

## Macroeconomic Variables and Stock Returns Revisited

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**Abstract:** I revisit the relation between macroeconomic activities and stock prices by selecting the most important macroeconomic variables that are appropriate for analyzing their impact on stock returns. Using vector autoregressive models (VAR), combined with cointegration analysis and the vector error correction model (VECM) I estimate the explanatory power of each macroeconomic variable on the variations of the stock prices and distinguish the short-run from long-run movements among all key macroeconomic variables. I find that (1) in the short-run macroeconomic variables do not appear help explain changes in stock returns, (2) in the long-run the real interest rate and industrial production are the most important macroeconomic factors, and (3) in the long-term the real economic activity and stock returns Granger-cause each other.

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### INTRODUCTION

A confluence of factors moves the stock price up and down. There are factors such as the influence of market psychology that might have effects on the stock markets. If this turned out to be true, the estimated results of the fundamental variables tend to over-estimate the effects of these macroeconomic factors. Interestingly, professional investors think that the reasons that behind the stock market crash is mostly psychological. A survey, conducted right after the stock market crash on October 19, 1987 by Robert J. Shiller, asked both institutional and individual investors "Which of the following better described your theory about the declines: a theory about investor psychology [or] a theory about fundamentals such as profits or interest rates?". Among those answers, 67.5% of the institutional investors and 64% of the individual investors picked a theory about investor psychology.

However, I do not intend on studying the impact of investors' psychological effects on the stock price. The objective of this study is to identify macroeconomic variables that are most relevant to changes in stock prices hence stock returns measured by S&P 500 stock index. How much variation in these macroeconomic variables helps explain the variation in changes in the stock returns. The relationship between macroeconomic activities and stock markets (stock returns, stock prices, etc.) has been well documented by Fama (1977), Fama (1981), Chen et al (1986), Lee (1992), Gjerde and Sattelm (1999), Canova and De Nicolo (2000), among others.

Research suggests that the relation between the stock markets and the macro economy is not unidirectional. On one hand, stock prices are believed to react to both expected and unexpected economic news, on the other hand, stock prices are used as one of the leading indicators in macro economy. In this sense, all economic variables can be said to be endogenous and interact with one and another in certain ways. Financial theory suggests that the following macroeconomic variables could affect stock market returns: interest rates, expected and unexpected inflation, and industrial production. Business activities that shift either the expected cash flows or the discount rate should also move stock prices through the two channels. The discount rate changes with the levels of the risk-less interest rate, risk premium, and the term-structure spreads across different maturities. Unanticipated innovations in price changes lead to unexpected inflation. Unexpected inflation changes affect the nominal interest rate, which in turn affect the expected future cash flows; hence, unanticipated changes in inflation will in theory have some impact on stock prices. Shareholders can be rewarded only if the operating and investment generate returns that are higher than the cost of capital, which depends on the level of real production on both the supply side and the real consumption on the demand side. Therefore, innovations in the economic activities such as industrial production should have some influences on stock prices through their impact on cash flows.

The effect of inflation on stock prices has been controversial. Early literature from Fama (1977) and Schwert (1981) found negative relationship between inflation and the stock returns, whereas Pearce and Roley (1985) and Hardouvelis (1988) found no

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significant relations between inflation and the stock prices. In more recent work, Bekaert and Engstrom (2009) found highly positive correlation between dividend yield and the yield on nominal Treasury bonds due to expected inflation. Lee (2009) showed that inflation illusion hypothesis could explain the post-war negative relationship between stock returns and inflation. Valcarcel (2012) found evidence for the negative relationship between US stock prices and inflation.

The movements in the discount rates affect the real economy activities through capital markets including the stock markets. In developed countries, strategic changes in benchmark interest rates have caused other interest rates to move accordingly. Sellin (2001) surveyed the relationship between monetary policies and stock prices and concluded that there was small positive impact of monetary policy on stock prices prior to 2000. Using the US data over the period 1890 – 1987, Giovanni and Labadie (1991) found that the nominal interest rate did a good job predicting nominal stock returns. Using weekly data, Huang et al (2016) found linkages between interest rates and the US S&P 500 stock returns in post January 2009 period. Klyuev et al (2009) found that the lowered benchmark rates during the 2007-2009 recessions had an impact on the prices of the financial assets. Interactions between inflation and interest rates influence the stock returns. Lee (1992) found that interest rates explain a substantial variation in inflation and that inflation responds negatively to shocks in real interest rates. Balduzzi (1995) concluded that interest rates account for a significant portion of the negative correlation between inflation and stock returns.

