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FINANCIAL PLANNING FOR RETIREMENT: AN ACTUARIAL AND ECONOMIC ANALYSIS

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ABSTRACT

This thesis provides an actuarial and economic analysis of financial saving for retirement throughout the lifetime. I set forth a model based on the economic theory of the life cycle model with consumption smoothing over the lifetime. The general approach could be applied to individuals in determining whether or not they are currently saving accordingly for an adequate retirement. Micro data collected by the Bureau of Labor Statistics Consumer Expenditure Survey is then used to determine general answers as to whether Americans are saving too much, not enough, or adequately for retirement.

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Introduction

Retirement is meant to be a time to enjoy the hard work put in over a working lifetime. It is something that many people look forward to with great anticipation. However, the recession that began in 2007 has made retirement planning a source of great stress. The stock market's value declined 47 percent from September 30, 2007 to December 2, 2008. Moreover, the popularity of defined contribution retirement plans, has generated a high correlation between retirement savings and the stock market. The recent recession eliminated $2.8 trillion of value in 401(k) and individual retirement accounts. Older people began to think twice about retiring. In 2007, 29.7 percent of adults ages 65 to 69 were still in the labor force, this up from only 20.2 percent in 1982. It is no wonder that many people are concerned about the adequacy of their savings, and want to educate themselves about proper retirement preparation. There are many factors that need to be taken into account when analyzing financial planning for retirement. This paper will address many of these variables and attempt to reveal much of the mystery that surrounds the subject. (Johnson, 2008)

The main question I ask in this paper is, "Are people saving enough for retirement?" In order to work towards an answer to this question, I will use the life cycle model and its consumption smoothing characteristics. This economic model will be adjusted for actuarial improvement and matching to sample data. The data is obtained from the Bureau of Labor Statistics Consumer Expenditure Survey. While analyzing the subset of single person consumer units, I find that most people are currently over-saving for retirement. There are some demographic characteristics that demonstrate different saving habits. While trying to determine preparedness for retirement, another result of this research supports the usefulness of annuities in retirement planning.

I will first address the types of income that people often rely on to provide them with an adequate retirement lifestyle: social security, defined benefit plans, and defined contribution plans such as 401(k) plans. Each of these retirement plans works in a separate and distinct way as to how benefits are earned and paid out. In addition to an explanation of the forms of retirement income, Section 1 will also delve into the arena of retirement consumption. There are a number of factors that contribute to altering the amount of income needed to support the same level of consumption during retirement as opposed to pre-retirement. It is important to take these factors into account when financially planning for the future.

Section 2 will discuss an economic model known as the life cycle model. This provides an economic framework and a set of assumptions to analyze current saving and expenditure habits. It subscribes that each person should attempt to smooth their consumption over their lifetime, instead of over-saving at some times and over-spending at others. The economic model can be improved upon with actuarial techniques and the use of a mortality table. The life cycle model combined with actuarial adjustments is the basis for the quantitative models of this paper.

Section 3 presents the quantitative models and a discussion of the data that will be used to produce results regarding Americans' saving habits for retirement. Both models use the consumption smoothing assumption resulting from the life cycle model combined with different financial planning approaches. The first model uses a set of assumptions to calculate the probability that each person will have enough money to maintain their current level of consumption throughout their lifetime. The second model forces each person to buy an annuity at retirement, then determines how much he or she should increase or decrease their current consumption in order to maintain a smooth consumption throughout their lifetime (using wages to support consumption while employed, and social security and their annuity payments while retired). The results of each model will be analyzed individually and collectively to attempt to provide useful insight into retirement saving habits. After producing results for the models, I will

discuss possible ways that this research can be expanded, and conclude by considering the limitations of the models and areas for additional research while further discussing the results of this analysis.

Section 1

Financial Retirement Needs

Forms of Income Retirement

The income needed for retirees is often funded from a number of different sources. The government provides some limited benefits in the form of social security payments. All working Americans pay social security taxes on wages earned. The purpose of these taxes is to fund the retirement of the current retirees, and if funded adequately, another generation will fund your retirement. Also, employers often contribute to their employees' retirement financing in one of two ways, a defined benefit plan (traditional pension) or a defined contribution plan (the most common of which is a 401(k) plan). The traditional forms of retirement income were social security and employer defined benefit pensions. Defined benefit pension plans, sponsored by employers, previously dominated the retirement landscape. In 1974, the Employee Retirement Income Security Act (ERISA) redefined a pension as "any employer or government-sponsored capital accumulation program with a stated purpose of providing funds for retirement." This encompasses defined benefit plans, defined contribution plans, annuity payments, and lump sum distributions of retirement accounts. The all-encompassing definition foreshadows a trend to defined contribution plans that would follow to the current date. Instead of having the employer determine the amount to save in order to pay out a certain retirement benefit, the responsibility now often falls onto the employee. This has manifested itself in the form of a 401(k) plan, whereby employers often match employee contributions. Yet, the employee must then decide how to invest the money and determine how much to contribute themselves. This can be quite a burden to those who have little financial education. (Rajnes, 2002)

Social Security

Social security benefits fit to a rather general formula. It depends on family status (single, one-earner married couple, double-earner married couple), income, and age. For a single person retiring at the normal retirement age in 2010, the benefit formula is as follows. First, an average indexed earnings amount is determined. This is done by taking the wage history of the person, and indexing each year's earnings by multiplying it by an indexing factor. These indexing factors inflate wages earned earlier in life to an inflation-adjusted wage in near-current dollars; the factors for each given retirement year can be found on the social security administration's website. An average of the highest 35 years of indexed earnings is divided by 12 to determine the person's average indexed monthly earnings (AIME). For the first $761 of AIME, social security will replace 90 percent of income at retirement. For AIME between $761 and $4586, 32 percent of income will be replaced at retirement. For any AIME greater than $4586, only 15 percent of income will be replaced, up to a maximum of $7500. To get a better idea of how this formula behaves, for a person with average annual indexed earnings of $20,000 pre-retirement, social security will provide more than half of this annual income ($11,641) upon retirement. Yet, for someone with average indexed earnings of $90,000 pre-retirement, it will provide for slightly less than a third of this annual income ($28,007). Figure 1-1 delineates the social security benefits for varying wage history of a single person household. (Social Security Online, n.d.)

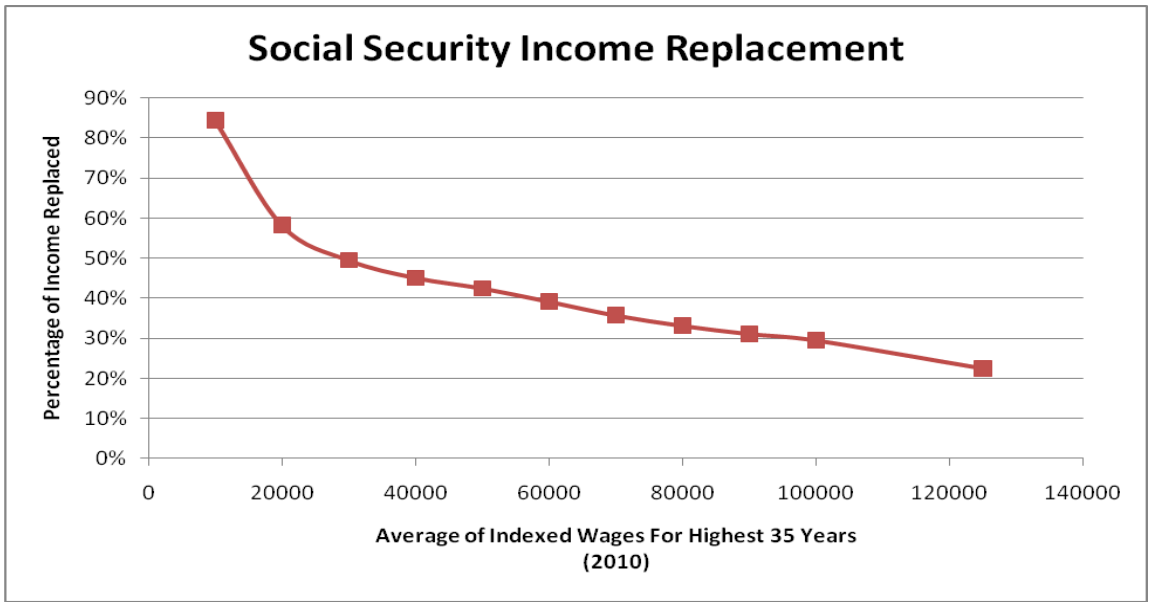

Figure **1-1**: Social security income replacement rates in 2010 for varying wage history

Source: Calculated from formula presented in Social Security Online, "Your Retirement Benefit How it is Figured" < http://ssa.gov/pubs/10070.html>

Defined Benefit Plans

Employer pension benefits are usually clearly defined by the plan administrator. The employer promises to pay a portion of the employee's salary from their retirement to death. Pension benefits can greatly vary based on salary, employer plan specifications, years of service, and so on. Equation 1-1 provides an example of a calculation of an individual's pension benefit. The employer would then determine how much to save, and where to invest its money in order to pay out the obligation.

$$Annual\ Pension\ Benefit$$
$$= (.01) \times (Years\ of\ Service)$$
$$\times (Avg\ Salary\ of\ Highest\ 5\ Annual\ Salaries)$$

Equation **1-1**: Example formula for annual defined benefit pension benefit. Years of service often has a maximum value (usually 30 years).

The Pension Benefit Guaranty Corporation (PBGC) protects the pensions of employees covered by defined benefit pension plans. Plan sponsors must pay premiums to the PBGC set by Congress in order to fund this insurance protection. The PBGC specifically protects normal retirement age pension benefits, most early retirement benefits, annuity benefits for survivors of participants, and disability benefits. The benefits paid out have maximum limits set out each year. See Appendix A for the maximum benefit table for 2009. In 2001 the PBGC insured just over 35,200 defined benefits plans, down from an all-time high in 1985 of 114,400. This decrease in defined benefits plans is attributed to the development and rise of defined contribution retirement plans. (Rajnes, 2002)

401(k) Plan and Defined Contribution Trend

The 401(k) plan has many saving advantages due to its use as a vehicle for retirement capital accumulation. The employee is able to make pre-tax elective deferrals via payroll deductions. These contributions are currently limited to $16,000 annually, with cost of living increases taken into account for future years. At ages 50 and older, additional "catch-up" contributions are allowed to be made up to $5,500 annually. Any employer matching contributions are also tax deductible. These matching contributions allow the employer to pay higher wages to saving employees, who often are high quality workers (Rajnes, 2002). Many

times there are vesting requirements based on years of service to gain the full benefit of the employer matching contributions.

In addition to these tax benefits, most employers have put in place automatic enrollment programs, where the employee must opt out if they want to be excluded from the contribution program. Otherwise, a certain percentage will be deducted from their payroll. This strategy has proven effective in increasing participation in voluntary defined contribution plans. This is all done to encourage saving, but there are distribution limitations that must be followed. If limitations are violated, a penalty tax of 10% will be assessed. The penalty-free distributions are as follows: upon death, disablement, plan termination without a successor defined contribution plan named, attainment of age 59½, or demonstrated financial hardship. Additionally, for those who wait past age 59½ to receive distributions, funds must begin to be withdrawn from the 401(k) plan on April 1 of the year after turning age 70½. In the event that the plan owner would like to access capital in the 401(k), there is an option for borrowing up to 50% (without taxation) of your own 401(k) plan balance. This loan must be repaid within five years to not incur any penalty fees. (401(k) Resource Guide, 2010)

Defined contribution plans place the responsibility on the employee to adequately save for retirement. Although this relieves some burden from the employer, it is not the sole reason for the shift away from defined benefit plans. Government regulation and legislation regarding pension, tax policy, accounting measures, and employee demand all contribute to the trend. The demographics of employees and shifts in industrial composition have affected the mobility of employees, encouraging the use of defined contribution plans. Using these individualized plans does not take advantage of the economies of scale or the distribution of investment risk that defined benefit plans offer (Broadbent, Palumbo, & Woodman, 2006). Figure 1-2 demonstrates the trend within the pension industry.

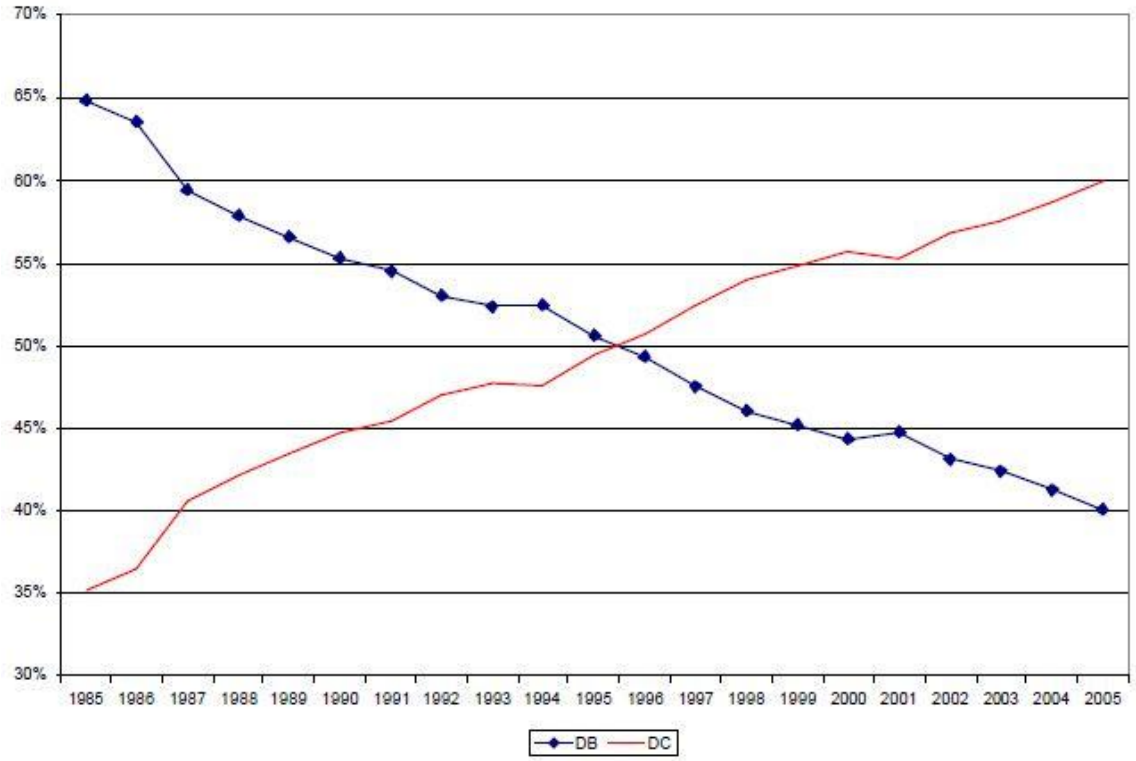

Figure **1-2**: Percentage share of assets in US DB and DC pension plans: 1985-2005
Source: Broadbent, Palumbo and Woodman

