



John Hancock

Numerical Investigation for Variable Universal Life

A Major Qualifying Project Report
Submitted to the faculty
of the
Worcester Polytechnic Institute
in partial fulfillment of the requirements for
the Degree of Bachelor of Science
in Actuarial Mathematics
by

Maarja-Liisa Sokk

Han Yang

April 26, 2012

Jon Abraham, Project Advisor

Bruce Kearnan & Steven O'Brien, Liaisons

Abstract

During the sales process of an insurance product an illustration is used to show a customer the potential benefits and cash values of a policy. Our project was to determine what annual rate of return John Hancock should be using to illustrate their Indexed Universal Life policy at. To accomplish this we built a model for projected stock market returns using the Random Walk and Regime Switching models as a basis. We also layered on certain policy features to see how they affected the annual rate of return.

Executive Summary

John Hancock is a leader in the insurance and financial service industry. This project focused on John Hancock's Indexed Universal Life Insurance and how to best model and predict how much money a customer would need to put into an accumulation fund to have a certain amount of money in N years with probability $P\%$. A part of the sales process for any insurance product is an "illustration" which provides a projection of the benefits a prospective buyer can anticipate. Using a high interest rate in the illustration will aid the sales process but can lead to customer dissatisfaction later, while low interest rates may not provide an attractive illustration.

The goal of this project was to determine what interest rate(s) would be reasonable to use to illustrate Indexed Universal Life Insurance so that a customer has a reasonable probability of realizing the projected payout from the contract. To achieve this goal our project team completed the following objectives:

- Collected and reviewed historical data from the S&P 500
- Developed parameters for the Random Walk Model (RW) and modeled stock market returns
- Developed parameters for the Regime Switching Model (RS) and modeled stock market returns
- Developed both RW and RS models with an adjustable collar, having a cap and floor on the returns
- Compared the RW model and RS model to determine which was a better fit to the data
- Created a model that allowed new contributions to or withdrawals from the account as well

The methodology required an understanding of the many different life insurance options, including the new indexed universal life which was introduced in 2011. The students also needed to research various modeling techniques and how to determine the parameters for the random walk and

regime-switching models. These models were then built using Microsoft Excel and were used to generate 10,000 outcomes of multiple scenarios and to create distributions of the expected returns under each scenario. Using these models as a basis an adjustable floor and cap were built in to demonstrate that the adding of a collar tightened the returns. The floor and the cap correspond to typical Indexed Variable Life policy provisions. Finally the model was extended to include cash flow additions and withdrawals.

The purpose of the project was to provide John Hancock with models that project the future stock market returns, provide estimates of how much policyholders would be willing to pay for their products, and determining what interest rates they should be using to illustrate their Indexed Universal Life insurance. This project provides John Hancock with an opportunity to better understand and improve their product.

Table of Contents

Abstract	1
Executive Summary	2
Table of Contents	4
Table of Figures	6
Table of Tables	6
1. Introduction	7
2. Background	8
2.1 1999's Major Qualifying Project	8
2.1.1 Previous Project.....	8
2.1.2 1999 Methodology	9
2.1.3 1999 Results	9
2.2 Variations of Life Insurance	10
2.2.1 Variable-Universal Life.....	10
2.2.2 Indexed Universal Life.....	10
2.3 Illustrations in Sales Process.....	10
3. Methodology.....	12
3.1 Random Walk Model.....	12
3.2 Regime Switching Model.....	16
3.3 Model Inputs.....	18
3.3.1 Range of Historical Data	18
3.3.2 Length of Projection	20
3.3.3 Cap & Floor Adjustments	21
3.3.4 Cash Flow Patterns	22
3.3.4.1 Lump Sum Deposit.....	22
3.3.4.2 Level Monthly Cashflows	22
3.3.4.3 Varying Monthly Cashflows.....	23
3.3.4.4 Lump Sum Deposit followed by recurring monthly withdrawals	24
3.3.4.5 Level Cashflows followed by recurring monthly withdrawals.....	24
3.3.4.6 Compound cashflows followed by recurring monthly withdrawals.....	24
4. Analysis and Discussion	26

5. Conclusion and Recommendations	29
6. Appendix	30
Appendix A: How the Regime Switching Model Works	30
Appendix B: Manual on how to use the Excel spreadsheet.....	31
7. Bibliography	34

Table of Figures

Figure 1: 10,000 Random Walk Observations.....	13
Figure 2: Counts of Observations.....	14
Figure 3: Cumulative Probability.....	15
Figure 4: Random Walk Model.....	15
Figure 5: Regime Switching Model.....	16
Figure 6: Range of Historical Data.....	18
Figure 7: Cumulative Probability of Altered Range of Historical Data	19
Figure 8: Different Length of Projections	20
Figure 9: Collared Stock Market Returns.....	21
Figure 10: Comparison of Cashflow Deposits	23
Figure 11: Various Cashflow Withdrawals.....	25

Table of Tables

Table 1: Maximum Likelihood Parameters for Regime Switching Model.....	17
Table 2: Comparison of Selection Information for Lognormal, Autoregressive, and Regime Switching Models.....	17

1. Introduction

There are so many insurance products today for customers to choose from. Each product is designed to fit a group of individuals looking for something specific in their life insurance, whether that is term or permanent life, whole life, variable life, universal life, or some combination of the above. New forms of insurance were developed to appease customers that requested certain changes to the old policies. Two examples of this include having flexible contracts on when and how much to pay for premiums and having a designated portion invested in funds such as bonds and stocks. John Hancock recently released their new Indexed Universal Life policy, which is a combination of Variable Life and Universal Life, offering choices on how much to invest in indexes which follow the stock market.

John Hancock was founded in 1862 as a four-person company, named after one of our nation's forefathers. This company is involved in providing many financial solutions to their clients. John Hancock offers life insurance, mutual funds, 401k plans, long-term care insurance, and annuities. In 2004 John Hancock merged with Manulife Financial Corporation, the largest Canadian life insurer. Today John Hancock continues to operate under its own name as the US subsidiary of Manulife. John Hancock just celebrated 150 years of promises kept. This shows that the company has long stood for integrity and commitment.

The focus of this project is to help John Hancock determine what interest rates are reasonable to use in illustrating their policies during the sales process. We will discuss the final model our project team developed using the Random Walk and Regime Switching models as a foundation. Our model is designed to simulate the returns of the S&P 500 that a policy holder could see, layering in certain guarantees on the returns. We will analyze the many variable parts of our model to determine the impacts on the annual rates of return. The results of our project provide John Hancock an idea of if the interest rates they are using to illustrate indexed universal life policies at are reasonable.

2. Background

In this section we present information on various subjects to help the reader better understand the process and goal of our project. We will begin by providing a brief summary of a previous project completed in 1999, as our project is based upon providing a reorganized version of this report for a new type of life insurance policy. Then we will offer simplified descriptions of different types of life insurance and insight into the illustration process of an insurance product.

2.1 1999's Major Qualifying Project

This project, Pricing Guaranteed Medallion Variable Life Insurance Policies by Aaron Korthas and Shelby Woods, simulated hypothetical Medallion Variable Life Insurance policies, which are a unique kind of life insurance in which policy holders can determine where their money is invested. The variability of the many different investment opportunities causes the performance of each of the policies to be very difficult to predict. This in turn makes it difficult to determine appropriate premiums that customers should pay to maintain their accounts. John Hancock has software that determines how many premiums will have to be paid in order to make a policy succeed, given a certain premium amount and a fixed rate of return. This is called FRNOP, fixed rate number of premiums. Unfortunately this approach does not allow for variability in rates of return, and therefore is unrealistic when trying to model investments which are rather variable.

2.1.1 Previous Project

This project also takes a look back at a previous project by Heather Stultz and Jonathan Van Haste, Estimating Success Probabilities of Variable Life Insurance via Simulation. In this project the team wrote a C++ program to generate random rates of return and used these to simulate the behavior of hypothetical policies. With this program they were able to estimate the probability of success using

payment structures from the FRNOP. Their project showed that when variability is entered into the FRNOP model it was possible for only between 30-45% of policies to become fully funded by age 100.

2.1.2 1999 Methodology

The results of the previous project were so shocking that the sponsors needed a continuation of the investigation into the MVL product. The first step was to investigate the levels of variability previously used and determine more appropriate parameters. This project however, was working with a different life insurance product which John Hancock guaranteed an agreed upon death benefit for a given number of years (N). This project determined the premiums for the modified version of Medallion Variable Life.

The project team modified the C++ program from the previous project in order to determine the premium required to guarantee a death benefit of \$100,000 for N years. The guaranteeable premiums required that 95% of the policies simulated with that premium succeed, had a positive surrender value at the end of an N-year period. The program simulated each policy on a month to month basis, taking into account any deposited premiums, administration charges, and the cost of insurance charge.

2.1.3 1999 Results

The project team from 1999 determined that the longer of a guarantee John Hancock would like to offer their customers, the more difficult pricing the product becomes. This is because the Medallion Variable Life Insurance allows customers to choose their own investment path, each of which has the potential for remarkable variability. The results of this project showed that investments involving more risk are always expected to require larger premiums.

2.2 Variations of Life Insurance

There are many types of life insurance being sold to customers today. In this section we will discuss the two products offered by John Hancock that our project focused on, Variable-Universal Life and Indexed Universal Life.