Although various studies have established significant relations between macroeconomic indicators and stock prices in the US market, this study extends our knowledge about this topic through using updated datasets. We focus on the causal relations among macroeconomic variables and stock returns in the US stock markets by identifying the macroeconomic factors that are most relevant to stock price changes and then using VAR models and error correction models to establish dynamic interactions and identify long-run relations among the selected macroeconomic variables and stock returns. If such relations exist, deviations from a long-run path are characterized by a mean reversion to its long-run relationship.

The paper is organized as follows. The econometric methodology, the data are and empirical results discussed in the following section. And the last section concludes the paper.

### DATA AND EMPIRICAL ANALYSIS

The selected macroeconomic variables are the monthly US real S&P500 stock price index, the monthly U.S. real industrial production index, the monthly US inflation calculated based on the US CPI index, the monthly US real interest rate computed based on the expected inflation and nominal interest rate which is provided by the 3-month US treasury bill rate<sup>1</sup>, the US monthly money (M1) supply, and the monthly US unemployment rate. We obtain the US S&P500 stock price index, the US industrial production index, the US consumer price index, the US M1 supply, and the US unemployment from the Federal Reserve St. Louis database. The 3-month US treasury bill rate is obtained from the IMF website. The sample period for this investigation is from January 1982 to February 2020<sup>2</sup>.

The selection of industrial production as a macroeconomic variable that potentially affects stock prices is based on Chen et al. (1986), Cheung and Ng (1998), Binswanger (2004), and Humpe and Macmillan (2009). It is suspected that unanticipated inflation negatively affects the stock price through the influence on firms' profitability and discount rates. DeFina (1991) argue that such negative impact comes from the immediate rising costs and slowly adjusting output prices. I compute the unexpected inflation by taking the difference between realized inflation and expected inflation. The change in the interest rates directly influence the discount rate in the DCF model, hence potentially affects stock prices. I also include the unemployment rate to account for the additional macroeconomic activity. Depending on the nature of the dummies, I include linear time trend and seasonal dummies to account for any remaining trend and seasonality. Including exogenous variables does not pose any problems (Levendis, 2019).

#### A. Cross-correlations

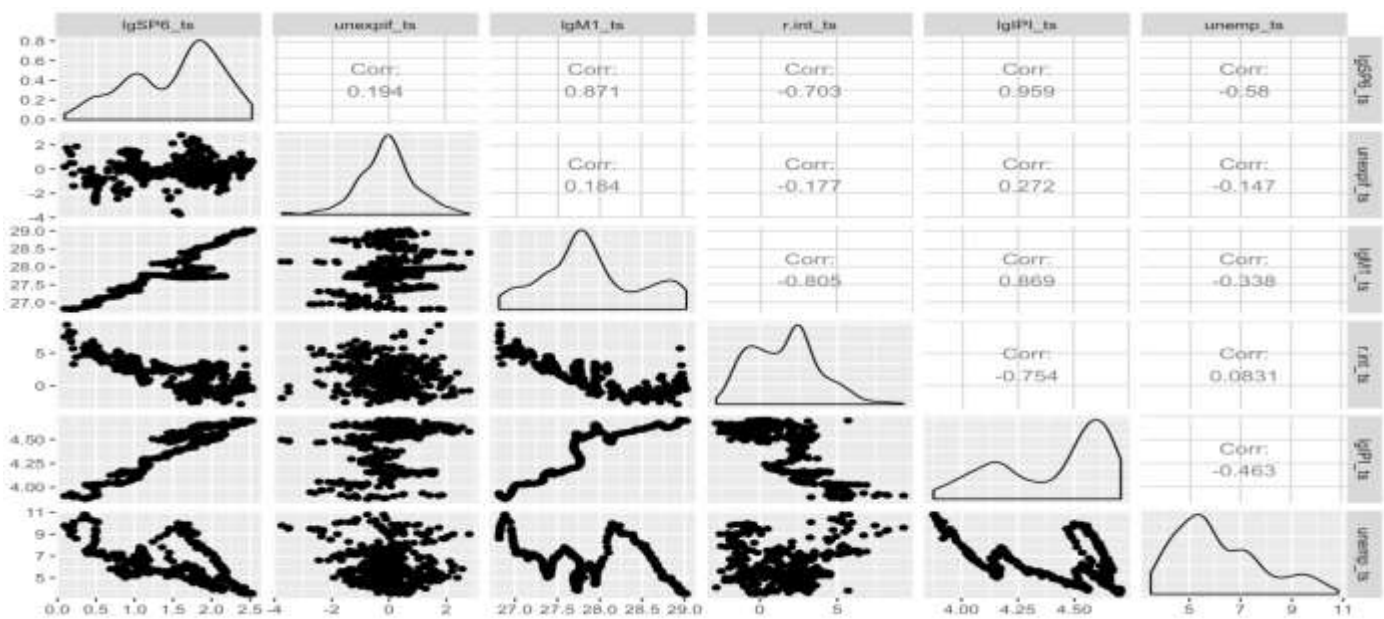
Figure 1 presents the cross-correlation matrices for the period February 1982 to April 2020 in their levels. I specifically examine the relationship between real stock prices and other macroeconomic variables. The scatter plots and correlation values indicate that M1 supply, real industrial production, unexpected inflation and the US stock prices are positively correlated. While real interest rate and unemployment are negatively correlated with the real stock price.

