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NONLINEAR THRESHOLD RELATIONSHIPS BETWEEN INFLATION AND NOMINAL RETURNS: A TIME SERIES APPROACH TO 39 DIFFERENT COUNTRIES

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ABSTRACT

A linear null relationship between nominal returns and inflation is tested against threshold alternatives using quarterly and monthly data for 39 different countries. These tests frequently reject the null in favor of the alternative. The threshold alternatives and the linear nulls are estimated to uncover the nature of the linear and threshold relationships. Estimation results reveal that "low-average-inflation" countries tend to display a negative or negative but insignificant linear relationship between returns and inflation, while "high-average-inflation" countries often evince a strong positive or positive but insignificant linear relationship. The same pattern occurs in the threshold models, after a threshold level of inflation is reached. Before this threshold, the relationship is weaker and often insignificant.

JEL Classifications: G15, C12, C13

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Inflation and Nominal Returns Revisited: A TAR Approach to 39 Countries

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A linear null relationship between nominal returns and inflation is tested against threshold alternatives using quarterly and monthly data for 39 different countries. These threshold alternatives and the linear nulls are then estimated to uncover the nature of the linear and threshold relationships between nominal returns and inflation. Tests of the linear null against the threshold alternative frequently reject the null of a linear relationship between nominal returns and inflation. These tests imply that the threshold relationship between nominal returns and inflation is a better specification than the linear relationship for most of the 39 countries tested. Estimation results of both the linear and threshold relationships reveal an interesting pattern. Low-average-inflation countries tend to display a negative or negative but insignificant linear relationship between nominal returns and inflation over the entire sample, while medium to high-average-inflation countries often evince a strong positive or positive but insignificant linear relationship between nominal returns and inflation. The threshold relationships generally indicate an insignificant relationship between the two variables before an estimated threshold level of inflation, and a more strongly negative (for low-average-inflation countries) or positive (for medium to high-average-inflation countries) relationship between nominal returns and inflation after the threshold level of inflation is reached.

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1 Introduction

Since the 1970s financial economists have been puzzled by evidence suggesting that common stocks are poor hedges against inflation. As claims against real assets, stocks should protect stockholders from changes in inflation, in that expected returns should move positively with expected inflation. The accumulated evidence thus far indicates either a negative or insignificant relationship between expected returns from common stocks and expected inflation, as well as between expected returns and unexpected inflation, for many different countries (Bodie (1976), Jaffe and Mandelker (1976), Nelson (1976) Fama and Schwert (1977), Schwert (1981), Fama (1981), Gultiken (1983), Pearce and Roley (1985), Hardouvelis (1987), McQueen and Roley (1993), Amihud (1996)).[1] The empirical evidence is also puzzling since an extension of the Fisher (1930) hypothesis to the nominal returns of common stocks states that the expected nominal return is the sum of the real return and the expected rate of inflation. Thus, this hypothesis points to a direct positive relationship between expected nominal stock returns and expected inflation, given independence of real returns and expected inflation.

The relationship between inflation and returns is not just of interest to investors and economists who want to know whether nominal stock returns provide a hedge against inflation, but it is also of importance to economists and practitioners who study the links among inflation, financial markets and growth. Empirically, a negative cross-sectional relationship has been found to exist between inflation and indicators of financial market development, while a positive cross-sectional relationship has been found to exist between inflation and nominal stock returns and between inflation and the volatility of such returns (e.g.: Boyd, Levine and Smith (1996), Branch (1974), and Cagan (1974)). Another branch of this empirical literature has found positive correlations between financial market development and growth (e.g.: Levine and Zervos (1996)), and recent studies (Boyd, Levine and Smith (1996), and Bruno and Easterly (1995)) have found that these cross-sectional relationships detailed above appear to be nonlinear in that they display "thresholds," before and after which the relationship between the variables changes.

Boyd, Levine and Smith (1996) discovered evidence of threshold effects

[1] Boudoukh and Richardson (1993) is a notable exception. In contrast to the aforementioned studies, Boudoukh and Richardson (1993) analyze the relationship between the long-horizon nominal returns and both *ex ante* and *ex post* long-term inflation and find that the relationship is positive for both the UK and the USA.

across countries. The authors found that the relationship between inflation and indicators of financial market development, as well as nominal stock returns, changed for countries whose average rate of inflation was above 12%.[2] By interfering with the allocative function of capital markets, inflation reduces the level of activity in capital markets, which decreases the rate of return to holding stocks. Bruno and Easterly (1996) found that inflation and growth are negatively related only after inflation reaches an annual level of 40% in a cross-section of 31 countries from 1961 through 1994. Similarly, Bullard and Keating (1994) find that a permanent positive inflation shock increases the long run level of real activity if the initial inflation rate is low. These results suggest that there is a threshold effect in the relationship between inflation and growth, between inflation and financial market development, and between inflation and nominal returns.

Choi, Smith and Boyd (1995) develop a theoretical model in which financial market efficiency affects decisions about savings and capital allocation in the presence of informational asymmetries. In this model high rates of inflation can aggravate financial market frictions. This can interrupt efficient provision and allocation of capital, which can negatively effect real activity. In their model these effects depend on the initial level of the inflation rate. Countries with high initial rates of inflation, when hit by a positive inflation shock, will face rationed credit markets, inhibiting the amount of capital that is allocated to productive investment opportunities. At low rates of inflation, this mechanism of credit rationing does not occur, hence nonlinearities in the form of thresholds arise. The relationship between inflation and returns is different in quality above and below a particular threshold. Above the threshold, the credit-rationing mechanism kicks in, below it, rationing may not occur at all, or financial market frictions may be loosened.

One of the testable hypotheses of their model is that a threshold relationship exists between real returns and expected inflation. When inflation is high enough, real returns are adversely affected by expected inflation, below that point there may be zero or positive correlation. The usual assumption in the literature on the relationship between nominal returns and inflation is that expected inflation and real returns are independent, so that

[2]Boyd, Levine and Smith (1996) note that the financial market and inflation variables may be negatively correlated only because both variables are correlated with another variable, such as the status of fiscal policy. For example, government seniorage needs could lead simultaneously to high inflation and governmental repression of the financial system. Their findings remain robust to controlling for such factors.

there should be a positive, one to one relationship between expected nominal returns and growth via the Fisher effect. The Choi, Smith and Boyd (1995) model predicts a negative relationship between real returns and expected inflation for high-inflation countries, once expected inflation reaches a threshold level. Analogously, for low-inflation countries, once expected inflation reaches a particular threshold, a positive or insignificant relationship can exist between real returns and expected inflation.[3][4]

This paper tests the null of a linear relationship between expected nominal returns and expected inflation, which represents the state of the empirical literature on this relationship to date, against threshold alternatives for the relationship between expected nominal returns and expected inflation, as intimated in Choi, Smith and Boyd (1995). In support of this endeavour the time series of some 39 different countries are tested for the null of linearity against general nonlinear alternatives and specific threshold alternatives, both on a quarterly and monthly basis.[5] The alternative threshold models are then estimated, along with the null linear model. The results are similar for the quarterly and monthly data, so only the monthly results are reported.

Not surprisingly, the tests indicate the presence of nonlinearities in the returns data. Tests of the linear null against threshold alternatives also tend to reject the null, indicating the presence of threshold effects in the relationship between expected nominal returns and expected nominal inflation. Estimation results show two broad tendencies. For low-average-inflation countries, the linear relationship estimated displayed a negative or insignificant relationship between nominal returns and inflation, which is, although still puzzling, consistent with the literature extant on this relationship. The estimated threshold relationships tended to display an insignificant relationship between the two variables below the threshold point, and a more strongly negative, often significant relationship above the threshold. As for those countries with the medium or high-average inflation, the tendency was the

[3] Other models which derive a threshold relationship of the type found in Boyd, Levine and Smith (1996) are Azariadis and Smith (1994, 1996), Boyd, Choi and Smith (1996), Huybens and Smith (1996, 1997) and Boyd and Smith (1998).

[4] There have been other extensions of the Fisher hypothesis that posit an interaction between the real rate of interest and inflation: Mundell (1963) showed an inverse relationship between the real rate of interest and inflation using the Pigou real balance effect, while Santomero (1973) maintained that changes in population invoke a positive relationship between the real rate of interest and inflation. A parallel could perhaps be drawn for the real return on stocks.

[5] The countries are listed in Table 1.

opposite: In the linear specification the relationship between nominal returns and inflation was more often positive and significant or positive and insignificant than otherwise, which is more consistent with what financial economists expected to find in the 1970s. For these latter countries, the threshold specification typically showed an insignificant relationship before the threshold, and a positive and more significant relationship between the two thereafter.[6] The goodness of fit for all threshold models estimated for the 39 different countries was larger than that of the linear specification, almost always by an order of magnitude. This supports the presence of a threshold, but does not support the hypothesis in Choi, Smith and Boyd (1995) about low and high inflation countries.

