Opportunist to Risk Manager: reverse engineering the Taylor Rule.

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Volume One of One

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy is entirely my own work and has not been taken from others save and to the extent that such work has been cited and acknowledged within the text of my work.

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All remaining errors are mine.

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Abbreviations

AR:	Autoregression
ARCH:	Autoregressive Conditional Heteroscedasticity
ADF:	Augmented Dickey Fuller
BOE:	Bank of England
BOG:	Board of Governors
CPI:	Consumer Price Index
CME:	Chicago Mercantile Exchange
DW:	Durbin-Watson statistic
ECB:	European Central Bank
ERM:	Exchange Rate Mechanism
ESTAR:	Exponential Smooth Transition Autoregressive model
EWMA:	Exponentially Weighted Moving Average
FF:	Federal Funds
FOMC:	Federal Open Market Committee
GARCH:	Generalized Autoregressive Conditional Heteroscedasticity
GDP:	Gross Domestic Product
GNP:	Gross National Product
HICP:	Harmonised Index of Consumer Prices
ILS:	Inflation Linked Swap
IP:	Industrial Production
IRS:	Interest Rate Swap
IT:	Inflation Targeting
ITer:	Inflation Targeter
LAD:	Least Absolute Deviation
LET:	Limited Exploitable Trade-off
LIFFE:	London International Financial Futures Exchange
MPC:	Monetary Policy Committee
NAIRU:	Non-Accelerating Inflation Rate of Unemployment
NET:	No Exploitable Trade-off
OTC:	Over the Counter
OLS:	Ordinary Least Squares
PDF:	Probability Density Function
PPP:	Purchasing Power Parity
PTA:	Policy Target Agreement
RPI:	Retail Price Index
STAR:	Smooth Transition Autoregression
STRIPS:	Separate Trading of Registered Interest and Principal of Securities
TAR:	Threshold Autoregressive Model
'The Greeks'	constitute the sensitivities of any option, c to its arguments and are significant in trading and hedging portfolios. The partial derivatives of c with respect to its arguments have been accorded specific Greek letters or option sensitivities Delta: $\Delta = \partial c / \partial S$ Gamma: $\Gamma = \partial^2 c / \partial S^2$ Theta: $\theta = \partial c / \partial t$ Vega: $v = \partial c / d\sigma$
TIPS:	Treasury Inflation-Indexed Securities

Findings

Chapter 1

A risk management (option) framework for monetary policy is set out in this thesis. The option's approach is developed using the Derman and Taleb (2005) consistency argument which does not require continuous dynamic hedging to establish risk neutrality. The Derman and Taleb (2005) consistency argument is found to be robust even when the Black-Scholes (1973) assumptions relating to frictionless markets and Geometric Brownian motion are violated. The well-known no-arbitrage relationship, implied by put-call parity is used to establish risk neutral conditions and the time value of an inflation option portfolio is applied where merely static replication is thought possible. The inflation option portfolio is developed as a target variable for monetary policy. Initially, a lognormal random walk process is developed as a baseline analytic tool for considering inflation behavior and monetary policy reactions. This permits the risks to price stability from deflation to be construed as being minimal, while permitting the risk of hyperinflation to be preserved for policy analysis. Simulation of the lognormal process is extended to incorporate different upside and downside risks to inflation using Heston Monte Carlo. In chapter 2, deflation risks are also modeled using a Vasicek Monte Carlo model.

The Aksoy et al. (2006) opportunistic framework can be extended to incorporate inflation risk. Using the option's framework, set out in Proposition 1.4, it is found that under uncertainty policy makers will not remain inactive to changes in inflation even when inflation remains inside a desired target zone. The magnitude of this reaction is found to be sensitive to inflation volatility, the time horizon for preserving the target and to bandwidth. It is found that the parameter inputs associated with classic option pricing can be used to describe the conditions under which policy makers will remain responsive to expected inflation. That is, policy makers can increase the policy rate, even when expected inflation is below the upper bound of an opportunistic or zone targeting monetary policy framework. Departures of expected inflation from the lognormal model can be captured without violating the assertion of Proposition 1.4 that under uncertainty, Central Bankers can increase the policy rate even when expected inflation is below the upper bound. Monetary policy decisions that apply a risk management paradigm can incorporate varying levels of skew and kurtosis into forecasts by allowing the assumption of constant volatility to be relaxed. Heston inflation fan charts are generated and are used to demonstrate that the option's framework when applied to monetary policy can be made flexible.

Chapter 2

The opportunistic approach to disinflation, as proposed by Aksoy et al. (2006) can be motivated alternatively by using institutional and committee dynamics. Even when individual members of the board or rate setting committee have individually adhered to linear rate setting, the dynamics of majority voting when policy makers disagree permit their collective behaviour to be characterised by nonlinear responses. Under opportunistic interest rate setting, the monetary policy response to inflation can also be modelled as the payoff from an option's framework. Using this framework, the monetary policy response to expected inflation can be modelled as the intrinsic payoff from a portfolio of options when future inflation is known with certainty.

