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# Inflation, Inflation Expectations and Investment Performance Volatility: Evaluating Potential Causal Interactions

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**Abstract**

This study explores trend dynamics and potential causal interactions among three core macroeconomic conditions/variables. Employing modified Granger causality estimation method propounded by Toda-Yamamoto, this study finds significant bidirectional and uni-directional causal interactions among variables tested even after controlling for other key macroeconomic conditions/variables. Empirical results for instance, suggest significant mutual causal interactions between inflation expectations and measured or prevailing inflation; with relatively stronger causal influence emanating from measured inflation towards inflation expectations. Similar mutual or bi-directional causal interaction between inflation expectations and investment performance volatility with stronger causal influence running from inflation expectations is also found. Our results however, found only uni-directional causal interaction between inflation and investment performance volatility with direction influence emanating from measured inflation towards investment performance volatility.

**Keywords:** inflation, inflation expectations, investment performance volatility, causality, Toda-Yamamoto test

## 1. Introduction

Understanding underlying relationship between measured inflation and inflation expectations, and how the interaction between the two conditions ultimately impacts investment behavior, is one of the key macroeconomic issues confronting most policy makers. Over the years, this interest has spurred efforts geared towards understanding evolving effects of the relationship to inform policy measures geared towards insulating critical economic indicators from such effects. Reviewed literature suggests significant progress in our understanding of the dynamic relationship between the two macroeconomic conditions; and how the relationship impacts economic activity. However, despite significant inroads made, policy documents published by agencies such as the US Federal Reserve, Bureau of Economic Analysis etc. suggest significant divergent views on the causal nature of the interaction between the two macroeconomic conditions; and how the condition impact key economic indicators. Reviewed evidence for instance, diverge on whether there exists a uni-directional or feedback effect between the two macroeconomic conditions. The ongoing discussions on the potential effect of the interactions between inflation and inflation expectations according to our review, have been driven in part, by two main factors. The first, is the growing evidence suggesting that the interaction between the two macroeconomic conditions has the potential to influence key macroeconomic indicators defining the strength of an economy, such as consumption and GDP growth. The second factor; relates to the frequency with which anticipated effects of the relationship garner attention in policy seminars and economic conferences focusing on macroeconomic policy and price instability. Together, these factors continue to fuel ongoing discussions shaping our understanding of the effects of the interactions between inflation and inflation expectations. Policy discussions focusing on the relationship in question, often seem to suggest a definite causal interaction between the two macroeconomic conditions; however, it is cogent to point out that academic views on the exact direction of causal interactions between the two macroeconomic conditions (inflation and inflation expectations) still differs significantly and continue to evolve with complexities of modern macroeconomic environment.

A critical examination of present divergent views on causal interaction between inflation and inflation expectations suggests that, the difficulty in arriving at a consistent form of causal interactions between the two macroeconomic conditions could be attributed to legion of factors. Prominent among them, is the transient nature of macroeconomic conditions; this argument suggest that the potential always exist for underlying process by

which one variable (e.g. inflation expectations) influence the other (measured inflation) to change over time in an evolving macroeconomic environment. In order words, lack of permanency of macroeconomic conditions prevents static and consistently verifiable interactions among some macroeconomic conditions such as inflation and inflation expectations. Additionally, it has also been argued that the transitory nature of expectation formation among economic agents (consumers, investors etc.) about macroeconomic conditions tend to impact the nature of a specific variable (inflation expectations) through time, and its interactions with other macroeconomic variables of interest. That is, changes in the manner in which expectations are formed among economic agents about an economic condition could influence how such condition (such as inflation expectations) impacts other variables and vice versa. In order words, if economic agents anticipates significant increases in the general price levels, its impact on current economic activity may depend on how long they hold on to such expectations or how severe they measure such expectations.

The objective of this study, is to employ proven econometric procedures to address specific macroeconomic questions relating to the historical interaction between inflation and inflation expectations; and how effects of the relationship influences investment behavior. Apart from legion of potential policy implication which could be deduced from this study's findings; the primary objective however, is to address the following: whether prevailing inflationary conditions tend to reflects or is caused by projected inflationary expectations and vice versa. In order words, this study tests for causal interaction if any, between inflation expectations and realized inflation; and the extent to which these conditions impact investment performance behavior.

