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Negative Discount Rates for Health Insurance

Abstract

This paper measures the discount rate of health insurance by surveying a sample of nearly 1,000 Washington and Lee alumni. We calculated the discount rate from a series of open-ended survey questions, eliminating some of the bias introduced in past studies that presented respondents with a series of pre-calculated options. Results showed that a large majority (81%) of individuals had negative discount rates for health insurance, meaning they prefer insurance in the future as opposed to the present. The study also indicates that people with negative discount rates behave differently with respect to time horizon than people with positive discount rates. These results suggest that a demand-side policy approach to increasing the number of people insured will be relatively ineffective.

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I. Introduction

In 2002, U.S. expenditures on health care came to $1.42 trillion, an amount that is larger than France's economy (Wessel, 2003). As costs continue to rise by 15% per year (*New York Times*, 10/15/02), issues relating to health coverage are emerging as a top priority for policymakers. Although Mocan et. al. (2000) showed that demand for health care is positively correlated with wealth, the U.S. still finds that 5% of the non-elderly with incomes over $50,000 lack health insurance (Chernew, et al). In addition, employer contributions do not appear to have a large impact on employee decisions to purchase insurance. A large increase in employer contribution would only produce a small decrease in the number of people uninsured (Chernew, et al). Some policymakers would like to know what types of government policy could increase number of people insured without sacrificing the benefits of a privatized system. Most debates revolve around a supply side approach to this problem. This paper, however, answers questions for those who take a demand side approach: how can government help to increase demand for health insurance? Since demand for health insurance involves present utility for current consumption, the discount rate[1] of health insurance will be one key factor in answering questions regarding demand-side policy.

This project contributes several novelties to the field. Although current literature measures the discount rate of health status, quality adjusted life years, and lives saved, none of the literature to date has directly measured the discount rate of health *insurance*. This study will be the first to fill this gap. In addition, most studies on discounting health have used small sample sizes (less than 150) consisting primarily of students, a very nonrandom sample (See Chart A). Through a web based survey of Washington and Lee alumni, however, I was able to collect nearly 1000 data points. This large sample size allows for analysis that has not been possible in past studies. For instance, only a small handful of studies have studied the effect of demographic characteristics on discount rate. The large sample size allows for analysis of more detailed demographic characteristics not considered in past research.

Many past studies have offered a series of pre-set choices to individuals, restricting precision of the measurement of discount rate, and opening up opportunity for biased expectations to effect results. My study derives the discount rate from a series of *open ended* answers. From these open-ended numerical answers, we wrote a program in Maple[2] to accurately estimate each respondent's unique discount rate. This not only increases precision but also eliminates boundaries for individual responses. Other experiments set up a set of choices based on what the experimenter believes to be "reasonable" answers. This introduces bias into the studies because it does not allow participants to respond in a way that is not predicted by the current models. By using open-ended questions, I avoid this problem, leaving room for unexpected results and anomalies, such as negative discount rates.

The Discounting Utility model involves a discount rate that is constant over time. However, a growing body of empirical evidence supports a hyperbolic discount rate, one that increases when looking at longer time horizons. The literature shows mixed results about the discount rate of health-related goods. Some studies indicate a higher than normal discount rate and others show negative discount rates. Neither theory nor

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[1] Some literature refers to this as the time preference rate.
[2] Maple is a piece of mathematical software used for solving complex equations.

empirical evidence has painted a clear picture of behavior regarding the discount rates of health insurance. Thus I ask:

1. Do people have negative discount rates for health insurance?
2. Do people exhibit behavior in accordance with the standard discounting model? If not, is the Hyperbolic Discounting Model a more appropriate predictor of behavior?
3. What demographic and personal factors affect the magnitude of the discount rate for health insurance?

II. Review of Literature and Theory

A. Question #1:

Do people have negative discount rates for health insurance?

1. Review of Literature

We can expect to observe some particular anomalies in discounting health insurance as opposed to money or other consumable goods. One problem with the literature on discounting health is that it shows two very different trends. On one hand, many studies find people who have negative discount rates. Someone with a negative discount rate would place a higher value on the future than on the present, for a given situation. On the other hand, many studies also observe a higher discount rate for health than for money. Theoretical models can support either claim. This may mean that the range of discount rates varies more widely because people have more difficulty in thinking about health in the future than they do in thinking about money. CHART A shows the range of discount rates measured by various studies.

CHART A

	Author(s)	Sample	Time range	Annual Discount Rate
1	Redelmeier and Heller (1993)	121 medical students, house officers and physicians	1 day to 10 yrs	0%
2	Chapman and Elstein (1995)	104 psychology undergraduates	6 mos. To 12 yrs.	11% to 263%
3	Chapman (1996)	148 psychology undergraduates	1 yr. To 12 yrs.	negative to 300%
4	Van der Pol and Cairns (1999)	163 members of the general public	5 yrs. To 13 yrs.	7%
5	Van der Pol and Cairns (2001)		2 yrs. To 15 yrs.	6% to 9%
6	Chapman, Nelson and Hier (1999)		1 mon. to 6 mos.	13% to 19000%
7	Ganiats et al. (2000)		6 mos. To 20 yrs.	negative to 116%
8	Cairns, (1992)	29 economics undergraduates	10 to 28 yrs.	
9	Dolan and Gudex (1995)	39 Members of general public	9 yrs.	
10	Olsen (1993)	250 membrs of general public and 77 health planners	4 to 19 yrs.	

The problem with many studies looking at health discount rates is that the discount rate depends heavily on the situation. Some researchers set up unlikely hypothetical scenarios or make great assumptions about key variables, such as risk, that will have a large effect on the discount rate. For example, one study (Cairns and Vanderpol 1999) asked people whether they would like to experience a cold starting tomorrow or delay the cold for two years. Not surprisingly, this study observed a high number of people with negative discount rates. This means people were placing a higher value on their (healthy) time in the future than their time today. People preferred to get the cold out of the way earlier. This situation, however does not translate well into the discounting of health insurance because it eliminates risk, a variable that will likely affect discounting. The whole idea behind insurance is that it is uncertain whether you will get sick, and if you do get sick, there are other risks involved such as prolonged illness or fatality. If subjects of this study thought there was a chance that the cold would kill you, they would most likely prefer to delay the cold; they would show positive discount rates.

One theory on negative discount rates for health says that people account for the disutility of dread in anticipating a negative event (Lowenstein, 1991). This might help explain the negative discount rate phenomenon. Psychological literature on durability bias shows that people tend to dread negative events in the future more than is necessary. For instance, Gilbert et. al. (1998) asked a group of young couples how they would feel 3 months after they had broken up, and compared this to how people reported feeling who had broken up in the past 3 months. Comparing the two groups, the couples looking forward at the hypothetical break up reported that they would significantly unhappier than those who actually experienced a break up.

The theory of dread applies in particular to health scenarios, such as Cairns and Vanderpol's study mentioned above, where an illness is inevitable. The problem with this theory is that to dread something, you must be fairly certain that it will occur. For health care, the uncertainty involved with developing an illness would be enough to flush out any dread. Most people don't go around dreading malaria because the chances of getting it are low. Indeed many of the studies that measure negative discount rates ask people to make choices between particular events under the assumption that the event is certain given their choice. So despite their focus on discounting health, it would not be plausible to apply results from some of these studies to my study, which involves health *insurance*.

Of the seven studies that measured *some* individuals as having negative and zero discount rates, all observed at least 60% of people as having positive discount rates. In addition, Chapman (1996) conducted three experiments observing negative time preference rates for health when the time horizon was less than a year, but *not* when the time horizon was greater than one year. This indicates that long run, and indeed life-cycle, considerations may reduce the occurrence of negative and zero time preference rates.

Other empirical and theoretical evidence supports a higher discount rate for future health status. For instance, in much of Chapman's research, he observes discount rates of over 200% (see chart). The DU model assumes that well-being in all periods is independent (Frederick, Loewenstein, 2002). Clearly when it comes to health, a major health problem that occurs in one period may still have negative effects in the next period. For instance, someone who goes blind in period two will still be blind in period three. Some diseases are irreversible and others will have long-term effects. Bleichrodt and Quiggin (1999) found that the value people place on additional years of life depends on health *and* quality of those years in terms of consumption. Since health care in the near future could affect well-being and consumption in the distant future, we might expect the discount rate for health status to be higher than for money. Barberan, Lazaro, and Rubio (2001) found that, in fact, students in their study had higher time-preference rates for health than for money. Also, Barberan, Lazaro, and Rubio (2002) compare the discount rate of money won in a lottery to the discount rate of a period of good health. In this case, even though risk has been eliminated through choices, subjects still showed higher discount rates for health than for money.

One problem with the empirical literature on discounting of health is that in most cases, subjects are discounting a negative – i.e. disease, death, etc. Again and again, literature has shown a phenomenon called loss aversion (Thaler, 1992), meaning subjects prefer to pay off debts quickly in order to avoid pending debts. The phenomenon involving negative discount in health may be explained in part due to loss aversion. In this study, however, subjects will be discounting a positive, health insurance, rather than a negative health outcome. This means that my study may bring about results that do not resemble those in past studies on health discounting.

Olsen (1993) argues that it may not be appropriate at all to apply a psychological discount rate to health status. For one, she says, health is not tradable in a market. The theory of an interest rate assumes that people's preferences for future versus present benefits can be exchanged so that everyone ends up at the maximum point of utility, given the exchanges. No such market can ever exist for health. The nature of health also prevents inter-temporal trade off, to a large degree. Without being able to transfer health either to other people in a market, or to future selves through some means of saving, a discount rate on health would be essentially meaningless, according to Olsen. My project avoids this problem by seeking the discount rate for health insurance, rather than health status. Health insurance is a tradable good, even if the market for insurance packages is closely tied in with the labor market.

2. Theory

It is important to understand what a negative discount rate means, theoretically. Basically this means that someone values something more in the future than in the present. For example, if I asked, "Do you want this apple right now or do you want it in 1 year?" most people would say that they want the apple right now. That is why people have positive discount rates; they have a preference for consumption in the present as compared to consumption in the future. The discount rate for a non-monetary good, thus, is largely reflective of tastes and preferences. Is it possible for someone's tastes and preferences to be such that they prefer something in the future as opposed to something today?

