



## Empirical analysis of real and financial volatilities on stock excess returns: evidence from Taiwan industrial data

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### Abstract

This paper tests the relation between stock excess returns and risk factors measured by volatility. The sources of the volatility are based on the volatility of macroeconomic factors and time-series volatility. To model the macroeconomic fundamentals, we divide the risk into real and financial volatilities pertinent to Taiwan's economic environment. By examining the data of industry excess returns and market excess returns, we find evidence to reject the hypothesis that the stock excess returns are independent of the real and financial volatilities. © 2000 Elsevier Science Inc. All rights reserved.

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In studies of expected returns by Merton (1973), Lucas (1978), and Cox, Ingersoll, and Ross (1985), among others, uncertain changes in the investment opportunity set play a vital role in determining asset demand by wealth holders. It is generally agreed that investors must be compensated, by expected returns, for bearing the risk of unfavorable shifts in opportunities as well as for assuming systematic market risk. Although the asset pricing model has provided some guidance in modeling risk, identification of the state variables that characterize uncertainty remains an unsettled matter. Although much research has been done on the relation of stock excess returns to some economic variables and macrovolatilities (Chiang & Chiang, 1996; Schewert, 1989), no attempt has been made to investigate whether real or financial volatility

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plays a significant role in explaining the stock excess returns.<sup>1</sup> It is also difficult to find comparable research in analyzing a semi-industrialized country such as Taiwan. This paper attempts to identify and test the sources of macrovolatilities in explaining the Taiwanese stock market. Specifically, we develop a model that integrates time-series volatility and macroeconomic fundamental volatility, which consists of the real and financial shocks.

This paper is organized as follows. Section 1, on the basis of the arbitrage pricing theory (APT) and the modern intertemporal asset pricing theory, derives a model for the stock excess returns explanation. Section 2 describes the data sets and provides the measures of the volatility of the fundamental variables. Section 3 reports the empirical evidence for the test question. Section 4 offers concluding remarks.

### 1. A model for stock excess returns

In the arbitrage pricing theory model, the factors determining asset prices can be specified by a set of state variables. It follows that the excess returns can be written as:

$$R_{pt} - R_{ft} = \alpha_p + \sum_{k=1}^n \beta_{pk} F_{kt} + \epsilon_{pt} \quad (1)$$

where  $\alpha_p$  is a constant term,  $\beta_{pk}$  is the factor loading (i.e., the sensitivities of the stock excess return to the innovations on factor  $k$ ),  $F_{kt}$  is the time-series observation of the  $k$ th factor at time  $t$ , and  $\epsilon_{pt}$  is a random error term. This error term is assumed to have an expected value of zero. All the  $\beta$ 's are assumed to be constant over time.

Equation (1), in the vein of both the APT (Ross, 1976) and the intertemporal capital asset pricing model (CAPM) (Breedon, 1986; Merton, 1973), proposes that expected excess returns are assumed to be linearly related to the factor loadings:

$$R_{pt} - R_{ft} = \lambda_{p0,t} + \sum_{k=1}^n \lambda_{pk,t} \hat{\beta}_{pk} + \mu_{pt} \quad (2)$$

where  $\lambda_{pk,t}$  is the risk premium, which denotes sensitivity to the end-of-period innovation in state variable  $k$ ;  $\hat{\beta}_{pk}$  is the factor loading; and  $\mu_{pt}$  is the error term. Equation (2) states that the expected excess return on a portfolio is compensated for the sensitivity of shocks to state variables.

In modeling this equation, Breedon (1986), Campbell (1987), French, Schwert, and Stambaugh (1987), Lauterbach (1989), and Shanken (1990) relate the price of risk to the conditional volatility of the state variables.<sup>2</sup> Thus, it is relevant to specify that:

$$\lambda_{pk,t} = \alpha_{pk,t} + \gamma_{pk} \sigma_{X_{k,t}} \quad (3)$$

where  $\lambda_{pk,t}$  is the risk premium per unit of sensitivity to the end-of-period innovation in state variable  $X_k$  and  $\sigma_{X_{k,t}}$  is the ex ante standard deviation of  $X_k$  at time  $t$  conditional on the information available at time  $t - 1$ .

