

# Asset Price Dynamics and Taylor Rule Fundamentals

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## Abstract

The purpose of this paper is to develop a forecasting equation from the dividend discount model. Our reduced form asset pricing equation features lagged dividend per share, term spread, short-term interest rates, inflation rates, the output gap and real effective exchange rates. The results indicate that our forecasting model has significant and powerful relationships and outperforms the other models which are compared against it. We conclude that the reduced form forecasting model has merit and can influence the portfolio decisions of profit-seeking investor.

# 1 Introduction

This paper forecasts asset prices, in particular equity returns, using Taylor rule fundamentals for three emerging markets. Since Fama (1965) and Jensen and Benington (1969) the Random Walk theory has often been cited as one of the main counter-arguments to the forecastability of asset prices. The theory states that asset prices follow a random walk and casts doubt on the ability of trading strategies, such as buy-and-hold, to generate excess returns. Goyal and Welch (2008), reemphasize this point of lack of predictability by finding that models predicting the equity premium are unstable and poorly predict both in-sample and out-of-sample data.

However, from as early as Lo and Mackinlay (1988) the random walk hypothesis is rejected by simple volatility based specification tests providing a platform for recent studies, which find that asset prices are predictable. Numerous financial variables have also been tested for their predictive power of future equity returns. Campbell and Shiller (1988a) find value in the dividend-price ratio's forecasting ability whilst Fama and French (1989) add to this body of literature by identifying the term and default spread on bonds as having the highest predictive strength for both stocks and bonds amongst their examined variables.

This view is shared by Rapach and Wohar (2006) who show that short-term interest rates, amongst other variables, have predictive ability at the one year horizon and Ang and Bekaert (2007) who demonstrate that dividend yields and short-term interest rates predict returns at the short horizons and that short rates have a negative predictive relation with returns.

In this paper, we investigate the extent to which the dividend discount model and short-term interest rates, using Taylor rule fundamentals, contribute towards forecasting equity returns in three emerging markets: South Africa,

South Korea and Poland. The motivation for selecting these countries is two-fold, firstly the study focuses on emerging markets and the selected countries allow for a cross-sectional sample across three different continents. Secondly and most importantly there is a limitation of share price data in emerging markets and as such the selected countries offer an extensive share price data set, which allows for inferences to be made.

The contribution of this paper is that, firstly it extends the dividend discount model to account for the perpetual nature of equity prices. Secondly we derive a forecasting model that comprises of both financial and macroeconomic variables from first principles. Thirdly, a link is drawn between the dividend discount model and the Arbitrage Pricing Theory (APT) model by deriving the APT model from the dividend discount model.

Lastly, Taylor rule fundamentals are used to estimate the short-term nominal interest rate. The hypothesis that this paper seeks to prove is that deriving a forecasting model, using Taylor rule fundamentals to estimate short-term nominal interest rates, computes a better estimate of the true deviation value of equity returns from fundamentals, as pointed out by Campbell and Shiller (1988) and Ang and Bekaert (2007).

The most relevant place in which asset price forecasts can be applied is in enable academics and practitioners to empirically determine factors that drive equity returns. Blanchard and Watson (1982) state that when asset prices deviate from their fundamental values, asset bubbles may form which have real effects on the economy. The authors continue to highlight that it is possible to mitigate these real effects through an increased level of accuracy in asset price predictions. Furthermore asset prices carry informational content which can be used by monetary policy-makers to infer market expectations, this information can potentially be used to generate forecasts of macroeconomic aggregates stated by Hordahl and Parker (2007).

Most recently Vivian and Wohar (2013) further highlight the value of forecasting asset prices as enabling both the asset manager and corporate treasurer in their asset allocation and financing decisions, respectively. Using annual S&P 500 real stock returns Rapach and Wohar (2006) propose that the value of forecasting is in its ability to allow the practitioner to select the best forecasting model based on profit generation.

A number of studies estimate asset prices using macroeconomic fundamentals for example Chen, Roll and Ross (1986) identify four macroeconomic variables which are significant in explaining the expected returns of stocks. These variables are, namely, Industrial Production, term structure, risk premium (i.e. returns on bonds rated Baa and under less long-term government bonds) and variants of inflation. Furthermore Flannery and Protopapadakis (2002) find six out of seventeen macroeconomic variables that cause higher return volatility, with the same variables resulting in higher trading volume.

In their comprehensive study Vivian and Wohar (2013) prove that the output gap predicts in-sample cross-sectional portfolios. Following this pattern, our paper makes use of short-term interest rates, estimated from the backward-looking Taylor reaction function, which incorporates inflation rate, excess demand, real effective exchange rate and the previous period short-term interest rate as noted by Moura and de Carvalho (2010).

A particular gap in the literature is that many studies have focused mainly on macroeconomic variables such as real output, the inflation rate (Chen, Roll and Ross, 1986), consumption (Da,2009) and liquidity (Liu, 2006) in determining asset returns. However very little attention has been paid to forecasting asset prices using Taylor rule fundamentals, in estimating the short term real interest rate and whether or not this estimation can lead to improved accuracy in forecasting equity returns. This paper builds on the literature that uses Taylor rule fundamentals to forecast variables. Molodtsova

and Papell (2009) and Mohanty and Klau (2004) are examples where the Taylor rule is used to forecast exchange rate, with the same success, we extend this literature by forecasting equity returns.

The purpose of this paper is to develop a forecasting equation from the dividend discount model. Our reduced form asset pricing equation features lagged dividend per share, term spread, short-term interest rates, inflation rates, the output gap and real effective exchange rates. Thus our model falls within the Arbitrage Pricing Theory (APT), which was first established by Ross (1971) as an alternative to the mean-variance capital asset pricing model (CAPM) proposed Sharpe (1964), Lintner (1965) and Black (1972). The theory uses a factor model to express the returns on a subset of assets.

Therefore the motivation of the study is to reduce the gap in literature with regards to estimating short term nominal interest rates using Taylor rule fundamentals and to explore a potential source of risk that can improve, when priced, the accuracy of forecasting asset prices, in turn allowing us to compute a better estimate of the true deviation value of equity returns from fundamentals.

The rest of the paper is organized as follows: Section 2 presents the literature, section 3 derives the asset price forecasting model that uses the short-term nominal interest rate to test for the presence or absence of predictability. Section 4 provides the methodology and section 5 presents the empirical results. Section 6 checks the robustness of our results and section 7 concludes.



