



Claims Prediction Model and the Simulation of Health Savings Account Performance

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Vincent Kane, FSA, MAAA

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Promoting Fair and Efficient Health Care

Outline

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Health Savings Account (HSA) Background

- HSAs are individual health care financing vehicles legislated into existence by the 2003 MMA
 - A product of “consumerism”, which attempts to engage consumers in their health care choices, mitigate moral hazard and expose consumers to the true cost of health care
 - HSAs are increasingly under scrutiny because of their novelty and because President Bush has set out an agenda to expand HSA enrollment and eligibility through further tax subsidies and changes to contribution limits
 - Available public data for empirical research has been very sparse to date.

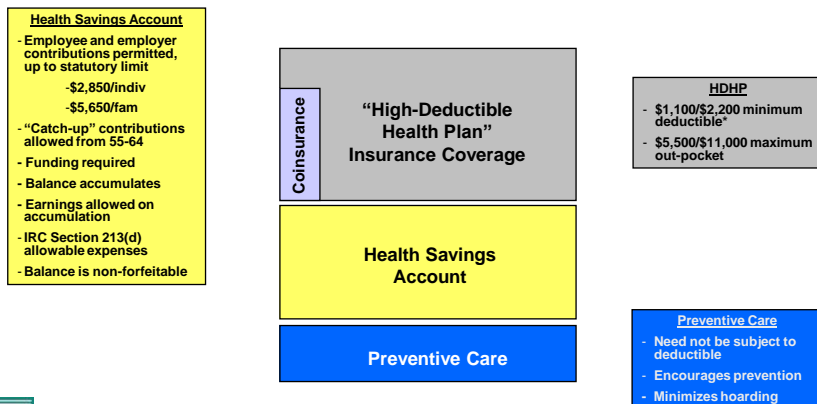


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What does an HSA look like? *Design*

- For 2007, the HSA contributions used to fund the “donut hole” are limited by the lesser of \$2,850 (indexed) or the HDHP deductible
 - Amounts not used in current year roll over to the next



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Empirical Research to Date

- What is the nature of employees who have enrolled in these plans?
- Do HSAs really produce medical costs savings through increased cost-sharing and reduced utilization?
- Will adverse selection cause a death spiral of traditional HMO/PPO plan costs, leading to increased overall costs?
- Will HSAs increase or reduce the number of uninsured? Will they lead to a halt or reversal of the downward trend in employer insurance offers?
- What will be the fiscal impact of tax credits/subsidies to expand coverage, eligibility and maximum contributions to HSAs?



Objectives of this Project

My Research Focus:

- The focus of this project will be to evaluate whether HSAs allow for “adequate” account build-up to finance future medical costs for a specific subset of the US population (50-65 year olds)
 - Do these plans allow for accumulation of HSA account balances that will meaningfully finance future health care needs, even into retirement?
- How is HSA performance impacted by the self-reported health status or the number of chronic medical conditions?
 - What is the distribution of HSA performance measures?
 - What percentage of potential accumulated HSA contributions are left at age 65?



Objectives of this Project

Why do we care about the 50-65 year old population cohort?

- According to the 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 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% of HRS survey respondents had history of unstable coverage since age 50



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Objectives of this Project

This project comprises two major components:

- Model of inference from which interpretations may be made regarding the impact of past expenditures, insurance coverage, health status, lifestyle variables, income, and demographic factors on *current period expenditure levels*
 - Will provide estimates of the elasticity of expected expenditures with respect to insurance due to demand and moral hazard effects
 - Will help identify valuable predictors for claims forecast model
- Model of forecasting claims with which to simulate Health Savings Account performance for the cohort of pseudo Baby Boomers



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Data

- Used survey data from the University of Michigan Health & Retirement Survey (HRS), cleansed and made available by RAND
- As of 2005, included several cohorts of respondents interviewed longitudinally from 1992 to 2002
 - Extracted pseudo-Baby Boomers from the “HRS Cohort” born 1931 through 1941, and “War Baby Cohort” born 1942 through 1947
 - Captured respondents and spouses in the age range 50 – 65 years old at three points in time: 1998, 2000 and 2002.
 - Only included persons who responded to all three interview waves
 - There are no deceased persons in the sampled data, so predicted claims are biased downward
 - Eliminated any person covered by Medicare, Medicaid or Champus (VA) for each of the three waves
 - Ideally, the population should reflect those who would be eligible for HSA coverage in an individual or employer setting