Substituting Eq. (3) into Eq. (2), we obtain:

$$R_{pt} - R_{ft} = \xi_{pt} + \sum_{k=1}^n \gamma_{pk} \hat{\beta}_{pk} \sigma_{X_{k,t}} + \mu_{pt} \quad (4)$$

where  $\xi_{pt}$  is an intercept:

$$\xi_{pt} = \lambda_{p0,t} + \sum_{k=1}^n \alpha_{pk,t} \hat{\beta}_{pk}$$

Reparameterizing Eq. (4), we Obtain:

$$R_{pt} - R_{ft} = b_{p0} + \sum_{k=1}^n b_{pk} \sigma_{X_{k,t}} + \epsilon_{pt} \tag{5}$$

where  $b_{p0} = \xi_{pt}$  and  $b_{pk} = \gamma_{pk} \hat{\beta}_{pk}$ .

In an examination of the historical economic development in Taiwan, it is reasonable to employ real income and the exchange rate as the main arguments in modeling stock excess returns. In a standard valuation model, the value of the stock is determined by the present value of the future income streams (dividends), which in turn are determined by the strength of the economy. Because the value of corporate equity on the aggregate level depends on the growth of real income, the volatility of that real income can be viewed as a proxy for the dividend’s volatility. This real income volatility is defined as a “real volatility” in this study.

Next, we employ the exchange rate as a key variable associated with financial variability. The reason for doing so is that the wealth in a semi-industrialized country such as Taiwan is derived essentially from its exports, which are tied to the variable of the exchange rate. The volatile movements of a country’s exchange rate will affect its expected cash flows and, even more, could change its competitive position. As a result, the volatility of the exchange rate plays a vital role in explaining corporate performance, as indicated in the stock excess returns. Therefore, the volatility of the exchange rate can be viewed as a nominal (financial) volatility to the system.

It has been recognized generally that the error term in Eq. (5) is characterized with conditional heteroskedasticity. The appeal of the autoregressive conditional heteroskedasticity (ARCH)-type model applied to the finance area is that stock excess returns can be modeled in relation to risk factors captured by the conditional variance.<sup>3</sup> One way to specify the model is to assume that the variance is a linear function of lagged conditional variance and squared past residual errors. A typical form of generalized GARCH(1,1)-M process that includes exogenous variables can be expressed as:

$$(R_{pt} - R_{ft}) = b_0 + \sum_{k=1}^n b_k \sigma_{X_{k,t}} + \gamma h_{pt}^{1/2} + \epsilon_{pt} \tag{6}$$

$$\epsilon_{pt} / \Omega_{t-1} \sim N(0, h_{pt})$$

$$h_{pt} = \varpi + \alpha \epsilon_{p,t-1}^2 + \beta h_{p,t-1} \tag{7}$$

The volatilities in the system of Eqs. (6) and (7) are derived from macroeconomic activity and from a time-series element. Note that the work by French, Schwert, and Stambaugh (1987), Chou (1988), and Ballie and DeGennaro (1990) can be viewed as a special case of Eqs. (6) and (7). Particularly, the research by these authors concerns only the relation between the expected excess returns and the conditional volatility (time-series volatility) of the aggregate market index. The question of ex ante volatility from macroeconomic variables was ignored by previous model specification.

## 2. Description of data

Owing to the lack of consistent data available for the industrial indices of Pacific Asian markets, the empirical studies in this paper are concentrated on the data in Taiwan's market. Moreover, the industrial development and performance in Taiwan have maintained a very steady pace, and their operations are tied closely with the international markets. Thus, the industrial performance and international linkage provide a relevant forum to investigate the effects of industrial output and exchange rate variations on the stock market. In particular, we shall examine the empirical relation between industrial stock excess returns and risk associated with output fluctuations and exchange rate movements. The monthly returns of eight industry portfolios were constructed by using eight industry indexes from the Taiwan Stock Exchange. They are the cement and ceramics industry (I11), the food industry (I12), the plastics and chemical industry (I13), the textiles industry (I14), the electric and machinery industry (I16), the paper and pulp industry (I19), the construction industry (I25), and the banking and insurance industry (I28). Stock returns are defined as the first difference in the log of daily indexes. The change in the Taiwan weighted-average stock index serves as our market portfolio return.