The Employee Benefit Research Institute has modeled retirement trends, and has come to conclude that "there will be a definite increase in retiree income that will need to be managed by the individual" (Rajnes, 2002). This will inevitably lead to financial literacy becoming a necessity among many more people (Lusardi and Mitchell, 2005). Annuities are the most reliable option for protecting against outliving the wealth accumulated during employment. Annuities are a form of investment that guarantees a stream of payments with a specified rate of return. These payments, formally known as rents, can vary in their amounts (increasing, decreasing, or level) over the duration of the contract (which can also vary). The most useful type of annuity for retirement planning purposes is a level whole life annuity where level rents are paid out until death; this investment option creates a stream of payments very similar to that of an employer

sponsored pension. The shift to defined contribution plans should lead to an increase in demand for annuities. However, annuity markets in the United States are underdeveloped for two main reasons. First, the demand for annuities has not been high enough to breed maturity within the market. This is partially due to price increases associated with the decline of long term interest rates over the past several years. Also, traditionally high loading costs caused financial planners to advise against the purchase of annuities. The recent advent of no-load annuities offer a more competitive option that could stimulate demand. Second, adverse selection, in the form of mostly healthy people purchasing annuities, has also increased prices. There have been policy proposals to make annuitization of retirement accounts compulsory in an effort to eliminate the adverse selection problem. (Broadbent, Palumbo, & Woodman, 2006)

Consumption Adjustments during Retirement

During retirement, less income is needed to support the same amount of pre-retirement consumption. There are a number of factors that contribute to this fact. Social security and Medicare taxes no longer need to be paid, and income taxes will be significantly less. Contributions to pension plans or savings accounts are not necessary once retired. These tax changes only affect the income needed to support the same consumption at retirement. However, if looking purely at the consumption pre-retirement and during retirement, there are different factors that must be taken into account. Work-related expenses (Ex. Buying suits, dry cleaning services, etc.) drop off at retirement, and with more time to find lower cost alternatives, meals and home maintenance costs can also decrease. These effects are more significant for those who are willing and able to use their free time to be economically productive. Such expenses can account for up to 7% of income. (Gebhardstbauer, 2004)

There is one area where expenses may increase during retirement, healthcare. For those whose employer stops paying for health care after retirement, additional income would be required to pay for these insurances out-of-pocket. Although Medicare covers those ages 65 and older, premiums of about $3,000 per year are needed for Medigap Insurance (covering items that Medicare does not). Long term care is another consideration. Many people depend on their homes to pay for any long term health needs. However, for those that don't own a home, or are married and the home won't be sold upon the first spouse's need for long term care, a long term care insurance policy may be needed. This costs approximately another $3,000 for each year during retirement. Given the above circumstances, an increase of about $6,000 per year is needed to compensate for new health care insurance. This is a nominal amount in 2004 dollars, and not contingent upon the income of each individual person. All changes in costs will have to be accounted for in the models set forth in this research. (Gebhardstbauer, 2004)

Section 2

The Life Cycle Model

It can safely be assumed that most people do not want to be forced to decrease their consumption in retirement to assure them of solvency until death. In fact, many economists have proposed that if given the appropriate information, a life cycle model with consumption smoothing would be the preferred economic decision. This model maintains that consumption remain constant over the lifetime. This involves savings during the most lucrative years of employment, and using this saved money to support retirement. For some, they may even have to borrow in early years, when income is low, to accomplish this goal. In reality, many people misjudge variables that go into the life cycle model calculations. This often results in under-consumption both early and late in life, with over-consumption during the years when more saving should occur. With proper education, this common effect can be minimized, and possibly eliminated.

The life cycle model is simply a framework for thinking about decision making, in both the present day and future, allowing for sequential decisions to be made to reach a specific goal, with the given information. Economic examination of the model, with rational decision leads to the phenomenon known as consumption smoothing. Such smoothing can be examined at a number of different frequencies. It could occur over the period of a week, year, business cycle, or throughout all of these stages within the life cycle (which will be the assumption for this paper). It is important to note that consumption smoothing doesn't necessarily refer to the same consumption amount; it is actually referring to the marginal utility of consumption that should remain constant. (Browning and Crossley, 2000)

In a two period model, assuming that the marginal utility of consumption decreases as more is consumed, consumption in the second period then begins to look more appealing. This

will lead to a rational person consuming up to an amount where the marginal utility of another dollar of consumption today is equal to the marginal utility of another dollar of consumption in the next period. When using nominal dollars with interest rate 'r', consumption in the first period 'c_1', consumption in the second period 'c_2', income in the first period 'y_1', income in the second period 'y_2', taxes in the first period 't_1' and taxes in the second period 't_2', Equation 2-1 shows the inter-temporal budget constraint, setting the present value of consumption to the present value of income. By setting the present value of income equal to wealth, 'we', we can arrive at the consumer's problem to maximize the utility of consumption today and consumption tomorrow, subject to Equation 2-2.

$$c_1 + \frac{c_2}{(1+r)} = (y_1 - t_1) + (\frac{y_2}{(1+r)} - \frac{t_2}{(1+r)})$$

Equation **2-1**: Inter-temporal budget constraint for the life cycle model, setting the present value of consumption equal to the present value of income.

$$c_2 = we(1+r) - c_1(1+r)$$

Equation **2-2**: Constraint to consumer's utility problem, setting consumption in the second period equal to wealth minus consumption in the first period indexed to second period dollars.

The resulting consumption smoothing will be utilized when determining the amount of money needed to support retirement, as the characteristics of the individual change at this point in their life.

Economists' analysis has brought about a number of different observations. Households with similar characteristics often times end up with very different wealth levels at retirement, some with even little or no wealth. This suggests that the model should also allow for

heterogeneity across households. Each person who, by assumption, makes consumption and savings decisions according to the life cycle model faces very different circumstances with different preferences, opportunities, and information. This may be a cause for inaccurate results when analyzing data on a homogeneous basis. Yet, the drawbacks in information availability can easily occur when examining each single individual. It is also important to highlight the reality of imperfect credit markets whereby people are not always able to borrow and save as they please. (Browning and Crossley, 2000)

For a single person to attempt to use the framework of the life cycle model, they must know or assume a number of aspects; his or her future lifetime income is one of them. While it is possible to assume future income amounts based on your current situation, there is variation involved. This variation is well known by the predicting individual, and introduces additional risk to the model. In an effort to offset this risk, some may decide to save more than the model would suggest. This over-saving is economically known as precautionary savings. Another omission of the life cycle model involves the imperfection of credit markets. The model assumes that the given individual can borrow immediately borrow any amount needed to support his or her economic decisions. However, when access to capital is limited, the result is once again an appearance of over-saving when compared to model results.

Jonathon Skinner addresses the life cycle model for retirement in his article, "Are you saving enough for retirement?" He delineates a model based on non-housing net worth, with the assumption that most people would want to remain in their house until absolutely forced to do otherwise. In this model non-housing wealth is composed of 401(k) plan balances, IRAs, stock investments, equity in second houses. Note, it excludes pension plans and social security payments that are included as portions of retirement income. A target wealth for consumption smoothing is then calculated by subtracting the present value of lifetime net earnings, pension flows, and social security payments from the present value of lifetime non-housing consumption

plus bequests. In order to calculate the present value of a stream of cash flows, some actuarial formulas must be utilized.

Equation 2-3 shows the basic formula for calculating the present value of 'n' annual payments of $1, discounted at an interest rate, 'i'. Variations of this formula (Equation 2-3 – Equation 2-7) are used to make calculations for the present value of income and consumption that are needed to determine the target wealth amount (Equation 2-7). The intermediate formulas calculate the present value of a worker's consumption from now until the time of death, the present value of a worker's retirement income (social security and pension cash flows), and the present value of a worker's income from now until the time of retirement.

$$a_{n]} = \sum_{j=1}^{n} \frac{1}{(1+i)^j}$$

Equation **2-3**: Formula for present value of 'n' annual payments of $1

$$PV\ Lifetime\ Consumption\ =\ (Annual\ Consumption)a_{(Age\ of\ Death - Current\ Age)]}$$

Equation **2-4**: Based on Equation 2-3, discounts the annual consumption amount for each year between the current age and age of death to the present day.

$$PV\ Retirement\ Income = \left(\frac{1}{(1+i)}\right)^{(Retirement\ Age - Current\ Age)} \times (Social\ Security + Pension)a_{(Age\ of\ Death - Retirement\ Age)]}$$

Equation **2-5**: Based on Equation 2-3, discounts annual retirement income amount for each year between the retirement age and age of death to the present day.

$$PV\ NonRetirement\ Income =\ (After\ Tax\ Income)a_{(Retirement\ Age - Current\ Age)]}$$

Equation **2-6**: Based on Equation 2-3, discounts annual after tax income amount for each year between the current age and retirement age to the present day.

$$Target\ Wealth = PV\ Lifetime\ Consumption - PV\ Retirement\ Income - PV\ NonRetirement\ Income$$

Equation **2-7**: Based on the results of Equation 2-4 – Equation 2-6, determines a target wealth value for the present day.

If the current non-housing net wealth is less than the target wealth, then the given household is not saving enough to smooth consumption throughout their retirement.

Looking at the above formulas, there is one variable that should stick out as difficult to approximate. Estimating annual consumption may be time consuming, and determining one's pension and social security benefit requires going through paperwork. However, it is much more difficult to predict an age of death with a high level of certainty. The age of death can greatly affect retirement planning decisions, and the use of mortality tables allows us to determine the probability of dying at each age. (Skinner, 2007)

Actuarial Adjustments to the Economic Model

All models require some degree of assumption. While some assumptions are necessary, others can be improved upon or eliminated. In his model, Skinner uses a single life expectancy number with certainty to determine the present value of pre-retirement income, retirement income, and consumption. Instead of making this assumption, it is possible to use stochastic techniques to introduce uncertainty in the length of each person's life while making the model more accurate.

This is where an actuarial education becomes very useful. Instead of simply using an average life expectancy number, actuaries track statistics regarding the lifetime lengths of different types of people. Mortality tables are developed, often separated by distinguishing

demographic features, such as smokers/non-smokers and male/female. These mortality tables display the number of people who die within each year. From this the probability that a given person age 'x' lives to age 'x+s' and dies before turning age 'x+s+1.' In actuarial symbols, this is represented by '$_{s|1}q_{x'}$.' With this probability, we can then calculate a probability that, with a given level of wealth, a person will die before running out of money. This of course assumes a certain interest rate. The calculation would look similar to Table 2-1, with age values that reach from the person's current age to the last age value on the mortality table (where all people are assumed to die, usually 120). The sum of these probabilities should, if calculated correctly, be equal to one.

Table **2-1**: Data for sample calculation of probability of wealth lasting through retirement. Target wealth would be calculated as in Equation 2-7, and current wealth as non-housing wealth of the individual.

Age	Prob. of Dying	Target Wealth	Current Wealth
70	.03	100,000	110,000
71	.05	120,000	110,000

$$Sum\ Probabilities\ for\ all\ Ages\ where\ Target\ Wealth \leq Current\ Wealth$$

Equation **2-8**: Probability of wealth lasting through retirement example calculation

The above calculation would allow different people to determine which level of certainty with which they are comfortable. One person may be worry-free, knowing that there is an 85 percent chance that they won't have to decrease their consumption to have their money last through retirement. Another may want a higher probability, all depending on risk aversion preferences. The preceding discussion assumes that there is no insurance market available. The next section will discuss the option of purchasing an annuity to guarantee income until death.

Annuity Option for Guaranteed Retirement Income

In order to have complete certainty that you will be able to have constant consumption throughout retirement, an annuity is the simplest solution. A whole life annuity is basically insurance against outliving one's economic means, paying out rents to the annuitant until death. The amount of these rents is dependent upon how much money is paid into the financial instrument. For the purposes of this analysis, we will examine a level whole life annuity with a single premium payment. All assets would be put towards buying an annuity at the time of retirement, inherently smoothing income throughout retirement. For example: A 65 year old male has accumulated wealth of $100,000 which will be put towards the purchase of an annuity today. Based on the person's age (65) and gender (male) the annuity would be priced at $16.32 per $1 annual rent (Table 3-1). This means that the given person would be able pay $100,000 for a contract that promises to pay out (100,000/16.32) = $6,127.45 annually from age 65 until death. With this approach, we can calculate, given current wealth, income, and saving/spending habits, how consumption can increase or decrease at retirement. However, for those not yet retired, this does not solve the problem of lifetime consumption smoothing, as this method provides two separate consumption levels: retirement and pre-retirement.

By adjusting current saving/spending habits, we can match retirement consumption with pre-retirement consumption. Saving more pre-retirement pays a "double dividend." Increasing savings inherently decreases consumption, making it easier to match that consumption when retirement comes around. This adjustment requires an iterative calculation to continue pricing annuities, until the annuity payout matches current consumption. It is important to note that in annuity pricing, rating variables are limited by law. This would eliminate the effect of demographic information on the calculation, as can be taken into account for the probabilistic

approach. Annuity prices are only allowed to depend on gender, age, current interest rates, and preferences on premiums and rents.

Section 3

SAS Models Using Micro Data

Consumer Expenditure Survey Data

In order to conduct some analysis on the savings and expenditure habits of Americans, data was obtained from the Bureau of Labor Statistics. This department conducts an annual Consumer Expenditure Survey which contains income, expenditure, assets and liability, and demographic data for American consumer units. The most recent data available was used for the analysis; this was data from the 2009 survey. A number of different approaches were taken with this data to determine if the given consumer units are appropriately saving for retirement given a set of assumptions, including consumption smoothing over the lifetime.

Only single person consumer units were considered. For many reasons these are the consumer units that can most easily be analyzed, with all assets, liabilities, income, and expenditure attributed solely and exactly to that one person. The assumption must also be made that these people will remain single over their lifetimes. In the 2009 Consumer Expenditure Survey, single person consumer units comprised only about 10 percent of the entire sample. I took other steps to create a data set that is homogeneous in some aspects. The single person consumer units were limited to those who had a complete survey income response, were not under the poverty threshold in the current or previous year, and recorded salary. Once eliminating observations that did not meet these criteria, the sample size was reduced to 98 observations, only 13 percent of all single person consumer units, and approximately 1.3 percent of all surveyed consumer units.

Let's take a closer look at the 98 consumer units that I will use for my analysis. The data shows that 62 percent of the sample is male, while only 38 percent is female. This is generally

acceptable as we see more males remaining single throughout their lifetime. Broken down by collar, we see that the majority of the sample, 78 percent, is white collar workers. It is also important to see the data broken down by gender and education level as in Figure 3-1.