First of all, it is important to note that people may have different discount rates with regards to different goods (Frederick, Loewenstein, and O'Donoghue, 2002). An apple may have a different discount rate than money, which may have a different discount rate than health insurance. This paper separates the discount rate associated with health insurance and momentary benefits, which have a more clearly defined opportunity cost, associated with interest rates and opportunity costs. If someone gives you $10, you have the option of investing it, whereas if someone gives you a free year's worth of health insurance, it will be difficult to bring such a benefit to any sort of market, particularly considering health insurance depends on the demographic characteristics of the individual.

Could there ever be such a thing as a negative discount rate? Thaler (1992) gives several examples of negative discount rates that we observe in every day life. One good example he sites is that teachers are sometimes given the option of receiving a salary on a 9-month basis, starting in September, versus a 12 month basis. A large percentage chose the 12-month basis. This means that they would prefer to defer consumption to the future. In essence, there is a negative discount rate involved.

Are negative discount rates counterintuitive? Are people who show negative discount rates acting irrationally? Not always. The discount rate is essentially a matter of tastes and preferences. In some instances, for instance with monetary benefits that hold a very well defined opportunity cost, it could be said that negative discount rate are irrational, simply because we can tell that the person has not considered the opportunity cost of holding money. In other cases, however, the negative discount rate may be associated with some other positive utility someone gets from consuming later as opposed to sooner. In the example of the teacher who wants her salary given out in 12 month increments rather than 9 month increments, we could say that she is not considering the opportunity cost of investing the money she receives in her 9 months and gaining. However, in another sense, the teacher may get positive utility from not having to worry about investing it. Or, perhaps, when her money is given out in 12 month increments, it helps her control her spending (or her husband's spending) in a way that she would have difficulty doing if she received money over 9 months. When the benefit in consideration is not monetary, such as an apple or health insurance, the opportunity cost becomes more difficult to weigh and tastes and preferences will play an even larger comparative role. Thus negative discount rates are neither counterintuitive nor irrational.

B. Question #2:

Do people exhibit behavior in accordance with the standard discounting model? If not, is the hyperbolic discounting model a more appropriate predictor of behavior?

1. Review of Literature

Although economists have built numerous discounting models, my project focuses on the two leading models: the Discounting Utility Model and the Hyperbolic Discounting Model.

i. Discounting Utility Model (DU Model):

The basic Discounting Utility Model assumes that present value of something equals the stream of future values (V_n), discounted at a certain rate per year (r).

$$P_v = \sum \frac{V_n}{(1+r)^n}$$

Empirical evidence generally supports the idea that people usually value future payoffs less than present payoffs, although there is also evidence of negative discount rates and other anomalies, discussed later. Economists, however, generally dismiss the notion that a single discount rate applies in all situations with all types of people.

Discount rates vary from individual to individual and the measured average discount rate varies across studies, depending on the situation (Frederick, Loewenstein, 2002).

ii. Hyperbolic Discounting

The best-documented revision of the DU model is the hyperbolic discounting model. This model is similar to the DU model except that it says that people have a higher discount rate for the near future than for the distant future. Although this is basically an empirical regularity, rather than an idea backed by intuition, Thaler (1992) attributes the phenomenon to a flaw in mental discounting. People may categorize goods into two categories – goods for saving and goods for consuming. Goods people put into their "consuming" mental account, can be consumed any time in the short run. Some people may find it easier to stay away from goods in their "savings" mental account than to hold off on the "consumption" goods for a few more months. For this reason, short term time horizons may have higher discount rates than long term time horizons.

Hyperbolic discounting has been used to explain many phenomena observed in the real world, and has been documented in many empirical studies. Evidence across studies also supports the hyperbolic discounting model. Studies looking at short periods of time (less than one year) generally measure higher discount rates than those looking at longer periods of time (Frederick, Loewenstein, 2002). However, among studies that look at periods of time greater than one year, the average discount rate remains fairly constant. This suggests that hyperbolic discounting may occur primarily in the short run, but not in the long run. David Laibson (1994) built this into a mathematical model:

$$P_V = V_{period1} + \beta \sum_{n=1}^{N} \frac{V_n}{(1+r)^n}$$

When $\beta < 1$.

In this case, the discount factor between today and the first period is greater than the discount factor between all subsequent periods. Of the studies supporting the hyperbolic discounting model, the majority use Laibson's variation of the model. However, other studies also support a more gradual decline in the discount rate. For example Thaler (1981) observed a discount rate of 345% for a 3-month horizon, 120% for a 1-year horizon, and 19% for a 10-year horizon.

Hyperbolic discounting does not go unchallenged, however. Fernandez-Villaverde and Mukherji (2002) contend that hyperbolic discounting results from the uncertainty of receiving payoffs in the future as opposed to the certainty of receiving them now. They designed an experiment for undergraduate students involving the use of video games using a time horizon of 1 month. Indeed they found that "once uncertainty is included, the observed behavior is compatible with exponential discounting." In other words, they claim it is difficult to attribute the behavior to a hyperbolic discounting model as opposed to the regular DU model. However, their study involved discounting video game privileges for undergraduate students, a good that may not even have positive utility for all subjects involved. They also did not look at multiple time horizons, a key to any study involving hyperbolic discounting.

2. Theory

i. Derivation of the Discount Rate

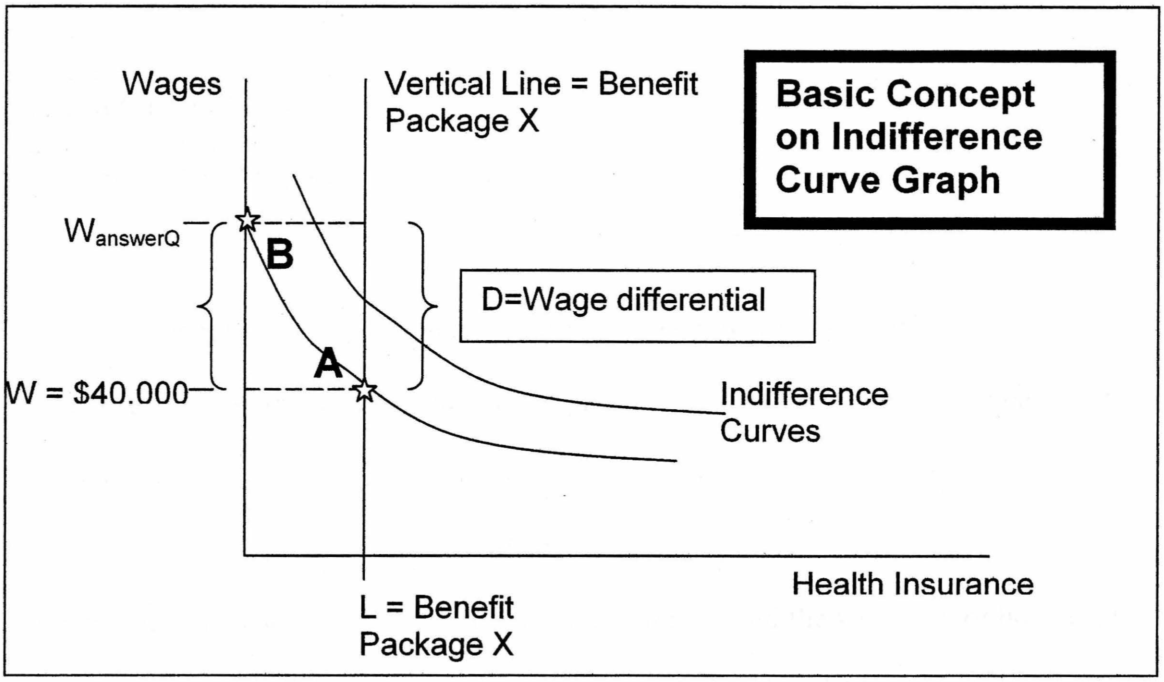
a. Simple Graphical Model

In order to estimate people's discount rates, we asked people to answer the following survey question:

Question Q The health care package for the following questions includes family coverage for the following items in full: 1. Emergency room visits 2. Doctors visits 3. Hospitalization 4. Prescription Drugs Job A: Health benefits (listed above) begin immediately, $40,000 Job B: Health benefits begin after ***n* years** of employment You are applying for a job and face two options. As outlined above, Job A offers health care benefits that begin immediately. Job B offers health care benefits that begin only after 2 years of working with the company. Otherwise, the jobs are identical. If Job A pays $40,000 a year, what is the lowest salary that could persuade you to take Job B? $ANSWERQ

This question allowed us to plot two points in an individual's indifference curve as shown on Figure A, below. These indifference curves show the tradeoff between wages and health insurance people would be willing to make without changing utility. The bottom indifference curve shown crosses the y-axis at point B. This point represents job B in Question Q because the person is receiving no health insurance, just a wage premium. Point A represents Job A, which receives Benefit Package X and a wage of $40,000. Since the wage at AnswerQ ($W_{answerQ}$) *marginally* convinces the person to switch from Job A to Job B, we can assume they have equal utility to the person, and thus lie on the same indifference curve.

Figure A:



b. Algebraic Model and Additional Complexities

Algebraically, what the indifference curves are saying looks like this:

Utility of (Wage differential) = Utility of (Benefit Package)

Utility, however, is difficult to work with unless we can quantify it in some way. The easiest way of doing this is to put utility in terms of dollars. The left side of the equation is easy to change to dollars because it is already in wage dollars. We can change the right side of the equation to dollars by asking cohorts to assign a dollar value to the utility of the benefit package. We did this by asking the following survey question:

Question A
If your employer did not offer health care benefits, how much **per month** would you be willing to pay for a health care package that includes family coverage for the following items in full?
1. Emergency room visits
2. Doctors visits
3. Hospitalization
4. Prescription Drugs

By changing the utility into a dollar value, we now can say that the present value of the wage differential will be equal to the present value of the valuation of health care benefits:

$$P_v(d) = P_v(v)$$

To derive the present value of both the wage differential and the valuation of health care, we will build two main factors into the model: (a) the likelihood of staying with the job and (b) the respective discount rates for health and money. We get the likelihood of staying with a job for n years from the survey question:

Question C
If you just began a job, such as the job in the above questions, what do you think is the likelihood that you would still be working for the same company ***n* years** from now?
ANSWER: p

For the discount rate of money, we use the market discount rate associated with an n-year T-Bill. The discount rate for health, of course, is our dependent variable, so that will be what we are trying to solve for. Building these factors into the model for present value of the wage differential equal to the present value of the benefit package, we get the following equation:

$$\frac{(\sqrt[n]{p})^1 d}{(1+r)} + \frac{(\sqrt[n]{p})^2 d}{(1+r)^2} + \ldots + \frac{(\sqrt[n]{p})^n d}{(1+r)^n} = \frac{(\sqrt[n]{p})^1 v}{(1+i)} + \frac{(\sqrt[n]{p})^2 v}{(1+i)^2} + \ldots + \frac{(\sqrt[n]{p})^n v}{(1+i)^n}$$

