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Abstract

This paper explores whether investors carefully watch the export intensity and net foreign position of Japanese firms, and whether this information is properly reflected in the stock prices. By estimating a multi-factor model including the TOPIX, the call rate, the exchange rate and other variables representing the characteristics of individual firms, we find that investors do properly respond to a change in the exchange rate when considering the firms' foreign assets and liabilities since 1992. Investors are also shown to be aware of the export intensity of firms since 1985.

JEL Classification Number: G12; G14; G15.

Keywords: Exchange rate; Stock price; Market efficiency; Panel unit root test.

1. Introduction

In a modern world where trade between countries is extremely significant, exchange rates are very important determinants of a firm's profitability. In particular, the exchange rate is vital to the profitability of both exporting and importing firms, as well as any multinational corporation. For example, changing exchange rates most heavily impacts countries like Japan. In Japan there has been a tendency of a significant balance of payment surplus and a large proportion of the industrial production directed to export over the last two decades. For entities that have assets or liabilities measured in foreign currency, the exchange rate directly determines the value of those operations, and therefore affects their stock prices, if investors evaluate them properly.

Firms with a significant portion of their business involved in the export or import of goods, as well as in foreign exchange positions are strongly influenced by changes in the exchange rate. Thus one can consider the exchange rate as another major economic factor, in addition to the classical market index. This approach leads to the application of a simple test of a multi-factor model by running a multi-factor model which incorporates variables such as export intensity (export/sales) and the net position of the foreign assets and foreign liabilities for each firm.

The effect of exchange rate on stock prices has been investigated in line with the Arbitrage Pricing Theory (APT), which examines whether the arbitrage condition is well explained when the exchange rate is added to common factors. Surprisingly, many studies deny the explanatory power of the exchange rate for the U.S.[1] For Japan, Hamao (1988) does not find the exchange rate significant, but Choi *et al*. (1998) and He *et al*. (1997) report that the exchange rate is an important factor.

This paper considers export intensity and foreign net position as the principal channels

[1]See Jorion (1991) among others for these results.

through which the exchange rate affects stock prices of individual firms. The effect of these variables differs depending on the level of export intensity and foreign net position of the firm. For example, firms with positive net positions and firms with negative net positions see opposite effects when there are changes in the exchange rate. Thus, grouping firms may average out the effects of individual firms. This paper examines directly how the effect of exchange rate on stock prices differs depending on the firms' characteristics.[2]

Another feature of this paper is the use of daily data, while previous studies used monthly data. The analysis is interesting from the viewpoint of testing the market efficiency of the semi-strong form.[3] The amount of export and the foreign asset position is the type of public information that a stock investor should watch. It is interesting to see whether or not investors are alert to this information, which could be a valuable test of market efficiency.

In this paper, we examine whether the stock prices of the firms that export their products or have a net position of foreign assets, are influenced by a change of exchange rate. The data used contains over 330,000 observations of stock prices and other financial data of 114 major Japanese firms, from January 5, 1983 to March 29, 1996.

The rest of the paper is organized as follows: Section 2 is a presentation of the model and the data used for this analysis. Section 3 gives the estimation results, and examines whether the market efficiency has changed over the sample period. Section 4 concludes the paper.

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[2] The effect of export intensity and foreign position is examined in Bodner and Gentry (1993) and He *et al.* (1997), but in more indirect way.

[3] For details of market efficiency, see Roberts (1967), Fama (1970, 1991) and Grossman and Stiglitz (1980).

2. Model

We assume that a stock price of a firm is determined both by factors common to all firms, and those attributed to the individual firm. As for the common factors that could relate to a stock price for an individual firm we use TOPIX, the call rate and the yen-dollar exchange rate. TOPIX is the stock price index of Tokyo Stock Exchanges, which may represent the price of the market portfolio; however, many studies suggest that the market portfolio should be a broader portfolio including various international financial assets, as well as other non-financial assets, such as human capital. Therefore, additional macroeconomic variables and indicators may be important common factors. Interest rate is a good candidate of such a factor, since a rise in the call rate will raise the expectation of the future interest rates, resulting in a fall of the stock prices. The yen-dollar exchange rate may be a good variable representing foreign phenomena that affect the stock prices.[4]