## 2 Literature

### 2.1 *Predictability of Stock Returns*

Literature exists for both arguments in favour of and against equity predictability, for example Campbell and Shiller (1988a) examine the effects of the dividend-price ratio and the earnings ratio on equity predictability and future real dividends, using US stock market data from 1871 to 1986, the authors find that when stock returns are measured over longer horizons that the earnings variable is a powerful predictor for both stock returns and future real dividends.

Fama and French (1989) address questions relating to the movement of stock and bond returns and whether this movement is related in any way to business conditions. Their results indicate that stock and bond returns are predicted by dividend yields and measures of term and default premiums and that when business conditions are weak, the dividend yield, term premium and the default premium forecast high returns.

Rapach and Wohar (2006) analyze the empirical evidence on equity return forecastability by testing in-sample and out-of-sample equity returns. They find that numerous financial variables aid in the predictability of equity returns. Ang and Bekaert (2007) support the hypothesis on equity return predictability, they use ordinary least squares regressions to test for the predictability of cash flows, stock returns and interest rates using dividend yields, their results show that short interest rates and dividend yields predict equity returns at short horizon.

This view on equity return predictability is shared by Vivian and Wohar (2013) who make use of US equity market data from 1948 to 2010 to verify

whether or not the output gap can predict equity returns. They conclude that in-sample equity returns are forecastable using the output gap.

Chen, Roll and Ross (1986) identify four macroeconomic variables which are significant in explaining the expected returns of stocks, namely Industrial Production, term structure, risk premium (i.e. returns on bonds rated Baa and under less long-term government bonds) and variants of inflation. Flannery and Protopapadakis (2002) find six out of seventeen macro variables that cause higher return volatility, these same variables result in higher trading volume.

In addition Flannery and Protopapadakis (2002) find six out of seventeen macro variables that cause higher return volatility, with the same variables resulting in higher trading volume, whilst Vivian and Wohar (2013) prove that the output gap predicts in-sample cross-sectional portfolios.

## **2.2 *Mean Reversion***

One set of literature argues that mean reversion exists. Fama and French (1988) analyze the predictability of stock returns by paying attention to the behaviour of stock prices in the long run. Their results indicate that there is negative serial correlation, which suggests that a slow mean-reverting component is present in the prediction of stock prices in the period 1926 to 1985. Poterba and Summers (1988) examine temporary components of stock prices by analyzing the data of 18 countries, they find evidence of mean reversion, particularly in small equity markets outside the USA.

Fama (1998) warns against ignoring mean reversion in forming expectation, as performance tends to be mean reverting. Fama (1998) further argues that Initial Public Offerings are usually too high because investors tend to overlook the mean reverting component of earnings growth. In examining "how the

evidence of predictability in asset returns affects optimal portfolio choice for investors with long horizons", Barberis (2000) attribute the long horizon effects to the time variation in expected returns which is induced by mean reversion. Chaudhri and Wu (2004) investigate whether or not random walk or mean reversion characterizes equity price indices of emerging markets from the period 1986 to 2002. Chaudhri and Wu (2004) tests these characteristics by using panel-based tests, their tests show that the random walk hypothesis is rejected in favour of mean reversion.

Another set of literature argues that mean reversion is not a long term characteristic of stock prices. Lo and Mackinlay (1988) use variance estimators to test the random walk hypothesis, they reject the random walk hypothesis. Kim, Myung Jig, Nelson and Startz(1991) examine empirical evidence on mean reversion in stock prices, their results imply that mean reversion is a characteristic of equity prices before the war,i.e. this component of stock prices is not observed in the period past 1946. Cochran and Defina(1995) examine mean reversion by studying indices of 18 countries, after implementing regression based tests they find no mean reversion in all but 5 countries. Cochran and Defina(1995) further examine the 5 countries that exhibit mean reversion and they find that the mean reversion is due to common and country specific factors.

### **2.3 *Dividend Persistency***

The effects of the future expected dividends can often be seen in return forecasts,this variable has been found to add to the explanation of what moves stock markets. Any changes in expected dividend have the power to affect future expected returns. Numerous studies attest to the persistency of expected dividends such as Campbell (1991) who uses contemporaneous regressions on U.S. monthly data from 1927 to 1988 to decompose unexpected

returns. Campbell (1991) finds that one-third of movements in unexpected returns is accounted for by expected dividends, he further states that there is a negative correlation between changes in expected returns and expected dividends.

Hodrick (1992) examines the measurements used to forecast equity prices over longer horizons, in particular paying attention to the dividend yield in the forecasting process. The results from this study indicate that changes in dividend yields are persistent and aid in explaining changes in expected equity returns.

## ***2.4 Equity Prices and Inflation***

The relationship between equity prices and inflation has long since been a puzzle to finance scholars. A number of studies have found a negative relationship between equity prices and inflation, which is counter-intuitive. Fama (1981) start off by hypothesizing that this relationship can possibly be explained by proxy effect, however the empirical evidence does not support this hypothesis. Instead Fama (1981) concludes that the regressions obtained in explaining this relationship are spurious and such no conclusions is made about this matter.

Kaul (1987) examines this relationship for the United States, Germany, United Kingdom and Canada. Kaul(1987) argues that it is the "equilibrium process in the monetary sector" that causes the negative relationship between stock prices and inflation. Kaul (1987)'s results support this hypothesis and show a counter-cyclical movement of stock prices, prices and money on the 1920's and a pro-cyclical movement in the 1930's.

Balduzzi (1994) re-examines the proxy effect used by Fama (1981) to explain the stock price and inflation relationship. Balduzzi(1994)'s results support

the notion of innovations in interest rates and inflation rates as the main driver behind this relationship. On the other hand Alagidede(2009) uses OLS to examine this relationship in six African countries, contrary to other studies, this author finds a positive relationship between stock prices and inflation in two of the six African countries, i.e. Nigeria and Kenya. Alagidede(2009) proposes the Fisher relation as the primary explanation in Nigeria, Tunisia and Kenya, citing that stock prices act as hedge against inflation in the long run.

### 3 Theoretical Framework

Our starting point is the dividend discount model following Gordon (1959). This model states that the value of any asset is determined by the present value of the stream of future income, which is discounted using the short-term nominal interest rate.

$$Q_t = E_t \sum_{j=0}^n \frac{D_{t+j}}{(1 + r_{t+j})^j} + \sum_{j=n+1}^{\infty} \frac{D_{t+j}}{(1 + r_{t+j})^j}, \quad (1)$$

where  $E_t$  is the expectations operator,  $Q_t$  is the share price,  $D_t$  is the dividend per share,  $r_t$  is the discount rate,  $j$  represents time, such that if  $j = 0$ , then the dividend per share is at time  $t$ ,  $D_t$  and  $n$  is the date to maturity. We add a second term known as the terminal value which accounts for the perpetual nature of equity prices, however as  $n$  approaches infinity the terminal value approaches zero.

