

## Section 4: Literature Review

Brief Summaries of Articles Reviewed and Relevant to the Project Involving  
Modeling of Economic Series Coordinated with Interest Rate Scenarios

- Ahlgrim, D'Arcy and Gorvett, 1999, "Parameterizing Interest Rate Models," *Casualty Actuarial Society Forum*, Summer 1-50.  
<http://www.casact.org/pubs/forum/99sforum/99sf001.pdf>
  - *Uses simulation to develop future scenarios for various applications. Wilkie's Provides a review of historical interest rate movements from 1953-1999, summarizes the key elements of several interest rate models and describes how to select parameters of the models to fit historical movements.*
- Ait-Sahalia, 1999, "Do Interest Rates Really Follow Continuous-Time Markov Diffusions?" University of Chicago Working Paper
  - *Examines whether interest rates follow a diffusion process (continuous time Markov process), given that only discrete-time interest rates are available. Based on the extended period 1857 to 1995, this work finds that neither short-term interest rates nor long-term interest rates follow Markov processes, but the slope of the yield curve is a univariate Markov process and a diffusion process.*
- Bernstein, 1996, *Against the Gods: The Remarkable Story of Risk*, New York: John Wiley & Sons, Inc.
  - *Provides an excellent long term perspective of risk and the development of methods to measure and deal with risk. Explains the shift from a focus on hazard risk to financial risk over the last few decades.*
- Casualty Actuarial Society Financial Analysis Committee (CASFAC), 1989, "A Study of the Effects of Asset/Liability Mismatch on Property/Casualty Insurance Companies," *Valuation Issues*, 1-52. <http://www.casact.org/pubs/dpp/dpp89/89dpp001.pdf>
  - *Discusses the potential impact of an asset-liability mismatch for property-liability insurers. By "mismatch," this article means that anticipated cash flows from existing assets and liabilities will not precisely offset each other. Several mismatch scenarios are evaluated, and it is found that both potential risk and reward are greater, the greater the mismatch.*
- Chan, Karolyi, Longstaff, and Schwartz, 1992, "An Empirical Comparison of Alternative Models of the Short-Term Interest Rate," *Journal of Finance*, 47: 1209-1227.
  - *CKLS estimate the parameters of a class of term structure models using the generalized method of moments technique and the time series of monthly interest rate data from 1964-1989. They find that the volatility of interest rates is extremely sensitive to the level of the rate.*
- Chapman and Pearson, 2001, "What Can Be Learned from Recent Advances in Estimating Models of the Term Structure," forthcoming.

- *Provides a comprehensive review of term structure models. They conclude that volatility increases with the level of the short term interest rate and, within normal interest rate ranges, mean reversion is weak. They also point out that the appropriate measure for volatility depends on whether the period 1979-1982 (when the Federal Reserve shifted policy from focusing on interest rates to inflation rates) is treated as an aberration or included in the sample period. They also conclude that more research is needed to determine which interest rate model is best.*
- Chapman and Pearson, 2001, “Recent Advances in Estimating Term-Structure Models,” *Financial Analysts Journal* (July/August), 77-95.
  - *Provides a summary of term structure literature and contrasts the issues that have been resolved with those areas that require further research. They point out that mean reversion of interest rates is weak and that absolute volatility appears to be related to rate levels. Unfortunately, the specific nature of volatility is currently unresolved.*
- Cox, Ingersoll, and Ross, 1985, “A Theory of the Term Structure of Interest Rates,” *Econometrica*, 53: 385-407.
  - *Using a general equilibrium framework, CIR develop a process for the short-term interest rate. The CIR term structure model is:*