By surveying a much larger group of countries over a much longer time period (c.f. Gultiken (1983)), this paper makes a further contribution to the literature by revealing that the linear relationship between nominal returns and inflation depends on the average level of inflation. Countries with medium or high-average inflation tend to have a significant positive relationship between nominal returns and inflation, while low-average-inflation-rate countries typically exhibit a negative or insignificant relationship between the two variables, in keeping with the results of other researchers noted above.

The paper is organized as follows. Section two introduces the concept of a simple threshold model, and details the Fisher hypothesis along with the model posited by Choi, Smith and Boyd (1995). In section three, the tests for linear nulls against general nonlinear and specific threshold alternatives, and the econometric methodology of estimating threshold models, are presented. The results of these tests for nonlinearities and the estimated threshold relationships found in the various countries are discussed in section four. The last section summarizes the results detailed in this paper and concludes with recommendations for future research.

[6] The average estimated threshold for the medium/high-monthly-average-inflation countries was 1.5% on a monthly basis. For low-average-inflation countries the average estimated threshold was 0.6% on a monthly basis.

2 The Linear Null and The Alternative Threshold Model

2.1 What is a Threshold Model?

The development of the threshold autoregressive (TAR) model is generally attributed to Tong (see Tong (1978), Tong and Lim (1980), Tong (1983), and Tong (1990) for a broad treatment of the different classes of TAR models.) The most basic threshold regression model is:

$$y_t = \beta_1' x_i + e_i, \; q_{(i-d)} \leq \gamma \quad (1)$$
$$y_t = \beta_2' x_i + e_i, \; q_{(i-d)} \leq \gamma, \quad (2)$$

where x_i is a set of predetermined endogenous and/or exogenous variables and $q_{(i-d)}$ is the threshold variable with delay parameter d, the value of which determines where the sample is split into two groups or "regimes." Naturally, this can be generalized to r different regimes. In this paper, the alternative thresholds posited will always have two different regimes. The model tested in this paper follows the theoretical model developed in Choi, Smith and Boyd (1995), in which the relationship between inflation and returns changes once inflation crests the single threshold value, implying two regimes. More detail about the class of threshold models estimated in this paper is provided in section three.

2.2 The Economic Theory Behind The Linear Null

The "Fisher Effect" refers to the hypothesis that the nominal interest rate "fully reflects" all the information available about potential future values of inflation. This hypothesis maintains that the market is efficient. The most basic or common hypothesis is that expected nominal interest rates are directly and positively related to expected inflation on a one-to-one basis, which implies that the (ex ante) real rate of interest and expected inflation are independent. Often, the real rate of return is assumed to be constant (Fama (1975)). Fisher maintained that the expected real rate of interest is independent of the expected inflation rate, as a consequence of his belief that the real and monetary components of the economy are independent.[7]

[7]Fisher thought that the expected real rate of return is determined by the productivity of capital and the time preference of savers.

Fama and Schwert (1977) illustrate that the "Fisher Effect" can be maintained for all assets over all periods of time, or that:

$$\sum_{i=1}^{j} R_{(t+i)} = \alpha_j + \beta_j E\left[\sum_{i=1}^{j} \pi_{(t+i)} | \vartheta_t\right] + \varepsilon_t\,(j)\,, \tag{3}$$

with $H_0 : \beta_j = 1$, where R_t is the continuously compounded return on an asset, π_t is the continuously compounded rate of inflation, ϑ_t is the information set upon which the expectation is conditioned, and ε_t is the prediction error. The *ex ante* real rate of return is the difference between the expected return and the expected rate of inflation. Any test of the "Fisher Effect" must be applied to observable time series, however, where the realized nominal rate of return and the realized rate of inflation are related to their respective *ex ante* rates by

$$R_t = E\left[R_t|\vartheta_t\right] + \mu_t \tag{4}$$

$$\pi_t = E\left[\pi_t|\vartheta_t\right] + \upsilon_t \tag{5}$$

where μ_t and υ_t are prediction errors, uncorrelated with the predicted values. This extension of the Fisher hypothesis to asset returns, coupled with assumption of independence à la Fisher, ensures the hedging effect of stock returns against inflation. In particular it suggests there is a one-to-one positive relationship between expected returns and expected inflation, and it is this relationship that many researchers have sought to confirm.

As mentioned in the introduction, there are many extensions of the "Fisher" hypothesis involving differing relationships between real rates and expected inflation. Mundell (1963) augments the hypothesis by including a negative interaction between the real rate of interest and inflation, while Santomero (1973) augments the hypothesis by including a positive interaction between these two variables. These alternative extensions would naturally influence the null hypothesis that the relationship between nominal rates and inflation is positive and one-for-one. The Mundell extension would imply that β would be less than one, whereas the Santomero extension would imply that β would be greater than one. As illustrated in the introduction, the Choi, Smith and Boyd (1995) model posits a more complicated relationship between real stock returns and inflation: a positive or insignificant relationship for low-average inflation countries, and a negative relationship for high-average inflation countries. Thus, they maintain the hypothesis that the relationship between nominal stock returns and inflation is of a threshold type. Specifically they suggest that once the threshold of γ is reached , β is greater than or equal to one for low-average-inflation countries and β is less than one for high-average-inflation countries.

2.3 A Synopsis of The Economic Theory Behind The Threshold Alternative

Choi, Smith and Boyd (1995) develop a model in which inflation reduces real returns to savings, and by doing so, inflation aggravates an informational friction that hinders the financial market. The informational friction is modelled as an adverse selection problem in capital markets. It is important for the functioning of their model that the strength of the capital market friction be endogenous, and move positively with inflation.

The intuition behind their model is that inflation reduces the real rate of return garnered by savers, and lowers the real rate of interest owed by borrowers. This induces more agents to want to be borrowers, including those who were not getting credit before the shift in inflation. The latter are "lower-quality borrowers" who represent higher default risks. Since investors do not want to lend to these riskier borrowers, to prevent these borrowers from securing external finance, the market rations credit. In turn, this limits the amount of investment capital, inhibits the functioning of credit markets and decreases the level of real activity. An increase in the rate of inflation reduces investor's real rate of returns.

The threshold arises because credit market rationing can be harmless or even helpful at lower rates of inflation. When this is the case, their model can exhibit a "Mundell-Tobin effect" whereby higher inflation leads to higher levels of real activity.

3 Testing for General Nonlinear and Specific Threshold Relationships and Estimating Threshold Models

3.1 The Data

Following Gultiken (1983), who studied the linear null using the broadest base of countries to date, the data come from the CD-ROM version of the

International Financial Statistics (IFS), which is published by the International Monetary Fund. Data are assembled for 39 countries, which are listed in Table 1. Nominal returns are calculated from the stock market indices (exclusive of dividends)[8] as the natural log difference of the indices at time t and $(t-1)$. Similarly, the rate of inflation is calculated from the CPI indices. For two countries, Australia (2) and Ireland (36), the CPI was unavailable on a monthly basis so the Wholesale Price Index (WPI) was analyzed instead. The data were obtained and analyzed both on a quarterly and monthly basis from January (or the first quarter) of 1957 through August (or the third quarter of) 1996.[9] As the results are similar, only monthly results are reported.

3.2 Statistical Tests For Nonlinearities and Threshold Effects

A battery of nine tests is applied to the return series of each of the countries. Each test captures departures from linearity of multifarious form. The following seven statistics are designed to test the null of linearity, $y_t = x_t'\theta + e_t,$ where $x_t = \left(y_{(t-1)}, \ldots, y_{(t-p)}\right)$ against nonlinear alternatives which are not specifically threshold alternatives: the RESET test (Ramsey (1969) and Thursby and Schmidt (1977)), the Keenan (1985) test, the Tsay (1986) test, the McLeod-Li (1983) test, the LM-ARCH test due to Engle (1982), the Neural Network test proposed by Lee *et al.* (1993), and the BDS test (Brock, Dechert and Scheinkman (1986)). The two remaining statistics are instead used to test against particular threshold alternatives: Tsay (1989) and Hansen (1996) F-tests. With the exception of the Hansen (1996), Tsay (1989) and the Neural Network tests, all tests are performed on data which are demeaned and then pre-whitened with an AR filter chosen by minimizing the BIC criterion.

Augmented Dickey Fuller tests are performed on the return series, to

[8] Many of these studies, which test whether or not expected or unexpected inflation can be hedged by holding stock, perform their analysis on indices which do not include dividends. Schwert (1981) states that "it is unlikely that omitting dividends has an important effect on the tests, since firms don't seem to adjust their investment decisions in response to monthly unexpected inflation or deflation." In his study, he replicated his results using the CRSP value-weighted portfolio including dividends, obtaining similar results.

[9] This analysis therefore extends that of Gultiken (1983) by some 17 years and 13 countries.