Applying the Taylor approximation to equation (1) allows us to get the following relationship:

$$Q_t = Q^* + D^* \hat{d}_t - \sum_{j=1}^n D^* j (1 + r^*)^{-j-1} \hat{r}_{t+j} + \varepsilon_t, \quad (2)$$

where  $Q^*$  is the share price at the steady state,  $D^*$  is the steady state dividend per share,  $\hat{d}_t$  is the percentage deviation of the dividend per share from steady state,  $r^*$  is the steady state short-term nominal interest rate,  $\hat{r}_{t+j}$  is the percentage deviation of the short-term nominal interest rate from steady state at time  $t+j$  and  $\varepsilon_t = \sum_{j=1}^n (1+r_0)^{-j} D^* \hat{d}_{t+j}$  represents the future expected dividend. Expressing equation (2) in percentage deviation terms, we obtain the following equity return relation:

$$\hat{q}_t = \left( \frac{D^*}{Q^*} \right) \hat{d}_t - \sum_{j=1}^n \frac{D^* j (1 + r^*)^{-j-1}}{Q^*} \hat{r}_{t+j} + \varepsilon_t, \quad (3)$$

where  $\hat{q}_t = \frac{Q_t - Q^*}{Q^*}$ , is the percentage deviation of the share price from the steady state, i.e. the share return.

However from equation (3) we identify a link to the term structure relation, which relates the term to maturity to the yield to maturity for bonds of different maturity, the relation is as follows:

$$R_t = \frac{1}{n} r_t + \frac{1}{n} \sum_{j=1}^n r_{t+j}, \quad (4)$$

where  $R_t$  is the long-term nominal interest rate,  $n$  is the date to maturity of a bond. We multiply both sides of equation (4) by  $\sum_{j=1}^n \frac{D^*j(1+r^*)^{-j-1}}{Q^*}$ , and as such we obtain the following relation:

$$\left[ \sum_{j=1}^n \frac{D^*j(1+r^*)^{-j-1}}{Q^*} \right] R_t = \frac{1}{n} \left[ \sum_{j=1}^n \frac{D^*j(1+r^*)^{-j-1}}{Q^*} \right] r_t + \frac{1}{n} \left[ \sum_{j=1}^n \frac{D^*j(1+r^*)^{-j-1}}{Q^*} \right] r_{t+j}, \quad (5)$$

From equation (5) we note a link to duration. Duration is the weighted average time to full recovery of principal and interest payments in present value terms and is used to measure the interest sensitivity of a portfolio. Let steady state Macaulay Duration be:

$$\phi^* = \sum_{j=1}^n \frac{D^*j(1+r^*)^{-j}}{Q^*}, \quad (6)$$

Note that  $\sum_{j=1}^n \frac{D^*j(1+r^*)^{-j-1}}{Q^*} = \phi^*(1+r^*)^{-1}$ . We can rewrite eq.(5) to obtain the following relation:

$$\sum_{j=1}^n \frac{D^*j(1+r^*)^{-j-1}}{Q^*} r_{t+j} = n\phi^*(1+r^*)^{-1}R_t - \phi^*(1+r^*)^{-1}r_t \quad (7)$$

Eq.(7) can be stated in terms of the term spread as follows:

$$\sum_{j=1}^n \frac{D^* j (1+r^*)^{-j-1}}{Q^*} r_{t+j} = n\phi^* (1+r^*)^{-1} (R_t - r_t) + \phi^* (1+r^*)^{-1} (n-1) r_t \quad (8)$$

Substituting the term  $\sum_{j=1}^n \frac{D^* j (1+r^*)^{-j-1}}{Q^*} r_{t+j}$  from eq.(3) using eq.(8) and letting  $\psi = \phi^* (1+r^*)^{-1}$  and  $\delta = \left(\frac{D^*}{Q^*}\right)$ , we obtain the following asset pricing equation:

$$\hat{q}_t = \delta \hat{d}_t - n\psi (R_t - r_t) - (n-1)\psi r_t + \varepsilon_t, \quad (9)$$

Eq.(9) is the linearized asset pricing equation similar to that of Campbell and Shiller (1988). Furthermore eq.(9) shows the close relationship between the term spread and the share price. An increase in the term spread leads to a decrease in the stock price because in this instance expected future short rates increase, leading to an increase in the discount factor for future dividends.

Eq.(9) can be expressed in terms of the percentage deviation of the dividend yield from the steady state, instead of the dividend per share.

$$\hat{q}_t = \frac{\delta}{1-\delta} \tilde{d}_t - \frac{n\psi}{1-\delta} \tilde{R}_t - \frac{(n-1)\psi}{1-\delta} r_t + \frac{1}{1-\delta} \varepsilon_t, \quad (10)$$



where  $\tilde{d}_t = \hat{d}_t - \hat{q}_t$  and the first term is the linearized dividend yield and  $\tilde{R}_t = R_t - r_t$  is the term spread. Following Fama and French (1988), we postulate that stock prices adjust in response to deviations from fundamentals as given by eq.(11). The adjustment process follows:

$$\Delta q_{t+1} = -\lambda(q_t - q^*), \quad (11)$$

where  $\lambda < 0$  is the speed of adjustment of the stock price in response to deviations from fundamentals and  $q_t - q^* = \hat{q}_t$ . Eq.(11) explains the determinants of stock returns, which are given by:

$$\Delta q_{t+1} = -\lambda \frac{\delta}{1-\delta} \tilde{d}_t + \lambda \frac{n\varphi}{1-\delta} \tilde{R}_t + \lambda \frac{(n-1)\varphi}{1-\delta} r_t \quad (12)$$

However the discount rate can be estimated through the backward-looking Taylor reaction function, which states:

$$r_t = \alpha_r r_{t-1} + \alpha_\pi \pi_t + \alpha_y y_t + \alpha_e e_t, \quad (13)$$

where  $r_t$  is the monthly short-term nominal interest rate,  $\pi_t$  is the monthly rate of inflation,  $y_t$  percent deviation of actual output from potential output (i.e. lagged monthly excess demand),  $e_t$  is the monthly log level of the real effective exchange rate and  $r_{t-1}$  is the monthly short-term nominal interest rate, this lagged variable smooths interest rate changes, according to Mohanty and Klau (2004) the rationale behind smoothing is that "moving the policy rate by small steps in the same direction increases its impact on the long-term interest rate because market participants expect the change to continue and hence price their expectations into forward rates".