The sample period of this research spans January 1987 through December 1996. The reason for choosing 1987 as the starting year is the fact that Taiwan's stock market became more popular and so experienced larger trading volume from that date. At the same time, market pressure, mainly from the United States, forced the New Taiwan dollar to appreciate against the U.S. dollar. Because Taiwan is an export-oriented country, currency appreciation will produce a negative effect on trade flows and, in turn, on earnings and stock returns. Moreover, the indexes of the banking and insurance industry (I28) were available only from January 1987.

The change in real output is proxied with the annual growth rate of the industrial production index (YP),<sup>4</sup> defined as the natural log of the ratio of the level of industrial production in month  $t$  to the level of industrial production in month  $t - 12$ ; whereas, the nominal shock is proxied with the change in the exchange rate (EX),<sup>5</sup> measured as the natural log of the ratio of the NT price of one U.S. dollar at the end of month  $t$  to the NT price of one U.S. dollar at the end of month  $t - 1$ . All of the variables are measured at monthly intervals.

To estimate the monthly volatility of macroeconomic variables from the monthly data, we use the procedures suggested by Schwert (1989). First, we assume that the best forecast of monthly  $X_t$  is provided by an AR model, as in Eq. (8):

$$X_t = \sum_{i=1}^{12} \alpha_i X_{t-i} + \sum_{j=1}^{12} \beta_j D_{jt} + \epsilon_t \quad (8)$$

where  $X_t$  represents the predicted macroeconomic variables (the annual growth rate of industrial production and the change in the exchange rate) and  $D_{jt}$  is the dummy variable for month  $j$ . Next, to generate the predicted volatility of macrofactors, we fit absolute residuals derived from Eq. (8) into a 12th-order autoregression:

$$|\hat{\epsilon}_t| = \sum_{i=1}^{12} \delta_i |\hat{\epsilon}_{t-i}| + \sum_{j=1}^{12} \omega_j D_{jt} + \nu_t \quad (9)$$

where  $D_{jt}$  represents monthly dummies. The predicted absolute error,  $|\hat{\epsilon}_t|$ , from Eq. (9) represents the predicted standard deviation of  $X_t$ , conditional on the information available at month  $t - 1$ . This equation is a form of autoregressive conditional heteroskedasticity in the forecast errors.

### 3. Empirical results

#### 3.1. Time-series properties of industry returns and market returns

To provide a general understanding of the properties of industry portfolio returns and to compare the distinct properties across different industry portfolios, we present summary statistics for the eight industry portfolios and the market portfolio for the period from January 1987 through December 1996 in Table 1. The statistics include the average monthly return, standard deviation, skewness, excess kurtosis, autocorrelations, and the Ljung-Box Q(18) value (Ljung & Box, 1978).

The sample means of all monthly industry portfolio returns range from 0.73% to 2.31%. The weighted-average stock index has a mean return of 1.58% and a standard deviation of 14.73%. The banking and insurance industry (I28) has the largest mean (2.31%), with the highest standard deviation of 18%. These percentages seem to be consistent with the general perception that the banking and insurance industry is more sensitive to a change in economic conditions and has been the leading industry on the Taiwan Stock Exchange in the past decade. The paper and pulp industry (I19) has the lowest return (0.73%) and a standard deviation of 14.87%.

If the data are normally distributed, then the coefficients of skewness and excess kurtosis should be equal to zero. The evidence indicates that many of the industry portfolio returns and the market return depart from normality.<sup>6</sup> The independence assumption for the  $T$  observations in each time series is tested by calculating the autocorrelation coefficients. With the use of the usual approximation of  $1/\sqrt{T}$  as the standard error of the estimate, the statistics for all portfolios cannot reject the null hypothesis of the absence of first-order autocorrelation at the 10% significance level.<sup>7</sup> There seems to be a lack of predictability of the returns for the eight industry portfolios and the market portfolio. Table 1 also presents the Ljung-Box portmanteau test statistics for independence in the industry return series, denoted by Q(18), which follow a  $\chi^2$  distribution with 18 degrees of freedom (Ljung & Box, 1978). The Ljung-Box Q(18) statistic is designed to test whether the series correlations up to 18 orders as a group are all equal to zero.<sup>8</sup> The critical value of a 10% confidence level for Q(18) is 25.98. The evidence shows that all industry portfolio returns cannot reject the null hypothesis of absent dependency.