2.2.1 Variable-Universal Life

Variable Universal Life was introduced in 1993 in response to customers wanting a Universal Life product with certain guarantees. Variable Universal Life blends the features of Variable Life, where the customer takes on risks, with those of Universal Life to offer a choice of underlying investment accounts, flexible premiums, and an adjustable death benefit. The customer was given more control of the cash value portion of their policy than with any other type of insurance.

2.2.2 Indexed Universal Life

John Hancock launched its new Indexed Universal Life product in 2011 which is a permanent life insurance policy with cash value accumulation potential and protection against market downturns. Indexed Universal Life took the standard Universal Life design but provided choices on how much to invest in indexes which follow the market and try to match the S&P 500's performance. The Indexed Universal Life offers two Indexed Account options, the Capped Indexed Account which currently credits up to 13% rate of return and an Uncapped Indexed Account that credits up to the full performance of the S&P 500, less 5%. Both Indexed Account options offer a 0% minimum interest rate floor – eliminating market-based losses.

2.3 Illustrations in Sales Process

One of the big concerns for John Hancock is how to illustrate the potential benefits and cash values for these policies. Illustrations are used as part of the Sales Process for insurance policies as they show how the value of the policy can be expected to grow under certain economic conditions. By law,

illustrations are based on a single interest rate that is assumed reasonable for the duration of the illustration. This can lead to some internal conflicts, as the Sales and Marketing areas might lobby for a high interest rate, which would produce a favorable looking illustration, while the Actuaries may be reluctant to over-extend on the interest rate.

3. Methodology

One big goal of our project was to develop a tool that John Hancock can use to set confidence intervals on various outcomes, given a variety of model inputs. To accomplish this we modeled stock market returns, layered on various policy features, and considered a variety of possible cashflow patterns for the policies. We started the project by looking at the stock market returns of the S&P 500 because this was the index that our Indexed Universal Life policy's performance was trying to match. After gathering all the monthly historical returns from 1961-2010 we used these to determine the mean and standard deviation for the Random Walk Model.

3.1 Random Walk Model

We determined the parameters for the Random Walk model using the monthly historical returns from 1961 to 2010. We found a mean of 0.506% and a standard deviation of 4.379%. Using these parameters we ran 10,000 trials of the Random Walk model as seen below in Figure 1. The green line on this graph is the median where a customer would have earned 11 times their principal in a 50 year projection. As you can see the blue line, showing the 0 percentile, ends up negative after 50 years, meaning a customer would have lost money. The measurement of the percentiles was taken at the end of 50 year projection. If the percentiles were determined at any other period they wouldn't necessarily be the same.

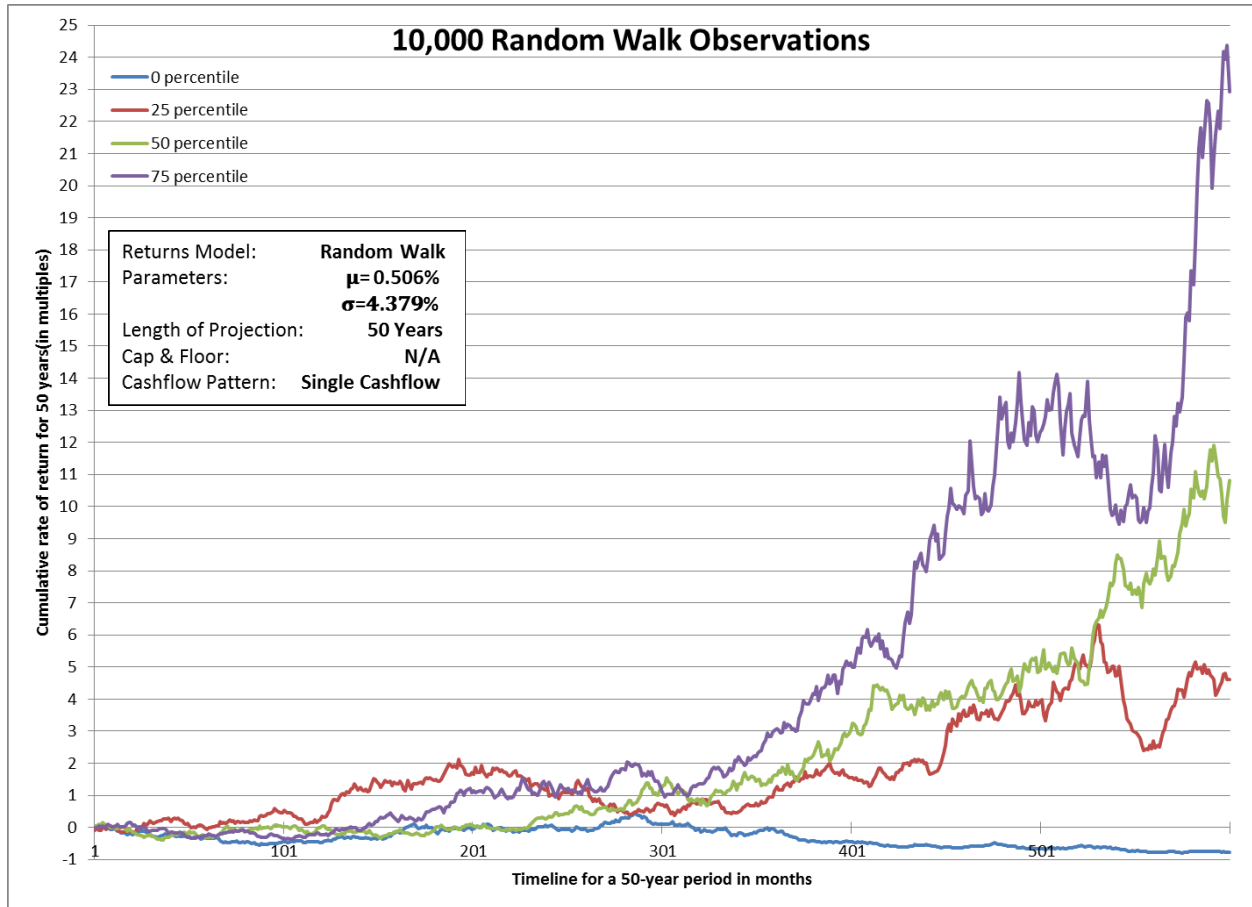


Figure 1: 10,000 Random Walk Observations

We then counted up the number of observations that ended up being in each multiple. The results of this can be seen in Figure 2. The most number of observations were at 5 times the principle in a 50 year projection. As you can see the Cumulative Rate of Return (in multiples) has increased in this graph up to 60, whereas in Figure 1 the graph only went up to 25. This was done to show the full range of observations in the second figure, which if shown in Figure 1 would have made the rest of the percentiles too small to see. By excluding the 100th percentile from Figure 1 you are able to much easily see the intertwining of the curves as they progress towards the 50 year mark.