As for individual factors, various characteristics of the sample firms are available. Among them, we put special emphasis on whether a firm exports its products and whether it has foreign assets or liabilities.[5] Because depreciation of the yen relative to the currency of an importing country tends to make export easier, firms which rely more on export are expected to benefit more when a depreciation occurs. Thus, the effect of the change in the exchange rate should be larger for these firms. Depreciation of the yen implies a rise in the yen value of the foreign assets and liabilities, denominated by the dollar. If a firm has more foreign assets than foreign liabilities, so that the firm's net foreign asset position is positive, depreciation of the yen results in larger firm value. Given these arguments, coefficients of the exchange rate are formalized as

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[4] It may be restrictive that only the yen-dollar rate is considered as the exchange rate in this paper. However, because the U.S. is a particularly important trade partner for Japan, the analysis is appropriate as a first approximation.

[5] Although import is undoubtedly an important element as is export of a firm, such data are not available. No one knows exactly how much a firm uses import goods as input, because a considerable portion of imports may be used as an intermediate goods.

a function of export intensity and foreign net position, whose coefficients are expected to be positive.

Other variables considered as individual factors are firm size and debt-asset ratio. While there is no definite theory of how firm size effects stock prices, debt-asset ratio is considered to have two opposite effects on stock prices. One effect is that the larger the debt, the smaller the free cash flow, leading to the larger probability of bankruptcy. This, in turn, results in disciplining the firm's managers and higher stock prices (Jensen and Meckling, 1976). On the other hand it can be argued that there exists agency costs between debtors and stockholders concerning the risks of projects, so that an increase of debt-asset ratio results in higher agency costs and lower stock prices (Myers and Myluf, 1984). Which effect is stronger is not assumed *a priori*.

Our basic equation is:

$$r_{i,t}^{s} = a_i + \left(b_1 + b_2 \cdot x_{i,t}^{e} + b_3 \cdot x_{i,t}^{n}\right) \cdot r_t^{e} + g_1 \cdot r_t^{m} + g_2 \cdot r_t^{c} + d_1 \cdot x_{i,t}^{s} + d_2 \cdot x_{i,t}^{d} + \tilde{e}_{i,t},$$

$$i = 1,\ldots,N,\ t = 1,\ldots,T, \qquad (1)$$

where $r_{i,t}^{s} \equiv \left(SP_{i,t} - SP_{i,t-1}\right)/SP_{i,t-1}$, $r_t^{e} \equiv \left(ER_t - ER_{t-1}\right)/ER_{t-1}$, $r_t^{c} \equiv \left(CALL_t - CALL_{t-1}\right)/CALL_{t-1}$, $r_t^{m} \equiv \left(TOPIX_t - TOPIX_{t-1}\right)/TOPIX_{t-1}$, $x_{i,t}^{e} \equiv ES_{i,t}/TS_{i,t}$, $x_{i,t}^{n} \equiv \left(FA_{i,t} - FL_{i,t}\right)/TA_{i,t}$, $x_{i,t}^{s} \equiv TA_{i,t}\Big/\left(\sum_i \sum_t TA_{i,t}\right)$ and $x_{i,t}^{d} \equiv TL_{i,t}/TA_{i,t}$.

Here, $SP_{i,t}$ stands for the stock price (closing price) of firm *i* at date *t*, ER_t, exchange rate, $TOPIX_t$, the market portfolio index of Tokyo Stock Exchanges, $CALL_t$, the call rate, $ES_{i,t}$, exporting sales, $TS_{i,t}$, total sales, $FA_{i,t}$, foreign assets, $FL_{i,t}$, foreign liabilities, $TA_{i,t}$, total assets and $TL_{i,t}$, total liabilities. The subscript *t* stands for the date, while the subscript *i* stands for the *i*-th firm. As argued above, we expect $b_2 > 0$, $b_3 > 0$, $g_1 > 0$ and $g_2 < 0$, but the signs of b_1, d_1 and d_2 have yet to be determined.

Equation (1) formalizes explicitly the channel of the possible effect of changes in the exchange rate on stock prices, by specifying the coefficient of exchange rate as a function of export intensity and net foreign position. To make estimation viable, b_1, b_2, b_3, g_1 and g_2 are assumed to be constants. Thus, the differences in stock price among individual firms are explained by individual intercepts, a_i, and individual factors, $x^e_{i,t}$, $x^n_{i,t}$, $x^s_{i,t}$ and $x^d_{i,t}$.