Country	*Number*	*Country*	*Number*
Argentina	1	Korea	14
Australia	2	Luxembourg	31
Austria	3	Malaysia	15
Belgium	32	Mexico	16
Brazil	33	Netherlands	17
Canada	4	New Zealand*	18
Chile	5	Norway	19
Columbia	34	Pakistan	39
Denmark	6	Peru	20
Finland	7	Phillipines	21
France	8	Portugal	22
Germany	9	South Africa	23
Greece	10	Spain	24
India	30	Sweden	25
Indonesia**	35	Switzerland	26
Ireland	36	Thailand	40
Israel	11	Turkey**	27
Italy	12	United Kingdom	28
Jamaica	37	United States	29
Japan	13	Venezuela	41
Jordan	38	Zimbabwe	42

Table 1: *Country and Country Number Correspondence. *indicates that CPI data was available only on a quarterly basis; **indicates that there were less than 90 observations for that country.*

ensure the stationarity necessary for valid testing of the linear null hypothesis. It should be noted here that there are many studies which suggest that CPI is integrated of order 2, or that inflation has a unit root. None of the studies outlined in the introduction bothered testing the inflation series for a unit root. To remain consistent with earlier studies, it is assumed that inflation is a stationary process. In further support of this stance, there is evidence that inflation is a long memory process that has been misidentified as being a unit root process. ADF tests are not particularly robust to long memory alternatives (Diebold and Rudebusch (1989), Hassler and Wolters (1995)). If it were the case that inflation has long memory and not a unit root, the distributional characteristics of the estimates would still be valid since a long memory process is covariance stationary.[10] Nonetheless, the inflation series should be tested for unit roots and - when and if discovered - the entire analysis should be redone with differenced inflation as the explanatory variable.

The RESET (1977), Keenan (1985), and Tsay (1986) tests are all sensitive to departures from linearity in mean. These tests work as follows. Initially, y_t is regressed on x_t, yielding an estimate of θ, $\widehat{\theta}$, a forecast, $f_t = x_t'\widehat{\theta}$, and estimated residuals of $\widehat{e}_t = y_t - x_t'\widehat{\theta}$. The Keenan test seeks departures of linearity in mean by evaluating the correlation of $\widehat{e}_t$ with f_t^2, to see if the squared forecast has any additional ability to forecast. Tsay's test (1986) is similar to the Keenan test, but augments that test by including cross-product terms of the variables in x_t. The RESET tests generalize the Keenan test by including $k(k+1)/2$ polynomials of the forecast in the initial regression. Issues of collinearity arise in the RESET type tests, and are addressed by using the principal components in extracting the estimated residuals for testing purposes.

The McLeod-Li test is sensitive to ARCH and departures from linearity in mean which appear to have ARCH structure. This test applies a Box-Ljung portmanteau test for serial correlation to the squared estimated residuals from the initial linear regression model. It is based on the idea that for a stationary linear process,

$$corr\left(y_t^2, y_{(t-k)}^2\right) = \left[corr\left(y_t, y_{(t-k)}\right)\right]^2, \forall k. \tag{6}$$

[10]Barnes (1998) discovered that the theoretical relationship which exists between the Geweke Porter-Hudak (1983) estimate of d and the estimate of Lo's (1991) modified Hurst coefficient breaks down when the series being tested is an aggregate, so these studies should be interpreted with some care.

The BDS test captures general stochastic nonlinearity. The test statistic is:

$$BDS = n^{(1/2)} \left[C_m(\varepsilon) - C_1(\varepsilon)^m \right], \tag{7}$$

where

$$\begin{aligned} C_m(\varepsilon) &= n^{-2}[\text{No. of Pairs, } (i,j), \text{ s.t.} \\ |y_i - y_j| &< \varepsilon,\ |y_{i+1} - y_{j+1}| < \varepsilon,\ \ldots,\ |y_{i+m-1} - y_{j+m-1}| < \varepsilon], \end{aligned} \tag{8}$$

where $y_i, \ldots, y_{i+m-1}$ and $y_j, \ldots, y_{j+m-1}$ are segments of the series of length m such that all corresponding pairs of points differ from each other by ε. The Neural Network test captures departures from linearity of general form by testing the null hypothesis against the alternative that $y_t = x_t'\theta + \sum_{j=1}^{q} \beta_j \psi\left(\gamma_j x_t\right) + e_t$. The series is filtered for nonlinearities by using an augmented single hidden layer network as captured by the logistic function, ψ, and random variables drawn from a uniform distribution, γ. To avoid problems of collinearity with x_t, the principal components are used to perform the test. For further exposition of this test see Lee *et al.* (1993).

All of the above tests involve extracting nonlinearity from the return series itself. The next two tests, due to Tsay (1989) and Hansen (1996), test the null against nonlinear alternatives in the form of particular threshold models of the relationship between inflation and returns. For the Tsay (1989) F-test, predictive residuals are obtained from a sequence of arranged regressions. Before the threshold point is reached these predictive residuals are asymptotically white noise and orthogonal to the regressors. Once the threshold is passed, the predictive residual is biased because of the model switch, at which point the predictive residual is a function of the regressors. Thus, the orthogonality between the predictive residuals and the regressors is destroyed as soon as the recursively arranged regression includes observations which occur after the threshold point. To obtain the F-test for threshold nonlinearity, the predictive residuals are regressed on the original regressors. The test is performed for a given d, or delay parameter on the threshold variable, and for a given p, the order of the autoregressive terms specified in the model. Before γ is determined, this test selects an estimate of the delay parameter, d_p, as $\widehat{F}(p, d_p) = \max_{v \in S} \left\{ \widehat{F}(p, v) \right\}$, where $\widehat{F}(p, v)$ is the F-test described above, S is a collection of prespecified delay parameters, and the subscript p on d emphasizes that the delay parameter may be a function of the set of regressors chosen for the model.

Hansen (1996) develops an F-test and heteroskedasticity-consistent LM and Wald tests of the null of linearity against a particular threshold alternative even in the presence of the nuisance parameter γ, the threshold value. The non-standard asymptotic distribution of the test statistic is estimated with a bootstrap procedure. The F-statistic of the linear null against the alternative $H_1 : \beta_1 \neq \beta_2$ is $F_n = \sup_{\gamma \in \Gamma} F_n(\gamma)$, with $\Gamma = \left[\underline{\gamma}, \overline{\gamma}\right]$, where the point-wise F-statistic against the alternative when γ is known is:

$$F_n(\gamma) = n\left(\frac{\widetilde{\sigma}_n^2 - \widehat{\sigma}_n^2(\gamma)}{\widehat{\sigma}_n^2(\gamma)}\right) \tag{9}$$

with $\widetilde{\sigma}_n^2 = \frac{1}{n}\sum_{t=1}^{n}\left(y_t - x_t^{'}\widetilde{\beta}\right)^2$ and $\widetilde{\beta} = \left(\sum_{t=1}^{n} x_t x_t^{'}\right)^{-1}\left(\sum_{t=1}^{n} x_t y_t\right)$. (Due to the nuisance parameter γ, the asymptotic distribution of F_n is not chi-square.)

The bootstrap procedure recommended by Hansen (1996) to approximate the asymptotic distribution is as follows. Let u_t^*, $t = 1, \ldots, n$ be random draws from $i.i.d.N(0,1)$, and let $y_t^* = u_t^*$. Regress y_t^* on x_t and obtain the residual variance, $\widetilde{\sigma}_n^{*2}$. Similarly regress y_t^* on $x_t(\gamma)$ to get the residual variance of $\widehat{\sigma}_n^{*2}(\gamma)$. From this, calculate $F_n^*(\gamma) = n\left(\frac{\widetilde{\sigma}_n^{*2} - \widehat{\sigma}_n^{*2}(\gamma)}{\widehat{\sigma}_n^{*2}(\gamma)}\right)$, and determine $F_n^* = \sup_{\gamma \in \Gamma} F_n^*(\gamma)$. Hansen (1996) proves that the distribution of F_n^* converges weakly to the null distribution of F_n under local alternatives for β^2. In this way, repeated bootstrap draws from F_n^* can be used to approximate the asymptotic null distribution of F_n . Bootstrap p-values are obtained by establishing the percentage of bootstrap samples for which $F_n^* > F_n$. The procedure for the heteroskedasticity-consistent Wald or LM statistic is similar, except that for this test $y_t^* = \widehat{e}_t u_t^*$, where $\widehat{e}_t = y_t - x_t(\widehat{\gamma})^{'}\beta$.