### *1.1 Making the Case for the Study*

Apart from the rational already articulated above, this study has also been informed to a large extent by policy statements in the literature surmising significant causal relationship between inflation and inflation expectations. For instance, this study has been influenced significantly by related statements by former chairman of the US Federal Reserve Ben Bernanke. In a policy address in Bernanke (2004), which forms part of periodic forum during which the Federal Reserve seeks to provide some form of forward guidance on its expectations, the former chairman intimated direct association between inflation expectations and prevailing inflation in the following statement: "An essential prerequisite to controlling inflation is controlling inflation expectations". This statement, all things being equal, suggests that realized inflation ultimately mimics or reflects inflation expectations among rational economic agents in a macroeconomic environment. In other words, his statement suggests inflation expectation, all things being equal; Granger cause variability in prevailing inflationary conditions. This earlier position was further re-echoed in Bernanke (2007), in which the former chairman of the Federal Reserve again made the following statement: "Undoubtedly, the state of inflation expectations greatly influences actual inflation and thus the central bank's ability to achieve price stability". Together, these statements pertaining to macroeconomic interactions between the two variables in discussion, alludes to some form of causal relationship; and this study seeks to verify this projected causal interactions between the two macroeconomic conditions. Below is the full excerpt of the statement by the former chairman of the Federal Reserve articulating the dynamic relationship between inflation and inflation expectations.

"*Undoubtedly, the state of inflation expectations greatly influences actual inflation and thus the central bank's ability to achieve price stability. But what do we mean, precisely, by "the state of inflation expectations"? How should we measure inflation expectations, and how should we use that information for forecasting and controlling inflation? I certainly do not have complete answers to those questions, but I believe that they are of great practical importance. I hope my remarks here will stimulate some of you to work on these issues*" *Bernanke (2007).*

This study hinges on the view that if the above statements are consistent with available data, then the condition suggest some form of causal relationship between expected inflation or forecasted inflation by economic agents, and prevailing inflation. It is important however, to also point out that these views espoused by the former chairman of Federal Reserve on the relationship between inflation and inflation expectations is consistent to some extent with predictions of rational expectation theory. This classical economic theory (rational expectations theory), among other things, posits that, decisions made by forward looking, rational economic agents are informed to a large extent by the volume of information at their disposal including rational expectations of macroeconomic conditions. In order words, if this line of reasoning pertaining to rational expectation theory, defines how economic agents make decisions, then expectations of future inflationary conditions by such agents could influence ongoing decision making dynamics all things being equal. Stated differently, inflation expectations by theoretical necessity should influence prevailing inflation since such information is expected to be incorporated into present pricing decisions by economic agents.

If hypothesized relationship suggested by rational expectations theory actually defines the relationship between the two macroeconomic conditions in question, does this also supports related view among some researchers that inflation expectation is a self-fulfilling prophesy? Or the condition is just an economic anomaly emanating from the dynamic nature of macroeconomic environment with no verifiable causal relationship? According to the literature, 'self-fulfilling prophecy' as it relates to inflation expectations defines forecast or expectations which directly or indirectly cause itself to occur, because of some form of feedback interactions. If this description aptly captures a self-fulfilling phenomenon, then the condition to some degree, also describes the interaction between inflation and inflation expectations. This view was supported in an economic letter by J. Scott Davis of the Dallas Fed (2012). In his letter, Davis noted that experiences of the 1970s suggest that when inflation expectations become unanchored, they tend to be self-fulfilling; that is, growing expectations of inflationary condition if not anchored, impacts economic behavior, ultimately influencing present inflationary conditions. This complex trend relationship, in which expectations of a condition has the potential to actually cause the condition to occur by influencing present behavior of economic agents, describes to some extent, the dynamic relationship between inflation and inflation expectations this study seeks to further explore.

If anticipated inflationary conditions could influence measured inflation, and vice versa via decisions made by rational economic agents in a macroeconomic environment, then this study projects that there must exist some form of causal relationship as defined by Granger (1969). In other words, inflation expectations could be responsible for the shape and form of prevailing inflationary conditions and vice versa in Granger sense. This projected causal interaction between the two macroeconomic conditions could be either unidirectional or bidirectional in nature; and this study seeks to verify the presence of this causal interactions; and how each condition ultimately influence investment behavior. Proposed empirical tests, estimation analysis and ensuing study conclusions are all meant to provide further insight onto how the variables in treatment interact in the US macroeconomic environment. The rest of this study proceed as follows: Analysis highlighting relationship between inflation and inflation expectations; inflation and investment behavior; and inflation expectations and investment behavior are presented in section 2 in our review of relevant literature. These analysis focuses particularly on potential signals or information which might suggest potential direction of causal interactions between combinations of the macroeconomic variables employed in this study. Section 3 detail the type and sources of data, nature of variables in treatment and the methodology to be employed in verifying the various interactions pursued in this study. Pre-estimation testing as well as actual estimation of the various relationship stated are performed in section 4. Tests conducted will include assessing conditional features of variables employed, modeling conditional variance associated with investment performance, as well as deployment of key models in our assessment of projected causal relationships between variables in treatment. Finally, section five discuses and evaluates results from various tests conducted; and highlights potential policy implication.