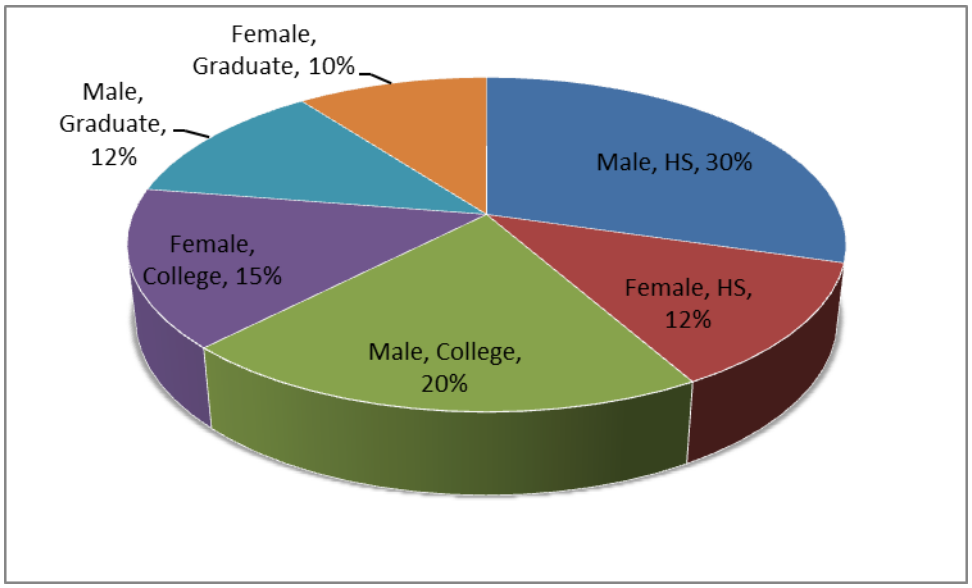

Figure **3-1**: Proportions of demographic groups within data to be used in model analysis, broken down by gender and education level (HS = High School).

It is interesting to see these proportions as I will eventually be analyzing these groups' savings decisions separately. I will also be analyzing and discussing model results based on three age groups: young (ages 20-35), middle aged (ages 35-50), and old (ages 50+). The prevalence of each of these age groups within the data can be seen in Figure 3-2.

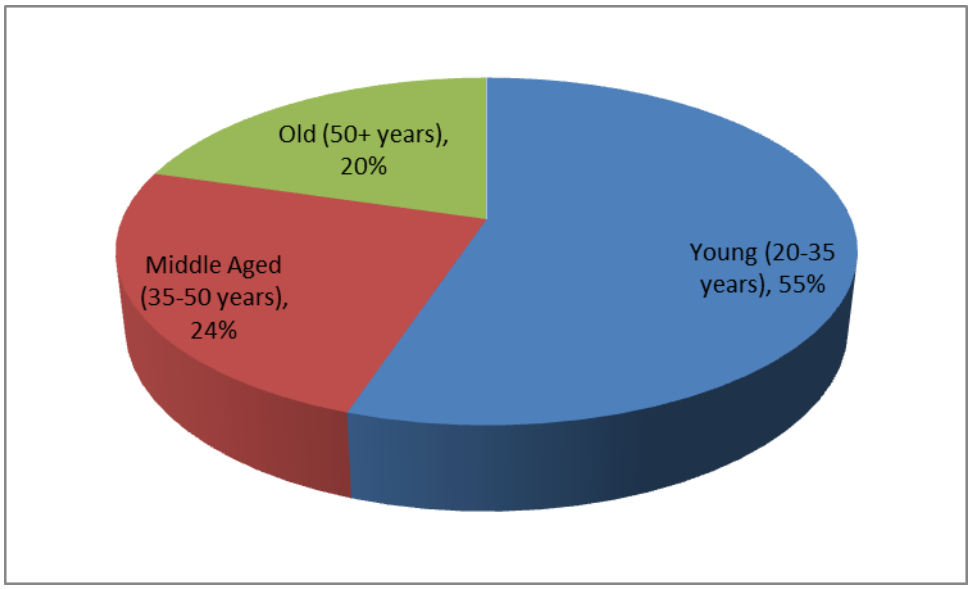

Figure **3-2**: Proportions of demographic groups within data to be used in model analysis, broken down by age.

An important aspect of the data that will be used in the models to follow is the savings rates of the consumer units. The final visual representation of the data presented is the frequencies of different ranges of savings rates within the data. Although it appears that the savings rates are generally higher than would be expected, the distribution does resemble a normal curve which provides optimism for its preciseness (Figure 3-3).

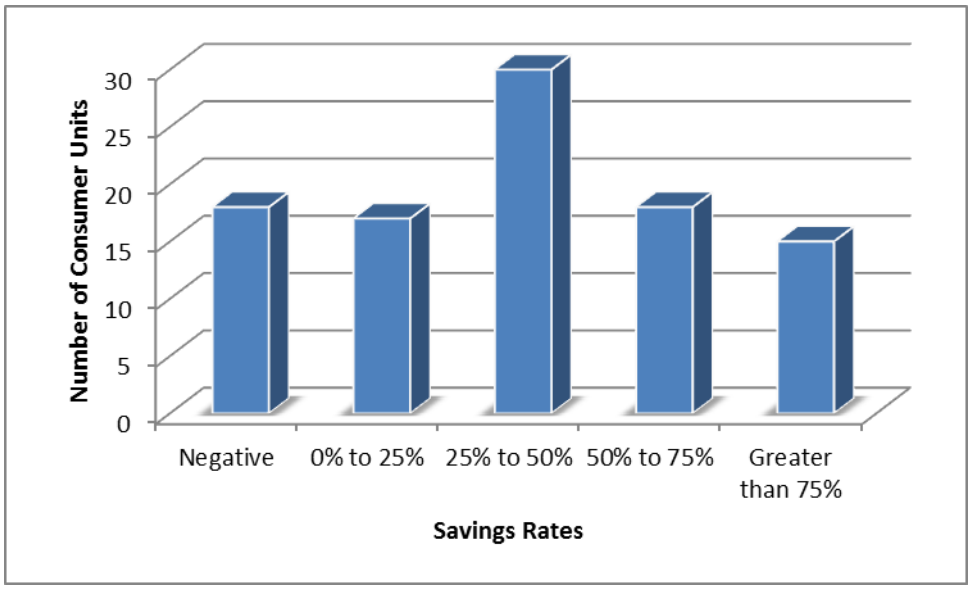

Figure **3-3**: Frequency of different ranges of savings rates in the selected group of the Consumer Expenditure Survey.

As was noted, these savings rates seem higher than expected. The way that the survey collects the expenditure data provides some insight as to why this may be the case. Total expenditures are reported, separated into different spending categories. However, the expenditures are not classified as either normal expenditure or large one time purchases. Therefore, those with very low savings rates derived may have recently made a large purchase, such as a house or car. They most likely would have saved over a period of time to build up enough money to make the purchase. During the "saving period" time their savings rate would be reported as higher than their average, and when making the purchase much lower than their average. This will make a representative person an important tool in the model analysis. By taking the average over a group of people with similar demographic characteristics, hopefully we can account for these misperceptions in savings rates.

With a better understanding of the characteristics of the data that will be used in the analysis, the quantitative model can begin to be built. In order to apply the economic life cycle

model to the data of the Consumer Expenditure Survey, variables were matched from the survey to formulas as closely as possible, and some other adjustments were made.

Probability Model

In the probability model, I calculate the probability that, given certain assumptions, each person will have enough assets to support their retirement at their current consumption level. I will assume that each person analyzed will continue to accumulate wealth based on current saving habits, with income adjustments over the lifetime, and constant consumption.

Mortality Table Matching

The RP2000 Mortality Table, found in Appendix B, was used to provide probabilities for specific types of people living from one age to another. This actuarial table has mortality rates separated into four different groups: male, blue collar; male, white collar; female, blue collar; female, white collar. The occupation variable in the Consumer Expenditure Survey was used to determine the collar value. White collar occupations categories: administrative and managerial operations, teachers, technologists, technicians, marketing and sales operations, administrative support (including clerical). Blue collar occupation categories: service, agricultural, forestry, fishing, mechanics, repairs, construction, transportation, handlers, helpers and laborers. Using the derived collar variable and given gender data, each consumer unit in the survey was matched to the appropriate RP2000 mortality table. (Papageorgiou, 2010)

Income Projections

After tax income was used as the baseline for pre-retirement income. Income adjustments were made to project income amounts for each person's future years of employment. The Consumer Expenditure Survey member file contains after tax income information for all reference persons in each consumer unit. This data was extracted, along with age, sex, and education variables. Four separate groups were formed from these reference persons, broken down by sex (male or female) and education (high school degree or less, some college level degree, and some graduate level degree). An income profile based on age was developed for each group. This profile was smoothed by taking five year averages for the following age brackets: 18-22, 23-27, 28-32, 33-37, 38-42, 43-47, 48-52, 53-57, 58-62, and 63-67. The income profiles can be seen in Figure 3-4.

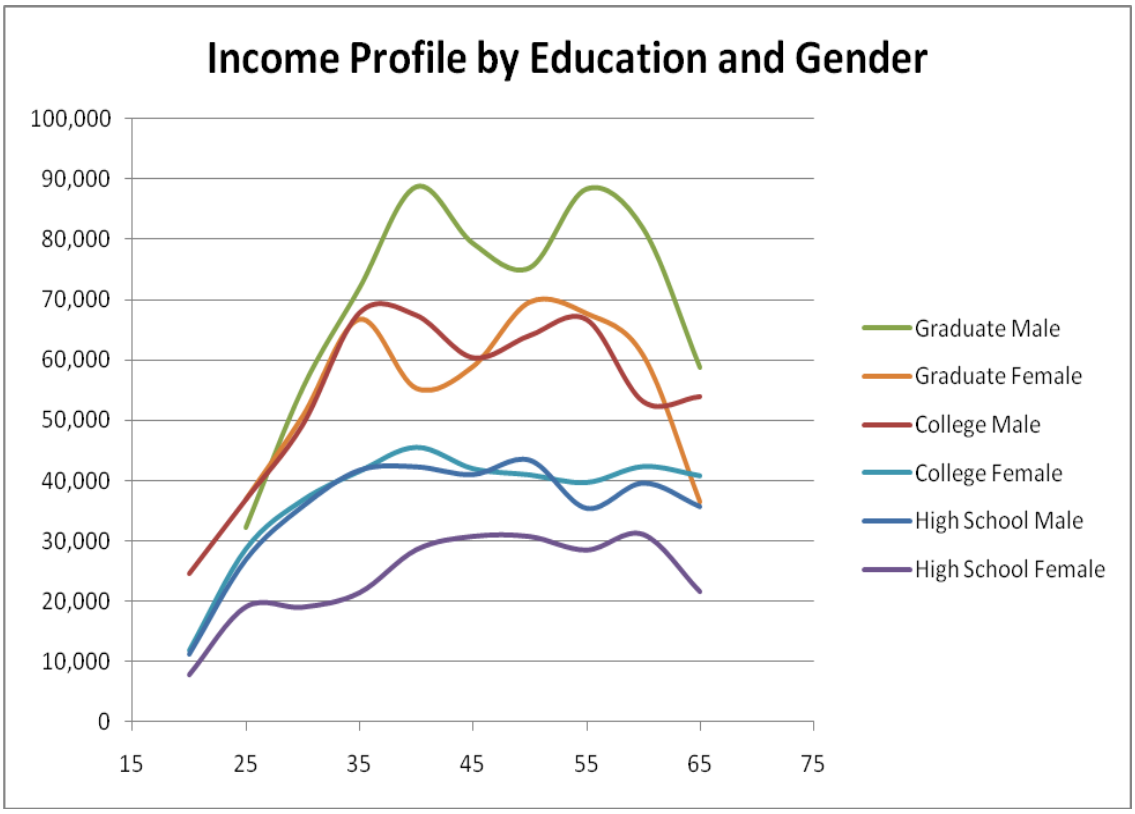

Figure **3-4**: Income profiles for groups separated by age and education

Factors were then calculated to go from one age bracket to another. These five-year factors were broken down to annual factors which would be held constant for each five year period between median ages for each bracket. Appendix C contains the resulting income adjustment factors that were used to project income into the future and back through the past.

The normal retirement age for social security benefits is based on the year of birth. For those born after 1960, the normal retirement age is 67; for those born before 1960, the normal retirement age ranges from 65 to 66 and 10 months. The normal retirement age is the age at which social security benefits can begin to be paid out without a reduction or increase in the amount calculated from the benefits formula. For simplicity's sake, I assumed a retirement age of 67 for persons born after 1960, and 65 for persons born before 1960. The social security benefit formula explained in the Social Security section of Chapter 1 was coded into the model to calculate its portion of retirement income for each person. (Social Security Online, n.d.)

Tracking Expenditure for Consumer Units

The Consumer Expenditure Survey measures expenditure on a quarterly basis. Each quarter the consumer unit reports the current quarter's expenditure as well as the prior quarter's expenditures. We will use the prior quarter variable to more accurately capture total expenditure for the quarter. Using the current quarter's expenditure could be incomplete if the respondent doesn't account for future expenditure within the quarter. Even if future expenditure is taken into account, there is still an element of uncertainty that would go with it. There are two possible approaches to determine annual consumption: take one quarter's expenditure and multiply it by four, or add the four separate quarters of expenditure while tracking each consumer unit. The latter option is more precise. However, a number of consumer units did not consistently respond

to the survey. Removing consumer units whose expenditure was incomplete for at least one of the four quarters decreased our sample size from 98 to 63. This sacrifice in sample size is too large to ignore. A combination of the two approaches was used to keep the sample size at 98. Consumption was tracked through the four quarters all consumer units, but an average of all available quarters' expenditure was used to replace missing data.

Derivation of Current Wealth

The Consumer Expenditure Survey does not provide an explicit variable for wealth. For the purposes of this model, wealth was derived as the sum of the amounts held on the last day of the previous month of all checking, brokerage, and savings accounts, the estimated value of securities (stocks, mutual funds, private bonds, government bonds, and treasury notes), the amount held in U.S. savings bonds, and the amount of money owed to the person from people outside the consumer unit. Again, to provide a sample with complete information, any consumer units that were missing all values to comprise the wealth derivation were removed. It is important to note that debt was not included in the calculation of wealth. Any debt, such as mortgages, loans, or credit cards were assumed to be factored into the expenditure variable. The payments currently being made on these liabilities may be over-exaggerated, as they are assumed to be part of the lifetime consumption of the consumer unit. In reality, these liabilities should eventually become completely paid off (assuming that appropriate payments are currently being made) and this expenditure would then cease to exist from that point forward.

Annuity Purchase Model

This model takes a different approach to financial planning for retirement. The annuity purchase model keeps the assumption that each consumer unit will keep their current saving/spending habits from the present day throughout their lifetime. Instead of looking at a percentage chance that they will have enough assets to support their retirement, I will now look at determining the level of consumption that will allow each person to guarantee a smooth level of consumption throughout their lifetime. The purchase of an annuity at retirement is the key aspect of this model.

