The Nonlinear Dynamic Relationship between Stock Returns and Inflation: Evidence from Turkey

Nilgün Çil Yavuz, Istanbul of University, Turkey

Abstract: In this paper, we re-examine the dynamic relationship between stock returns and inflation in Turkey for the period 1996:1-2009:11. The results indicate that linearity is rejected in favor of a TVECM specification. Thus, our results suggest the presence of nonlinear cointegration between stock returns and inflation.

Keywords: Stock returns; Inflation; Nonlinearity; Threshold cointegration

1. Introduction

The effect of inflation on the returns of financial assets has been the subject of many studies (both theoretically and empirically) over years and has received much attention in monetary and financial economics. The basic theoretical concept in this area commonly attributed to Fisher (1930) who claimed that the nominal interest rate fully reflects the available information concerning the possible futures values of the rate of inflation. In other words, nominal interest rates are reliable predictors of inflation. This hypothesis known as the “Fisher effect” and suggests that expected nominal interest rates on financial assets should move one to one with expected inflation. This implies that real values of common stocks are constant (or stationary) and determined by real factors independently from the rate of inflation.

Nelson (1976) and Boudoukh – Richardson (1993) extended this relation to return of common stocks by following Fishers (1930). Early studies in this field, mainly focus on possible relationship between stock return and inflation, and also interpret the magnitude and sign if there is a relationship. Contrary to traditional view, most of the empirical studies evidence suggest a negative rather than positive relationship between stock return and inflation and many studies do not find any evidence of a relationship between them. However, studies which employ the conventional econometric methods, assume there is a symmetric relationship between stock return and inflation. But, one point to emphasize is that, the reaction of stock return to inflation is not same in the periods when the inflation increases or decreases. In other words, there can be asymmetric relationship between these series.

Boyd et.al.(1996) theoretically demonstrated that the relationship between stock returns and inflation is nonlinear. After this study, Boyd et.al.(2001) also proved that there is a threshold effect between stock return and inflation empirically. Barnes (1999) tested the possible linear and nonlinear relationship between nominal returns and inflation for a sample of 39 countries that grouped as “low-average-inflation” and “high-average-inflation” countries. He found positive but insignificant relationship between them in the linear framework. By employing threshold models, the relationship found to be weaker and insignificant. Liu et.al.(2005) found threshold effect in the long-run equilibrium between
stock return and inflation for three out of the ten major markets using Threshold VECM. Kim and In (2005) approached the Fisher hypothesis using wavelet analysis. The results of the paper indicate there is a positive relationship between stock prices and inflation at the short and long scales but a negative relationship at the intermediate scales. Hoque et al. (2007) examined the long run relationship between real stock prices and inflation for G7 countries allowing asymmetry by employing TAR and M-TAR models. They found that positive changes in inflation erode real stock prices, but negative changes have no effect on the prices.

Spyrou (2004) tested the relationship between stock return and inflation in a linear framework for ten Emerging Stock Markets including Turkey, and found a negative relation for Turkey. Sari and Soytas (2005) investigated the relation between real stock return and inflation by using linear econometric tools and found negative relationship between them. The study of Kutan and Aksoy (2003) indicates that Turkey’s inflation increased more than stock return and interest rates and also detects significant asymmetric effects. This result also shows that relationship between stock return and inflation is nonlinear. While they couldn’t find any evidence for the Fisher effect in Turkish financial markets except for the financial sector, they find that financial sector can serve as a hedging tool against anticipated inflation.

Under the light of previous empirical studies, this is the first study to analyze the Fisher effect for Turkey by employing Threshold Vector Error Correction Model (TVECM).

This paper is organized as follows. Section 2 explains details of the empirical methodology. Section 3 describes the data. Section 4 presents the main empirical results and finally Section 5 concludes the paper.

2. Methodology

This study utilized threshold vector error correction model developed by Hansen and Seo (2002) which examines a two-regime vector error-correction model with a single cointegrating vector and threshold effect in the error-correction term. This method can be expressed as follows:

\[ x_t \text{ is a } p\text{-dimensional } I(1) \text{ time series which is cointegrated with one } p \times 1 \text{ cointegration vector } \beta, \text{ with } n \text{ observations, with } l \text{ as the maximum lag length. } u_t \text{ is an error term. A linear VECM of order } l+1 \text{ can be written as } \]

\[ \Delta x_t = A'X_{t-1}(\beta) + u \quad (1) \]

where

\[ X_{t-1}(\beta) = \begin{pmatrix} 1 \\ w_{t-1}(\beta) \\ \Delta x_{t-1} \\ \Delta x_{t-1} \\ \Delta x_{t-1} \end{pmatrix} \]
and $\Delta$ is the first-order difference operator; the regressor $X_{t-1}(\beta)$ is $k \times 1$; $A$ is $k \times p$ where $k = pl + 2$. $w_t(\beta) = \beta'x_t$ denote the $l(0)$ error-correction term. $u_t$ is the error term assumed to be an iid Gaussian sequence with a finite covariance matrix $\sum = E(u_t'u_t)$. Variables in this model respond linearly to deviations from the long-run equilibrium.