## 2. Review of Empirical Literature

Ongoing policy discussions suggests that potential causal associations being verified in this study constitutes key macroeconomic policy concern facing policy makers seeking to provide some form of forward guidance to economic actors. A quick review of existing literature focusing on the associations under study, however, suggest that despite ongoing discussions, actual empirical analysis ascertaining causal relationship as defined by Granger, tend to be few and far between; despite the fact that, the issue continue to garner attention at policy forums and conferences at the theoretical level. In the following sub-sections we provide succinct account of existing discussions relating to the dynamic relationship among the three variables being verified in this study.

### *2.1 Inflation and Inflation Expectations*

In their assessment of the dynamic associations between the two macroeconomic conditions, Demertzis et al (2008), argued that credible monetary policy regime will be characterized by disconnect between inflation and inflation expectations. In other words, this submission suggest that some form of relationship might exist between inflation and inflation expectations in economies where economic agents have less confidence in prevailing/anticipated monitory policies. This presumption of some form of relationship supports existing views espoused by most policy makers. However, the cardinal issue of whether inflation expectations are responsible for variability in prevailing or measured inflation in Granger sense or otherwise, remain fully unresolved due to the complex nature of how expectations are formed. In an effort to provide some empirical evidence on this relationship, it is important to point out that over the years some compelling cases have been made at various levels about the potential direction of causal interaction between the variables in question. However, the view that inflation expectations tend influence prevailing inflationary condition tend to be more prevalent in macroeconomic policy discussions than the reverse condition. The Federal Reserve for instance, continue to submit its concerns about how inflation expectations among economic agents might influence prevailing or

measured inflationary conditions. For instance, if submission by Bernanke (2004), that "an essential prerequisite to controlling inflation is controlling inflation expectations" constitutes an apt description of the dynamic relationship between the two macroeconomic conditions, then the submission seem to suggest that inflation expectations all things being equal, Granger cause measured or prevailing inflation.

Contrary to the submission by Bernanke (2004), the literature also provide some evidence suggesting that current or prevailing inflationary conditions might rather be responsible for inflationary expectations. For instance, Lowenkron and Garcia (2007) who studied similar association, found evidence of causality running from prevailing inflation rate to expected inflation. Moreira (2013), in a related study also found evidence suggesting that inflationary shock is responsible for heightened inflation expectations. In order words, for these researchers' persistent increases in general price levels are rather responsible for future inflationary condition expectations. Again, Van der Cruijsen and Demertzis (2011) further provided evidence suggesting that inflation expectations are caused by lagged actual inflation among some economies in the European Monetary Union; a condition which further suggest that present or previous inflationary conditions rather influence variability in inflation expectations. These divergent submissions to some degree captures prevailing views on the relationship between the two macroeconomic conditions this study is examining. Figure 1 below provides quarterly trend relationship between inflation and inflation expectations spanning the period 1984 to 2013. The figure shows almost similar trend dynamics between the two macroeconomic conditions; a condition which further suggest the two conditions have similar trend trajectory. However, despite similar trend trajectory, one cannot posit with absolute certainty whether one is responsible for the trend of the other and vice versa just based on this graphical representation.

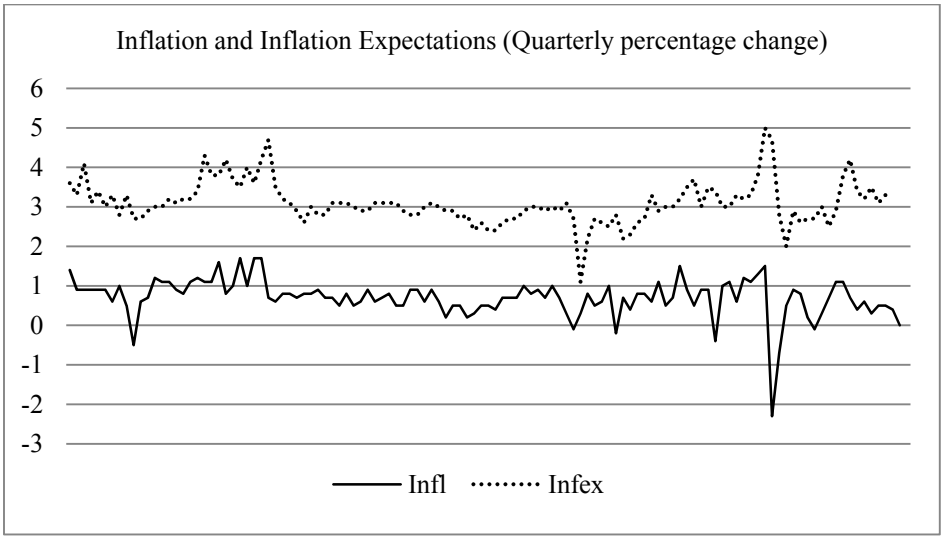


Figure 1. Quarterly trend analysis between inflation and inflation expectations (1984-2013)