Aspects from Probability Model

This model borrows more than just the simple consumption smoothing assumption from the probability model. The income factors that are used to project after tax income in both the future and the past are used in the same manner in this model. Also, salary projections and social security benefit calculations remain the same. The probabilities that are calculated in the probability model are unnecessary when taking the annuity purchase approach. However, a mortality table is still needed in order to price the annuities that are to be purchased. A new portion of the RP2000 mortality table was used for the pricing purposes. Let's take a closer look at the annuity model.

Annuity Pricing

The mortality statistics used to price annuities are based on a more specific group of people than the general American population. Those who choose to purchase annuities usually plan to live longer than the average person, and therefore, purchasing an annuity is a better

investment choice. In order to account for this, annuity sellers take only mortality data for a subset of "healthy" people. The annuity pricing only allows for pricing to be separated by age and gender, as can be seen in the last two columns of the RP2000 mortality table in Appendix B.

Because I assume a retirement age equivalent to the normal retirement age according to the U.S. Social Security Administration, there are only two ages at which an annuity needs to be priced. The general method of pricing an annuity is to take the probability that the person will live to each time of payment, and multiplying that probability by the amount of the payment and the discount factor to bring the dollar amount to a present value. Equation 3-1 shows this calculation in a mathematical formula.

$$a_x^{\cdot\cdot} = \sum_{t=0}^{\omega-x-1} (v^t)({}_tp_x)$$

Equation **3-1**: Formula for actuarial present value of an annuity that pays $1 annually. 'ω' is equal to the age at which all people in the mortality table are dead. 'x' is the current age of the person being evaluated. 'v' is equal to the discount factor at a given interest rate. '${}_tp_x$' is the probability of a person age 'x' living to age 'x+t'.

Sellers of annuities will not charge a price as low as this actuarial present value. They take this number and multiply it by a loading factor in order to account for other, non-mortality expenses and expected profits. For this model I assumed a loading factor of 1.05, in agreement with Gebhardstbauer in his paper, "How Much Money Do I Need to Retire?" The given mortality table and loading factor resulted in the four annuity prices displayed in Table 3-1.

Table **3-1**: Annuity prices at two retirement ages by gender

Gender	Age	Price of Annuity (per $1 annual payment)
Female	65	18.23
Female	67	17.03
Male	65	16.32
Male	67	15.11

Calculation of Wealth at Retirement

In order to determine the annual rent payments of the annuity that is assumed to be purchased by each person at retirement, a calculation of wealth at that time is essential. The income projections up to the age of retirement and the constant consumption amount are used to determine annual savings. Those savings are assumed to accumulate a 1.52% real rate of return, based on the current long-term treasury yield (Federal Reserve Statistical Release, 2010). In this model I assume that all the wealth that is built up during wage earning years is put towards buying an annuity at retirement. This number for wealth at retirement is divided by the appropriate annuity price from Table 3-1 to determine the annual rent payments due the retiree who is surrendering their wealth asset. For example, a male who has accumulated $100,000 of wealth at his retirement age of 65, would be able to buy an annuity that has annual rents of (100,000/16.32)=$6,127.45 until death. A female with the same amount of wealth at age 65 would be able to buy an annuity that has annual rents of (100,000/18.23)=$5,485.46. The difference between the annual rents that each person can afford is due to females living, on

average, longer than males. Hence, the annuity seller must plan on making more rent payments to the female, and charge her a higher price.

The calculations as explained up to this point for the annuity purchase model do not satisfy the lifetime consumption smoothing assumption. Two levels of consumption would exist during each person's lifetime, one that occurs pre-retirement and another that occurs during retirement. Further analysis is required in order to smooth out this disparity.

Lifetime Consumption Smoothing

As explained in Section 1, changing consumption today pays a "double dividend" whereby the amount that you increase or decrease consumption goes directly towards saving less or more for retirement. In order to determine the level that creates lifetime consumption smoothing, an iterative calculation must be made. There are two directions to make the calculation. If current consumption is less than retirement consumption (the annual sum of annuity payments and social security benefits), then current consumption is increased by $1, retirement wealth and its matching annual annuity rent is determined, this loop then continues until current consumption is greater than or equal to retirement consumption. It is necessary to say "greater than or equal" to rather than simply equal to due to the fact that not all numbers are rounded. This method will produce a smooth consumption within $1. If current consumption is greater than retirement consumption, then the same calculation is made in the opposite direction (subtracting $1 and continuing until current consumption is less than or equal to retirement consumption).

Also mentioned in Section 1, the amount of money needed at retirement to support the same level of consumption is different. This is due to the absence of work-related expenses, the opportunity to turn time into cheaper alternatives, and an increase in medical expenses. In this

model I assumed the amount of money during retirement needed to support pre-retirement consumption is 93% of pre-retirement consumption plus $6,000 for medical expenses (Gebhardstbauer, 2004).

Results

This section will discuss the results of both the probability and annuity purchase models. While the two models examine the same topic through different approaches, we will see that the annuity purchase model provides greater insight into the saving habits for retirement. With that said, this model also demonstrates that for this sample, it generally appears that people are over-saving in terms of consumption smoothing and the life cycle model.

When comparing any number of specific groups to the rest of the sample population, there was almost never any evidence of a statistically significant difference using a T-test procedure. The groups that proved to be statistically insignificant compared to all others are: retirement account contributors (pension, individual retirement account, government), education (high school or less, college degree, graduate degree), race (white, black, Asian), homeowners, sex (male, female), and collar (blue, white).[1]

The one category that showed statistical significance in difference in retirement preparedness is age. When comparing the probability that their wealth will last through retirement, young people (ages 20-35) have a statistically significant higher probability of successfully smoothing their consumption throughout their lifetime. Meanwhile, middle-aged (ages 35-50) and older (50+) people have a statistically significant lower probability of

[1] This can partially be attributed to the sample being of inadequate size to have a significant number of observations within each group.

successfully smoothing their retirement throughout their lifetime. This is also the case when comparing the results of the annuity model. The results of the T-tests can be found in Table 3-2.

Table **3-2**: T-test results for comparing each category to the rest of the sample population. A t-value of less than .10 (marked with a *) will be accepted as statistically significant at the 90% confidence level, indicating that the means of the two categories are different for the population.

	Sample Size	Avg. Prob. Of Wealth Lasting	t-Value		Avg. Change to Smooth Consumption	t-Value
Young	54	.6628	.0083*		1.670	.0002*
Not Young	44	.4321			.412	
Middle Aged	24	.3675	.0121*		.455	.0310*
Not Middle Aged	74	.6215			1.323	
Old	20	.5097	.5704		.360	.0279*
Not Old	78	.5720			1.303	

This supports the general theory of the life cycle model and its limitations. It has been found that one of the problems with applying the life cycle model to reality is that credit markets are imperfect. This is especially true for younger people who are not always able to borrow the money that is needed to allow for lifetime consumption smoothing, and therefore, the data generally shows that this age of people tend to over-save. Figure 3-5 demonstrates the breakdown of current saving habits by age group. Figure 3-6 shows a similar trend for the probability model. In both figures it can be seen that a much larger proportion of young people are over-saving (in the annuity purchase model) or have a high probability of successfully smoothing consumption throughout their lifetime based on current habits (in the probability model).

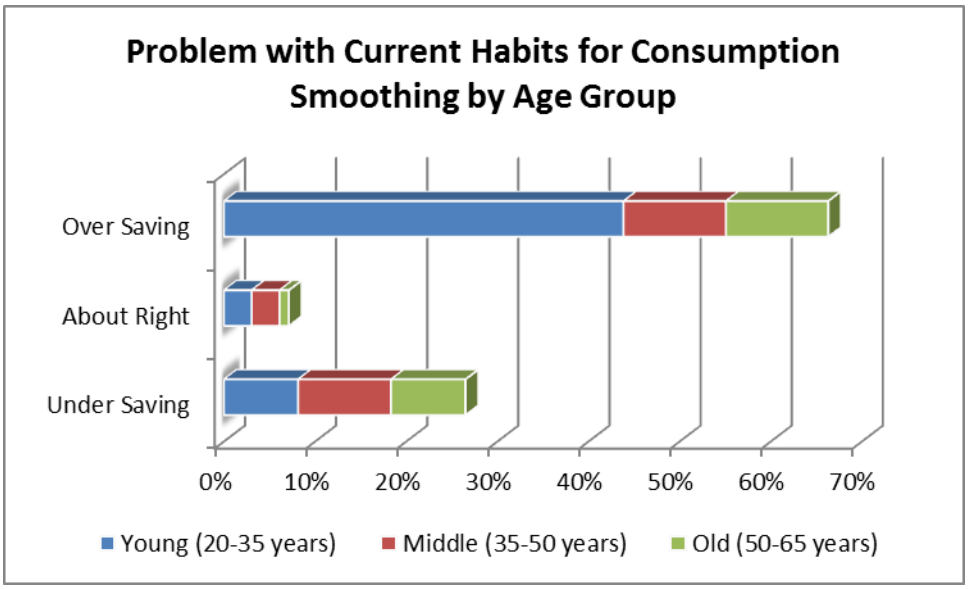

Figure **3-5**: Proportional break down of current saving habits compared to what has been calculated to allow for lifetime consumption smoothing with the purchase of an annuity.

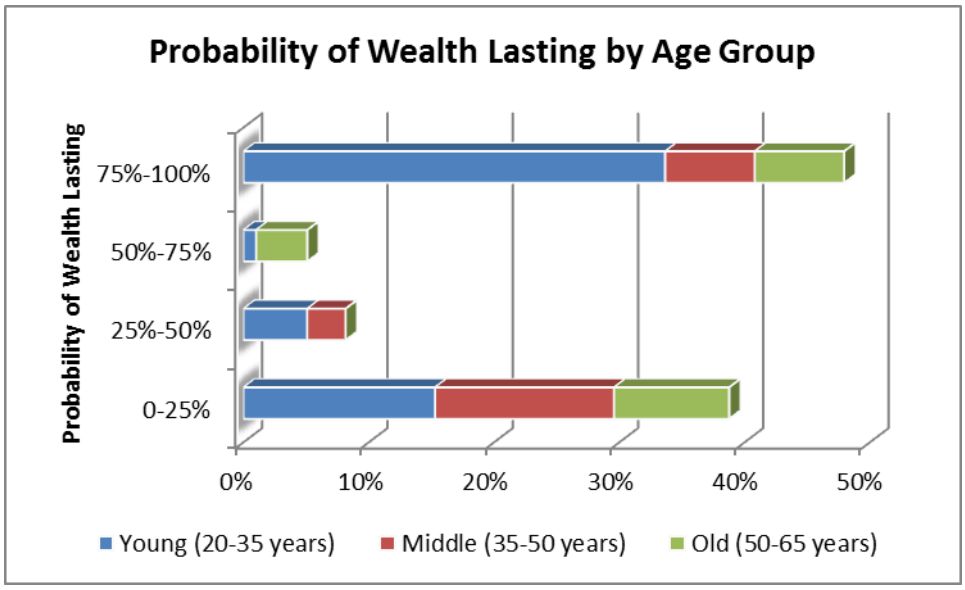

Figure **3-6**: Proportional breakdown of probability of wealth lasting, as calculated by the probability model, analyzed by age group.

Figure 3-5 and Figure 3-6 together show another aspect of the results to analyze. With the annuity purchase model, over 60 percent of the consumer units are determined to be able to increase their current consumption and have a guarantee of that higher consumption level

throughout their lives with the purchase of an annuity. However, the probability model results show that not even 50 percent of consumer units could continue their current consumption habits with greater than 75 percent certainty of their wealth lasting through retirement. This would lead us to believe that the annuity purchase option is the superior saving method. Figure 3-7 shows data for the subgroup of consumer units who were determined to be over-saving in the annuity purchase model. The presence of people in the categories between 0 and 75 percent chance of their wealth lasting through retirement shows that it would be a much better decision to increase their current and lifetime consumption, while also increasing the probability of their wealth lasting to 100 percent certainty.

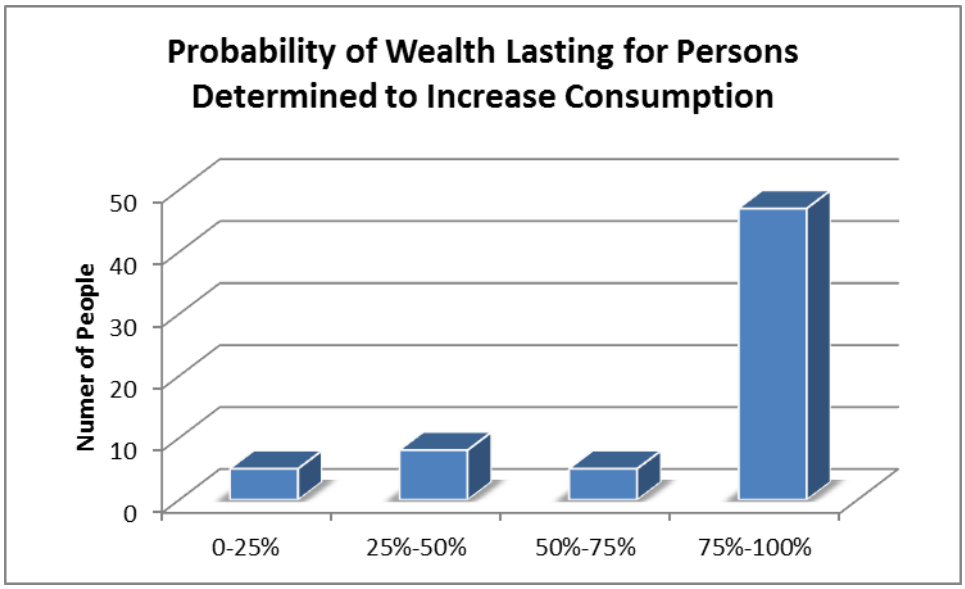

Figure **3-7**: Frequencies of each probability bracket occurring within the subgroup of consumer units who have been determined to be over-saving by the annuity purchase model.

Representative Members Analysis

The consumer units of the survey were initially broken into six groups based on gender and education level. This was done to project income for groups that have been historically

different in earnings throughout their lives. I conducted the annuity purchase model analysis for a representative member from each group. The representative person was determined by using the general demographic characteristics of the group and taking the mean annual after tax income, salary, wealth, and total annual expenditure. Table 3-3 and Figure 3-8 shows the results of the model calculations.

Table **3-3**: Results produced by the annuity purchase model for a representative person from each gender/education group.