Therefore substituting equation (13) into equation (12) and simplifying, we obtain the following reduced form forecasting equation :

$$\Delta \hat{q}_t = \lambda \frac{\delta}{1-\delta} \tilde{d}_t + \frac{n\psi}{1-\delta} \tilde{R}_t + \gamma_r \alpha_r r_{t-2} + \gamma_\pi \alpha_\pi \pi_{t-1} + \gamma_y \alpha_y y_{t-1} + \gamma_e \alpha_e e_{t-1}, \quad (14)$$

where the parameters are  $\gamma_r = \lambda \frac{(n-1)\psi}{1-\delta}$ ,  $\gamma_\pi = \lambda \frac{(n-1)\psi}{1-\delta}$ ,  $\gamma_y = \lambda \frac{(n-1)\psi}{1-\delta}$  and  $\gamma_e = \lambda \frac{(n-1)\psi}{1-\delta}$ .

$(R_{t-1} - r_{t-1})$  is the long term nominal rate less the short nominal term rate in the previous period, i.e. the lagged term spread,  $r_{t-1}$  is the short term nominal rate in the previous period and  $\zeta_t$  is the error term, which is made up of expected dividend payments per share.

To specify the short term nominal interest rate we use a simplified open economy Taylor rule reaction function, following Taylor (1993), Mohanty and Klau (2004), Molodtsova and Papell (2009) and Moura and de Carvalho (2010). This reaction function enables us to investigate the possibility of whether or not estimating the short term nominal interest rate improves the accuracy of equity returns. Following Mehrotra and Sanchez-Fung (2011), Moura and de Carvalho (2010) and Molodstova and Pappel (2009), we use OLS regressions to specify the open economy Taylor rule function.

Equation (14) is the reduced form forecasting equation and is used to formulate the share price at equilibrium. We use the broad Taylor rule to formulate the short term nominal interest rate in emerging markets following Mohanty and Klau (2004), Moura and Carvalho (2010) and Galimberti and Moura (2013), because "the need for greater monetary discipline in emerging market economies has been generally stressed against the backdrop of their relatively high inflation and low policy credibility" but also because

there have been few studies in the finance literature that use macroeconomic factors, particularly the Taylor rule, to forecast stock returns. Terms structure has been found to explain the characteristics of equity returns such as predictability and excess volatility by Wachter (2006).

## 4 Methodology

### 4.1 *Data description*

The data set consists of both macroeconomic and financial variables. We use monthly data from the International Monetary Fund (IMF) database from June 2002 to June 2013 for most of the emerging market economies. Industrial production is used to proxy GDP whilst 10 year government bond rates proxy long term interest rates and 3 month Treasury bill rates proxy short term interest rates. Furthermore the following variables also form part of the data set, monthly Consumer Price Index (CPI) and the exchange rates. Dividends per share and share prices are proxied by various indices such as the JSE All Share Index for South Africa, obtained from the McGregor BFA Research Domain.

In the other emerging market economies the dividend per share and share prices are proxied by the following indices, obtained from the Bloomberg database: In South Korea the KOSPI is used, which is an index of all common shares on the Korean Stock Exchanges. In Poland we use the Warsaw Stock Exchange Warszawski Indeksy Gieldowy (WIG) Index, this is a total return index, which includes all domestic companies, except investment funds, listed on the main Warsaw Stock Exchange. (Bloomberg Database, retrieved December 5, 2013 from [http:// www.bloomberg.com](http://www.bloomberg.com)) .

The output gap, spread gap and short term interest rate gap are constructed as the deviation of output, spread and short term interest rates from a linear trend as per Wohar and Vivian (2013) whilst the growth rate is generated from the real rates for the remaining variables. The dividend yield was constructed from the dividend per share and in countries like South Africa the variable is omitted as it displays insignificance. The akaike information criterion is also used to determine the optimal lag length when forecasting

## **4.2 *Ordinary Least Squares Regressions and Forecasting***

### **4.3**

We use the first-order Taylor expansion to linearize the dividend discount model equations for two reasons, namely to approximate deviations around a equilibrium point, as noted by Campbell and Shiller (1988), to convert a non-linear dividend discount function to a linear function which will enable us to use Ordinary Least Squares (OLS) regressions, which requires a linear regression.

To specify the short term nominal interest rate we use a simplified open economy Taylor rule reaction function, following Taylor (1993), Mohanty and Klau (2004), Molodtsova and Papell (2009) and Moura and de Carvalho(2010). This reaction function enables us to investigate the possibility of whether or not estimating the short term nominal interest rate improves the accuracy of equity returns. Following Mehrotra and Sanchez-Fung (2011), Moura and de Carvalho (2010) and Molodstova and Papell (2009), Ordinary Least Squares (OLS) Regressions are used to estimate the open economy Taylor rule function.

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To forecast the equation (14) we use dynamic forecasting by using rolling regressions and constructing the Clark and West (CW) Statistic. To implement the rolling regressions we follow Molodtsova and Papell (2006) by constructing a one-month, three-month and twelve-month ahead forecasts, at each estimation point we re-estimate the model and incorporate the re-estimating in forecasting the next period, this allows us to capture all available information at the time.

The forecasting is implemented for a portion of the sample, this enables us to forecast for out-of sample data by reserving part of the sample. Furthermore Molodtsova and Papell (2006) note that the CW statistic, which compares the mean squared prediction errors (MSPE's) of nested models, allows for the testing of equal predictive ability of a linear model and the random walk model. The CW statistic allows for the adjustment of the noise introduced by the larger model and is a better statistic to use when dealing with nested models as highlighted by Molodtsova and Papell (2006) .

## 5 Empirical Results

The tables below present the regression results from our share price forecasting model and other models. These other models include the forecasting model without the Taylor rule, the random walk model with a constant and the auto-regressive model, which will later be used to test the robustness of the forecasting model. The future expected dividends, which are captured by the error term, interact with the other explanatory variables such as the short term interest rates as well as the dividend per share.

