	1.6%	10.3%	5.5%	2.9%	12.1%	7.2%	2.8%
Average Annual HSA Contribution	$982	$962	$920	$973	$960	$911	$972	$953	$881
Average Annual Claim	$5,602	$11,321	$19,874	$5,312	$9,804	$19,401	$4,623	$8,625	$17,159
Average Accumulated Claims (all years)	$117,706	$234,666	$413,787	$93,445	$168,887	$339,778	$66,808	$122,318	$241,205
Accumulated Average Out-of-Pocket (OOP)	$34,771	$46,178	$57,933	$28,224	$35,707	$46,217	$21,620	$27,365	$36,193
Accumulated Amounts Paid by Insurance	$82,935	$188,488	$355,855	$65,221	$133,180	$293,561	$45,189	$94,953	$205,012
Final Average Insurance Plan Value	70.5%	80.3%	86.0%	69.8%	78.9%	86.4%	67.6%	77.6%	85.0%
Accumulated Average Paid from HSA	$22,927	$23,706	$23,004	$18,388	$19,101	$18,605	$14,629	$15,117	$14,632
% of OOP Paid from HSA Withdrawals	65.9%	51.3%	39.7%	65.2%	53.5%	40.3%	67.7%	55.2%	40.4%
Average Household Income	$106,111	$74,505	$56,248	$95,064	$73,653	$54,377	$83,682	$61,866	$50,122
Average Intitial Household Wealth Level	$272,557	$193,683	$113,233	$297,624	$199,894	$71,211	$344,353	$223,276	$190,949
Accumulated Average Wealth Reduction	($14,655)	($29,401)	($41,534)	($10,602)	($19,922)	($33,776)	($7,381)	($14,661)	($26,102)
Final Average Accumulated Wealth	$258,954	$167,614	$73,708	$285,915	$179,755	$38,352	$335,609	$207,697	$163,776
Final Average % Wealth Reduction	-5.4%	-15.2%	-36.7%	-3.6%	-10.0%	-47.4%	-2.1%	-6.6%	-13.7%

Age Bracket	**Age 56-57**			**Age 58-59**			**Age 60-61**		
Health Status:	Exc/V.Good	Good	Fair/Poor	Exc/V.Good	Good	Fair/Poor	Exc/V.Good	Good	Fair/Poor
Count of respondents	580	363	189	498	348	222	414	288	150
Forecast Periods to Age 65	5	5	5	4	4	4	3	3	3
Number of actual years in forecast	9	9	9	7	7	7	5	5	5
Final Average Accumulated HSA Account	$1,951	$1,020	$594	$1,959	$1,080	$626	$1,678	$1,147	$628
Potential Average Accumulated HSA Value	$13,057	$12,794	$11,927	$9,914	$9,577	$9,063	$7,114	$6,835	$6,266
Average % of HSA Contributions Remaining	14.9%	8.0%	5.0%	19.8%	11.3%	6.9%	23.6%	16.8%	10.0%
Average Annual HSA Contribution	$966	$946	$883	$966	$933	$883	$973	$935	$857
Average Annual Claim	$4,113	$8,582	$15,237	$3,662	$7,212	$11,565	$3,306	$5,262	$8,088
Average Accumulated Claims (all years)	$47,496	$99,127	$175,316	$32,678	$64,452	$101,606	$21,580	$33,747	$51,164
Accumulated Average Out-of-Pocket (OOP)	$16,294	$21,738	$27,040	$11,793	$15,546	$18,927	$8,002	$9,618	$12,005
Accumulated Amounts Paid by Insurance	$31,202	$77,388	$148,276	$20,885	$48,906	$82,679	$13,578	$24,129	$39,159
Final Average Insurance Plan Value	65.7%	78.1%	84.6%	63.9%	75.9%	81.4%	62.9%	71.5%	76.5%
Accumulated Average Paid from HSA	$11,106	$11,774	$11,332	$7,955	$8,497	$8,437	$5,436	$5,687	$5,637
% of OOP Paid from HSA Withdrawals	68.2%	54.2%	41.9%	67.5%	54.7%	44.6%	67.9%	59.1%	47.0%
Average Household Income	$102,131	$67,804	$42,004	$73,980	$63,997	$51,041	$75,726	$49,672	$35,802
Average Intitial Household Wealth Level	$404,123	$234,303	$108,246	$391,656	$221,989	$290,558	$441,372	$183,510	$102,880
Accumulated Average Wealth Reduction	($5,065)	($10,386)	($16,923)	($3,259)	($6,497)	($8,851)	($1,306)	($2,873)	($5,329)
Final Average Accumulated Wealth	$397,350	$221,264	$87,683	$386,461	$212,382	$276,297	$437,769	$177,922	$93,781
Final Average % Wealth Reduction	-1.3%	-4.4%	-15.6%	-0.8%	-2.9%	-3.0%	-0.3%	-1.6%	-5.2%

Age Bracket	**Total**		
Health Status:	Exc/V.Good	Good	Fair/Poor
Count of respondents	2610	1631	884
Forecast Periods to Age 65	5.3	5.2	5.1
Number of actual years in forecast	9.6	9.4	9.2
Final Average Accumulated HSA Account	$1,954	$1,061	$556
Potential Average Accumulated HSA Value	$14,633	$13,841	$12,665
Average % of HSA Contributions Remaining	13.4%	7.7%	4.4%
Average Annual HSA Contribution	$971	$946	$885
Average Annual Claim	$4,337	$8,177	$14,320
Average Accumulated Claims (all years)	$58,934	$107,839	$187,726
Accumulated Average Out-of-Pocket (OOP)	$18,972	$23,657	$29,047
Accumulated Amounts Paid by Insurance	$39,962	$84,181	$158,680
Final Average Insurance Plan Value	67.8%	78.1%	84.5%
Accumulated Average Paid from HSA	$12,679	$12,780	$12,109
% of OOP Paid from HSA Withdrawals	66.8%	54.0%	41.7%
Average Household Income	$89,070	$64,481	$47,262
Average Intitial Household Wealth Level	$366,504	$212,003	$162,415
Accumulated Average Wealth Reduction	($6,477)	($12,220)	($18,652)
Final Average Accumulated Wealth	$358,666	$198,256	$141,119
Final Average % Wealth Reduction	-1.8%	-5.8%	-11.5%

Shown below in Table 10 are the corresponding "Total Population" results for the 50-51 age cohort based on the number of chronic conditions reported (maximum was five for this cohort).

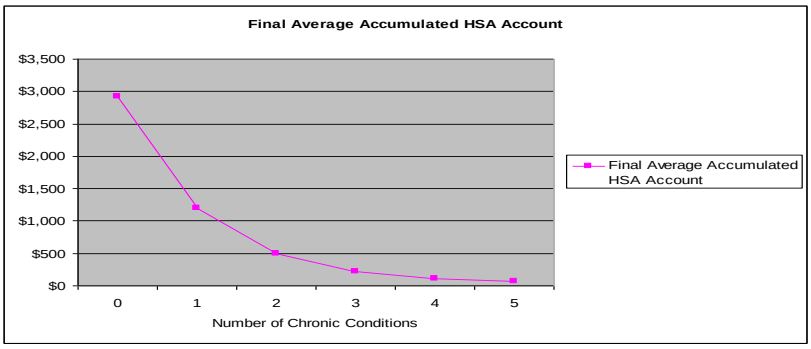
Table 10: Simulation Results for HRS Age 50-51, by Number of Chronic Conditions

HSA Account Performance: Total Population simulated 100 times for each hypothetical HSA enrollee
With Medical Trend

	Age 50-51 Year Olds						
Number of Chronic Conditions:	**Zero**	**One**	**Two**	**Three**	**Four**	**Five**	**Total**
Count of respondents	178	196	121	73	17	6	591
Forecast Periods to Age 65	8	8	8	8	8	8	8
Number of actual years in forecast	15	15	15	15	15	15	15
Final Average Accumulated HSA Account	$2,915	$1,202	$497	$215	$106	$75	$1,409
Potential Average Accumulated HSA Value	$24,862	$25,101	$24,028	$23,826	$23,958	$21,544	$24,583
Average % of HSA Contributions Remaining	11.7%	4.8%	2.1%	0.9%	0.4%	0.3%	5.7%
Average Annual HSA Contribution	$978	$987	$945	$937	$942	$849	$967
Average Annual Claim	$4,578	$7,327	$11,535	$17,503	$27,981	$29,317	$9,435
Average Accumulated Claims (all years)	$96,084	$152,391	$238,762	$363,361	$597,318	$619,582	$196,716
Accumulated Average Out-of-Pocket (OOP)	$31,041	$39,012	$46,346	$57,937	$68,511	$72,151	$41,635
Accumulated Amounts Paid by Insurance	$65,043	$113,379	$192,416	$305,424	$528,807	$547,431	$155,081
Final Average Insurance Plan Value	67.7%	74.4%	80.6%	84.1%	88.5%	88.4%	78.8%
Accumulated Average Paid from HSA	$21,947	$23,900	$23,532	$23,611	$23,851	$21,469	$23,174
% of OOP Paid from HSA Withdrawals	70.7%	61.3%	50.8%	40.8%	34.8%	29.8%	55.7%
Average Household Income	$102,575	$94,579	$81,129	$64,353	$69,268	$38,039	$89,198
Average Intitial Household Wealth Level	$303,580	$263,313	$160,387	$75,724	$131,824	$46,572	$225,214
Accumulated Average Wealth Reduction	($11,146)	($19,625)	($30,250)	($40,631)	($47,248)	($63,175)	($23,078)
Final Average Accumulated Wealth	$293,152	$245,735	$133,714	$37,081	$82,433	($9,557)	$204,019
Final Average % Wealth Reduction	-3.7%	-7.5%	-18.9%	-53.7%	-35.8%	-135.6%	-10.2%

Based on the significant total marginal effects from the prediction model, there is clearly an increasing trend in average claims and OOP expenses with an increasing number of chronic conditions. As a result, those with more chronic conditions have much lower remaining HSA balances and higher decreases in the initial store of wealth. Those reporting no chronic conditions retain $2,900 at age 65, or almost 12%, of contributions. There is a significant decline with the first chronic condition reported (from 12% to less than 5%), with those reporting 4 or 5 conditions only retaining less than 0.4%. Clearly, without implementing policy provisions that make this an attractive insurance vehicle for the chronically ill, such enrollees will experience substantially lower HSA balances compared to healthier counterparts. The HSA performance exponentially declines with the number of conditions, as shown in Figure 6 below.

Figure 6: Average Remaining HSA Balance by Number of Chronic Conditions, Age 50-51



Finally, the last simulation using the "Total Population" compares the HSA asset experience when no medical trend is assumed in the claims forecast. This is the method employed by EMW in their analysis of Individual Health Accounts. Table 11 below, which is analogous to Table 7, compares output measures without increases in the underlying costs of medical care.