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<sup>1</sup>The expected inflation is retrieved from Federal Reserve Bank of Cleveland.

<sup>2</sup>The period of the data selected is determined by the availability of the data range of the expected inflation.

Figure 1: cross-correlation mastics among variables



Despite the shared trend and relatively high correlations among the macroeconomic variables, we need to be very careful before ascribing any causal relationship. High correlations shown Figure 1 do not necessarily imply causal relationships. Common extraneous factors or stochastic elements can give rise to the underlying trend. Furthermore, it is possible for the underlying stochastic trends in these series to be coincident. That means, these correlations could have resulted by chance. To avoid the risk of finding spurious relationship, we conduct further analysis in the following sections. It may be that an underlying relationship can be justified even when these series exhibit stochastic trends.

I explore the short-run relationship between variables by constructing a VAR model. To form an appropriate VAR model, I check stationarity of each variable and transform the variables if necessary to acquire stationary time series.

**B. Stationarity of the time series**

To test for stochastic trends, I conduct unit roots tests for every one of these time series. Table 1 presents the test results for the selected time series. I base the results on Augmented Dicky Fuller (Said and Dickey, 1984). The Phillips-Person (PP) test (Person, 1988) and Elliott, Rothenberg, and Stock test (Elliott, Rothenberg, and Stock, 1996) are also added for robustness and possibly an improved power on the unit root test. First six rows display the results for the six original times series. We can see that stationary can be rejected in five out of six time series. Unexpected inflation is stationary according to all three test results. The next five rows show the results for first difference of the five original time series. All three test results show that the five first differenced time series are stationary at all levels of significance. However, the residuals in a VAR system constructed using these variables are autocorrelated. In addition, the autocorrelations do not diminish as we increase the number of lags. To fix this problem, I decide to fit an appropriate ARMA (p,q) model to each series and then retrieve the residuals as replacements for the time series to conduct the analysis.

Table 1: unit-root test results based on three methods

Variable	ADF	Phillios-Perron	ERS
log S&P500	-1.73	-2.17	1.27
log M1	0.22	-0.57	2.13
Unexpected inflation	-5.20**	-5.93***	-2.08**
Real interest rate	-3.14**	-5.80***	-1.50
log IPI	3.26	-1.15	0.96
Unemployment	-1.54	-1.45	-0.02

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Variable	ADF	Phillios-Perron	ERS
diff. log S&P500	-12.11***	-437.41***	-3.97***
diff. log M1	-7.59***	-19.45***	3.52***
diff. Real interest rate	-15.13***	-27.84***	2.77***
diff. log IPI	-6.69***	-18.66***	2.75***
diff. Unemployment	-21.88***	-67.82***	-4.88***

### C. Selection for lags

To select the appropriate lag length for the VAR model, I combine insights indicated by Akaike Information Criterion (AIC), Schwarz-Bayes Criterion (BIC), Hannan-Quinn Criterion (HQ), and Akaike's Final Prediction Error (FPE) and the examination of the autocorrelation of residuals in the VAR model. The AIC and FPE results suggest three lags, while HQ and BIC results support one lag. I experiment with VAR (1), VAR(3), VAR(4) and VAR(5) models. The asymptotic Portmanteau test results indicate that specifications with fewer than five lags fail to pass the test for uncorrelated residuals at the 5% significance level. As suggested by Legends (2019), I fit the data with VAR(3), VAR(5), and VAR(6) models and compare the three models. I determine an optimal lag length for an unrestricted VAR model for a maximal lag length of six. I conclude that a VAR model with five lags is the appropriate one.