Table 1: Estimation of Eq.(14) and Eq.. (11)

Variables	South Africa			South Korea			Poland		
	1	3	12	1	3	12	1	3	12
Horizon	$\Delta \hat{q}_t = \frac{\lambda \delta}{1-\delta} \hat{d}_{t-1} + \frac{m\psi}{1-\delta} \tilde{R}_t + \gamma_r \alpha_r r_{t-2} + \gamma_\pi \alpha_\pi \pi_{t-1} + \gamma_y \alpha_y y_{t-1} + \gamma_e \alpha_e e_{t-1}$								
$\hat{d}_{t-1}$	-	-	-	-0.49 (0.15)*	-0.08 (0.13)	0.02 (0.22)	-0.60 (0.09)	-0.48 (0.10)	0.32 (0.12)
$\tilde{R}_{t-1}$	1.14 (0.76)	1.19 (0.76)	2.26 (1.06)	15.96 (4.94)	18.21 (4.38)	-5.24 (7.48)	22.01 (6.15)	10.52 (6.77)	7.67 (7.79)
$r_{t-2}$	-3.63 (1.23)	-0.85 (1.23)	7.72 (1.43)	3.55 (6.47)	-12.24 (5.64)	5.28 (9.37)	-4.70 (8.81)	-15.54 (9.70)	23.00 (11.07)
$\pi_{t-1}$	-4.51 (0.54)	-4.99 (0.54)	-1.39 (1.05)	1.51 (2.07)	-5.21 (1.88)	1.30 (3.56)	-15.19 (1.88)	-11.83 (2.07)	-3.05 (2.36)
$y_{t-1}$	2.43 (0.49)	0.06 (0.49)	-0.71 (0.94)	1.04 (0.53)	0.36 (0.46)	-2.64 (0.77)	-0.54 (0.27)	-1.26 (0.30)	-3.18 (0.40)
$e_{t-1}$	-0.17 (0.08)	-0.04 (0.08)	-0.61 (0.22)	0.96 (0.14)	0.71 (0.12)	0.45 (0.20)	0.83 (0.24)	-0.11 (0.26)	-0.28 (0.31)
$R^2$	0.53	0.53	0.51	0.57	0.69	0.22	0.71	0.65	0.59
$\chi^2_{(12)}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	$\Delta \hat{q}_t = \frac{\lambda \delta}{1-\delta} \hat{d}_{t-1} + \frac{m\psi}{1-\delta} \tilde{R}_t + \gamma_r \alpha_r r_{t-2}$								
$\hat{d}_{t-1}$	-	-	-	-0.72 (0.15)	-0.53 (0.15)	0.38 (0.17)	-0.67 (0.12)	-0.44 (0.13)	0.56 (0.15)
$\tilde{R}_{t-1}$	4.66 (0.75)	5.12 (0.77)	3.86 (0.88)	11.22 (6.27)	10.71 (5.94)	-7.82 (7.47)	-8.75 (7.77)	-10.94 (7.92)	-0.33 (9.41)
$r_{t-2}$	-4.94 (1.41)	-3.37 (1.44)	9.47 (1.63)	3.10 (6.23)	-14.29 (5.93)	-26.00 (7.14)	-47.07 (9.57)	-52.44 (9.75)	7.61 (11.55)
$R^2$	0.33	0.31	0.17	0.27	0.37	0.19	0.40	0.39	0.16
$\chi^2_{(12)}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: SEs in parentheses

The results reported in table 5 for eq.(14) indicate that there is a negative and significant relationship between stock prices and dividend yields for South Korea and Poland in periods 1 and 3 months ahead. However this is not the case for period 12 across both countries. The spread is only significant 4 out of 9 times but has the expected positive sign, this is an indication of a possible increase in the short term interest rates. Short term interest rates display a negative relationship with share returns, as opposed to the expected positive relationship, however this variable is insignificant and as such has no economic weight.

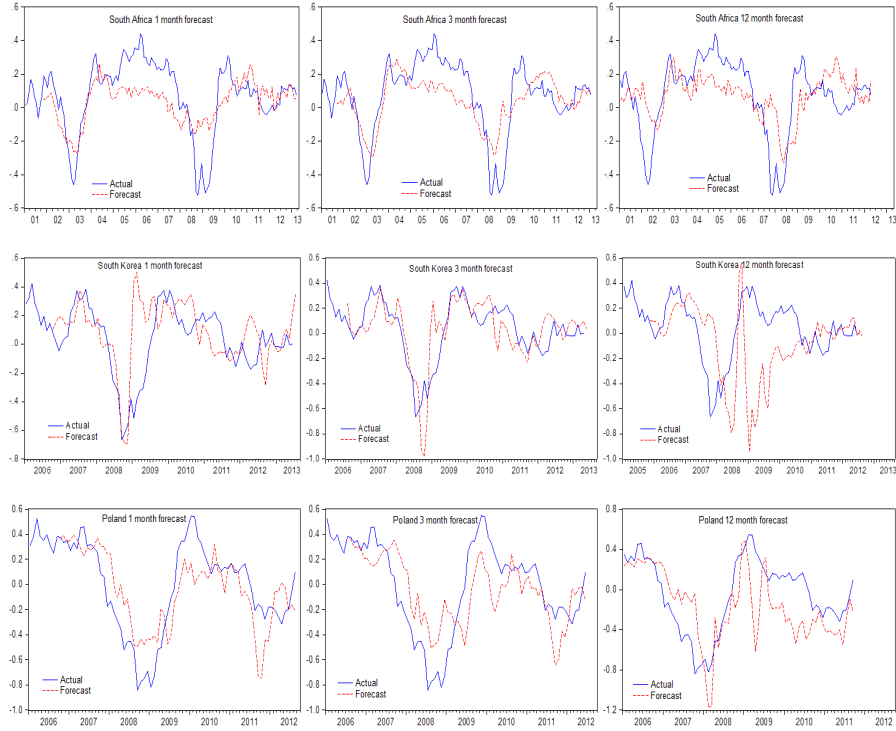
According to Fama (1981), Balduzzi (1994) and Alagidede(2009) there is a negative relationship between inflation and stock prices, this observation can be clearly seen from the results of eq.(14) above. Industrial production and exchange rates display a mixed relationship with stock prices with largely the 12 month forecast period and Poland across all periods being negative and insignificant three out of the nine runs. All three countries exhibits serial correlation as indicated by the probability of the chi squared statistic, this serial correlation is corrected as per the results presented in table 2. There is also evidence of relatively high  $R^2$ , with the exception of South Korea in the twelfth period.

For comprehensive purposes the second part of table 1 presents results from the model without the Taylor rule, the dividend yield once again exhibits a negative and highly significant relationship in most cases as anticipated. The spread is positive and significant more than 50% of the runs, whilst the short term interest rates are negative and significant 67% of the time.

Figure 1 shows the actual versus the forecasted values of the main model with Taylor rule for the three different countries at the three different forecast periods. Note that the forecasted value closely tracks the actual value. This further emphasizes the ability of our model to forecast stock returns.