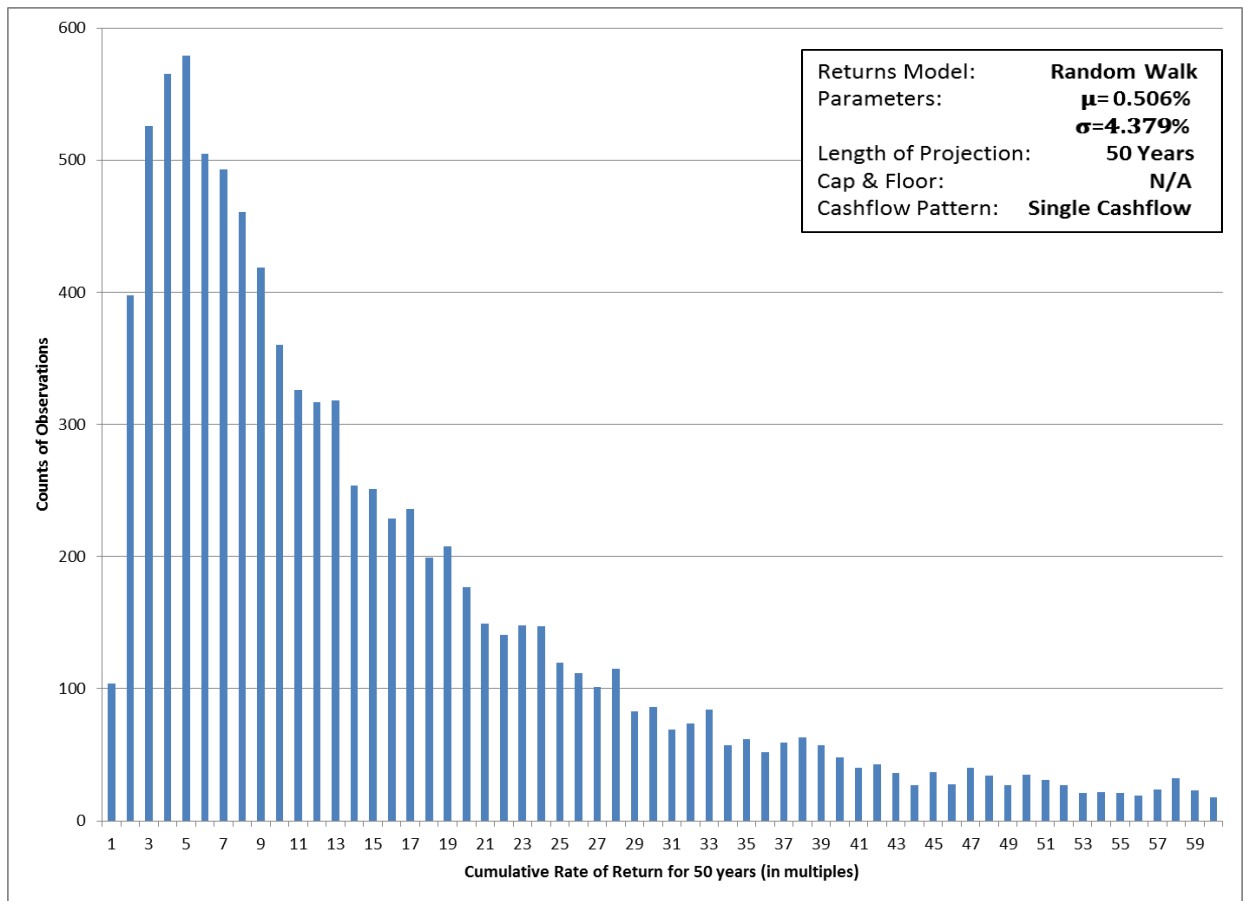


Figure 2: Counts of Observations

From the histogram in Figure 2 we then developed a cumulative probability distribution shown in Figure 3. This will be the format used for most of the future graphs in this project. This graph helps determine with what percent confidence a policy will end up with an annual rate of return up to a given percent. This can be a useful tool in determining what interest rate to illustrate insurance policies at.

The traditional Random Walk model has two parameters as mentioned earlier, an expected return and a volatility component. Each day's return is independent of the previous day's return. This model has become well accepted and is one of the models we used in modeling our project. Below, in Figure 4 you will see an exaggerated picture of the returns resulting from a Random Walk. The red line is

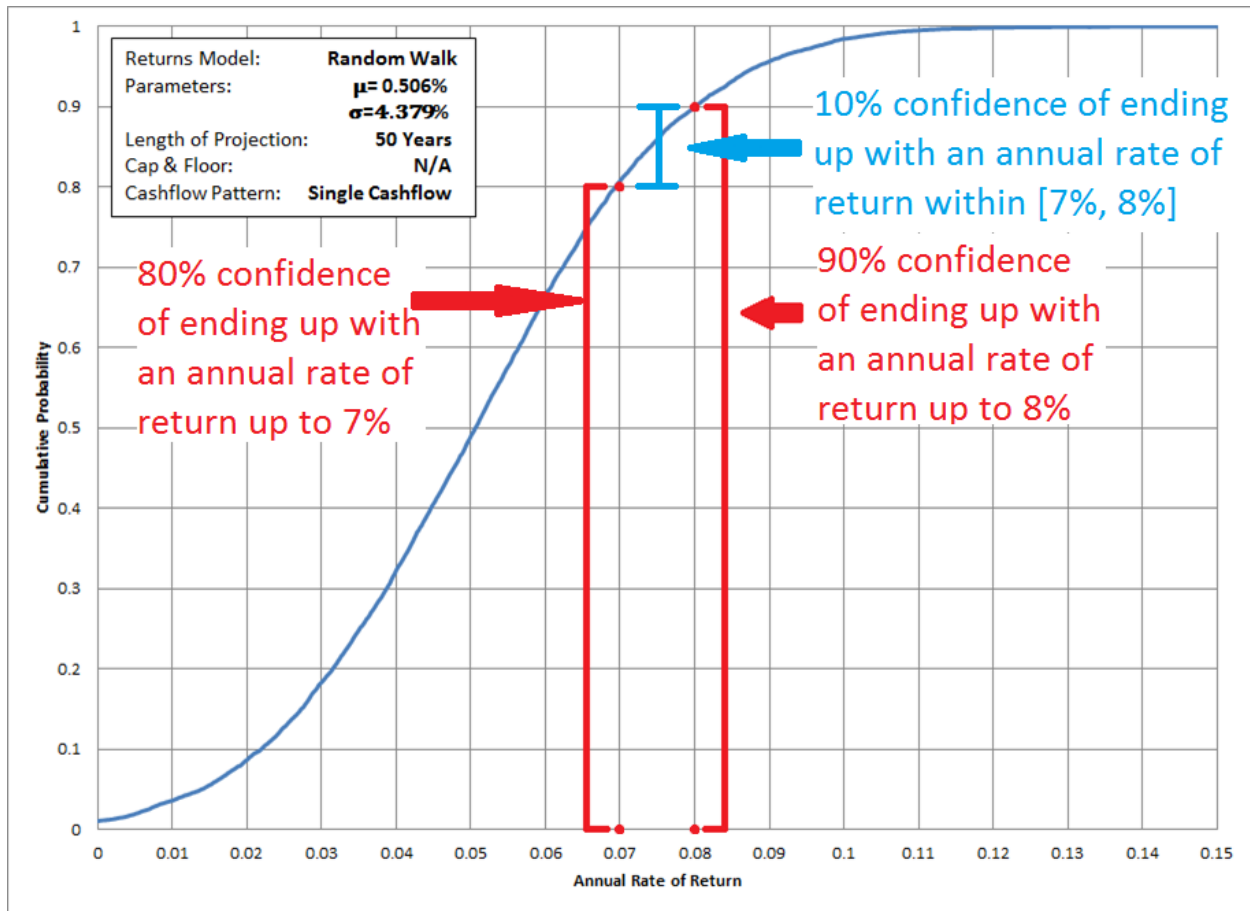


Figure 3: Cumulative Probability

the expected return, the blue line moves up and down around this line due to volatility. Changing the long-term return will raise or lower the red line, while changing the volatility will smooth out or further disturb the blue line.

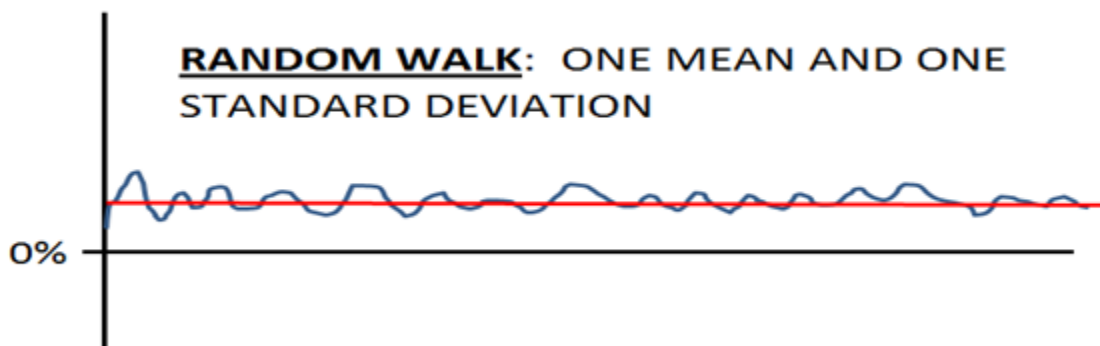


Figure 4: Random Walk Model

3.2 Regime Switching Model

In researching various modeling techniques we came across an academic paper that suggested that the actual stock market returns may not be quite as random as implied by the Random Walk model. Mary Hardy the author of [A Regime-Switching Model of Long-Term Stock Returns](#) illustrates an alternative view of the market – what if there are periods of “good times” when returns fluctuate around a higher mean and periods of “bad times” when returns fluctuate around lower means? The resulting model postulates two “regimes”, corresponding to the good times and the bad times. Each regime has its own expected return and its own volatility. The chance of transitioning between the “upper regime” and the “lower regime” adds two more parameters to this model. In Figure 5 below you will see an exaggeration of the Regime Switching model, which you can compare to Figure 4’s Random Walk model.

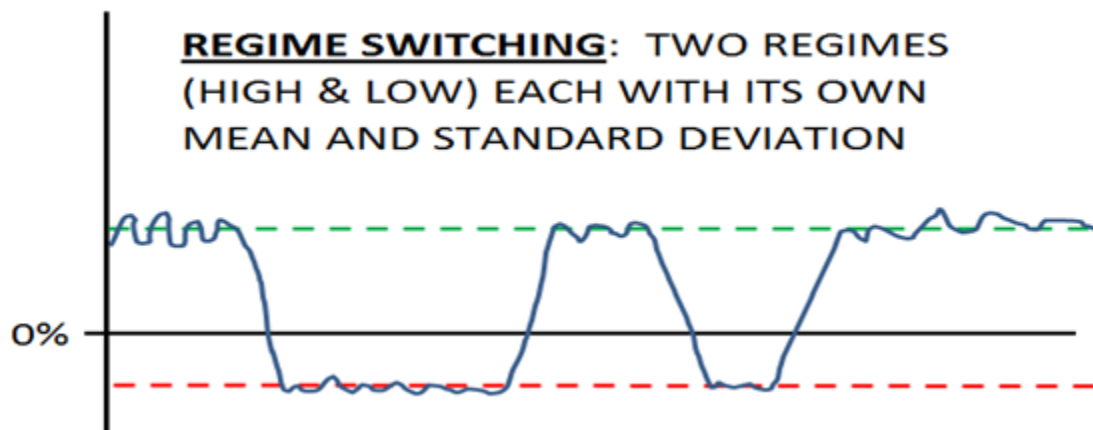


Figure 5: Regime Switching Model

There are 6 maximum likelihood parameters for the Regime Switching model as seen below in Table 1. The key difference between the Random Walk and Regime Switching models is that in the regime switching model every observation is generated according to the behavior of the previous one. The process that the regime switching model follows is depicted in Appendix A. When the past 50 years of stock market returns are modeled with a Random Walk model, and with a 2-Regime model, the paper