	Male HS	Female HS	Male College	Female College	Male Graduate	Female Graduate
Age	32	36	39	34	41	42
Salary	34,139	29,933	54,460	48,271	77,119	78,300
After Tax Income	35,315	29,679	48,071	44,607	77,072	72,753
Wealth	12,318	44,351	33,287	20,093	113,549	14,120
Annual Expenditure	23,778	19,991	35,815	25,161	34,408	36,433
Annuity Price	15.11	17.03	15.11	17.03	15.11	17.03
Annuity Rent	17,676	16,566	18,158	20,110	34,404	30,314
Retirement Consumption	34,102	32,892	39,353	40,937	59,713	57,365
Pre-retirement Consumption	30,217	28,912	35,863	37,566	57,753	55,228
Percent Change in Consumption	27.08%	44.62%	0.13%	49.30%	67.85%	51.59%

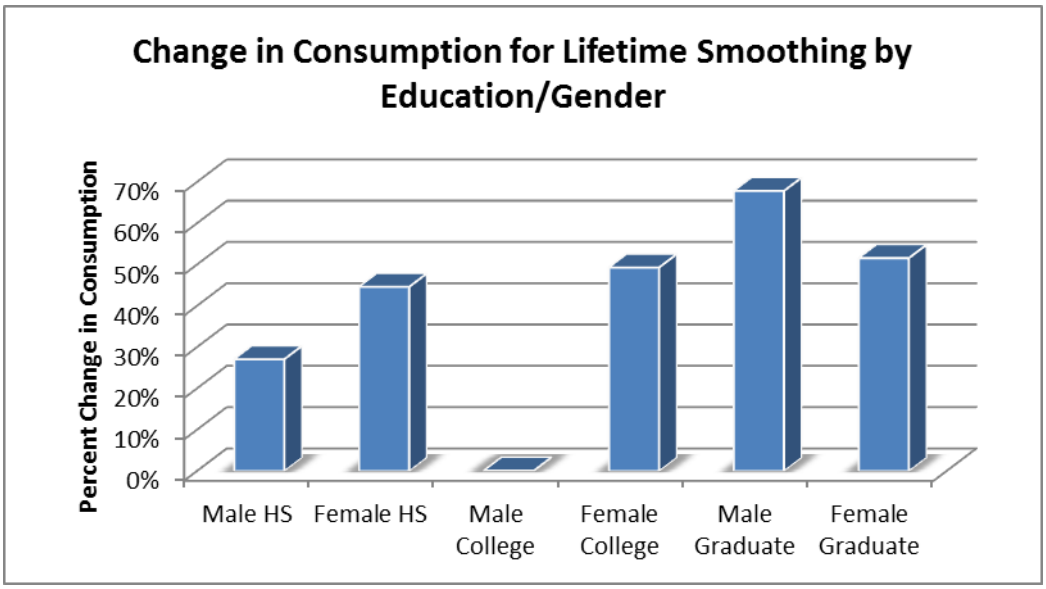

Figure **3-8**: The change in consumption required for guaranteed lifetime smoothing (according to the annuity purchase model) for the representative person from each education level and gender group.

This shows that for the representative person, the male with a college level degree appears to currently execute the exact consumption amount needed for lifetime smoothing according to the annuity purchase model. No strong conclusions can be made regarding differences in sex or education separately. The representative male with a graduate degree does obviously currently over-save the most of any of the groups presented.

Another visual representation of the data and results is interesting when comparing current after tax income to the calculated amount of consumption determined to provide lifetime smoothing (Figure 3-5).

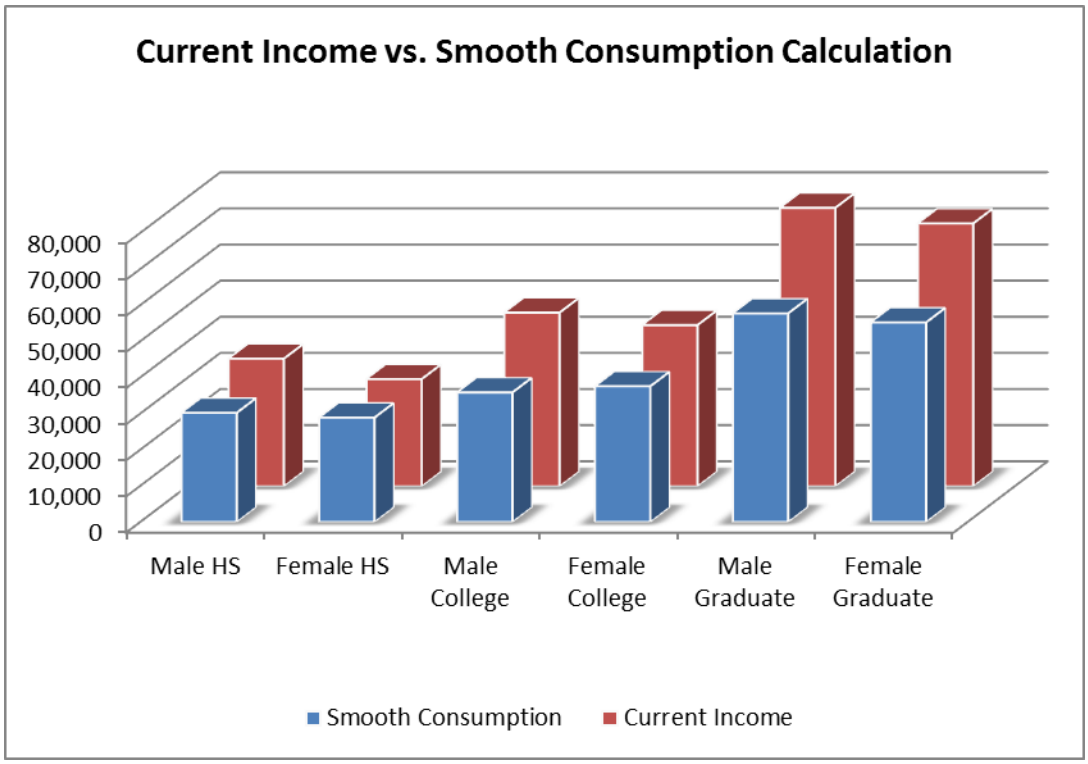

Figure **3-9**: Compares current income to the annuity purchase model's calculation for smooth consumption for the representative person from each education level and gender group.

We can see that for income, there is a disparity between males and females of the same education level. The males on average earn more than their female counterparts. However, the suggested level of smooth consumption for the lifetime evens out this difference. Although females have a lesser income, the annuity purchase model suggests that they do not need to save as much for retirement as their male counterparts (Table 3-4). This balances out the consumption levels for males and females within each education level.

Table **3-4**: Current savings rates compares to savings rates suggested by model for lifetime consumption smoothing for the representative person from each education level and gender group.

	Savings Rates	
	Current	Suggested
Male, HS	33%	14%
Female, HS	33%	3%
Male, College	25%	25%
Female, College	44%	16%
Male, Graduate	55%	25%
Female, Graduate	50%	24%

I cannot make any significant findings in differences within the population based on the data used and its somewhat small sample size. The one thing that could generally be concluded is that the planning in the annuity purchase model is a better choice than the planning in the probability model. These comparisons presented, based on the representative person from each gender/education category, are the best way to compare savings habits across demographic groups.

Section 4

Further Research

While the results of this paper suggest general over-saving and support the usefulness of annuities, several aspects of the study merit further research. I am only analyzing single person consumer units, a rather small portion of the American population, and of the Consumer Expenditure Survey data. There are a number of ways in which this research could be expanded. Some of these topics of further research include expanding the analysis to married couples and families, studying the future of social security benefits, and adjusting for mortality improvement in the future.

The area where the most progress could be made towards the retirement planning ideas presented in this paper is the expansion of the application of the model. As it stands currently, the model presented can only handle single person consumer units. It also assumes that these people will continue to be single for the remainder of their life. For those observations within the single consumer unit sample who are planning on having a family soon, additional saving would be appropriate. This may be another reason we see the model showing that households over-saving. These are the types of households that are the simplest to analyze. Adding other people to the household, be it a spouse, child, or both, complicates the analysis in numerous ways. The household consumption must then be split among all members of the consumer unit. Life insurance to support dependent family members may also need to be taken into account. The annuity choice and pricing becomes more difficult, as a joint and survivor annuity option may be desired, whereby a percentage of your rent payments continue to your spouse even after you pass away. In such an annuity product, both the age of the policyholder and his or her spouse must be known to calculate the actuarial present value of the expected rents. There is quite a bit of work

that would need to be done in order to appropriately fit this model to multiple person consumer units. It would, however, be very helpful to do so in order to expand the reach of retirement planning analysis of the life cycle model.

Even while examining only single person consumer units, there are some limitations and areas for improvement to the model. The limitations of the model must be considered when determining the validity of the results and their application to the discussion.

Social security is a hot button topic, and it is well known that the way that benefit amounts, and/or the way they are paid out, will most likely change in the future. The social security benefits calculated in the model are based on the formula presented on the Social Security Administration's website; however, there remain some shortcomings in the prediction of benefits for observations in the data. The vast majority of people present in the data used are not of age 65. Yet, their benefits were calculated as if they were age 65 in 2009, and deciding to retire that year. The difference between the predicted and actual social security benefits would be the greatest for the youngest people, and not as prevalent as we examine older observations. This model limitation probably produces results that overestimate young people's financial preparedness for retirement. If we take the vantage point that the young people realize the future limitations of social security, they would save more than if they assumed the current benefits system. This helps to explain young people's over-saving found in the model.

Another model imperfection that could influence the results, particularly for young people, is a lack of adjustment for mortality improvement. As medical advancements and pharmaceutical breakthroughs continue, the average American is able to live longer than his or her ancestors. It is generally expected that a person currently age 20 will be expected to live to a later age than a person currently age 60. Actuaries factor this trend into mortality tables with a technique known as mortality improvement. Appendix D shows a mortality improvement table and explains how it is used to calculate mortality statistics. The absence of such an adjustment

will influence the results to report that younger people are more prepared financially than perhaps what is true in reality.

The assumption of a single real interest rate in the model may also be seen as a crude estimation. The rate of return of a 30 year inflation indexed treasury as of November 8, 2010 was used as the real rate of return for all savings and for the pricing of annuities. For the savings component, this assumes that all saving assets are invested very conservatively. A higher interest rate would account for the investment in higher risk stocks and bonds. There are a number of theories as to how a person should invest their retirement savings related to their age and proximity to retirement. This analysis assumes the most risk-averse person, who will need to save more in order to make up for their low-risk strategy. In the annuity purchase model, the pricing of the annuity is also dependent on this interest rate. Again, the interest rate used was current as of November 8, 2010 making it the most accurate for those planning to retire and buy their annuity sooner rather than later. Interest rates change daily, and accurately predicting, for example, what the interest rate will be in 30 years, when a person currently age 35 will be retiring is impossible. This should be another consideration when drawing any conclusions from the results.

The retirement age (either 65 or 67) was assumed to match similarly to the Social Security Administration's current normal retirement age. In reality, we see many people retiring before this age, often near age 62 or 63. Retiring at this earlier age could eliminate anywhere from 2-5 years of earnings and add 2-5 years of retirement that need to be supported. This swing in saving period and support period results in the model possibly overestimating all people's preparedness for retirement. This model imperfection applies equally to all observations in the data, allowing for a comparison across the data to remain valid.

While there are various aspects of the model that can be improved upon, the data could also be improved upon. A larger data set of single person consumer units could be applied to the

model to produce more significant results. A more complete set of data in terms of home ownership, and savings for large one-time purchases may also yield more accurate results. The improvement of the model, using the same data would produce better results, as would a larger and more complete dataset with the present model. However, the combination of model and data improvement would allow for the strongest conclusions.

How Other Variables Could Contribute to the Model

Outside of variables that are essential to the probability calculation, the Consumer Expenditure Survey contains characteristics of each consumer unit that may help to provide insight into possible reasons why certain households save/spend a certain way. Some of these variables that we will look into include: housing tenure, completeness of income response, education, race, sex, and occupation category. Research suggests that many of these variables are tied to certain saving habits.

Housing tenure can be considered to decrease current saving once a person has purchased a home. T-tests checking the difference in model results between those who owned their home and those who did not produced insignificant results. Comparing housing tenure across the three age groups could provide insight to determine if younger people are saving more for the purchase of a house. However, this analysis was not conducted with this data. In Jonathon Skinner's model, the calculation of wealth did not take into account owning one's home. Skinner assumed, as did this model, that it would be the consumer's preference to remain living at their home until death. This may not be true in reality; many households use their house as an asset to support retirement.

One popular way of using housing equity during retirement is a reverse mortgage. This provides the opportunity to convert housing value into cash by taking out a loan against the equity

of the house. The unique aspect of this loan is that it does not have to be repaid as long as you are living in your home and have not sold it. The lender will sell your house once you no longer occupy it in order to pay off the loan. The amount of the loan payments is based on a percentage of the value of the house and the expected time that you will remain in your home (often based on age). (Investopedia, n.d.)

There are other simpler options available to utilize housing wealth as a means to support financial retirement needs. This includes people who plan to sell their home near retirement and move into some other living situation. Both the income from the selling of the home and the increased spending on rent would be taken into account. Considering that only single person homes are analyzed in this model, we can assume that the non-housing wealth calculation is suitable, as downsizing to a smaller home (as would be appropriate for a large family with children moving out of the house) should not be a significant issue.

Conclusion

The trend from defined benefit to defined contribution pension plans places a greater responsibility on the individual to be forward-looking and save appropriately for retirement. The importance of financial literacy is unquestionably growing due to this shift in responsibility. The recession that began in 2007 was a harsh reminder that careful and maybe more conservative financial planning is necessary. This paper has provided some educational insight as to different methods for saving for retirement, and forms of retirement income. The two models presented each offer different choices, the lower risk and often times financially superior opportunity proved to be the purchase of an annuity upon retirement.

All groups generally appear to be at least adequately saving for retirement. The analysis of different groups within the data based on sex, race, collar, retirement account contributions, homeownership, and education level were not significant enough to draw any statistically sound conclusions. However, the analysis of the representative person from six different gender/education level combinations provided some insight as to the demographic features of retirement planning.

Males appear to require a higher savings rate than their female counterparts. The typical difference in income between males and females is balanced out, in portion, by this saving disparity. The lifetime consumption smoothing amount for males and females of the same education level is more level than their respective income comparisons.

The other major result produced is the over-saving of the youthful portion of the sample. While this is in congruence with the life cycle model theory, whereby credit markets are imperfect and liquidity is an issue, there are also some model imperfections that may contribute to this fact. The absence of mortality improvement within the annuity pricing and overestimation of

social security benefits may influence the results to show younger people being more prepared for retirement than they are in reality.

When applying a general set of assumptions to a large group of people, there is always going to be imperfections. One of the main points in the economic theory of the life cycle model and consumption smoothing is to account for heterogeneity. Each person has different preferences, information, and opportunities, and will not make the same decisions. For any individual household examined in this paper, the results are dependent upon making the decisions that are forced into the model. Saving for retirement is a personal decision where those individual preferences highly influence the end result.

This paper is intended as an educational tool to reveal some of the mystery that surrounds retirement planning for many individuals. The model and its results are to be taken under consideration when planning for your own retirement. The reality is that a great amount of thought should be put into planning for one's retirement, and the earlier this planning takes place, the easier it will be to meet the goals set forth.