*2.2 Inflation and Volatility in Investment Performance*

Macroeconomic theory suggests that, inflationary conditions tend to have significant influence on investment growth through decisions made by economic agents (consumers and investors). For instance, persistent rise in the general price levels have been shown to have constraining effects on purchasing power among consumers; and in a system of macroeconomic interactions, this decline in purchasing power, has the potential to reduce savings and effective demand, two core variables with significant impact on investment growth. For businesses and the average investor, inflationary conditions also generate some measure of uncertainty about future price trajectory, interest rates changes (which could impact cost of loanable funds) and future demand conditions. For instance, Friedman (1977) submitted that inflationary condition intensifies uncertainty stemming from relative price variability. Again, Inflationary conditions according to (Banerjee et al., 2007) constitute an important source of uncertainty by inducing and influencing relative price variability in an economy. These conclusions on the effects of inflation, suggest that effects of the condition on investments growth, are predominantly channeled through uncertainty generated by the macroeconomic condition (inflation). It is important however, to point out that although it is often believed that uncertainty will constrain investments growth when one subscribe to rational behavior on the part of the average investor, this view has not always been the case; since firms and

investors tend to have varied perception of specific macroeconomic uncertainty and how it might impact investments returns. This notwithstanding, significant portion of existing empirical studies tend to support the notion that inflationary conditions leading to growing uncertainty reduces propensity to invest all things being equal (Byrne & Davis, 2004; Fisher, 2009). Additionally, Barro (1995), further showed that holding country specific characteristics constant, increases in average inflation reduces propensity to invest; and that the condition, is responsible for reduction in the ratio of investment to GDP growth by .4 to .6 percentage point per year.

The relationship between inflation and investments growth has also been discussed in what has been termed the Negative Tobin's effects by Stockman (1981). This perspective on the relationship in question, advances theoretically negative long run relationship between inflation and investment growth; similar conclusions could also be found in Mansoorian and Mohsin (2006) and Smith and Egteren (2005) respectively. Apart from this projected inverse relationship, empirical evidence also exist suggesting that long run inflationary conditions may lead to lower real interest rate–a positive Tobin effect according to Rapach and Wohar 2005; a condition with the potential to induce positive investment performance contrary to negative relationship conclusion indicated above. Thus, apart from the widely verified inverse relationship between inflation and investment performance, significant studies also exist supporting the potential for a positive relationship between the variables under some specific macroeconomic conditions. If these conclusions on the dynamic relationship between inflation and investment performance accurately capture fundamental mechanics at play between the two variables, then inflationary conditions, all things being equal, could be said to be responsible for investment performance variability. In order words, in Granger sense, above conclusions suggest a unidirectional causal relationship, with direction of causality emanating from inflationary conditions to volatility in investment growth. Consequently, this study anticipates a unidirectional causal relationship between the two macroeconomic variables all things being equal. Figure 2 depicts quarterly US trend relationship between inflation and investment performance volatility between 1984 and 2013. Compared to figure 1, figure 2 tend to exhibit significant differences in historical trend trajectory over the period under consideration.

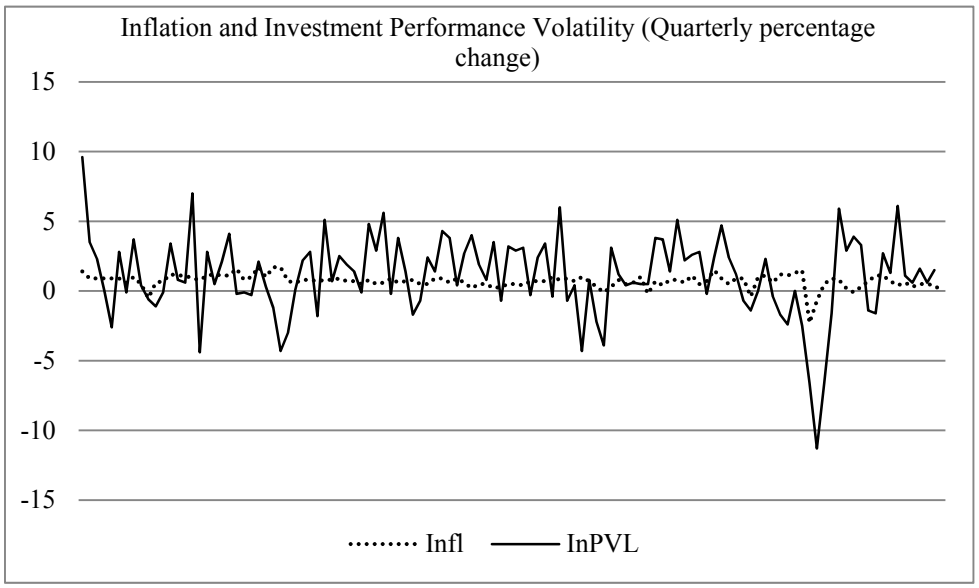


Figure 2. Quarterly trend analysis between inflation and investment performance volatility (1984-2013)