As an extension of model (1), a two-regime threshold cointegration or a non-linear VECM of order $l+1$ can be expressed as follows;

$$
\Delta x_i = \begin{cases} 
A'_1X_{t-1}(\beta) + u_t & \text{if } w_{t-1}(\beta) \leq \gamma \\
A'_2X_{t-1}(\beta) + u_t & \text{if } w_{t-1}(\beta) > \gamma 
\end{cases}
$$

where $\gamma$ is the threshold parameter. This may alternatively be written as

$$
\Delta x_i = A'_1X_{t-1}(\beta)d_1(\beta, \gamma) + A'_2X_{t-1}(\beta)d_2(\beta, \gamma) + u_t,
$$

(2)

where

$$
d_1(\beta, \gamma) = I(w_{t-1}(\beta) \leq \gamma)
$$

$$
d_2(\beta, \gamma) = I(w_{t-1}(\beta) > \gamma)
$$

and $I(.)$ denotes the indicator function.

The threshold model has two regimes, defined by the value of the error-correction term. The coefficient matrices $A_1$ and $A_2$ describe the dynamics in each of the regimes. The threshold model (Equation 2) allows all coefficients, except the cointegrating vector $\beta$, to switch between two regimes. The threshold effect only has content if $0 < P(w_{t-1} \leq \gamma) < 1$, otherwise the model simplifies to linear cointegration. The limitation of $\beta$ is $\pi_0 \leq P(w_{t-1} \leq \gamma) \leq 1 - \pi_0$, where $0 < \pi_0 < 1$ is a trimming parameter. The threshold VECM can be estimated using the maximum likelihood method proposed by Hansen and Seo(2002).

Hansen and Seo(2002) propose two heteroskedastic-consistent LM test statistics to test there is no threshold effect under the null, against the alternative of threshold cointegration(i.e. Equation 2). This means that there is no threshold under the null, so that Equation 2 reduces to a conventional linear VECM. The first test would be used when the true cointegrating vector is known a piori, and is denoted as

$$
\sup_{\gamma \leq \gamma \leq \gamma_U} \text{LM}^\theta = \sup_{\gamma \leq \gamma \leq \gamma_U} \text{LM}(\beta_0, \gamma),
$$

where $\beta_0$ is the known value of $\beta$ (i.e., set $\beta_0$ at unity), while the second case can be used when cointegrating vector is unknown, and the test statistic is given by;

$$
\sup_{\gamma \leq \gamma \leq \gamma_U} \text{LM}^\theta = \sup_{\gamma \leq \gamma \leq \gamma_U} \text{LM}(\hat{\beta}, \gamma),
$$

where $\hat{\beta}$ is the null estimate of $\beta$. In both tests $[\gamma_L, \gamma_U]$ is the search region so that $\gamma_L$ is the $\pi_0$ percentile of $w_{t-1}$, and $\gamma_U$ is the $(1-\pi_0)$ percentile. Andrews(1993) suggests setting $\pi_0$.
between 0.05 and 0.15. The bootstrap method proposed by Hansen and Seo (2002) is employed to calculate the asymptotic critical values and \( p \)-values.

3. Data

The dataset comprise consumer Price Index (CPI) and price index of Istanbul Stock Exchange (ISE-100) over the period from January 1990 to December 2008 and are obtained from International Monetary Fund’s *International Financial Statistics* (IFS) and Central Bank of the Republic of Turkey’s *Electronic Data Delivery System* (CBRT-EDDS), respectively.

4. Empirical Results

An important preliminary step of the analysis is to determine the integration properties of the variables, because the estimation of threshold VECM depends on the assumption that the underlying data generating process of variables are \( I(1) \).

In this paper Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are used to determine the order of integration of the series. Table 1 summarizes the results of these tests. Here, \( sr \) and \( inf \) are the natural logarithm of the stock price index and the CPI, respectively. We cannot reject the null of unit root by using the ADF and the PP tests. However after first differencing, the null hypothesis of unit root is rejected at the 1% level for each series. These results indicate that both \( sr \) and \( inf \) are integrated at the first difference \( I(1) \) and so, we can test for cointegration between these series. Therefore, to make a benchmark for TVECM, we first apply Johansen cointegration test to examine the long-run relationship between the stock returns and inflation rates.