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Appendix A

PBGC Maximum Monthly Guarantees for 2009*

Age	Straight-Life Annuity	Joint and 50% Survivor Annuity**
65	$4,500.00	$4,050.00
64	$4,185.00	$3,766.50
63	$3,870.00	$3,483.00
62	$3,555.00	$3,199.50
61	$3,240.00	$2,916.00
60	$2,925.00	$2,632.50
59	$2,745.00	$2,470.50
58	$2,565.00	$2,308.50
57	$2,385.00	$2,146.50
56	$2,205.00	$1,984.50
55	$2,025.00	$1,822.50
54	$1,935.00	$1,741.50
53	$1,845.00	$1,660.50
52	$1,755.00	$1,579.50
51	$1,665.00	$1,498.50
50	$1,575.00	$1,417.50
49	$1,485.00	$1,336.50
48	$1,395.00	$1,255.50
47	$1,305.00	$1,174.50
46	$1,215.00	$1,093.50
45	$1,125.00	$1,012.50

*** Amounts shown ignore IRC Section 415 limits, which may reduce payable amounts**
**** Assumes participant and spouse are same age**

Source: Pension Benefit Guaranty Corporation <http://www.pbgc.gov/workers-retirees/benefits-information/content/page789.html>

Appendix B

RP2000 Mortality Table

Age	Male Blended White Collar $_1q_x$	Male Blended Blue Collar $_1q_x$	Female Blended White Collar $_1q_x$	Female Blended Blue Collar $_1q_x$	Male Healthy Annuitant $_1q_x$	Female Healthy Annuitant $_1q_x$
1	0.0006	0.0006	0.0006	0.0006		
2	0.0004	0.0004	0.0004	0.0004		
3	0.0004	0.0004	0.0003	0.0003		
4	0.0003	0.0003	0.0002	0.0002		
5	0.0003	0.0003	0.0002	0.0002		
6	0.0002	0.0002	0.0002	0.0002		
7	0.0002	0.0002	0.0002	0.0002		
8	0.0002	0.0002	0.0001	0.0001		
9	0.0002	0.0002	0.0001	0.0001		
10	0.0002	0.0002	0.0001	0.0001		
11	0.0002	0.0002	0.0001	0.0001		
12	0.0002	0.0002	0.0001	0.0001		
13	0.0002	0.0002	0.0002	0.0002		
14	0.0003	0.0003	0.0002	0.0002		
15	0.0003	0.0003	0.0002	0.0002		
16	0.0003	0.0003	0.0002	0.0002		
17	0.0003	0.0003	0.0002	0.0002		
18	0.0003	0.0003	0.0002	0.0002		
19	0.0003	0.0003	0.0002	0.0002		
20	0.0003	0.0003	0.0002	0.0002		
21	0.0004	0.0004	0.0002	0.0002		
22	0.0004	0.0004	0.0002	0.0002		
23	0.0004	0.0004	0.0002	0.0002		
24	0.0004	0.0004	0.0002	0.0002		
25	0.0004	0.0004	0.0002	0.0002		
26	0.0004	0.0004	0.0002	0.0002		
27	0.0004	0.0004	0.0002	0.0002		
28	0.0004	0.0004	0.0002	0.0002		
29	0.0004	0.0004	0.0002	0.0002		
30	0.0004	0.0007	0.0003	0.0003		

Age	Male Blended White Collar	Male Blended Blue Collar	Female Blended White Collar	Female Blended Blue Collar	Male Healthy Annuitant	Female Healthy Annuitant
31	0.0004	0.0008	0.0003	0.0003		
32	0.0004	0.0009	0.0004	0.0004		
33	0.0005	0.0009	0.0004	0.0004		
34	0.0005	0.0010	0.0004	0.0005		
35	0.0006	0.0011	0.0005	0.0005		
36	0.0006	0.0012	0.0005	0.0006		
37	0.0007	0.0012	0.0005	0.0006		
38	0.0008	0.0013	0.0006	0.0007		
39	0.0008	0.0013	0.0006	0.0008		
40	0.0009	0.0014	0.0006	0.0009		
41	0.0010	0.0014	0.0007	0.0010		
42	0.0010	0.0015	0.0008	0.0011		
43	0.0011	0.0016	0.0008	0.0012		
44	0.0012	0.0017	0.0009	0.0013		
45	0.0013	0.0018	0.0010	0.0014		
46	0.0015	0.0019	0.0011	0.0015		
47	0.0016	0.0020	0.0012	0.0016		
48	0.0017	0.0021	0.0013	0.0017		
49	0.0018	0.0023	0.0015	0.0018		
50	0.0020	0.0024	0.0016	0.0020	0.0053	0.0023
51	0.0023	0.0027	0.0018	0.0021	0.0055	0.0025
52	0.0025	0.0030	0.0019	0.0022	0.0056	0.0026
53	0.0027	0.0033	0.0021	0.0024	0.0057	0.0029
54	0.0029	0.0036	0.0023	0.0026	0.0058	0.0032
55	0.0033	0.0042	0.0026	0.0028	0.0059	0.0035
56	0.0037	0.0050	0.0030	0.0031	0.0061	0.0039
57	0.0041	0.0056	0.0033	0.0034	0.0064	0.0044
58	0.0045	0.0064	0.0037	0.0038	0.0069	0.0049
59	0.0050	0.0073	0.0042	0.0043	0.0075	0.0055
60	0.0056	0.0083	0.0047	0.0049	0.0082	0.0062
61	0.0064	0.0094	0.0053	0.0058	0.0090	0.0069
62	0.0073	0.0108	0.0060	0.0068	0.0099	0.0077
63	0.0085	0.0123	0.0068	0.0080	0.0110	0.0085
64	0.0097	0.0138	0.0077	0.0091	0.0121	0.0094
65	0.0111	0.0155	0.0087	0.0104	0.0134	0.0104
66	0.0126	0.0176	0.0098	0.0118	0.0149	0.0114
67	0.0140	0.0195	0.0109	0.0132	0.0165	0.0125
68	0.0156	0.0217	0.0122	0.0147	0.0182	0.0138

Age	Male Blended White Collar	Male Blended Blue Collar	Female Blended White Collar	Female Blended Blue Collar	Male Healthy Annuitant	Female Healthy Annuitant
69	0.0172	0.0239	0.0135	0.0164	0.0201	0.0152
70	0.0193	0.0268	0.0152	0.0186	0.0222	0.0167
71	0.0214	0.0293	0.0169	0.0207	0.0246	0.0186
72	0.0239	0.0322	0.0188	0.0231	0.0273	0.0207
73	0.0267	0.0354	0.0209	0.0256	0.0304	0.0230
74	0.0300	0.0391	0.0232	0.0282	0.0339	0.0255
75	0.0336	0.0431	0.0257	0.0309	0.0378	0.0281
76	0.0378	0.0477	0.0285	0.0338	0.0422	0.0310
77	0.0424	0.0527	0.0315	0.0369	0.0469	0.0341
78	0.0475	0.0581	0.0350	0.0404	0.0521	0.0376
79	0.0532	0.0641	0.0388	0.0444	0.0579	0.0415
80	0.0594	0.0705	0.0431	0.0490	0.0644	0.0459
81	0.0668	0.0782	0.0479	0.0542	0.0720	0.0508
82	0.0749	0.0864	0.0534	0.0602	0.0805	0.0563
83	0.0840	0.0952	0.0595	0.0670	0.0897	0.0625
84	0.0938	0.1047	0.0664	0.0747	0.0998	0.0695
85	0.1047	0.1151	0.0742	0.0831	0.1108	0.0774
86	0.1168	0.1264	0.0828	0.0923	0.1228	0.0864
87	0.1302	0.1386	0.0925	0.1024	0.1360	0.0963
88	0.1449	0.1519	0.1030	0.1133	0.1506	0.1073
89	0.1611	0.1663	0.1143	0.1248	0.1664	0.1192
90	0.1783	0.1818	0.1262	0.1367	0.1834	0.1317
91	0.1950	0.1964	0.1385	0.1487	0.1998	0.1446
92	0.2121	0.2116	0.1510	0.1605	0.2166	0.1576
93	0.2295	0.2274	0.1634	0.1720	0.2337	0.1704
94	0.2464	0.2432	0.1755	0.1826	0.2507	0.1828
95	0.2632	0.2595	0.1869	0.1926	0.2675	0.1945
96	0.2839	0.2839	0.2054	0.2054	0.2839	0.2054
97	0.2999	0.2999	0.2152	0.2152	0.2999	0.2152
98	0.3153	0.3153	0.2239	0.2239	0.3153	0.2239
99	0.3302	0.3302	0.2314	0.2314	0.3302	0.2314
100	0.3446	0.3446	0.2375	0.2375	0.3446	0.2375
101	0.3586	0.3586	0.2448	0.2448	0.3586	0.2448
102	0.3717	0.3717	0.2545	0.2545	0.3717	0.2545
103	0.3830	0.3830	0.2660	0.2660	0.3830	0.2660
104	0.3920	0.3920	0.2791	0.2791	0.3920	0.2791
105	0.3979	0.3979	0.2931	0.2931	0.3979	0.2931
106	0.4000	0.4000	0.3078	0.3078	0.4000	0.3078

Age	Male Blended White Collar	Male Blended Blue Collar	Female Blended White Collar	Female Blended Blue Collar	Male Healthy Annuitant	Female Healthy Annuitant
107	0.4000	0.4000	0.3227	0.3227	0.4000	0.3227
108	0.4000	0.4000	0.3374	0.3374	0.4000	0.3374
109	0.4000	0.4000	0.3515	0.3515	0.4000	0.3515
110	0.4000	0.4000	0.3646	0.3646	0.4000	0.3646
111	0.4000	0.4000	0.3762	0.3762	0.4000	0.3762
112	0.4000	0.4000	0.3860	0.3860	0.4000	0.3860
113	0.4000	0.4000	0.3935	0.3935	0.4000	0.3935
114	0.4000	0.4000	0.3983	0.3983	0.4000	0.3983
115	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000
116	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000
117	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000
118	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000
119	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000
120	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Source: RP 2000 Mortality Table

Appendix C

Income Adjustment Factors

Age	Male High School Factor	Male College Factor	Male Graduate Factor	Female High School Factor	Female College Factor	Female Graduate Factor
18	1.132	1.060	1.000	1.135	1.135	1.000
19	1.132	1.060	1.000	1.135	1.135	1.000
20	1.132	1.060	1.000	1.135	1.135	1.000
21	1.132	1.060	1.000	1.135	1.135	1.000
22	1.132	1.060	1.000	1.135	1.135	1.000
23	1.132	1.060	1.000	1.135	1.135	1.000
24	1.132	1.060	1.000	1.135	1.135	1.054
25	1.058	1.059	1.114	0.999	1.051	1.054
26	1.058	1.059	1.114	0.999	1.051	1.054
27	1.058	1.059	1.114	0.999	1.051	1.054
28	1.058	1.059	1.114	0.999	1.051	1.054
29	1.058	1.059	1.114	0.999	1.051	1.054
30	1.031	1.066	1.054	1.024	1.025	1.057
31	1.031	1.066	1.054	1.024	1.025	1.057
32	1.031	1.066	1.054	1.024	1.025	1.057
33	1.031	1.066	1.054	1.024	1.025	1.057
34	1.031	1.066	1.054	1.024	1.025	1.057
35	1.003	0.999	1.043	1.059	1.018	0.963
36	1.003	0.999	1.043	1.059	1.018	0.963
37	1.003	0.999	1.043	1.059	1.018	0.963
38	1.003	0.999	1.043	1.059	1.018	0.963
39	1.003	0.999	1.043	1.059	1.018	0.963
40	0.994	0.978	0.978	1.015	0.984	1.013
41	0.994	0.978	0.978	1.015	0.984	1.013
42	0.994	0.978	0.978	1.015	0.984	1.013
43	0.994	0.978	0.978	1.015	0.984	1.013
44	0.994	0.978	0.978	1.015	0.984	1.013
45	1.011	1.012	0.990	1.000	0.995	1.034
46	1.011	1.012	0.990	1.000	0.995	1.034
47	1.011	1.012	0.990	1.000	0.995	1.034
48	1.011	1.012	0.990	1.000	0.995	1.034
49	1.011	1.012	0.990	1.000	0.995	1.034
50	0.960	1.008	1.033	0.985	0.994	0.995
51	0.960	1.008	1.033	0.985	0.994	0.995
52	0.960	1.008	1.033	0.985	0.994	0.995
53	0.960	1.008	1.033	0.985	0.994	0.995
54	0.960	1.008	1.033	0.985	0.994	0.995
55	1.023	0.955	0.985	1.017	1.013	0.979
56	1.023	0.955	0.985	1.017	1.013	0.979
57	1.023	0.955	0.985	1.017	1.013	0.979
58	1.023	0.955	0.985	1.017	1.013	0.979
59	1.023	0.955	0.985	1.017	1.013	0.979
60	0.985	1.002	0.954	0.949	0.995	0.903
61	0.985	1.002	0.954	0.949	0.995	0.903
62	0.985	1.002	0.954	0.949	0.995	0.903

Age	Male High School Factor	Male College Factor	Male Graduate Factor	Female High School Factor	Female College Factor	Female Graduate Factor
63	0.985	1.002	0.954	0.949	0.995	0.903
64	0.985	1.002	0.954	0.949	0.995	0.903
65	0.985	1.002	0.954	0.949	0.995	0.903
66	0.985	1.002	0.954	0.949	0.995	0.903
67	1.000	1.000	1.000	1.000	1.000	1.000

Source: Calculated from Consumer Expenditure Survey member file data.

Appendix D

Mortality Improvement

The RP2000 table was constructed for to calculate mortality probabilities for the year 2000. Therefore, the ${}_1q_{20}$ value reports the probability of a person who is age 20 in the year 2000 dying before reaching age 21, and ${}_1q_{21}$ reports the probability of a person who is age 21 in the year 2000 dying before age 22. A person who is age 20 in the year 2000 is 21 in the year 2001, this is the adjustment that must be made to the table. This is done by using Scale AA mortality improvement. The value in Scale AA for a male age 21 is 1.8%, to get the 1q21 value for someone who is 21 in the year 2001 the original ${}_1q_{21}$ value is multiplied by ((1-.018)^(2001-2000))=.982. The value in Scale AA for a male age 22 is 1.7%, to get the 1q22 value for someone who is 22 in the year 2002, the original ${}_1q_{22}$ value is multiplied by ((1-.017)^(2002-2000))=.966. This pattern can be repeated for the entire table to account for mortality improvement in the future.