Table 1: Maximum Likelihood Parameters for Regime Switching Model

	Mean	Volatility	Probability to Switch Regime
Regime 1	$\hat{\mu}_1$	$\hat{\sigma}_1$	$\hat{p}_{1,2}$
Regime 2	$\hat{\mu}_2$	$\hat{\sigma}_2$	$\hat{p}_{2,1}$

by Mary Hardy found that the 2-Regime model had a significantly better log-likelihood, indicating a better fit. You can see her results below in Table 2. The red boxes indicate the ILN (Random Walk) and

Table 2: Comparison of Selection Information for Lognormal, Autoregressive, and Regime Switching Models

Model (j)	Parameters (k_j)	log L (l_j)	SBC ($l_j - \frac{1}{2}k_j \log n$)	AIC ($l_j - k_j$)	LRT (p)
TSE 300 (1956-99 Monthly Total Returns)					
ILN	2	885.6	879.4	883.6	$<10^{-8}$
AR(1)	3	887.4	878.0	884.4	$<10^{-8}$
ARCH	3	888.5	879.1	885.5	$<10^{-8}$
AR-ARCH	4	890.8	878.3	887.8	$<10^{-8}$
GARCH	4	896.0	883.5	892.0	$<10^{-8}$
AR-GARCH	5	897.9	882.2	894.9	$<10^{-8}$
RSLN-2	6	922.7	903.9	917.7	
RSAR-2	8	922.9	897.8	914.9	0.82
RSLN-3	12	925.9	888.3	913.9	0.38
S&P 500 (1956-99 Monthly Total Returns)					
ILN	2	929.4	923.1	927.4	$<10^{-8}$
AR(1)	3	929.6	917.1	926.6	$<10^{-8}$
ARCH	3	933.3	923.9	930.3	$<10^{-8}$
AR-ARCH	4	933.4	920.9	929.4	$<10^{-8}$
GARCH	4	938.9	926.4	934.9	$<10^{-6}$
AR-GARCH	5	939.1	923.4	934.1	$<10^{-6}$
RSLN-2	6	952.5	933.6	946.5	
RSAR-2	8	952.6	927.5	944.6	0.91
RSLN-3	12	960.8	923.2	948.8	0.01

the RSLN (Regime Switching) for both the Toronto Stock Exchange (TSE) and S&P 500. We were able to replicate these calculations, and also tested the 2-Regime model for shorter periods of time. Overall it seems as if the Regime Switching Model is a reasonable model to consider in addition to the Random Walk model. We built our model to allow either the Random Walk or the Regime Switching parameters to be used as an input, and for a variety of time periods.

3.3 Model Inputs

We altered many inputs to the basic model to see how different variables would affect the cumulative probability distribution. We altered the range of historical data used for the projections, the length of the projections themselves, adding on a collar, and having various cash flow patterns.

3.3.1 Range of Historical Data

As noted earlier, we developed our model to use either Random Walk or Regime Switching parameters. We also added the ability to select returns from different historical periods so that we had the ability to illustrate bad, average, and good periods for stock market returns. Figure 6

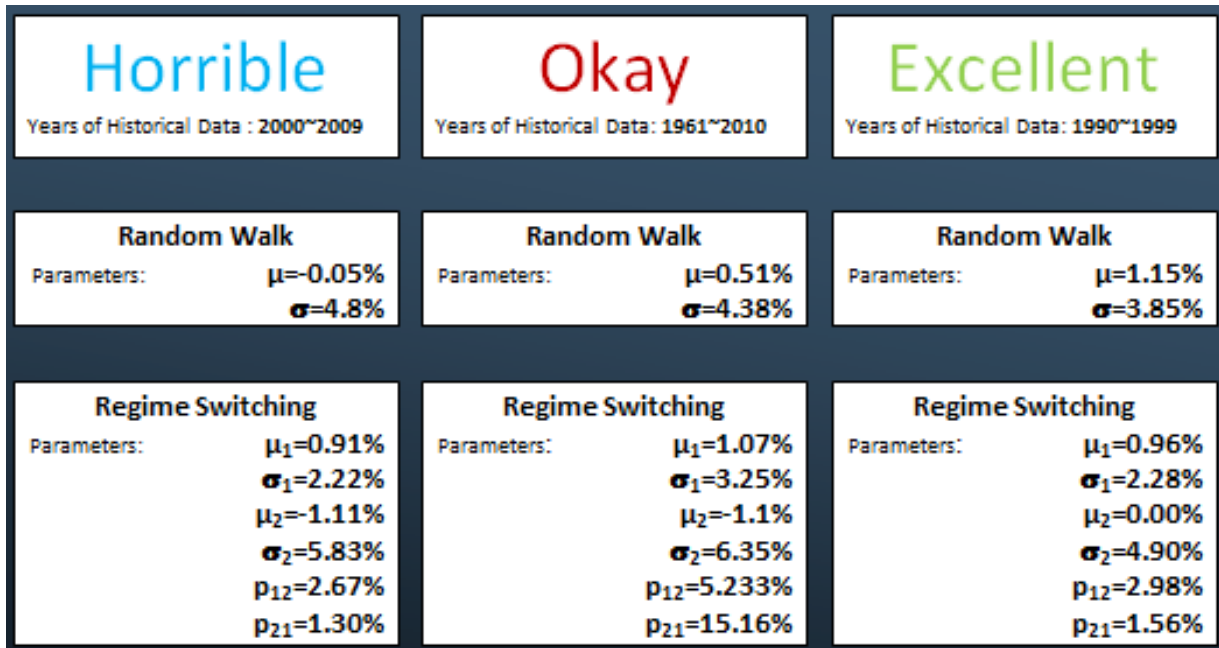


Figure 6: Range of Historical Data

shows the three different time periods we selected for modeling how the range of historical data would affect the cumulative probability. As most people know the 21st century was a Horrible time for the stock market and this can be seen in the parameters. During this time period the Random Walk actually has a negative mean. The Okay time period shown is the average of all the years from 1961 to 2010 which was developed earlier for both models. The years from 1990 to 1999 were Excellent in terms of

stock market returns. In this case on the Regime Switching model it is interesting to note that the low mean is at 0%, which denotes that on average you will not lose money. As seen below in Figure 7 the

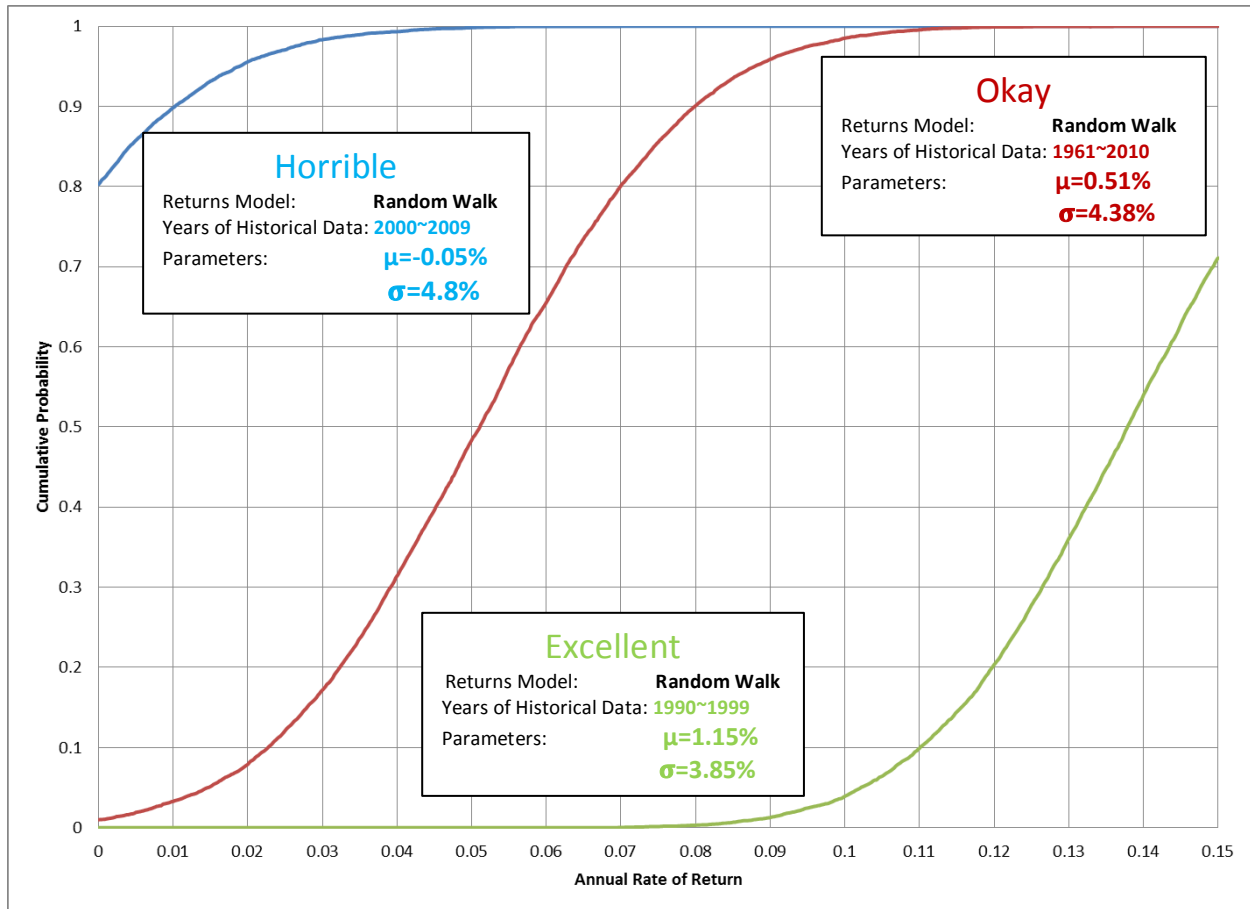


Figure 7: Cumulative Probability of Altered Range of Historical Data

Cumulative probability is greatly affected by using diverse sets of historical data. The historical data from the Horrible range shows that you have an 80% chance of getting at or below a 0% rate of return, in other words 80% of the time a customer would lose the money they put in. In stark contrast to this is the Excellent range of data which indicates that you have a 0% chance of getting below an 8% rate of return on your investment.