3.3 Estimation of Threshold Models

The estimation methodology used in this study follows Hansen (1996). Equations 1 and 2 can be rewritten as $y_t = x_t(\gamma)^{'}\theta + e_t$, with $\theta = \left(\beta_1^{'}, \beta_2^{'}\right)$. The main parameters to be estimated are θ and γ. Assuming that e_t is distributed as $i.i.d.N(0, \sigma^2)$, least squares is equivalent to maximum likelihood estimation. Thus, Hansen (1996) uses sequential conditional Least Squares (LS) to estimate the parameters. For a given γ, the LS estimate of θ is $\widetilde{\theta} = \left(\sum_{t=1}^{n} x_t(\gamma) x_t^{'}(\gamma)\right)^{-1}\left(\sum_{t=1}^{n} x_t(\gamma) y_t(\gamma)\right)$ with estimated residuals of

$\widehat{e}_t(\gamma) = y_t - x_t(\gamma)' \widehat{\theta}(\gamma)$ and residual variance $\widehat{\sigma}_n^2(\gamma) = \frac{1}{n}\sum_{t=1}^{n} \widehat{e}_t(\gamma)^2$. The LS estimate of γ is $\widehat{\gamma} = \min_{\gamma\in\Gamma} \widehat{\sigma}_n^2(\gamma)$. To obtain an estimate of the delay parameter, the estimation problem is extended to include a search over various values of the delay parameter, as well as over a range of threshold values. The parameter space for the delay parameter is discrete, which implies that the LS estimate of the delay parameter is super-consistent. Thus, in making inference about the other parameters, the delay parameter can be treated as if it were known with certainty. The LS estimates of θ is $\widehat{\theta} = \widehat{\theta}(\gamma)$, with LS residuals of $\widehat{e}_t = y_t - x_t(\widehat{\gamma})' \widehat{\theta}$, and a sampling variance of $\widehat{\sigma}_n^2 = \widehat{\sigma}_n^2(\widehat{\gamma})$.

4 Discussion of The Results

4.1 The Results of The Tests of the Linear Null

Before performing the tests for nonlinearity, the null hypothesis of a unit root was tested and rejected for all countries, using the ADF test. This ensures stationarity of the return series, a condition which must be satisfied for the linearity tests to be valid. Where required, return series were de-meaned and pre-whitened with an $AR(p)$ filter chosen by minimizing the BIC criteria before the linearity tests were applied to the time series. In general, there is a lot of evidence of nonlinearities, both of an unspecified type (general nonlinearity in mean or variance and apparent $ARCH$ in variance), and of the threshold type.

The RESET test developed by Thursby and Schmidt (1977), RESET2B, rejects the linear null for 30 of the 39 countries (77%) at the 10% level of significance.[11] All 39 countries discussed had at least 90 monthly observations.[12] The other two RESET tests performed yield similar results and are not reported for brevity's sake. The parameter values used for the RESET-type tests are $(k-1) > P^* = 1$ (which specifies that only the first largest principal component after the initial principal component is used), and $2 \leq k = 5$ (which implies that the polynomials of the predicted forecast used as regressors in the test are of order two through five), as per Lee *et al.* (1993). Similarly, the Tsay (1986) test detects departures from linearity in mean in

[11] The nine exceptions were Argentina (1), Canada (4), India (30), Jordan (38), Korea (14), Luxembourg (31), South Africa (23), Spain (24), and Switzerland (26).

[12] The countries for which results are provided but not discussed are Indonesia (35) and Turkey (27) because they had less than 80 observations.

77% of the cases.[13] Again following Lee *et al.* (1993), the number of cross-product terms used as regressors in this test are $5\,(5+1)\,/2$. The Keenan test, however, which is a special case of Tsay (1986) with $k = 2$, suggests that the null of linearity can be rejected in only 5 of 39 countries at the 10% level of significance.[14] Apparently there are higher order dependencies which the Keenan test is not detecting. (These three statistics and their associated p-values are reported in Tables 2 and 3. The order of the autoregressive pre-whitening filter is also detailed in the table.)

The McLeod-Li test not only checks for departures in linearity in mean, it can also check for nonlinearities in variance such as those caused by $ARCH$ effects. The $ARCH-LM$ test looks specifically for this effect in the variance. In 25 of 39 countries, the McLeod-Li test rejects the linear null at the 10% level of significance.[15] The $ARCH-LM$ test rejects slightly more frequently: 27 of the 39 countries appear to have $ARCH$ effects in the return series.[16] The McLeod-Li test indicates that there are nonlinearities apparent both in mean and in variance. The McLeod-Li test has 20 degrees of freedom, as in Lee *et al.* (1993). (These test statistics and their p-values are in Tables 4 and 5.)

The BDS test, which tests for general stochastic nonlinearities, and its associated p-values are given in Tables 6 and 7. This test was developed while its creators were working on tests for chaos, so it was developed from a different perspective. Nonetheless, it yields very strong evidence of nonlinearities for the present sample: 37 of the 39 countries can reject the null of linearity using this test with $m = 5$. The two exceptions are Chile (5) and Jordan (38). For the BDS test, $\varepsilon =$ (standard deviation of the pre-whitened series), and $2 \leq m \leq 5$.

The results of the Neural-Network test are also in Tables 6 and 7. Using the Hochberg (1988) modification of the Bonferroni inequality to provide an

[13] For this test the nine exceptions were France (8), Jordan (38), Korea (14), Luxembourg (31), Malaysia (15), The Netherlands (17), Portugal (22), Switzerland (26), and Thailand (40).

[14] The five countries for which the null can be rejected are Austria (3), Columbia (34), Denmark (6), Israel (11), and Pakistan (39).

[15] The 14 countries for which the null can not be rejected are Belgium (32), Canada (4), India (30), Korea (14), Luxembourg (31), Malaysia (15), Mexico (16), Netherlands (17), Pakistan (39), Philippines (21), South Africa (23), Switzerland (26), and Thailand (40).

[16] The 12 countries for which the null can not be rejected are Belgium (32), Canada (4), India (30), Jordan (38), Korea (14), Luxembourg (31), Malaysia (15), Pakistan (39), South Africa (23), Switzerland (26), Venezuela (41) and Zimbabwe (42).

Cntry	*P*	*RESET2B*	*P-val.*	*Tsay(86)*	*P-val.*	*Keenan*	*P-val.*
1	2	2.382	0.124	1.800	0.037	1.856	0.175
2	1	35.090	0.000	2.459	0.002	0.049	0.824
3	1	8.954	0.003	2.357	0.003	18.250	0.000
32	1	2.715	0.100	2.256	0.005	0.108	0.743
33	2	6.926	0.009	1.588	0.080	0.514	0.474
4	1	1.460	0.228	2.552	0.001	0.279	0.598
5	14	10.100	0.002	2.045	0.013	0.254	0.615
34	1	11.900	0.001	5.449	0.000	4.357	0.037
6	1	3.334	0.069	6.742	0.000	3.110	0.079
7	1	3.291	0.070	1.819	0.030	0.000	0.986
8	1	30.370	0.000	1.405	0.140	0.302	0.583
9	1	10.270	0.001	2.881	0.000	0.871	0.351
10	1	39.810	0.000	4.481	0.000	0.651	0.421
30	1	0.184	0.668	2.360	0.003	2.379	0.124
35*	1	0.203	0.655	0.645	0.811	0.066	0.799
36	1	4.677	0.031	1.742	0.041	0.853	0.356
11	2	3.400	0.066	2.904	0.000	3.914	0.048
12	1	39.090	0.000	5.181	0.000	0.516	0.473
37	1	38.530	0.000	1.914	0.022	1.522	0.218
13	1	39.060	0.000	5.687	0.000	1.228	0.269
38	3	0.564	0.454	1.166	0.303	0.067	0.797
14	1	0.290	0.591	0.735	0.748	0.749	0.388

Table 2: *Tests of Linear Null against Nonlinear Alternatives on the Return Series: Reset, Tsay (1986) and Keenan Tests. P is the order of the autoregressive prewhitening filter. * Indicates Country has Less than 90 Observations. (Table contents for the balance of the countries are in the next table).*

Cntry	*P*	*RESET2B*	*P-val.*	*Tsay(86)*	*P-val.*	*Keenan*	*P-val.*
31	1	0.386	0.535	1.407	0.148	0.035	0.853
15	1	6.456	0.013	0.932	0.533	0.437	0.510
16	2	8.471	0.004	2.265	0.007	0.845	0.360
17	1	4.420	0.036	0.735	0.749	2.693	0.102
19	5	97.180	0.000	6.282	0.000	0.193	0.660
39	1	6.185	0.013	1.906	0.021	4.495	0.035
20	2	9.782	0.002	2.552	0.004	0.592	0.444
21	4	13.700	0.000	2.820	0.000	0.181	0.671
22	1	4.571	0.035	0.538	0.911	0.038	0.846
23	1	1.004	0.317	1.691	0.050	0.016	0.901
24	1	0.491	0.484	2.111	0.009	2.276	0.132
25	4	13.890	0.000	6.732	0.000	1.729	0.189
26	2	0.146	0.702	1.442	0.124	2.000	0.158
40	1	10.630	0.001	1.205	0.271	0.014	0.907
27*	1	0.001	0.971	0.506	0.928	2.002	0.162
28	1	4.848	0.028	2.407	0.002	1.368	0.243
29	1	3.483	0.063	2.968	0.000	0.531	0.467
41	1	8.666	0.003	2.999	0.000	0.000	0.988
42	3	6.615	0.011	2.167	0.009	1.242	0.267