Figure 1: Actual and forecast estimates of share returns



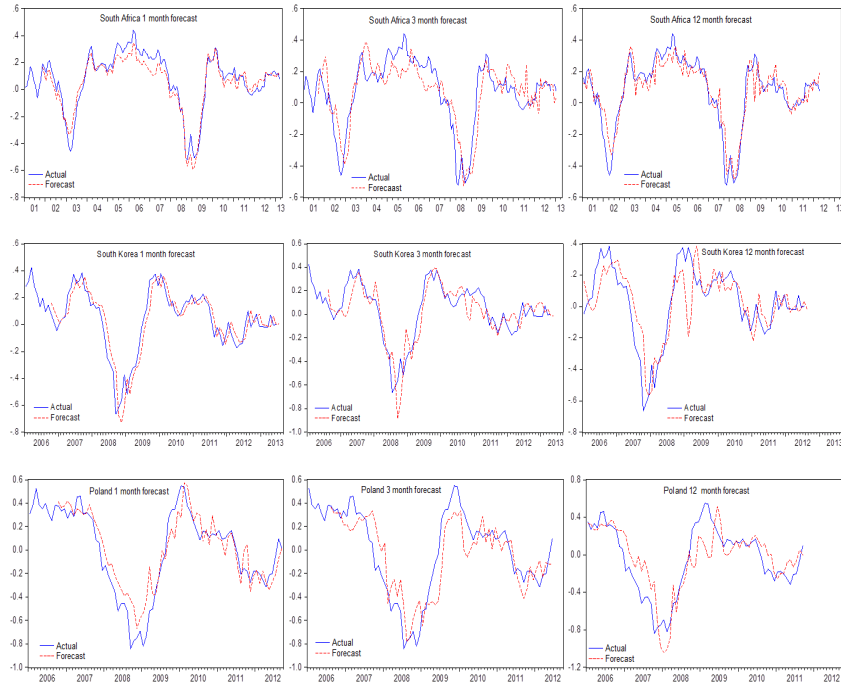
Although the model is tracking the actual values, there are significant errors which reflect the serial correlation. Based on eq.(10) these errors reflect expected future dividends as such the serial correlation arises due to the interaction of the future expected dividends with the other explanatory variables. The serial correlation is corrected in Table 2, using Heteroskedasticity and Autocorrelation Consistent Covariance (HAC). However the  $R^2$  decreases as we move from the model with the Taylor to the model without the Taylor rule from an average of 0.8 to 0.29 respectively.

Table 2 Estimations of Eq.(14) and Eq.(11) corrected for serial correlation

Variables	South Africa			South Korea			Poland		
	1	3	12	1	3	12	1	3	12
Horizon	$\Delta \hat{q}_t = \frac{\lambda \delta}{1-\delta} \hat{d}_{t-1} + \frac{n\psi}{1-\delta} \tilde{R}_t + \gamma_r \alpha_r r_{t-2} + \gamma_\pi \alpha_\pi \pi_{t-1} + \gamma_y \alpha_y y_{t-1} + \gamma_e \alpha_e e_{t-1} + \varepsilon_t$								
$\hat{d}_{t-1}$	-	-	-	-0.43 (0.11)	0.01 (0.09)	-0.09 (0.10)	-0.60 (0.06)	-0.48 (0.06)	0.32 (0.07)
$\tilde{R}_{t-1}$	3.37 (0.74)	1.27 (0.36)	0.90 (0.48)	12.91 (3.57)	18.12 (2.98)	-7.84 (3.57)	22.01 (4.31)	10.52 (4.40)	7.67 (5.01)
$r_{t-2}$	0.88 (0.96)	0.36 (0.61)	11.16 (0.76)	-12.09 (4.85)	-12.49 (3.75)	-1.74 (4.39)	-4.70 (6.02)	-15.54 (6.12)	23.00 (6.84)
$\pi_{t-1}$	-3.32 (0.73)	-5.07 (0.03)	-3.30 (0.33)	3.21 (1.47)	-6.48 (1.26)	4.28 (1.67)	-15.19 (0.18)	-11.83 (0.18)	-3.05 (0.24)
$y_{t-1}$	0.93 (0.62)	-0.15 (0.24)	-1.04 (0.31)	0.53 (0.38)	0.55 (0.31)	-1.50 (0.37)	-0.54 (0.05)	-1.26 (0.00)	-3.18 (0.00)
$e_{t-1}$	0.03 (0.15)	-0.03 (0.04)	0.24 (0.05)	0.73 (0.10)	0.69 (0.08)	0.35 (0.09)	0.83 (0.16)	-0.11 (0.16)	-0.28 (0.19)
$\varepsilon_{t-1}$	-0.38 (0.13)	-0.03 (0.07)	0.86 (0.02)	0.59 (0.06)	0.76 (0.07)	0.91 (0.05)	0.78 (0.06)	0.81 (0.06)	0.39 (0.11)
$\varepsilon_{t-2}$	0.76 (0.13)	-0.21 (0.07)	0.86 (0.04)	-	-	-	-	-	-
$R^2$	0.81	0.90	0.85	0.79	0.86	0.83	0.89	0.65	0.59
	$\Delta \hat{q}_t = \frac{\lambda \delta}{1-\delta} \hat{d}_{t-1} + \frac{n\psi}{1-\delta} \tilde{R}_t + \gamma_r \alpha_r r_{t-2} + \varepsilon_t$								
$\hat{d}_{t-1}$	-	-	-	-0.72 (0.08)	-0.53 (0.11)	0.38 (0.15)	-0.67 (0.07)	-0.44 (0.07)	0.56 (0.06)
$\tilde{R}_{t-1}$	4.66 (0.75)	5.12 (0.43)	3.86 (0.57)	11.22 (3.18)	10.71 (4.59)	-7.82 (7.51)	-8.75 (4.27)	-10.94 (4.44)	-0.33 (3.61)
$r_{t-2}$	-4.94 (1.41)	-3.37 (0.84)	9.47 (1.06)	3.10 (3.09)	-14.29 (4.49)	-26.00 (6.99)	-47.07 (5.21)	-52.44 (5.43)	7.61 (4.37)
$\varepsilon_{t-1}$	1.07 (0.07)	1.10 (0.09)	0.79 (0.10)	0.86 (0.05)	0.07 (0.07)	-0.28 (0.10)	0.85 (0.05)	0.86 (0.05)	0.94 (0.04)
$\varepsilon_{t-2}$	-0.19 (0.07)	-0.22 (0.09)	0.16 (0.10)	-	-	-	-	-	-
$R^2$	0.33	0.31	0.17	0.27	0.37	0.19	0.40	0.39	0.16
$\chi^2_{(12)}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The results from table 2 above show a remarkable improvement in the  $R^2$  of the corrected equations. There is also an improved relationship between the variables with more variables depicting the expected signs and significance.