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Data

- Final data set is quite heterogeneous and representative of the general US population for this age cohort that might enroll in an HSA
 - Respondents and spouses included are
 - employed or unemployed,
 - with or without medical insurance,
 - working or not working,
 - single or married,
 - rich or poor,
 - with or without higher education,
 - geographically dispersed,
 - with a wide range of health status,
 - etc
 - Final sample is a little over 5,000 respondents and spouses



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Data

- **Dependent variable** is “Total medical expenditures” (“Claims”) reported for the respondent and spouse separately (e.g., for 2001-2002)
 - Includes out-of-pocket costs and amounts ultimately covered by insurance (don’t have to plan-design-adjust the gross claims)
 - As the waves were 2 years apart, the “Claims” values are for a two-year look-back period (two years of costs for each respondent are combined)
 - Some claim values were imputed



Data

- The set of **independent variables** available for analysis is extremely rich and includes levels of micro-data possibly not available to group insurers (though perhaps available to individual insurers):
 - Demographic: Age, Gender, Marital Status, Race
 - Geographic Region: (Northeast, South, Midwest, West)
 - Health Status: Self-reported and coded as (Excellent, Good, Poor)
 - ADLs: Self-reported and coded as (No ADLs, One ADL, 2+ ADLs)
 - Back Problems
 - Chronic Conditions: Count of those ever diagnosed by a doctor, including: high blood pressure, diabetes, cancer, lung disease, heart problems, stroke, psych problems and arthritis
 - Educational Level, Household Income, Employment Status
 - Prior Wave Expenditures (for period 1997-1998 at 1st wave, and period 1999-2000 for 2nd wave)
 - Behavioral/Lifestyle: Smoking, Drinking, Frequent Exercise
 - Presence and Type of Health Insurance (None, Individ., Employer, Govt)
 - Utilization Variables (Office Visit, Rx use, OP Surgery, Hospital Stay)



Model of Inference: Part 1 Probit for probability of a claim

- Set up 3rd wave claims (2001- 2002) as a latent variable Y^* , such that $Y^* = X\beta + \varepsilon$, where X is set of predictors (excluding utilization)
- Assuming ε is distributed as $N(0, \sigma^2)$, define indicator variable for Y^* :

$$Y_i = 1 \text{ if } \beta'x_i + \varepsilon_i > 0$$

$$0 \text{ if } \beta'x_i + \varepsilon_i < 0$$
- Then the probability of having a claims is modeled as:

$$\text{Prob}(Y_i = 1 | x_i) = \Phi(\beta'x_i)$$
where Φ is the Normal(0,1) CDF
- Under this setup, marginal effects for predictor x_k are calculated as:

$$\delta/\delta x_k[\Phi(\beta'x_i)] = \phi(\beta'x_i) * \beta_k$$
- For categorical variables, marginal effects are:

$$\Phi(\beta'x_i | x_k=1) - \Phi(\beta'x_i | x_k=0)$$
- I have computed marginal effects calculations two ways:
 - Using the “average” $X\beta$ in these formulae
 - Averaging the function over all individual levels of $\beta'x_i$



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Model of Inference: Part 1 Probit for probability of a claim

