



Japan's Stock Market Performance: Evidence from Toda-Yamamoto and Dolado-Lutkepohl Tests for Multivariate Granger Causality

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ABSTRACT

This paper empirically examines the causal linkages of Japan's stock market (proxied by Nikkei 225 index) performance with selected key macroeconomic fundamentals. Relatively recent Toda-Yamamoto and Dolado-Lutkepohl, multivariate Granger causality tests are implemented. Monthly time series data from September 1974 to February 2017 with a large sample size of 510 monthly observations covering the floating exchange rate regime were utilized. The study documents some interesting and some unexpected results. Bi-directional causality is evidenced only between the stock market and the industrial production. Somewhat counterintuitively, unidirectional causality runs from stock market to money supply. Furthermore, unidirectional causality flows from interest rate (bond yield) to stock market. Not so surprisingly, no causality is detected between the stock market and the general price level. This is also true for stock market and exchange rate. The above findings may aid Japanese policy makers to formulate appropriate financial, monetary and exchange rate management policies. Japan should give second thought on the efficacy of its over reliance on monetary policy with interest-rates targeting and should prepare itself for launching a pragmatic fiscal stimulus program.

Keywords: Stock Market, Macroeconomics Fundamentals, Granger Causality

JEL Classifications: E44, F41, G15

1. INTRODUCTION

Causal interactions between stock market and selected key macroeconomic fundamentals have been a topic of considerable interest among academicians, research scholars, policy makers and investors in the past three decades. Especially, this issue has become more intense and has drawn more attention due to the 2008-2009 Great Recession in the USA that affected economies and equity markets in many other countries including Japan. An early attempt using the multivariate Arbitrage Pricing Theory (APT) was made by Chen et al. (1986), subsequently followed by several other studies relating stock prices with macroeconomic variables over the past several decades. An extensive literature

review on this topic reveals a general lack of consensus among researchers about the direction of causality and the lead-lag relations among stock prices and some key macroeconomic variables. From the existing body of related literature review, key macroeconomic indicators related to stock prices can be grouped into five categories: (a) Indicators of real sector performance such as GDP (or GNP), Industrial Production Index, and Unemployment Rate, among others; (b) Money supply, measured as M1, M2 or M3; (c) General Price level measured by Consumer Price Index (CPI), Producer Price Index (PPI) or GDP Deflator; (d) various measures of Short, Medium or Long-term Interest Rates; and (e) some measure of external influences such as Exchange Rate, Trade Deficits/Surpluses, Foreign Direct Investment (FDI), etc.

This study solely focuses on possible causal relationships of Japan's stock market performance with five selected key macroeconomic variables, namely, Consumer Price Index, Money supply, Interest rate, Exchange rate, and Industrial Production Index. For a cursory overview, Japan is a market-oriented and trade-dependent developed country and is a member of the G-7 and the OECD. From 1968 until 2009, Japan had the second largest economy in the world. Exports and advances in manufacturing technologies played a vital role in Japan's economic miracle. Since 1986, the economy started losing momentum. For Japan, the 1990s was characterized as the lost decade. For the last three decades, Japan has been struggling to recover amid prolonged deep recession and occasional deflation with subdued inflation expectation. Despite dismal economic performance and ultra-low interest rate environment, Japan's stock market has been performing relatively better in the twenty-first century amid random fluctuations. The yen, in general, has been gaining strength against several key currencies due mainly to its perceived-safe haven status. In particular, the yen gains strength when China's financial markets are in turmoil.

To add further, Japan enjoyed golden period with generally stable broad-money growth, steady real GDP growth, and low inflation during 1974-1984. Then, monetary policy was derailed by the 1985 Plaza Accord and the 1987 Louvre Accord. The Bank of Japan dropped monetary targets and began to focus on interest-rate targets. The result was Japan's disastrous bubble from 1987 through 1990, followed by the so-called lost decade and then turning into a lost generation. The basic idea of interest-rate targeting to push interest rates low enough to boost household and business spending for economic revival (Greenwood and Hanke, 2019). Japan believed that the government may run budget deficits without limits as long as they can be financed by yen-denominated securities. But budget deficits have little to do with inflation unless they are financed by rapid money-growth. Recent increase in sales tax is destined to lead to further economic contraction.

Currently, Japan ranks as the third largest economy in the world in term of annual real GDP, its second rank being replaced by China. Overly expansionary monetary policy and ultra-low interest rate policies thus far failed to lift the economy out of the long-lasting doldrum. In the first quarter of 2019, the real GDP growth on record was barely 0.6. The short-term interest rate is in negative territory. Inflation rate remains far below the 2% target-level. Exports are falling and the manufacturing sector is in contractionary mode. Japan has mounting public debt (246% of annual real GDP), high proportion of aging population, shrinking active-age population, negative local population growth rate, evolving acute labor shortage, lackluster consumption growth, etc. These are the current structural challenges Japan is confronted with. Considering the above, the real economy of Japan is seemingly disconnected from its stock market and exchange rate movement. In brief, Japan reveals an uncharted trajectory of real economic and financial performances over the last several consecutive decades.

All the above have motivated the authors for undertaking this study to investigate the influences of several key macroeconomic fundamentals on Japan's stock market performance. Nikkei225 is

used to represent the broadest proxy for stock market of Japan. This price-weighted index includes common stocks of 225 Japanese BlueChip companies that is comparable to the US DJIA. A host of studies investigated this issue in the past lacking in consensus on their empirical findings. So, there is renewed curiosity on our part to revisit this issue. Unlike many other studies, this paper utilizes a robust methodology of testing Granger causality in a multivariate framework (not bivariate) involving non-stationary variables such as that suggested by Toda and Yamamoto (1995) and Dolado and Lutkepohl (1996). Henceforth, we will call this methodology TYDL approach for Granger causality in a multivariate context. This paper employs monthly data over four decades from September 1974 through February 2017 to cover the floating exchange rate regime. In our view, the use of such an extended sample period with higher frequency monthly data would better capture the long-run dynamic relationships between/among key time series macroeconomic variables.

Unlike the above, several earlier causality studies ignored the time series non-stationary properties of the variables and hence might have suffered from spurious correlations (Granger and Newbold, 1974). Some other studies investigated the non-stationary properties to perform the Granger causality tests using simple VAR or VECM or Johansen-Juselius cointegration procedures. But Toda and Phillips (1993) have provided evidence that the Granger causality tests in error-correction models still contain the possibility of incorrect inference and asymptotically suffer from nuisance parameter dependency. Another issue with previous studies is their use of bivariate framework. However, multivariate relationships may be quite different and more appropriate than bivariate relationships. Love and Chandra (2005a and 2005b) and Stock and Watson (2001) highlight the flaws in conducting bivariate analysis when multivariate relationships exist. A two-variable Granger causality test that does not consider the effects of other variables may be subject to specification bias because causality tests are sensitive to model specifications and to the number of lags, as discussed in Gujarati and Porter (2003).

Considering the aforementioned, the present study is expected to make important contributions to the growing body of empirical literature through application of relatively recent and robust econometric methodologies by utilizing adequately long monthly time series data. To our knowledge, these relatively recent and robust methodologies have not been implemented in such context for Japan.

2. REVIEW OF THEORETICAL REASONING AND EMPIRICAL LITERATURE

To shed some light on applicable theoretical arguments in favor of the topic of our interest and to unveil some of the controversies around the empirical findings in the selected literature review, the subsequent discussions follow.

Efficient Market Hypothesis (EMH), with early roots in the pioneering work of Gibson (1889) and the early works of leading

thinkers like Samuelson (1965) and Fama (1965a; 1965b; 1976; 1990 and 1991) have popularized the idea that stock prices follow a random walk process. According to the EMH, the best prediction of the next period's stock price is today's price plus a drift term implying that stock returns are not predictable. Attempts to verify the validity of this assertion led to enormous interest in studying stock market returns predictability with growing evidence that stock market returns are predictable at least to some degree. The literature documents predictability of stock index returns from lagged returns, lagged financial and macroeconomic variables, and calendar or event dummies. As also argued in Guru-Gharana et al. (2008) that stock return predictability does not necessarily indicate that those markets are not reasonably efficient. This is because of time-varying expected returns that can be attributed to changing business conditions and risks that might be partially predictable even when the EMH holds. Evidence of stock index returns predictability implies that markets can be beaten by using the above variables. According to Cutler et al. (1990), "The Efficient Market Hypothesis was probably the right place for serious research on asset valuation to begin, but it may be the wrong place for it to end."

The causal linkages between stock market returns with a host of macroeconomic variables such as real GDP growth, industrial production, short-term interest rate, inflation rate, interest rate spread, changes in monetary aggregates, among others, are extensively studied. Discussed below are the theoretical arguments and empirical evidence on the relationships of these key macroeconomic variables with Japan's stock market returns.

2.1. Inflation and Stock Returns

According to the simple discounted cash flow model, the discount rate will increase with inflation causing the present value of expected future cash flows (including dividends) to decrease, which in turn, will have negative impact on stock returns. In addition, the increased cost of living caused by inflation may result in diverting funds from investment to consumption thereby reinforcing negative impact on stock market performance. Increased inflation may also reduce corporate profits causing reduction in dividends and future cash flows. Fama and Schwert (1977) and Chen et al. (1986) supports this negative relation because inflation raises production costs, diminishes competitiveness, decreases expected future revenues and cash flows. A number of empirical studies including Mukherjee and Naka (1995), Chatrath et al. (1997), Pal and Mittal (2011), Hsing (2011a; 2011b), Naik and Padhi (2012), and Forson et al. (2013) among others, have found evidence in support of the negative relation between these variables.