Figure 2. Actual and forecast estimates of share returns adjusted for serial correlation



Having controlled for serial correlation, the figure 2 depicts closer tracking of actual values by forecast values. The relationship between the future expected dividend and the other variables has improved and moves closer to zero, as displayed pictorially in figure 2. The difference between the actual and forecasted values for South Africa in period 12 is small compared to period 3, this could be as a result of mean reversion observed in South Africa.

## 6 Robustness Tests

We examine the robustness of our forecasting model by including two other models, eq.(1) which runs the share return against a constant and an auto-regressive model.

The main model proves to be robust as can be seen by the standard errors in table 3. The standard errors decrease and become smaller indicating that our sample is representative of the overall population i.e. changes in share prices closely reflect movements on the respective exchanges.

Table 3: Estimations for model with constant and auto-regressive model

Variables	South Africa			South Korea			Poland		
	1	3	12	1	3	12	1	3	12
$\Delta \hat{q}_t = c$									
$c$	0.05 (0.01)	0.05 (0.01)	0.05 (0.01)	0.08 (0.02)	0.08 (0.02)	0.07 (0.02)	0.09 (0.03)	0.08 (0.03)	0.05 (0.03)
$\Delta \hat{q}_t = \lambda \hat{q}_{t-1} + \lambda \hat{q}_{t-2}$									
$\hat{d}_{t-1}$	0.00 (0.00)	1.12 (0.16)	0.03 (0.22)	1.01 (0.09)	1.20 (0.18)	-0.21 (0.23)	1.12 (0.09)	0.52 (0.34)	0.52 (0.34)
$\hat{d}_{t-2}$	1.27 (0.07)	-0.51 (0.16)	-0.13 (0.22)	-0.10 (0.09)	-0.66 (0.18)	-0.10 (0.23)	-0.17 (0.09)	-0.62 (0.34)	-0.62 (0.34)

Note:SEs in parentheses

## 6.1 Performance of forecasting models

Following Clark and West (2007), we use the Clark-West (CW) Statistic to evaluate the performance of each model at the three forecast periods. The CW statistic examines nested models to determine which model has the smallest Mean Square Prediction Error (MSPE) and in turn the best predictor. According to Clark and West (2007), the contribution of the CW statistic is that it makes an adjustment to the measurement, allowing for the noise introduced by the larger model. The tables below compares the predictive performance of our with Taylor rule model against the without Taylor rule model, the random walk 1 model with a constant and the auto-regressive model.

Table 4 CW statistic

Coefficient	South Africa			South Korea			Poland			
	Horizon	1	3	12	1	3	12	1	3	12
Model with Taylor rule										
Without T.R	0.01 (4.51)	0.03 (1.30)	0.05 (7.14)	0.03 (4.16)	0.03 (2.61)	0.08 ( <b>1.27</b> )*	0.00 ( <b>0.33</b> )*	0.01 ( <b>0.53</b> )*	0.05 ( <b>1.20</b> )*	
S.E	0.03	0.05	0.07	0.10	0.09	0.49	0.06	0.09	0.35	
Constant Model	0.04 (7.19)	0.05 (7.17)	0.04 (5.58)	0.07 (2.58)	0.10 (3.68)	-0.05 ( <b>-3.80</b> )*	0.20 (5.29)	1.16 (4.30)	-0.00 ( <b>0.00</b> )*	
S.E	0.09	0.08	0.10	0.26	0.25	0.10	0.32	0.31	0.27	
A.R	0.01 (3.48)	0.05 (5.67)	0.05 (5.82)	0.06 (3.91)	0.12 (4.79)	0.01 ( <b>0.57</b> )*	0.01 (1.41)	0.12 (3.80)	0.12 (2.23)	
S.E	0.03	0.03	0.10	0.15	0.22	0.08	0.08	0.26	0.40	

Note: T-stat in parentheses

According to Clark and West (2007) the null hypothesis states that the models have equal MSPE and the alternative is that model 2(model with Taylor rule) has smaller MSPE than model 1. that is in order for the model with

Taylor rule to outperform the other models the t-stat has to be greater than +1.282. From the results above only in seven instances do we fail to reject the null hypothesis. These results indicate that our model with Taylor rule outperforms the other models approximately 75% of the time.

## 7 Conclusion

There is a growing body of literature that provides evidence for the forecastability of asset prices. This paper forecasted stock returns using a reduced form factor model which incorporates Taylor rule fundamentals and the dividend discount model. We used Ordinary Least Squares (OLS) Regressions to estimate the open economy Taylor rule function and rolling regression to forecast the model with the Taylor rule. The results are firstly, once serial correlation had been controlled, the main model display the expected results and significance. The puzzle of the stock price and inflation relationship is observed similar to Fama (1981) and Kaul ((1987). However no attempt is made to explain this relationship and this aspect of research is left to future studies.

Secondly the performance measure, as per the CW statistic, highlighted a significant out-performance of our forecasting model compared to the other three models, suggesting that our forecasting model is a powerful tool to be considered by an investor in making portfolio decisions. These results shed some light on the subject matter of factors that drive stock returns and also enables monetary policy makers to infer market expectations and as such generate forecasts of macroeconomic aggregates.

## 8 Appendix

### 8.1 CW Stat results for models with errors

For comprehensive purposes, we also run the CW statistic test again, this time we included the models having controlled for serial correlation. The null



hypothesis remains the same and we compare the predictive performance of our with Taylor rule model against the without Taylor rule model (Robust), the model with a constant c (RW 1) and the auto-regressive model (RW 2).

Table 5 CW statistic main model adjusted for serial correlation

Coefficient	South Africa			South Korea			Poland			
	Horizon	1	3	12	1	3	12	1	3	12
Model with Taylor rule										
Robust	0.00 (0.37)*	0.01 (4.29)	0.00 (-0.93)*	0.00 (1.00)*	0.00 (-1.19)*	-0.00 (-1.64)*	0.03 (3.28)	0.01 (1.64)	0.00 (0.39)*	
S.E	0.00	0.01	0.01	0.00	0.00	0.00	0.07	0.05	0.04	
Constant Model	0.12 (6.34)	0.02 (6.01)	-0.00 (-0.09)*	0.02 (5.18)	0.10 (1.70)	0.04 (5.00)	0.04 (3.90)	0.00 (0.04)*	-0.00 (-0.01)*	
S.E	0.21	0.23	0.01	0.04	0.02	0.19	0.10	0.03	0.05	
A.R model	0.01 (4.99)	0.01 (6.08)	0.00 (0.23)*	0.02 (4.27)	0.00 (4.98)	0.00 (0.76)*	0.05 (4.24)	0.01 (1.31)	0.51 (4.08)	
S.E	0.02	0.02	0.01	0.04	0.02	0.03	0.10	0.03	1.06	

Note: T-stat in parentheses

From the results above there are eleven instances where we fail to reject the null hypothesis. These results indicate that our model with Taylor rule and its errors outperforms the other models and errors approximately 60% of the time.