In summation form, the equation looks like this:

$$\sum_{k=1}^{n} \frac{(\sqrt[n]{p})^k d}{(1+r)^k} = \sum_{k=1}^{n} \frac{(\sqrt[n]{p})^k v}{(1+i)^k}$$

c. <u>Modifications for Accuracy</u>

We took two measures to improve the accuracy of the model in estimating the discount rate. First of all, instead of compounding annually, we compounded monthly. This was because people generally receive wages monthly rather than annually. The same equation above, adjusted for monthly compounding, follows:

$$\sum_{k=1}^{12n} \frac{(\sqrt[12n]{p})^k d}{\sqrt[12]{(1+r)}^k} = \sum_{k=1}^{12n} \frac{(\sqrt[12n]{p})^k v}{\sqrt[12]{(1+i)}^k}$$

The second measure we took to ensure accuracy was to relax the assumption that i remains constant for all periods of time. After all, the purpose of this project is to test whether or not i changes. Thus, we cannot at any time assume i remains constant. For this reason, we take the result, "i", of the equation above as the *average discount rate* from now until year n. By assuming that the outcome rate is an average, we can calculate the actual discount rate at different points in time by using integrals. For a more detailed discussion on how we used integrals to calculate the specific discount rates, see Appendix B. Besides being more accurate, this also allows us to calculate seven discount rates over time, rather than just four. This increase in the data will allow for more accurate regression analysis and more precise estimates of the hyperbolic function of discounting, if it exists.

d. Assumptions

1. **The discount rate we are calculating is the average rate between now and year n.** This assumption is not completely accurate, but it is the closes estimate we can come to with the given information. It will certainly show trends in the correct direction.

2. **Interest rates associated with current *n*-year T-Bills, r, accurately portray people's current depiction of the opportunity cost of holding money for *n* years into the future.** This assumption also may be faulty, but it is an assumption that economists often make and will suffice for the purpose of this project.

3. **Cohorts correctly understood the survey questions.** We clearly cannot control for misunderstandings of different sorts that may occur when individuals answer the survey. However, given the large sample size, we can assume that the overall bias factor of any misunderstanding will have roughly a mean of zero; some will be biased higher based on misunderstanding and some will be biased lower. These will roughly cancel out.

4. **People believe that their indifference curves will not change in the future.** Theoretically, people's indifference curves probably become steeper as they age. Typical indifference curves might look like this:

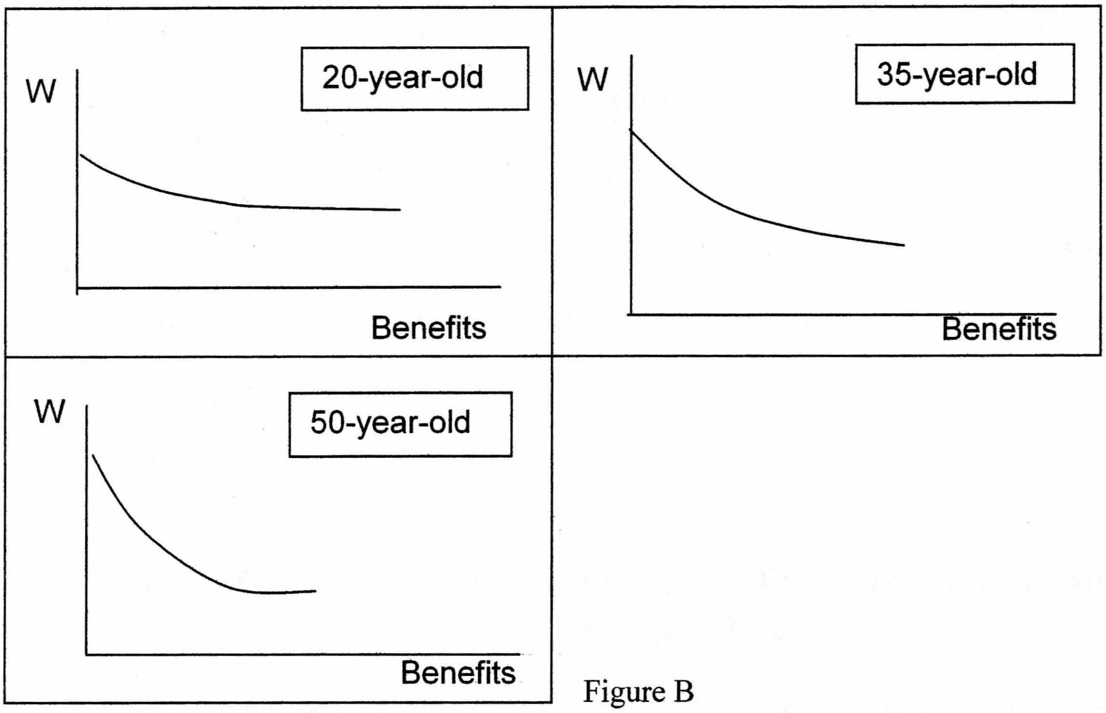
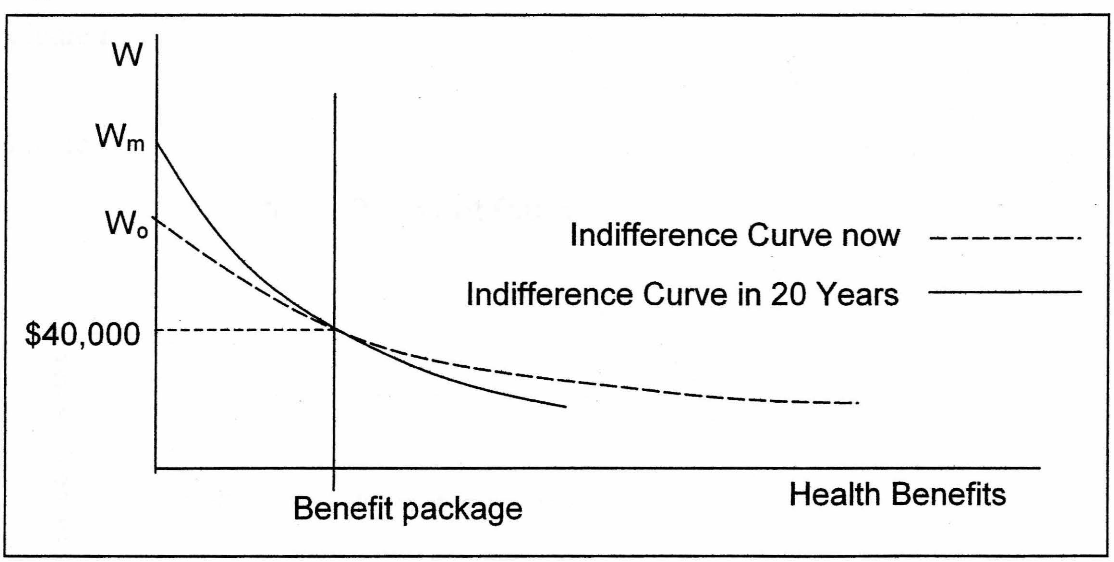


Figure B

If a person was aware that their indifference curves were going to become steeper, then they might account for this in their present value calculation.

Figure C:



For instance, disregarding changes in discount rates, they might change the wage differential simply because they would anticipate a change in the shape of their indifference curves, as shown above. It is not clear, however, whether or not people are aware that their indifference curves will change and whether they account for this when they mentally figure out a present value for health care benefits. Assuming that they do not helps to simplify the model into something that we can estimate using the given information.

ii. Graphical Representations of the Hyperbolic and DU Models

Once we have the discount rates, we want to plot the mean discount rate for each year and observe the trends. If the data fits the DU Model, then the mean discount rate should stay the same over all time horizons. Plotted on a graph, the mean discount rates should look like Figure D and the rate of change between discount rates should look like Figure E.

Figure D

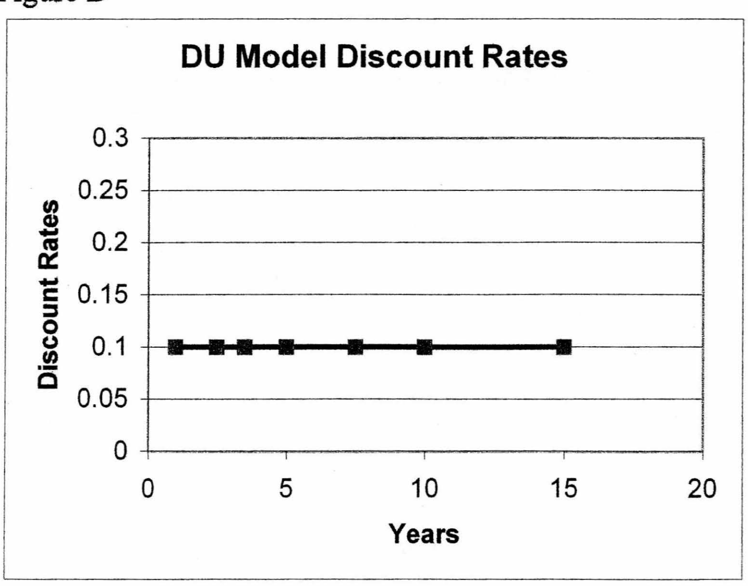
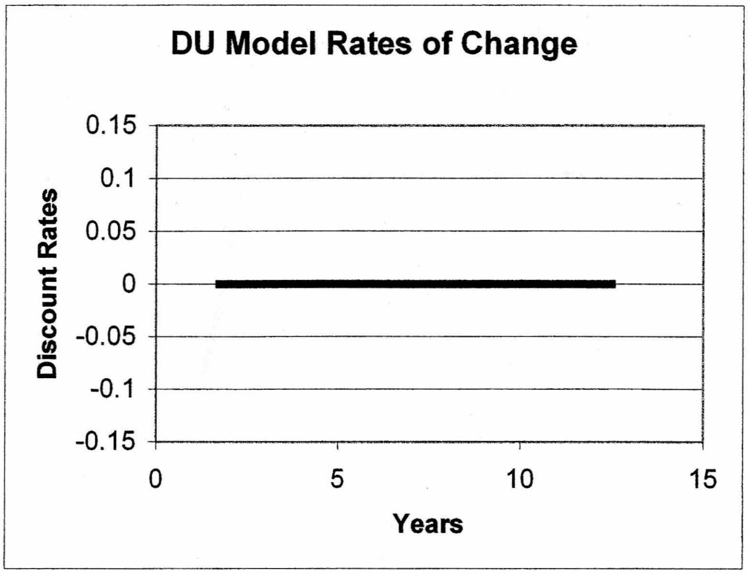


Figure E



If, on the other hand, the data fits the Hyperbolic Discounting Model better, then the mean discount rate should decline between one year and two and a half years, and then stay constant after that. In which case, plotting the mean discount rates for each time horizon, we should get a graph similar to Figure F, and rates of change similar to Figure G.