In contrast, Christie-David et al. (2000), Maysami et al. (2004), Ratanapakorn and Sharma (2007), Kuwornu and Owusu-Nantwi (2011), Hosseini et al. (2011), and Giri and Joshi (2017) have found that stock returns and inflation are positively related. The explanation is that stocks perhaps serve as inflation hedge. Another explanation is that the respective government actively embarking on counter-cyclical policies to combat surging inflation cause upturns in stock returns. Osamwonyi and Evbayiro-Osagle (2012) find that inflation is positively related, but the relation is significant only in the long run. Chandra (2007) argues that inflation can have

bidirectional impact on stock return depending on the nature of the business. Similarly, Wongbangpo and Sharma (2002) find bidirectional Granger causality between stock prices and key macroeconomic variables in the short as well as in the long run for five ASEAN countries.

2.2. Interest Rate and Stock Returns

Chandra (2007) argues that increased interest rate makes money market assets more attractive compared to stocks. As a result, stock prices and hence returns get depressed. This occurrence is in line with a kind of substitution effect in the context of portfolio revisions. Moreover, increased cost of capital due to rising interest rate may depress business profits on the one hand and increase the rate of discount of expected future cash flows on the other. Both tendencies act like double-edged sword to depress stock prices. This hypothesis of negative relation is empirically supported by Maysami and Koh (2000), Wongbangpo and Sharma (2002), Gunasekarage et al. (2004), McMillan (2005), Ratanapakorn and Sharma (2007), Kandir (2008), Shaharudin and Hon (2009), Buyuksalvarci (2010), Hsing (2011a; 2011b), Kuwornu and Owusu-Nantwi (2011), and Peiro (2016), among others.

2.3. Money Supply and Stock Returns

Increased money supply, if unaccompanied by increased productivity, may cause inflation which inversely influences stock returns since investors likely divert resources from financial assets to real/tangible assets. This negative relation was confirmed by Rahman et al. (2009), Humpe and Macmillan (2009), and Osamwonyi and Evbayiro-Osagle (2012). But Homa and Jaffe (1971) and Brunie et al. (1972) found the opposite effect in the event that past increases in money supply lead (cause) to increases in equity prices. Fama (1990) sought to explain a positive relation between money supply and stock prices through a simple model of quantity theory of money wherein money demand is stimulated through increase in real economic activity. This, in turn, drives up stock returns. Mukherjee and Naka (1995) also reason that money supply may boost commercial activities and have positive impact on stock prices. Similarly, Flannery and Protopapadakis (2002), Maysami et al. (2004), Brahmasrene and Jiranyakul (2007), Ratanapakorn and Sharma (2007), Sohail and Hussain (2009), and Forson et al. (2013) showed positive relation between these variables.

The Granger causality test by Ratanapakorn and Sharma (2007) indicated that macroeconomic variables cause the stock prices in the long run but not in the short run. Hosseini et al. (2011) find negative impact of money supply on stock prices for India but positive for China. Mahedi (2012) finds short- and long-run causality running from money supply to stock returns for UK, and only short-run causality from money supply to stock returns for Germany. Zubair (2013) finds causality from money supply to stock index for Nigeria before the global financial crisis, but the relationship vanished during the 2008-2009 financial crisis. On the other hand, Cooper (1974) and Rozeff (1974) demonstrate that causality runs from stock prices to money supply. Similarly, Buyuksalvarci and Abdioglu (2010) reported unidirectional long-run causality from stock prices to variables including Money Supply) for Turkey. But Rogalski and Vinso (1977) argued

that relationship may be bidirectional. This is supported by Wongbangpo and Sharma (2001) and Hashemzadeh and Taylor (1988). In contrast, Hernandez (1999) found no causal relationship between past changes in the money supply and current changes in stock prices for Canada, France, Germany, UK and the United States. However, changes in money supply led to changes in stock prices in Japan. Similarly, Kimura and Koruzomi (2003), Alatiqi and Fazel (2008) find no significant long-term causal relation between changes in money supply and stock returns.

2.4. Exchange Rate and Stock Returns

Traditionally, it is stipulated that exchange rates caused stock prices and the transmission channel is from exchange rate fluctuations to global competitiveness of firms, changes in the valuation of firms' assets and liabilities dominated in foreign currencies and thereby affecting firms' profits and equity valuation Hernandez-Trillo (1999). In contrast, such fluctuations would affect cost of imported inputs and hence profits in opposite ways as highlighted by Bodnar and Gentry (1993). For example, home country currency depreciation makes exports more competitive, enhances revenues of exporting firms and their stock values as found by Dornbusch and Fischer (1980), Gavin (1989), Ma and Kao (1990), Jorion (1991), Mukherjee and Naka (1995), Hsing (2011), and Kuwornu and Owusu-Nantwi (2011). In a different study, Maysami and Koh (2000) found that home country currency depreciation in an import-oriented economy negatively impacts stock prices because of increased cost of imports. In contrast, local currency depreciation boosts stock prices in export-oriented countries, as reported in Ratanapakorn and Sharma (2007), and Sohail and Hussain (2009). Tiwari et al. (2019) examined the relationship between equity returns with exchange rate for Bangladesh using a relatively novel and non-traditional approach known as continuous Wavelet approach. The empirical results strongly support the traditional hypothesis that the exchange rate leads (causes) stock prices compared to the alternative portfolio-based hypothesis.

In the modern world of rising global competition in every sector, all firms are affected to some extent by exchange rate fluctuations. In particular, firms with foreign operations (exports, imports or international production) are likely to be more intensely affected. Bahmani-Oskooee and Sohrabian (1992) find bi-directional causality since stock prices, in turn, affect exchange rates and interest rates through wealth effect and changes in the real money balances. Similarly, Bhat and Shah (2015) find a bidirectional causality for Pakistan. Abdalla and Murinde (1997) find that exchange rates Granger cause stock prices for India, Korea and Pakistan, while Stock prices lead exchange rates in the case of the Philippines. Similarly, Smith (1992) report that stock prices significantly influence exchange rates in Germany, Japan and the United States. Osamwonyi and Evbayiro-Osagle (2012) report that exchange rates are positively related to stock market index in the short run but negatively related in the long run in the Nigerian economy. Similarly, Giri and Joshi (2017) find positive influences of exchange rate on stock prices in India. Khalid and Khan (2017) draw the same inference for Pakistan. On the other hand, some studies such as Nieh and Lee (2001) found absence of significant long-run relation between stock prices and exchange rates in the G-7 countries. Likewise, Bhattacharya and Mukherjee (2005)

and Rahman and Uddin (2009) find no significant relationship between these variables for South Asian countries. In addition, Zubair (2013) finds no causal relation between exchange rate and stock index for Nigeria.

2.5. Industrial Production Index and Stock Returns

Industrial Production Index measures real output of manufacturing, mining, electricity, gas and utility industries located in the country. This is used as an indicator of the performance of the real sector of an economy. Geske and Roll (1983), b Chen et al. (1986), Fama (1990), and Mukherjee and Naka (1995), among others, suggest positive relation between stock prices and the real sector. The level of real economic activity impacts corporate profitability and expected future cash flows in the same direction. Equity prices may rise due to the potential for higher profits from a growing economy, as argued by Chandra (2007). Naik and Padhi (2012), Hsing (2011), Peiro (2016), and Giri and Joshi (2017) support positive relation between economic growth and stock returns. Mahedi (2012) also finds short-run causality stemming from industrial production to stock prices. Furthermore, there is evidence of both short- and long-run causalities from stock returns to industrial production in Germany. For UK, the short- and long-run causalities run from industrial production to stock returns. In contrast, Forson et al. (2013) using Toda-Yamamoto methodology, find negative relation between industrial production index and stock index for Thailand.

3. DATA AND METHODOLOGIES

All variables used in this study are of monthly frequency time-series data covering the period from September 1974 to February, 2017 with total observations of 510 for each variable. The monthly time series data for Nikkei 225 Index (denoted by S) are collected from http://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=143.FM.M.JP.JPY.DS.EI.JAPDOWA.HSTA&periodSortOrder=ASC. Federal Reserve Bank of St. Louis data source is used to obtain data for Consumer Price Index with 2010 as the base-year (denoted by C); Broad money supply (M2 denoted by M); Exchange rate (Yen/US Dollar, denoted by X); and Total Industrial Production Index (denoted by P). Additionally, 5-year Japanese Government Bond rate (denoted by r) are collected using the Economagic.com website. The monthly data for each variable are seasonally unadjusted. The combined graphs of the variables and their first-order differenced series are provided in the Appendix A-D. The econometric software used is STATA 15 version.

3.1. The Toda-Yamamoto-Dolado-Lutkepohl (TYDL) Approach

The popular causality approach follows Granger's (1969) work, which builds on earlier research by Wiener (1956). The notion is one of predictability being synonymous with causality and is based on the idea that a cause cannot come after an effect. We say that "X Granger" causes Y if relevant available past information about X allows us to predict Y better than when past information of X is not used. This methodology is generally appropriate under the assumption of both X and Y being non-stationary.

In situation when X and Y are non-stationary, the standard Granger causality test would be. In such a situation, some form

of error correction framework would be more appropriate to conduct Granger causality tests. In a more commonly used bivariate model, the sequential testing procedure is implemented based on likelihood ratio tests within a dynamic VAR structure introduced by Johansen (1988 and 1991) and Johansen and Juselius (1990). Once the existence of long-run relationships is accepted, their direction of causality is checked on the basis of an error-correction representation by means of a joint significance test of the coefficients. Fugarolas et al. (2007) argue that though co-integration refers to equilibrium in the long run, but there also could be short-run interactive feedback effects. As long as an equilibrium relationship exists in the long run between a pair of series, there must be some Granger causation in at least one direction between them to provide necessary dynamics. Nevertheless, it turns out that there is weakness in this two-step causality approach.