## Reference

- Alagidede, P. (2009). Relationship between Stock Returns and Inflation. *Applied Economics Letters*, 6, 1403–1408
- Ang, A., and Bekaert, G. (2007). Stock Return Predictability: Is it There?. *The Review of Financial Studies*, 20(3), 651-707
- Balduzzi, P. (1995). Stock returns, inflation, and the 'proxy hypothesis': A new look at the data. *Economic Letters*, 48, 47-53
- Barberis (2000). Investing for the Long Run when Returns Are Predictable. *The Journal of Finance*, VL1, 225-264
- Black, F., (1972). Capital Market Equilibrium with Restricted Borrowing. *Journal of Business*, 45(3) 444-455
- Blanchard, O. and Watson, M. (1982). Bubbles, Rational Expectations And Financial Markets. *NBER Working Paper Series*, Working Paper No.945, 1-28
- Bloomberg Database, retrieved December 5, 2013 from [http:// www.bloomberg.com](http://www.bloomberg.com)
- Campbell (1991). A Variance Decomposition for Stock Returns. *Economic Journal*, 101 (405),157-179.
- Campbell, J.Y., and Shiller, R. J. (1988a). Stock Prices, Earnings and Expected Dividends. *Journal of Finance*, 43(3), 661–676.
- Chen,N., Roll, R. and Ross, S. (1986). Economic Forces and the Stock Market. *Journal of Business*, 59 (3), 383-403.
- Chaudhri and Wu (2004). Mean Reversion in Stock Prices: Evidence from Emerging Markets. *Managerial Finance*, 30(1), 22-37
- Clark, T.E., and West, K.D. (2007). Approximately normal tests for equal predictive accuracy in nested models. *Journal of Econometrics*, 138, 291–311
- Cochran and Defina(1995). International Evidence on Mean Reversion in Stock Prices. *Quarterly Journal of Business and Economics*, 33 (2),79-85
- Da, Z. (2009). Cash Flow, Consumption Risk, and the Cross-section of Stock Returns. *The Journal of Finance* , 62 (2), 923-956.

- Fama, E. F.(1981). Stock returns, real activity, inflation, and money. *American Economic Review*,71(4), 545-565
- Fama and French (1988).Temporary and Permanent Components of Stock Prices. *The Journal of Political Economy*, 96 (2), 246-273.
- Fama, E. F., and French, K. R. (1989). Business conditions and expected returns on stocks and bonds. *Journal of Financial Economics*, 25(1), 23–49
- Fama (1998). Market Efficiency, Long-Term Returns, and Behavioral Finance. *Journal of Financial Economics*, 49. 283-306
- Flannery, M.J. and Protopapadakis, A.A. (2002).Macroeconomic Factors Do Influence Aggregate Stock Returns. *The Review of Financial Studies*,15(3), 751-782
- Galimberti, J.K. and Moura, M.L. (2013).Taylor rules and exchange rate predictability in emerging economies. *Journal of International Money and Finance*, 32 ,1008–1031
- Gordon, M.J. (1959). Dividend Earnings, and Stock Prices. *The Review of Economics and Statistics*, 41(2), 99-105
- Hordahl, P., and Packer, F. (2007). Understanding Asset Prices: An Overview. *Bank for International Settlements Papers* (34), 1-38
- Hodrick (1992). Dividend Yields and Expected Stock Returns: Alternative Procedures for Inference and Measurement. *The Review of Financial Studies*, 5 (3), 357-386.
- Jensen, M.C. and Benington, G.A. (1969). Random Walks and Technical Theories: Some Additional Evidence. *The Journal of Finance*, 25 (2), 469-482.
- Kaul (1987). Stock Returns and Inflation: The Role of the Monetary Sector. *Journal of Financial Economics*, 18, 253-276.
- Kim, Myung Jig, Nelson and Startz(1991). Mean Reversion in Stock Prices? A Reappraisal of the Empirical Evidence. *Review of Economic Studies*, 58, 515-528

- Lintner, John. 1965. "The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets." *Review of Economics and Statistics*, 47(1), 13-37.
- Liu, W. (2006). A Liquidity-Augmented Capital Asset Pricing Model. *Journal of Financial Economics*, 82, 631-671
- Lo, A.W. and Mackinlay, A.C. (1988). Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test. *The Review of Financial Studies*, 1(1), 41-66
- Mehrotra, A. and Sanchez-Fung, J.R. (2011). Assessing McCallum and Taylor rules in a cross-section of emerging market economies. *Int. Fin. Markets, Inst. and Money*, 21, 207–228
- Mohanty, M.S. and Klau, M. (2004). Monetary policy rules in emerging market economies: issues and evidence. *Bank of International Settlements Working Paper* (149), 1-17
- Molodtsova, T. and Papell, D.H. (2009). Out-of-sample exchange rate predictability with Taylor rule fundamentals. *Journal of International Economics*, 77, 167–180
- Moura, M.L. and de Carvalho, A. (2010). What can Taylor rules say about monetary policy in Latin America?. *Journal of Macroeconomics*, 32, 392–404
- Poterba and Summers (1988). Mean Reversion In Stock Prices, Evidence and Implications. *Journal of Financial Economics*, 22, 27-59
- Rapach, D. E., and M. E. Wohar, 2006. In-Sample vs. Out-of-Sample tests of stock return predictability in the context of data mining. *Journal of Empirical Finance*, 13(2), 231–247.
- Sharpe, William F. 1964. "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk." *Journal of Finance*. 19(3), 425-442
- Vivian, A. and Wohar, M.E. (2013). The output gap and stock returns: Do cyclical fluctuations predict portfolio returns?. *International Review of Financial Analysis*, 26, 40-50

Wachter, J.A. (2006). A consumption-based model of the term structure of interest rates. *Journal of Financial Economics*, 79, 365–399

Ross, S.A. (1976). The Arbitrage Theory of Capital Asset Pricing. *Journal of Economic Theory*, 13, 341-360