3.3.2 Length of Projection

The next input that we modified was the length of the projections. We estimated the behavior of the stock market N years into the future where $N=10$ to $N=50$, increasing in increments of 10 years. For this group of simulations we used the parameters from the Okay time period which is more

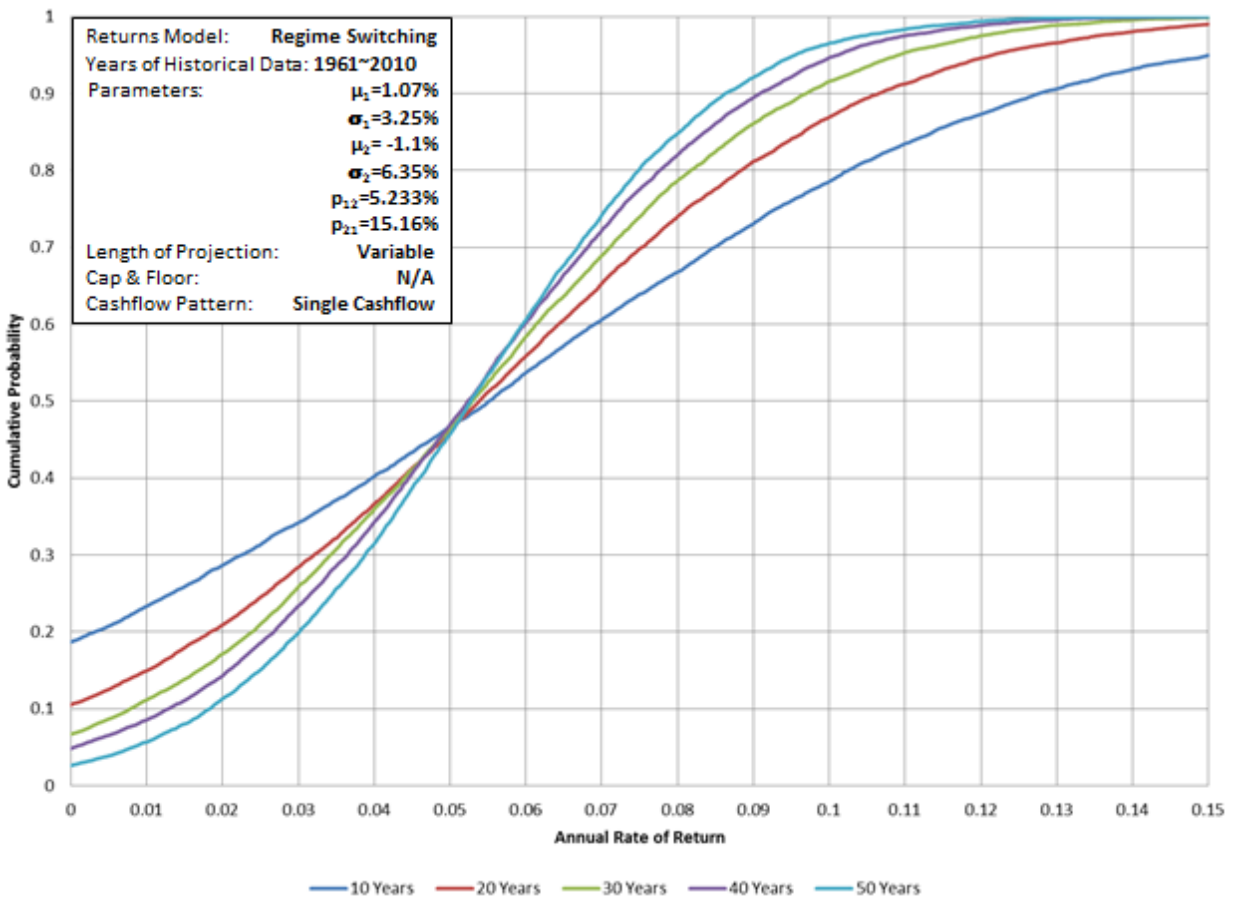


Figure 8: Different Length of Projections

likely to occur than the Horrible or Excellent times. As you can see above in Figure 8, the projection for only 10 years is much flatter than all the other projections. This means that there is much more uncertainty with in the short term. As you increase the length of the projection the curves get steeper and steeper which indicate less uncertainty in turn making the insurance companies happy.

3.3.3 Cap & Floor Adjustments

We also examined what the adding of a collar would do to the returns. A collar is put in place by insurance companies to control what rate of return the customer is actually getting back. For example if an insurance company sets the floor at 0% the customer is guaranteed to never lose money. While setting the cap at 18% means that if the customer earns more than 18% the excess gets taken away by the insurance company. Below in Figure 9 you can find all of the floor and cap scenarios that we tested. The

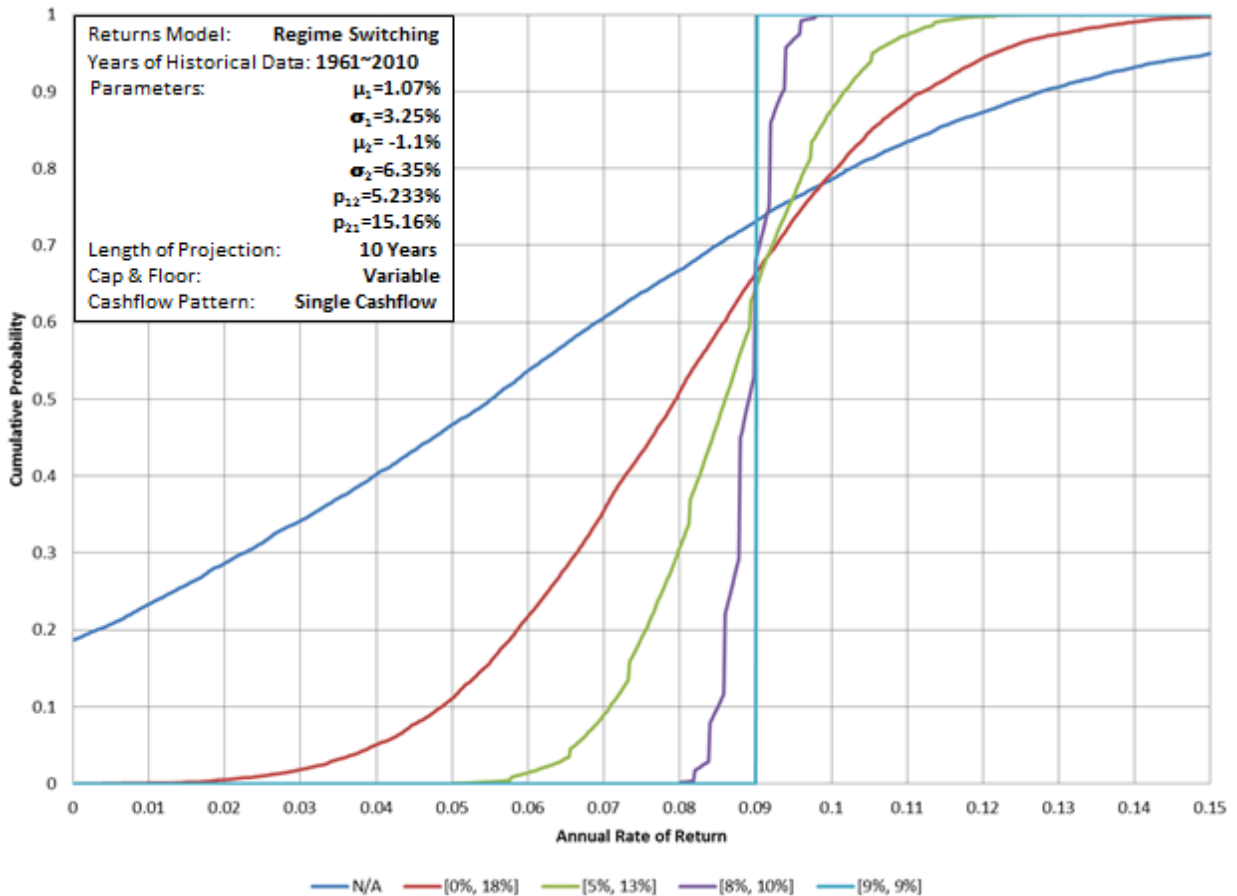


Figure 9: Collared Stock Market Returns

N/A collar means that the cap and floor were both set to infinity so a customer would earn whatever rate the market returned. The collar similar to that of John Hancock's Indexed Universal Life is the one

with a floor of 5% and a cap of 13%. This is the combination of their two options. For illustration purposes we also modeled a collar of 9% for both the cap and floor. We did this to make sure that our assumption was right and that our program worked properly. As you can see in Figure 9 you would be 100% sure that you will get an annual rate of return of exactly 9%.