$$dr_t = \kappa(\theta - r_t)dt + \sigma\sqrt{r_t}dB_t$$
- Fama, 1984, “The Information in the Term Structure,” *Journal of Financial Economics* 13, 509-528
  - *Examines the ability of forward rates to forecast future spot rates. Based on data for 1974 and subsequent, he finds evidence that very short-term (one-month) forward rates can forecast spot rates one month ahead. Data prior to 1974 indicate that this predictive power extends five months into the future.*
- Fama, 1990, Term Structure Forecasts of Interest Rates, Inflation, and Real Returns,” *Journal of Monetary Economics* 25, 59-76
  - *Examines the ability to forecast one-year spot interest rates in the context of forecasting its components: the one-year inflation rate, and the real return on one-year bonds. It is found that the expected values of those two components move opposite to one another. This results in a situation where the five-year yield spread (the yield on five-year bonds over the one-year spot rate) is unable to forecast near-term spot rates (one or two years ahead); while the spread has power to forecast the inflation and real return components of the spot rate, those components tend to offset somewhat. As the time horizon is extended, the ability to forecast the spot rate improves. Fama also finds that forecasts of these variables are related to the business cycle.*
- Fama and Bliss, 1987, “The Information in Long-Maturity Forward Rates,” *American Economic Review* 77, 680-692
  - *Examines expected returns on U.S. Treasury securities with maturities of up to five years. They find that the one-year interest rate has a mean-reverting tendency,*

*which results in one-year forward rates having some forecasting power two to four years ahead. Thus, the paper provides evidence that, while forward rates are not good forecasters of very near-term changes in interest rates, they are better at forecasting long-term changes.*

- Fisher, 1930, *Theory of Interest*, New York: The Macmillan Company.
  - *Summarizes the economic intuition behind adjusting nominal interest rates based on expected future inflation.*
- Hardy, 2001, “A Regime-Switching Model of Long-Term Stock Returns,” *North American Actuarial Journal*, 5 (2), 41-53. [http://www.soa.org/library/naaj/1997-09/naaj0104\\_4.pdf](http://www.soa.org/library/naaj/1997-09/naaj0104_4.pdf)
  - *Using monthly data from the S&P 500 and the Toronto Stock Exchange, a regime-switching lognormal model is parameterized and compared with other models. The author finds the performance of the regime-switching model to be favorable.*
- Heath, Jarrow, and Morton, 1992, “Bond Pricing and the Term Structure of Interest Rates: A New Methodology for Contingent Claims Valuation,” *Econometrica*, 60: 77-105.
  - *Rather than developing a process for the short rate, HJM model the movements of the entire term structure through a family of forward rate processes.*

$df(t,T) = \mu(t,T, f(t,T))dt + \sigma(t,T, f(t,T))dB_t$  where

$$f(t,T) = -\frac{\partial \ln P(t,T)}{\partial T}$$

*HJM find that the drift in forward rates can be restated in terms of the volatilities, implying that the market price of risk is unimportant in contingent claims valuation.*

- Hibbert, Mowbray, and Turnbull, 2001, “A Stochastic Asset Model & Calibration for Long-Term Financial Planning Purposes,” Technical Report, Barrie & Hibbert Limited
  - *This paper describes a model that generates consistent values for the term structure of interest rates, both real and nominal, inflation rates, equity returns and dividend payouts. The model can be used to generate multiple potential paths for each of these variables for use in financial modeling. The paper provides an excellent review of interest rates, inflation rates and equity returns over the last 100 years, or longer, as well as for more recent periods.*

*The real interest rate model is a 2-factor Hull-White model. The short-term rate reverts to a mean reversion value that is itself a random variable which reverts to the long term mean value. Inflation is also a 2-factor model, with a double mean reversion process. The equity model determines the equity return in excess of the nominal interest rate as a Markov regime-switching model with one regime having a higher expected return and lower variance, and the other regime a slightly lower expected return but much larger variance. The equity dividend yield model is a one factor first order autoregressive process.*

*The paper does an excellent job describing the calibration process for this model. Interest rates in the United Kingdom since 1725 are illustrated, and the question of*

*which time period should be used to determine the value is clearly demonstrated by the use of different time periods. Similarly, the average inflation rate in England for periods ranging from the last 700 years down to the last 10 years are shown. For example, the average annual inflation rate over the last 700 years is slightly less than 1%. Over the last 100 years the inflation rate averaged 4%, over the last 50 years 6%, over the last 30 years 8%, over the last 20 years 6% and over the last 10 years 4%.*