In a comparison of the means and the standard deviations for these eight industries, several results are noteworthy. First, the return volatility of the banking and insurance industry (I28) is relatively larger, whereas that of the cement and ceramics industry (I11) is relatively smaller. Second, the returns volatilities for the other six industries (I12, I13, I14, I16, I19, and I25) are about the same level (14.51–14.89%). However, the electric and machinery industry (I16) enjoys a much higher monthly mean return

Table 1  
Summary statistics of the industry portfolio returns and market

	I11	I12	I13	I14	I16	I19	I25	I28	RM
Mean	0.0134	0.0142	0.0111	0.0101	0.0168	0.0073	0.0114	0.0231	0.0158
Std. Dev.	0.1271	0.1478	0.1456	0.1451	0.1483	0.1487	0.1489	0.1800	0.1473
Skewness	-0.01	-0.58**	-0.60***	-0.62***	-0.62***	-0.29	-0.83***	0.19	-0.42*
Kurtosis	3.14***	1.95***	1.79***	1.46***	2.46***	0.96**	2.70***	1.89***	1.69***
ACF									
1	-0.0945	-0.0525	-0.0615	0.0215	-0.0284	0.0041	0.0304	0.1290	0.0634
2	0.0629	0.0406	0.0301	0.0363	0.0135	-0.0626	-0.0075	-0.0464	0.0031
3	-0.0346	-0.0167	0.0011	0.0234	-0.0154	0.0373	0.0382	-0.0836	-0.0412
4	0.0887	0.0446	0.0375	-0.0095	0.0223	0.0222	0.0384	0.0867	0.0619
5	0.1686	0.0848	-0.0191	0.0504	0.0426	0.0972	0.0303	0.0023	0.0158
6	-0.0904	-0.0427	-0.0532	-0.0917	-0.0595	-0.0396	-0.0149	0.0067	-0.0554
9	0.0848	0.0169	0.0328	0.0024	0.0669	0.0008	0.0447	0.0763	0.0685
12	0.1689	0.1845	0.1150	0.1348	0.1392	0.1407	0.1297	0.0757	0.1240
18	0.0824	0.1403	0.1311	0.0454	0.1351	0.0511	0.1139	0.1226	0.1320
Q(18)	22.7700	24.2100	15.0400	12.9600	18.5500	19.3200	16.3200	20.0900	16.2600

Note: \*, \*\*, and \*\*\*: statistically significant at 10%, 5%, and 1% levels, respectively.

of 1.68% compared with that of the paper and pulp industry (I19), at only 0.73%. Even though the returns for all the industries have similar patterns, the levels of the average returns for the industries are quite different. The question is whether the return differential is attributable to the risk differential or to other factors. Otherwise, an arbitrage may take place to achieve allocational efficiency.

### 3.2. GARCH(1,1)-M model

Because several empirical studies indicate that the GARCH(1,1) model adequately fits many economic time series,<sup>9</sup> we first employ the traditional GARCH(1,1)-M model for all the industry portfolios and for the market portfolio. The empirical specification of the traditional GARCH(1,1)-M is given by:

$$(R_{it} - R_{ft}) = a_0 + \gamma h_{it}^{1/2} + \epsilon_{it} \quad (10)$$

$$\epsilon_{it}/\Omega_{t-1} \sim N(0, h_{it})$$

$$h_{it} = \omega + \alpha \epsilon_{it-1}^2 + \beta h_{it-1} \quad (11)$$

where  $(R_{it} - R_{ft})$  is the excess return of industry  $i$  or the market excess return, and inequality restrictions of  $\omega > 0$ ,  $\alpha \geq 0$ , and  $\beta \geq 0$  are imposed to ensure that the conditional variance ( $h_{it}$ ) is positive. Equations (10) and (11) are estimated jointly and recursively by maximizing the log-likelihood function with respect to the parameters in return and variance equations. Because the model is nonlinear in nature, usually the ordinary least square (OLS) method is implemented to obtain the initial values (conditions) for the parameters in Eqs. (10) and (11). Then, a regression error and error square series are derived, and the latter can be used to generate conditional variance. Calculating the squared root of the conditional variance then becomes an argument in the return equation. The next step is to maximize the log-likelihood function from observation 2. This process will be continued until the parameters are converged [see Enders (1995), pp. 162–165]. The estimating method in this paper is based on RATS numerical procedures (Doan, 1995).