Table 1. ADF and PP unit root tests results

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADF</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>( sr )</td>
<td>-2.605</td>
<td>-2.682</td>
</tr>
<tr>
<td>( \Delta sr )</td>
<td>-9.309 (^a)</td>
<td>-9.315 (^a)</td>
</tr>
<tr>
<td>( inf )</td>
<td>-2.763</td>
<td>-3.03</td>
</tr>
<tr>
<td>( \Delta inf )</td>
<td>-4.057 (^a)</td>
<td>-3.977 (^a)</td>
</tr>
</tbody>
</table>

*Note: The symbol \(^a\) denotes significance at the 1% level.*

Table 2 shows the results of the Johansen cointegration test.

Table 2. Cointegration test results

<table>
<thead>
<tr>
<th>Null</th>
<th>Alternative</th>
<th>Trace Statistic</th>
<th>Critical Value(0.05)</th>
<th>Max-Eigen Statistic</th>
<th>Critical Value(0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r=0 )</td>
<td>( r&gt;=1 )</td>
<td>38.40367</td>
<td>25.87211</td>
<td>30.64146</td>
<td>19.38704</td>
</tr>
<tr>
<td>( r&lt;=1 )</td>
<td>( r&gt;=2 )</td>
<td>7.762208</td>
<td>12.51798</td>
<td>7.762208</td>
<td>12.51798</td>
</tr>
</tbody>
</table>

*Note:*

The empirical results presented here indicate that \( sr \) and \( inf \) series are non-stationary and there is a cointegrating relationship between stock returns and inflation rate. As is well known, if two time series data are cointegrated, the model should include the error correction
term which describes how the variables responds to deviations from the equilibrium. So, after detecting a cointegration relationship between the series, the two-regime threshold VECM can be estimated in order to investigate the nonlinear long-run relationship between stock market return and inflation rate as follows:

\[
\begin{pmatrix}
\Delta sr_t \\
\Delta \inf_t
\end{pmatrix} = \begin{pmatrix}
c_1 \\
c_2
\end{pmatrix} + \begin{pmatrix}
\alpha_1 \\
\alpha_2
\end{pmatrix} w_{t-1} + \sum_{i=1}^{p} \begin{pmatrix}
\Gamma_{11} & \Gamma_{12} \\
\Gamma_{21} & \Gamma_{22}
\end{pmatrix} \begin{pmatrix}
\Delta sr_{t-i} \\
\Delta \inf_{t-i}
\end{pmatrix} + \begin{pmatrix}
u_t \\
u_2
\end{pmatrix}
\]

where \( p \) is optimal lag length, \( sr_t \) and \( \inf_t \) are defined as above. \( \Delta \) is the difference operator. Thus, \( \Delta sr_t \) and \( \Delta \inf_t \) in threshold VECM correspond to the stock returns and the rate of inflation, respectively.

To test whether the equilibrium adjustment process between stock returns and inflation is nonlinear, we present the estimation results of the Sup LM statistic are reported in Table 3.

Table 3.
Test for threshold cointegration

<table>
<thead>
<tr>
<th></th>
<th>Sup LM^0</th>
<th>Sup LM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test statistic value</td>
<td>13.87(0.52)</td>
<td>34.75(0.00)</td>
</tr>
<tr>
<td>Tests for ECM coefficient</td>
<td>2.34(0.31)</td>
<td>14.07(0.00)</td>
</tr>
<tr>
<td>Tests for dynamic coefficients</td>
<td>7.53(0.11)</td>
<td>23.87(0.00)</td>
</tr>
<tr>
<td>Threshold value(( \gamma ))</td>
<td>5.36</td>
<td>0.85</td>
</tr>
<tr>
<td>Estimate of the co-integration vector(( \beta ))</td>
<td>1.00</td>
<td>3.15</td>
</tr>
</tbody>
</table>

The estimation of the threshold parameters are obtained by the grid search with 300 grid points, as done by Hansen and Seo(2002). The Sup LM^0 and Sup LM statistics and bootstrap p-values are calculated from a parametric residual bootstrap with 5000 replications. We selected the optimal lag length(\( l \)) of the VAR as 1, by using the Akaike and Bayesian Information criteria.

Initially, the nonlinearity and cointegration between the nominal stock returns and inflation rate are tested by using cointegrating vector \( \beta'=[1 \ -1] \). In this case (\( \beta=1 \)), long run equilibrium relationship is \( w=sr-\inf \), which shows real returns. As can be seen, stock return and inflation move one-to-one in the long run and real stock returns are constant (or stationary), thus common stocks are a complete hedge against inflation. Sup LM^0 test statistic reported in the first column in Table 3, rejects nonlinear long-run relationship between the stock returns and inflation rate when \( \beta=1 \).