Table 11: Simulation Results for Total HRS Population (*without* medical trend)

HSA Account Performance: Total Population simulated 100 times for each hypothetical HSA enrollee
Without Medical Trend

Age Bracket	**Age 50-51**	**Age 52-53**	**Age 54-55**	**Age 56-57**	**Age 58-59**	**Age 60-61**	**Total**
Count of respondents	591	689	793	1132	1068	852	5125
Forecast Periods to Age 65	8	7	6	5	4	3	5.2
Number of actual years in forecast	15	13	11	9	7	5	9
Final Average Accumulated HSA Account	$3,536	$3,160	$2,583	$2,144	$1,759	$1,430	$2,310
Potential Average Accumulated HSA Value	$24,583	$20,219	$16,264	$12,784	$9,627	$6,870	$14,042
Average % of HSA Contributions Remaining	14.4%	15.6%	15.9%	16.8%	18.3%	20.8%	16.5%
Average Annual HSA Contribution	$967	$960	$951	$946	$938	$939	$948
Average Annual Claim	$5,119	$5,145	$4,985	$5,262	$5,144	$4,303	$5,003
Average Accumulated Claims (all years)	$114,737	$95,112	$73,798	$62,598	$46,510	$27,867	$65,588
Accumulated Average Out-of-Pocket (OOP)	$33,224	$27,293	$21,909	$17,447	$13,340	$8,895	$19,003
Accumulated Amounts Paid by Insurance	$81,512	$67,819	$51,889	$45,151	$33,170	$18,971	$46,585
Final Average Insurance Plan Value	71.0%	71.3%	70.3%	72.1%	71.3%	68.1%	71.0%
Accumulated Average Paid from HSA	$21,047	$17,059	$13,681	$10,640	$7,868	$5,441	$11,731
% of OOP Paid from HSA Withdrawals	63.3%	62.5%	62.4%	61.0%	59.0%	61.2%	61.7%
Average Household Income	$89,198	$82,378	$71,487	$81,084	$65,959	$59,890	$74,033
Average Intitial Household Wealth Level	$225,214	$233,931	$282,388	$300,267	$315,356	$294,614	$282,132
Accumulated Average Wealth Reduction	($13,412)	($10,269)	($8,406)	($6,184)	($4,253)	($2,172)	($6,841)
Final Average Accumulated Wealth	$212,125	$222,292	$272,374	$291,584	$308,026	$289,744	$273,253
Final Average % Wealth Reduction	-6.0%	-4.4%	-3.0%	-2.1%	-1.3%	-0.7%	-2.4%

Notes:
HSA single member plan has $1,000 high deductible, 20% coinsurance, and $5,000 OOP max; Unused HSA balances accrue at interest rate of 5%
Assumes full $1,000 deductible is funded with HSA contributions subject to a 5% of salary limit and $500 minimum
Assumes HSA enrollee will draw down entire HSA account balance in any given period if OOP costs exceed current HSA balance
OOP Costs in excess of HSA balance are paid from the store of initial wealth with a 35% tax adjustment to OOP costs to reflect after-tax spending
Results are shown as of the end of the biennial policy period during which age 65 is attained
Individuals are assumed to be enrolled in an HSA plan effective immediately; all 5,125 individuals were simulated from attained age to age 65
Actual claim experience is used for first two biennial periods, followed by simulated claim experience for duration of forecast period to age 65
Medical trend not reflected in claim forecast; 9% biennial insurance plan value adjustment; 4% decrease in expenditures due to HDHP plan
100 simulated runs for each hypothetical HSA enrollee are averaged, and above statistics represent averages over all respondents in age bracket
Average accumulated wealth does not reflect HSA premiums or annual HSA contributions
Average accumulated wealth does not reflect zero-income respondents who would have to pay HSA premiums and contributions out of initial wealth
HSA contributions occur at beginning of each biennial policy period; claims and withdrawals occur at end of biennial policy period.
A discount rate of 5% is used for accumulating claims, out-of-pocket costs, and insurance payments
Initial wealth is not assumed to increase

In the absence of trend, overall HSA performance is naturally more favorable. Those enrollees with longer duration to age 65 still suffer from a lower percentage of contributions remaining, but the range over age cohorts is now tighter (14.4% to 20.8% from age 50-51 to 60-61 compared to 5.7% to 19.1% with trend). Moreover, longer duration enrollees are able to realize higher average *dollar* account balances, contrary to the trended scenario. Plan insurance values are obviously lower in the absence of trend, and wealth shocks mitigated by approximately 34%. Overall, participants in the "without trend" scenario retain 16.5% of contributions, or $2,300, which is 64% higher than the $1,400 accumulated with medical trend. It is evident from this sensitivity test that any simulation performed without a medical trend

assumption will depict unrealistically favorable account performance. Of course, this sensitivity test rests on the assumption that the plan design is constant over the simulation horizon. For future research, I intend to alter the plan design consistent with IRS legislated limits.

Simulation Results: Average Respondent

Rather than simulating performance for the entire population, the predictor values underlying the claims forecasting model were averaged to create an "average respondent" for simulation. The average respondent is "Unisex" at attained age 56, with 10 years remaining in the forecast period. Actual average 1997-1998 and 1999-2000 claims are used to initialize the prediction model. Running one individual through the simulation allows for greater statistical precision given our computational limitations. Table 12 below illustrates the convergence properties based on repeated runs of 10,000 claims forecasts for the "average respondent".

Table 12: Repeated Simulation Results for "Average Respondent"

HSA Account Performance: Average Respondent Simulated 10,000 Times, with 10 additional runs of 10,000 each

Average Respondent	**Baseline** *With Medical Trend*	**Repeat Runs** *Run 1*	*Run 2*	*Run 3*	*Run 4*	*Run 5*
Attained Age	Age 56	Age 56	Age 56	Age 56	Age 56	Age 56
Count of respondents	1	1	1	1	1	1
Forecast Periods to Age 65	5	5	5	5	5	5
Number of actual years in forecast	10	10	10	10	10	10
Final Average Accumulated HSA Account	$572	$585	$582	$562	$563	$589
Potential Average Accumulated HSA Value	$13,529	$13,529	$13,529	$13,529	$13,529	$13,529
Average % of HSA Contributions Remaining	4.2%	4.3%	4.3%	4.2%	4.2%	4.4%
25th Percentile of % HSA Contribs Remaining	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Median of % HSA Contribs Remaining	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
75th Percentile of % HSA Contribs Remaining	6.6%	6.9%	6.8%	6.5%	6.4%	7.1%
Percentage with over 50% of HSA Contribs	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Percentage with less than 20% of HSA Contribs	94.6%	94.1%	94.1%	94.5%	94.6%	94.3%
Average Annual HSA Contribution	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
Average Annual Claim	$5,897	$5,861	$5,960	$6,034	$5,829	$5,883
Average Accumulated Claims (all years)	$68,469	$68,120	$69,277	$70,014	$67,818	$68,419
Accumulated Average Out-of-Pocket (OOP)	$22,206	$22,131	$22,119	$22,303	$22,156	$22,045
Accumulated Amounts Paid by Insurance	$46,262	$45,989	$47,158	$47,711	$45,662	$46,374
Final Average Insurance Plan Value	67.6%	67.5%	68.1%	68.1%	67.3%	67.8%
Accumulated Average Paid from HSA	$12,957	$12,944	$12,947	$12,967	$12,966	$12,940
% of OOP Paid from HSA Withdrawals	58.3%	58.5%	58.5%	58.1%	58.5%	58.7%
Average Household Income	$74,033	$74,033	$74,033	$74,033	$74,033	$74,033
Average Initial Household Wealth Level	$282,132	$282,132	$282,132	$282,132	$282,132	$282,132
Accumulated Average Wealth Reduction	($10,016)	($9,920)	($9,897)	($10,150)	($9,925)	($9,794)
Final Average Accumulated Wealth	$270,095	$270,193	$270,224	$269,974	$270,186	$270,304
Final Average % Wealth Reduction	-3.6%	-3.5%	-3.5%	-3.6%	-3.5%	-3.5%

	Baseline *With Medical Trend*	**Repeat Runs** *Run 6*	*Run 7*	*Run 8*	*Run 9*	*Run 10*	*Overall Avg. Runs 1-10*
Attained Age	Age 56	Age 56	Age 56	Age 56	Age 56	Age 56	Age 56
Count of respondents	1	1	1	1	1	1	1
Forecast Periods to Age 65	5	5	5	5	5	5	5
Number of actual years in forecast	10	10	10	10	10	10	10
Final Average Accumulated HSA Account	$572	$562	$567	$589	$578	$581	$576
Potential Average Accumulated HSA Value	$13,529	$13,529	$13,529	$13,529	$13,529	$13,529	$13,529
Average % of HSA Contributions Remaining	4.2%	4.2%	4.2%	4.4%	4.3%	4.3%	4.3%
25th Percentile of % HSA Contribs Remaining	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Median of % HSA Contribs Remaining	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
75th Percentile of % HSA Contribs Remaining	6.6%	6.6%	6.5%	6.9%	6.7%	6.7%	
Percentage with over 50% of HSA Contribs	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	
Percentage with less than 20% of HSA Contribs	94.6%	94.8%	94.7%	94.0%	94.2%	94.0%	
Average Annual HSA Contribution	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
Average Annual Claim	$5,897	$5,957	$5,878	$5,821	$5,980	$5,874	$5,908
Average Accumulated Claims (all years)	$68,469	$69,157	$68,349	$67,788	$69,363	$68,270	$68,658
Accumulated Average Out-of-Pocket (OOP)	$22,206	$22,195	$22,052	$22,141	$22,121	$22,082	$22,134
Accumulated Amounts Paid by Insurance	$46,262	$46,962	$46,298	$45,647	$47,242	$46,189	$46,523
Final Average Insurance Plan Value	67.6%	67.9%	67.7%	67.3%	68.1%	67.7%	67.8%
Accumulated Average Paid from HSA	$12,957	$12,967	$12,962	$12,940	$12,951	$12,948	$12,953
% of OOP Paid from HSA Withdrawals	58.3%	58.4%	58.8%	58.4%	58.5%	58.6%	58.5%
Average Household Income	$74,033	$74,033	$74,033	$74,033	$74,033	$74,033	$74,033
Average Initial Household Wealth Level	$282,132	$282,132	$282,132	$282,132	$282,132	$282,132	$282,132
Accumulated Average Wealth Reduction	($10,016)	($9,984)	($9,771)	($9,942)	($9,895)	($9,839)	($9,912)
Final Average Accumulated Wealth	$270,095	$270,128	$270,324	$270,175	$270,209	$270,262	$270,198
Final Average % Wealth Reduction	-3.6%	-3.5%	-3.5%	-3.5%	-3.5%	-3.5%	-3.5%

As noted above in Table 12, all valuation output measures show very little variation across the 10 separate simulations, indicating that 10,000 claim forecasts is adequate given a prediction model using randomly drawn shock residuals. For the average respondent, about 4.3% of HSA contributions, or $576, is expected to remain in a simulation involving 100,000 claim forecasts. The baseline simulation, using 10,000 forecasts, resulted in $572, or 4.2% of HSA contributions remaining. Thus a single 10,000 person simulation shows strong statistical convergence based on this two-part prediction model- despite the large residual claim variance and potential for huge shock claims in any given biennial policy period. This simply speaks to the power of the law of large numbers.

All further results shown herein are based on 10,000 person simulations, including the sensitivity tests detailed in Table 13a below and in the Appendix.

