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Stock Market Returns and Real Activity: A Note

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THIS NOTE PRESENTS empirical results relating a measure of the variability of stock market returns to fluctuations in real economic activity. The results of our tests indicate that changes in the log of real GNP and unemployment are Granger-caused by the variation of stock market returns. This result can be interpreted as being supportive of the notion that the arrival of information relevant to production decisions impacts real output and employment slowly through time. Referred to elsewhere in the literature as the "lagged information hypothesis," this idea is common to a number of models relating changes in real variables to new information about commodity prices (e.g., Lucas [14], Sargent and Wallace [17]).[1] Based on the concept of rational expectations, the hypothesis is concerned with the predictive content of historical information in explaining real activity. It has been previously examined by, e.g., Sargent [16] and Nelson [15] for the case of known information captured by changes in commodity prices. In this note, we focus instead on information as reflected in security prices. Stock prices should portray a more general index of information (which should encompass information already impounded in commodity prices), and use of stock price data avoids many of the difficulties encountered in measuring and aggregating commodity prices. The relationship between stock returns and economic activity has also been explored in Fama [5], Fama and Gibbons [6], and others in various contexts.

I. Empirical Design

The test technique used is one advanced by Granger [9]. The Granger test is a natural choice for our analysis as the concept of Granger causality is directly related to the implications of the lagged information hypothesis, and its use in previous tests of the hypothesis is well-known.[2] But while these past tests have focused upon the implication that no correlation between real variables and

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[1] An excellent survey of this literature can be found in Futia [7].

[2] An alternative, but asymptotically equivalent test has been developed by Sims [18]. While the methodology employed in the Granger test is often referred to as a test of causation, this test does not establish that one variable *causes* another in the strict sense. Formally, Granger "causality" may be defined as follows. Let $(\hat{Y}_t \mid YX)$ be the unbiased prediction of Y_t, made at $t - 1$, based on information in the time series Y and X. Then let e_t be the prediction error at t, or,

$$e_t = Y_t - (\hat{Y}_t \mid YX).$$

known information should exist, we focus on the implication that these same real variables should be correlated with the arrival of new information or innovations. To carry out our test an operational measure of information arrival is therefore required.

The prospect that financial markets adjust to the arrival of information suggests that the volatility of financial asset prices may reflect changes in the arrival of information. In order for financial market prices to proxy for information relevant to real activity, two conditions are important. First, the information which affects the financial market must be common to that which affects output and employment decisions. And second, the adjustment of asset prices to new information must be rapid to accurately reflect the timing of information arrival. This is important since the existence of lagged effects on real variables is the central issue here. These requirements are most easily satisfied by the stock market. Stock prices reflect the market values of claims against firm output. Therefore, the stock market is the most logical market to study for the purpose of measuring the arrival of new information relevant to output decisions. Moreover, the reliability of stock price data compares favorably to that of alternative price series; the use of stock price data should significantly reduce the probability of measurement errors. In addition, market efficiency (as defined by Fama [4]) is a well-documented characteristic of the U.S. stock market.

In an efficient capital market, the arrival of information is quickly reflected by adjustments in prices which occur as a consequence of changes in expectations. In this sense changing prices convey the arrival of information. And if prices convey information, it follows that one can infer the information set used from prices. The role of prices as signals in the transfer of information is the observation made by Lucas [13].[3] We follow the same line of reasoning here in using the variability of market prices to measure the arrival of information. Our use of the variability of stock market prices as an information variable has precedent in the works of Castanias [2] and Clark [3].

To illustrate this more clearly, let $\ln p_t = E(\Omega_{t+1} \mid \theta_t)$, where Ω_{t+1} represents the model used by the market to assess the value of financial claims, p_t is the market price, and θ_t is the information set. This is consistent with the notion of an efficient stock market which is supported by numerous empirical studies. No specific model is required here; therefore what follows is consistent with a variety of specifications. Notice that p_t is a single-valued function of the information set, θ_t, If price changes are small, the return may be approximated by, $R_t \approx E(\Omega_{t+1} \mid \theta_t)$

The variance of this error series is labeled $\sigma^2(\hat{Y}_t \mid YX)$. If a similar error series is generated based only upon information in time series Y, then the variance of that error series is $\sigma^2(Y_t \mid Y)$. Variable X is said to Granger-cause variable Y if, $\sigma^2(Y_t \mid Y) > \sigma^2(Y_t \mid YX)$. In other words variable X is *informative* in predicting variable Y based on the reduced forecast error variance. In addition, Granger causation only from X to Y implies that,

$$\sigma^2(X \mid X) = \sigma^2(X \mid XY),$$

or for X to "cause" Y, it must not be the case that Y is useful in predicting X, after accounting for past values of X.