Variable	Probit Part 1			Difference in	Linear Probability Model	
	Marginal Effect Average of all	Marginal Effect Using the Avg.	P-Value		Coef. Est	P-Value
Intercept	N/A	N/A	0.5948	N/A	0.8638	<.0001
Exercises 3X+ Weekly	0.0024	0.0010	0.5903	0.0014	0.0019	0.6953
Ever drinks Alcohol	0.0091	0.0037	0.0526	0.0053	0.0103	0.0375
Number of Conditions	0.0189	0.0076	<.0001	0.0113	0.0149	<.0001
Currently Working for \$	-0.0043	-0.0017	0.3750	-0.0026	-0.0044	0.3947
50-55 versus 56-60	0.0019	0.0008	0.8511	0.0012	0.0027	0.7841
61-65 versus 56-60	0.0081	0.0033	0.2451	0.0048	0.0084	0.1993
Lives in Northeast vs. South	0.0000	0.0000	0.9996	0.0000	0.0004	0.9505
Lives in Midwest vs. South	0.0085	0.0033	0.1317	0.0052	0.0049	0.4037
Lives in West vs. South	-0.0011	-0.0005	0.8558	-0.0007	-0.0011	0.8721
Some College or Above	0.0123	0.0051	0.0148	0.0072	0.0127	0.0135
Is Married or Partnered	0.0020	0.0008	0.7146	0.0012	0.0018	0.7747
Health Status (Fair/Poor) vs. Excellent	-0.0022	-0.0009	0.7603	-0.0013	0.0036	0.6540
Health Status Good vs. Excellent	0.0038	0.0015	0.4659	0.0023	0.0036	0.5175
No Claims two waves prior	0.0069	0.0026	0.6314	0.0043	-0.1357	<.0001
No Claims one wave prior	-0.0727	-0.0453	0.0070	-0.0275	-0.2586	<.0001
Log Claims two waves prior	0.0061	0.0025	0.0021	0.0037	0.0034	0.0691
Log Claims one wave prior	0.0009	0.0003	0.6524	0.0005	-0.0015	0.4302
Is Male	-0.0141	-0.0060	0.0535	-0.0081	-0.0148	0.0569
Is Non-White	-0.0022	-0.0009	0.6987	-0.0013	-0.0030	0.6408
1 ADL problem versus None	0.0081	0.0030	0.5360	0.0051	0.0041	0.7265
2+ ADL problems versus None	0.0103	0.0037	0.5231	0.0066	0.0079	0.5962
Has back problems	-0.0011	-0.0005	0.8350	-0.0007	0.0033	0.5389
HH Income \$30-60K vs \$0-30K	0.0113	0.0043	0.0363	0.0069	0.0126	0.0572
HH Income \$60-100K vs \$0-30K	0.0076	0.0029	0.2389	0.0047	0.0080	0.2961
HH Income Over \$100K vs \$0-30K	0.0261	0.0096	0.0004	0.0165	0.0232	0.0055
Has Govt. Insurance vs. No Insurance	0.0222	0.0067	0.0071	0.0155	0.0615	<.0001
Has Indiv. Insurance vs. No Insurance	0.0183	0.0060	0.0036	0.0124	0.0503	<.0001
Has Employer Insurance vs. No Insurance	0.0538	0.0303	<.0001	0.0235	0.0705	<.0001
50-55 and Male, versus 56-60 and Male	-0.0041	-0.0017	0.7941	-0.0024	0.0030	0.8499
61-65 and Male, versus 56-60 and Male	-0.0112	-0.0049	0.2649	-0.0063	-0.0073	0.4651
Ever Smokes in Life	-0.0054	-0.0022	0.2386	-0.0032	-0.0051	0.2887



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Model of Inference: Part 2 GLM with Exponential Conditional Mean

- Conditional on positive reported claims for 2001-2002, estimated a Generalized Linear Model (GLM) for medical claims regressed on the same set of predictor variables:
- Under the Exponential Conditional Mean (ECM) specification, Part 2 expected claims may be estimated directly on the dollar scale, without retransformation, as:
$$E[Y_i^* | x_i, Y_i^* > 0] = \exp(\delta'x_i)$$
- The log-link is assumed and the exponential form may be modeled according to a variety of distributions (Normal, Poisson, Gamma, Inverse Gaussian).
- As shown by Mullahy (1998) in simulation, this procedure is more robust for interpretation of marginal effects and estimation of expected claims relative to the homoskedastic smearing factor approach, especially in the presence of heteroskedasticity



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Model of Inference: Part 2 GLM with Exponential Conditional Mean

- The ECM distributional specification that best approximates the large variance associated with the mean claim of \$12,860 is the Inverse Gaussian, which was used to estimate the Part 2 marginal effects.
 - Magnitude and significance of parameter estimates are fairly consistent across the Poisson, Gamma and Inverse Gaussian specifications
- Under the assumption of homoskedasticity, marginal effects are calculated as:
$$\begin{aligned} \delta/\delta x_k [E[Y_i^* | x_i, Y_i^* > 0]] \\ &= \exp(\delta'x_i) * \delta_k && \text{(for continuous vars)} \\ &= [\exp(\delta'x_i) \text{ at } x_k=1] - [\exp(\delta'x_i) \text{ at } x_k=0] && \text{(for categorical vars)} \end{aligned}$$
- The marginal effect can be calculated using either the average $X\delta$ or by averaging the functions over all individual levels of $\delta'x_i$



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Model of Inference: Part 2 GLM with Exponential Conditional Mean