Table 13a: Simulation Results for "Average Respondent": Sensitivity Tests to Baseline Run

HSA Account Performance: Average Respondent Simulated 10,000 Times, with Sensitivity to Assumption Changes

Average Respondent	**Baseline** *With Medical Trend*	*No Medical Trend*		*Low Trend at 5% annually*		*High Trend at 15% annually*		*No Initial Claims*		*HSA Interest Credited at 0%*		*HSA Interest Credited at 10%*		*No Biennial Insurance Value Adjustment*	
Attained Age	Age 56	Age 56		Age 56		Age 56		Age 56		Age 56		Age 56		Age 56	
Count of respondents	1	1		1		1		1		1		1		1	
Forecast Periods to Age 65	5	5		5		5		5		5		5		5	
Number of actual years in forecast	10	10		10		10		10		10		10		10	
Final Average Accumulated HSA Account	$572	$1,103	93%	$840	47%	$472	-17%	$4,387	667%	$388	-32%	$856	50%	$599	5%
Potential Average Accumulated HSA Value	$13,529	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$10,000	-26%	$18,366	36%	$13,529	0%
Average % of HSA Contributions Remaining	4.2%	8.2%	93%	6.2%	47%	3.5%	-17%	32.4%	667%	3.9%	-8%	4.7%	10%	4.4%	5%
25th Percentile of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	
Median of % HSA Contribs Remaining	0.0%	3.1%		0.0%		0.0%		30.4%		0.0%		0.0%		0.0%	
75th Percentile of % HSA Contribs Remaining	6.6%	13.7%		11.0%		4.3%		56.0%		4.7%		7.6%		7.1%	
Percentage with over 50% of HSA Contribs	0.1%	0.1%		0.1%		0.1%		30.5%		0.1%		0.0%		0.1%	
Percentage with less than 20% of HSA Contribs	94.6%	85.5%		90.0%		95.7%		41.7%		94.3%		94.0%		94.4%	
Average Annual HSA Contribution	$1,000	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%
Average Annual Claim	$5,897	$4,264	-28%	$4,846	-18%	$6,458	10%	$3,702	-37%	$5,969	1%	$5,853	-1%	$5,977	1%
Average Accumulated Claims (all years)	$68,469	$51,215	-25%	$57,422	-16%	$74,364	9%	$39,663	-42%	$69,315	1%	$68,144	0%	$69,420	1%
Accumulated Average Out-of-Pocket (OOP)	$22,206	$19,613	-12%	$20,740	-7%	$22,773	3%	$10,664	-52%	$22,216	0%	$22,094	-1%	$20,049	-10%
Accumulated Amounts Paid by Insurance	$46,262	$31,602	-32%	$36,682	-21%	$51,591	12%	$28,999	-37%	$47,099	2%	$46,049	0%	$49,371	7%
Final Average Insurance Plan Value	67.6%	61.7%	-9%	63.9%	-5%	69.4%	3%	73.1%	8%	67.9%	1%	67.6%	0%	71.1%	5%
Accumulated Average Paid from HSA	$12,957	$12,426	-4%	$12,689	-2%	$13,057	1%	$9,142	-29%	$9,612	-26%	$17,510	35%	$12,930	0%
% of OOP Paid from HSA Withdrawals	58.3%	63.4%	9%	61.2%	5%	57.3%	-2%	85.7%	47%	43.3%	-26%	79.3%	36%	64.5%	11%
Average Household Income	$74,033	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%
Average Intitial Household Wealth Level	$282,132	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%
Accumulated Average Wealth Reduction	($10,016)	($6,844)	-32%	($8,174)	-18%	($10,736)	7%	($2,342)	-77%	($10,864)	8%	($9,025)	-10%	($8,016)	-20%
Final Average Accumulated Wealth	$270,095	$273,074	1%	$271,823	1%	$269,413	0%	$279,907	4%	$268,660	-1%	$271,716	1%	$272,807	1%
Final Average % Wealth Reduction	-3.6%	-2.4%	-32%	-2.9%	-18%	-3.8%	7%	-0.8%	-77%	-3.9%	8%	-3.2%	-10%	-2.8%	-20%

Notes:

Specific to Baseline Scenario

Unused HSA balances accrue at interest rate of 5%
Assumes full $1,000 deductible is funded with HSA contributions subject to a 5% of salary limit and $500 minimum
Medical trend is reflected in claim forecast; 9% biennial insurance plan value adjustment; 4% decrease in expenditures due to HDHP plan
Baseline medical trend schedule indicated in text
Assumes HSA enrollee will draw down entire HSA account balance in any given period if OOP costs exceed current HSA balance

General to all Scenarios

HSA single member plan has $1,000 high deductible, 20% coinsurance, and $5,000 OOP max;
OOP Costs in excess of HSA balance are paid from the store of initial wealth with a 35% tax adjustment to OOP costs to reflect after-tax spending
Results are shown as of the end of the biennial policy period during which age 65 is attained
Individuals are assumed to be enrolled in an HSA plan effective immediately at average attained age 56
Actual claim experience is used for first two biennial periods, followed by simulated claim experience for duration of forecast period to age 65
Average results for 10,000 simulated runs of the average respondent are shown (sensitivities also done for 10,000 simulated runs)
Average accumulated wealth does not reflect HSA premiums or annual HSA contributions
Average accumulated wealth does not reflect zero-income respondents who would have to pay HSA premiums and contributions out of initial wealth
HSA contributions occur at beginning of each biennial policy period; claims and withdrawals occur at end of biennial policy period.
A discount rate of 5% is used for accumulating claims, out-of-pocket costs, and insurance payments
Initial wealth is not assumed to increase

The most telling sensitivity test above shows the dramatic improvement in HSA experience under the assumption of *zero* initial claims. That is, the claims prediction model is initialized with zero claims for both lag periods. This results in almost an eight-fold increase in the remaining HSA balance, and illustrates how early favorable claim experience can allow for a higher build-up of account assets (moreover, having zero claims "persists" to future policy periods due to the high correlation in claims over time embedded in the prediction model). A doubling of the HSA interest rate increases the remaining contributions by 50%. Having low or no medical trend likewise leads to more favorable HSA performance.

Table 13b below continues the sensitivity results for the "Average Respondent" baseline run.

Table 13b: Simulation Results for "Average Respondent": Sensitivity Tests *Continued*

HSA Account Performance: Average Respondent Simulated 10,000 Times, with Sensitivity to Assumption Changes

Average Respondent	**Baseline** *With Medical Trend*	*Demand Adjustment of 6%*		*Demand Adjustment of 2%*		*50% of HDHP Deductible Funded*		*100% of OOP Maximum Funded*		*Catch-up Contributions Allowed*		*Deduct only up to 50% HSA Balance*		*Deduct only up to 75% HSA Balance*	
Attained Age	Age 56	Age 56		Age 56		Age 56		Age 56		Age 56		Age 56		Age 56	
Count of respondents	1	1		1		1		1		1		1		1	
Forecast Periods to Age 65	5	5		5		5		5		5		5		5	
Number of actual years in forecast	10	10		10		10		10		10		10		10	
Final Average Accumulated HSA Account	$572	$585	2%	$532	-7%	$62	-89%	$45,495	7859%	$2,560	348%	$3,088	440%	$1,451	154%
Potential Average Accumulated HSA Value	$13,529	$13,529	0%	$13,529	0%	$6,764	-50%	$67,645	400%	$21,646	60%	$13,529	0%	$13,529	0%
Average % of HSA Contributions Remaining	4.2%	4.3%	2%	3.9%	-7%	0.9%	-78%	67.3%	1492%	11.8%	180%	22.8%	440%	10.7%	154%
25th Percentile of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		61.1%		0.0%		17.2%		0.0%	
Median of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		69.3%		9.2%		19.5%		0.0%	
75th Percentile of % HSA Contribs Remaining	6.6%	7.1%		5.9%		0.0%		74.3%		20.3%		26.0%		6.6%	
Percentage with over 50% of HSA Contribs	0.1%	0.1%		0.1%		0.1%		94.6%		0.1%		1.0%		0.1%	
Percentage with less than 20% of HSA Contribs	94.6%	94.3%		94.8%		99.4%		0.0%		74.4%		53.0%		94.6%	
Average Annual HSA Contribution	$1,000	$1,000	0%	$1,000	0%	$500	-50%	$5,000	400%	$1,600	60%	$1,000	0%	$1,000	0%
Average Annual Claim	$5,897	$5,902	0%	$6,076	3%	$5,933	1%	$5,934	1%	$5,815	-1%	$5,918	0%	$5,873	0%
Average Accumulated Claims (all years)	$68,469	$68,659	0%	$70,468	3%	$68,887	1%	$68,949	1%	$67,630	-1%	$68,734	0%	$68,240	0%
Accumulated Average Out-of-Pocket (OOP)	$22,206	$22,086	-1%	$22,296	0%	$22,097	0%	$22,150	0%	$22,160	0%	$22,168	0%	$22,154	0%
Accumulated Amounts Paid by Insurance	$46,262	$46,573	1%	$48,171	4%	$46,789	1%	$46,800	1%	$45,470	-2%	$46,566	1%	$46,086	0%
Final Average Insurance Plan Value	67.6%	67.8%	0%	68.4%	1%	67.9%	1%	67.9%	0%	67.2%	0%	67.7%	0%	67.5%	0%
Accumulated Average Paid from HSA	$12,957	$12,944	0%	$12,997	0%	$6,702	-48%	$22,150	71%	$19,086	47%	$10,441	-19%	$12,078	-7%
% of OOP Paid from HSA Withdrawals	58.3%	58.6%	0%	58.3%	0%	30.3%	-48%	100.0%	71%	86.1%	48%	47.1%	-19%	54.5%	-7%
Average Household Income	$74,033	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%
Average Intitial Household Wealth Level	$282,132	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%
Accumulated Average Wealth Reduction	($10,016)	($9,851)	-2%	($10,093)	1%	($14,460)	44%	$0	-100%	($4,729)	-53%	($8,816)	-12%	($8,782)	-12%
Final Average Accumulated Wealth	$270,095	$270,256	0%	$270,035	0%	$262,435	-3%	$282,132	4%	$277,819	3%	$267,392	-1%	$269,266	0%
Final Average % Wealth Reduction	-3.6%	-3.5%	-2%	-3.6%	1%	-5.1%	44%	0.0%	-100%	-1.7%	-53%	-3.1%	-12%	-3.1%	-12%

Notes:

Specific to Baseline Scenario

Unused HSA balances accrue at interest rate of 5%
Assumes full $1,000 deductible is funded with HSA contributions subject to a 5% of salary limit and $500 minimum
Medical trend is reflected in claim forecast; 9% biennial insurance plan value adjustment; 4% decrease in expenditures due to HDHP plan
Baseline medical trend schedule indicated in text
Assumes HSA enrollee will draw down entire HSA account balance in any given period if OOP costs exceed current HSA balance