The significant influence of conditional volatility on stock excess returns is captured by the estimated coefficient  $\gamma$ . A significant and positive coefficient on  $\gamma$  implies that investors were compensated by higher returns for bearing higher levels of risk. A significant negative coefficient indicates that investors were penalized for bearing risk. In Eq. (11), the size and significance of  $\alpha$  indicates the magnitude of the effect imposed by the lagged error square term ( $\epsilon_{it-1}^2$ ) on the variance ( $h_{it-1}$ ). Note that the significance of  $\alpha$  indicates the existence of the ARCH process in the variance equation.

The results of estimating the GARCH-M model for the eight industrial indexes and the market portfolio are reported in Table 2.<sup>10</sup> The evidence shows that the ARCH effect is present in all the industry portfolios and the market portfolio.<sup>11</sup> However, the coefficient on the lagged variance term ( $h_{it-1}$ ) is less impressive. Only the coefficients on the food industry (I12) and the construction industry (I25) are significant.

The influence of conditional volatility on stock returns ( $\gamma$ ) is found to have mixed signs but is insignificant for six industry portfolios and the market portfolio. Significant

Table 2  
GARCH-M models for the monthly stock excess returns

$$(R_{it} = R_{ft}) = b_0 + \gamma h_{it}^{1/2} + \epsilon_{it}$$

$$h_{it} = \varpi + \alpha \epsilon_{it-1}^2 + \beta h_{it-1}$$

Industry	$b_0$	$\gamma$	$\varpi$	$\alpha$	$\beta$	L.L. <sup>a</sup>	Q(12) <sup>b</sup>	$m_3^c$	$m_4^c$
I11	0.0292 (1.12)	-0.2812 (1.03)	0.0036*** (2.99)	0.7145*** (4.10)	0.1810 (1.15)	204.26	15.35	0.59**	0.48
I12	0.0357 (1.07)	-0.2561 (0.84)	0.0043** (2.45)	0.4837*** (2.93)	0.3189* (1.88)	187.26	13.15	0.26	-0.02
I13	0.1199*** (2.63)	-0.9321** (2.39)	0.0071** (2.45)	0.4062** (2.28)	0.2315 (0.97)	182.31	5.70	0.28	0.02
I14	0.0504 (1.15)	-0.3803 (1.02)	0.0055*** (3.09)	0.5070** (2.28)	0.2587 (1.47)	182.7	7.37	0.20	-0.04
I16	0.0669* (1.86)	-0.5168* (1.65)	0.0072*** (2.81)	0.6064*** (2.77)	0.0601 (0.35)	186.87	9.12	0.07	-0.21
I19	0.0623 (1.26)	-0.4770 (1.18)	0.0082*** (2.81)	0.4288** (2.18)	0.1921 (1.03)	178.19	9.99	0.29	0.02
I25	-0.0047 (0.16)	0.0882 (0.36)	0.0032** (2.18)	0.5032*** (2.98)	0.4098** (2.26)	185.76	10.32	0.03	1.04**
I28	0.0735 (1.08)	-0.3622 (0.92)	0.0106 (1.53)	0.2624* (1.94)	0.4092 (1.38)	150.38	15.95	0.72***	1.21***
RM	0.0565 (1.26)	-0.4057 (1.11)	0.0054** (2.15)	0.3584** (2.15)	0.3788 (1.60)	180.71	10.10	0.40*	0.31

The values in parentheses are the absolute t-statistics.

\*, \*\* and \*\*\*: significance at the 10%, 5%, and 1% levels, respectively.

<sup>a</sup>L.L. denotes the log-likelihood function.

<sup>b</sup>Q(12) is Box-Ljung Q-statistic that tests the joint significance of the autocorrelations of the innovations up to the 12th order. The critical values are 26.2, 21.0, and 18.5 for the 1%, 5%, and 10% levels, respectively.