Figure F

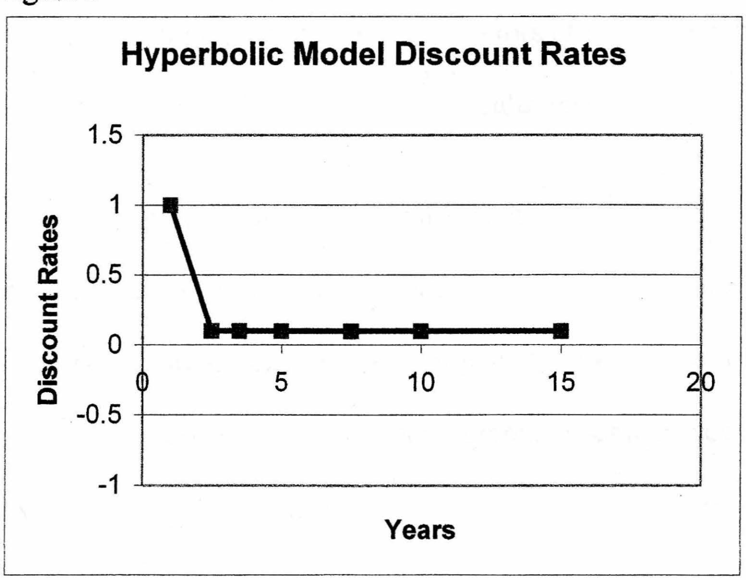
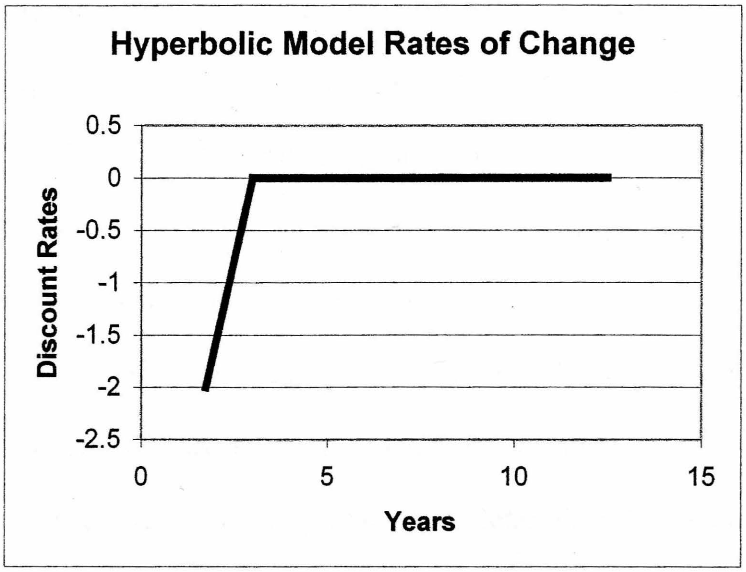


Figure G



If we observe hyperbolic discounting, we can test for significance by rejecting the null hypothesis that the rate of change between periods 1 (1 year) and 2 (2.5 years) is greater than or equal to zero. If the p-value is significant for the first period, but not for subsequent periods, then the hyperbolic model will be a good fit for the data.

C. Question # 3

What demographic and personal factors affect the magnitude of the discount rate for health insurance?

No matter what general pattern this study shows (hyperbolic or unchanging discount rates), there will most likely be a wide range of different discount rates among cohorts. Although there is not a large body of empirical literature comparing discount rates among different cohorts, demographic characteristics have been reported in at least two studies. A study (Barberan, Lazaro, and Rubio, 2002) showed that people with young children and people with lower personal incomes have lower discount rates. Also, Royalty (2000) compared how different people value health care benefits as compared to wages. She presented subjects with different options for benefit packages and analyzed their decisions. “Results suggested that families value health benefits substantially more than singles and that valuation of fringe benefit dollars is substantially less than one-for-one with wage dollars,” she reported.

Theoretical predictions help forecast the differences in discount rates among individuals. Theoretical considerations, however, lead to mixed conclusions. For instance, age will likely play a role in determining a person’s discount rate. Van Der Pol and Cairns (2000) hypothesized that young people would more often have lower discount rates for health status because they have more responsibilities in the future, and that older people would have higher discount rates because of their reduced life expectancy. The results of their experiment, however, were not sufficient to confirm this prediction. One reason for this may be that younger people tend to weigh the present more heavily because they have not had to deal with as many long-term responsibilities. Also supporting the theory that older people discount at a lower rate is the fact that older people will place a higher absolute value on health care, since they are more likely to get sick. At least 12 studies have shown that people discount small amounts at a higher rate than large amounts (Frederick, Loewenstein, 2002). This would imply that younger people, who place a smaller value on health care, would have higher discount rates than older people. Although the theory on discount rates for different ages is mixed, the evidence for a higher discount rate among young people is stronger. And indeed, the differences among ages may not be very pronounced because some economic theorists suggest that people establish time preferences early in life and they remain stable thereafter (Rae, 1834).

People with higher education will likely have lower discount rates. This follows from the Human Capital Model, which says that people with higher discount rates are more likely to forego the present costs of education and go straight to work. Also the fact that people discount larger amounts greater than smaller amounts would also lead us to believe that people in poor health will have lower discount rates than those in good health.

III. Hypotheses

Based on the above discussion, I expect to observe the following in my data:

1. **Some negative discount rates.**
2. **Hyperbolic discounting.** I expect that the discount rate will decline between the 1 year and 2.5 year time horizons, but not for subsequent time horizons. The data should resemble Figures F and G in the section above: "Graphical Representations of the Hyperbolic and DU Models".

3. **Higher discount rates for people who**:
    a. have less formal education
    b. are in better health
    c. have fewer children
    d. earn higher incomes
    e. are younger (mixed evidence)

IV. Procedure

A. Comparison with Other Studies

Research in the area of discounting generally takes the form of hypothetical surveys. In the few cases (i.e. Villaverde and Mukherji, 2002 and Loewenstein, 1988) where economists have run non-hypothetical experiments, the time frame has always been a matter of months, rather than a matter of years. The reason for this is practical; researchers don't want to spend five or ten years conducting an experiment. A lot can happen in that amount of time. For this reason, too, my survey was hypothetical.

Frequently researchers pre-calculate certain choices and allow subjects to choose from a list. This method limits subjects, however, and leaves room for researchers to overlook possible outcomes not included in their model. This builds bias into the results. My survey asks subjects to place a dollar value on a wage differential (from which, I calculate the discount rate). By allowing subjects to place their own values, I am attempting to obtain a direct measure of utility. The downfalls to this method are that it sometimes confuses subjects or makes it difficult for them to answer. Of the 1,888 responses I received, almost half chose not to answer one of the three questions necessary to calculate a discount rate. This could be because the task was too difficult. However, enough people answered the survey in full to generate 994 usable observations.

The success of my project in generating a large data set was likely due in part to the fact that alumni of Washington and Lee feel a great loyalty to the school and are more likely to be supportive of a student project because they were once undergraduate students of the school. Another factor in the success of the survey was likely the internet basis for it. Filling out an internet based survey takes much less time than a hand marked survey and can be done a couple of minutes after opening an e-mail with the link. The population of alumni (particularly the younger generation) as a whole is likely to be comfortable using internet resources, as well.

My study is unique in that it will be the first to build a regression model predicting the effect of different demographic characteristics on the discount rate for health insurance. Past studies have had a small number of observations, thus have not been able to find significant differences.

The main difference, however, between my study and other studies on the discount rate of health is the fact that I measure the discount rate of health insurance, rather than some other measure of health, such as sickness, life years, etc. Health insurance is a positive benefit, something people want to have, rather than want to avoid. When people measure the discount rate of negative health outcomes, they run into the same bias as they do if they were measuring the discount rate of a debt instead of a credit. Insurance can also be viewed as a benefit that is constantly consumed, rather than consumed at a certain time in the future. This is particularly true if we take into account the utility people get from not having to worry about health crisis. Thus looking at discount rate over time will have more meaning, since it is an asset that is constantly consumed.

Finding the discount rate of health care rather than health status also allows me to avoid some of the problems that Jan Olsen saw regarding discounting health. She complains, for instance, that health is not tradable either with other people or with future selves. Health insurance, however, can be traded in a free market. Although the market for health insurance in the US (and certainly in other countries) is not a perfectly free market, it has the potential to be. Also, if we consider the labor market as a free market and associate health insurance with the labor market, as I do in my survey, we come even closer to having a freely tradable good.

B. Method

The survey went through a pilot study involving 13 professors around campus. Based on interviews with these professors, the survey underwent several revisions before it was published. The final version of the survey is in Appendix A. Once the survey was published on the Internet, the alumni office sent a link for the survey to all alumni with registered e-mail addresses, about 16,000 people. The alumni had one month to complete the survey on the Internet and send in their answers. The response rate was about 12%, but 38% of these did not contain sufficient information to calculate the discount rate. In the end, 7.3% of the original population (W&L alumni) responded with usable information. The demographic characteristics of the population and sample are listed in Figure H, below.

		Sample		
Gender			**Maritial Status**	
Men	73.7%		Married	68.0%
Women	26.3%		Single	28.3%
			Divorced	3.4%
Ages			Widowed	0.3%
20's	30.9%			
30's	28.1%		**Personal Income**	
40's	18.6%		Under 30K	12.1%
50's	14.8%		30 - 50	15.2%
60's	6.0%		50 - 100	31.0%
70+	1.5%		100 - 200	27.6%
			Over 200	14.1%

Figure H

Although using alumni as a sample is more representative of the population than using only students, it has limitations. For instance, Washington and Lee did not admit women until 1985, meaning that the oldest woman in the sample was no more than 36, whereas there were men up through age 80. The age distribution also shows a larger percentage of younger people. This may be due in part to the fact that class size at Washington and Lee has increased over the years and in part due to the fact that the survey was conducted over the internet and younger people are more comfortable with internet resources, as a whole. Clearly the alumni population will have higher education and higher incomes than the average population, as well.