Table 3: *Tests of Linear Null against Nonlinear Alternatives on the Return Series: Reset, Tsay (1986) and Keenan Tests. P is the order of the autoregressive prewhitening filter. * Indicates Country has Less than 90 Observations. (cont.)*

Cntry	*OBS*	*P*	*ML*	*P-val.*	*LM*	*P-val.*
1	211	2	63.440	0.000	18.000	0.000
2	474	1	65.010	0.000	17.620	0.000
3	475	1	54.570	0.000	9.512	0.002
32	473	1	22.890	0.294	0.667	0.414
33	215	2	68.040	0.000	17.780	0.000
4	475	1	18.360	0.564	0.408	0.523
5	269	14	31.090	0.054	144.900	0.000
34	446	1	30.480	0.062	8.473	0.004
6	355	1	117.600	0.000	46.780	0.000
7	475	1	189.400	0.000	17.150	0.000
8	476	1	63.390	0.000	52.930	0.000
9	461	1	57.540	0.000	13.850	0.000
10	279	1	114.600	0.000	85.790	0.000
30	472	1	1.103	1.000	0.329	0.566
35	47	1	15.870	0.725	0.002	0.969
36	467	1	36.510	0.013	16.230	0.000
11	473	2	71.400	0.000	28.290	0.000
12	473	1	104.300	0.000	75.270	0.000
37	317	1	121.100	0.000	31.900	0.000
13	473	1	135.000	0.000	83.410	0.000
38	190	3	33.640	0.029	0.854	0.837
14	222	1	2.795	1.000	0.063	0.802

Table 4: *Tests of Linear Null Against Nonlinear Alternatives on the Return Series. McLeod-Li Test (ML) with 20 degrees of freedom, and ARCH-LM Test (LM). (Table contents for the balance of the countries are in the next table).*

Cntry	*OBS*	*P*	*ML*	*P-val.*	*LM*	*P-val.*
31	198	1	6.154	0.999	0.098	0.755
15	107	1	5.652	0.999	0.580	0.447
16	149	2	22.520	0.313	35.770	0.000
17	475	1	27.370	0.125	24.240	0.000
19	474	5	142.100	0.000	201.800	0.000
39	418	1	0.473	1.000	0.002	0.965
20	92	2	40.740	0.004	16.510	0.000
21	446	4	4.299	1.000	8.763	0.067
22	101	1	32.630	0.037	4.199	0.040
23	474	1	0.616	1.000	0.000	0.995
24	427	1	32.810	0.035	5.864	0.015
25	468	4	287.000	0.000	52.010	0.000
26	476	2	18.650	0.545	4.507	0.105
40	215	1	13.780	0.842	5.818	0.016
27	83	20	2.610	1.000	0.055	0.814
28	464	1	65.910	0.000	15.900	0.000
29	476	1	34.810	0.021	33.730	0.000
41	475	1	56.220	0.000	0.133	0.716
42	190	3	30.900	0.057	3.626	0.305

Table 5: *Tests of Linear Null Against Nonlinear Alternatives on the Return Series. McLeod-Li Test (ML) with 20 degrees of freedom, and ARCH-LM Test (LM). (cont.)*

Cntry	*BDS2*	*P-val.*	*BDS5*	*P-val*	*Bonferroni*	*Hochberg*
1	2.094	0.036	2.768	0.006	0.373	0.299
2	4.571	0.000	8.094	0.000	0.002	0.001
3	6.998	0.000	10.650	0.000	0.040	0.008
32	2.384	0.017	5.285	0.000	0.044	0.010
33	0.727	0.467	4.237	0.000	0.081	0.016
4	2.637	0.008	4.120	0.000	4.082	0.837
5	0.483	0.629	1.078	0.281	0.005	0.002
34	7.210	0.000	11.650	0.000	0.041	0.016
6	6.916	0.000	6.690	0.000	0.000	0.000
7	3.046	0.002	6.694	0.000	2.408	0.652
8	3.490	0.000	4.937	0.000	0.000	0.000
9	2.302	0.021	3.686	0.000	0.005	0.001
10	6.368	0.000	9.015	0.000	0.002	0.000
30	6.635	0.000	8.731	0.000	0.168	0.035
35	-1.555	0.120	-1.161	0.246	2.182	0.450
36	3.105	0.002	8.201	0.000	0.144	0.030
11	7.297	0.000	9.440	0.000	0.185	0.074
12	3.995	0.000	7.228	0.000	0.000	0.000

Table 6: *Tests of Linear Null Against Nonlinear Alternatives on the Return Series. BDS2 is BDS with m=2, BDS5 is BDS with m=5, Bonferroni is the Bonferroi Inequality and Hochberg is the Hochberg Modification of the Bonferroni Upper Bound, Calculated From 5 Random Draws. (Table contents for the balance of the countries are in the next table).*

Cntry	*BDS2*	*P-val.*	*BDS5*	*P-val*	*Bonferroni*	*Hochberg*
37	5.798	0.000	9.014	0.000	0.000	0.000
13	6.463	0.000	8.172	0.000	0.000	0.000
38	1.189	0.234	1.518	0.129	2.353	0.945
14	1.649	0.099	4.353	0.000	0.583	0.119
31	4.235	0.000	3.521	0.000	0.992	0.202
15	1.464	0.143	1.846	0.065	0.105	0.021
16	1.088	0.277	3.240	0.001	0.003	0.002
17	2.427	0.015	3.926	0.000	0.426	0.088
19	10.760	0.000	13.880	0.000	0.002	0.001
39	4.891	0.000	7.903	0.000	0.042	0.008
20	5.005	0.000	3.826	0.000	0.001	0.000
21	7.107	0.000	11.910	0.000	0.117	0.093
22	3.153	0.002	2.501	0.012	0.194	0.041
23	2.435	0.015	3.328	0.001	0.095	0.019
24	2.686	0.007	7.521	0.000	2.199	0.448
25	4.527	0.000	6.181	0.000	0.000	0.000
26	2.008	0.045	3.002	0.003	3.086	0.620
40	3.787	0.000	7.335	0.000	0.006	0.001
27	-1.353	0.176	-1.635	0.102	4.912	0.982
28	3.744	0.000	4.601	0.000	0.204	0.045
29	2.148	0.032	2.090	0.037	0.653	0.300
41	10.930	0.000	15.920	0.000	0.012	0.004
42	2.016	0.044	2.651	0.008	0.034	0.034

Table 7: *Tests of Linear Null Against Nonlinear Alternatives on the Return Series. BDS2 is BDS with m=2, BDS5 is BDS with m=5, Bonferroni is the Bonferroi Inequality and Hochberg is the Hochberg Modification of the Bonferroni Upper Bound, Calculated From 5 Random Draws. (cont.)*

upper-bound on the p-value for the five different random draws from the uniform distribution in computing this statistic, the null is rejected in 30 out of 39 countries.[17] Two principal components are used ($P^* = 2$). This procedure is described in more detail in Lee, *et al.* (1993). In general, then, there is a fair amount of evidence available to support the claim that many of the return series exhibit nonlinearities of a generic form. This is not a surprise given the extensive literature on $GARCH$ and the long memory characteristics of the volatility of return series. If there was little or no evidence of nonlinearities, there would not be much point in further pursuit of the exercize at hand.

The last two tests to be discussed are those which have a particular threshold model alternative to the null of linearity. Thus, rejection of the null in favor of the alternative for these two tests, Tsay (1989) and Hansen (1996), suggests the presence of a threshold effect. The Tsay (1989) test rejects the null in 35 of 39 countries (90%).[18] With the Hansen (1996) test, the rejection rate is somewhat lower: the null is rejected in 29 of the 39 countries (74%).[19][20]

The specific alternative threshold models posited in these tests are identical in every aspect except the delay parameter, d. That is to say they each specify two regimes for which the parameters to be estimated could differ across regimes once the threshold variable reaches a certain value, as outlined in Equations 1 and 2 above, and all of them regress a constant and inflation on nominal returns. The only thing which changes over all of the alternative threshold models considered for a given country is the delay parameter of the threshold variable, inflation. All tests are performed for thirteen different delay parameter values, $d = 0, \ldots, 12$. There appears to be more evidence of this particular form of nonlinearity, a threshold nonlinearity, than there is of

[17] The nine countries for which the null could not be rejected are Argentina (1), Canada (4), Finland (7), Jordan (38), Korea (14), Luxembourg (31), Spain (24), Switzerland (26), and USA (29).

[18] The four countries for which the null is not rejected are Canada (4), India (30), Jordan (38), and the USA (29).

[19] The countries for which the null is not rejected are Austria (3), Canada (4), India (30), Malaysia (15), Mexico (16), Norway (19), Pakistan (39), South Africa (23), Sweden (25), and Zimbabwe (42).