General to all Scenarios

HSA single member plan has $1,000 high deductible, 20% coinsurance, and $5,000 OOP max;
OOP Costs in excess of HSA balance are paid from the store of initial wealth with a 35% tax adjustment to OOP costs to reflect after-tax spending
Results are shown as of the end of the biennial policy period during which age 65 is attained
Individuals are assumed to be enrolled in an HSA plan effective immediately at average attained age 56
Actual claim experience is used for first two biennial periods, followed by simulated claim experience for duration of forecast period to age 65
Average results for 10,000 simulated runs of the average respondent are shown (sensitivities also done for 10,000 simulated runs)
Average accumulated wealth does not reflect HSA premiums or annual HSA contributions
Average accumulated wealth does not reflect zero-income respondents who would have to pay HSA premiums and contributions out of initial wealth
HSA contributions occur at beginning of each biennial policy period; claims and withdrawals occur at end of biennial policy period.
A discount rate of 5% is used for accumulating claims, out-of-pocket costs, and insurance payments
Initial wealth is not assumed to increase

As seen in the second set of sensitivity tests above, the demand adjustments used to reflect decreased moral hazard due to lower insurance value have very little impact on the HSA performance. Increasing the factor from 4% to 6%, which effectively reduces projected expenditures by an additional 2%, increases the final HSA value by only 2%. More significant are sensitivity tests related to the level of HSA contributions, which are somewhat intuitive. Lowering the HSA contribution to 50% of the $1,000 deductible ($500) decreases the remaining HSA value by almost 90%. Allowing legislated catch-up contributions beginning at age 55 ($600 assumed annually) leads to almost 350% higher HSA value at attained age 65, although the percentage of contributions remaining increases 180% from 4.2% to 11.8% (there are more contributions to be lost due to large claim shocks). One of the administration's current proposals is to allow maximum HSA contributions up to the total Out-of-Pocket (OOP) maximum (rather than the deductible). The sensitivity test above shows this policy would increase the remaining HSA balance almost 80 times over, while the percentage of contributions remaining increases from 4.2% to 67.3%. While only .1% of simulated enrollees retain over 50% of contributions in the baseline scenario, almost 95% would retain 50% or more under this scenario, assuming people could afford a level of contribution equal to the $5,000 per annum OOP maximum. As this is an unrealistic contribution amount for most individuals, the results of this policy change should be interpreted conservatively. I intend to model penetration of different maximum contribution levels for future research, taking into account marketplace data and consumption/savings tradeoff decisions in a multi-period utility context.

Also significant in Table 13b are tests that alter the HSA contribution rules. Requiring the member to only withdraw up to 50% or 75% of the HSA balance increases the percentage of remaining HSA contributions from 4.2% to 22.8% and 10.7% respectively. However, enforcing this rule does not dramatically affect the total cumulative HSA withdrawals at the end of the forecast horizon, but rather the *timing* of withdrawals. This gives the appearance of higher accumulated HSA value due to a one period deferral of HSA withdrawals. As a result, simulation results show artificially higher account values at age 65.

Exhibit 2 in the Appendix details additional sensitivity tests, not to assumption changes, but due to deviations in individual predictor values from the "Average Respondent". With respect to the number of chronic conditions, the HSA values again exponentially decrease from $1,137 (8.4%) to $111 (0.8%) when shifting from zero to seven conditions. HSA values increase

by 71% when moving from "fair / poor" to "good" self reported health status, and increase 78% from "good" to "very good / excellent", although the dollar differences are de minimis. Reporting two or more problems with ADLs, relative to no problems with ADLs, decreases the remaining HSA contributions from 4.8% to 2.9%, or about $250. Again, the impact is fairly immaterial given the terrible baseline performance of the accounts. Additional sensitivity results are shown for having higher education, abstaining from alcohol and cigarette use, exercising regularly, and suffering from back problems.

Simulation Results: Hypothetical Respondent

Three hypothetical enrollees were constructed based on varying the health status measures. Each enrollee was run 10,000 times through the Health Savings Account module. All three types are assumed to have employer health insurance. The model is parameterized with household income and non-housing wealth evaluated at the mean of all 50-55 year-olds. Attained age 50 is assumed, yielding 8 biennial policy periods (16 years) for forecasting purposes. All other non-health related variables are set at their average values (e.g., gender, geographic location, etc.). The three hypothetical enrollees are uniquely defined as follows:

"*Healthy*": Prediction model is initialized with 25th percentile of lagged claims. Enrollee is assumed to have zero chronic conditions, no ADL problems, and "excellent" or "very good" health status. Additionally, I assume the "Healthy" enrollee doesn't smoke or drink, engages in rigorous physical exercise at least three times weekly, and does not suffer from back problems.

"*Average Health*": Prediction model is initialized with 50th percentile (median) of lagged claims. Enrollee is assumed to have one chronic condition, one ADL presenting difficulty, and "good" health status. It is assumed that he or she smokes, drinks, exercises and suffers from back problems at the *average rate* of the population as a whole.

"*Unhealthy*": Prediction model is initialized with 75th percentile of lagged claims. Enrollee is assumed to have two chronic conditions, two or more ADLs presenting difficulty, and "fair" or "poor" health status. It is assumed that he or she smokes, drinks, does not exercise more than two times weekly, and suffers from back problems.

Shown below, in Table 14, are the simulation results for each of the three types of hypothetical respondent. Consistent with prior exhibits showing simulation results for increases in the number of chronic conditions, the average HSA contributions remaining at age 65 exponentially decrease with changes in overall aggregate health status. Healthy enrollees retain 15.2% of the possible final HSA value, average health enrollees retain 2.6%, and unhealthy enrollees retain a meager 0.3%. Healthy enrollees pay OOP expenses predominantly from the

HSA (85%) and have initial wealth decreases of only 2.4%. In contrast, unhealthy enrollees only pay 42% of OOP expenses from the HSA and have a significantly higher 20% reduction to initial wealth in order to cover expenses.

Table 14: Simulation Results for "Hypothetical Respondent": Healthy, Average Health, Unhealthy

HSA Account Performance: Hypothetical Respondent Simulated 10,000 Times

Hypothetical Respondents at Age 50	**Healthy**	**Average Health**	**Unhealthy**
Attained Age	Age 50	Age 50	Age 50
Count of respondents	1	1	1
Forecast Periods to Age 65	8	8	8
Number of actual years in forecast	16	16	16
Final Average Accumulated HSA Account	$3,873	$654	$88
Potential Average Accumulated HSA Value	$25,446	$25,446	$25,446
Average % of HSA Contributions Remaining	15.2%	2.6%	0.3%
25th Percentile of % HSA Contribs Remaining	0.0%	0.0%	0.0%
Median of % HSA Contribs Remaining	8.7%	0.0%	0.0%
75th Percentile of % HSA Contribs Remaining	25.9%	2.8%	0.0%
Percentage with over 50% of HSA Contribs	4.7%	0.0%	0.0%
Percentage with less than 20% of HSA Contribs	66.9%	97.3%	99.9%
Average Annual HSA Contribution	$1,000	$1,000	$1,000
Average Annual Claim	$3,354	$6,580	$21,330
Average Accumulated Claims (all years)	$68,080	$133,197	$431,875
Accumulated Average Out-of-Pocket (OOP)	$25,413	$38,024	$59,998
Accumulated Amounts Paid by Insurance	$42,667	$95,172	$371,877
Final Average Insurance Plan Value	62.7%	71.5%	86.1%
Accumulated Average Paid from HSA	$21,573	$24,792	$25,359
% of OOP Paid from HSA Withdrawals	84.9%	65.2%	42.3%
Average Household Income	$80,156	$80,156	$80,156
Average Intitial Household Wealth Level	$249,982	$249,982	$249,982
Accumulated Average Wealth Reduction	($5,908)	($20,357)	($49,677)
Final Average Accumulated Wealth	$245,163	$233,685	$209,190
Final Average % Wealth Reduction	-2.4%	-8.1%	-19.9%

Insurance plan values are naturally higher as morbidity increases. Average annual claims increase dramatically due to the significant total marginal effects of key health-status related predictor variables in the claims prediction model. While healthy enrollees have an average annual claim of $3,354, average and unhealthy enrollees have $6,580 and $21,330 respectively. The $6,580 annual claim for average health is very reasonable for this age cohort. Only healthy enrollees can possibly achieve an account balance higher than 50% of accumulated HSA contributions (4.7%). While 67% of healthy enrollees have less than 20% of contributions remaining, almost 100% of unhealthy enrollees have less than 20% of contributions remaining. It is clear from these simulations that health status has a dramatic impact on the resulting projected claims stream, and that higher morbidity translates into exponentially worsening HSA

performance. Even among the healthiest enrollees, less than $4,000 is accumulated at age 65 despite annual contributions of $1,000 in each of the near-retirement years. "Too little, too late" is the final inference that can be had from these HSA simulation results. Catch-up contributions may somewhat augment the final HSA balance available to fund retiree medical costs, leading to an average of $16,000 in the account at age 65, or 39% of total contributions. Most dramatically, as evident in the Sensitivity Test Exhibits 3-5 in the Appendix, allowing the full OOP maximum to be funded leads to a whopping 80% of contributions available at retirement for healthy enrollees, and even 53% of contributions for the sickest enrollees. Naturally, funding the HSA vehicle at a higher level in early duration years reduces the probability of ruin due to the presence of HSA "reserves" that fund short-term our-of-pocket costs. Higher reserves prevent the HSA balance from being exhausted due to short-term claim shocks, while providing a larger base upon which HSA interest accrues. While much of this seems obvious, this prediction and simulation model, if parameterized for a larger data set with a wider age-range of enrollees, will provide significant insight into optimal HSA contribution level that minimizes the probability of ruin over a fixed investment horizon in the presence of stochastic claim shocks, for a given plan design.

Discussion and Extensions for Further Research

The simulation results clearly show disappointing HSA performance over the near-retirement years using the two-part claims prediction model derived from the Health and Retirement Study. All three types of simulation, namely "total population", "average respondent", and "hypothetical respondent", result in small residual HSA values at Medicare eligibility age 65. Even when allowing for catch-up contributions, the remaining HSA assets will not adequately fund out-of-pocket expenses expected in retirement. On average, a "healthy" hypothetical respondent taking full advantage of catch-up contributions may accumulate $16,000 over the forecast period from age 50 to age 65. According to an EBRI Issue Brief (Fronstin and Salisbury, 2004), an individual will need about $137,000 if he or she lives to age 80 in order to cover premiums and out-of-pocket expenses (with costs escalating 7% annually). Even if the "healthy" enrollee were to fully fund the $5,000 OOP maximum consistent with proposed legislation to expand HSA contribution levels, only $102,000 would be accumulated over the simulation period. For someone of "average" health, this amount falls to $89,000. For the hypothetical "unhealthy" enrollee, this further falls to $67,000. Of course only very few

individuals nearing retirement would be able to afford this extreme level of contributions, making it highly unlikely that the cohort of Baby-boomers would be able to adequately finance retiree medical expenses through an HSA- *if beginning at age 50.* Also clear from the "total population" simulation is that for normal contributions at 100% of the deductible, the residual HSA value is, quite remarkably, independent of the member's duration to age 65. That is, no matter when the individual enrolled in the HSA over the time span from age 50 to age 65, they still had a meager $1,400 remaining in the HSA at age 65. The level of contributions is not adequate enough for this age cohort to sustain the large claim shocks expected in the near-retirement years, which basically wash away accumulated contributions such that only the last one or two periods prior to age 65 matter for determining the final HSA value.