Further, according to Giles and Mirza (1999), this methodology calls for pre-testing unit roots and co-integration before causality testing and the results may suffer from size distortions and inference biases leading to an over rejection of the non-causal null hypothesis. Therefore, there is risk in using Granger causality tests in levels or in difference VAR systems or even in ECMs as shown by Toda and Yamamoto (1995), Rambaldi and Doran (1996), and Zapata and Rambaldi (1997). Nuisance parameters and nonstandard distributions enter the limit theory when either of the required rank conditions is not satisfied in the VECM or the Johansen-Juselius route (Toda and Phillips, 1993; 1994). These studies have shown that the multi-step procedures which test causality conditional on the estimation of a unit root, a co-integration rank and co-integration vectors may suffer from severe pre-test biases. But most of the prevalent studies in this field ignore this issue.

To overcome the above issues, Toda and Yamamoto (1995) and Dolado and Lutkepohl (1996) propose a simple procedure requiring the estimation of an augmented VAR which guarantees the asymptotic distribution of the Wald-Statistic (an asymptotic χ^2 -distribution), since the testing procedure is robust to the integration and co-integration properties of the process. Therefore, unlike previous studies which used the flawed methodology discussed in the preceding paragraph, we employ the more appropriate and robust TYDL Granger Causality tests in this paper. This robust and advanced methodology requires the estimation of an “augmented” or “over-fitted” VAR that is applicable irrespective of the degree of integration or co-integration present in the system. It uses a modified Wald (MWALD) test to verify restrictions on the parameters of the VAR(k) model. This test has an asymptotic χ^2 -distribution with k degrees of freedom in the limit when a VAR [k + d] is estimated (where d is the maximal order of integration for the series in the system).

Four steps are involved in implementing this procedure. The first step involves the determination of the nonstationarity properties and the maximal order of integration (d) in the system. The second step is to determine the true lag length (k) of the VAR system using some suitable information criterion (or criteria). The augmented VARL(k + d) is then estimated

using some suitable estimation method (usually, the SUR, abbreviated for Seemingly Unrelated Regressions technique). The final step is to apply the standard Wald test for the first k VAR coefficient matrix only in order to draw inference on Granger causality while the coefficient matrices of the last d lagged vectors in the model are ignored. As shown by Toda and Yamamoto (1995), Dolado and Lutkepohl (1996) and Rambaldi and Doran (1996), it is enough to add extra and redundant lags in estimating the parameters of the structure to ensure the standard asymptotic properties of the Wald statistic so as to maintain its usual limiting χ^2 distribution. Therefore, the TYDL approach enables the proposed MWALD statistic to ascertain linear or nonlinear restrictions on these k coefficient matrices using the standard asymptotic theory (Fugarolas et al., 2007). More importantly, the TYDL technique avoids the need for the preliminary tests for co-integration. This methodology is applicable irrespective of the degree of integration or the presence/absence of co-integration in the system. This is so because the singularity involved in the asymptotic distributions of the LS estimators is removed by fitting the augmented VARL process whose order exceeds the true lag order by the highest degree of integration in the system. The study undertaken by Giles and Mirza (1999) also show that this augmented lag method performs consistently well over a wide range of systems including near-integrated, stationary and mixed integrated and stationary systems compared to cases for which the previously mentioned pretesting approaches tend to over detect causality (Giles and Williams, 2000a and 2000b).

As in Guru-Gharana (2012), the augmented VARL(k + d) system is shown as follows with six macroeconomic variables in this study:

$$\begin{bmatrix} S_t \\ C_t \\ r_t \\ M_t \\ X_t \\ P_t \end{bmatrix} = \begin{bmatrix} \alpha_s \\ \alpha_c \\ \alpha_r \\ \alpha_M \\ \alpha_X \\ \alpha_P \end{bmatrix} + \sum_{i=1}^k \begin{bmatrix} \beta_{ss,i} & \beta_{sc,i} & \beta_{sr,i} & \beta_{sm,i} & \beta_{sx,i} & \beta_{sp,i} \\ \beta_{cs,i} & \beta_{cc,i} & \beta_{cr,i} & \beta_{cm,i} & \beta_{cx,i} & \beta_{cp,i} \\ \beta_{rs,i} & \beta_{rc,i} & \beta_{rr,i} & \beta_{rm,i} & \beta_{rx,i} & \beta_{rp,i} \\ \beta_{ms,i} & \beta_{mc,i} & \beta_{mr,i} & \beta_{mm,i} & \beta_{mx,i} & \beta_{mp,i} \\ \beta_{xs,i} & \beta_{xc,i} & \beta_{xr,i} & \beta_{xm,i} & \beta_{xx,i} & \beta_{xp,i} \\ \beta_{ps,i} & \beta_{pc,i} & \beta_{pr,i} & \beta_{pm,i} & \beta_{px,i} & \beta_{pp,i} \end{bmatrix} \begin{bmatrix} S_{t-i} \\ C_{t-i} \\ r_{t-i} \\ M_{t-i} \\ X_{t-i} \\ P_{t-i} \end{bmatrix} + \sum_{i=k+1}^{k+d} \begin{bmatrix} \gamma_{ss,i} & \gamma_{sc,i} & \gamma_{sr,i} & \gamma_{sm,i} & \gamma_{sx,i} & \gamma_{sp,i} \\ \gamma_{cs,i} & \gamma_{cc,i} & \gamma_{cr,i} & \gamma_{cm,i} & \gamma_{cx,i} & \gamma_{cp,i} \\ \gamma_{rs,i} & \gamma_{rc,i} & \gamma_{rr,i} & \gamma_{rm,i} & \gamma_{rx,i} & \gamma_{rp,i} \\ \gamma_{ms,i} & \gamma_{mc,i} & \gamma_{mr,i} & \gamma_{mm,i} & \gamma_{mx,i} & \gamma_{mp,i} \\ \gamma_{xs,i} & \gamma_{xc,i} & \gamma_{xr,i} & \gamma_{xm,i} & \gamma_{xx,i} & \gamma_{xp,i} \\ \gamma_{ps,i} & \gamma_{pc,i} & \gamma_{pr,i} & \gamma_{pm,i} & \gamma_{px,i} & \gamma_{pp,i} \end{bmatrix} \begin{bmatrix} S_{t-i} \\ C_{t-i} \\ r_{t-i} \\ M_{t-i} \\ X_{t-i} \\ P_{t-i} \end{bmatrix} + \begin{bmatrix} \epsilon_{st} \\ \epsilon_{ct} \\ \epsilon_{rt} \\ \epsilon_{mt} \\ \epsilon_{xt} \\ \epsilon_{pt} \end{bmatrix}$$

The Granger Non-Causality hypotheses between S and the set of selected macroeconomic variables can be detected using MWALD test on the basis of the following sets of coefficient restrictions:

- i. $H_0: \beta_{sc,i} = 0$ for all $i \leq k \rightarrow$ General price level (inflation) does not Granger cause Stock Returns
- ii. $H_0: \beta_{sr,i} = 0$ for all $i \leq k \rightarrow$ Interest rate does not Granger cause Stock Returns

- iii. $H_0: \beta_{sm,i} = 0$ for all $i \leq k \rightarrow$ Money supply does not Granger cause Stock Returns
- iv. $H_0: \beta_{sx,i} = 0$ for all $i \leq k \rightarrow$ Exchange rate does not Granger cause Stock Returns
- v. $H_0: \beta_{so,i} = 0$ for all $i \leq k \rightarrow$ Industrial Production level does not Granger cause Stock Returns
- vi. $H_0: \beta_{cs,i} = 0$ for all $i \leq k \rightarrow$ stock return does not Granger cause General Price level
- vii. $H_0: \beta_{rs,i} = 0$ for all $i \leq k \rightarrow$ stock return does not Granger cause interest rate
- viii. $H_0: \beta_{ms,i} = 0$ for all $i \leq k \rightarrow$ stock return does not Granger cause Money supply
- ix. $H_0: \beta_{xs,i} = 0$ for all $i \leq k \rightarrow$ stock return does not Granger cause Exchange rate
- x. $H_0: \beta_{ps,i} = 0$ for all $i \leq k \rightarrow$ stock return does not Granger cause Industrial Production level

It is to be noted here that the above-mentioned coefficient restrictions represent our tests for causality between S and the selected five macroeconomic variables. However, our intention is not to test causality among the five letter macroeconomic variables themselves such as between inflation and interest rate or between money supply and interest rate, etc., as shown by the other coefficients in the system above. Those other coefficients serve as control variables.

4. ESTIMATION AND RESULTS

4.1. Unit Root Tests to Establish the Maximum order of Integration in the System

As the first step in the TYDL methodology outlined above, the stationarity properties of the data series are examined. In stationary time series, shocks will be temporary and over time their effects will decay as the series revert to their long-run mean values. In contrast, nonstationary series will contain permanent components and may show false or “spurious” relationships as per Granger and Newbold (1974). Further, Phillips (1987) demonstrated that the Durbin-Watson (DW) statistics converge towards zero, and thus equations that report high R^2 and low DW-value are typical characteristics of spurious correlation in the regressions. It has been well-documented that most macroeconomic variables are nonstationary at their levels. Looking at the combined graphs of the variables in levels and their first-order differenced series in Appendices A and B, one gets the impression that the variables are non-stationary in levels, while their first-order differences seem to be stationary with one or two possible structural breaks. But the visual impression needs to be confirmed by some standard unit root tests.