Variable	Exponential Conditional Mean Model Part 2: Inverse Gaussian			Difference in Marg. Eff
	E(Y _i X _i) Average of all	E(Y _i X _i) Using the Avg.	P-Value	
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



Interpreting Total Effects with ECM Approach

- Combining the Part 1 Probit model and preferred Part 2 ECM conditional expected claim model, we can estimate the unconditional claims (in dollars) as:

$$E[Y_i^*|X] = \text{Prob}(Y_i = 1 | x_i) * E[Y_i^* | x_i, Y_i^* > 0]$$

$$= \Phi(\beta'x_i) * \exp(\delta'x_i)$$

- The total marginal effect of any predictor on unconditional claims is:

$$\delta / \delta x_k [E[Y_i^*|X]] = (\delta / \delta x_k [\Phi(\beta'x_i)]) * \exp(\delta'x_i) + (\delta / \delta x_k [\exp(\delta'x_i)]) * \Phi(\beta'x_i)$$

$$= (\text{Part 1 Marg.Eff. } x_k) * E[Y_i^* | x_i, Y_i^* > 0] + (\text{Part 2 Marg.Eff. } x_k) * \text{Prob}(Y_i = 1 | x_i)$$

- Again, the total marginal effect can be calculated using either the average $X\beta$ and $X\delta$ or by averaging the functions over all individual levels of $\beta'x_i$ and $\delta'x_i$



Interpreting Total Effects with ECM Approach

2001-2002 Claims \$12,423

Variable	Total Effects		P-Val Part 1		P-Val Part 2		Effect on Mean		% Effect from Mean	
	Average of all	Using the Avg.			Average of all	Using the Avg.	Average of all	Using the Avg.		
Intercept	N/A	N/A	0.5948	<.0001			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	\$1,953	0.0148	0.0351	\$14,854	\$14,076	18.6%	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%		



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Claims Prediction Model & Simulation

Forecasting Total Medical Expenditures

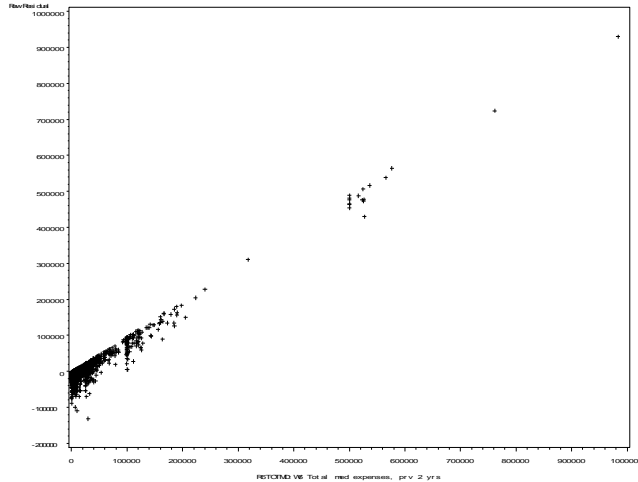
- First, before simulating claim streams for those in the 50-65 year old age cohort, we must decide on a claim prediction model.
 - The ECM Inverse Gaussian model was chosen for Part 2 inference
 - However, when evaluating the different Part 2 specifications for pure predictive power, the least root mean square prediction error was achieved by the Poisson ECM model:
 - ECM Poisson < ECM Gamma < ECM IG
 - Thus for this data set, I have chosen the ECM Poisson to generate the claim streams for HSA simulation
 - Even this specification which minimizes prediction error still systematically over-predicts low actual claims and under-predicts high outlier claims, but this is expected



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Forecasting Total Medical Expenditures

- Dollar-scale Residuals versus Actual Values for Part II ECM Poisson Model



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Forecasting Total Medical Expenditures for Simulation

- To reflect random claim shocks over the forecast period, I modified the Part 2 Poisson ECM model to sample the log-scale residuals from the baseline prediction model, conditional on the range of the predicted value $E[Y_i^* | x_i, Y_i^* > 0] = \exp(\delta'x_i)$.
 - I first predict $\exp(\delta'x_i)$ for 2001-2002 based on the set of independent variables (including lagged claims from 1997-2000). This is baseline.
 - Based on the range of the predicted value and the corresponding distribution of log-scale residuals conditional on that range, I sample a shock residual from an ordering of the log-scale residuals, using a Uniform(0,1) random draw.
 - The sampled shock residual is added to $\delta'x_i$ and the expression is exponentiated back to the dollar scale.
 - While there is still over-prediction/under-prediction using this approach, the median of the predicted claims for 2001-2002 was stabilized at a value closer to the actual claims median of \$4,300.