*2.3 Inflation Expectations and Investment Performance Volatility*

The major distinction between how inflation and inflation expectations impacts investment growth, centers on the difference between an actual macroeconomic condition, and an expectations of such macroeconomic condition among economic agents. In assessing how inflationary conditions influence investment performance, we focused on how existing or prevailing macroeconomic phenomenon affects investments. However, this second part, focuses on the extent to which expectations or potential occurrence of a macroeconomic phenomenon might influence investment performance. Potential causal association between inflation expectations and volatility in investment performance being verified in this study, to some extent depends on

whether such inflation expectations are well-anchored or un-anchored (i.e. whether inflation expectations are more or less sensitive to relevant future information or data). In policy analysis, inflation expectations are viewed as well-anchored if such expectations do not deviate significantly from explicit inflationary target. Related literature however, provides varied approaches in defining what constitutes anchored inflationary expectations. One of such approach is the news regression approach. This approach, surmise that well-anchored inflation expectations all things being equal, will be less sensitive to macroeconomic developments or economic news; Levin et al. (2004) and Gurkaynak et al. (2010). Gurkaynak et al. (2010) for instance, argued the following: 'if inflation expectations are firmly anchored, with a time invariant distribution around the specified target value, then economic news should have a much smaller impact on far-ahead forward inflation compensation'. In order words, a well-anchored inflationary expectation–i.e. inflationary condition closer to target or projections should not significantly impact prevailing macroeconomic dynamics and for that matter investment performance. These submissions on the structure and dynamics of inflation expectations suggest that, it is possible for such expectations to granger cause variability in investment performance (un-anchored inflation expectations) or have less significant impact on the same (anchored inflation). Stated differently, potential causal relationship between inflation expectations and volatility in investment performance, depend to some degree on whether such expectations are anchored or not.

If inflation expectations are well-anchored, such expectations might exert minimal influence if any, on present investment growth dynamics and vice versa. In this study however, since data on inflation expectations employed in our analysis does not make such distinction, it is projected that if causality analysis suggests a causal relationship running from inflation expectations to investment growth volatility or bidirectional causal relationship, the condition might be an indication that US inflationary expectations are not well-anchored around a targeted threshold. However, if no causality condition is found or causality running from investment growth volatility to inflation expectations is rather detected, then no definite empirical conclusion could be made on whether inflation expectations are well-anchored or otherwise. Figure 3 provides quarterly trend comparison between inflation expectations and investment performance volatility over the period (1984-2013).

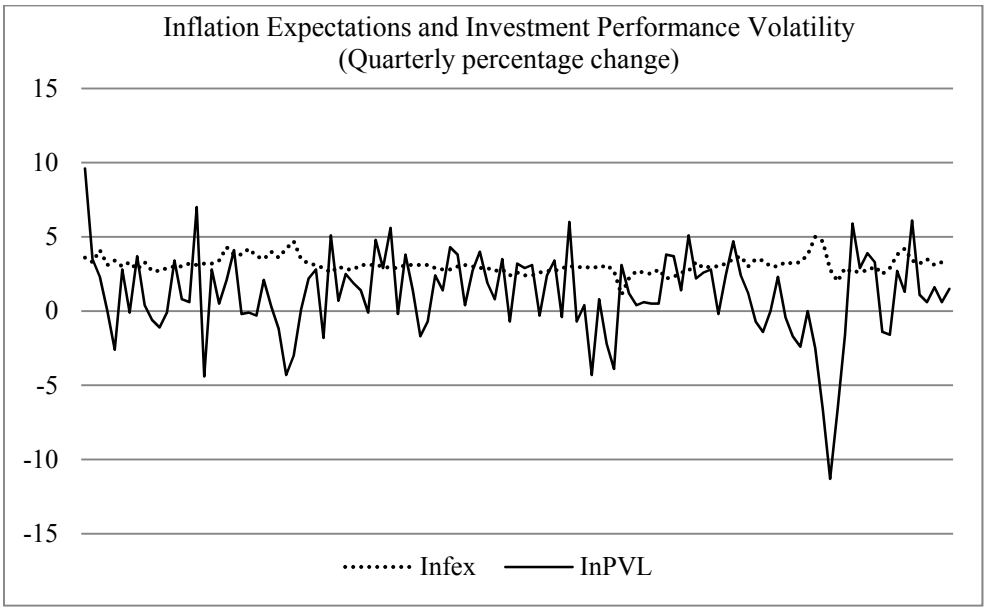


Figure 3. Quarterly trend analysis between inflation expectations and investment performance volatility (1984-2013)

## 3. Data, Variables and Methodology

### *3.1 Data Source and Study Variables*

This study is modeled on quarterly macroeconomic variables sourced from St. Louis Fed (FRED) and US Bureau of Economic Analysis (BEA) database. Variables utilized in this study include inflation (*INFL*), inflation expectations (*INFLEXp*) and investment growth volatility (*InPVOL*). Investment performance volatility variable, unlike inflation and inflation uncertainty variables, is derived using generalized autoregressive conditional

heteroskedasticity (*Garch*) process. Data employed in this empirical estimate is made up of time series data spanning the period 1984 to 2013.