*Two sets of parameter values are illustrated, one that allows negative interest rates and does not include a risk premium for long term interest rates and another that limits nominal interest rates to positive values. The model is used to simulate 1000 scenarios over a 30 year horizon based on monthly steps. The resulting means, standard deviations and distributions plotted several ways are then compared to illustrate the impact of this change in calibration. A graph termed the funnel of doubt is used to illustrate the range of outcomes for interest rates and inflation rates over the 30 year period.*

*Finally, the paper compares the results this model generates to the output from the Wilkie model. The Wilkie model is shown to generate inconsistent relationships among inflation, bank interest rates and the yield on consols. The autoregressive feature of equity returns included in the Wilkie model generates a distribution over a long term horizon that is much more compact than historical experience would indicate.*

*Their model is presented on [www.barrhibb.com](http://www.barrhibb.com).*

- Ho and Lee, 1986, "Term Structure Movements and Pricing Interest Rate Contingent Claims," *Journal of Finance*, 41: 1011-1029.
  - *Taking the existing term structure as an input, Ho and Lee develop an arbitrage-free term structure model. The original model is presented as a binomial tree, where the short-term rate is related to forward rates plus a random factor. It has since been shown that the continuous-time equivalent of their model is:*
$$dr_t = \theta(t)dt + \sigma dB_t$$
- Hodes and Feldblum, 1996, "Interest Rate Risk and Capital Requirements for Property/Casualty Insurance Companies," *Proceedings of the Casualty Actuarial Society*, 83:490-562. <http://www.casact.org/pubs/proceed/proceed96/96490.pdf>
  - *Examines the effect of interest rate risk on the assets and liabilities of a property-liability insurer. Indicates a need for greater detail on cash flows from assets.*
- Hull and White, 1990, "Pricing Interest-Rate-Derivative Securities," *Review of Financial Studies*, 3: 573-592.
  - *Extend the models of Vasicek and CIR to be arbitrage free. By introducing a time-dependent drift, the resulting term structure of the Hull and White model is consistent with current market prices of bonds. The paper goes on to compare*

*option prices under the model to Vasicek and CIR term structure models. The one-factor Hull-White model is:*

$$dr_t = \kappa(\theta(t) - r_t)dt + \sigma dB_t$$

- Hull and White, 1994, “Numerical Procedures for Implementing Term Structure Models II: Two-Factor Models,” *Journal of Derivatives* (Winter), 37-48.
  - ***Extend the one-factor Hull-White model (1990) to include a stochastic mean reversion level. The two-factor model allows for more flexible yield curve dynamics. The paper also reviews a numerical procedure (trinomial trees) for implementing the models. The two-factor Hull-White model is:***

$$dr_t = (\theta(t) + u_t - ar_t)dt + \sigma_1 dB_{1t}$$

$$du_t = -bu_t dt + \sigma_2 dB_{2t}$$
- Litterman and Scheinkman, 1991, “Common Factors Affecting Bond Returns,” *Journal of Fixed Income* (June), 54-61.
  - ***Use principal components analysis to determine the important factors that affect term structure movements. They found that only three specific shifts (level, steepness, and curvature) explain almost 99% of the variance in interest rates. In fact, the first factor, which represented level shifts in the term structure, explained almost 90% of the total variation in rates.***
- Masterson, 1968, "Economic Factors in Liability and Property Insurance Claims Costs, 1935-1967," *Proceedings of the Casualty Actuarial Society* 55, 61-89; subsequent updates published periodically in *Best's Review*.  
<http://www.casact.org/pubs/proceed/proceed68/68061.pdf>
  - ***Analyzes property-liability insurance claims costs in the context of economic factors. A variety of external economic series are considered.***
- Pennacchi, 1991, “Identifying the Dynamics of Real Interest Rates and Inflation: Evidence Using Survey Data,” *Review of Financial Studies*, 4: 53-86.
  - ***Over the period 1968-1988, there is evidence that the instantaneous real interest rates and expected inflation are significantly negatively correlated. The inflation expectations are based on surveys of professional economic forecasters, which may not necessarily correspond with market expectations.***
- Redington, 1952, “Review of the principles of life office valuations”, *Journal of the Institute of Actuaries*, 78: 1-40.
  - ***Represents a path-breaking approach to dealing with risk for insurers. Introduces the “funnel of doubt” terminology and explains a strategy for immunizing an insurer from interest rate risk.***
- Reitano, 1992, “Non-parallel Yield Curve Shifts and Immunization,” *Journal of Portfolio Management*, 18: 36-43.
  - ***Demonstrates the danger of immunizing against only parallel shifts in the yield curve. Using key rate durations (partial durations), Reitano shows that even small***