This somewhat disheartening result for HSAs is further aggravated by the clear reality that those with lower health status or chronic conditions experience exponentially worsening HSA values over the simulation horizon. This project has further demonstrated the somewhat obvious fact that sick people pay more and save less in a high-deductible health plan with a savings component. Most attempts to attract the chronically ill to CDHP or HSA plans have focused on the information and web-based tools that help these members manage their conditions and choose a high performing physician or hospital system. Given that such members represent the greatest share of claim expense, it is extremely valuable to engage these members directly through disease management initiatives that can be integrated into the CDHP/HSA platform. But this is not enough to make the member enroll in such a plan. Given they are more likely than average to penetrate the high deductible (and meet the OOP maximum), the premium savings from having a HDHP do not compensate for the increased OOP costs. However, a well-designed employer plan with a disease management component could financially reward engaged members by adding additional HSA contributions upon completion of health risk appraisals or submitting to direct case management of their conditions. These additional HSA contributions might "make whole" the chronically ill member relative to their healthier counterparts, while lowering overall medical expense and stabilizing the risk pool.

While the HSA performance is disappointing, it is important to consider the age of the population used in this study. Baby-boomers, who have very little time to finance future medical needs if they haven't done so already, will not be able to viably use HSAs unless they defer withdrawals until retirement. As the tax-advantaged nature of HSAs benefits these individuals

more in their working years (when marginal tax rates are presumably higher), it would not make sense for them to forego HSA withdrawals and instead pay for OOP expenses from their store of wealth, after-tax income, or other assets. Given the choice between spending pre-tax or after-tax dollars to finance current health care consumption, versus "saving" the HSA assets to accumulate for retirement, one needs to consider the consumption-savings tradeoff in an expected utility context based on HSA member's levels of risk aversion. The fact that HSA assets accumulate tax-free suggests that, in some circumstances, it may be wise to forego HSA withdrawals to meet current expenses. In future research, I plan on developing a model to determine the utility-maximizing level of contributions for a hypothetical enrollee (e.g., based on income and expected medical expenses). Also, as noted above, I plan on evaluating what level of contributions minimizes the "probability of ruin" for HSAs, where ruin is defined as having a zero account balance at retirement. The larger the level of contributions, and of course the earlier the enrollee enters the HSA plan (as claim shocks are smaller at early durations), the greater the percentage of HSA contributions remaining at retirement. This optimal level of contributions will be constrained by the expected utility model that balances current tax-advantaged HSA spending versus deferred HSA savings used to finance retiree health needs.

Regarding the simulation, I plan to model HSA performance using the IRS legislated maximum contributions for High Deductible Health Plans (HDHPs). Simulation results shown above hold the plan design constant. It would be expected that carriers would increase deductible and OOP maximums to allow members to take advantage of the maximum potential HSA contributions allowed by law, though this is not necessarily the case. Individuals may prefer to pay a higher premium for a lower deductible rather than using the premium differential (realized through lower insurance value) to make additional HSA contributions. This will be investigated using marketplace data. I will also gather data on the average HSA contributions made as a percentage of the deductible. Simulation results have aggressively assumed maximum funding. Using actual contribution data may unfortunately lead to more dire HSA performance.

An important extension of the simulation will be to test sensitivity to the initial claims used to initialize the prediction model. I have typically used average or median claims and tested HSA performance for *zero* initial claims, which results in quite favorable HSA experience. It is important to test this over a wider distribution of initial values given the high persistency of health shocks over a short simulation horizon. This would not be an important issue if I had data

encompassing a larger age-range of individuals, and therefore a longer simulation horizon. However, there are tradeoffs. With a longer simulation horizon, the variability in final HSA values would be much higher if I were to simulate performance based on stochastically generated claims. Moreover, certain assumptions, such as long-term medical trend, would be very critical and require a larger range of sensitivity tests. Most importantly, one could not confidently assume minimal changes in health status over a period during which members transition from age 20 or 30 to age 65. For the HRS population, there was very little change in health status measures over the three wave period, justifying the time-invariance assumption of independent variables in the prediction model. If younger participants were valued in the simulation, I would have to consider a primary stage regression that predicts health status or the number of chronic conditions, and allow this to change over time. Such a model is not implausible, as health status is highly dependent on age, gender, and other direct observables.

With regard to the claims prediction model itself, there are additional steps that could be taken to improve the forecasting tool used for the HSA simulation. First, I could re-specify the model as set forth in the "Alternative Model Specifications" above, although the current preferred model has yielded much insight into the total marginal effects for key predictor variables, particularly related to health status and insurance coverage status. In addition, I have considered running the two-part model based on a hurdle cutoff of $2,000 instead of zero. This will provide useful inference on the impact of predictor variables in exceeding a biennial high deductible claims threshold, as well as potentially improve claims prediction by splitting the distribution up (at roughly the 40th percentile) and estimating E[$Y_i^* \mid x_i, Y_i^*$ > $2,000] and E[$Y_i^* \mid x_i, Y_i^*$ <= $2,000], which may balance out the see-saw of over/under-prediction. Given the spikes in the claim response variable at other points besides zero, this could be accomplished with one Probit for under/over $2,000, or alternatively, telescoping probabilities could be used. Ultimately, to further this research, I will need to identify a claims data set with a truly random data-generating process (*sans* spikes), for a wider age-range of potential claimants, and over a longer period of time so as to explore the serial correlation and persistence of claim shocks. As the search for this data set continues, I will rely on the models put forth herein to evaluate HSA policy based on statistical and econometric techniques to work around the particular data deficiencies of the Health & Retirement Study.

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Appendix

Exhibit 1: Health Savings Account Module

HSA Balance Accumulator

Plan Details	*Biennial Inputs*	*Annual Inputs*
Unique ID	1	1
Deductible	$2,000	$1,000
Coinsurance	80%	80%
OOP Max	$10,000	$5,000
Salary	$160,312	$80,156
Salary Scale	6.1%	3.0%
HSA Contribution as %Sal	5.0%	5.0%
HSA Contribution Override		
Max % of HSA account paid	100%	100%
Initial Wealth	$249,982	$249,982
HSA Interest	10.3%	5.0%
Wealth Accumulator	0.0%	0.0%
Tax Rate	35.0%	35.0%
Age	50	50
Discount Rate	10.3%	5.0%
Bi-ennial Policy Year Adjustment	9.0%	9.0%

Counter
1

Age	Claim Input	Period	BOY HSA Balance	BOY Wealth	BOY Income	HSA Contribution	Annual Claim	EE OOP	*OOP Cut-off $42,000* Insurer Paid	EE from HSA	EOY HSA Balance	EOY Wealth
50	$1,775	1	$2,000	$249,982	$160,312	$2,000	$1,775	$1,775	$0	$1,775	$430	$249,982
52	$2,299	2	$2,430	$249,982	$170,075	$2,000	$2,299	$2,080	$220	$2,080	$599	$249,982
54	$3,227	3	$2,599	$249,982	$180,433	$2,000	$3,227	$2,327	$901	$2,327	$539	$249,982
56	$1,294	4	$2,539	$249,982	$191,421	$2,000	$1,294	$1,294	$0	$1,294	$1,505	$249,982
58	$10,976	5	$3,505	$249,982	$203,079	$2,000	$10,976	$4,388	$6,588	$3,865	$0	$249,177
60	$1,992	6	$2,000	$249,177	$215,446	$2,000	$1,992	$1,992	$0	$1,992	$213	$249,177
62	$1,306	7	$2,213	$249,177	$228,567	$2,000	$1,306	$1,306	$0	$1,306	$1,134	$249,177
64	$633	8	$3,134	$249,177	$242,486	$2,000	$633	$633	$0	$633	$2,823	$249,177
											37.3%	

Age	Period	Accumulated HSA Contribs	Accumulated HSA No Interest	Accumulated Insurance Paid	Accumulated EE OOP	Accumulated Claims	Accumulated HSA W/Ds	Accumulated Wealth Deds	Accumulated Claim
50	1	$2,205	$2,000	$0	$1,775	$1,775	$1,775	$0	$1,775
52	2	$4,636	$4,000	$220	$4,037	$4,257	$4,037	$0	$4,075
54	3	$7,316	$6,000	$1,143	$6,777	$7,921	$6,777	$0	$7,302
56	4	$10,271	$8,000	$1,260	$8,766	$10,026	$8,766	$0	$8,596
58	5	$13,529	$10,000	$7,977	$14,052	$22,029	$13,529	($805)	$19,572
60	6	$17,121	$12,000	$8,795	$17,484	$26,279	$16,907	($888)	$21,563
62	7	$21,080	$14,000	$9,696	$20,582	$30,278	$19,946	($979)	$22,869
64	8	$25,446	$16,000	$10,690	$23,325	$34,015	$22,623	($1,079)	$23,502
								$1,079	
								$23,325	

VALUATION OUTPUT	
Unique ID	1
Initial Age	50
Forecast Periods to Age 65	8
Number of actual years in forecast	16
Final Average Accumulated HSA Account	$2,823
Potential Average Accumulated HSA Value	$25,446
% of HSA Contributions Remaining	11.1%
Average Annual HSA Contribution	$1,000
Average Annual Claim	$1,469
Average Accumulated Claims (all years)	$34,015
Accumulated Average Out-of-Pocket (OOP)	$23,325
Accumulated Amounts Paid by Insurance	$10,690
Final Average Insurance Plan Value	31.4%
Accumulated Average Paid from HSA	$22,623
% of OOP Paid from HSA Withdrawals	97.0%
Average Household Income	$160,312
Average Intitial Household Wealth Level	$249,982
Accumulated Average Wealth Reduction	($1,079)
Final Average Accumulated Wealth	$249,177
Final Average % Wealth Reduction	-0.4%

Exhibit 2: Simulation Results for "Average Respondent": Sensitivity Tests to Changes in Predictor Variables

HSA Account Performance: Average Respondent Simulated 10,000 Times, with Sensitivity to Changes in Predictor Variables