*3.2 Modeling Investment Performance Volatility*

Investment Performance Volatility *(InPVOL)* variable tested in this study is modeled via generalized autoregressive conditional heteroskedasticity (GARCH) process originally propounded by Bollerslev (1986). This econometric process captures volatility inherent in investment growth performance over the period under consideration. This study employs *GARCH (1,1)* process modeled as follows:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{1}$$

Where ω is the constant term, $\varepsilon_{t-1}^2$ is the ARCH term and $\sigma_{t-1}^2$ is the GARCH operator. This equation assumes that current condition of volatility in investment growth is a function of similar prior condition and an error term.

*3.3 Methodology: Toda Yamamoto Non-Causality Test*

To ascertain potential causal interactions among inflation, inflation expectations and volatility in investment growth, this study employs bivariate VAR system using Toda-Yamamoto (1995) non Granger Causality test approach. This econometric procedure examines potential short-run causal relationships between pairs of variables in treatment. Proposed bivariate VAR causal analysis focuses on verifying relationships between inflation and inflation expectations; inflation and investment performance volatility; and inflation expectations and investment performance volatility. This study opted for Toda-Yamamato non-Granger causality approach to causality testing instead of the traditional version originally propounded by Granger (1969) due to verified advantages of this modified approach to causality testing. First, it has been shown that unlike the traditional Granger causality procedure, the Toda-Yamamoto approach does not necessarily require various pretest procedures often aimed at verifying the nature, form of integration and cointegration properties of variables in treatment. Additionally, existing literature further suggest that assessments of direction of causality based on the traditional Granger approach, tend to focus on time-precedence rather than true causality in academic sense. Furthermore, comparatively, the Toda- Yamamoto procedure is convenient to apply; and easily lends itself to linear as well as non-linear tests restrictions. Thus, the likelihood of flawed causal inference tends to be relatively minimal with this form of causality assessment compared to the original procedure propounded by Granger (1969).

Proposed Toda-Yamamoto Granger Non-causality tests verifying the absence of causality as defined by Granger between pairs of variables in this study are implemented using systems of bivariate VAR models which includes intercept in each level equation. The framework is formulated via series of equations as follows:

3.3.1 Causal Interactions between Inflation and Inflation expectations

Equation 2 and 3 estimates potential direction of causal interaction between inflation and inflation expectations in a macroeconomic environment. Equation 2, tests for unidirectional causal relationship between inflation and inflation expectations with the direction of causality running from inflation expectations towards prevailing or measured inflation. Equation 3, on the other hand test the reverse causal relationship between the variables in Granger sense. Ultimately, if both test results point to significant causal interactions between the two macroeconomic conditions, then a case could be made for bidirectional causal interaction between the two variables.

$$\ln INFL_t = \partial_1 + \sum_{i=1}^{k+t} \beta_{1i} \ln INFL_{t-i} + \sum_{i=0}^{k+t} \delta_{1i} \ln INFLEXp_{t-i} + U_{t_1} \tag{2}$$

$$\ln INFLEXp_t = \partial_2 + \sum_{i=1}^{k+t} \beta_{2i} \ln INFL_{t-i} + \sum_{i=0}^{k+t} \delta_{2i} \ln INFLEXp_{t-i} + U_{t2} \tag{3}$$

3.3.2 Causal Interactions between Inflation and Investment Performance Volatility

Equations 4 and 5, models this study's verification of bivariate causal relationship between inflationary conditions and investment performance volatility. Equation 4, in this regard test whether volatility in investment performance is responsible for variability in inflationary conditions in Granger sense; whereas equation 5, subsequently, tests the likelihood of the reverse causal condition. If significant causal interactions in both directions are detected, then a feedback effect or causal relationship could be inferred.

$$\ln INFL_t = \partial_1 + \sum_{i=1}^{k+t} \beta_{1i} \ln INFL_{t-i} + \sum_{i=0}^{k+t} \delta_{1i} \ln InPVOL_{t-i} + U_{t_1} \quad (4)$$

$$\ln InPVOL_t = \partial_2 + \sum_{i=1}^{k+t} \beta_{2i} \ln INFL_{t-i} + \sum_{i=0}^{k+t} \delta_{2i} \ln InPVOL_{t-i} + U_{t2} \quad (5)$$