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Forecasting Total Medical Expenditures for Simulation

- For the claims simulation, Part 1 Probit is used to determine if the individual will have a non-zero claim for the policy period
 - The estimated model is used to calculate the probability of having a claim
 - A random draw from Uniform(0,1) determines if the claim is realized
- Total claims are estimated as the Part 2 claim amount unless zeroed out by the Part 1 Probit hurdle component.
- To reflect the decreased utilization expected under a High Deductible Health Plan, I adjusted all forecasted claim amounts downward by 4% due to an assumed 10% reduction in insurer plan value.
 - Society of Actuaries claim databases for 50-65 year olds were used to compare plan values for a “standard” \$150 deductible, 90% coinsurance, \$5,000 OOP max plan with a HDHP with a \$1,000 deductible, 80% coinsurance and \$5000 OOP max.
 - A 40% elasticity of expenditures was assumed based on the total marginal effects associated with employer insurance coverage.



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HSA Simulation & Account Performance

- I ran the forecasted medical claims through a High Deductible Health Plan with companion Health Savings Account to calculate the final HSA account value at age 65.
- Several types of simulations were conducted:
 - 1) “Total Population”, 2) “Average Respondent”, 3) “Hypothetical Respondent”
- Assumptions (additional sensitivity tests were performed):
 - Ignored retirement rates and mortality over short duration, although these could be modeled
 - HDHP has \$1000 deductible, 20% member coinsurance, \$5000 OOP max
 - 5% HSA Interest credited on amounts rolled over to next policy period
 - Medical trend of 10.9/12.9%, 13.0/11.2%, 9.2/9.2%, 8/8%, 7/7% and 6/6% for periods 2001/2002, 2003/2004, 2005/2006, 2007/2008, etc.
 - Salary increases of 3%, discount rate of 5% for accumulating claims
 - 9% reduction in insurer claim payment due to use of biennial periods
 - OOP costs in excess of the HSA balance are paid from initial wealth with a 35% tax adjustment to OOP costs to reflect after-tax spending.



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HSA Simulation & Account Performance

- For each claim forecast generated in simulation (10,000 of them in the case of “hypothetical” and “average” 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 Initial Household Wealth Level
Accumulated Average Wealth Reduction
Final Average Accumulated Wealth
Final Average % Wealth Reduction



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HSA Simulation Results

- Simulation based on “**Total Population**”
 - 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.



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HSA Simulation Results

- Total Population Results by attained age at simulation, with 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	\$946
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 Initial 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%



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HSA Simulation Results

- Total Population Results by decile and attained age at simulation

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	\$5,216	\$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%



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HSA Simulation Results

- Simulation Results for Age 50-51, by Number of Chronic Conditions

Number of Chronic Conditions:	Age 50-51 Year Olds						
	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 Initial 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%	-36.8%	-135.6%	-10.2%

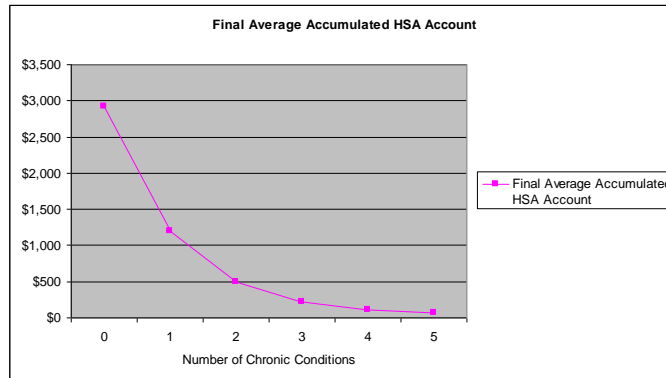


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HSA Simulation Results

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



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HSA Simulation Results

- Simulation based on the “Average Respondent”
 - I have simulated the HSA account 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.
 - Greater statistical precision than “total population” simulation
 - 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 account performance is to changes in health status, lifestyle behaviors or other indicator variables
 - 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.
 - Sensitivity tests were simulated to show the impact to the baseline scenario for the “average respondent”



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HSA Simulation Results

- “Average Respondent”