When \( \beta \) is estimated, the null hypothesis of no threshold is rejected at 1% .Thus, Sup LM test supports nonlinear long-run relationship between the nominal stock return and the inflation rates in Turkey. The estimated cointegration coefficient is \( \beta=-3.15 \), indicating strong responsiveness of the stock return to inflation. The Wald test for equality for the ECM coefficients are significant at the 1% level. Besides, the estimated threshold value(\( \gamma \)) is 0.85 and identifies two regimes with statistically different ECM coefficients. The cases where the
values of the threshold variable $w_{t-1}$ (real stock return) below or above the threshold parameter $\gamma$, allow the coefficients to switch between the two regimes. The estimated two-regime threshold VECM results (heteroskedasticity-consistent standard errors in parentheses) are presented in Table 4:

Table 4
Estimation results of Threshold VECM

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Regime I: $w_{t-1} \leq 0.85$</th>
<th>Regime II: $w_{t-1} &gt; 0.85$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage of Obs=0.5619</td>
<td>Percentage of Obs=0.4381</td>
</tr>
<tr>
<td>Constant</td>
<td>$\Delta sr$</td>
<td>$\Delta inf$</td>
</tr>
<tr>
<td></td>
<td>-0.014</td>
<td>-0.009</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>$w_{t-1}$</td>
<td>-0.081</td>
<td>0.149</td>
</tr>
<tr>
<td></td>
<td>(0.041)</td>
<td>(0.031)</td>
</tr>
<tr>
<td>$\Delta sr_{t-1}$</td>
<td>0.286</td>
<td>0.125</td>
</tr>
<tr>
<td></td>
<td>(0.122)</td>
<td>(0.101)</td>
</tr>
<tr>
<td>$\Delta inf_{t-1}$</td>
<td>2.098</td>
<td>-1.075</td>
</tr>
<tr>
<td></td>
<td>(0.697)</td>
<td>(0.351)</td>
</tr>
</tbody>
</table>

Negative log-likelihood= -1391.19  
AIC= -1359.19  
BIC= -1353.53  
Obs R1= 56.19 %  
Obs R2= 43.81 %

Note:  
1. The numbers in parentheses are the standard errors.

The empirical findings are presented as follows. The first regime has 56.19% of the observations, while the second regime has 43.81%. The estimate of the threshold parameter ($\gamma$) is 0.85, with the error-correction term defined as $w_{t-1} = \Delta sr_{t-1} - 3.15 \Delta inf_{t-1}$. The relationship between inflation and stock returns is different in cases where $w_{t-1}$ is above and below the threshold. Hence the first regime would occur when $\Delta sr_{t-1} - 3.15 \Delta inf_{t-1} \leq 0.85$. On the other hand, the second regime occurs when $\Delta sr_{t-1} - 3.15 \Delta inf_{t-1} > 0.85$. In both regimes, the inflation rate adjustment parameters (ECTs) and stock return adjustment parameters (ECTs) are significantly different from zero. But since we only interested in the first equation, we focus on the results of this equation. While ECT has a negative sign in the first regime, it has a positive sign in the second regime in the first equation. Fig. 1 plots the response of stock return and inflation to the error-correction term.
The effect of the lagged inflation \((\Delta \inf_{t-1})\) on the current stock return \((\Delta sr)\) is significant in both regimes. The lagged inflation rate has positive effect on the stock returns in the first regime. This result suggests that a 1% increase in inflation generates a 2.09% increase in nominal returns, ceteris paribus. These results also suggest that the Fisher effect holds in first regime. On the other hand, the lagged inflation rate has negative effect on the stock returns in second regime, which called as “puzzling sign” by Gultekin (1983), indicates that the stock market is not even a partial hedge against inflation.

The effect of the lagged stock return \((\Delta sr_{t-1})\) on the inflation rate \((\Delta \inf)\) is significant in both regimes.

When we look at the impact of the lagged stock returns \((\Delta sr_{t-1})\) on the current stock returns \((\Delta sr)\), we see that the lagged stock returns in second regime are not significant in explaining the current stock returns. This result is an evidence for the weak-form market efficiency. But, it is significant and positive in the first regime. This result indicates that Efficient Market Hypothesis is not valid in the first regime.

Surprisingly, the inflation can not be explained by its own lags, implying the temporary of inflation. However, in the sample period, inflation has a persistent property in Turkey.

5. Conclusions

In this study, the nonlinear dynamic relationship between inflation and stock returns is examined for Turkey. The main findings of our analyses can be summarized as follows. First, we reject the linearity in favour of the threshold nonlinearity. This result is consistent with the empirical literature that employs nonlinear models to test the Fisher hypothesis. The estimation results of Threshold Vector Error Correction Models show that the Fisher hypothesis is valid only in first regime but Efficient Market Hypothesis is not. On the other hand, in the second regime we can not reject the Efficient Market Hypothesis, but reject the Fisher hypothesis.
Acknowledgements
This research is supported by Science Research Center, Istanbul University.

References