Average Respondent	**Baseline** *With Medical Trend*	*Zero Chronic Conditions*		*One Chronic Condition*		*Three Chronic Conditions*		*Five Chronic Conditions*		*Seven Chronic Conditions*		*Fair/Poor Self-Reported Health Status*		*Good Self-Reported Health Status*		*Excellent Self-Reported Health Status*		*No problems with ADLs*		*1 Problem with ADL*		*2+ Problems with ADLs*	
Attained Age	Age 56	Age 56		Age 56		Age 56		Age 56		Age 56		Age 56		Age 56		Age 56		Age 56		Age 56		Age 56	
Count of respondents	1	1		1		1		1		1		1		1		1		1		1		1	
Forecast Periods to Age 65	5	5		5		5		5		5		5		5		5		5		5		5	
Number of actual years in forecast	10	10		10		10		10		10		10		10		10		10		10		10	
Final Average Accumulated HSA Account	$572	$1,137	99%	$717	25%	$325	-43%	$143	-75%	$111	-81%	$272	-52%	$465	-19%	$830	45%	$601	5%	$651	14%	$397	-31%
Potential Average Accumulated HSA Value	$13,529	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%
Average % of HSA Contributions Remaining	4.2%	8.4%	99%	5.3%	25%	2.4%	-43%	1.1%	-75%	0.8%	-81%	2.0%	-52%	3.4%	-19%	6.1%	45%	4.4%	5%	4.8%	14%	2.9%	-31%
25th Percentile of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	
Median of % HSA Contribs Remaining	0.0%	2.4%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	
75th Percentile of % HSA Contribs Remaining	6.6%	14.2%		8.8%		0.8%		0.0%		0.0%		0.0%		3.9%		10.4%		7.0%		7.9%		2.0%	
Percentage with over 50% of HSA Contribs	0.1%	0.5%		0.1%		0.0%		0.0%		0.0%		0.0%		0.1%		0.1%		0.1%		0.1%		0.0%	
Percentage with less than 20% of HSA Contribs	94.6%	84.0%		92.1%		97.5%		99.3%		99.7%		97.9%		95.5%		90.1%		93.4%		92.7%		96.3%	
Average Annual HSA Contribution	$1,000	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%
Average Annual Claim	$5,897	$4,110	-30%	$5,259	-11%	$8,319	41%	$13,886	135%	$21,894	271%	$9,350	59%	$6,941	18%	$4,666	-21%	$5,831	-1%	$5,441	-8%	$7,570	28%
Average Accumulated Claims (all years)	$68,469	$49,248	-28%	$61,646	-10%	$94,820	38%	$154,743	126%	$241,592	253%	$105,971	55%	$79,973	17%	$55,246	-19%	$67,767	-1%	$63,578	-7%	$86,785	27%
Accumulated Average Out-of-Pocket (OOP)	$22,206	$19,271	-13%	$21,149	-5%	$24,859	12%	$28,522	28%	$31,765	43%	$25,680	16%	$23,294	5%	$20,381	-8%	$21,941	-1%	$21,533	-3%	$23,960	8%
Accumulated Amounts Paid by Insurance	$46,262	$29,977	-35%	$40,497	-12%	$69,961	51%	$126,221	173%	$209,827	354%	$80,291	74%	$56,679	23%	$34,864	-25%	$45,826	-1%	$42,045	-9%	$62,824	36%
Final Average Insurance Plan Value	67.6%	60.9%	-10%	65.7%	-3%	73.8%	9%	81.6%	21%	86.9%	29%	75.8%	12%	70.9%	5%	63.1%	-7%	67.6%	0%	66.1%	-2%	72.4%	7%
Accumulated Average Paid from HSA	$12,957	$12,391	-4%	$12,812	-1%	$13,204	2%	$13,386	3%	$13,418	4%	$13,257	2%	$13,064	1%	$12,699	-2%	$12,928	0%	$12,878	-1%	$13,132	1%
% of OOP Paid from HSA Withdrawals	58.3%	64.3%	10%	60.6%	4%	53.1%	-9%	46.9%	-20%	42.2%	-28%	51.6%	-12%	56.1%	-4%	62.3%	7%	58.9%	1%	59.8%	2%	54.8%	-6%
Average Household Income	$74,033	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%
Average Intitial Household Wealth Level	$282,132	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%
Accumulated Average Wealth Reduction	($10,016)	($6,370)	-36%	($8,612)	-14%	($13,718)	37%	($19,073)	90%	($24,012)	140%	($14,899)	49%	($11,525)	15%	($7,606)	-24%	($9,653)	-4%	($9,102)	-9%	($12,446)	24%
Final Average Accumulated Wealth	$270,095	$273,460	1%	$271,400	0%	$266,743	-1%	$261,820	-3%	$257,401	-5%	$265,651	-2%	$268,743	-1%	$272,326	1%	$270,436	0%	$270,939	0%	$267,890	-1%
Final Average % Wealth Reduction	-3.6%	-2.3%	-36%	-3.1%	-14%	-4.9%	37%	-6.8%	90%	-8.5%	140%	-5.3%	49%	-4.1%	15%	-2.7%	-24%	-3.4%	-4%	-3.2%	-9%	-4.4%	24%

Average Respondent	**Baseline** *With Medical Trend*	*High School or Below*		*Some College or Above*		*Exercises Less than 3x Weekly*		*Exercises 3x Plus Weekly*		*Never drinks Alcohol*		*Drinks Alcohol*		*Has Never Smoked*		*Has Smoked*		*No Reported Back Problems*		*Reported Back Problems*	
Attained Age	Age 56	Age 56		Age 56		Age 56		Age 56		Age 56		Age 56		Age 56		Age 56		Age 56		Age 56	
Count of respondents	1	1		1		1		1		1		1		1		1		1		1	
Forecast Periods to Age 65	5	5		5		5		5		5		5		5		5		5		5	
Number of actual years in forecast	10	10		10		10		10		10		10		10		10		10		10	
Final Average Accumulated HSA Account	$572	$683	20%	$480	-16%	$561	-2%	$581	2%	$530	-7%	$626	9%	$652	14%	$551	-4%	$600	5%	$570	0%
Potential Average Accumulated HSA Value	$13,529	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%	$13,529	0%
Average % of HSA Contributions Remaining	4.2%	5.1%	20%	3.6%	-16%	4.1%	-2%	4.3%	2%	3.9%	-7%	4.6%	9%	4.8%	14%	4.1%	-4%	4.4%	5%	4.2%	0%
25th Percentile of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	
Median of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	
75th Percentile of % HSA Contribs Remaining	6.6%	8.5%		4.3%		6.5%		6.8%		5.4%		7.6%		7.9%		5.7%		7.0%		6.3%	
Percentage with over 50% of HSA Contribs	0.1%	0.1%		0.0%		0.0%		0.1%		0.1%		0.0%		0.1%		0.1%		0.1%		0.0%	
Percentage with less than 20% of HSA Contribs	94.6%	92.8%		95.4%		94.3%		94.3%		94.7%		93.7%		93.1%		94.1%		93.9%		94.2%	
Average Annual HSA Contribution	$1,000	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%
Average Annual Claim	$5,897	$5,375	-9%	$6,790	15%	$5,949	1%	$5,984	1%	$6,438	9%	$5,546	-6%	$5,391	-9%	$6,448	9%	$5,899	0%	$6,019	2%
Average Accumulated Claims (all years)	$68,469	$62,853	-8%	$78,315	14%	$69,111	1%	$69,466	1%	$74,585	9%	$64,743	-5%	$63,103	-8%	$74,651	9%	$68,594	0%	$69,934	2%
Accumulated Average Out-of-Pocket (OOP)	$22,206	$21,399	-4%	$23,229	5%	$22,192	0%	$22,058	-1%	$22,800	3%	$21,716	-2%	$21,614	-3%	$22,767	3%	$22,023	-1%	$22,326	1%
Accumulated Amounts Paid by Insurance	$46,262	$41,454	-10%	$55,086	19%	$46,918	1%	$47,408	2%	$51,785	12%	$43,027	-7%	$41,489	-10%	$51,884	12%	$46,571	1%	$47,608	3%
Final Average Insurance Plan Value	67.6%	66.0%	-2%	70.3%	4%	67.9%	0%	68.2%	1%	69.4%	3%	66.5%	-2%	65.7%	-3%	69.5%	3%	67.9%	0%	68.1%	1%
Accumulated Average Paid from HSA	$12,957	$12,846	-1%	$13,048	1%	$12,968	0%	$12,947	0%	$12,999	0%	$12,903	0%	$12,877	-1%	$12,978	0%	$12,929	0%	$12,959	0%
% of OOP Paid from HSA Withdrawals	58.3%	60.0%	3%	56.2%	-4%	58.4%	0%	58.7%	1%	57.0%	-2%	59.4%	2%	59.6%	2%	57.0%	-2%	58.7%	1%	58.0%	-1%
Average Household Income	$74,033	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%	$74,033	0%
Average Intitial Household Wealth Level	$282,132	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%	$282,132	0%
Accumulated Average Wealth Reduction	($10,016)	($8,946)	-11%	($11,449)	14%	($9,978)	0%	($9,802)	-2%	($10,864)	8%	($9,345)	-7%	($9,228)	-8%	($10,846)	8%	($9,777)	-2%	($10,198)	2%
Final Average Accumulated Wealth	$270,095	$271,083	0%	$268,810	0%	$270,134	0%	$270,294	0%	$269,348	0%	$270,724	0%	$270,828	0%	$269,363	0%	$270,329	0%	$269,955	0%
Final Average % Wealth Reduction	-3.6%	-3.2%	-11%	-4.1%	14%	-3.5%	0%	-3.5%	-2%	-3.9%	8%	-3.3%	-7%	-3.3%	-8%	-3.8%	8%	-3.5%	-2%	-3.6%	2%

Exhibit 3: Simulation Results for "Healthy Respondent": Sensitivity Tests to Changes in Assumptions

HSA Account Performance: Average Respondent Simulated 10,000 Times, with Sensitivity to Assumption Changes

Hypothetical "Healthy" Respondent Age 50	**Baseline** *With Medical Trend*	*No Medical Trend*		*Low Trend at 5% annually*		*High Trend at 15% annually*		*No Initial Claims*		*HSA Interest Credited at 0%*		*HSA Interest Credited at 10%*		*No Biennial Insurance Value Adjustment*	
Attained Age	Age 50	Age 50		Age 50		Age 50		Age 50		Age 50		Age 50		Age 50	
Count of respondents	1	1		1		1		1		1		1		1	
Forecast Periods to Age 65	8	8		8		8		8		8		8		8	
Number of actual years in forecast	16	16		16		16		16		16		16		16	
Final Average Accumulated HSA Account	$3,873	$8,157	111%	$5,935	53%	$2,365	-39%	$8,633	123%	$1,610	-58%	$9,653	149%	$4,638	20%
Potential Average Accumulated HSA Value	$25,446	$25,446	0%	$25,446	0%	$25,446	0%	$25,446	0%	$16,000	-37%	$41,428	63%	$25,446	0%
Average % of HSA Contributions Remaining	15.2%	32.1%	111%	23.3%	53%	9.3%	-39%	33.9%	123%	10.1%	-34%	23.3%	53%	18.2%	20%
25th Percentile of % HSA Contribs Remaining	0.0%	15.5%		6.0%		0.0%		8.0%		0.0%		4.9%		0.8%	
Median of % HSA Contribs Remaining	8.7%	32.5%		20.7%		0.3%		32.3%		2.3%		21.8%		14.0%	
75th Percentile of % HSA Contribs Remaining	25.9%	47.3%		37.5%		14.4%		54.3%		15.5%		37.7%		30.8%	
Percentage with over 50% of HSA Contribs	4.7%	20.8%		10.7%		2.2%		29.6%		2.8%		10.0%		6.0%	
Percentage with less than 20% of HSA Contribs	66.9%	31.3%		48.9%		80.5%		37.2%		80.1%		47.2%		59.2%	
Average Annual HSA Contribution	$1,000	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%
Average Annual Claim	$3,354	$1,745	-48%	$2,432	-27%	$4,792	43%	$2,871	-14%	$3,436	2%	$3,382	1%	$3,341	0%
Average Accumulated Claims (all years)	$68,080	$37,356	-45%	$50,465	-26%	$93,444	37%	$55,569	-18%	$69,663	2%	$68,411	0%	$67,955	0%
Accumulated Average Out-of-Pocket (OOP)	$25,413	$18,555	-27%	$21,754	-14%	$28,936	14%	$18,331	-28%	$25,504	0%	$25,366	0%	$23,381	-8%
Accumulated Amounts Paid by Insurance	$42,667	$18,801	-56%	$28,711	-33%	$64,508	51%	$37,238	-13%	$44,159	3%	$43,045	1%	$44,574	4%
Final Average Insurance Plan Value	62.7%	50.3%	-20%	56.9%	-9%	69.0%	10%	67.0%	7%	63.4%	1%	62.9%	0%	65.6%	5%
Accumulated Average Paid from HSA	$21,573	$17,289	-20%	$19,511	-10%	$23,082	7%	$16,813	-22%	$14,390	-33%	$31,775	47%	$20,808	-4%
% of OOP Paid from HSA Withdrawals	84.9%	93.2%	10%	89.7%	6%	79.8%	-6%	91.7%	8%	56.4%	-34%	125.3%	48%	89.0%	5%
Average Household Income	$80,156	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%
Average Intitial Household Wealth Level	$249,982	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%
Accumulated Average Wealth Reduction	($5,908)	($1,948)	-67%	($3,451)	-42%	($9,006)	52%	($2,335)	-60%	($9,186)	55%	($3,179)	-46%	($3,959)	-33%
Final Average Accumulated Wealth	$245,163	$248,520	1%	$247,267	1%	$242,323	-1%	$248,004	1%	$242,455	-1%	$247,415	1%	$246,745	1%
Final Average % Wealth Reduction	-2.4%	-0.8%	-67%	-1.4%	-42%	-3.6%	52%	-0.9%	-60%	-3.7%	55%	-1.3%	-46%	-1.6%	-33%