Unfortunately, the residuals of our VAR model fail the Jarque Bera test or the normality test. I apply bootstrap technique to calculate the standard errors for the impulse response functions and forecast error variance decomposition. On the other hand, standard errors calculated via asymptotic approximations are still valid in coefficient estimates because the fitted model is small relative to the sample size.

### D. VAR model results

In Table 2 I present the results of the VAR (5) model with six variables. I only report explanatory variables that are significant at least 5% significant level. Table 3 summarizes the 24-month forecast error variance explained by innovations. Figure 2 shows the orthogonalized impulse responses of each variable to different shocks.

**Table 2: selected results of the VAR (5) model**

Variable	Estimates	F-statistic
1 )	$SP_t = 0.9543IP_{t-1}$ (0.4147)	0.1963
2 )	$UNEXPINF_t = -0.1894RINT_{t-1}$ (0.0342)	0.0614
3 )	$M1_t = -0.1011M1_{t-1} - 0.1469IP_{t-2} - 0.0015RINT_{t-2}$ (0.0006) (0.0676) (0.0006) $-0.3234IP_{t-3} - 0.0016RINT_{t-3} - 0.1506IP_{t-4}$ (0.0661) (0.0006) (0.0674)	0.0020
4 )	$RINT_t = -0.2427UNEXPINF_{t-1} - 0.2710UNEXPINF_{t-3} + 0.1276RINT_{t-3}$ (0.0774) (0.0777) (0.0760) $+14.5400IP_{t-4} - 0.3193UNEXPINF_{t-5} - 12.4700M1_{t-5}$ (5.9090) (0.0767) (4.1710)	0.0000
5 )	$IP_t = -0.0063UNEMP_{t-1} + 0.0162SP_{t-2} + 0.1339IP_{t-2} - 0.0345SP_{t-3}$ (0.0019) (0.0061) (0.0521) (0.0061) $-0.0054UNEMP_{t-3} - 0.0010RINT_{t-3}$ (0.0019) (0.0005)	0.0000
6 )	$UNEMP_t = -3.7190IP_{t-1} - 0.1084UNEMP_{t-1} - 0.1871UNEMP_{t-2}$ (1.3550) (0.0505) (0.0513) $-4.0720IP_{t-3} - 0.0292RINT_{t-3}$ (1.3360) (0.0119)	0.0022

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**Table 3: forecast error variance explained by innovations**

	Variables	Variance Explained By					
		SP(%)	UNEMP(%)	M1(%)	RINT(%)	IPI(%)	UNEXPINF(%)
1)	SP	92.69	1.49	1.20	0.95	2.66	1.00
2)	UNEMP	2.49	91.03	1.07	0.97	3.06	1.38
3)	M1	2.11	0.54	87.89	2.98	5.58	0.89
4)	RINT	2.19	1.43	2.92	72.57	3.26	17.63
5)	IPI	10.29	9.62	3.18	1.98	73.57	1.35
6)	UNEXPINF	0.47	1.62	1.32	6.72	1.43	88.43

The first row in Table 2 tells us that domestic real activity has influence on real stock returns. In the meantime, we can see in the fifth row that real stock returns also affect real activity. And the relationships are negative in both ways. At the first glance, this finding is contradictory to the conventional view that the stock market leads in real activity. However, a closer examination reveals that this conclusion isn't necessarily true because real activity is represented by changes in the growth rate of industrial production. In Table 3, vast majority (92.69%) of the 24-month forecast error variance decomposition (FEVD) of stock returns is explained by its own shocks. Money growth, unemployment rate, and the growth rate of real activity all together account for about 5% variations in the variance of real stock returns. In addition, results in the first row of Table 1 indicate that the US stock market is efficient in the sense that the coefficients of all lagged real stock returns are statistically insignificant. Mispricing, if any, is quickly corrected.

I am unable to identify any significant relationship from unexpected inflation to real stock returns. Table 3 indicates that unexpected inflation explains merely 1% of the variations of the variance of real stock returns and real stock returns account for only 0.47% of the 24-month FEVD of unexpected inflation. Although unexpected inflation is part of actual inflation, neither the stock returns or unexpected inflation show significant results in each other's estimation equation. This finding indicate that there might not be a clear cut relationship between stock returns and the actual inflation.

Table 3 shows that real economic activity has some explanatory power (3.97%) for unexpected inflation, while unexpected inflation's influence on real activity is negligible (0.71%). Table 2 indicates that the growth rate of industrial production positively affects changes in unexpected inflation. This is consistent with the established view that faster than expected economic growth is likely to cause demand-pull inflation. On the other hand, a faster than expected inflation doesn't affect the growth rate of real activity.