The mathematical derivation of the discount rate is explained in the Theory section above and in greater detail in Appendix B. In order to conduct this calculation, I used Maple, a mathematics program, to plug in the necessary numbers for each respondent and spit out a discount rate. Prof. Paul Bourdon helped to write a program in Maple that would calculate the average discount rate for the 2-year, 5-year, 10-year, and 20-year time horizons. We tried compounding on both an annual and a monthly basis in Maple. For increased precision, we used the monthly compounded discount rates, although there was not a large difference between the two. The rest of the calculations, including the change of average rates into actual rates, took place in Excel. I used MiniTab for the regressions and some of the other data analysis.

V. Results

A. Results for Question 1:

Do people have negative discount rates for health insurance?

The answer is simple: yes. Eighty-one percent of respondents had negative discount rates for health. Figure R0 shows basic descriptive statistics of the discount rates.

Discount rates:	Number	Percent	Mean	Standard Deviation	Mid 50%
Positive discount rates:	189	18.96%	1.01	4.3	.81 to .62
Negative discount rates:	808	81.04%	-0.99	0.68	-1.47 to -.45
All cohorts:	997	100.00%	-0.65	1.24	-1.3 to -.15

Figure R0

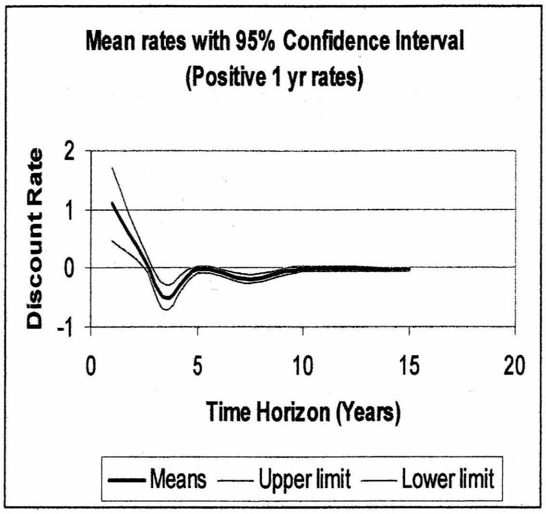
B. Results for Question 2:

Do people exhibit behavior in accordance with the standard discounting model? If not, is the hyperbolic discounting model a more appropriate predictor of behavior?

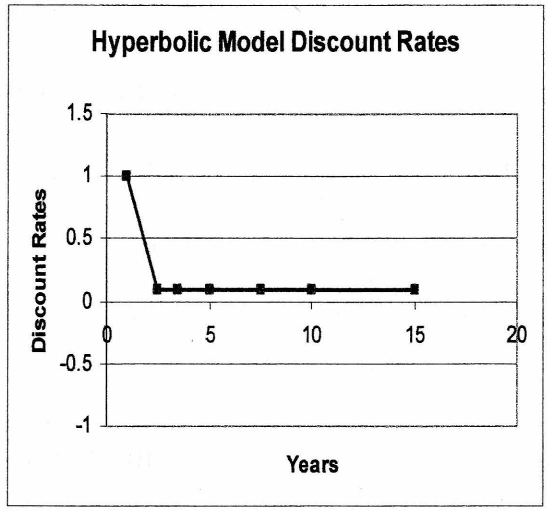
Regarding question #1, the data shows two different trends. There was not a particularly strong trend in the data until I separated the observations with positive 1-year discount rates from those with negative 1-year discount rates.

1. Cohorts with positive 1-year discount rates

Those with positive discount rates show strong evidence of hyperbolic discounting. This becomes clear from a graph of discount rates versus time horizon, including only those observations with positive 1-year rates (Figure R1, below). Comparing them with the theoretical prediction of the hyperbolic model (Figure R2, below), the trends mirror one another:



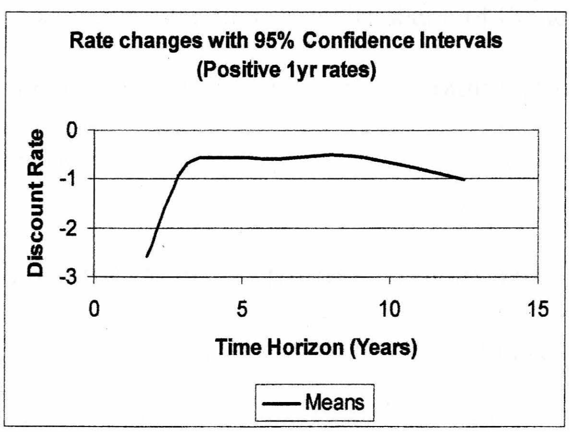
R1 – Based on a subset of 189 with positive 1-year rates



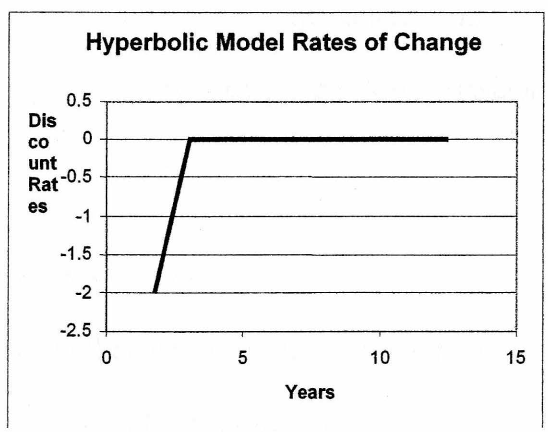
R2 – Based on the theoretical prediction

The Hyperbolic Discounting Model basically says that the discount rate in the first period will be higher than the discount rate in subsequent periods. The graph above shows that, with a 95% level of confidence, the 1-year discount rate is higher than all subsequent periods.

In graphing the mean rates of change against time horizon (Figure R3, below), the graph resembles the theoretical prediction based on the Hyperbolic Discounting Model (Figure R4, below):



R3 – Based on a subset of 189 with positive 1-year rates

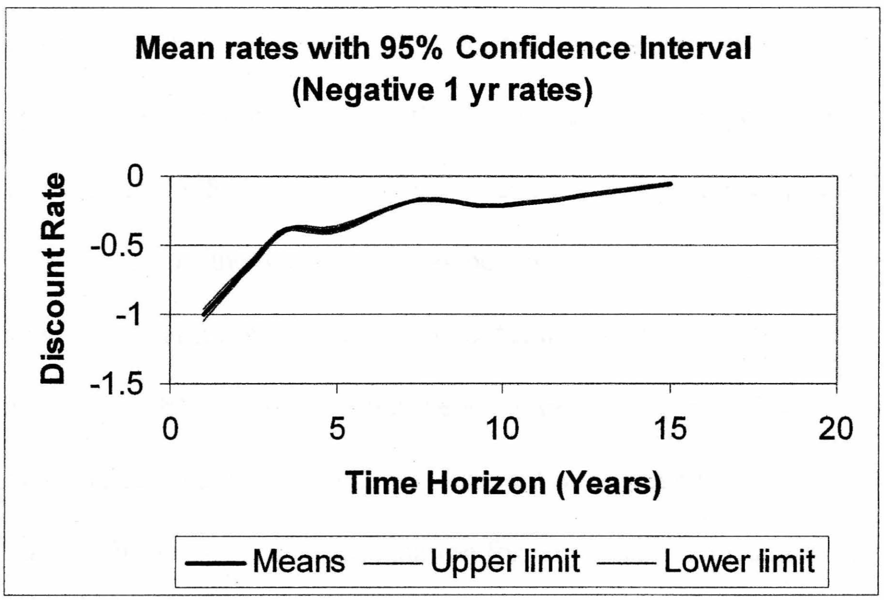


R4 – Based on the theoretical prediction

Appendix NUMBR contains figures for these rates.

2. Cohorts with negative 1-year discount rates

The trend for individuals with negative discount rates neither fits the Hyperbolic Discounting Model or the Discounting Utility Model. The discount rates for individuals with negative 1-year discount rates are shown below, in Figure R5:



R5 – Based on a subset of 808 responses with negative 1-year discount rates

Clearly the discount rates are increasing, not decreasing, as time horizon increases for all years. Neither does the shape of the graph indicate a hyperbolic pattern to the increase in discount rate. The discount rate increases, if not linearly, at a fairly constant rate over the years.

3. Theoretical Explanations for the Results

Many people realize that health insurance will benefit them more in the future as opposed to today, because of their increased likelihood of getting sick as they get older. For this reason, they may have negative discount rates for health insurance, as 81% of those participating in this survey did. However, as people look farther and farther into the future, they become more neutral regarding their valuation of benefits in the future compared to benefits today. As people look farther into the future, their discount rate becomes closer and closer to zero.

There could be several explanations as to why this happens. The simplest model of thinking about the future is to say that benefits in the future are worth exactly the same as they are today, without any discounting. This is similar to Friedman's assumption regarding people's projection of their real wage in future periods (they believe that their real wage in the future will be equal to their real wage today). Factoring in a discount rate complicates the matter, but may be a more accurate way of valuing things. As people look farther and farther into the future, however, it becomes more and more difficult for them to weigh future benefits and present benefits. Therefore, people tend towards a simpler model (with a 0 discount rate) when they must project farther into the future. This could be one explanation for why negative discount rates increase towards zero as time horizon increases.

Thaler (1992) offers an explanation for a hyperbolic discounting pattern, as observed with the sub-set of individuals with positive 1-year rates. People may have higher discount rates for near-future periods because they have two different mental accounts: a mental account for saving and a mental account for spending. People may be willing to forgo benefits in the "savings" account for a long time, thus giving it a low discount rate. With regards to their "spending" mental account, however, people may not be willing to wait a long time. They want to spend it now, and require a high premium to forgo benefits for even a short period of time. Benefits in the "spending" account, thus, have a higher discount rate. When people think about future benefits, they may consider those received in the first few periods, or within 2 years, to be in the "spending" mental account rather than the savings mental account. For this reason, benefits in these time horizons may have a higher discount rate than in subsequent periods.

4. Summary of Results for Question 1:

For cohorts with positive 1-year discount rates, the data fits the Hyperbolic Discounting Model remarkably well. For those with negative 1-year discount rates, however, the hyperbolic model does not fit the data. This implies that a modification should be made to the Hyperbolic Discounting Model. This model effectively describes behavior *only* if discount rates are negative. For a negative discount rate, a better model would imply a steady increase in the discount rate as time horizon increases.