Hypothetical "Healthy" Respondent Age 50	**Baseline** *With Medical Trend*	*Demand Adjustment of 6%*		*Demand Adjustment of 2%*		*50% of HDHP Deductible Funded*		*100% of OOP Maximum Funded*		*Catch-up Contributions Allowed*		*Deduct only up to 50% HSA Balance*		*Deduct only up to 75% HSA Balance*	
Attained Age	Age 50	Age 50		Age 50		Age 50		Age 50		Age 50		Age 50		Age 50	
Count of respondents	1	1		1		1		1		1		1		1	
Forecast Periods to Age 65	8	8		8		8		8		8		8		8	
Number of actual years in forecast	16	16		16		16		16		16		16		16	
Final Average Accumulated HSA Account	$3,873	$4,011	4%	$3,816	-1%	$254	-93%	$101,870	2530%	$15,912	311%	$6,117	58%	$4,583	18%
Potential Average Accumulated HSA Value	$25,446	$25,446	0%	$25,446	0%	$12,723	-50%	$127,231	400%	$40,714	60%	$25,446	0%	$25,446	0%
Average % of HSA Contributions Remaining	15.2%	15.8%	4%	15.0%	-1%	2.0%	-87%	80.1%	426%	39.1%	157%	24.0%	58%	18.0%	18%
25th Percentile of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		75.8%		24.9%		14.1%		5.2%	
Median of % HSA Contribs Remaining	8.7%	9.6%		8.5%		0.0%		81.0%		41.0%		20.3%		12.2%	
75th Percentile of % HSA Contribs Remaining	25.9%	27.4%		25.5%		0.0%		85.2%		54.1%		30.3%		26.9%	
Percentage with over 50% of HSA Contribs	4.7%	5.0%		4.8%		0.3%		100.0%		32.7%		5.4%		5.1%	
Percentage with less than 20% of HSA Contribs	66.9%	65.8%		67.9%		97.5%		0.0%		19.2%		49.0%		65.0%	
Average Annual HSA Contribution	$1,000	$1,000	0%	$1,000	0%	$500	-50%	$5,000	400%	$1,600	60%	$1,000	0%	$1,000	0%
Average Annual Claim	$3,354	$3,275	-2%	$3,459	3%	$3,420	2%	$3,375	1%	$3,338	0%	$3,451	3%	$3,403	1%
Average Accumulated Claims (all years)	$68,080	$66,436	-2%	$70,304	3%	$69,320	2%	$68,317	0%	$67,696	-1%	$69,745	2%	$68,895	1%
Accumulated Average Out-of-Pocket (OOP)	$25,413	$25,104	-1%	$25,567	1%	$25,418	0%	$25,361	0%	$25,274	-1%	$25,490	0%	$25,362	0%
Accumulated Amounts Paid by Insurance	$42,667	$41,333	-3%	$44,738	5%	$43,902	3%	$42,956	1%	$42,422	-1%	$44,255	4%	$43,532	2%
Final Average Insurance Plan Value	62.7%	62.2%	-1%	63.6%	2%	63.3%	1%	62.9%	0%	62.7%	0%	63.5%	1%	63.2%	1%
Accumulated Average Paid from HSA	$21,573	$21,435	-1%	$21,630	0%	$12,469	-42%	$25,361	18%	$24,802	15%	$19,329	-10%	$20,863	-3%
% of OOP Paid from HSA Withdrawals	84.9%	85.4%	1%	84.6%	0%	49.1%	-42%	100.0%	18%	98.1%	16%	75.8%	-11%	82.3%	-3%
Average Household Income	$80,156	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%
Average Intitial Household Wealth Level	$249,982	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%
Accumulated Average Wealth Reduction	($5,908)	($5,644)	-4%	($6,056)	3%	($19,922)	237%	$0	-100%	($726)	-88%	($9,479)	60%	($6,922)	17%
Final Average Accumulated Wealth	$245,163	$245,375	0%	$245,040	0%	$234,014	-5%	$249,982	2%	$249,394	2%	$242,544	-1%	$244,436	0%
Final Average % Wealth Reduction	-2.4%	-2.3%	-4%	-2.4%	3%	-8.0%	237%	0.0%	-100%	-0.3%	-88%	-3.8%	60%	-2.8%	17%

Exhibit 4: Simulation Results for "Average Health Respondent": Sensitivity Tests to Changes in Assumptions

HSA Account Performance: Average Respondent Simulated 10,000 Times, with Sensitivity to Assumption Changes

Hypothetical "Average Health" Respondent Age 50	**Baseline** *With Medical Trend*	*No Medical Trend*		*Low Trend at 5% annually*		*High Trend at 15% annually*		*No Initial Claims*		*HSA Interest Credited at 0%*		*HSA Interest Credited at 10%*		*No Biennial Insurance Value Adjustment*	
Attained Age	Age 50	Age 50		Age 50		Age 50		Age 50		Age 50		Age 50		Age 50	
Count of respondents	1	1		1		1		1		1		1		1	
Forecast Periods to Age 65	8	8		8		8		8		8		8		8	
Number of actual years in forecast	16	16		16		16		16		16		16		16	
Final Average Accumulated HSA Account	$654	$2,651	305%	$1,394	113%	$236	-64%	$3,197	389%	$314	-52%	$1,659	154%	$775	18%
Potential Average Accumulated HSA Value	$25,446	$25,446	0%	$25,446	0%	$25,446	0%	$25,446	0%	$16,000	-37%	$41,428	63%	$25,446	0%
Average % of HSA Contributions Remaining	2.6%	10.4%	305%	5.5%	113%	0.9%	-64%	12.6%	389%	2.0%	-24%	4.0%	56%	3.0%	18%
25th Percentile of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	
Median of % HSA Contribs Remaining	0.0%	6.8%		0.8%		0.0%		2.4%		0.0%		0.0%		0.0%	
75th Percentile of % HSA Contribs Remaining	2.8%	16.6%		7.9%		0.0%		21.5%		0.1%		4.9%		3.8%	
Percentage with over 50% of HSA Contribs	0.0%	0.4%		0.1%		0.0%		5.5%		0.1%		0.0%		0.0%	
Percentage with less than 20% of HSA Contribs	97.3%	80.5%		92.1%		99.3%		73.6%		98.3%		94.9%		96.8%	
Average Annual HSA Contribution	$1,000	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%
Average Annual Claim	$6,580	$3,196	-51%	$4,441	-33%	$9,297	41%	$5,694	-13%	$6,338	-4%	$6,346	-4%	$6,350	-4%
Average Accumulated Claims (all years)	$133,197	$68,778	-48%	$92,375	-31%	$180,995	36%	$111,134	-17%	$128,741	-3%	$128,624	-3%	$128,860	-3%
Accumulated Average Out-of-Pocket (OOP)	$38,024	$29,202	-23%	$33,223	-13%	$42,149	11%	$28,003	-26%	$37,822	-1%	$37,846	0%	$34,902	-8%
Accumulated Amounts Paid by Insurance	$95,172	$39,576	-58%	$59,153	-38%	$138,846	46%	$83,131	-13%	$90,919	-4%	$90,778	-5%	$93,958	-1%
Final Average Insurance Plan Value	71.5%	57.5%	-19%	64.0%	-10%	76.7%	7%	74.8%	5%	70.6%	-1%	70.6%	-1%	72.9%	2%
Accumulated Average Paid from HSA	$24,792	$22,795	-8%	$24,052	-3%	$25,210	2%	$22,249	-10%	$15,686	-37%	$39,769	60%	$24,672	0%
% of OOP Paid from HSA Withdrawals	65.2%	78.1%	20%	72.4%	11%	59.8%	-8%	79.5%	22%	41.5%	-36%	105.1%	61%	70.7%	8%
Average Household Income	$80,156	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%
Average Intitial Household Wealth Level	$249,982	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%
Accumulated Average Wealth Reduction	($20,357)	($9,856)	-52%	($14,109)	-31%	($26,060)	28%	($8,852)	-57%	($23,660)	16%	($15,762)	-23%	($15,739)	-23%
Final Average Accumulated Wealth	$233,685	$242,511	4%	$238,908	2%	$228,622	-2%	$242,427	4%	$231,187	-1%	$237,294	2%	$237,348	2%
Final Average % Wealth Reduction	-8.1%	-3.9%	-52%	-5.6%	-31%	-10.4%	28%	-3.5%	-57%	-9.5%	16%	-6.3%	-23%	-6.3%	-23%