The present study employs several confirmatory and complementary unit root tests with and without structural breaks because establishing the maximum d-value is the crucial first step in the TYDL methodology. We start with the Dickey-Fuller-Generalized-Least-Squares (DF-GLS) unit root test instead of the popular Augmented Dickey-Fuller (ADF) test for the reasons clearly explained in Baum (2005). The DF-GLS test by Elliott et al. (1996) is more efficient than the standard ADF test since the latter is highly sensitive to lag-selections. To add further, in the DF-GLS

test, the time series is transformed via a generalized least squares (GLS) regression before performing the ADF test. Again, Elliott et al. (1996) have shown that this test has significantly greater power than the previous versions of the augmented Dickey-Fuller test when an unknown mean or trend is present.

As shown in Table 1a below, the DF-GLS test shows presence of unit root (or nonstationarity) in all six variables in levels. As such, we proceed to perform the DF-GLS test on the first-order differenced values of the variables. The results are reported in Table 1b. These two tables clearly show that S, r, X and P are all $I(1)$, while the test is somewhat inconclusive in the case of C and M. The variable C is clearly nonstationary even at first difference (except for first four lags) but gives mixed results at higher order of differences as shown for second order of difference (D2C) in the table. This is true even when higher order of differences is tested (to be provided upon request). Similarly, M shows stationarity only up to 10 lags at first difference (as well as higher order of differences). The first-order differenced values are denoted as DS, DC, Dr, DM, DX and DP, respectively. The second-order differenced series for C is indicated by D2C. The third-order differenced values are not reported to economize on space but can be provided upon request.

Considering the ambiguities in the traditional tests for unit root, we perform a confirmatory Phillips-Perron (PP) test as reported in Table 2 below. The results in Table 2 provide strong evidence that C is $I(0)$ and all other variables are $I(1)$. Since these tests are usually found to be biased towards not rejecting the Null of Unit root, the PP test with greater clarity establishes that d is no more than 1 in our data set. However, before accepting the maximum value of d as 1, it is necessary to examine possible structural breaks in our series spanning over four decades. There is a possibility that d could even be equal to 0. We discuss the issue of structural breaks and corresponding tests below.

4.2. Unit Root Tests with Structural Breaks

A well-known, the weakness of the ADF and the PP unit root tests is in their potential confusion about structural breaks in the series. This may cause them to fail to reject the null hypothesis of unit root, if the series have structural breaks. In other words, for the series that are found to be $I(1)$, there may be a possibility that they are, in fact, stationary around the structural break(s) with $I(0)$, but are erroneously classified as $I(1)$. Perron (1989) shows that failure to allow for an existing break leads to a bias that reduces the ability to reject a false unit root null hypothesis. To overcome this potential problem, allowing for a known or exogenous structural break in the Augmented Dickey-Fuller (ADF) tests is appropriate. To address this issue, Zivot and Andrews (1992) and Perron (1997), proposed determining the break point ‘endogenously’ from the data. We perform the Zivot-Andrews test which has the advantage because it does not require an *a priori* knowledge of the structural break dates. The results of Zivot-Andrews test show highly significant coefficients associated with optimally selected breakpoints for all the variables. The graphs are placed in Appendices C and D. The t-values reported in Table 3 clearly show that X is $I(0)$ and all other variables are $I(1)$.

Table 1a: DF-GLS Test for the Variables in Levels DF-GLS tau (test statistic) and critical values

Lags	1% critical	5% critical	10% critical	S tau	C tau	r tau	M tau	X tau	P tau
18	-3.480	-2.819	-2.537	-1.646	-0.656	-2.821	-2.083	-1.173	-0.987
17	-3.480	-2.823	-2.540	-1.599	-0.583	-2.664	-2.239	-1.112	-1.050
16	-3.480	-2.827	-2.544	-1.604	-0.607	-2.666	-2.246	-1.207	-0.996
15	-3.480	-2.831	-2.547	-1.570	-0.625	-2.591	-2.176	-1.347	-1.080
14	-3.480	-2.835	-2.551	-1.568	-0.565	-2.801	-2.568	-1.449	-1.183
13	-3.480	-2.838	-2.554	-1.524	-0.720	-2.838	-2.797	-1.313	-1.119
12	-3.480	-2.842	-2.557	-1.595	-0.677	-2.881	-3.289	-1.509	-1.223
11	-3.480	-2.845	-2.560	-1.695	-0.084	-2.900	-1.012	-1.595	-1.294
10	-3.480	-2.849	-2.563	-1.651	0.072	-2.823	-1.039	-1.429	-1.422
9	-3.480	-2.852	-2.566	-1.629	-0.113	-2.579	-1.723	-1.384	-1.562
8	-3.480	-2.856	-2.569	-1.576	-0.136	-2.401	-1.370	-1.388	-1.655
7	-3.480	-2.859	-2.572	-1.522	-0.046	-2.216	-1.119	-1.246	-1.620
6	-3.480	-2.862	-2.575	-1.440	0.196	-2.234	-1.105	-1.181	-1.709
5	-3.480	-2.865	-2.578	-1.574	0.357	-2.301	-1.048	-1.289	-1.658
4	-3.480	-2.868	-2.581	-1.516	0.536	-2.208	-0.864	-1.349	-1.605
3	-3.480	-2.871	-2.583	-1.330	0.590	-2.260	-0.919	-1.240	-1.557
2	-3.480	-2.874	-2.586	-1.393	0.545	-2.304	-0.753	-1.055	-1.443
1	-3.480	-2.876	-2.588	-1.505	0.306	-2.586	-1.338	-1.213	-1.197
Stationary	-	-	-	No	No	No	No	No	No

Maxlag=18 chosen by Schwartz criterion; No of Obs.=491 (lag orders reported in descending order for this test by STATA)

Table 1b: DF-GLS Test for the Differenced Variables DF-GLS tau (Test statistic) and critical values

Lags	1% critical	5% critical	10% critical	DS tau	DC tau	Dr tau	DM tau	DX tau	DP tau	D2C tau	D2M tau
18	-3.480	-2.819	-2.537	-3.494***	-1.126	-5.007***	-1.753	-5.313***	-3.284**	-3.442**	-0.143
17	-3.480	-2.823	-2.540	-3.597***	-1.141	-4.613***	-1.943	-5.056***	-3.500***	-3.238**	-0.198
16	-3.480	-2.827	-2.544	-3.825***	-1.165	-4.980***	-1.830	-5.409***	-3.607***	-3.100**	-0.187
15	-3.480	-2.831	-2.547	-3.951***	-1.162	-5.100***	-1.845	-5.331***	-3.988***	-3.025**	-0.339
14	-3.480	-2.835	-2.551	-4.194***	-1.162	-5.386***	-1.935	-5.130***	-4.093***	-2.702*	-0.446
13	-3.480	-2.838	-2.554	-4.376***	-1.190	-5.131***	-1.614	-5.041***	-4.157***	-2.402	-0.533
12	-3.480	-2.842	-2.557	-4.712***	-1.139	-5.190***	-1.462	-5.564***	-4.633***	-2.234	-0.888
11	-3.480	-2.845	-2.560	-4.723***	-1.156	-5.243***	-1.184	-5.224***	-4.743***	-1.901	-1.410
10	-3.480	-2.849	-2.563	-4.652***	-1.598	-5.344***	-4.733***	-5.175***	-4.953***	-1.857	-3.446**
9	-3.480	-2.852	-2.566	-4.997***	-1.889	-5.643***	-5.000***	-5.809***	-5.021***	-1.853	-1.796
8	-3.480	-2.856	-2.569	-5.331***	-1.699	-6.397***	-3.276**	-6.203***	-5.051***	-1.854	-1.959
7	-3.480	-2.859	-2.572	-5.841***	-1.729	-7.202***	-4.242***	-6.487***	-5.203***	-1.952	-4.289***
6	-3.480	-2.862	-2.575	-6.476***	-1.976	-8.319***	-5.483***	-7.427***	-5.709***	-2.106	-5.348***
5	-3.480	-2.865	-2.578	-7.451***	-2.597*	-8.927***	-6.057***	-8.285***	-5.951***	-3.206**	-6.380***
4	-3.480	-2.868	-2.581	-7.443***	-3.306**	-9.460***	-7.108***	-8.394***	-6.674***	-4.167***	-9.160***
3	-3.480	-2.871	-2.583	-8.550***	-4.660***	-11.012***	-10.140***	-8.796***	-7.637***	-6.093***	-14.089***
2	-3.480	-2.874	-2.586	-11.373***	-6.472***	-12.368***	-12.033***	-10.392***	-8.959***	-8.790***	-18.067***
1	-3.480	-2.876	-2.588	-13.240***	-9.013***	-14.562***	-23.045***	-13.729***	-11.519***	-12.945***	-33.094***
Stationary				Yes	No	Yes	Up to 10 lags	Yes	Yes	Mixed	Mixed

Maxlag=18 chosen by Schwartz criterion; No of Obs.=490. Mixed indicates non-conclusive result

Based on the reported unit root test with structural breaks, the hypothesis that $d=1$ is accepted. We can now proceed to implement the TYDL methodology with $d=1$.

4.3. Determination of Optimal Lag Order (k) in the VAR System

The next step is to determine the optimal lag order (k) in the VAR system. We employ several popular criteria allowing up to 20 lags. The results are shown in the Table 4 below. Two criteria FPE and AIC select optimal lag order of 13, HQIC and SBIC select 3, and LR seems to be an outlier with values alternatively rising and falling, although the smallest reported value occurs at lag order 15. Interestingly, both HQIC and SBIC have a small dip at lag order 3 as well as at lag order 13. We accept the conclusion of FPE and

AIC and determine the optimal lag order for the VAR system to be $k = 13$. Thus, our unrestricted augmented VARL(k+d) system is of order $k + d = 13 + 1 = 14$.