C. Results for Question 3:

What demographic and personal factors affect the magnitude of the discount rate for health insurance?

Basically the findings of this study indicate that none of the demographic factors surveyed had a large, economically-significant impact on the discount rate. Some of the factors, however, had a minor impact. These factors tend to be associated with people's uncertainty about the nature of their economic and social support systems in the future. In general, if people were uncertain about their future (for instance young people, people with lower incomes, single people, women, etc) then they generally had lower discount rates than people with secure systems of support in place. What does this mean?

People with lower discount rates place a higher value on health care received in the future as compared to today. This means that a person with a very low (negative) discount rate might tell you, "I'll pay you a huge sum of money if you will apply this benefit package to the future rather than today." Figure R6 helps to explain the meaning of higher versus lower discount rates. People who face a large amount of uncertainty in the future will have lower discount rates because they would prefer to be covered for insurance during a time of uncertainty as opposed to now, when they have a clear picture of how they can manage. If someone has a large cushion, on the other hand, they will be more neutral as to when they want health care benefits, because they know that they will not be in a bind if they were to face a health crisis in the future.

		Attitude interpretation with regards to different discount rates
	Discount rate:	
High rate	0.1	It's <u>very important</u> that I have the benefits NOW
	0.05	I'd prefer the benefits now, but whatever
zero rate	0	Whatever. I don't care
	-0.05	I'd prefer the benefits in the future, but whatever
Low rate	-0.1	It's <u>very important</u> that I have the benefits in the FUTURE

Figure R6

The results of this project support the idea that people who face more uncertainty in the future will have lower discount rates. Figure R7 (along with more detailed results in Figure R8), summarizes the demographic characteristics that have a statistically significant effect on a person's discount rate.

Who has lower discount rates?
People with lower incomes
Younger people
Women
Singles
People who have considered fewer factors
People with fewer children
People with past health crisis

Figure R7

The hypothesis correctly predicted that people with higher incomes would have higher discount rates. Past studies have shown that people with lower incomes have lower discount rates on non-health related goods, so it does not surprise us that their discount rates for health are lower as well. People with higher incomes have a lower risk involved with health crisis that may occur in the future. Their high income could provide to be a cushion for future uncertainty regarding health crises.

As mentioned earlier, the theoretical predictions regarding age and discount rate give mixed implications. Cairns and Van der Pol (2000) predicted lower discount rates on health for younger people because younger people have more at stake in terms of a future that could be hindered by a poor health outcome today. Although their studies were insufficient in showing evidence for this, my study has confirmed it. Young people also are less likely to have a social support system in place to take care of them in case of a medical crisis. This would mean that they would prefer benefits in the future when the state of their support system is unknown as opposed to today when they are aware of the sort of support they have in place. Similarly, wealthier have a financial support systems in place to take care of themselves during a health crisis, thus are less concerned with delaying benefits to the uncertain future than poorer people, who cannot always predict the state of their financial support system in the future. Also, both young people and wealthy people are more likely to be currently in good health, meaning they would prefer the benefits in the future since they have little or no use for health coverage today.

The other factors listed also indicate that people with higher risk involved with medical crisis have lower discount rates. For instance, married people have a greater assurance that someone will be there to help out in the case of a medical emergency. Singles might rely more heavily on the resources of the health care system in a crisis, thus they have lower discount rates. Women face greater economic risk when considering women have a greater chance of becoming a single parent, and may face more challenges in the labor market if they were hindered by a major health crisis.

People who have experienced past health crisis within their family ("Claims History", Figure R9) have lower discount rates. These people don't necessarily have less of a support system than other people, but they may view themselves as having less support because of the crisis within their past. Having been through the process and having seen the real damages that a major claim can cause would cause people to feel like their future is vulnerable and thus may want to transfer benefits to the vulnerable future rather than today when they feel secure.

	Coefficient	P-value
Married	0.31826	0.001
Gender	0.30774	0.001
Answer Change	0.18148	0.045
Claims History	-0.1755	0.09
Number of children	0.11393	0.006
Income (1 standard deviation increase)	0.122033016	0
Age (1 standard deviation increase)	0.052098274	0

Figure R8

Discount Rate Descriptive Statistics	
Mean	-0.6536
Standard Deviation	1.2408
Mid 50% between	:-1.3 and - .15

Figure R9

Figure R8 indicates how much of an effect each of the demographic characteristics has on discount rate. As chart R9 shows, the mid 50% of discount rates lie between -1.3 and -0.15. This indicates that most of the factors discussed have a relatively small impact on discount rate. They are not extremely economically significant. None-the-less, the findings from this section indicate that perceived risk and lack of a support system in the future will cause individuals to have *somewhat* lower discount rates.

VI. Implications

A. Policy Implications

National health care is emerging in political debates. Several ideas lie behind the notion of national health care, including the possibility that increased health coverage could increase worker productivity and the idea that individuals have a right to basic health coverage. In a free market, however, a substantial number of individuals remain uninsured, including individuals who could afford insurance, but chose not to buy it (those who have an income of over $50,000 per year). Policy makers who aim to increase the number of people insured have an option of approaching the issue with either a supply-side or a demand-side policy. An example of a demand side policy might be for the government to subsidize part of insurance, shifting the demand curve out. Whether or not this will work will depend on the elasticity of the demand curve.

The shape and elasticity of the demand curve, of course, depends on a number of factors including preferences *and* discount rate of health insurance. Since health care is a continuously consumed good, individuals must make decisions about what kind of coverage they want for the future, and whether they will be willing to pay the present value for them.

The implications of this study have to do with the timing of individual choices regarding health insurance purchase. According to this study, if individuals can make the decision to buy health insurance at any time, they will be much less likely to purchase it than if they had to decide now whether they want insurance two years from now. The reason for this is that people value benefits that will be received two years from now more than they value benefits received today. People tend to have a rosy view of their own health today as compared to the near future. This can be implied from the large number of constituents with negative discount rates for health insurance. If people are continuously making the decision whether or not to buy health insurance, they will be more likely to continuously reject insurance because they value it less now than they do in the near future. If they put the decision off until the near future, the near future soon becomes now, and they still value insurance less now than in the near future. This sort of paradox carried out to an infinite future will result in the individual never buying health insurance.

Of course, this is only a theoretical model based on the negative discount rates. In actuality, the person will likely realize at some point that they are undervaluing the insurance. However, the implications will have some effect on the demand for health insurance. Someone with a negative discount rate will require a larger drop in price to be persuaded to buy insurance now as opposed to waiting. In effect their logic goes like this: "I do not need insurance now. My money would be better spent if I were to save it and buy insurance in the future, when I really need it." Since this logic carries into the future, people with negative discount rates may not easily be persuaded to buy insurance today.

Despite the above discussion, it is unclear from this project whether the impact of discount rate outweighs other factors, such as absolute income, or cost of insurance. This leaves room for future studies to investigate the overall significance of the discount rate effect on demand for health insurance.

B. Future

The most significant thing this paper has shown in terms of future economic research involves negative discount rates. Few studies so far have shown strong evidence for the existence of negative discount rates.

In addition to observing negative discount rates, this study has shown that the theories that apply when considering positive discount rates, such as the Hyperbolic Discounting Model, may not apply when discount rates are negative. This leaves open questions regarding the nature and motivation behind individuals having negative discount rates.

Some questions that have yet to be answered are:

(a) To what degree do negative discount rates affect a person's decision whether or not to buy health insurance? Within what demographic groups does the discount rate most effect this decision?

(b) Why does the model for hyperbolic discounting apply only when the discount rate is positive? Why is there a different pattern of discount rate change for negative and positive discount rates?

(c) How much does discount rate affect health insurance demand, as compared to income and price of health insurance?

(d) What model best represents the change in discount rate as time horizon changes for individuals with negative discount rates?

VII. Conclusions

First, the methods of data collection and derivation of the discount rate for this project turned out to be very effective. An internet-based survey proved to be a cheap and painless way of generating nearly 1000 data points. The fact that we were able to derive a discount rate from open-ended questions allowed us to reduce bias. Because we did not pre-construct a set of answers, we did not rule out any answers that seemed unreasonable. Because of these efforts we were able to observe a phenomenon that might have otherwise been ruled out: negative discount rates.

Second, the most novel finding from this study is that a large majority of people have negative discount rates for health insurance. In fact, about 80% of the respondents of our survey have negative rates. This means that they place a higher value on health insurance 10 years from now as opposed to health insurance today.

Third, people with negative discount rates behave differently from those with positive discount rates with respect to change in rate as time horizon (distance looking into the future) changes. The Hyperbolic Discounting Model predicts that rates will decrease hyperbolically as time horizon increases. This model fits the data well for people with positive discount rates, a finding consistent with past studies. None of the leading models, however, describes the behavior of people with negative discount rates. Their rates *increase* linearly with time horizon, rather than decreasing at a hyperbolic rate.

Fourth, demographic characteristics have very little economically significant effect on discount rate. Although most characteristics were statistically significant because of the large data set, the largest impact on discount rate was age and income (multiplied) which had only a .1 change in discount rate for every standard deviation change in age*income. This was insignificant given the distribution of discount rates observed in this study.

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Appendix

Appendix A

Survey for Economics Honors Thesis

Directions

Completing the survey: Questions 5 through 8 are hypothetical. Simply answer to the best of your ability. Some questions require you to type in answers.
Sending the survey: Send your responses by clicking the "Send" button at the bottom of the page.

Anonymity

The data collected from individual answers on this survey is kept strictly confidential. Results will be reported only in the aggregate.

Question 1
You are currently:

- ○ Working full time
- ○ Retired
- ○ Not in the labor force
- ○ Working part time
- ○ Looking for work
- ○ Other: [ ]

Question 2
Your spouse is currently

- ○ Working full time
- ○ Retired
- ○ Other
- ○ Working part time
- ○ Not working
- ○ N/A

Question 3
How many years during your lifetime have you worked full time for an employer?

[ ]

Question 4
How many times have you changed employers since graduating from W&L?

[ ]

For Questions 5 - 8:

The health care package for questions 5 - 8 includes family coverage for the following items in full:

1. Emergency room visits
2. Doctors visits
3. Hospitalization
4. Prescription Drugs

Question 5
Job A: Health benefits (listed above) begin immediately, $40,000
Job B: Health benefits begin after **2 years** of employment

You are applying for a job and face two options. As outlined above, Job A offers health care benefits that begin immediately. Job B offers health care benefits that begin only after 2 years of working with the company. Otherwise, the jobs are identical. If Job A pays $40,000 a year, what is the lowest salary that could persuade you to take Job B?