3.3.4 Cash Flow Patterns

In order to build up value in an insurance account a customer must make certain deposits. These can vary from a lump sum at the beginning, to level amounts each month, or even varying monthly deposits. Just like making deposits customers may want to withdraw money from their accounts in various ways. Our project investigated the effect of recurring monthly withdrawals after making various deposits.

3.3.4.1 Lump Sum Deposit

The lump sum deposit is the basic model that has been used previously in this paper. This means that a customer makes only one deposit into the account at the beginning of the n-year projection. Then this account is allowed to accumulate until the end of the period. A 10 year lump sum deposit is shown below in blue in Figure 10. This basic lump sum deposit was used as a basis for the policy modifications above such as the length of the projection and the cap and floor adjustments.

3.3.4.2 Level Monthly Cashflows

Level Monthly cashflows are when you deposit the same amount into your account every month. Each month in this simulation is treated like a separate account, so one could think of each year as having 12 different accounts. This occurs because you let each deposit accumulate for 12 months and then at the end of the 12 month bracket you can adjust for a cap and floor. In this model you have 12 rolling segments, one for each month. Each segment is locked in for a whole year of

accumulation. You can see that the level monthly cashflows, in red, seen below in Figure 10 have a flatter cumulative probability curve than the lump sum deposit.

3.3.4.3 Varying Monthly Cashflows

Varying monthly cashflows means that instead of having level cashflows each month the customer decides to increase the cashflow each month by a certain percent. The accumulation works the same way as for level cashflows, where there are 12 rolling segments. However the deposit is increased by a given percent, in Figure 10 the green line was compounded by 5%. This means that the initial deposit is increased by 5% every month. The green line flattens out even more showing that the result is more uncertain.

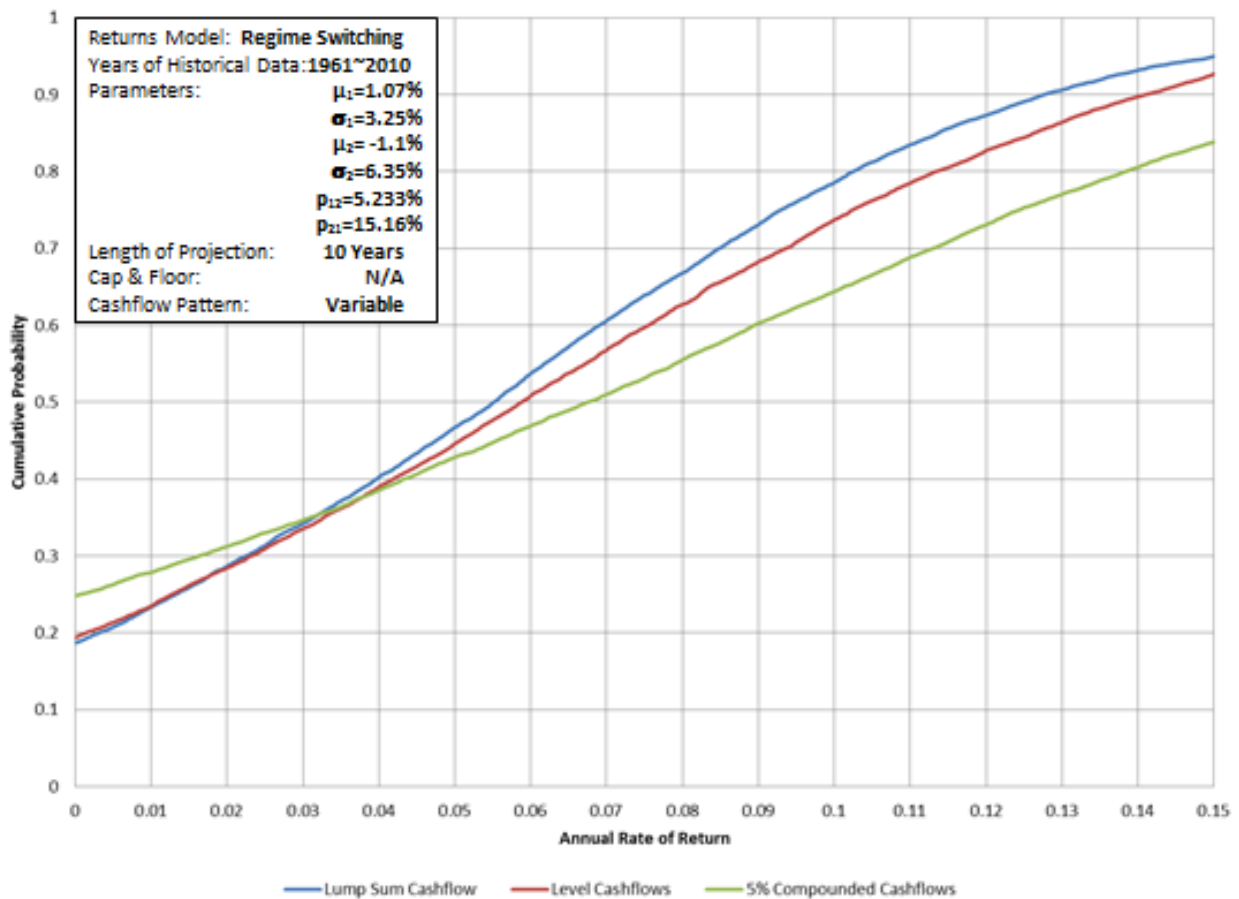


Figure 10: Comparison of Cashflow Deposits

3.3.4.4 Lump Sum Deposit followed by recurring monthly withdrawals

For recurring monthly withdrawals we used the formula $\frac{\text{Balance}_t}{\ddot{a}_{\overline{n-t}|j}}$ seen to the right where n =the length of the projection, t =the current time, and j =the lowest assumed rate of return. The j is set equal to the floor in our model. The goal of this section was to determine the maximum amount that a customer could withdraw every month from their account without running out of money before time n . Our model recalculates the maximum account every month and adjusts for monthly factors. The maximum withdrawal amount increases as time goes on because our model assumes that the fund earns only the floor rate. The account is likely to earn more than the floor, which means that you have a higher balance and therefore can withdraw more from the accumulated balance each month. The lump sum deposit followed by monthly withdrawals can be seen below in Figure 11 as the blue curve.

3.3.4.5 Level Cashflows followed by recurring monthly withdrawals

For the first 25 years cashflows are deposited in level amounts. Then during the second 25 years withdrawals are made. The withdrawals follow the same pattern as above for a lump sum deposit. This is because the accumulation period ends before the withdrawals start. We are treating the accumulated value after the first 25 years as a lump sum deposit and then withdrawing from the “lump sum” using j =floor rate to determine the maximum monthly withdrawals. We then adjust this every month to add in any market returns above the floor rate. In Figure 11 the red line represents level cashflows for the first 25 years followed by recurring monthly withdrawals for the final 25 years.

3.3.4.6 Compound cashflows followed by recurring monthly withdrawals

Compounded cashflows are deposited for the first 25 years, in which the cashflow is increased every month by a certain percent. The accumulated value is then treated as a “lump sum” deposit and is used to determine the maximum withdrawals for the next 25 years. This is done like above using the floor rate to determine the maximum monthly withdrawals. Adjustments are

made every month for market returns above the floor rate. This can be seen in Figure 11, where the green line represents a 2% compounded cashflow for 25 years followed by recurring monthly withdrawals for the last 25 years.