[3] For a review of the importance of this insight see Grossman [10].

$- E(\Omega_t \mid \theta_{t-1})$. Let R_t' be the return when $\theta_t = \theta_{t-1}$ so that no information arrival occurs. Hence,

$$R_t - R_t' \approx E(\Omega_{t+1} \mid \theta_t) - E(\Omega_{t+1} \mid \theta_{t-1}).$$

The difference between R_t and R_t' captures the changes in market expectations of Ω_{t+1} due to new information received between $t - 1$ and t. This unanticipated information, or innovation, has the property that it is uncorrelated with R_t'. Therefore, it follows that

$$\mathrm{var}(R_t) = \mathrm{var}(R_t') + \mathrm{var}(\eta_t),$$

where η_t is the innovation $E(\Omega_{t+1} \mid \theta_t) - E(\Omega_{t+1} \mid \theta_{t-1})$. Therefore, $\mathrm{var}(R_t)$ is greater than $\mathrm{var}(R_t')$ if unanticipated information arrives between $t - 1$ and t.[4] In what follows, we use the variance of stock returns to assess the arrival of information relevant to changes in real output or unemployment (y_t). Note that this measure is sufficiently general to be consistent with a number of underlying return generating functions. However, it is necessary to assume that the distribution of returns is stationary with finite variance.

Since the implication of the lagged information hypothesis is that y_t is correlated with unexpected information, we measure the arrival of new information by the demeaned variance of stock returns. This is equivalent to assuming that $\mathrm{var}(R_t')$ is equal to the mean $\mathrm{var}(R_t)$, and is analogous to the mean-adjusted return criterion used in residual analysis or event-time studies (see e.g., Brown and Warner [1]).[5] Conceptually, this assumption about $\mathrm{var}(R_t')$ is similar to the assumption about the natural rate involved in previous tests of the lagged information hypothesis.

If the demeaned variance of stock returns is sufficient to summarize the arrival of information in the market, the question remains as to whether information relevant to stock price changes is also related to changes in y_t. Since the shares of the firm traded in the market can ultimately be viewed as ownership claims on the output of the firm, this connection is logical. Information which affects output and employment decisions should also be relevant to the owners of factors of production including shareholders.

The test for Granger causality consists of estimating the following equation:

$$Y_t = a + \textstyle\sum_{i=1}^{n} b_i Y_{t-i} + \sum_{i=1}^{n} b_i' X_{t-i} + ct + e_t \tag{1}$$

in which a is a constant, c is estimated to control for systematic trends in the data, and e_t is a random disturbance. The first step in the test procedure is to estimate two versions of Equation (1). In the first version, only lagged values of the dependent variable are used as regressors which effectively imposes the restriction that $b_i' = 0$ (for all i). In the second version, an unrestricted form of (1) is estimated in which the coefficients b_i' are estimated. The null hypothesis,

[4] A more detailed discussion of the proposed measure can be found in Huang [12].

[5] The assumption here, however, is concerned with the constancy of the variance of R_t^n and not R_t^n itself as in residual analyses.

$H_0: b_i' = 0$ (for all i), is tested by comparing the error sum of squares for the restricted version (ESS_R) with that of the unrestricted version (ESS_{UR}):[6]

$$\frac{\dfrac{\mathrm{ESS}_R - \mathrm{ESS}_{UR}}{r}}{\dfrac{\mathrm{ESS}_{UR}}{N-k}} \sim F(r, N-k),$$

where r is the number of restricted variables, N is the number of observations, and k is the number of variables in the unrestricted version.

A second step in the test procedure is performed to verify that if X is useful in explaining Y, the reverse is not the case. To do this, restricted and unrestricted versions of (1) are re-estimated, but with X and Y interchanged. In order to infer that only X causes Y in the Granger sense, the null hypothesis must be rejected when estimating the first regression pair but accepted when estimating the second pair.

II. Results

Granger tests were performed using quarterly data spanning the period 1962 II to 1978 IV. Quarterly changes in the log of real GNP (GG) and unemployment (UG) were used to measure changes in the level of aggregate output. The variance of stock market returns was calculated for each quarterly interval from daily observations of the value-weighted index of Standard and Poors 500. The demeaned variance of stock returns (DV) was calculated from this series and used as an index of information arrival in subsequent tests. Changes in the level of commodity prices were proxied by changes in the log of the GNP price deflator.[7] The choice of the appropriate number of lags (n) is important in at least two respects. When fewer lags are used, the probability of an errors-in-variables problem is increased. But when more lagged variables are added, the number of degrees of freedom becomes smaller reducing the statistical power of the tests. In light of these considerations, we include enough lagged values to capture any seasonal effects not already reflected in the seasonally adjusted data by letting $n = 4$ and $n = 6$.