*non-parallel shifts in the yield curve may cause extreme changes in asset values. Reitano suggests a specific remedy for immunizing against specific shifts in the yield curve.*

- Risa, 2001, “Nominal and Inflation Indexed Yields: Separating Expected Inflation and Inflation Risk Premia,” Columbia University Working Paper.
  - *This paper provides an excellent review of the literature on the relationship between inflation and interest rates. Based on nominal and inflation indexed bonds from the United Kingdom from 1983-1999, the nominal and inflation indexed interest rates are derived. The inflation risk premium is determined based on a four factor pricing model.*
  
- Santomero and Babbel, 1997, “Financial Risk Management: An Analysis of the Process,” *Journal of Risk and Insurance* 64:231-270.
  - *Provides an extensive analysis of financial risk management as performed by insurers. Based on a series of interviews with management at a variety of insurers, reports on the current state of this process in the insurance industry. Concludes that significant improvements in financial risk management are necessary and that even the most advanced insurers are not doing an effective enough job managing these risks.*
  
- Shiller, 2000, *Irrational Exuberance*, Princeton, NJ: Princeton University Press.
  - *Analyses long term patterns in stock returns. Presents the case that the stock market was significantly overvalued by the beginning of 2000. Compares recent market valuation to similar situations over the prior 130 years.*
  
- Sornette, 2003, *Why Stock Markets Crash: Critical Events in Complex Financial Systems*, Princeton, NJ: Princeton University Press.
  - *Examines the behavior of stock markets, and proposes a simple theory, built upon the author’s expertise in non-linear processes and complex systems, for why markets crash.*
  
- Staking and Babbel, 1995, “The Relation Between Capital Structure, Interest Rate Sensitivity, and Market Value in the Property-Liability Insurance Industry,” *Journal of Risk and Insurance*, 62:690-718.
  - *Utilizes a modification of the Taylor Separation Method to project the total cash flows from claim payments, rather than focusing solely on loss severity. This approach incorporates the volume and type of business written and historical loss development. This method assumes that inflation in a given year affects all unpaid losses for a given line equally, regardless of the accident year. The relationship between the market value of the firm and its leverage and surplus duration is then measured. The results of these relationships calculated for 25 insurers over 7 years are displayed graphically by a saddle-shaped curve representing the relationship among leverage, surplus duration, and the Tobin’s Q value (which measures the ratio of market to book value). These results suggest the need for further study on the duration measure. While the mean value of leverage for this sample, 3.47, lies*

*along the crest of the saddle, suggesting that on average insurers adopt a leverage ratio that maximizes the market value of the firm, the mean value of surplus duration, 9.68, lies near the minimum values of the curve. If surplus duration were any lower or higher than the average value, then the market value of the firm would increase. Since the distribution of surplus duration values was not bimodal, this suggests that insurers were operating at a surplus duration level that minimized the firm's value. This finding suggests either that surplus duration is not measured accurately, or that insurers need to look at duration much more closely.*

- Tilley, 1988, “The Application of Modern Techniques to the Investment of Insurance and Pension Funds” (New York: Morgan Stanley & Co.)
  - *Provides an excellent, non-mathematical discussion regarding the problem of immunization for insurance companies and pension plans. This paper explains the classical measures of interest sensitivity and then describes the effects of interest-sensitive cash flows and how duration measures need to be adapted for these instruments.*
  