What's interesting in this finding is the relation between real activities and the stock return. The growth rate of industrial production appears in four equations: SP, UNEMP, RINT, and IPI. Although no other macroeconomic variables seem to affect the stock return, the stock return seems explain a great portion of the growth rate of real economic activity. Table 3 shows that stock return and unemployment explain big fractions (10% and 9,62%) of the variance of real economic activity. The growth rate of industrial production is also important in explaining the growth rate of money supply, but not the other way around. Unexpected inflation appears only in the real interest rate equation. Table 3 shows that unexpected inflation accounts for a substantial change (17.63%) in the variance of real interest rate.

### E. Cointegration

I investigate the long-run relationship between variables in their levels whether two or more variables are cointegrated. In Table 1 I already show that unit roots tests results indicate that all variables are individually integrated of order 1 or  $I(1)$ , except for the real interest rate. I conduct Johansen's (Johansen, 1988, 1991, and 1995b) test to the levels of the time series data to test for the presence of cointegration relationships. Both the trace and maximum eigenvalue statistics are used to cross-verify the number of cointegrating vectors. The Portmanteau Test results suggest that no serial correlation can be detected in the residuals.

According to the trace statistic results, there is strong evidence to reject the null hypothesis of no cointegration for  $r = 0$  and  $r \leq 1$ . In the maximum eigenvalue test, we reject the null hypothesis that  $r = 0$  at all levels of significance. However, I cannot reject the null hypothesis that  $r = 1$ . Based on results from the two tests, I can conclude that the rank of the matrix of the

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$r$  is equal to or greater than 1 and the best estimate is  $r = 1$ . This implies that there is one fundamental relationship between the monthly US real S&P500 price and other macroeconomic variables in the long run. More is discussed in the following sections.

### Granger Causality

I follow the Toda and Yamamoto (Toda and Yamamoto, 1995) procedure to test for Granger causality between the levels of the time series variables. In Table 1 we already know that logarithm of S&P500, logarithm of M1, real interest rate, logarithm of IPI, and unemployment are all integrated of order 1 or  $I(1)$  and that unexpected inflation is integrated of order 0 or  $I(0)$ . I fit the levels of the data to a VAR model and conduct Portmanteau Test to ensure that there is no autocorrelation in the residuals. I also control for seasonal effects to eliminate the additional seasonal pattern by the frequency of the data. The lag order of 14 is selected based on the information criterion. And Johansen's method shows that the variables are cointegrated. Since these variables are cointegrated, we use F-statistics to test for long-run Granger-causality relationships by the joint significance of the coefficients of the explanatory variables. The results are shown in Table 5.

**Table 5. Granger causality results**

Long-run Granger-causality (both ways)	Long-run Granger-causality (one way)
SP $\Leftrightarrow$ IPI	RINT $\rightarrow$ M1
UNEXPINF $\Leftrightarrow$ RINT	IPI $\rightarrow$ M1
RINT $\Leftrightarrow$ IPI	SP $\rightarrow$ UNEMP
UNEMP $\Leftrightarrow$ IPI	UNEXPINF $\rightarrow$ UNEMP
UNEMP $\Leftrightarrow$ RINT	

In the short-run, there are no Granger-causality relationships exist among these variables. In other words, none of the variables Granger-cause the US S&P500 stock returns (SP). This situation changes in the long-run. The industrial production index (IPI) Granger-cause the US S&P500 stock returns, and vice versa. Other two-way Granger-causality relationships are between unexpected inflation (UNEXPINF) and the real interest rate (RINT), the real interest rate (RINT) and industrial production index (IPI), the unemployment rate (UNEMP) and industrial production index (IPI), and the unemployment rate (UNEMP) and the real interest rate (RINT). Both the industrial production index (IPI) and the real interest rate (RINT) Granger-cause the money supply (M1). The US S&P500 stock returns (SP) Granger-cause the unemployment rate (UNEMP). And unexpected inflation (UNEXPINF) Granger-cause the unemployment rate (UNEMP). I observe that there are no real exogenous variables in a sense that all the variables are either caused or cause some other variables. Only relative exogeneity exists among macroeconomic variables. I find that unexpected inflation and the US S&P500 stock returns are relatively the most exogenous. Another interesting finding is that the money supply does not influence any macroeconomic variable. On the other hand, both the real interest rate and the real economic activity affect the money supply. This means that the money supply is neutral in the long-run.