<sup>c</sup>The statistics  $m_3$  and  $m_4$  are the sample skewness and kurtosis of the standardized residuals.

negative  $\gamma$  is present in the plastics and chemical industry (I13) and in the electric and machinery industry (I16). It should be noted that an inverse relation between risk and return also is possible.<sup>12</sup> As indicated by Glosten et al. (1993), if the future seems risky, investors may want to save more in the present, thus not requiring a large risk premium. This behavior may produce an inverse relation between return and variance.

### 3.3. The full model

In testing the excess returns in relation to the real and financial risks, we add predicted macroeconomic volatilities on the right side of Eq. (10). The full model is given by:

$$(R_{it} - R_{ft}) = a_0 + b_1 \sigma_{YP,t} + b_2 \sigma_{EX,t} + \gamma h_{it}^{1/2} + \epsilon_{it} \tag{12}$$

$$\epsilon_{it} / \Omega_{t-1} \sim N(0, h_{it})$$

$$h_{it} = \varpi + \alpha \epsilon_{it-1}^2 + \beta h_{it-1} \tag{13}$$

where  $\sigma_{Y_{P,t}}$  is the predicted standard deviation of the annual growth rate of the industrial production index and  $\sigma_{EX,t}$  is the predicted standard deviation of the change in exchange rate. These two measures of macroeconomic risk are generated by the procedure suggested by Schwert (1989) in Eqs. (8) and (9), as described in Section 2.

A special feature of this model is that the stock excess returns are explained by the predicted volatility of macrofactors and the conditional standard deviation. In Eq. (12), the volatility of macrofactors consists of the volatilities arising from real (internal) and financial (external) shocks, whereas the time-series volatility is due to previous shocks, as represented by Eq. (13). Apparently, Eq. (10) is nested in Eq. (12). In the regression estimation, if the restriction  $b_1 = b_2 = 0$  is rejected, we can claim that the stock excess return is associated with the volatility of macrofactors. Alternatively, if  $\gamma = 0$  is rejected, the stock excess return can be explained by a standard mean-variance framework. However, if both  $b_1 = b_2 = 0$  and  $\gamma = 0$  are rejected simultaneously, we conclude that the stock excess return is attributed to both macrofactor volatility and time-series volatility.

The estimated coefficients of the full model are presented in Table 3. At first glance, all the industry excess returns and the market excess return are related to the real volatility, whereas only four industry excess returns are significantly related to the exchange rate volatility. The industries, including the textiles industry (I14) and the electric and machinery industry (I16), are considered to be export-oriented business, and therefore higher risk premia are needed to compensate for the higher volatility on the exchange rate. As can be seen from Table 3, the estimated statistics ( $LR$ ) that test the joint hypothesis of  $b_1 = b_2 = 0$  are well above the critical value, thereby rejecting the hypothesis that the stock excess returns for all eight industries and the market are independent of the real and financial shocks.<sup>13</sup> However, the evidence in Table 3 indicates that only four industries (the food industry (I12), the plastics and chemical industry (I13), the textiles industry (I14), and the electric and machinery industry (I16)) have significant coefficients on the conditional volatility. Taken together, the estimated results from the return equation suggest that the domestic real output volatility plays a dominant role in explaining the stock excess returns. With respect to the variance equation, we continue to find the ARCH component to be significant and the coefficient of the lagged variance to be less significant.

#### 4. Conclusion

Much research effort in recent years has been dedicated to investigating the relation between stock excess return and volatility. To capture the time-varying risk premium, most studies have focused on the conditional volatility generated from econometric models. Very little attention has been given to a search for other risk factors. In addition to the conventional conditional volatility, this paper attempts to provide a direct test in relating stock excess returns to risk factors measured by the volatility of macroeconomic variables for Taiwan's industrial indexes.