- Tuckman, 1996, *Fixed Income Securities*, New York: John Wiley & Sons, Inc.
  - *Chapter 9 of the book discusses some differences between arbitrage-free and equilibrium term structure models. While providing an overview of the approaches of both types of models, Tuckman also summarizes the advantages and disadvantages of the model classes.*
  
- Vasicek, 1977, “An Equilibrium Characterization of the Term Structure,” *Journal of Financial Economics*, 5: 177-188.
  - *Derives a general form for the term structure of interest rates. The Vasicek term structure model is:*

$$dr_t = \kappa(\theta - r_t)dt + \sigma dB_t$$

*Vasicek also uses arbitrage arguments between two generic bonds to show how the market price of risk is constant.*
  
- Wilkie, 1986, “A Stochastic Investment Model for Actuarial Use,” *Transactions of the Faculty of Actuaries*, 39: 341-403.
  - *Uses simulation to develop future scenarios for various applications. Wilkie’s model postulates that inflation is the independent variable – the “driving force” – in the model and uses a “cascade” approach to model other variables, including (1) dividends, (2) dividend yields, and (3) interest rates (more specifically, the yield on long-term Consols). Wilkie uses a first-order autoregressive model for inflation and the other variables are linked to the realization of inflation.*
  
- Wilkie, 1995, “More on a Stochastic Model for Actuarial Use,” *British Actuarial Journal*, pp. 777-964
  - *Wilkie updates his 1986 model by spelling out many of the time series issues involved in the generation of economic scenarios. Wilkie presents the methodology for selecting the structural form of a process that will be used to represent key*

*variables in his “stochastic investment model.” The paper includes several appendices that fully develops the time series tools used throughout the presentation including cointegration, simultaneity, vector autoregression (VAR), autoregressive conditional heteroscedasticity (ARCH), and forecasting.*

*In some cases, Wilkie provides an economic argument for the structural form of an assumption. He then estimates parameters for each equation of the model by looking at data from 1923-1994 and performs tests on competing models for fit. The subsequent analysis in many circumstances is inconclusive. In many circumstances, these tests flatly reject the realism of the proposed models or the analysis indicates some violation of the underlying statistical assumptions. Wilkie ignores many of these issues and simply resolves conflicts through personal preference without formal guidelines. Wilkie also comments on using annual vs. monthly data and presents some parameter estimates for the equations based on data from several different countries.*

*The following presents an overview of the variables in Wilkie’s stochastic investment model:*

*(1) Inflation - Wilkie’s primary variable in the entire model is inflation. He uses a first-order autoregressive process to capture the dynamics of inflation. However, the distribution of actual inflation is more positively skewed and more fat-tailed than implied by the AR(1) process. Using an ARCH process for inflation reduced these problems.*

*(2) Wages are analyzed in several ways to test for the different potential relationships with inflation:*

- a. Cointegration with inflation – real wages may follow a deterministic drift or they follow their own distinct autoregressive process.*
- b. Simultaneous determination where wages and inflation are based on past wages and past inflation (VAR).*

*(3) Dividend Yields – Yields on common stock follow an AR(1) process, but also depend on inflation. Wilkie verifies that looking at yields is the correct approach since dividends and share prices are indeed cointegrated.*

*(4) Dividends are driven by current and past levels of inflation, plus a carryover effect from previous yields and dividends.*