Age	Male Scale AA	Female Scale AA	Age	Male Scale AA	Female Scale AA	Age	Male Scale AA	Female Scale AA	Age	Male Scale AA	Female Scale AA
0	0.0%	0.0%	31	0.5%	0.8%	62	1.5%	0.5%	93	0.3%	0.2%
1	2.0%	2.0%	32	0.5%	0.8%	63	1.4%	0.5%	94	0.3%	0.2%
2	2.0%	2.0%	33	0.5%	0.9%	64	1.4%	0.5%	95	0.2%	0.2%
3	2.0%	2.0%	34	0.5%	1.0%	65	1.4%	0.5%	96	0.2%	0.2%
4	2.0%	2.0%	35	0.5%	1.1%	66	1.3%	0.5%	97	0.2%	0.1%
5	2.0%	2.0%	36	0.5%	1.2%	67	1.3%	0.5%	98	0.1%	0.1%
6	2.0%	2.0%	37	0.5%	1.3%	68	1.4%	0.5%	99	0.1%	0.1%
7	2.0%	2.0%	38	0.6%	1.4%	69	1.4%	0.5%	100	0.1%	0.1%
8	2.0%	2.0%	39	0.7%	1.5%	70	1.5%	0.5%	101	0.0%	0.0%
9	2.0%	2.0%	40	0.8%	1.5%	71	1.5%	0.6%	102	0.0%	0.0%
10	2.0%	2.0%	41	0.9%	1.5%	72	1.5%	0.6%	103	0.0%	0.0%
11	2.0%	2.0%	42	1.0%	1.5%	73	1.5%	0.7%	104	0.0%	0.0%
12	2.0%	2.0%	43	1.1%	1.5%	74	1.5%	0.7%	105	0.0%	0.0%
13	2.0%	2.0%	44	1.2%	1.5%	75	1.4%	0.8%	106	0.0%	0.0%
14	1.9%	1.8%	45	1.3%	1.6%	76	1.4%	0.8%	107	0.0%	0.0%
15	1.9%	1.6%	46	1.4%	1.7%	77	1.3%	0.7%	108	0.0%	0.0%
16	1.9%	1.5%	47	1.5%	1.8%	78	1.2%	0.7%	109	0.0%	0.0%
17	1.9%	1.4%	48	1.6%	1.8%	79	1.1%	0.7%	110	0.0%	0.0%
18	1.9%	1.4%	49	1.7%	1.8%	80	1.0%	0.7%	111	0.0%	0.0%
19	1.9%	1.5%	50	1.8%	1.7%	81	0.9%	0.7%	112	0.0%	0.0%
20	1.9%	1.6%	51	1.9%	1.6%	82	0.8%	0.7%	113	0.0%	0.0%
21	1.8%	1.7%	52	2.0%	1.4%	83	0.8%	0.7%	114	0.0%	0.0%
22	1.7%	1.7%	53	2.0%	1.2%	84	0.7%	0.7%	115	0.0%	0.0%
23	1.5%	1.6%	54	2.0%	1.0%	85	0.7%	0.6%	116	0.0%	0.0%
24	1.3%	1.5%	55	1.9%	0.8%	86	0.7%	0.5%	117	0.0%	0.0%
25	1.0%	1.4%	56	1.8%	0.6%	87	0.6%	0.4%	118	0.0%	0.0%
26	0.6%	1.2%	57	1.7%	0.5%	88	0.5%	0.4%	119	0.0%	0.0%
27	0.5%	1.2%	58	1.6%	0.5%	89	0.5%	0.3%	120	0.0%	0.0%
28	0.5%	1.2%	59	1.6%	0.5%	90	0.4%	0.3%			
29	0.5%	1.2%	60	1.6%	0.5%	91	0.4%	0.3%			
30	0.5%	1.0%	61	1.5%	0.5%	92	0.3%	0.3%			

Source: RP2000 Mortality Table

Appendix E

SAS Code

CEX Data Manip.sas

```
/* Data I Need for Analysis */
proc sql;
create table work.CEX as
        select
                /* Consumer Unit Characteristics */
                newid,
                cuid,
                bls_urbn,
                cutenure,
                earncomp,
                fam_type,
                fam_size,
                no_earnr,
                respstat,
                pov_cy,
                pov_py,
                age_ref,
                educ_ref,
                marital1,
                ref_race,
                sex_ref,
                occucod1,
                /* Income */
                fincatax,
                fincbtax,
                tottxpdx,
                /* finbtax is the sum of these variables */
                fsalaryx,
                /*******/
                /* Wealth as derived by Andrew Parr */
                sum(ckbkactx,monyowdx,savacctx,secestx,usbndx) as wealth,
                ckbkactx,
                monyowdx,
                savacctx,
                secestx,
                usbndx,
                /*******/
                /* Total Expenditure Prior Quarter */
                totexppq as totexppq_4,
                /**** Retirement Deduction and Savings ****/
                FPRIPENX,
                findretx,
                fgovretx
                /*******/
        from aparr.fmli094
        where inclass in ('04','05','06','07','08','09')
                and pov_cy <> '1'
                and pov_py <> '1'
```

```
                and fam_size = 1
                and respstat = '1'
                and marital1 = '5'
                and no_earnr = 1
                and fsalaryx > 0
        ;
        quit;
run;

proc sql;
create table work.cex2 as
        select *
        from work.cex
        where wealth <> .
        ;
        quit;
run;

proc sql;
create table work.cex2_1 as
        select a.*,
                b.totexppq as totexppq_3
        from work.cex2 a left join aparr.fmli093 b
        on a.cuid=b.cuid
        ;
        quit;
run;

proc sql;
create table work.cex2_2 as
        select a.*,
                b.totexppq as totexppq_2
        from work.cex2_1 a left join aparr.fmli092 b
        on a.cuid=b.cuid
        ;
        quit;
run;

proc sql;
create table work.cex2_3 as
        select a.*,
                b.totexppq as totexppq_1
        from work.cex2_2 a left join aparr.fmli091x b
        on a.cuid=b.cuid
        ;
        quit;
run;

data aparr.cex_complete;
        set work.cex2_3;
        exp_avg = mean(totexppq_1,totexppq_2,totexppq_3,totexppq_4);
        if totexppq_1=. then totexppq_1=exp_avg;
        if totexppq_2=. then totexppq_2=exp_avg;
        if totexppq_3=. then totexppq_3=exp_avg;
        totexpyr=sum(totexppq_1,totexppq_2,totexppq_3,totexppq_4);
run;
```

Member File Income Data.sas

```
/* Extract Income Data from Member File for all Reference People */
proc sql;
create table income2 as
        select
                educa,
                sex,
                earner,
                cu_code,
                salaryx,
                age
                from aparr.memi094
                where earner='1'
                and cu_code='1';
quit;
```

Probability Model.sas

```
/**** the table CEX2 is created by the program CEX Data Manip *****/
/*************************************************/
/*** Beginning of Temporary Work File Creation **/
/*************************************************/

/*****Mortality Table IDs *****/
DATA work.Prob_Cex3;
        set aparr.Cex_complete;
        collar=".";
        IF occucod1="01" or occucod1="02" or occucod1="03" or occucod1="04" or occucod1="05" or
occucod1="06" or occucod1="07" THEN collar="white";
        IF occucod1="08" or occucod1="09" or occucod1="10" or occucod1="11" or occucod1="12" or
occucod1="13" or occucod1="14" or occucod1="15" or occucod1="16" or occucod1="17" or occucod1="18" THEN
collar="blue";
        IF sex_ref=1 AND collar="w" THEN id=1;
        IF sex_ref=1 AND collar="b" THEN id=2;
        IF sex_ref=2 AND collar="w" THEN id=3;
        IF sex_ref=2 AND collar="b" THEN id=4;
run;

/* Matches mortality table to each observation */
Proc sql;
        create table work.Prob_complete
        as select a.*,
                                b.*
        from work.Prob_Cex3 a, aparr.RP2000 b
        where a.id=b.id;
        quit;
run;

/* Set Income Codes to Data */
DATA work.Prob_complete_1;
        set work.Prob_complete;
```

```
            IF sex_ref=1 and educ_ref <= 13 THEN inc_cd=1;
            IF sex_ref=2 and educ_ref <= 13 THEN inc_cd=2;
            IF sex_ref=1 and educ_ref >13 and educ_ref <=15 THEN inc_cd=3;
            IF sex_ref=2 and educ_ref >13 and educ_ref <=15 THEN inc_cd=4;
            IF sex_ref=1 and educ_ref >15 THEN inc_cd=5;
            IF sex_ref=2 and educ_ref >15 THEN inc_cd=6;
run;

/***** Add Income factors *****/
/* Matches Income Factors with each Observation */
Proc sql;
            create table work.Prob_complete_incadj
            as select a.*,
                                    b.*
            from work.Prob_complete_1 a, aparr.inc_fcts b
            where a.inc_cd=b.inc_cd;
            quit;
run;

/************************************************/
/******* End of Temporary Work File Creation ****/
/************************************************/
/************************************************/
/************************************************/
/************************************************/

/***** Assumptions and Variable Creation *****/
DATA aparr.Prob_calcs;
            set work.Prob_complete_incadj;
            a = 0;
            i = .0152;
            v = 1/(1+i);
            multiplier = 1;
            prob_wealth_lasting = 0;
            IF (2009-age_ref) >= 1960 THEN retage = 67;
            ELSE retage = 65;
            h=age_ref-1;

/* Create arrays for loop use */
            ARRAY p_x {120} p_x1-p_x120; /***** where p_1 to p_110 are variables in the data set, or define them
here *****/
            ARRAY prob_death_age {120};
            ARRAY pv_cnsmptn {120};
            ARRAY pv_preret_inc {120};
            ARRAY pv_postret_inc {120};
            ARRAY target_wealth {120};
            ARRAY incfct {50} inc18-inc67;
            ARRAY income {120};

/***** Calculation loop *****/

            DO k = age_ref to 120 by 1;

/***** calculate probability of dying at each age *****/

                        multiplier = 1;
                        a = a+1;
                        IF a = 1 THEN multiplier = 1;
                                    ELSE
                                    DO j = 1 to (a-1) by 1;
```

```
                                        multiplier = multiplier*p_x{k-j};
                                END;
                        ;
                        prob_death_age{k} = multiplier*(1-p_x{k});

/***** Calculate Annual Income Amounts through Retirement *****/
                        IF k<= retage THEN
                                IF k=age_ref THEN income{k}=fincatax;
                                        ELSE income{k}=income{k-1}*incfct{k-17}
                                ;
                                ELSE income{k}=0
                        ;
                END;

/***** Past Income Assumption *****/

                DO WHILE (h ge 18);
                        income{h}=income{h+1}*incfct{h-16};
                        h=h-1;
                END;

                highest_35 = 0;
                DO n=1 to 35;
                        highest_35 = highest_35+LARGEST(n, of income18-income67);
                END;

/***** Social Security *****/
                socsec_35yravg = highest_35/35;
                month_inc = socsec_35yravg/12;
                if month_inc <= 761 then socsec = 12*(.9*month_inc);
                if month_inc > 761 and month_inc <= 4586 then socsec = 12*((.9*761)+.32*(month_inc-761));
                if month_inc > 4586 and month_inc <=7500 then socsec = 12*((.9*761)+(.32*(4586-
761))+(.15*(month_inc-4586)));
                if month_inc > 7500 then socsec = 12*2346;

/***** calculate present values of consumption and income *****/
                DO k=age_ref to 120 by 1;
                        IF k < retage THEN pv_cnsmptn{k} = totexpyr*(k-age_ref+1);
                        IF k >= retage THEN pv_cnsmptn{k} = totexpyr*(retage-age_ref+1)+((totexpyr*.93)+6000)*(k-
retage+1);
                        IF k < retage THEN pv_postret_inc{k} = 0;
                                ELSE pv_postret_inc{k} = (socsec)*(1-v**(k-retage))/i*v**(retage-age_ref)
                        ;
                        IF k=age_ref THEN pv_preret_inc{k}=income{k};
                                ELSE pv_preret_inc{k}=pv_preret_inc{k-1}+(income{k}*v**(k-age_ref))
                        ;
                END;

/***** Calculate probability of wealth lasting till death *****/
                DO z=age_ref to 119 by 1;
                        target_wealth{z} = pv_cnsmptn{z} - pv_preret_inc{z} - pv_postret_inc{z};
                        IF wealth >= target_wealth{z} THEN prob_wealth_lasting = prob_wealth_lasting +
prob_death_age{z};
                                ELSE prob_wealth_lasting = prob_wealth_lasting
                        ;
                END;
                total_prob_check=sum(of prob_death_age1-prob_death_age120);
run;

/*********************************************************/
```

```
/*************************************************************/
/********** END OF CALCULATIONS *****************************/
/*************************************************************/
/*************************************************************/
```