[20] The Tsay (1989) test is designed to begin the recursive arranged regressions with exactly 20 observations to start off with, whereas the Hansen (1996) test is designed to start with at least 20 such observations. Thus, the delay parameters are not surprisingly different across the two tests.

the more general type of nonlinearity discussed above. These results can be found in Tables 8 and 9. Since there is evidence of thresholds, it is of interest to explore what characteristics the estimated threshold models have.

4.2 The Results of The Threshold Alternative Model Estimation

For purposes of determining whether there is an asymmetric threshold relationship between nominal returns and inflation for low-average-inflation countries and high-average-inflation countries, the group of countries is divided into two sub-groups on the basis of their average inflation rate. If their average inflation rate lies below the median average-inflation rate across countries, the country is placed in the "low-average-inflation" category. If it is above the median, it is placed in the "medium/high-average-inflation" category. The median average-inflation value across countries is 0.006 (0.6% per month), while the average average-inflation value across the 39 different countries is 0.012 (1.2% per month).

Some broad patterns emerge from the estimated linear and threshold models when the estimation results in Tables 10, 11, 12, 13, 14, and 15 are approached from this perspective. Of the 20 high-average-inflation countries, 13 tend to experience a positive, or more positive relationship, between inflation and nominal returns once the threshold variable reaches the threshold (which is 1.5% per month on average across these countries). For 7 countries, the reverse holds, although for 4 of the 7 there is a significantly positive or insignificant relationship in the linear specification, the relationship before and after the threshold is insignificant. Tables 16 and 17 highlight the relationship between inflation and nominal returns before and after the threshold for countries classified according to their average rates of inflation.

This is in contrast to most of the literature on the linear relationship between inflation and nominal returns. As noted in the introduction, most studies have found negative or insignificant linear relationships between these two variables of interest. The one exception would be Gultiken (1983), who found with the same data source and model specification (though over a different sample period) that only Israel (11) and the UK (29) of the 26 countries he studied had statistically significant positive coefficients on inflation. In using more countries over a longer period of time, the current study recognizes that most of the countries which exhibit a positive or insignificant,

Cntry	*Tsay-d*	*Tsay(89)*	*P-val.*	*Wald-d*	*Wald*	*P-val.*
1	6	4.361	0.005	6	10.207	0.038
2	11	2.939	0.054	10	14.307	0.004
3	6	6.109	0.002	7	6.571	0.232
32	4	4.090	0.017	2	8.278	0.099
33	1	3.848	0.011	3	12.854	0.009
4	8	2.264	0.105	3	7.046	0.206
5	4	4.049	0.000	10	12.137	0.012
34	10	3.910	0.021	8	14.911	0.000
6	2	5.815	0.003	10	11.072	0.007
7	7	7.811	0.000	7	20.716	0.000
8	12	5.026	0.007	12	12.344	0.015
9	7	12.240	0.000	12	11.272	0.029
10	4	8.970	0.000	7	13.479	0.002
30	4	2.183	0.114	0	7.119	0.163
35	2	4.769	0.019	11	4.743	0.180
36	12	5.708	0.004	9	12.354	0.012
11	11	3.386	0.018	11	16.176	0.002
12	5	5.173	0.006	12	11.033	0.034
37	4	4.501	0.012	6	18.774	0.000
13	6	37.610	0.000	6	11.226	0.025
38	2	1.912	0.111	2	11.737	0.011

Table 8: *Tests of Linear Null Against TAR. Tsay-d d Chosen by Tsay(89). Tsay(89) is F-test. Wald-d d Chosen by Chosing Specification which Gives the Minimum SSE. Set of Thresholds to Search Over Trimmed from Above and Below by 15% or Such That Each Regime Has At Least 20 Obs ofr The Wald Test. (Table contents for the balance of the countries are in the next table).*

Cntry	*Tsay-d*	*Tsay(89)*	*P-val.*	*Wald-d*	*Wald*	*P-val.*
14	8	3.234	0.042	5	10.027	0.027
31	6	7.995	0.000	3	10.888	0.015
15	7	6.686	0.002	12	6.869	0.129
16	1	3.194	0.026	2	6.142	0.207
17	2	6.843	0.001	2	13.448	0.003
19	6	6.943	0.000	3	6.681	0.158
39	8	2.348	0.097	2	4.254	0.577
20	11	2.407	0.076	9	8.092	0.061
21	12	3.618	0.003	3	11.482	0.023
22	4	4.334	0.017	6	11.185	0.006
23	9	5.672	0.004	11	2.252	0.882
24	9	9.255	0.000	11	11.497	0.020
25	12	4.003	0.001	5	4.039	0.517
26	10	6.417	0.000	9	9.060	0.071
40	8	8.104	0.000	12	9.195	0.053
27	8	6.129	0.004	12	5.003	0.302
28	12	5.176	0.006	12	18.106	0.001
29	9	2.034	0.132	4	9.036	0.068
41	8	5.020	0.007	12	8.774	0.047
42	12	3.237	0.014	10	7.704	0.125

Table 9: *Tests of Linear Null Against TAR. Tsay-d d Chosen by Tsay(89). Tsay(89) is F-test. Wald-d d Chosen by Chosing Specification which Gives the Minimum SSE. Set of Thresholds to Search Over Trimmed from Above and Below by 15% or Such That Each Regime Has At Least 20 Obs ofr The Wald Test. (cont.)*

Cntry	*Regime*	*Const.*	*T-stat.*	*Inflat.*	*T-stat.*	R^2/*Joint*	$\widehat{Thresh.}$
1	*Linear*	0.042	1.204	0.643	1.686	0.066	0.079
1	*1*	-0.062	-3.194	1.682	9.243	0.238	(0.000
1	*2*	0.179	4.067	-0.007	-0.022	0.238	1.087)
2	*Linear*	0.006	3.024	-0.090	-0.344	0.000	0.010
2	*1*	0.006	2.715	-0.699	-2.979	0.055	-(0.045
2	*2*	0.004	0.740	2.332	3.927	0.055	0.038)
3	*Linear*	0.005	1.944	0.044	0.161	0.000	0.007
3	*1*	0.001	0.466	0.257	0.855	0.018	-(0.027
3	*2*	0.018	3.034	-0.761	-1.287	0.018	0.051)
32	*Linear*	0.003	1.168	-0.056	-0.081	0.000	0.007
32	*1*	0.002	0.606	1.284	1.819	0.032	-(0.012
32	*2*	0.002	0.306	-1.910	-1.372	0.032	0.016)
33	*Linear*	0.062	2.660	2.096	2.775	0.034	0.012
33	*1*	-0.015	-0.344	1.005	0.622	0.081	(0.004
33	*2*	0.099	3.753	1.431	1.800	0.081	0.082)
4	*Linear*	0.007	3.094	-0.524	-1.102	0.002	0.005
4	*1*	0.008	3.582	0.455	0.766	0.021	-(0.007
4	*2*	0.000	-0.062	-0.468	-0.623	0.021	0.025)
5	*Linear*	0.022	3.114	0.751	2.290	0.062	0.037
5	*1*	0.018	2.295	0.438	0.983	0.136	-(0.008
5	*2*	0.113	4.239	-0.045	-0.116	0.136	0.192)

Table 10: *Estimation Results For the Linear Null and the Particular TAR Alternative. (Table contents for the balance of the countries are in the next tables).*

Cntry	*Regime*	*Const.*	*T-stat.*	*Inflat.*	*T-stat.*	R^2*/Joint*	$\widehat{Thresh.}$
34	*Linear*	0.008	2.257	0.240	1.412	0.002	0.011
34	*1*	0.002	0.618	-0.269	-1.490	0.028	-(0.060
34	*2*	0.010	1.854	0.546	2.154	0.028	0.078)
6	*Linear*	0.016	2.379	-1.391	-2.118	0.006	0.003
6	*1*	-0.006	-0.618	-2.146	-1.395	0.039	-(0.026
6	*2*	0.032	3.678	-1.550	-2.056	0.039	0.059)
7	*Linear*	0.009	3.102	0.015	0.049	0.000	0.010
7	*1*	0.008	2.588	0.623	1.928	0.028	-(0.068
7	*2*	0.012	2.186	-1.862	-4.043	0.028	0.088)
8	*Linear*	0.003	0.860	0.347	0.421	0.001	0.009
8	*1*	0.011	2.824	-2.106	-2.526	0.055	-(0.011
8	*2*	-0.027	-2.393	5.230	3.779	0.055	0.040)
9	*Linear*	0.007	2.121	-0.527	-0.725	0.002	0.006
9	*1*	0.005	1.443	-1.264	-1.484	0.031	-(0.012
9	*2*	0.024	2.331	-0.899	-0.553	0.031	0.018)
10	*Linear*	0.008	1.312	-0.223	-0.712	0.002	0.014
10	*1*	0.027	2.967	-0.446	-1.143	0.051	-(0.019
10	*2*	-0.013	-1.759	0.120	0.248	0.051	0.058)
30	*Linear*	0.005	1.823	0.022	0.127	0.000	0.009
30	*1*	0.001	0.160	-0.812	-1.714	0.019	-(0.029
30	*2*	0.025	2.684	-0.738	-1.363	0.019	0.042)