Hypothetical "Average Health" Respondent Age 50	**Baseline** *With Medical Trend*	*Demand Adjustment of 6%*		*Demand Adjustment of 2%*		*50% of HDHP Deductible Funded*		*100% of OOP Maximum Funded*		*Catch-up Contributions Allowed*		*Deduct only up to 50% HSA Balance*		*Deduct only up to 75% HSA Balance*	
Attained Age	Age 50	Age 50		Age 50		Age 50		Age 50		Age 50		Age 50		Age 50	
Count of respondents	1	1		1		1		1		1		1		1	
Forecast Periods to Age 65	8	8		8		8		8		8		8		8	
Number of actual years in forecast	16	16		16		16		16		16		16		16	
Final Average Accumulated HSA Account	$654	$685	5%	$608	-7%	$42	-94%	$89,215	13541%	$6,562	903%	$3,603	451%	$1,573	140%
Potential Average Accumulated HSA Value	$25,446	$25,446	0%	$25,446	0%	$12,723	-50%	$127,231	400%	$40,714	60%	$25,446	0%	$25,446	0%
Average % of HSA Contributions Remaining	2.6%	2.7%	5%	2.4%	-7%	0.3%	-87%	70.1%	2628%	16.1%	527%	14.2%	451%	6.2%	140%
25th Percentile of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		64.8%		2.0%		10.1%		3.0%	
Median of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		71.0%		12.2%		12.0%		3.7%	
75th Percentile of % HSA Contribs Remaining	2.8%	3.0%		2.4%		0.0%		76.4%		27.3%		15.9%		7.0%	
Percentage with over 50% of HSA Contribs	0.0%	0.1%		0.0%		0.0%		98.2%		2.3%		0.2%		0.1%	
Percentage with less than 20% of HSA Contribs	97.3%	97.4%		97.7%		99.9%		0.0%		63.5%		87.2%		96.4%	
Average Annual HSA Contribution	$1,000	$1,000	0%	$1,000	0%	$500	-50%	$5,000	400%	$1,600	60%	$1,000	0%	$1,000	0%
Average Annual Claim	$6,580	$6,324	-4%	$6,470	-2%	$6,382	-3%	$6,370	-3%	$6,311	-4%	$6,283	-5%	$6,463	-2%
Average Accumulated Claims (all years)	$133,197	$128,478	-4%	$130,957	-2%	$129,270	-3%	$129,216	-3%	$128,148	-4%	$127,786	-4%	$131,040	-2%
Accumulated Average Out-of-Pocket (OOP)	$38,024	$37,605	-1%	$38,174	0%	$37,773	-1%	$38,017	0%	$37,787	-1%	$37,761	-1%	$37,957	0%
Accumulated Amounts Paid by Insurance	$95,172	$90,873	-5%	$92,784	-3%	$91,498	-4%	$91,200	-4%	$90,361	-5%	$90,025	-5%	$93,083	-2%
Final Average Insurance Plan Value	71.5%	70.7%	-1%	70.9%	-1%	70.8%	-1%	70.6%	-1%	70.5%	-1%	70.4%	-1%	71.0%	-1%
Accumulated Average Paid from HSA	$24,792	$24,761	0%	$24,839	0%	$12,681	-49%	$38,017	53%	$34,152	38%	$21,843	-12%	$23,874	-4%
% of OOP Paid from HSA Withdrawals	65.2%	65.8%	1%	65.1%	0%	33.6%	-49%	100.0%	53%	90.4%	39%	57.8%	-11%	62.9%	-4%
Average Household Income	$80,156	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%
Average Intitial Household Wealth Level	$249,982	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%
Accumulated Average Wealth Reduction	($20,357)	($19,761)	-3%	($20,515)	1%	($34,504)	69%	$0	-100%	($5,593)	-73%	($20,391)	0%	($20,926)	3%
Final Average Accumulated Wealth	$233,685	$234,209	0%	$233,518	0%	$220,635	-6%	$249,982	7%	$245,445	5%	$231,568	-1%	$232,934	0%
Final Average % Wealth Reduction	-8.1%	-7.9%	-3%	-8.2%	1%	-13.8%	69%	0.0%	-100%	-2.2%	-73%	-8.2%	0%	-8.4%	3%

Exhibit 5: Simulation Results for "Unhealthy Respondent": Sensitivity Tests to Changes in Assumptions

HSA Account Performance: Average Respondent Simulated 10,000 Times, with Sensitivity to Assumption Changes

Hypothetical "Unhealthy" Respondent Age 50	**Baseline** *With Medical Trend*	*No Medical Trend*		*Low Trend at 5% annually*		*High Trend at 15% annually*		*No Initial Claims*		*HSA Interest Credited at 0%*		*HSA Interest Credited at 10%*		*No Biennial Insurance Value Adjustment*	
Attained Age	Age 50	Age 50		Age 50		Age 50		Age 50		Age 50		Age 50		Age 50	
Count of respondents	1	1		1		1		1		1		1		1	
Forecast Periods to Age 65	8	8		8		8		8		8		8		8	
Number of actual years in forecast	16	16		16		16		16		16		16		16	
Final Average Accumulated HSA Account	$88	$454	418%	$195	122%	$30	-66%	$323	268%	$57	-35%	$154	76%	$95	9%
Potential Average Accumulated HSA Value	$25,446	$25,446	0%	$25,446	0%	$25,446	0%	$25,446	0%	$16,000	-37%	$41,428	63%	$25,446	0%
Average % of HSA Contributions Remaining	0.3%	1.8%	418%	0.8%	122%	0.1%	-66%	1.3%	268%	0.4%	3%	0.4%	8%	0.4%	9%
25th Percentile of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	
Median of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	
75th Percentile of % HSA Contribs Remaining	0.0%	1.2%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	
Percentage with over 50% of HSA Contribs	0.0%	0.1%		0.0%		0.0%		0.2%		0.0%		0.0%		0.0%	
Percentage with less than 20% of HSA Contribs	99.9%	99.3%		99.8%		99.9%		97.9%		99.9%		99.9%		99.9%	
Average Annual HSA Contribution	$1,000	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%	$1,000	0%
Average Annual Claim	$21,330	$10,669	-50%	$14,884	-30%	$30,841	45%	$18,972	-11%	$20,997	-2%	$20,866	-2%	$21,554	1%
Average Accumulated Claims (all years)	$431,875	$228,508	-47%	$309,178	-28%	$600,525	39%	$367,880	-15%	$424,692	-2%	$422,544	-2%	$435,829	1%
Accumulated Average Out-of-Pocket (OOP)	$59,998	$49,550	-17%	$54,617	-9%	$63,898	7%	$45,168	-25%	$59,808	0%	$59,688	-1%	$54,962	-8%
Accumulated Amounts Paid by Insurance	$371,877	$178,957	-52%	$254,561	-32%	$536,628	44%	$322,712	-13%	$364,883	-2%	$362,856	-2%	$380,867	2%
Final Average Insurance Plan Value	86.1%	78.3%	-9%	82.3%	-4%	89.4%	4%	87.7%	2%	85.9%	0%	85.9%	0%	87.4%	1%
Accumulated Average Paid from HSA	$25,359	$24,992	-1%	$25,252	0%	$25,417	0%	$25,124	-1%	$15,943	-37%	$41,273	63%	$25,351	0%
% of OOP Paid from HSA Withdrawals	42.3%	50.4%	19%	46.2%	9%	39.8%	-6%	55.6%	32%	26.7%	-37%	69.1%	64%	46.1%	9%
Average Household Income	$80,156	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%
Average Intitial Household Wealth Level	$249,982	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%
Accumulated Average Wealth Reduction	($49,677)	($34,168)	-31%	($41,563)	-16%	($55,588)	12%	($30,838)	-38%	($51,828)	4%	($46,586)	-6%	($43,149)	-13%
Final Average Accumulated Wealth	$209,190	$222,000	6%	$215,767	3%	$203,972	-2%	$224,018	7%	$206,785	-1%	$212,282	1%	$214,807	3%
Final Average % Wealth Reduction	-19.9%	-13.7%	-31%	-16.6%	-16%	-22.2%	12%	-12.3%	-38%	-20.7%	4%	-18.6%	-6%	-17.3%	-13%

Hypothetical "Unhealthy" Respondent Age 50	**Baseline** *With Medical Trend*	*Demand Adjustment of 6%*		*Demand Adjustment of 2%*		*50% of HDHP Deductible Funded*		*100% of OOP Maximum Funded*		*Catch-up Contributions Allowed*		*Deduct only up to 50% HSA Balance*		*Deduct only up to 75% HSA Balance*	
Attained Age	Age 50	Age 50		Age 50		Age 50		Age 50		Age 50		Age 50		Age 50	
Count of respondents	1	1		1		1		1		1		1		1	
Forecast Periods to Age 65	8	8		8		8		8		8		8		8	
Number of actual years in forecast	16	16		16		16		16		16		16		16	
Final Average Accumulated HSA Account	$88	$95	8%	$91	4%	$10	-88%	$67,359	76825%	$698	697%	$2,691	2974%	$909	938%
Potential Average Accumulated HSA Value	$25,446	$25,446	0%	$25,446	0%	$12,723	-50%	$127,231	400%	$40,714	60%	$25,446	0%	$25,446	0%
Average % of HSA Contributions Remaining	0.3%	0.4%	8%	0.4%	4%	0.1%	-77%	52.9%	15285%	1.7%	398%	10.6%	2974%	3.6%	938%
25th Percentile of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		46.1%		0.0%		9.6%		3.0%	
Median of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		53.0%		0.0%		9.7%		3.0%	
75th Percentile of % HSA Contribs Remaining	0.0%	0.0%		0.0%		0.0%		59.6%		0.8%		10.6%		3.2%	
Percentage with over 50% of HSA Contribs	0.0%	0.0%		0.0%		0.0%		61.6%		0.0%		0.0%		0.0%	
Percentage with less than 20% of HSA Contribs	99.9%	99.9%		99.9%		100.0%		0.0%		98.9%		99.2%		99.9%	
Average Annual HSA Contribution	$1,000	$1,000	0%	$1,000	0%	$500	-50%	$5,000	400%	$1,600	60%	$1,000	0%	$1,000	0%
Average Annual Claim	$21,330	$20,813	-2%	$22,103	4%	$21,346	0%	$21,211	-1%	$21,295	0%	$21,407	0%	$21,382	0%
Average Accumulated Claims (all years)	$431,875	$420,392	-3%	$446,073	3%	$430,522	0%	$428,644	-1%	$429,843	0%	$433,073	0%	$432,072	0%
Accumulated Average Out-of-Pocket (OOP)	$59,998	$59,518	-1%	$60,511	1%	$59,729	0%	$59,872	0%	$59,769	0%	$59,915	0%	$59,745	0%
Accumulated Amounts Paid by Insurance	$371,877	$360,875	-3%	$385,562	4%	$370,793	0%	$368,772	-1%	$370,074	0%	$373,159	0%	$372,327	0%
Final Average Insurance Plan Value	86.1%	85.8%	0%	86.4%	0%	86.1%	0%	86.0%	0%	86.1%	0%	86.2%	0%	86.2%	0%
Accumulated Average Paid from HSA	$25,359	$25,351	0%	$25,355	0%	$12,713	-50%	$59,872	136%	$40,016	58%	$22,755	-10%	$24,537	-3%
% of OOP Paid from HSA Withdrawals	42.3%	42.6%	1%	41.9%	-1%	21.3%	-50%	100.0%	137%	67.0%	58%	38.0%	-10%	41.1%	-3%
Average Household Income	$80,156	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%	$80,156	0%
Average Intitial Household Wealth Level	$249,982	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%	$249,982	0%
Accumulated Average Wealth Reduction	($49,677)	($48,950)	-1%	($50,472)	2%	($62,002)	25%	$0	-100%	($30,388)	-39%	($46,839)	-6%	($47,194)	-5%
Final Average Accumulated Wealth	$209,190	$209,674	0%	$208,563	0%	$195,868	-6%	$249,982	19%	$225,771	8%	$207,543	-1%	$209,032	0%
Final Average % Wealth Reduction	-19.9%	-19.6%	-1%	-20.2%	2%	-24.8%	25%	0.0%	-100%	-12.2%	-39%	-18.7%	-6%	-18.9%	-5%