By employing industry and market excess return data, we find supporting evidence to reject the hypothesis that stock excess returns are independent of the volatility of

Table 3  
Full model for monthly stock excess returns and volatilities

$$(R_{it} = R_{ft}) = b_0 + b_1\sigma_{Y_{P,t}} + b_2\sigma_{EX,t} + \gamma h_{it}^{1/2} + \epsilon_{it}$$

$$h_{it} = \varpi + \alpha \epsilon_{i,t-1}^2 + \beta h_{i,t-1}$$

Industry	$b_0$	$b_1$	$b_2$	$\gamma$	$\varpi$	$\alpha$	$\beta$
I11	-0.0245 (0.70)	0.8919** (2.32)	1.8796 (1.00)	-0.1827 (0.70)	0.0032*** (2.76)	0.7178*** (3.73)	0.1908 (1.30)
I12	0.0069 (0.15)	1.0967** (2.09)	3.7122 (1.28)	-0.5322* (1.66)	0.0073*** (2.62)	0.6168*** (2.87)	0.0152 (0.07)
I13	0.0468 (0.87)	0.8203* (1.71)	3.7931 (1.44)	-0.8353** (2.33)	0.0071*** (2.67)	0.4775** (2.41)	0.1673 (0.85)
I14	0.0111 (0.20)	1.0986** (2.32)	5.1702** (2.14)	-0.6680* (1.67)	0.0065*** (3.26)	0.5212*** (2.61)	0.1491 (0.98)
I16	-0.0247 (0.60)	1.0475** (2.27)	6.1209*** (2.69)	-0.4466* (1.65)	0.0063*** (2.92)	0.6774*** (2.92)	0.0330 (0.26)
I19	-0.0085 (0.15)	1.1149** (1.97)	6.1285** (2.45)	-0.6024 (1.54)	0.0086*** (2.99)	0.4552** (2.33)	0.1146 (0.61)
I25	-0.0589 (1.23)	0.8529* (1.83)	5.4001* (1.78)	-0.0492 (0.20)	0.0036* (1.88)	0.5113*** (2.92)	0.3610* (1.67)
I28	-0.0213 (0.27)	1.5573*** (2.81)	4.6563 (1.18)	-0.3433 (0.96)	0.0102** (2.13)	0.3418** (2.01)	0.3408 (1.36)
RM	-0.0336 (0.64)	1.3843*** (3.50)	5.6423** (2.26)	-0.4488 (1.37)	0.0055** (2.14)	0.5416** (2.37)	0.2160 (0.95)

  

Industry	L.L. <sup>a</sup>	Q(12) <sup>b</sup>	$m_3^c$	$m_4^c$	LR <sup>d</sup>
I11	207.90	15.60	0.52**	0.47	7.28**
I12	190.31	16.44	0.26	-0.15	6.08**
I13	184.60	7.50	0.32	0.06	4.57*
I14	186.73	8.86	0.15	-0.30	7.87**
I16	191.72	10.00	-0.07	-0.40	9.68**
I19	182.20	11.20	0.23	-0.06	8.02**
I25	189.14	11.56	-0.19	0.99**	6.77**
I28	153.60	14.00	0.64***	1.06**	6.45**
RM	185.95	10.33	0.29	0.05	10.47***

Note: The values in parentheses are the absolute t-statistics.  
\*, \*\* and \*\*\*: significance at the 10%, 5%, and 1% levels, respectively.

<sup>a</sup>L.L. denotes the log-likelihood function.

<sup>b</sup>Q(12) is Box-Ljung Q-statistic that tests the joint significance of the autocorrelations of the innovations up to the 12th order.

<sup>c</sup>The statistics  $m_3$  and  $m_4$  are the sample skewness and kurtosis of the standardized residuals.

<sup>d</sup>LR is the likelihood ratio statistic testing the null hypothesis that  $b_1 = b_2 = 0$ .

macrofactors. When these macrovolatilities are divided into real (domestic output) and financial (exchange rate) components, the real output volatility appears to be more dominant in explaining the excess returns, although other sources of volatility also have some explanatory power. This new evidence has not been singled out in previous studies, especially in the research based on aggregate stock data.