Table 11: *Estimation Results For the Linear Null and the Particular TAR Alternative. (Table contents for the balance of the countries are in the next tables).*

Cntry	*Regime*	*Const.*	*T-stat.*	*Inflat.*	*T-stat.*	R^2*/Joint*	$\widehat{Thresh.}$
35	*Linear*	0.009	0.385	-2.494	-1.056	0.025	0.003
35	*1*	0.085	1.754	-7.374	-1.650	0.191	-(0.004
35	*2*	-0.023	-0.863	-1.588	-0.551	0.191	0.022)
36	*Linear*	0.006	2.127	0.504	1.653	0.008	0.001
36	*1*	0.014	3.754	0.902	2.306	0.032	-(0.025
36	*2*	-0.001	-0.354	0.579	1.384	0.032	0.055)
11	*Linear*	0.008	2.195	0.745	5.442	0.140	0.020
11	*1*	0.005	1.167	0.369	1.626	0.171	-(0.049
11	*2*	0.034	3.859	0.546	3.090	0.171	0.243)
12	*Linear*	0.004	1.169	0.124	0.246	0.000	0.011
12	*1*	0.009	2.414	-1.020	-1.763	0.027	-(0.014
12	*2*	-0.024	-1.774	3.121	3.372	0.027	0.031)
37	*Linear*	0.017	2.944	-0.023	-0.085	0.000	0.024
37	*1*	0.014	2.343	-0.629	-2.291	0.095	-(0.008
37	*2*	0.060	3.671	0.071	0.137	0.095	0.126)
13	*Linear*	0.009	4.275	-0.282	-0.897	0.002	0.002
13	*1*	0.010	3.496	1.197	2.540	0.033	-(0.016
13	*2*	0.008	2.670	-0.753	-1.933	0.033	0.040)
38	*Linear*	0.007	2.108	0.380	1.449	0.018	0.001
38	*1*	-0.007	-1.470	0.267	0.377	0.077	-(0.066
38	*2*	0.016	3.573	0.368	1.578	0.077	0.072)

Table 12: *Estimation Results For the Linear Null and the Particular TAR Alternative. (Table contents for the balance of the countries are in the next tables).*

Cntry	*Regime*	*Const.*	*T-stat.*	*Inflat.*	*T-stat.*	R^2*/Joint*	$\widehat{Thresh.}$
14	*Linear*	0.015	2.453	-1.150	-1.107	0.021	0.006
14	*1*	0.030	3.428	-3.456	-1.572	0.103	-(0.009
14	*2*	-0.010	-1.335	1.040	2.624	0.103	0.043)
31	*Linear*	0.011	2.044	-1.274	-1.112	0.006	0.005
31	*1*	0.006	1.007	1.486	1.353	0.080	-(0.005
31	*2*	0.047	3.263	-8.828	-3.818	0.080	0.015)
15	*Linear*	-0.003	-0.188	5.360	1.569	0.052	0.002
15	*1*	-0.028	-1.620	13.589	2.641	0.193	-(0.007
15	*2*	0.037	3.106	-3.122	-1.356	0.193	0.009)
16	*Linear*	0.020	1.409	1.020	1.617	0.043	0.010
16	*1*	0.054	2.631	-6.288	-4.012	0.126	(0.004
16	*2*	0.042	2.210	0.781	1.114	0.126	0.144)
17	*Linear*	0.006	2.915	-0.030	-0.106	0.000	0.002
17	*1*	0.012	4.611	0.176	0.496	0.028	-(0.030
17	*2*	0.001	0.356	-0.319	-0.613	0.028	0.045)
19	*Linear*	0.003	0.397	0.544	0.653	0.001	0.009
19	*1*	0.012	1.562	0.163	0.220	0.024	-(0.015
19	*2*	-0.064	-1.632	5.464	1.202	0.024	0.059)
39	*Linear*	0.003	0.809	-0.043	-0.274	0.000	0.013
39	*1*	0.006	2.612	0.115	0.526	0.014	-(0.035
39	*2*	-0.011	-0.778	-0.016	-0.048	0.014	0.082)

Table 13: *Estimation Results For the Linear Null and the Particular TAR Alternative. (Table contents for the balance of the countries are in the next tables).*

Cntry	*Regime*	*Const.*	*T-stat.*	*Inflat.*	*T-stat.*	R^2/*Joint*	$\widehat{Thresh.}$
20	*Linear*	0.056	2.598	0.617	4.906	0.278	0.031
20	*1*	0.024	0.866	-1.778	-1.091	0.339	(0.003
20	*2*	0.114	3.192	0.527	5.861	0.339	1.603)
21	*Linear*	0.005	1.126	-0.021	-0.096	0.000	0.006
21	*1*	0.017	2.553	0.307	1.336	0.025	-(0.039
21	*2*	-0.007	-0.980	-0.158	-0.407	0.025	0.086)
22	*Linear*	0.003	0.328	0.210	0.145	0.000	0.009
22	*1*	0.020	1.937	-1.794	-1.282	0.093	-(0.002
22	*2*	-0.040	-2.832	3.731	1.580	0.093	0.023)
23	*Linear*	0.010	2.237	-0.453	-0.641	0.003	0.013
23	*1*	0.007	1.910	-0.006	-0.016	0.041	-(0.067
23	*2*	0.065	1.161	-6.138	-0.915	0.041	0.087)
24	*Linear*	0.008	2.915	-0.339	-2.480	0.009	0.008
24	*1*	0.010	2.747	-0.133	-1.349	0.034	-(0.161
24	*2*	0.017	2.976	-1.750	-3.902	0.034	0.188)
25	*Linear*	0.004	0.575	1.022	0.959	0.003	0.009
25	*1*	0.002	0.401	0.008	0.009	0.027	(0.009
25	*2*	0.013	0.605	5.732	1.729	0.027	0.009)
26	*Linear*	0.007	2.931	-1.038	-1.692	0.008	0.004
26	*1*	0.005	1.579	0.595	0.810	0.038	-(0.009
26	*2*	0.013	2.699	-3.309	-3.007	0.038	0.022)

Table 14: *Estimation Results For the Linear Null and the Particular TAR Alternative. (Table contents for the balance of the countries are in the next tables).*

Cntry	*Regime*	*Const.*	*T-stat.*	*Inflat.*	*T-stat.*	R^2/*Joint*	$\widehat{Thresh.}$
40	*Linear*	0.009	1.352	-0.073	-0.104	0.000	0.008
40	*1*	0.015	2.053	0.666	0.664	0.041	-(0.016
40	*2*	-0.019	-1.588	0.191	0.222	0.041	0.036)
27	*Linear*	0.094	1.592	-1.178	-1.150	0.024	0.029
27	*1*	-0.013	-0.298	0.621	1.112	0.147	-(0.009
27	*2*	0.270	2.482	-4.984	-2.422	0.147	0.106)
28	*Linear*	0.006	2.741	0.201	0.656	0.001	0.008
28	*1*	0.004	1.629	-0.722	-3.017	0.058	(0.008
28	*2*	0.014	2.654	0.832	1.544	0.058	0.008)
29	*Linear*	0.013	5.564	-1.741	-3.258	0.030	0.005
29	*1*	0.010	4.305	-1.643	-2.598	0.054	-(0.005
29	*2*	0.032	4.553	-3.610	-3.424	0.054	0.018)
41	*Linear*	0.003	0.777	0.287	1.210	0.004	0.022
41	*1*	0.000	0.162	-0.401	-1.291	0.041	(0.022
41	*2*	0.021	1.128	0.575	1.234	0.041	0.022)
42	*Linear*	0.022	2.284	-0.471	-1.041	0.007	0.017
42	*1*	0.008	0.730	0.217	0.736	0.067	-(0.017
42	*2*	0.068	3.824	-2.797	-3.553	0.067	0.145)

Table 15: *Estimation Results For the Linear Null and the Particular TAR Alternative. (cont.)*