4.4. Test for Autocorrelation in Residuals of the VAR (k=13) Model

Before estimating the VARL (k+d=14) model for TYDL causality test, pre-testing of the VAR (k=13) model is conducted for the presence of serial correlation using the Varlmar command of STATA. The test results, based on the Lagrange multiplier test, are reported in Table 5 as follows:

The last column in Table 5 indicates that Null Hypothesis of “No Autocorrelation” cannot be rejected. The above result assured that

Table 2: Phillips-Perron (PP) Test for Unit Root Newey-West Lags=5

Variable	Z (rho) Test Statistic	Z (t) Test Statistic	MacKinnon approximate P value for Z (t)	Stationary
S	-5.711	-1.826	0.3674	No
DS	-351.186***	-16.652***	0.0000	Yes
C	-4.894	-8.498***	0.000	Yes
r	-2.060	-1.187	0.6791	No
Dr	-324.514***	-16.213***	0.0000	Yes
M	0.091	0.351	0.9796	No
DM	-451.804***	-25.085***	0.0000	Yes
X	-4.635	-2.309	0.1690	No
DX	-341.230***	-15.947***	0.0000	Yes
P	-5.213	-2.125	0.2346	No
DP	-577.734***	-22.663***	0.0000	Yes

***denotes significant at 1%; Z (rho) critical values: 1% (-20.700); 5% (-14.100); 10% (-11.300); Z (t) critical values: 1% (-3.430); 5% (-2.860); 10% (-2.570)

the estimating VAR model is well-behaved. Hence, the augmented VARL(14) system is estimated to test Granger causality using the TYDL methodology.

4.5. Estimation of the Augmented VARL(14) System and the Results of Hypotheses Tests

Following the methodology, as discussed above, the following augmented VAR (14) system is estimated.

$$\begin{bmatrix} S_t \\ C_t \\ r_t \\ M_t \\ X_t \\ P_t \end{bmatrix} = \begin{bmatrix} \alpha_s \\ \alpha_c \\ \alpha_r \\ \alpha_m \\ \alpha_x \\ \alpha_p \end{bmatrix} + \sum_{i=1}^{13} \begin{bmatrix} \beta_{ss,i} & \beta_{sc,i} & \beta_{sr,i} & \beta_{sm,i} & \beta_{sx,i} & \beta_{sp,i} \\ \beta_{cs,i} & \beta_{cc,i} & \beta_{cr,i} & \beta_{cm,i} & \beta_{cx,i} & \beta_{cp,i} \\ \beta_{rs,i} & \beta_{rc,i} & \beta_{rr,i} & \beta_{rm,i} & \beta_{rx,i} & \beta_{rp,i} \\ \beta_{ms,i} & \beta_{mc,i} & \beta_{mr,i} & \beta_{mm,i} & \beta_{mx,i} & \beta_{mp,i} \\ \beta_{xs,i} & \beta_{xc,i} & \beta_{xr,i} & \beta_{xm,i} & \beta_{xx,i} & \beta_{xp,i} \\ \beta_{ps,i} & \beta_{pc,i} & \beta_{pr,i} & \beta_{pm,i} & \beta_{px,i} & \beta_{pp,i} \end{bmatrix} \begin{bmatrix} S_{t-i} \\ C_{t-i} \\ r_{t-i} \\ M_{t-i} \\ X_{t-i} \\ P_{t-i} \end{bmatrix} + \begin{bmatrix} \gamma_{ss,14} & \gamma_{sc,14} & \gamma_{sr,14} & \gamma_{sm,14} & \gamma_{sx,14} & \gamma_{sp,14} \\ \gamma_{cs,14} & \gamma_{cc,14} & \gamma_{cr,14} & \gamma_{cm,14} & \gamma_{cx,14} & \gamma_{cp,14} \\ \gamma_{rs,14} & \gamma_{rc,14} & \gamma_{rr,14} & \gamma_{rm,14} & \gamma_{rx,14} & \gamma_{rp,14} \\ \gamma_{ms,14} & \gamma_{mc,14} & \gamma_{mr,14} & \gamma_{mm,14} & \gamma_{mx,14} & \gamma_{mp,14} \\ \gamma_{xs,14} & \gamma_{xc,14} & \gamma_{xr,14} & \gamma_{xm,14} & \gamma_{xx,14} & \gamma_{xp,14} \\ \gamma_{ps,14} & \gamma_{pc,14} & \gamma_{pr,14} & \gamma_{pm,14} & \gamma_{px,14} & \gamma_{pp,14} \end{bmatrix} \begin{bmatrix} S_{t-14} \\ C_{t-14} \\ r_{t-14} \\ M_{t-14} \\ X_{t-14} \\ P_{t-14} \end{bmatrix} + \begin{bmatrix} \varepsilon_{st} \\ \varepsilon_{ct} \\ \varepsilon_{rt} \\ \varepsilon_{mt} \\ \varepsilon_{xt} \\ \varepsilon_{pt} \end{bmatrix}$$

The tables containing results of VARL estimation are too large to report here. After VARL estimation, the hypotheses for MWALD test are as follows:

- i. $H_0: \beta_{sc,i} = 0$ for all $i \leq 13 \rightarrow$ General price level (inflation) does not Granger cause Stock Market Returns
- ii. $H_0: \beta_{sr,i} = 0$ for all $i \leq 13 \rightarrow$ Interest Rate does not Granger cause Stock Market Returns
- iii. $H_0: \beta_{sm,i} = 0$ for all $i \leq 13 \rightarrow$ Money Supply does not Granger cause Stock Market Returns
- iv. $H_0: \beta_{sx,i} = 0$ for all $i \leq 13 \rightarrow$ Exchange Rate does not Granger cause Stock Market Returns
- v. $H_0: \beta_{sp,i} = 0$ for all $i \leq 13 \rightarrow$ Industrial Production does not Granger cause Stock Market Returns

Table 3: Zivot-Andrews Unit Root Test For Structural Breaks in Both Intercept and Trend (Lag selection via AIC)

Variable	Minimum t-statistic	At (Break point)	Stationary
S	-3.295	1990m8 (Obs. 192)	No
DS	-10.918***	1990m1 (Obs. 185)	Yes
C	-3.913	2008m11 (Obs. 411)	No
DC	-11.550***	1998m12 (Obs. 292)	Yes
r	-4.047	1995m2 (Obs. 246)	No
Dr	-15.223***	1990m10 (Obs. 194)	Yes
M	-2.163	1986m11 (Obs. 147)	No
DM	-11.862***	1991m1 (Obs. 197)	Yes
X	-5.183**	1985m10 (Obs. 134)	Yes
DX	-11.217***	1982m11 (Obs. 99)	Yes
P	-4.573	1987m6 (Obs. 154)	No
DP	-14.187***	2009m4 (Obs. 4165)	Yes

Critical values: 1%: -5.57 5%: -5.08 10%: -4.82

Table 4: VAR Lag-Selection Criteria and Results. Sample: 1976m5-2017m2 Number of Observations = 490; Variables: S, C, r, M, X, P; Exogenous: Constant Selection Criteria

Lag	LR	FPE	AIC	HQIC	SBIC
0	n.a.	904e + 19	63.03118	63.032	63.031
1	13154	2.4e + 08	36.3138	36.455	36.6734
2	231.11	1.7e + 08	35.9891	36.2513	36.6568
3	283.93	1.1e + 08	35.5566	35.9399*	36.5325*
4	74.169	1.1e + 08	35.5522	36.0565	36.8362
5	59.632	1.1e + 08	35.5774	36.2027	37.1696
6	111.64	1.1e + 08	35.4965	36.2429	37.3968
7	58.822	1.1e + 08	35.5234	36.3908	37.7319
8	53.525	1.1e + 08	35.5611	36.5495	38.0778
9	87.409	1.1e + 08	35.5297	36.6391	38.3545
10	69.483	1.1e + 08	35.5348	36.7352	38.6678
11	116.28	1.0e + 08	35.4444	36.7959	38.8856
12	67.597	1.0e + 08	35.4534	36.9259	39.2027
13	566.621	3.7e + 07*	34.4444*	36.0375	38.5015
14	55.984	3.9e + 07	34.4767	36.1912	38.8423
15	29.211	4.2e + 07	34.564	36.3996	39.2378
16	53.633	4.4e + 07	34.6015	36.5581	39.5834
17	40.526	4.8e + 07	34.6657	36.7433	39.9558
18	42.667	5.1e + 07	34.7256	36.9242	40.3239
19	53.619	5.3e + 07	34.7631	37.0828	40.6695
20	64.399*	5.5e + 07	34.7786	37.2193	40.9932

LR: Sequential modified Likelihood Ratio test statistic; FPE: Final Prediction Error; AIC: Akaike Information Criterion; HQIC: Hannan-Quinn Information Criterion; SBIC: Schwarz-Bayesian Information Criterion

Table 5: Lagrange-Multiplier test for Autocorrelation

Lag	Chi-square	df	Prob>Chi-square
1	39.0309	36	0.33514
2	31.3893	36	0.68756

H0: No autocorrelation at lag order; Critical values: 1% 58.619; 5% 50.998; 10% 47.212

- vi. $H_0: \beta_{cs,i} = 0$ for all $i \leq 13 \rightarrow$ Stock Market Returns do not Granger cause changes in General Price level
- vii. $H_0: \beta_{rs,i} = 0$ for all $i \leq 13 \rightarrow$ Stock Market Returns do not Granger cause Interest Rate
- viii. $H_0: \beta_{ms,i} = 0$ for all $i \leq 13 \rightarrow$ Stock Market Return do not Granger cause Money Supply
- ix. $H_0: \beta_{xs,i} = 0$ for all $i \leq 13 \rightarrow$ Stock Market Returns do not Granger cause Exchange Rate