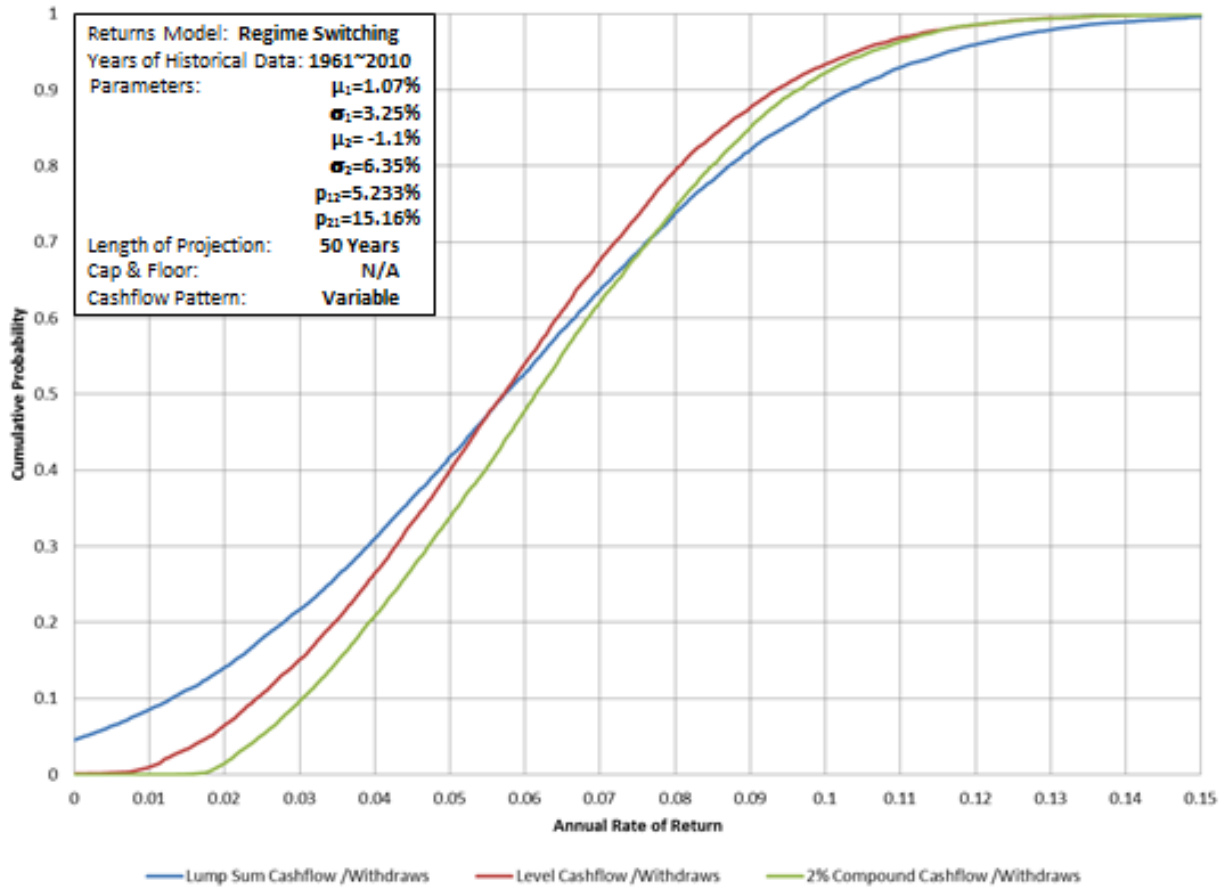


Figure 11: Various Cashflow Withdrawals

4. Analysis and Discussion

The model our project team built has many variable components. We worked with both the Random Walk model and the Regime Switching model to determine the annual rate of return that would be best for illustrating life insurance policies at. The basic model as seen in Figure 3 shows how we measured most of our results. We were trying to determine with what percent confidence a policy would earn up to a certain annual rate of return. In modeling our returns we came across a paper by Mary Hardy that described the Regime Switching model, which we believe is a more accurate illustration of how the market actually moves. When the times are good the market tends to stay up versus when times are bad the market also does poorly. The Random Walk model can be thought of as a regime switching model with no chance of switching between regimes. We used this fact to build a single model where you can modify the parameters to suit either the Random Walk or Regime Switching models.

There are many inputs that can be altered in our model. The first is the range of historical data being used. As seen in Figure 6 the parameters used for projecting future returns are very different for many time periods. In a horrible time period such as from 2000-2009 the market was doing very badly and as a result any projection using that data would also be terrible. Having 80% confidence in the fact that you will earn below 0% annual rate of return is not something a customer would want to see illustrated. That would mean they would lose the money they invested in the account 80% of the time. Customers would much rather see an illustration of the 1990's where the stock market was doing excellent. In this case they would be almost 100% confident that you will earn an annual rate of return over 8%. These however are two cases where the stock market was at an extreme. A much more likely time period to illustrate is from 1961-2010 where the stock market was slowly increasing.

The second input that had a significant impact was the length of the projections. As the projections got longer the curves became steeper. This meant that there was less uncertainty which

insurance companies would like to see. This makes sense in modeling the stock market because in the long run stocks are more likely to increase than just making short term gains. Our model was able to capture this aspect very well as seen in Figure 8.

Adding a collar to the returns also altered the projection greatly. In Figure 9 one can see that the adding of a cap and floor greatly steepened the curve. This is true because you are only allowing the account to collect earnings in a particular range. The annual rate of return in this case is being more closely refined until the instance where both the cap and floor are equal to 9%. This proves what we were expecting that limiting the return to 9% all the time means that the annual rate of return for that scenario is also 9%.

Next, we looked at adding various cashflow deposits. We began by examining the lump sum model which we have been using all along. In this case money is deposited into the account at the beginning of the projection and is just able to grow without interruption. Adding level monthly deposits meant that each month the same amount of money was deposited into rolling segments. These segments were locked in for a full year until they were subject to more additions. This can also be thought of as having 12 separate accounts, one for each month, and keeping track of them individually before combining them for a final accumulated value. With varying monthly cashflows, the amount of the deposit increased every month by a certain percentage. This type of deposit also used the 12 rolling segments. As you can see in Figure 10 the lump sum has the steepest curve, followed by the level cashflows, and finally the 5% compounded cashflows. This result was expected because in the lump sum the whole value accumulated from month 1 and therefore had a longer time to build up. For level cashflows and compounded cashflows the balance gets higher as time goes on and therefore doesn't have as much time to accumulate funds.

Finally we looked at making withdrawals from the account for specified cases. We started with just a simple lump sum deposit followed by recurring monthly withdrawals. This meant that every month our model would need to calculate the maximum amount of money that could be taken out of the account. We chose to do this by assuming the floor rate as the lowest rate of return possible. Because most months you will end up with a value above the floor the model would need to recalculate to tell the customer how much they could withdraw every month until time n when the fund would be exhausted. We then looked at having level cashflows for 25 years followed by recurring monthly withdrawals for 25 years. In this case we split the problem into two parts. First we accumulated level cashflows for 25 years which we then set equal to a "lump sum". We then used the same process for determining monthly withdrawals. For the compounded cashflows and monthly withdrawals the model was again broken down into two pieces. The compounded cashflow deposits were first accumulated to one final "lump sum". Using this in the withdrawal portion of the model we were able to determine the maximum amount a customer could withdraw from their account every month to run it out in a certain number of years.

5. Conclusion and Recommendations

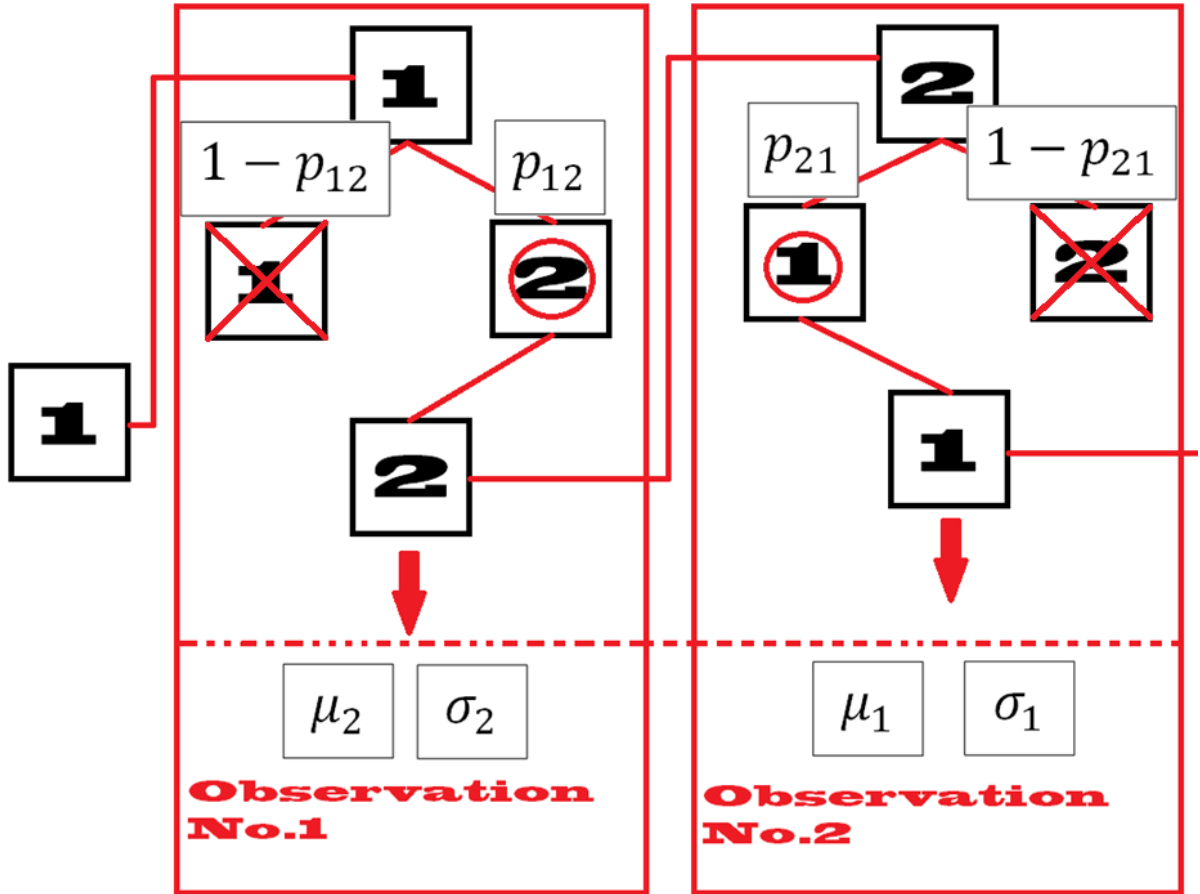
Due to the flexible features of Indexed Universal Life, the interest rate used for illustration is highly variable. The model is dependent on the historical data used to determine parameters, the length of investment, the cap and floor values, the method of depositing funds into the account, and withdrawals from the account. Using the model we created, we can make estimates, with a certain degree of confidence, of the rate of return for different policy features. The model we developed can be used by John Hancock as they try to decide on a reasonable interest rate to use in illustrating their policies.