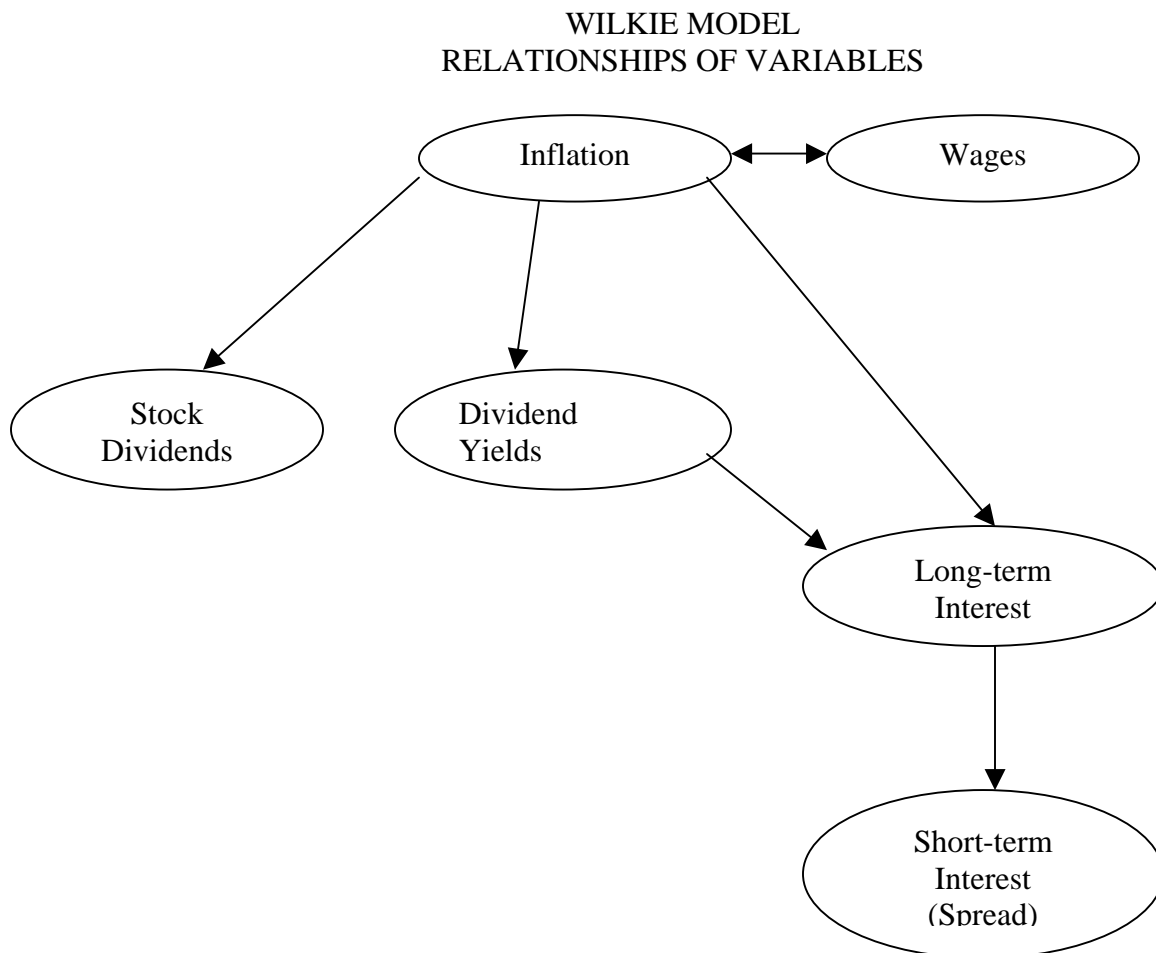
*(5) Long-term Interest Rates – Yields on fixed-interest consols are driven by an exponentially weighted average of past levels of inflation, plus an AR process for the real interest rate. In addition, the unpredictable component of the dividend yield has an influence on the consol yield.*

*(6) Short-term Interest Rates - Wilkie models the spread between short- and long-term rates as an AR(1) process.*

*(7) Real Estate – Analogous to dividends and dividend yields on stocks, Wilkie uses a process for property yields and property income.*

*(8) Foreign exchange – Wilkie also looks at a model of exchange rates as fluctuations around those implied by purchasing power parity.*

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- Wilmott, 1998, *Derivatives: The Theory and Practice of Financial Engineering*, John Wiley & Sons: Chichester, England.
  - *A large book which provides a thorough discussion of derivatives theory and pricing.*
- Yan, 2001, “Dynamic Models of the Term Structure,” *Financial Analysts Journal*, July/August: 60-74.
  - *Discusses the application of dynamic term structure models for the pricing of interest rate derivatives.*