Cntry	$\widehat{Thresh.}$	*Avg.* π	↑/↓	π*-Linear*	π*-Reg. 1*	π*-Reg. 2*	$\widehat{d}$
1	0.079	0.062	↑	0.643*	1.682***	-0.007	6
2	0.010	0.004	↓	-0.090	-0.699***	2.332***	10
3	0.007	0.003	↓	0.044	0.257	-0.761	7
32	0.007	0.003	↓	-0.056	1.284*	-1.910	2
33	0.012	0.071	↑	2.096***	1.005	1.431*	3
4	0.005	0.004	↓	-0.524	0.455	-0.468	3
5	0.037	0.030	↑	0.751**	0.438	-0.045	10
34	0.011	0.014	↑	0.240	-0.269	0.546**	8
6	0.003	0.005	↓	-1.391**	-2.146	-1.550**	10
7	0.010	0.005	↓	0.015	0.623*	-1.862***	7
8	0.009	0.005	↓	0.347	-2.106**	5.230***	12
9	0.006	0.003	↓	-0.527	-1.264	-0.899	12
10	0.014	0.009	↑	-0.223	-0.446	0.120	7
30	0.009	0.006	=	0.022	-0.812*	-0.738	0
35	0.003	0.010	↑	-2.494	-7.374*	-1.588	11
36	0.001	0.005	↓	0.504*	0.902**	0.579	9
11	0.020	0.024	↑	0.745***	0.369	0.546***	11
12	0.011	0.006	=	0.124	-1.020*	3.121***	12

Table 16: *Tabulation of the Avg. Inflation Each Country, Avg. is Above, Below, or Equal to the Median Monthly Inflation Rate Across Countries, Assoc. Threshold Estimate and Estimated Delay Param., d, and Estimates of Coefficients on PI for Null and the Threshold Alternative. *** Indicates Significance at the 1% Level, ** Indicates Significance at the 5% Level, and * Indicates Significance at the 10% Level. (Table contents for the balance of the countries are in the next tables).*

Cntry	$\widehat{Thresh.}$	*Avg.* π	$\uparrow/\downarrow$	π*-Linear*	π*-Reg. 1*	π*-Reg. 2*	$\widehat{d}$
37	0.024	0.012	$\uparrow$	-0.023	-0.629**	0.071	6
13	0.002	0.004	$\downarrow$	-0.282	1.197**	-0.753*	6
38	0.001	0.006	=	0.380	0.267	0.368	2
14	0.006	0.008	$\uparrow$	-1.150	-3.456	1.040***	5
31	0.005	0.003	$\downarrow$	-1.274	1.486	-8.828***	3
15	0.002	0.003	$\downarrow$	5.360	13.589***	-3.122	12
16	0.010	0.017	$\uparrow$	1.020	-6.288***	0.781	2
17	0.002	0.003	$\downarrow$	-0.030	0.176	-0.319	2
19	0.009	0.005	$\downarrow$	0.544	0.163	5.464	3
39	0.013	0.006	=	-0.043	0.115	-0.016	2
20	0.031	0.045	$\uparrow$	0.617***	-1.778	0.527***	9
21	0.006	0.008	$\uparrow$	-0.021	0.307	-0.158	3
22	0.009	0.009	$\uparrow$	0.210	-1.794	3.731	6
23	0.013	0.007	$\uparrow$	-0.453	-0.006	-6.138	11
24	0.008	0.007	$\uparrow$	-0.339**	-0.133	-1.750***	11
25	0.009	0.005	$\downarrow$	1.022	0.008	5.732*	5
26	0.004	0.003	$\downarrow$	-1.038*	0.595	-3.309***	9
40	0.008	0.005	$\downarrow$	-0.073	0.666	0.191	12
27	0.029	0.031	$\uparrow$	-1.178	0.621	-4.984**	12
28	0.029	0.005	$\downarrow$	0.201	-0.722***	0.832	12
29	0.005	0.004	$\downarrow$	-1.741***	-1.643***	-3.610***	4
41	0.022	0.012	$\uparrow$	0.287	-0.401	0.575	12
42	0.017	0.013	$\uparrow$	-0.471	0.217	-2.797***	10

Table 17: *Tabulation of the Avg. Inflation Each Country, Avg. is Above, Below, or Equal to the Median Monthly Inflation Rate Across Countries, Assoc. Threshold Estimate and Estimated Delay Param., d, and Estimates of Coefficients on PI for Null and the Threshold Alternative. *** Indicates Significance at the 1% Level, ** Indicates Significance at the 5% Level, and * Indicates Significance at the 10% Level. (cont.).*

as opposed to negative, relationship between inflation and nominal returns in a linear specification are of medium to high-average inflation countries.

The results of the threshold estimation suggest that for countries whose average-rate of inflation is above the median average-inflation value across countries, after the threshold inflation variable reaches a particular value, the relationship between inflation and nominal returns often increases in magnitude and/or significance. This is opposite what Choi, Smith and Boyd (1995) predicts. In their model, financial market frictions should kick in and hamper financial market activity, leading to a negative relationship between inflation and nominal returns after the threshold inflation variable reaches the threshold value. Thus, though the statistical tests for nonlinearities indicate the presence of thresholds, as their study predicts, their hypothesis about the nature of these thresholds is not born out in the data, at least not with this simple threshold specification. However, these results do underscore the cross-sectional findings of Boyd, Levine and Smith (1996). In their study they found that when annual inflation rates are less than 15%, a unit increase in inflation is unrelated to a unit increase in nominal equity returns. This implies that below this annual level of inflation, stocks are not a good hedge against inflation. They find, though, that at higher inflation rates, unit increases in inflation are matched almost one to one with increases in nominal stock returns. Similarly, the current study finds that for high-average inflation countries, stocks provide a better hedge against inflation once inflation reaches some threshold value. In fact, there is then a tendency for overcompensation, with coefficients on inflation often being greater than one. So there is cross-sectional and time-series empirical evidence of this effect. It should be noted, though, that the methodology for estimating the threshold relationship differs between these two papers: Boyd, Levine and Smith (1996) use an interaction variable of a dummy for inflation rates over 15% multiplied by the rate of inflation, while this study uses a less ad-hoc estimation procedure for uncovering these results.

The low-average inflation countries with significant threshold effects per Hansen (1996) generally show a more negative relationship between inflation and nominal returns, once the inflation threshold variable reaches a particular threshold. These countries generally display negative (4 countries) or negative but insignificant (8 countries) relationships between inflation and nominal returns in a linear specification, also.[21] Although this corroborates

[21] One low-average-inflation country had a significant and positive coefficient on inflation

the cross-sectional empirical findings of Boyd, Levine and Smith (1996) in that for low-inflation countries an increase in inflation is not matched by greater nominal returns (even though this does happen for high-inflation countries and there is a positive relationship between the two variables in their threshold-inflation interaction cross-sectional regressions), these results are exactly contrary to the prediction of Choi, Smith and Boyd (1995). According to that paper, for low-inflation countries, an increase in the rate of inflation should have at worst an insignificant effect on nominal returns and at best a positive effect on nominal returns, whereas the empirical evidence found in this study indicates that the correlation between inflation and nominal returns worsens for low-average-inflation countries, once inflation reaches a particular threshold.

5 Conclusion

In general, there is (not surprisingly) a lot of statistical evidence for non-linearities in the nominal return series for all of these countries. What is a surprise is that there is even a higher predominance of threshold effects. Although the findings of this study do support the cross-sectional "threshold" findings of Boyd, Levine and Smith (1996) with respect to the relationship between inflation and nominal equity returns, the theory articulated in Choi, Smith and Boyd (1995) is not evidenced in the data. There are significant thresholds, but the quality of the relationship between inflation and nominal equity returns before and after the threshold value for high and low-average-inflation rate countries is generally opposite of that described in their paper.

Low average inflation countries tend to have a negative or insignificant (often negative and insignificant) relationship between inflation and nominal returns in the linear specification that gets exacerbated in the second regime. High-average-inflation rate countries tend to have a positive or positive but insignificant relationship between inflation and nominal returns in a linear regression without a threshold, and this relationship intensifies in the second regime when a threshold is specified. (In the first regime, an opposite or less significant or insignificant or an economically smaller size relationship usually holds.)

Too, this study, by simple breadth of the countries it surveys, has uncovered an empirical regularity in the simple linear specification of the relation-

in the linear specification: Ireland (36).

ship between inflation and nominal returns as well. For some high-average-inflation-rate countries, stocks provide a good hedge against inflation. Note that this is what the cross-sectional literature maintains. In contrast, nominal returns do not move positively with inflation for low-average-inflation-rate countries. This is in sync with the time-series literature on this subject to date. It appears, then, that the Fisher effect exists only for some high-inflation countries.

There are several potentially interesting extensions of this paper. One would be to redo the exercize with unexpected inflation as a regressor, with or without the addition of expected inflation as a regressor. Another possibility is to look at real instead of nominal returns, since the hypothesis that comes out of Choi, Smith and Boyd (1995) is that there are threshold relationships which exist between real returns and inflation. Even more interesting, though, would be to study the threshold relationships which both theoretical studies and empirical studies indicate exist as a triangle among inflation, financial market development and activity, and growth. Naturally, another extension would be to let the transition from one regime to another be probabilistic, and estimate a regime-switching model. Azariadis and Smith (1994) have a theoretical model in which such changes in the relationship between financial market and inflation variables are probabilistic instead of deterministic in nature. Finally, it would be useful to recast the problem in a panel framework to capture the informational content of the cross-section domain.

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