There are certainly a number of ways in which we could have improved upon our project. There are many more variables to take into consideration when building this model. A very prominent one to study is mortality characteristics such as age, sex, and risk classification because we are trying to model a life insurance product. The mortality rates for the customers are very different and can have all sorts of effects on the model of their potential life insurance policy. Another addition to the model would be to include an insurance death benefit. A death benefit is the amount on a life insurance policy that is payable to the beneficiary when the person upon whom a life insurance contract is based passes away.

Combining all the elements into one model should allow for a final determination of what level amount a policy holder should expect to pay for insurance over a lifetime, given certain requirements of the death benefits. These requirements could range for example having a high degree of certainty, say 70%, that the fund will not be exhausted before the end of life, or having the fund accumulate enough of an account to make monthly withdrawals from age 70 on so that with a high degree of certainty, say 70%, the fund will not be exhausted before the end of life.

6. Appendix

Appendix A: How the Regime Switching Model Works



This is a diagram of how the Regime Switching model works. Basically you randomly determine which regime you are starting in. You then use the starting regimes parameters to determine the first regime, by looking at the probability of switching from one regime to the other. After determining which regime you are in now, you use these regimes parameters to determine the probability of switching from one regime to the other. Using this result you determine which new regime you are in. This process continues until the end of the projection.

Appendix B: Manual on how to use the Excel spreadsheet

	A	B	C
1			
2			
3	Regimes	I	II
4	Monthly Drift	1.07%	-1.10%
5	Monthly Volatility	3.25%	6.35%
6	Monthly Mean	1.02%	-1.30%
7	Chance to Switch	5.23%	15.16%
8	Overall Duration	74.35%	25.65%
9			
10	Adjust Rate	Annually	Monthly
11	Annual Upper Limit	1.13	1.0102
12	Annual Lower Limit	1.05	1.0041
13			Compound
14	Initial CF Positive	1000	0.00%
15	COI	0	
16	Expenses	0	
17	Initial Lumpsum Deposit	0	
18	Withdrawal Rate assume	0	
19	Annuities Rate @Time t	$0^{(n-t)}$	

There are 14 input cells controlling this spreadsheet and we will go through them one by one in this manual

1. Parameters inputs

	A	B	C
1			
2			
3	Regimes	I	II
4	Monthly Drift	1.07%	-1.10%
5	Monthly Volatility	3.25%	6.35%
6	Monthly Mean	1.02%	-1.30%
7	Chance to Switch	5.23%	15.16%
8	Overall Duration	74.35%	25.65%

The generated 6 parameters for the Regime-Switching model go into the 6 marked cells in the following ways.

μ_1	μ_2
σ_1	σ_2
p_{12}	p_{21}

Note: In order to make the spreadsheet model the behaviors or a Random Walk model, just put the drift and volatility in cells B4 and B5, and put 0 in cell B7 (The second regime will be disabled in this way)

2. Cap & Floors setting

	A	B	C
10	Adjust Rate	Annually	Monthly
11	Annual Upper Limit	1.13	1.0102
12	Annual Lower Limit	1.05	1.0041

Set the Cap and Floor for the spreadsheet by adjusting values in cells B11 and B12

Capped Annual Rate of Returns **Floor of the Annual Rate of Returns**

Note: In order to disable the cap and floors for the model, just put 0 in B12 and a large number in B11, say 100.

3. Cashflow Patterns

	A	B	C
13			Compound
14	Initial CF Positive	1000	0.00%
15	COI	0	
16	Expenses	0	
17	Initial Lumpsum Deposit	0	
18	Withdrawal Rate assumed	0	
19	Annuities Rate @Time t	$0^{(n-t)}$	

These 6 cells are controlling the cashflow pattern of this spreadsheet in the following ways.

B14: The amount of initial positive cashflow going into the account in the beginning of the first month.
 C14: The compound rate of the monthly cashflow. (0% means the amount indicated in B14 will last for the whole policy)

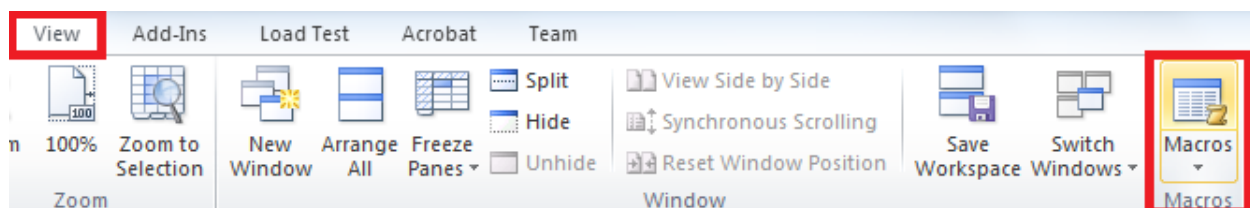
B15: Cost of Insurance in dollar amount.

B16: Expenses of account maintenance in dollar amount.

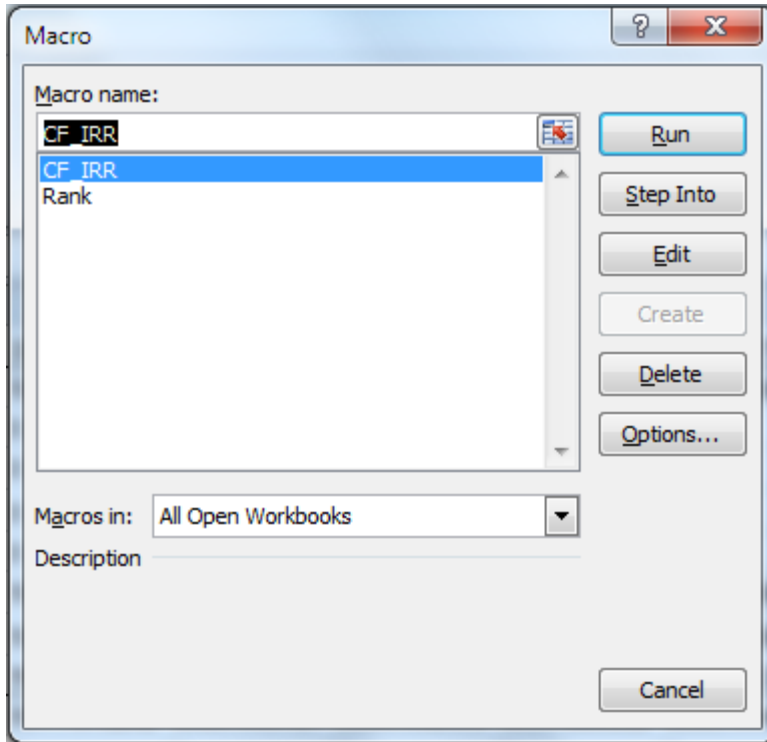
B17: The amount assumed to be in the account before the beginning of the policy.

B18: The assumed rate of return while calculating the maximum amount of withdrawal can be made at time t. Normally assumed to be the floor rate when cap & floor are applied to the policy.

4. Running the Spreadsheet:



Go to the tab "View" => click "Macros"



Select the macro "CF_IRR" => click Run

	A	B	C	D
20	Ranked Cumulative IRRs	Ranks	IRR interval	Cumulative Prob
21	0	1	0	0
22	0.004196587	2	0.0002	0
23	0.004301531	3	0.0004	0
24	0.00432197	4	0.0006	0
25	0.00432768	5	0.0008	0
26	0.004396446	6	0.001	0
27	0.004410681	7	0.0012	0
28	0.004449796	8	0.0014	0
29	0.004489787	9	0.0016	0
30	0.004495468	10	0.0018	0
31	0.00450757	11	0.002	0
32	0.00452574	12	0.0022	0
33	0.004532589	13	0.0024	0
34	0.00454401	14	0.0026	0
35	0.004563188	15	0.0028	0

A21:D10021 are the outputs of "CF_IRR"

A22:A10021 are the 10000 IRR calculated by the excel macro "CF_IRR"

D21:D771 represent an estimate of the Cumulative Probability pattern of the 10000 trials generated.

7. Bibliography

News. (2011, November 1). Retrieved 2012, from John Hancock:

http://www.johnhancock.com/about/news_details.php?fn=nov0111-text&yr=2011

Our Company. (2012). Retrieved 2012, from John Hancock:

<http://www.johnhancock.com/about/index.html>

Freedom.Opportunity.Strength. (n.d.). Retrieved 2012, from John Hancock Financial Network:

<https://www.johnhancockfinancialnetwork.com/about>

Hardy, M. R. (2001). *A Regime-Switching Model of Long-Term Stock Returns.*

Korthas, A., & Woods, S. (1999). *Pricing Guaranteed Medallion Variable Life Insurance Policies.*

Powers, S. (2009, August 7). *Indexed Universal Life: Cash, Flexibility and Safety.* Retrieved 2012, from

Investopedia: <http://www.investopedia.com/articles/insurance/09/indexed-universal-life-insurance.asp#axzz1t46qbARE>