3.3.3 Causal Interactions between Inflation Expectations and Investment Performance Volatility

Equations 6 and 7 finally estimate potential causal associations between inflation expectations and investment performance volatility. Equation 6 tests the condition that investment performance volatility does not Granger cause variability in inflation expectations whereas equation 7 tests the reverse condition.

$$\ln INFLEXp_t = \partial_1 + \sum_{i=1}^{k+t} \beta_{1i} \ln INFLEXp_{t-i} + \sum_{i=0}^{k+t} \delta_{1i} \ln InPVOL_{t-i} + U_{t_1} \quad (6)$$

$$\ln InPVOL_t = \partial_2 + \sum_{i=1}^{k+t} \beta_{2i} \ln INFLEXp_{t-i} + \sum_{i=0}^{k+t} \delta_{2i} \ln InPVOL_{t-i} + U_{t2} \quad (7)$$

From equations 2 to 7, $InINFL_{t-1}$ captures the lag inflationary variable (*InINFL)*; $InINFLEXp_{t-1}$ the lag variable of inflation expectations (*InINFLEXp)*, and $InInPVOL_{t-1}$ the lag of investment performance volatility (*InPVOL)* respectively. $U_{t1}$ and $U_{t2}$ are random disturbances. K, in this instance, represents the optimal lag order and *t* captures the maximum order of integration of the various variables employed in the equations. Equation (2) in this case test the condition that *InINFLEXp*, does not Granger cause *InINFL*; by verifying the following hypothesis:

$H_0$: $\delta_{1i} = 0$ against $H_1$: $\delta_{1i} \neq 0$ where *i* is $\leq$ k.

Equation (3) on the other hand test for the reverse condition that *InINFL,* does not Granger cause *InINFLEXp* testing the hypothesis in the form:

$H_0$: $\beta_{2i} = 0$ against the $H_1$: $\beta_{2i} \neq 0$ where *i* is $\leq$ k.

Similarly, causal interactions between inflation and investment performance volatility; and inflation expectations and investment performance volatility are subsequently tested via similar hypothesis testing procedures. Using the above equations, Toda-Yamamoto causality testing procedure is performed using *WALD* test which verifies if resultant coefficients of lagged variables in treatments are significantly different from zero.

Compared to original approach to causality testing based on methodology proposed by Granger (1969), Toda and Yamamoto (1995) approach employs a relatively simple causal inference method using *WALD* test based on an augmented VAR (vector autoregressive). This approach employs augmented VAR modeling which asymptotically provides chi-square distribution irrespective of the order of integration or cointegration properties of the variables in treatment. Test results using this approach have been shown to be significant regardless of whether variable series are I(0), I(1) or cointegrated or otherwise. This study follows similar approach adopted by Rambadi and Duran (1996) in estimating causality via the Toda Yamamoto procedure.

## 4. Empirical Results and Analysis

Tables 1 and 2 present results of estimated causal interactions between combinations of macroeconomic conditions/variables in treatment. Reported results are structured into two. Table 1 present result of causal interactions via Toda Yamamoto approach without controlling for two significant variables (prevailing economic performance and level of financial development) we believe has the potential to moderate to some extent, the causal interactions between combination of variables tested in the study.

Table 1. Test for granger-causality applying Toda and Yamamoto modified wald test

| Inflation Expectations, Inflation and Investment Performance Volatility | | |
|---|---|---|
| **Null Hypothesis ($H_0$)** | $\chi^2$ | ***P-Value*** |
| *Inflation Expectations does not Granger cause Inflation* | 6.8036 | 0.033 |
| *Inflation does not Granger cause Inflation Expectations* | 112.45 | 0.000 |
| *Inflation Expectations does not Granger cause InPVOL* | 37.446 | 0.000 |
| *InPVOL does not Granger cause Inflation Expectations* | 7.2165 | 0.027 |
| *Inflation does not Granger cause InPVOL* | 46.978 | 0.000 |
| *InPOVL does not Granger cause Inflation* | 0.22692 | 0.893 |

Reported results in Table 1, which does not control for potential moderating effects of two key macroeconomic conditions alluded to in earlier discussions, suggest significant causal relationships among variables in treatment in a typical macroeconomic environment using modified Wald test for causality proposed by Toda and Yamamoto (1995). Test results, show significant bi-directional or mutual causal relationship between inflation and inflation expectations with the strength of the causal interactions being stronger from the direction of measured inflationary conditions towards inflation expectations. In order words, prevailing inflationary conditions all things being equal, Granger cause, or is responsible for variability in future inflation conditions or inflation expectations and vice versa in the US economy. Reported chi-square coefficients in Table 1 further suggest another significant bi-directional causal interactions between inflation expectations and investment performance volatility with a much stronger causal influence emanating from inflation expectations towards investment performance volatility all things being equal. This result, suggest that, inflation expectations formed among investors impacts investment decisions which ultimately influence variability in investment growth.