Table 6: TYDL multivariate granger non-causality test results

Null	Chi-square (df=13)	P-value	Inference
i. General price level (inflation) does not Granger cause Stock Market Returns	9.63	0.7240	Cannot reject Null even at 10%
ii. Interest Rate does not Granger cause Stock Market Returns	23.36**	0.0375	Reject Null at 5%
iii. Money Supply not Granger cause Stock Market Returns	17.51	0.1772	Cannot reject Null even at 10%
iv. Exchange Rate does not Granger cause Stock Market Returns	9.27	0.7522	Cannot reject Null even at 10%
v. Industrial Production does not Granger cause Stock Market Returns	25.61**	0.0192	Reject Null at 5%
vi. Stock Market Returns do not Granger cause Changes in General Price Level	12.03	0.5252	Cannot reject Null even at 10%
vii. Stock Market Returns do not Granger cause Interest Rate	18.85	0.1279	Cannot reject even at 10%
viii. Stock Market Returns do not Granger cause Money Supply	32.90***	0.0018	Reject Null even at 1%
ix. Stock Market Returns do not Granger cause Exchange Rate	12.90	0.4552	Cannot reject Null even at 10%
x. Stock Market Returns do not Granger cause Industrial Production	31.97***	0.0024	Reject Null even at 1%

Critical values: 1% 13.277; 5% 9.488 and 10% 7.779

- x. $H_0: \beta_{ps,i} = 0$ for all $i \leq 13 \rightarrow$ Stock Market Returns do not Granger cause Industrial Production

The results of MWALD test on the above ten null hypotheses are shown in Table 6 below with the null hypotheses numbers running from (i) to (x).

The TYDL Granger causality tests result on the above-mentioned ten null hypotheses are reported in Table 6. Comparing the results two null hypotheses reported under (i) and (vi), none can be rejected at the conventional significance level. This it seems that there is no causal connection between stock market returns and inflation. Similarly, comparing (ii) with (vii), while the null hypothesis in (ii) is rejected but not that in (vii). As such it is concluded that interest rate causes stock market returns but not the other way around (unidirectional causality). In comparing (iii) with (viii), while (iii) could not be rejected but (viii) is rejected, indicating that stock market returns have a unidirectional causal effect on money supply. Further, comparing (iv) with (ix), none of the null hypotheses could be rejected; hence, there seem to be no causal linkage between exchange rate and stock market returns. Finally, comparing (v) with (x), both null hypotheses could be rejected; indicating that the stock market returns, and industrial production have bi-directional causal relationship between them.

Below we give some more economic interpretation of the above results briefly for the cases where causality in either direction is established. Firstly, with respect to the bidirectional causality between the stock market and industrial production, industrial production rises due to surges in consumer demand resulting in better profit prospects for firms. As sales and profits rise, stock prices go up. The reverse is also true. Again, if stock market acts as a leading economic indicator, industrial production will expand. So, the evidence of bi-directional causal flows between them is meaningful in economic and financial terms. Secondly, with respect to the unidirectional causality from stock market to money supply, as stock market gains momentum, the transaction and speculative components of aggregate money demand increase. To match higher money demand, the Bank of Japan seems to increase money supply. So, improved stock market performance leads to increase in money supply, although it apparently seems somewhat counterintuitive. Thirdly, for the unidirectional causality from interest rate to stock market returns, as the interest rate (bond yield) declines as a result of higher bond prices, the stock market

might be offering relatively higher risk-adjusted return. As a result, investors' degree of risk aversion might diminish, resulting in greater investment in common stocks reflecting the substitution effect. In other words, stock market gains at the expense of bond market as a usual case via the interest rate channel.

As for the relationship involving exchange rate and stock market returns, it seems that there is no causal linkage between them in any direction for Japan. This can be explained as follows: Nikkei 225 is a broad mix of export- and import-oriented firms, among others. As yen depreciates against major key currencies (e.g., US dollar, Euro), exporting firms will earn higher profit in yen and importing firms' profit will shrink following higher cost of imported input. The converse is also true. Consequently, share prices of exporting firms will rise, while those of importing firms will fall meaning they will move in opposite directions. Their net impact on the stock market is thus likely to be negligible or neutral. Finally, with respect to the finding about no causal linkage between the stock market returns and inflation, Japanese inflation expectations have remained very subdued over the last several decades due to lackluster consumption demand and poor economic performance. Moreover, the inflation rate has been stubbornly far below the 2 percent target. Thus, general price level has no bearing for Japan's stock market over the sample period.

It is to be mentioned here that the above results are obtained after controlling for other variables in the model in our multivariate TYDL based Granger causality study. In contrast, most previous studies on Japan failed to use a multivariate causality framework. Besides, this study have utilized a very large high frequency (monthly) data set for many years on relationships involving six macroeconomic variables with ten null hypotheses tested. As such, the results in this study are arguably superior and more robust than previous studies on Japan.

5. CONCLUSIONS

To summarize, we find some interesting and apparently a few somewhat counterintuitive results based on the TYDL causality tests. The only statistically significant bi-directional causality exists between stock market index and total industrial production index. This is expected as stock market and industrial sector are generally believed to be intertwined through mutually reinforcing feedback effects. There is evidence of unidirectional causality from

interest rate (bond yield) changes to stock market performance. Somewhat counterintuitively, causality stems from positive stock market performance to monetary expansion. For the other two variables, no causal connection in either direction were detected between exchange rate and stock market index and between prices (inflation) stock market index.

As for policy implications, the Bank of Japan should not unduly pivot on inflation and exchange rate movement to design monetary policy, given the decades-long pessimistic economic circumstances. Appropriate policy measures should simultaneously focus on both stock market development and industrial expansion, although this is a very difficult task in view of lackluster consumption demand. Overly expansionary monetary policy and accompanying ultra-low interest rate did not succeed in improving the overall economy. Ultra-low interest rate environment has seemingly contributed to the formation of liquidity trap wherein expansionary fiscal policy should work. More importantly, policy makers in Japan face serious structural economic challenges that may not necessarily be successfully tackled with the traditional macroeconomic policies. For policy makers, there is a growing need for new and creative policy thinking for mitigating the chronic economic ills, if not probably curing them altogether. The monetary policy of Japan is overburdened with no much firepower left. The Bank of Japan has to reconsider it and should prepare for fiscal stimulus.

In closing, the findings of this study should be considered with due caution since they vary from one sample period to another, and from one country to another, depending on the applications of econometric techniques, data coverage, estimating model selection, variables used, types of data used, etc., as we found in the literature review. So, there are no wonders for obtaining empirical mixed evidence on this topic of great importance. However, the results of this study are based on relatively more robust estimations utilizing a very large number of monthly observations to date. To our knowledge, no previous studies applied such advanced multivariate Granger causality tests to investigate this issue. However, this study may have several other shortcomings.

REFERENCES

- Abdalla, I.S., Murinde, V. (1997), Exchange rate and stock price interactions in emerging financial markets: Evidence on India, Korea, Pakistan and the Philippines. *Applied Financial Economics*, 7, 25-35.
- Alatiqi, S., Fazel, S. (2008), Can money supply predict stock prices? *Journal for Economic Educators*, 8, 54-59.
- Bahmani-Oskooee, M., Sohrabian, A. (1992), Stock prices and the effective exchange rate of the dollar. *Applied Economics*, 24, 459-464.
- Baum, C.F. (2005), Stata: The language of choice for time-series analysis? *The Stata Journal* 5(1), 46-63.
- Bhat, K.U., Shah, S.Z. (2015), Empirical investigation of the relationship between exchange rate movements and stock market volatility in the context of Pakistan. *Pakistan Business Review*, 814, 744-758.
- Bhattacharya, B., Mukherjee, J. (2005), An Analysis of Stock Market Efficiency in the Light of Capital Inflows and Exchange Rate Movements: The Indian Context. Annual Conference of Money and Finance. Mumbai: Indira Gandhi Institute of Development Research.
- Bodnar, G., Gentry, W. (1993), Exchange rate exposure and industry characteristics-evidence from Canada, Japan and USA. *Journal of International Money and Finance*, 12(1), 29-45.
- Brahmasrene, T., Jiranyakul, K. (2007), Cointegration and causality between stock index and macroeconomic variables in an emerging market. *Academy of Accounting and Financial Studies Journal*, 11, 17-30.
- Brunie, C.H., Hamburger, M.J., Kochin, L.A. (1972), Money and stock prices: The channels of influence. *The Journal of Finance*, 27, 231-249.
- Buyuksalvarci, A. (2010), The effects of macroeconomics variables on stock returns: Evidence from Turkey. *European Journal of Social Sciences*, 14, 404-416.
- Buyuksalvarci, A., Abdioglu, H. (2010), The causal relationship between stock prices and macroeconomic variables: A case study for Turkey. *International Journal of Economic Perspectives*, 4, 601.
- Chandra, P.P. (2007), The nexus between stock market and economic activity: An empirical analysis for India. *International Journal of Social Economics*, 34, 741-753.
- Chatrath, A., Ramchander, S., Song, F. (1997), Stock prices, inflation and output: Evidence from India. *Applied Financial Economics*, 7, 439-445.
- Chen, N.F., Roll, R., Ross, S.A. (1986), Economic forces and the stock market. *Journal of Business*, 59(3), 383-403.
- Christie-David, R., Chaudhry, M., Koch, T.W. (2000), Do macroeconomics news releases affect gold and silver prices? *Journal of Economics and Business*, 52, 405-421.
- Cooper, R.V. (1974), Efficient capital markets and the quantity theory of money. *The Journal of Finance*, 29, 887-908.
- Cutler, D.M., Poterba, J.M., Summers, L.H. (1990), Speculative Dynamics and the Role of Feedback Traders, National Bureau of Economic Research.
- Dolado, J.J., Lütkepohl, H. (1996), Making Wald tests work for cointegrated VAR systems. *Econometric Reviews*, 15, 369-386.
- Dornbusch, R., Fischer, S. (1980), Exchange rates and the current account. *The American Economic Review*, 70, 960-971.
- Elliott, G., Rothenberg, T.J., Stock, J.H. (1996), Efficient tests for an autoregressive unit root. *Econometrica*, 64, 813-836.
- Fama, E.F. (1965a), Portfolio analysis in a stable Paretian market. *Management Science*, 11, 404-419.
- Fama, E.F. (1965b), The behavior of stock-market prices. *The Journal of Business*, 38, 34-105.
- Fama, E.F. (1976), Efficient capital markets: Reply. *The Journal of Finance*, 31, 143-145.
- Fama, E.F. (1990), Stock returns, expected returns, and real activity. *The Journal of Finance*, 45, 1089-1108.
- Fama, E.F. (1991), Efficient capital markets: II. *The Journal of Finance*, 46, 1575-1617.
- Fama, E.F., Schwert, G.W. (1977), Asset returns and inflation. *Journal of Financial Economics*, 5, 115-146.
- Flannery, M.J., Protopapadakis, A.A. (2002), Macroeconomic factors do influence aggregate stock returns. *The Review of Financial Studies*, 15, 751-782.
- Forsor, J., Janrattanagul, J., Carsamer, E. (2013), Culture Matters: A Test of Rationality on Economic Growth.
- Fugarolas, G., Manalich, I., Matesanz, D. (2007), Are Exports Causing Growth? Evidence on International Trade Expansion in Cuba, 1960-2004.
- Gavin, M. (1989), The stock market and exchange rate dynamics. *Journal of International Money and Finance*, 8, 181-200.
- Geske, R., Roll, R. (1983), The fiscal and monetary linkage between stock returns and inflation. *The Journal of Finance*, 38, 1-33.
- Gibson, G. (1889), *The Stock Markets of London, Paris and New York*. New York: G.P. Putnam's Sons.