[ ]

Question 6
Job A: Health benefits begin immediately, $40,000
Job C: Health benefits begin after **5 years** of employment

Similarly, what is the lowest salary that would persuade you to take job C?

Question 7
Job A: Health benefits begin immediately, $40,000
Job D: Health benefits begin after **10 years**of employment

Similarly, what is the lowest salary that could persuade you to take job D?

Question 8
Job A: Health benefits begin immediately, $40,000
Job E: Health benefits begin after **20 years**of employment

Similarly, what is the lowest salary that could persuade you to take Job E?

Question 9
What factors went into your decision for Questions 5 - 8?

Question 10
If your employer did not offer health care benefits, how much **per month** would you be willing to pay for a health care package that includes family coverage for the following items in full?
1. Emergency room visits
2. Doctors visits
3. Hospitalization
4. Prescription Drugs

Question 11
If you just began a job, such as the job in the above questions, what do you think is the likelihood that you would still be working for the same company . . .

2 years from now? (Example: If your likelihood is 50%, type "50")

5 years from now?

10 years from now?

20 years from now?

Question 12
How many times in the past 10 years have you been hospitalized?

○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 or more

Question 13
Have you, your spouse, or your children had any "major" health crisis during your lifetime? (i.e. an incidence or chronic illness with health care expenses over $50,000. This would include cancer, prolonged hospitalization, etc)

○ Yes ○ No ○ Unsure

Question 14
For your age, you consider yourself in:

○ Excellent health ○ Average health ○ Poor health

Question 15
When your mother was your age, she was in:

○ Excellent health ○ Average health ○ Poor health ○ Unsure ○ N/A

Question 16
When your father was your age, he was in:

○ Excellent health ○ Average health ○ Poor health ○ Unsure ○ N/A

Question 17
Mark all that apply:

☐ I have private health insurance

☐ I am on Medicare or Medicade

☐ My spouse has private health insurance

☐ My spouse is on Medicare or Medicade

☐ I do not carry health insurance

☐ I am unsure where my health insurance comes from

Question 18
My health insurance plan(s) cover(s):

(a) Prolonged hospitalization/Medical crisis

○ In full ○ Not at all

○ In full after a certain deductible ○ Unsure

○ In a copayment

(b) Emergency room visits

○ In full ○ Not at all

○ In full after a certain deductible ○ Unsure

○ In a copayment

(c) Prescription drugs

○ In full ○ Not at all

○ In full after a certain deductible ○ Unsure

○ In a copayment

(d) Visits to the doctors' office/check ups

○ In full ○ Not at all

○ In full after a certain deductible ○ Unsure

○ In a copayment

(e) Dental care

○ In full ○ Not at all

○ In full after a certain deductible ○ Unsure

○ In a copayment

Question 19

If you are under your employers' health care package, how much do you contribute to it monthly? [If uncertain, type "?"; If not applicable, type "NA"]

Question 20

To the best of your judgement, how likely is it that you will file a major medical claim within the next . . .

2 years? (Example: If your likelihood is 50%, type "50")

5 years?

10 years?

20 years?

There are a few more background questions needed for statistical purposes. Again, we will in no way attempt to trace your identity from your responses. Results will be reported only in aggregate.

Question 21

Region of country:

○ Northeast ○ Mid-Atlantic ○ South ○ Midwest ○ Southwest ○ West

Question 22

My place of work is:

○ Rural ○ Suburban ○ Urban

Question 23

My place of residence is:

○ Rural ○ Suburban ○ Urban

Question 24

Age:

Question 25

Gender:

○ Male ○ Female

Question 26

Annual personal income:

○ Under $30,000 ○ $50,000 - $100,000 ○ Over $200,000

○ $30,000 - $50,000 ○ $100,000 - $200,000

Question 27
Annual family income:

○ Under $30,000 ○ $50,000 - $100,000 ○ Over $200,000
○ $30,000 - $50,000 ○ $100,000 - $200,000

Question 28
Maritial status:

○ Married ○ Single ○ Divorced ○ Widowed

Question 29
Number of children currently living with you:

○ none ○ 1 ○ 2 ○ 3 ○ 4 or more

Question 30
Number of dependents other than children:

○ none ○ 1 ○ 2 ○ 3 ○ 4 or more

Question 31
Profession:
(If retired or not working, put your most recent profession)

[ ]

Question 32
Industry:

○ Health Care ○ Agriculture
○ Finance, Insurance, Real Estate ○ Government or Military
○ Law ○ Education
○ Retail, Wholesale, or Manufacturing
○ Other: [ ]

Question 33
Major(s) at W&L:

[ ]

Question 34
Degrees [mark all that apply]:

☐ BA or BS ☐ Masters other than MBA ☐ MD
☐ MBA ☐ JD ☐ other doctorate degree

Question 35
While taking this survey, did you go back and change your answers for questions 5 - 8?

○ Yes ○ No

[Send Answers]

APPENDIX B
Calculation of Dependent Variable – Discount Rate

Equation for calculating the average discount rate over years 1 through *n*.
We will call this "*i*" to begin with. The average discount rate at time horizon n will be called $i_{@n}$.

$$\frac{(\sqrt[12n]{p})^1 d}{12\left(1+\frac{r}{12}\right)} + \frac{(\sqrt[12n]{p})^2 d}{12\left(1+\frac{r}{12}\right)^2} + \ldots + \frac{(\sqrt[12n]{p})^{12n} d}{12\left(1+\frac{r}{12}\right)^{12n}} = \frac{(\sqrt[12n]{p})^1 v}{12\left(1+\frac{i}{12}\right)} + \frac{(\sqrt[12n]{p})^2 v}{12\left(1+\frac{i}{12}\right)^2} + \ldots + \frac{(\sqrt[12n]{p})^{12n} v}{12\left(1+\frac{i}{12}\right)^{12n}}$$

Multiplying both sides by 12, we can re-write this equation as:

$$\sum_{k=1}^{12n} \frac{(\sqrt[12n]{p})^k d}{\sqrt[12]{(1+r)}^k} = \sum_{k=1}^{12n} \frac{(\sqrt[12n]{p})^k v}{\sqrt[12]{(1+i)}^k}$$

Solve for "*i*"

Variables:
n = Time Horizon, Years in the Future being considered
v = Valuation of Benefit Package per Year
d = Compensating Wage Differential
p = Probability of Being in same job N years from now

Where do the numbers come from?

***n* (Time Horizon, Years in the Future)**
2 years
5 years
10 years
20 years
Exogenous variables given in the survey

***v* (Valuation)**
If your employer did not offer health care benefits, how much **per month** would you be willing to pay for a health care package that includes family coverage for the following items in full?
1. Emergency room visits
2. Doctors visits
3. Hospitalization
4. Prescription Drugs
ANSWERA

V = ANSWERA * 12 months = Valuation per year

d (Compensating Wage Differential)

Job A: Health benefits (listed above) begin immediately, $40,000
Job B: Health benefits begin after ***n* years** of employment

You are applying for a job and face two options. As outlined above, Job A offers health care benefits that begin immediately. Job B offers health care benefits that begin only after 2 years of working with the company. Otherwise, the jobs are identical. If Job A pays $40,000 a year, what is the lowest salary that could persuade you to take Job B?
$ANSWERQ

D= $ANSWERQ – $40,000 = Extra salary required per year to compensate for loss of benefits during the next ***n* years.**

p (Probability of being at the same job N years in the future)

If you just began a job, such as the job in the above questions, what do you think is the likelihood that you would still be working for the same company ***n* years** from now?
ANSWERC%

P = ANSWERC/100 = Likelihood of being at the same job *n* years from now.

r (Market Interest Rate)

T-Bill interest rates for January 16, 2003 that match up with *n*. For instance, the 2-year T-Bill will be used when $n = 2$ and so forth.

Logic behind this calculation:

Note:
$(\sqrt[12n]{p})^3$ = Probability of being in the same job 3 months from now, given the probability of being in job *n* years from now is *n*. This assumes that the probability of staying at the job is the same for any given month between now and year n. More formally, $(\sqrt[12n]{p})^w$ = P (still in job during month *w*)

Left Side of the Equation

Present Value of extra wages received over ***n* years** by foregoing health care benefits, (discounted at the market discount rate, or the discount rate for money)

This is equal to the sum of the expected monetary payoff each month from now until year n, adjusted with the current market interest rate to get the present value. The expected payoff in month w is the extra wage (above $40,000) the person receives for foregoing benefits times the probability that the person will still be working at this job in month t.
Expected value (month t) = P(still in job during month w) * Extra wages earned month t

Expected value (month t) = $d(\sqrt[12n]{p})^t$

Present value (month t) = $\dfrac{d(\sqrt[12n]{p})^t}{\sqrt[12]{(1+r)}^t}$

Thus, the sum of all present values from month 1 to month $12n$ (or year n) =

$$\sum_{k=1}^{12n} \frac{(\sqrt[12n]{p})^k d}{\sqrt[12]{(1+r)}^k}$$

Right Side of the Equation

Present Value of health care benefits received over t months (discounted at the discount rate health care benefits, my dependent variable).