Unlike the first two causal interactions analyzed above, test of similar interactions between realized inflation and investment growth volatility suggest only a uni-directional causal relationship between these two variables. This study finds that prevailing inflationary conditions rather Granger cause variability in investment growth without any feedback effect as was the case in the two prior analyses. In all the cases analyzed with the exception of the condition between investment performance volatility and inflation, the asymptotic chi-square ($\chi^2$) tests of $(H_0)$ is rejected given the reported P-Value. On the dynamic relationship between inflation and inflation expectations, reported results to a greater extent lend credence to concerns; sentiments and policy views often espoused by policy making bodies such as the US Federal Reserve and policy makers on the effects of inflation expectations on measured inflation. These results further highlights views held by some on the role measured inflation and inflation expectations play in investment growth and aggregate performance of the economy as whole. Above evidence, thus, suggest that these related macroeconomic conditions (inflation and inflation expectations) are critical in investment performance.

Table 2. Test for Granger-causality applying Toda and Yamamoto modified wald test

| Inflation Expectations, Inflation and Investment Performance Volatility (Controlling for financial development and Economic Performance) | | |
|---|---|---|
| **Null Hypothesis ($H_0$)** | $\chi^2$ | ***P-Value*** |
| *Inflation Expectations does not Granger cause Inflation* | 5.3748 | 0.068 |
| *Inflation does not Granger cause Inflation Expectations* | 98.357 | 0.000 |
| *Inflation Expectations does not Granger cause InPVOL* | 16.195 | 0.000 |
| *InPVOL does not Granger cause Inflation Expectations* | 5.7482 | 0.056 |
| *Inflation does not Granger cause InPVOL* | 28.696 | 0.000 |
| *InPOVL does not Granger cause Inflation* | 0.9783 | 0.613 |

Table 2, just like in Table 1 verifies potential causal associations among the three macroeconomic variables in treatment via the Toda Yamamoto approach. However, reported results in this regard controls for level of financial development and economic performance which we believe could have some moderating influence on causal interactions between stated paired variables. The goal of this augmented procedure is to verify if controlling for these core macroeconomic conditions or variables significantly alters reported causal associations among tested macroeconomic conditions/variables. Reported results in table two however, show that, controlling for these fundamental macroeconomic conditions does not significantly alter the nature of causal interactions among test variables. Empirical results reported in Table 2 suggests similar bi-directional and uni-directional causal interactions among the variables in treatment as reported in an earlier estimate although the actual chi-square values differ somewhat–which is expected. For instance, controlling for the level of financial development and economic growth conditions does not significantly alter the dynamics of bi-directional causal relationship between inflation and inflation expectations with much stronger causal influence emanating from measured inflation towards inflation expectations though chi-square values differ. Similar causal interactions as found in the first scenario reported in table 1 between inflation and investment performance volatility; inflation expectations and investment performance volatility is also found in this second estimate; where level of financial development and economic performance are controlled for. These outcomes suggest that, causal interactions between macroeconomic variables tested in this study tend to define dynamic associations between combinations of variables tested; and that such interactions are least perturbed by trends in economic growth and level of

financial development.

## 5. Conclusion and Policy Recommendations

This study verified the presence of causal interactions among three macroeconomic variables (inflation, inflation expectations and investment performance volatility) under two macroeconomic conditions. The study employed Toda Yamamoto's approach to causal interaction estimation in its estimation. Reported results suggest significant causal relationships among combination of variables in treatment; and a significant empirical basis supporting sentiments often espoused by policy makers on tested causal relationships and the impact of such relationships. Empirical estimation performed in this study focused on two scenarios; a condition where potential moderating effects of two key macroeconomic variables are controlled for; and a condition where they are not. In both scenarios however, our results suggest similar significant bi-directional causal relationship between inflation and inflation expectations with a much stronger causal influence emanating from inflation towards inflation expectations. Similar bi-directional or mutual causal relationship was also found between inflation expectations and investment performance volatility; with a stronger causal influence running from inflation expectations towards investment performance volatility. Finally, reported chi-square estimates further found a uni-directional causal interaction between inflation and investment performance volatility with the direction of causality running from inflationary conditions towards investment performance volatility. These outcomes provide data driven evidence in support of significant causal linkages among macroeconomic variables tested; and emphasize the need for policy making bodies such as the U.S FED to monitor trend dynamics among the variables in order offer appropriate policy response that will help maintain price and economic stability. These findings further suggest that ensuring provision of adequate forward guidance for instance, might help moderate the extent to which conditions such as inflation expectations impact measured inflation and other core macroeconomic variables of interest.

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