## Notes

1. Many studies provide evidence by using some state variables to document predictable variation in asset returns. Fama and French (1988) showed that U.S. stock returns can be predicted by U.S. Treasury-bill rates. Fama and French (1988) documented the explanatory power of dividend yields. Keim and Stambaugh (1986) found that the junk-bond premium as well as dividend yields have explanatory power for excess stock returns. Chen, Roll, and Ross (1986) used industrial production, term-structure premium, default premium, and changes in expected inflation as proxies for the state variables that drive asset returns. Campbell (1987) showed that the term structure has predictive ability with respect to stock returns. For outside the United States, Asperm (1989) provided studies for European countries and supported the fact that some economic variables can help to explain the movement of stock prices. Chiang (1998) and Su (1998) also found some supportive evidence in Pacific Asian countries with respect to the relation between stock excess returns and conditional variances.
2. Breeden (1986) derived a relation between the expected term premium and the conditional variance of consumption. French, Schwert, and Stambaugh (1987) found a positive relation between the expected premium on the stock and the conditional standard deviation of the return on the stock market. Campbell (1987) showed that the expected returns on some cleverly chosen hedge portfolios depend on the conditional variances of the hedge portfolios' returns. Lauterbach (1989) related the expected premium on a treasury bill to the ex ante conditional volatilities of consumption, spot interest rate, and industrial production. Shanken (1990) conducted tests of a two-factor asset pricing model in which expected stock returns are related to the conditional volatility of the short-term interest rate.
3. Bollerslev, Chou, and Kroner (1992) provided an excellent survey of studies by using the ARCH methodology to model returns on speculative assets. Generalized ARCH (GARCH) models were used by French, Schwert, and Stambaugh (1987), Akgiray (1989), and Ballie and DeGennaro (1990) to model the daily stock index and by Lamoureux and Lastrapes (1990) and Kim and Kon (1994) to model individual stock return data.
4. Many authors document that the yearly growth rate of the industrial production index has more explanatory power than the monthly growth rate. See Chen, Roll, and Ross (1986) and Chen (1991).
5. In their study of economic exposure, Jorion (1991) and Bodnar and Gentry (1993) found that the changes in the exchange rate have different effects across industries.
6. Early evidence (Fama, 1965; Mandelbrot, 1963) suggested that the distribution of stock returns was not normal and that the distribution had fat tails owing to outliers. More recently, Campbell and Wasley (1993) documented a substantial degree of nonnormality in stock returns that persist even at the portfolio level.

7. The lack of significant lag-one autocorrelation coefficients is not consistent with findings in some other countries. Laurance (1986) indicated the existence of lag-one coefficients in Singapore. Panas (1990) found significant autocorrelation on the Athens exchange. In thinly traded markets, Butler and Malaikah (1992) observed significant lag-one coefficients in Kuwait and Saudi Arabia. Ratner (1996) reported significant lag-one coefficients for the general index and other five industries of the Madrid market.
8. The formula for the Ljung-Box statistic is:

$$Q(k) = T(T + 2) \sum_{j=1}^k \rho_j^2 / (T - j)$$

where  $\rho_j$  is the  $j$ th lag autocorrelation,  $k$  is the number of autocorrelations, and  $T$  is the sample size. The null hypothesis is  $H_0: \rho_1 = \dots = \rho_k = 0$ . Rejection of the null hypothesis indicates the presence of serial correlation.

9. See Bollerslev (1986), Akgiray (1989), and Engle and Ng (1993).
10. Box-Ljung statistics fail to indicate the presence of serial correlation at 10% in any of the standardized residuals. Therefore, the results in Table 2 support the specification in Eqs. (10) and (11).
11. On the basis of the studies of Bollerslev et al. (1992), the ARCH effect in stock markets could be due to clustering of trading volumes, nominal interest rates, dividend yields, money supply, oil price index, and so forth.
12. According to Black (1976) and Christie (1982), a reduction in the equity value of a firm would raise its debt-to-equity ratio, hence raising the riskiness of the firm as manifested by an increase in future volatility. As a result, the future volatility will be negatively related to the current return on that stock. Glosten et al. (1993), using ARCH-M and GARCH-M models, respectively, find a significant negative relation between risk and return for U.S. data.
13. The hypothesis that  $b_1 = b_2 = 0$  is tested on the basis of the likelihood ratio test. The likelihood ratio statistic is calculated as  $LR = -2(L_R - L_U)$ , where  $L_R$  is the value of the log likelihood under the null hypothesis and  $L_U$  is the log likelihood under the alternative. The statistic is distributed as  $\chi^2$  with two degrees of freedom.

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