Expected value of health care insurance (month t) =

P(still in job during month t) * Valuation of benefits = $v(\sqrt[12n]{p})^t$

Present value of insurance (month t) = $\dfrac{v(\sqrt[12n]{p})^t}{\sqrt[12]{(1+i)}^t}$

Where i = discount rate of health insurance (dependent variable)

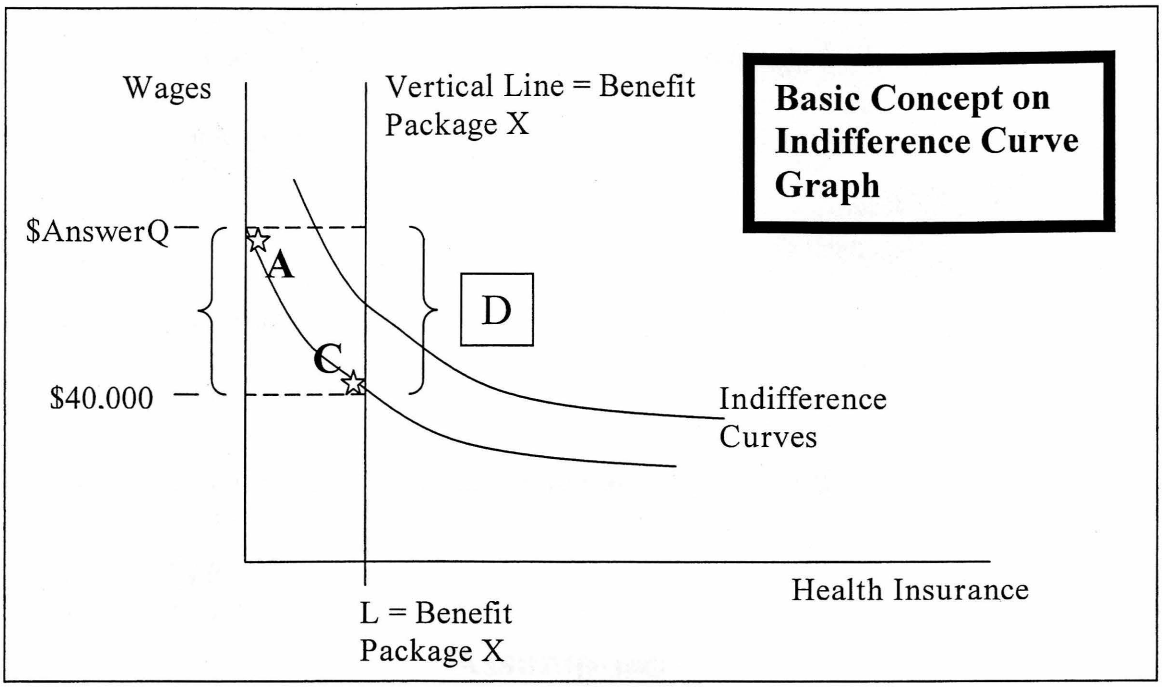
Thus, the sum of all present values from month 1 to month $12n$ (year n) =

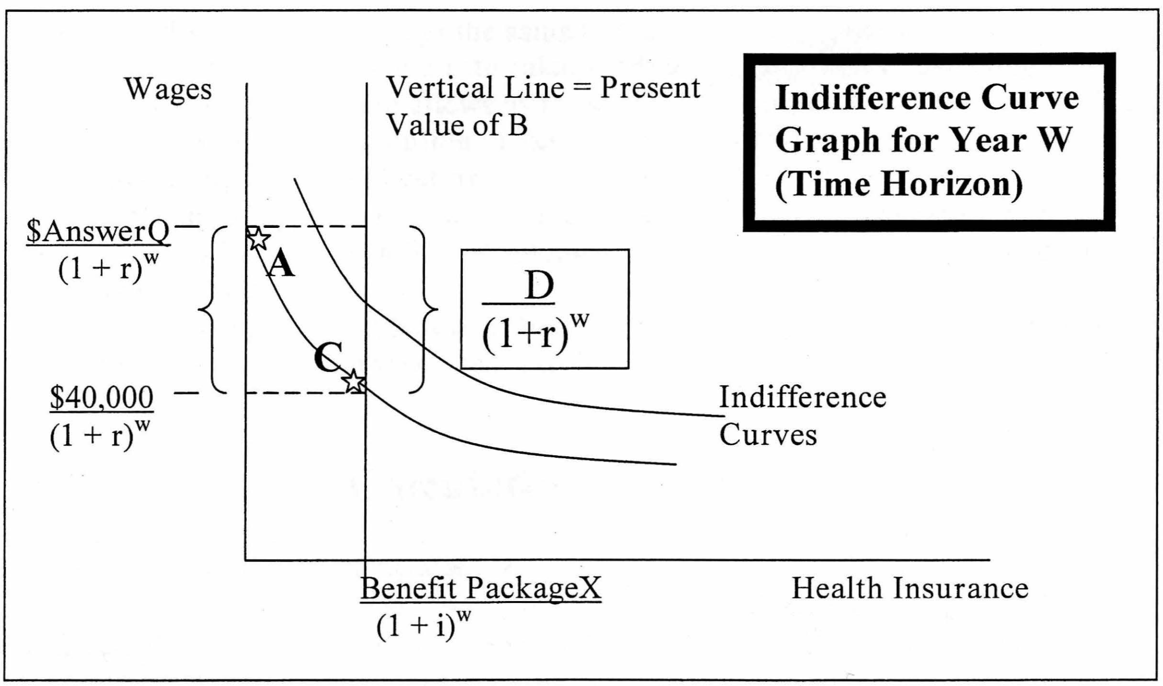
$$\sum_{k=1}^{12n} \frac{(\sqrt[12n]{p})^k v}{\sqrt[12]{(1+i)}^k}$$

Set the Sides Equal

The survey asked people for the "lowest salary that could persuade you to take Job B". This is taken to mean the point of *indifference* because if the job offered one cent less, theoretically, the person should switch back to option A. For this reason, we must set the two sides equal.

On indifference curves, the model looks like this:





Algebraically, then,

Point A = Point B
A=Answer B
C=$40,000 + Benefit Package X
D = Answer B – $40,000

Answer B = $40,000 + Benefit Package X

Subtract $40,000 from both sides:
Answer B - $40,000 = ($40,000 - $40,000) + Benefit Package X

D = Benefit Package X
Value of Benefit Package X = V

D = V

Adjusted for discounting of each axis:

$$\frac{d}{(1+r)^w} = \frac{v}{(1+i)^w}$$

Building in probabilities for leaving the job before year, we get:

$$\frac{d(\sqrt[n]{p})^w}{(1+r)^w} = \frac{v(\sqrt[n]{p})^w}{(1+i)^w}$$

Assumptions:

- The discount rate, i, stays the same between now and **year *n***. Although we are aware it changes at a rate calculated later in this study, assuming a constant discount rate allows us to estimate the discount rate for **year *n***. We will re-visit this assumption in the section "Calculating i from $i_{@20}$" below and interpret its implications.
- Interest rates associated with current ***n*-year** T-Bills, r, accurately portray people's current depiction of the opportunity cost of holding money for ***n* years** into the future.
- Cohorts correctly understood the survey questions listed in the section below: "Where do the numbers come from?"

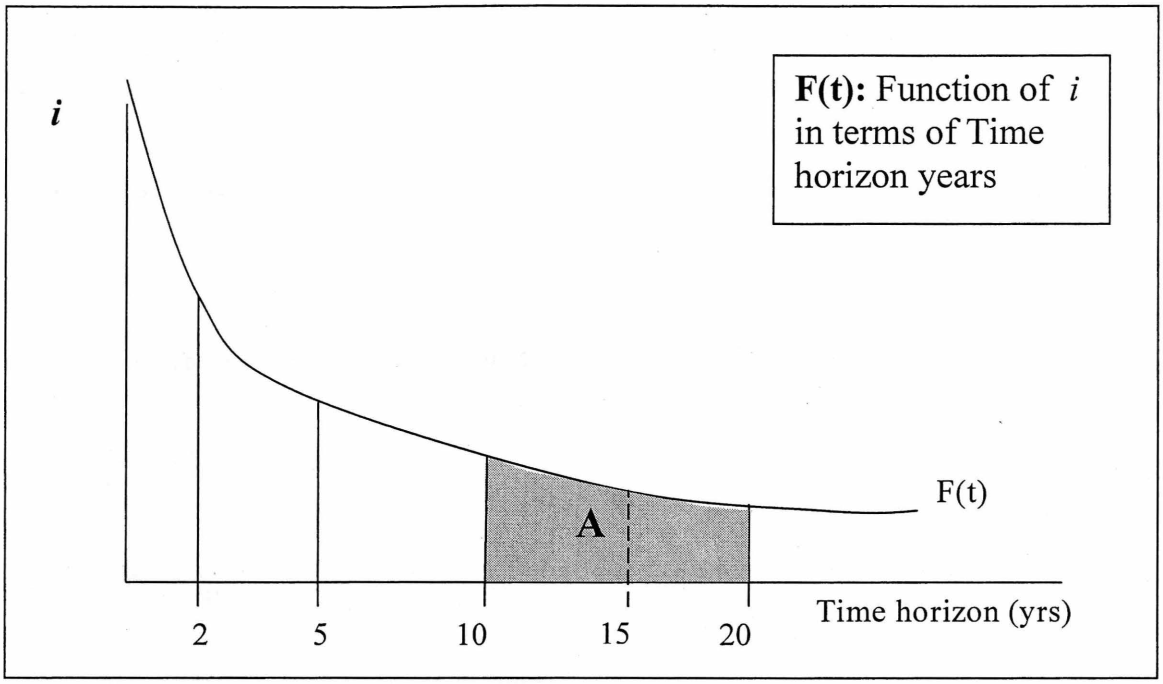
Calculating *i* from $i_{@20}$

After calculating the "i" value associated with each year (2, 5, 10, and 20), we must ask what this means. For now I will call the value calculated above $i_{@20}$ for the i value calculated using the 20 year time horizon. The model listed above makes the assumption that the discount rate stays the same over the entire time horizon. From this, we realize that the "i" we have calculated is not the discount rate associated with year 20, but the *average* discount rate from now until year 20. In other words,

i_{20} = discount rate at a time horizon of 20 years.

$$i_{@20} = \text{average } i \text{ over years } 1 - 20 = \frac{\int_{1}^{20} f(t)dt}{20}$$

f(t) = function of i in terms of time horizon years



Since

$$i_{@20} = \frac{\int_{0}^{20} f(t)dt}{20}$$

Then,

$$\int_{0}^{20} f(t)dt = 20\, i_{@20} = \text{The area under f(t) from 0 to 20}$$

Similarly, the area under f(t) from 0 to 10 = 10 $i_{@10}$

From this, we can calculate the area A, shaded above

Area A = 20 $i_{@20}$ - 10 $i_{@10}$

The average discount rate over the interval t = 10 to t = 20 will be an OK estimate for the discount rate at t = 15.

Thus

$$i_{15} = \frac{20i_{@20} - 10i_{@10}}{20-10}$$

In general

$$i_{\text{midpoint of t=a and t=b}} = \frac{ai_{@a} - bi_{@b}}{a-b}$$

where a>b.

From this equation, we can estimate seven values of f(t), or seven *i* values:

$$i_1 = \frac{2i_{@2}}{2} = i_{@2}$$

$$i_{2.5} = \frac{5i_{@5}}{5} = i_{@5}$$

$$i_{3.5} = \frac{5i_{@5} - 2i_{@2}}{5-2}$$

$$i_5 = \frac{10i_{@10}}{10} = i_{@10}$$

$$i_{7.5} = \frac{10_{@10} - 5i_{@5}}{10-5}$$

$$i_{10} = \frac{20i_{@20}}{20} = i_{@20}$$

$$i_{15} = \frac{20i_{@20} - 10i_{@10}}{20-10}$$