Annuity Model.sas

```
/**** the table CEX_complete is created by the program CEX Data Manip *****/

/***********************************************/
/*** Beginning of Temporary Work File Creation **/
/***********************************************/

/* ID Creation for Merging */
DATA work.Ann_Cex3;
        set aparr.Cex_complete;
        collar=".";
        IF occucod1="01" or occucod1="02" or occucod1="03" or occucod1="04" or occucod1="05" or
occucod1="06" or occucod1="07" THEN collar="white";
        IF occucod1="08" or occucod1="09" or occucod1="10" or occucod1="11" or occucod1="12" or
occucod1="13" or occucod1="14" or occucod1="15" or occucod1="16" or occucod1="17" or occucod1="18" THEN
collar="blue";
        IF sex_ref=1 THEN id=5;
        IF sex_ref=2 THEN id=6;
run;

/***************************/

/* Matches mortality table to each observation */
Proc sql;
        create table work.Ann_complete
        as select a.*,
                        b.*
        from work.Ann_Cex3 a, aparr.RP2000 b
        where a.id=b.id;
        quit;
run;
/***************************/

/* Set Income Codes to Data */
DATA work.Ann_complete_1;
        set work.Ann_complete;
        IF sex_ref=1 and educ_ref <= 13 THEN inc_cd=1;
        IF sex_ref=2 and educ_ref <= 13 THEN inc_cd=2;
        IF sex_ref=1 and educ_ref >13 and educ_ref <=15 THEN inc_cd=3;
        IF sex_ref=2 and educ_ref >13 and educ_ref <=15 THEN inc_cd=4;
        IF sex_ref=1 and educ_ref >15 THEN inc_cd=5;
        IF sex_ref=2 and educ_ref >15 THEN inc_cd=6;
run;
/***************************/
```

```
/***** Add Income factors *****/
/* Matches Income Factors with each Observation */
Proc sql;
        create table work.Ann_complete_incadj
        as select a.*,
                        b.*
        from work.Ann_complete_1 a, aparr.inc_fcts b
        where a.inc_cd=b.inc_cd;
        quit;
run;

/************************************************/
/******* End of Temporary Work File Creation ****/
/************************************************/
/************************************************/
/************************************************/
/************************************************/

/***** Model Calculations *****/
DATA aparr.Ann_calcs;
        set work.Ann_complete_incadj;
        a = 0;
        i = .0152;
        v = 1/(1+i);
        multiplier = 1;
        prob_wealth_lasting = 0;
        IF (2009-age_ref) >= 1960 THEN retage = 67;
        ELSE retage = 65;
        h=age_ref-1;

/* Create arrays for loop use */
        ARRAY p_x {120} p_x1-p_x120;
        ARRAY incfct {50} inc18-inc67;
        ARRAY income {120};
        ARRAY salary {120};

/***** Calculation loop *****/
        DO k = age_ref to 120 by 1;

/***** Calculate Annual Income Amounts through Retirement *****/
                IF k<= retage THEN
                        IF k=age_ref THEN income{k}=fincatax;
                                ELSE income{k}=income{k-1}*incfct{k-17}
                        ;
                ELSE income{k}=0
                ;
                IF k<= retage THEN
                        IF k=age_ref THEN salary{k}=fsalaryx;
                                ELSE salary{k}=salary{k-1}*incfct{k-17}
                        ;
                ELSE salary{k}=0
                ;
        END;

/***** Past Income Assumption *****/
        DO WHILE (h ge 18);
                income{h}=income{h+1}/incfct{h-16};
                salary{h}=salary{h+1}/incfct{h-16};
                h=h-1;
        END;
```

```
            highest_35 = 0;
            DO n=1 to 35;
                        highest_35 = highest_35+LARGEST(n, of salary18-salary67);
            END;

/***** Social Security *****/
            socsec_35yravg = highest_35/35;
            month_inc = socsec_35yravg/12;
            if month_inc <= 761 then socsec = 12*(.9*month_inc);
            if month_inc > 761 and month_inc <= 4586 then socsec = 12*((.9*761)+.32*(month_inc-761));
            if month_inc > 4586 and month_inc <=7500 then socsec = 12*((.9*761)+(.32*(4586-
761))+(.15*(month_inc-4586)));
            if month_inc > 7500 then socsec = 12*2346;

/***** Annuity Pricing *****/
            multiplier2=1;
            Annuity_Price=1;
            DO z=retage to 110;
                        multiplier2=multiplier2*p_x{z};
                        Annuity_Price=Annuity_Price + multiplier2*(v**(z-retage+1));
            END;
            Annuity_Price=Annuity_Price*1.05;


/***** Calculate Wealth at Retirement (Given current spending/saving habits) *****/
            Retirement_Wealth=wealth;
            DO n=age_ref to retage;
                        Retirement_Wealth=Retirement_Wealth + ((income(n)-totexpyr)*((1+i)**(n-age_ref+1))); /*add
interest*/
            END;


/***** Compare Annuity Payments to Consumption *****/
            annual_annuity=Retirement_Wealth/Annuity_Price;
            annual_ret_cnsmptn=annual_annuity+socsec;

/***** Consumption Smoothing for Lifetime *****/
            cnsmptn_smooth = totexpyr;
            IF cnsmptn_smooth < (annual_ret_cnsmptn-6000)/.93 THEN
                        DO UNTIL (cnsmptn_smooth>=(annual_ret_cnsmptn-6000)/.93);
                                    cnsmptn_smooth=cnsmptn_smooth+1;
                                    Retirement_Wealth=wealth;
                                    DO n=age_ref to retage;
                                                Retirement_Wealth=Retirement_Wealth + ((income(n)-
cnsmptn_smooth)*((1+i)**(n-age_ref+1))); /*add interest*/
                                    END;
                                    annual_annuity=Retirement_Wealth/Annuity_Price;
                                    annual_ret_cnsmptn=annual_annuity+socsec;
                        END;
            ;
            IF cnsmptn_smooth > (annual_ret_cnsmptn-6000)/.93 THEN
                        DO UNTIL (cnsmptn_smooth<=(annual_ret_cnsmptn-6000)/.93);
                                    cnsmptn_smooth=cnsmptn_smooth-1;
                                    Retirement_Wealth=wealth;
                                    DO n=age_ref to retage;
                                                Retirement_Wealth=Retirement_Wealth + ((income(n)-
cnsmptn_smooth)*((1+i)**(n-age_ref+1))); /*add interest*/
                                    END;
                                    annual_annuity=Retirement_Wealth/Annuity_Price;
```

```
                        annual_ret_cnsmptn=annual_annuity+socsec;
                END;
        ;
run;

/*********************************************************/
/*********************************************************/
/********** END OF CALCULATIONS **************************/
/*********************************************************/
/*********************************************************/
```

Annuity Model Rep.sas

```
/**** the table CEX_complete is created by the program CEX Data Manip *****/

/***********************************************/
/*** Beginning of Temporary Work File Creation **/
/***********************************************/

/* Set Income Codes to Data */
DATA work.Rep_1;
        set aparr.cex_complete;
        IF sex_ref=1 and educ_ref <= 13 THEN inc_cd=1;
        IF sex_ref=2 and educ_ref <= 13 THEN inc_cd=2;
        IF sex_ref=1 and educ_ref >13 and educ_ref <=15 THEN inc_cd=3;
        IF sex_ref=2 and educ_ref >13 and educ_ref <=15 THEN inc_cd=4;
        IF sex_ref=1 and educ_ref >15 THEN inc_cd=5;
        IF sex_ref=2 and educ_ref >15 THEN inc_cd=6;
run;

/*****************************/
proc sql;
create table work.rep_2 as
        select      inc_cd,
                        round(mean(age_ref),1) as age_ref,
                        mean(fincatax) as fincatax,
                        mean(fincbtax) as fincbtax,
                        mean(fsalaryx) as fsalaryx,
                        mean(wealth) as wealth,
                        mean(totexpyr) as totexpyr
        from work.rep_1
        group by inc_cd;
        quit;
run;

/***** Add Income factors *****/
/* Matches Income Factors with each Observation */
Proc sql;
        create table work.rep_3
        as select a.*,
                                b.*
        from work.rep_2 a, aparr.inc_fcts b
        where a.inc_cd=b.inc_cd;
        quit;
```

```
run;

Data work.rep_4;
        set work.rep_3;
        IF inc_cd=1 or inc_cd=3 or inc_cd=5 THEN id=5;
        IF inc_cd=2 or inc_cd=4 or inc_cd=6 THEN id=6;
run;

/* Matches mortality table to each observation */
Proc sql;
        create table work.rep_5
        as select a.*,
                        b.*
        from work.rep_4 a, aparr.RP2000 b
        where a.id=b.id;
        quit;
run;
/************************************************/
/******* End of Temporary Work File Creation ****/
/************************************************/

/*****************************/
/***** Model Calculations ***/
/*****************************/

DATA aparr.Rep_ann_calcs;
        set work.Rep_5;
        a = 0;
        i = .0152;
        v = 1/(1+i);
        multiplier = 1;
        prob_wealth_lasting = 0;
        IF (2009-age_ref) >= 1960 THEN retage = 67;
        ELSE retage = 65;
        h=age_ref-1;

/* Create arrays for loop use */
        ARRAY p_x {120} p_x1-p_x120;
        ARRAY incfct {50} inc18-inc67;
        ARRAY income {120};
        ARRAY salary {120};

/***** Calculation loop *****/
        DO k = age_ref to 120 by 1;
                IF k<= retage THEN
                        IF k=age_ref THEN income{k}=fincatax;
                                ELSE income{k}=income{k-1}*incfct{k-17}
                        ;
                ELSE income{k}=0
                ;
                IF k<= retage THEN
                        IF k=age_ref THEN salary{k}=fsalaryx;
                                ELSE salary{k}=salary{k-1}*incfct{k-17}
                        ;
                ELSE salary{k}=0
                ;
        END;

/***** Past Income Assumption *****/
        DO WHILE (h ge 18);
```

```
                income{h}=income{h+1}/incfct{h-16};
                salary{h}=salary{h+1}/incfct{h-16};
                h=h-1;
        END;

        highest_35 = 0;
        DO n=1 to 35;
                highest_35 = highest_35+LARGEST(n, of salary18-salary67);
        END;

/***** Social Security *****/
        socsec_35yravg = highest_35/35;
        month_inc = socsec_35yravg/12;
        if month_inc <= 761 then socsec = 12*(.9*month_inc);
        if month_inc > 761 and month_inc <= 4586 then socsec = 12*((.9*761)+.32*(month_inc-761));
        if month_inc > 4586 and month_inc <=7500 then socsec = 12*((.9*761)+(.32*(4586-
761))+(.15*(month_inc-4586)));
        if month_inc > 7500 then socsec = 12*2346;

/*      socsec=socsec*.85;*/

/***** Annuity Pricing *****/
        multiplier2=1;
        Annuity_Price=1;
        DO z=retage to 110;
                multiplier2=multiplier2*p_x{z};
                Annuity_Price=Annuity_Price + multiplier2*(v**(z-retage+1));
        END;
        Annuity_Price=Annuity_Price*1.05;


/***** Calculate Wealth at Retirement (Given current spending/saving habits) *****/
        Retirement_Wealth=wealth;
        DO n=age_ref to retage;
                Retirement_Wealth=Retirement_Wealth + ((income(n)-totexpyr)*((1+i)**(n-age_ref+1))); /*add
interest*/
        END;


/***** Compare Annuity Payments to Consumption *****/
        annual_annuity=Retirement_Wealth/Annuity_Price;
        annual_ret_cnsmptn=annual_annuity+socsec;

/***** Consumption Smoothing for Lifetime *****/
        cnsmptn_smooth = totexpyr;
        IF cnsmptn_smooth < (annual_ret_cnsmptn-6000)/.93 THEN
                DO UNTIL (cnsmptn_smooth>=(annual_ret_cnsmptn-6000)/.93);
                        cnsmptn_smooth=cnsmptn_smooth+1;
                        Retirement_Wealth=wealth;
                        DO n=age_ref to retage;
                                Retirement_Wealth=Retirement_Wealth + ((income(n)-
cnsmptn_smooth)*((1+i)**(n-age_ref+1))); /*add interest*/
                        END;
                        annual_annuity=Retirement_Wealth/Annuity_Price;
                        annual_ret_cnsmptn=annual_annuity+socsec;
                END;
        ;
        IF cnsmptn_smooth > (annual_ret_cnsmptn-6000)/.93 THEN
                DO UNTIL (cnsmptn_smooth<=(annual_ret_cnsmptn-6000)/.93);
                        cnsmptn_smooth=cnsmptn_smooth-1;
```

```
                                Retirement_Wealth=wealth;
                                DO n=age_ref to retage;
                                        Retirement_Wealth=Retirement_Wealth + ((income(n)-
cnsmptn_smooth)*((1+i)**(n-age_ref+1))); /*add interest*/
                                END;
                                annual_annuity=Retirement_Wealth/Annuity_Price;
                                annual_ret_cnsmptn=annual_annuity+socsec;
                        END;
                ;
run;

/*************************************************************/
/*************************************************************/
/********** END OF CALCULATIONS ***************************/
/*************************************************************/
/*************************************************************/
```

Results.sas

```
/***** Merge results from Annuity and Probability Models *****/
proc sql;
create table results as
        select
                a.cuid,
                a.age_ref,
                a.sex_ref,
                a.ref_race,
                a.retage,
                a.collar,
                a.educ_ref,
                a.id,
                a.inc_cd,
                a.cutenure,
                a.fpripenx,
                a.findretx,
                a.fgovretx,
                a.fsalaryx,
                a.fincatax,
                a.wealth,
                a.totexpyr,
                a.prob_wealth_lasting,
                a.socsec_35yravg,
                a.socsec,
                b.retirement_wealth,
                b.annuity_price,
                b.annual_annuity,
                b.annual_ret_cnsmptn,
                b.cnsmptn_smooth
                from aparr.prob_calcs a, aparr.ann_calcs b
                where a.cuid=b.cuid;
quit;
```

```
/***** Indicator Creation for T-test Analysis by Many Variables *****/
Data results_1;
        set results;
        Pct_Chg_Cnsmptn = (cnsmptn_smooth/totexpyr)-1;
        IF fpripenx=0 THEN Pension_Ind=0;
                ELSE Pension_Ind=1;
        IF findretx=0 THEN IRA_Ind=0;
                ELSE IRA_Ind=1;
        IF fgovretx=0 THEN GovRet_Ind=0;
                ELSE GovRet_Ind=1;
        IF Educ_Ref=00 or educ_ref=10 or educ_ref=11 or educ_ref=12 THEN HS_Ind=1;
                ELSE HS_Ind=0;
        IF Educ_Ref=13 or educ_ref=14 or educ_ref=15 THEN Col_Ind=1;
                ELSE Col_Ind=0;
        IF Educ_Ref=16 or educ_ref=17 THEN Grad_Ind=1;
                ELSE Grad_Ind=0;
        IF Ref_race=1 THEN White_Ind=1;
                ELSE White_Ind=0;
        IF Ref_race=2 THEN Black_Ind=1;
                ELSE Black_Ind=0;
        IF Ref_race=4 THEN Asian_Ind=1;
                ELSE Asian_Ind=0;
        IF CuTenure=1 or CuTenure=2 or CuTenure=3 THEN OwnHome_Ind=1;
                ELSE OwnHome_Ind=0;
        IF inc_cd=1 THEN Male_HS_ind=1;
                ELSE Male_HS_ind=0;
        IF inc_cd=2 THEN Female_HS_ind=1;
                ELSE Female_HS_ind=0;
        IF inc_cd=3 THEN Male_Col_ind=1;
                ELSE Male_Col_ind=0;
        IF inc_cd=4 THEN Female_Col_ind=1;
                ELSE Female_Col_ind=0;
        IF inc_cd=5 THEN Male_Grad_ind=1;
                ELSE Male_Grad_ind=0;
        IF inc_cd=6 THEN Female_Grad_ind=1;
                ELSE Female_Grad_ind=0;
        IF age_ref<35 THEN young_ind=1;
                ELSE young_ind=0;
        IF age_ref>=35 AND age_ref<50 THEN Mid_ind=1;
                ELSE mid_ind=0;
        IF age_ref>=50 THEN Old_ind=1;
                ELSE Old_ind=0;
run;

/***** Example T-test for Difference in Means of Probability of Wealth Lasting by Sex *****/
Proc Ttest data=results_1;
        title "Probability of Wealth Lasting: By Sex";
        class sex_ref;
        var prob_wealth_lasting;
run;

/***** Example T-test for Difference in Means of Percentage Change in Consumption by Sex *****/
Proc Ttest data=results_1;
        title "Pct Change: By Sex";
        class sex_ref;
        var pct_chg_cnsmptn;
run;
```

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VITA

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- Schreyer Honors College, The Pennsylvania State University
- Academic Excellence Scholarship, The Pennsylvania State University
- Dean's List, The Pennsylvania State University, Every Semester from Fall 2006 through Fall 2010
- Penn State Varsity Men's Soccer Team
    - 2009 Big Ten Distinguished Scholar Award
    - Three Time Academic All Big Ten

Association Memberships
- Beta Gamma Sigma Business Honor Society

Professional Experience
- Actuarial Analyst Intern, The Chubb Insurance, June 2010-August 2010
- Actuarial Analyst Intern, Watson Wyatt, June 2010-August 2010

Research in Progress
"Financial Planning for Retirement: An Actuarial and Economic Analysis" Departments of Economics and Insurance and Real Estate, supervisor Theodore Papageorgiou, to be completed by December 2010