### F. VECM model

Now I'm in a position to construct a VECM (vector error correction model) to capture the relationships between the levels of the time series variables indicated by their long-run cointegration relations. Since the VAR model has a lag order of 14, the corresponding VECM has 13 lags. Following the recommendation by Zivot and Wang (2007), I assume that the first-differenced macroeconomic variables do not exhibit a deterministic linear trend and that the cointegrating equations are not stationary around a deterministic trend. The VECM model is structured as follows

$$\Delta Y_t = \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \dots + \Gamma_{k-1} \Delta Y_{t-k} + \alpha(\beta Y_{t-k-1} + \mu) + \gamma + e_t$$

where  $\Delta Y_{t-k}$  is the vector of first differenced macroeconomic variables at lag  $k$ ;  $\Gamma_k$  is the matrix of coefficients;  $\mu$  and  $\gamma$  are constant terms in the cointegration equation and first differenced variables, respectively;  $e_t$  is the error term.

I am able to find a steady relationship between the variables in their levels. Based on the results in Table 4, I combine one of the levels of the time series to form a stationary series and this is our long-run cointegrating equation.

$$\begin{aligned} \lg SP = & -9.0542 - 0.0911 \text{UNEXPINF} - 0.0219 \lg M1 - \\ & + 0.0347 \text{RINT} + 2.66911 \lg IPI - 0.1991 \text{UNEMP} \end{aligned}$$

where  $\lg SP$  is the logarithm of the monthly real S&P500 index, UNEXPINF is monthly unexpected inflation,  $\lg M1$  is the logarithm of the monthly money supply, RINT is the monthly real interest rate,  $\lg IPI$  is the logarithm of monthly industrial production index, and UNEMP is the monthly unemployment rate. This cointegration equation reflects the underlying relationship between the



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stock returns and macroeconomic variables. Based on our estimation, it takes roughly fifteen months for the US economy to notice the disequilibrium and begin the initial adjusting.

### G. Variance decomposition

To account for both indirect and direct effects, I use orthogonalized impulse response functions to detect how innovations in one variable affect all the other variables in the VECM model.

**Table 6: long run forecast error variance explained by innovations**

		Percentage of 24-month forecast error variance explained by innovations in each variable	
		By itself	By other variables
1)	$\Delta SP$	83.98%	$\Delta IPI$ 7.52%
2)	$UNEXPINF$	61.92%	$\Delta RINT$ 14.85%, $\Delta IPI$ 18.12%
3)	$\Delta M1$	60.11%	$\Delta RINT$ 11.46%, $\Delta IPI$ 25.38%
4)	$\Delta RINT$	65.24%	$\Delta M1$ 19.67%, $\Delta IPI$ 10.13%
5)	$\Delta IPI$	56.74%	$\Delta SP$ 30.84%, $\Delta RINT$ 6.41%
6)	$\Delta UNEMP$	31.80%	$\Delta SP$ 40%, $\Delta IPI$ 15.60%

I report the forecasting error variance decomposition (FEVD) scores that are higher than 5%. We find that real interest rate (RINT), industrial production (IPI), and S&P500 stock returns (SP) are the most important factors in the long run. Their innovations account for more than 5% of the 24-month forecasting error variance. The percentage of the FEVD that is accounted for by its own innovations is high for stock returns (83.98%) and moderately high for unexpected inflation (61.92%), M1 growth rate (61.92%) and real interest rate (65.24%). We find evidence that S&P500 stock returns explain a significant portion (more than 30%) of the variance of industrial production and the variance of unemployment. Both variables represent are used to proxy real economic activity. In addition, industrial production explain more than 10% of the variance of unexpected inflation, the variance of money growth rate, and the variance of real interest rate. This indicates that in the long run the US stock market and real economic activity affect each other.

### CONCLUSION

Using the U.S. data, we construct a VAR model and a VECM model to investigate both the short-run and long-run causal relations and dynamic interactions between the macroeconomic variables and stock returns. I apply Toda and Yamamoto to (1995) method to detect possible long-run causal relationships among these macroeconomic variables. I find that although stock returns help explain a substantial fraction of the variance in real economic activity; no causal relations exist among the macroeconomic variables in the short-run. The real economic activity appear to Granger-cause the real stock returns only in the long run. And the relations are positive. In the long run the US stock market and real economic activity affect each other. I also find that real interest rate, industrial production, and S&P500 stock returns are the most important macroeconomic factors in the long run.

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