A forward-looking opportunistic reaction function (a.2.1.16) which embeds an inflation option portfolio is derived in appendix A.2.1. This reaction function is specified for varying bounds, volatilities, data sets and is estimated for varying time periods using OLS. It is found that taking the entire Greenspan incumbency, or in part up to 2002, monetary policy responded more robustly when inflation threatened to exceed three percent. The 1% – 3% targeting specification appears to offer an improvement over the linear and other nonlinear representations of policy for real time forecasts and historic data sets that were subject to subsequent revision.

The Delta of the collar option portfolio is developed to describe monetary policy inertia/activism (interest rate smoothing). The portfolio Delta is normally estimated to be minimised, when expected inflation resides within the strikes. This would suggest that monetary policy when guided by a risk management paradigm is generally least active or most graduated when expected inflation falls between the upper and lower target. A widening of the zone, between the exercise rates (i.e. greater disagreement between policy makers), precipitates greater nonlinearity and a lower policy response, *ceteris paribus*. A Vasicek delta is also developed to benchmark a number of asymmetries associated with the lognormal model.

The Gamma of the collar portfolio is used to establish the level of expected inflation at which policy is least responsive to a change in expected inflation or where the policy rate adjustment is most graduated. Using the Black model, it is found that the expected inflation rate, associated with the lowest Delta, is inferior to the arithmetic average of the upper and lower bounds. This means that the Delta curve for the Black model is asymmetric. If the upper and lower bounds (strikes) are equal, this implies Gamma is zero and Delta is constant for all levels of expected inflation. That is, using Gamma it is possible to show that an agreed inflation point target produces a linear policy.

In chapter 2, the option's framework is extended to incorporate a wider set of inflation behaviours that would not be consistent with Black-Scholes. The parameter values of the Vasicek (1977) model can be selected to reflect varying degrees of central banker uncertainty and the speed of adjustment to a long term mean inflation rate. This implies that the option's framework can be extended to a policy context where expected inflation is considered to be predictable/mean reverting and to incorporate the possibility of negative inflation. The Vasicek model permits the drift of the inflation process to be dependent on the policy instrument. In other words, expected inflation can be made to be endogenous to the rate decision. The Black model engenders a proportionately greater policy response as the underlying expected inflation rate increases. This can be benchmarked against the Vasicek model where policy responses defined by the Vasicek Delta are found to be symmetric.

Chapter 3

Nonlinear policy responses are supported by empirical evidence reported in chapters 2 and 3. The Taylor Rule nevertheless is still extremely relevant in a world where policy is conceived to be nonlinear. Using 'the Greeks' it was found that uncertainty can be shown to lessen nonlinearity. If policy makers agree the target level of inflation, then the policy rule becomes linear. Greater agreement produces a more conventional monetary policy response both under conditions of certainty and uncertainty.

If the interest rate decision is designed to preserve price stability over a longer term, uncertainty regarding the future lessens the non-linearity of a path-dependent policy. By applying a number of benchmark measures from portfolio option theory, it is found that as the time horizon for containing inflation increases, the monetary policy response becomes increasingly linear.

As inflation volatility increases the monetary policy response also becomes increasingly linear and less path dependent.

Abstract

Taylor (1993) advocated that the short term policy rate should respond linearly to the inflation rate and to the output gap. The Taylor Rule also seemed to track the federal funds rate over the formative years of the Greenspan regime, then considered to have experienced a number of early successes. While acknowledged as being simple and robust, the Taylor Rule does not, however, capture the nonlinearity of monetary policy as expressed by a number of Federal Reserve 'insiders'. In this thesis, the argument is made that as monetary aggregates were being de-emphasised from the early 1980s, some policy makers felt it was necessary to preserve latitude for economic shocks. From the late 1980s opportunistic monetary policy, devised by FOMC members, has been used to expound policy judgements that reflected a more discretionary posture. Chairman Greenspan also used risk management rhetoric to explain deviations from a conventional linear framework. Within this framework, discretion can be achieved by crafting the inflation forecast and the zone targeting bounds. The opportunistic reaction function as set out by Aksoy, Orphanides, Small, Wieland and Wilcox (2006) is augmented to take into account risk management perspectives using portfolio option theory. This reaction function is estimated and found to offer some improvement in describing rate decisions over a linear Taylor reaction function for the Greenspan tenure. Risk management implies policy makers pre-emptively target the expectation of inflation. Portfolio option theory is used to extend the opportunistic model as set out by Aksoy et al. (2006) and from this a number of parameter sensitivities, better known as 'the Greeks', are developed. The Greeks are used innovatively to consider how rate adjustment is likely to be affected by altering varying measures of uncertainty. In particular, delta is developed to provide a dynamic measure of interest rate inertia. Portfolio option theory and committee dynamics are also used to describe under what circumstances a linear Taylor type rule can also constitute the *de facto* policy rule, even for rate setting with a very defined zone target. As a consequence, the nonlinearity described by the portfolio option model is found to be highly nuanced. The impact of increasing uncertainty when policy is pre-emptive largely serves to reduce the effect of nonlinearity.