The results are reported in Table I. For each equation the restricted and unrestricted R^2 are reported (R_1^2 and R_2^2, respectively) as is the F-statistic used to test the null hypothesis ($H_0: b_i' = 0\ \forall i$). The results here indicate clear cut support for the lagged information hypothesis. At both $n = 4$ and $n = 6$, lagged values of DV were significant in explaining current values of GG and UG after accounting for lagged values of GG and UG. But, at the same time, lagged GG

[6] An alternative to the F-test applied here is the S-test designed by Haugh [11]. We employ the F-test here since Geweke [8] demonstrates it to be superior to S-tests in small samples.

[7] Data for stock market returns were compiled from the daily file maintained by the Center for Research in Security Prices at the University of Chicago. Quarterly data for real GNP, unemployment, and GNP deflator were compiled from *Business Statistics, Survey of Current Business* (U.S. Department of Commerce).

Table I

Regression of: $Y_t = a + \sum_{i=1}^{n} b_i Y_{t-i} + \sum_{i=1}^{n} b_i' X_{t-i} + ct + e_t$

Regression Number	Lag (n)	Regression Pair Y	X	R_1^2/R_2^2	$F(H_0\colon b_i' = 0\ \forall i)$
1	4	GG	DV	0.182/0.387	4.336*
2	4	DV	GG	0.461/0.498	0.939
3	4	UG	DV	0.196/0.410	4.709*
4	4	DV	UG	0.486/0.523	0.897
5	6	GG	DV	0.250/0.459	2.954*
6	6	DV	GG	0.486/0.546	1.015
7	6	UG	DV	0.207/0.468	3.77*
8	6	DV	UG	0.486/0.549	1.091

* Indicates significance at 5% level (reject H_0).

and UG were not significant in explaining current values of DV after accounting for lagged DV. This indicates that DV Granger-causes GG and UG which lends support to the notion that the arrival of information, captured by DV, has a lagged effect on the aggregate variables GG and UG.

As was noted, previous research into the lagged information hypothesis has focused on the arrival of information about commodity prices to explain changes in output (see Nelson [15]). But we argue here that stock price changes provide a more comprehensive and reliable indication of information arrival. If this is the case, information arrival impounded in commodity price changes can be of no use in explaining variation in aggregate output beyond that already explained by changes in DV. Table II reports the results of running two additional tests designed to detect if lagged changes in the log of the real GNP deflator (DP) are helpful in explaining variation in current values of GG or UG, after accounting for lagged values of DV and GG or UG. In these tests, the unrestricted versions of regressions 1, 3, 5, and 7 in Table I each become restricted versions of regressions 1, 2, 3, and 4 in Table II, respectively, which are of the form,

$$Y_t = a + \sum_{i=1}^{n} b_i Y_{t-i} + \sum_{i=1}^{n} b_i' X_{t-i} + \sum_{i=1}^{n} b_i'' DP_{t-i} + ct + u_t,$$

when the restriction $b_i'' = 0$ is imposed for all i. The unrestricted regressions add lagged values of DP as independent variables and estimate the coefficients b_i''. Again, the error sum of squares of each version is compared to evaluate whether lagged DP significantly improves goodness of fit. The F-statistic reported in Table II tests the hypothesis, $H_0\colon b_i'' = 0$ (for all i). At each lag we find that the null hypothesis cannot be rejected at the 5% level of significance. This indicates that any "causality" running from DP to either GG or UG is already impounded in DV.

III. Summary

The notion of whether known information affects real activity has been previously examined using historical (changes in) commodity prices to reflect known information. In this note, we propose measuring new information arrival with

Table II

Regression of:

$$Y_t = a + \sum_{i=1}^{n} b_i Y_{t-i} + \sum_{i=1}^{n} b_i' X_{t-i} + \sum_{i=1}^{n} b_i'' DP_{t-i} + ct + e_t$$

Regression Number	Lag (n)	Regression Pair Y	Regression Pair X	$F(H_0{:}b_i'' = 0)$
1	4	GG	DV	1.722
2	4	UG	DV	1.235
3	6	GG	DV	1.153
4	6	UG	DV	0.846

the variance of stock returns, and present empirical results which indicate that measures of real activity are Granger-caused by stock return variations. Results which show that changes in commodity prices provide no additional explanatory power not already captured by stock return variance are also presented. The results are therefore consistent with a lagged impact of information (relevant to output decisions) on real activity. However, no specific formal model of real activity and information is tested, and future studies utilizing specific paradigms can lead to more powerful tests of the null hypothesis.

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