- Giles, J.A., Williams, C.L. (2000a), Export-led growth: A survey of the empirical literature and some non-causality results. Part 1. *The Journal of International Trade and Economic Development*, 9, 261-337.
- Giles, J.A., Williams, C.L. (2000b), Export-led growth: A survey of the empirical literature and some non-causality results. Part 2. *Journal of International Trade and Economic Development*, 9, 445-470.
- Giles, J.A., Mirza, S. (1999), *Some Pretesting Issues on Testing for Granger Non-causality*. Canada: Department of Economics, University of Victoria.
- Giri, A.K., Joshi, P. (2017), The impact of macroeconomic indicators on Indian stock prices: An empirical analysis. *Studies in Business and Economics*, 12, 61-78.
- Granger, C.W. (1969), Investigating causal relations by econometric models and cross-spectral methods. *Econometrica: Journal of the Econometric Society*, 37(3), 424-438.
- Granger, C.W.J., Newbold, P. (1974), Aspurious regressions in econometrics. *Journal of Econometrics*, 2(1), 111-120.
- Greenwood, J., Hanke, H.S. (2019), *Magical monetary theory*. Wall Street Journal, 2019, 1-4.
- Gujarati, D.N., Porter, D.C. (2003), *Basic Econometrics*. 4th ed. New York: McGraw-Hill.
- Gunasekarage, A., Pisedtasalasai, A., Power, D.M. (2004), Macroeconomic influence on the stock market: Evidence from an emerging market in South Asia. *Journal of Emerging Market Finance*, 3, 285-304.
- Guru-Gharana, K.K., Rahman, M., Parayitam, S. (2008), Influences of selected macroeconomic variables on U.S. stock market returns and their predictability over varying time horizons. *Academy of Accounting and Financial Studies Journal*, 13(1), 13-32.
- Guru-Gharana, K.K. (2012), Econometric investigation of relationships among export, FDI and growth in India: An application of Toda-Yamamoto-Dolado-Lutkepohl Granger causality test. *Journal of Developing Areas*, 46(2), 231-247.
- Hashemzadeh, N., Taylor, P. (1988), Stock prices, money supply, and interest rates: The question of causality. *Applied Economics*, 20, 1603-1611.
- Hernandez-Trillo, F. (1999), Financial derivatives introduction and stock return volatility in an emerging market without clearinghouse: The Mexican experience. *Journal of Empirical Finance*, 6, 153-176.
- Homa, K.E., Jaffee, D.M. (1971), The supply of money and common stock prices. *The Journal of Finance*, 26, 1045-1066.
- Hosseini, S.M., Ahmad, Z., Lai, Y.W. (2011), The role of macroeconomic variables on stock market index in China and India. *International Journal of Economics and Finance*, 3, 233.
- Hsing, Y. (2011a), Macroeconomic determinants of the stock market index and policy implications: The case of a central European country. *Eurasian Journal of Business and Economics*, 4, 1-11.
- Hsing, Y. (2011b), The stock market and macroeconomic variables in a BRICS country and policy implications. *International Journal of Economics and Financial Issues*, 1, 12-18.
- Humpe, A., Macmillan, P. (2009), Can macroeconomic variables explain long-term stock market movements? A comparison of the US and Japan. *Applied Financial Economics*, 19, 111-119.
- Tiwari, A.K., Islam, A.M., Islam, M. (2019), Relationship between exchange rate and equity prices in an emerging market: A continuous wavelet-based analysis for Bangladesh. *International Journal of Business and Economics*, 18(2), 165-186.
- Johansen, S. (1988), Statistical analysis of co-integrating vectors. *Journal of Economic Dynamics and Control*, 12, 231-245.
- Johansen, S. (1991), Estimation and hypothesis testing of co-integration vectors in Gaussian vector autoregressive models. *Econometrica*, 59, 1551-1580.
- Johansen, S., Juselius, K. (1990), Maximum likelihood estimation and inference on co-integration-with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52, 169-210.
- Jorion, P. (1991), The pricing of exchange rate risk in the stock market. *Journal of Financial and Quantitative Analysis*, 26, 363-376.
- Kandir, S.Y. (2008), Macroeconomic variables, firm characteristics and stock returns: Evidence from Turkey. *International Research Journal of Finance and Economics*, 16, 35-45.
- Kimura, T., Koruzomi, T. (2003), Optimal monetary policy in a micro-founded model with parameter uncertainty. *Journal of Economic Dynamics and Control*, 31(2), 399-432.
- Kuwornu, J.K., Owusu-Nantwi, V. (2011), Macroeconomic variables and stock market returns: Full information maximum likelihood estimation. *Research Journal of Finance and Accounting*, 2, 49-63.
- Love, J., Chandra, R. (2005a), Testing export-led growth in Bangladesh in a multivariate VAR framework. *Journal of Asian Economics*, 15, 1155-1168.
- Love, J., Chandra, R. (2005b), Testing export-led growth in South Asia. *Journal of Economic Studies*, 32, 132-145.
- Ma, C.K., Kao, G.W. (1990), On exchange rate changes and stock price reactions. *Journal of Business Finance and Accounting*, 17, 441-449.
- Mahedi, M. (2012), Electricity consumption and economic growth. *Global Journal of Management and Business Research*, 12, 46-56.
- Maysami, R.C., Koh, T.S. (2000), A vector error correction model of the Singapore stock market. *International Review of Economics and Finance*, 9, 79-96.
- Maysami, R.C., Loo, S.W., Koh, T.K. (2004), Co-movement among sectoral stock market indices and co-integration among dually listed companies. *Journal Pengurusan*, 23, 33-52.
- McMillan, D.G. (2005), Non-linear dynamics in international stock market returns. *Review of Financial Economics*, 14, 81-91.
- Mukherjee, T.K., Naka, A. (1995), Dynamic relations between macroeconomic variables and the Japanese stock market: An application of a vector error correction model. *Journal of Financial Research*, 18, 223-237.
- Naik, P.K., Padhi, P. (2012), Interaction of Macroeconomic Factors and Stock Market Index: Empirical Evidence from Indian Data.
- Nieh, C.C., Lee, C.F. (2001), Dynamic relationship between stock prices and exchange rates for G-7 countries. *The Quarterly Review of Economics and Finance*, 41, 477-490.
- Osamwonyi, I., Evbayiro, E. (2012), The relationship between macroeconomic variables and stock market index in Nigeria. *Journal of Economics*, 3(1), 55-63.
- Pal, K., Mittal, R. (2011), Impact of macroeconomic indicators on Indian capital markets. *The Journal of Risk Finance*, 12, 84-97.
- Peiró, A. (2016), Stock prices and macroeconomic factors: Some European evidence. *International Review of Economics and Finance*, 41, 287-294.
- Perron, P. (1989), The great crash, the oil price shock, and the unit root hypothesis. *Econometrica*, 57, 1361-1401.
- Perron, P. (1997), Further evidence on breaking trend functions in macroeconomic variables. *Journal of Econometrics*, 80, 355-385.
- Phillips, P.C.B. (1987), Time series regression with a unit root. *Econometrica*, 55(2), 277-301.
- Rahman, A.A., Sidek, N.Z., Tafri, F.H. (2009), Macroeconomic determinants of Malaysian stock market. *African Journal of Business Management*, 3, 95-106.
- Rahman, M.L., Uddin, J. (2009), Dynamic relationship between stock prices and exchange rates: Evidence from three South Asian countries. *International Business Research*, 2, 167.
- Rambaldi, A.N., Doran, H.E. (1996), *Testing for Granger Non-Causality in Co-integrated Systems Made Easy*. New England: Department of Econometrics, University of New England.
- Ratanapakorn, O., Sharma, S.C. (2007), Dynamic analysis between the