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

Average Respondent	Baseline With Medical Trend	No Biennial Insurance Value						
		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%	Adjustment
		Age 56	Age 56	Age 56	Age 56	Age 56	Age 56	Age 56
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	\$1,103	\$840	\$472	\$4,387	\$388	\$856	
Potential Average Accumulated HSA Value	\$13,529	\$13,529	\$13,529	\$13,529	\$10,000	\$18,366	\$13,529	
Average % of HSA Contributions Remaining	4.2%	8.2%	6.2%	3.5%	32.4%	3.9%	4.7%	
25th Percentile of % HSA Contrihs Remaining	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Median of % HSA Contrihs Remaining	0.0%	3.1%	0.0%	0.0%	30.4%	0.0%	0.0%	
75th Percentile of % HSA Contrihs Remaining	6.6%	13.7%	11.0%	4.3%	56.0%	4.7%	7.6%	
Percentage with over 50% of HSA Contrihs	0.1%	0.1%	0.1%	0.1%	30.5%	0.1%	0.0%	
Percentage with less than 20% of HSA Contrihs	94.6%	85.5%	90.0%	95.7%	41.7%	94.3%	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	\$4,264	\$4,846	\$6,458	\$3,702	\$5,969	\$5,853	
Average Accumulated Claims (all years)	\$68,469	\$51,215	\$57,422	\$74,364	\$39,663	\$69,315	\$68,144	
Accumulated Average Out-of-Pocket (OOP)	\$22,206	\$19,613	\$20,740	\$22,773	\$10,664	\$22,216	\$22,094	
Accumulated Amounts Paid by Insurance	\$46,262	\$31,602	\$36,682	\$51,591	\$28,999	\$47,099	\$46,049	
Final Average Insurance Plan Value	67.6%	61.7%	63.9%	69.4%	73.1%	67.9%	67.6%	
Accumulated Average Paid from HSA	\$12,957	\$12,426	\$12,689	\$13,057	\$9,142	\$9,812	\$17,510	
% of OOP Paid from HSA Withdrawals	58.3%	63.4%	61.2%	57.3%	85.7%	43.3%	79.3%	
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)	(\$5,844)	(\$8,174)	(\$10,736)	(\$2,342)	(\$10,864)	(\$9,025)	
Final Average Accumulated Wealth	\$270,095	\$273,074	\$271,823	\$269,413	\$279,907	\$268,660	\$271,716	
Final Average % Wealth Reduction	-3.6%	-2.4%	-2.9%	-3.8%	-0.8%	-3.9%	-3.2%	



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HSA Simulation Results

• “Average Respondent”

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



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HSA Simulation Results

- Simulation based on “Hypothetical Respondents”
- Three hypothetical enrollees were constructed based on varying health status measures. Each enrollee was run 10,000 times through the Health Savings Account module.
 - “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, 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.



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HSA Simulation Results

- “Hypothetical Respondent”

HSA Account Performance: Hypothetical Respondent Simulated 10,000 Times

Hypothetical Respondents at Age 50

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



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Discussion & Conclusions

- Funding the HSA vehicle at a higher level in earlier duration years reduces the probability of ruin due to the presence of HSA “reserves” that fund out-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.
 - A larger data set might 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.
 - Also need to consider expected utility framework for savings versus tax advantaged consumption



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Discussion & Conclusions

- The simulation results clearly show disappointing HSA performance over the years leading up to age 65
- All three types of simulation generate 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 Medicare premiums and out-of-pocket expenses (with costs escalating 7% annually).
 - **Baby-boomers better rely on additional sources of health care financing!**



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Discussion & Conclusions

- This project also demonstrates the somewhat obvious fact that sick people pay more and save less under such a plan
- Attempts to attract the chronically ill to CDHPs and HSAs often focus on the informational tools to help members manage their conditions
 - Given that such members represent the greatest share of claim expense, it is extremely valuable to engage them directly through disease management programs integrated into the CDHP/HSA plan of benefits.
 - A well-designed employer plan might financially reward engaged members by adding contributions to the HSA upon completion of health risk appraisals or submitting to case management of their conditions.
 - Risk adjustment of HSA contributions is also an important option
- 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.



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Questions?

Feel free to contact me at:

Vincent Kane, FSA, MAAA

Research Scientist

DxCG – A Division of Urix, Inc.

99 Summer Street, Suite 520

Boston, MA 02110

Phone: 617.896.5966 | Fax: 617.303.3797

vincent.kane@dxcg.com

www.dxcg.com

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