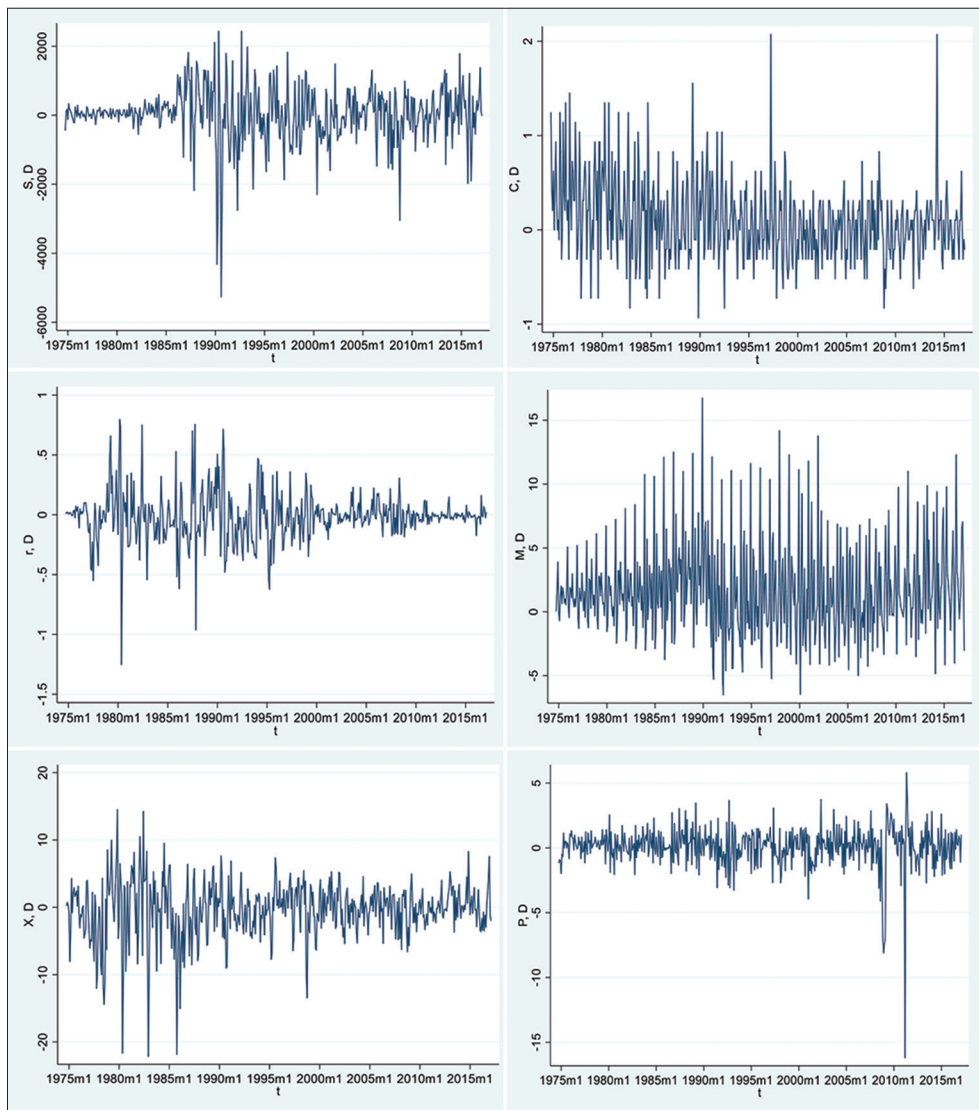
- US stock returns and the macroeconomic variables. *Applied Financial Economics*, 17, 369-377.
- Rogalski, R.J., Vinso, J.D. (1977), Stock returns, money supply and the direction of causality. *The Journal of Finance*, 32, 1017-1030.
- Rozeff, M.S. (1974), Money and stock prices. *Journal of Financial Economics*, 1, 245-302.
- Samuelson, P. (1965), Proof that properly anticipated prices fluctuate randomly. *Industrial Management Review*, 6, 41-49.
- Shaharudin, R.S., Fung, H.S. (2009), Does size really matter? A study of size effect and macroeconomic factors in Malaysian stock returns. *International Research Journal of Finance and Economics*, 24, 101-116.
- Smith, C.E. (1992), Stock markets and the exchange rate: A multi-country approach. *Journal of Macroeconomics*, 14, 607-629.
- Sohail, N., Hussain, Z. (2009), Long-run and short-run relationship between macroeconomic variables and stock prices in Pakistan: The case of Lahore stock exchange. *Pakistan Economic and Social Review*, 47(2), 183-198.
- Stock, J.H., Watson, M.W. (2001), Vector auto-regressions. *Journal of Economic Perspectives*, 15, 101-115.
- Toda, H.Y., Phillips, P.C. (1993), Vector auto-regressions and causality. *Econometrica: Journal of the Econometric Society*, 61(6), 1367-1393.
- Toda, H.Y., Phillips, P.C. (1994), Vector auto-regression and causality: A theoretical overview and simulation study. *Econometric Reviews*, 13, 259-285.
- Toda, H.Y., Yamamoto, T. (1995), Statistical inference in vector auto-regressions with possibly integrated processes. *Journal of Econometrics*, 66, 225-250.
- Wiener, N. (1956), *The Theory of Prediction*, Modern Mathematics for Engineers.
- Wongbangpo, P., Sharma, S.C. (2002), Stock market and macroeconomic fundamental dynamic interactions: ASEAN-5 countries. *Journal of Asian Economics*, 13, 27-51.
- Zapata, H.O., Rambaldi, A.N. (1997), Monte Carlo evidence on co-integration and causation. *Oxford Bulletin of Economics and Statistics*, 59, 285-298.
- Zivot, E., Andrews, D.W.K. (1992), Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of Business and Economic Statistics*, 10, 251-270.
- Zubair, A. (2013), Causal relationship between stock market index and exchange rate: Evidence from Nigeria. *CBN Journal of Applied Statistics*, 4, 87-110.

APPENDIX

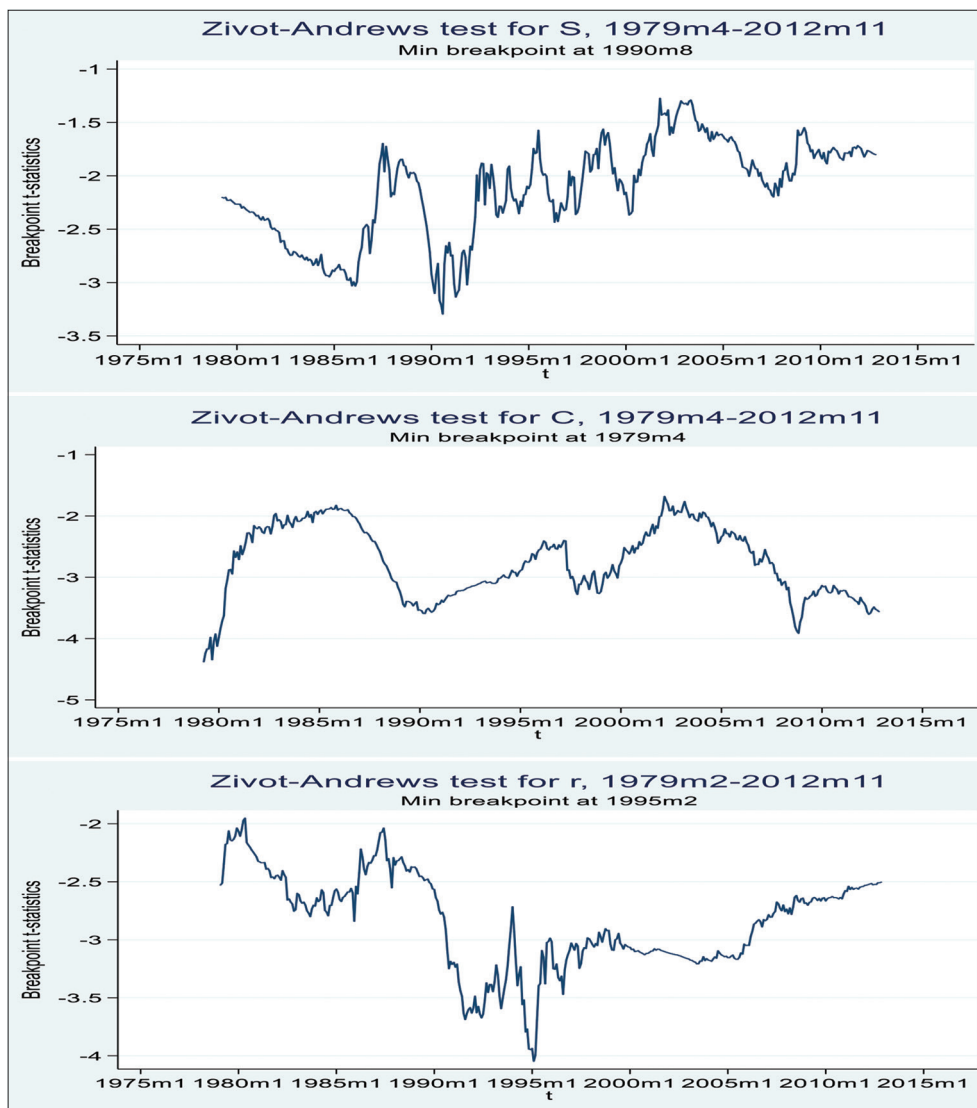
Appendix A: Timeline plot of variables (1974-2017)



Appendix B: Timeline plots of first differences of variables



Appendix C: Graphs of Zivot-Andrews Test for S, C and r (Lagmethod [AIC] Break [both])



Appendix D: Graphs of Zivot-Andrews Test for M, X and P (Lagmethod [AIC] Break [both])