To examine the robustness of the results of equation (1), we estimate a model where foreign assets and foreign liabilities are separately adopted as explanatory variables rather than using foreign net position. Since an increase in foreign assets should have the same effect on the firm values as a decrease in foreign liabilities, we expect that the coefficient of foreign assets is positive and that of foreign liabilities is negative, both with equal magnitudes.

The regression equation is

$$r^s_{i,t} = a_i + \left(b_1 + b_2 \cdot x^e_{i,t} + b_4 \cdot x^a_{i,t} + b_5 \cdot x^l_{i,t}\right) \cdot r^e_t + g_1 \cdot r^m_t + g_2 \cdot r^c_t + d_1 \cdot x^s_{i,t} + d_2 \cdot x^d_{i,t} + \tilde{e}_{i,t},$$

$$i = 1,\ldots,N,\ t = 1,\ldots,T, \qquad (2)$$

where $x^a_{i,t} \equiv FA_{i,t} / TA_{i,t}$ and $x^l_{i,t} \equiv FL_{i,t} / TA_{i,t}$.

The data description is given in Table 1. The selection criterion of stock prices is that the closing price is given on all days in the sample period. We must heed to the difference between the frequency of individual factors and that of stock prices and common factors. The former is accounted yearly, while the latter is daily. Thus, we assume that the individual factors take on the same value each year. This assumption may not be awkward because these figures are announced only annually in the financial statement, so that investors are informed of the change of these variables at this frequency.

Because the export intensity and net foreign position are annual data, we are forced to change the manner in which we characterize the test of market efficiency. We do not examine how fast the information on the characteristics of firms are reflected in the stock prices, like many event studies in corporate finance, but instead examine whether the daily change of exchange rate is properly reflected in the stock prices. We conduct this test given the characteristics of the firms' export intensity and foreign net position. If investors pay adequate attention to the annual information of these characteristics, they should respond to the daily change of the exchange rate. Thus, this paper should provide a test of informational market efficiency of the semi-strong form. The sample period is from January 5, 1983 to March 29, 1996. The data set contains 114 individual firms, 2336 minimum time periods and 3067 maximum time periods, summing to 335,392 observations of daily data.

3. Estimation Results

3.1. Panel Unit Root Test

Since the time series dimension of $r_{i,t}^{s}$, r_t^e, r_t^m and r_t^c is very large, we conduct unit-root tests on them. To provide meaningful estimates these variables should be stationary. Since r_t^e, r_t^m and r_t^c do not have the cross-sectional dimension, we use the usual Augmented Dickey Fuller (ADF), weighted symmetric and Phillips-Perron tests on them (Dickey and Fuller, 1979, Park and Fuller, 1993, Phillips and Perron, 1988).

As for $r_{i,t}^{s}$, we use the panel versions of the unit root tests because the additional cross-sectional dimension in the panel leads to better power properties of the panel tests, when compared with the well-known low power of the standard individual-specific Dickey-Fuller

(DF) and Augmented Dickey-Fuller (ADF) tests.[6] The panel unit root tests differ from each other by the degree of heterogeneity between individuals. Among them, tests suggested by Im, Pesaran and Shin (1997), henceforth denoted IPS, are attractive in that they allow complete heterogeneity between individuals. IPS developed panel unit root tests based on the average across individuals of the Lagrange multiplier test (LM-bar) and the ADF t statistic (t-bar). IPS showed that the estimated test statistics ($\Gamma_{\overline{LM}}$ and $\Gamma_{\bar{t}}$) are asymptotically distributed as $N(0,1)$. IPS also demonstrated that, in general, both the LM-bar and t-bar tests have better power performance than the test suggested by Levin and Lin (1993), and that the t-bar test also tends to perform better than the LM-bar test. Hence we use the t-bar test on $r_{i,t}^{s}$ in this paper.

The results are shown in Tables 2A and 2B. The number of augmenting lags K is selected by the Ljung-Box Q-statistics, $Q(p)$. Our arbitrary choice of the maximum number of autocorrelations for $Q(p)$ is 23. For all stock prices, the selected K is the minimum number of augmenting lags in which we cannot reject the null hypothesis that $Q(p)=0$ for all $r=1,2,...,23$ at a 10% significance level. The null hypothesis that each series of $r_{i,t}^{s}$, r_{t}^{e}, r_{t}^{m} and r_{t}^{c} contains a unit root is resoundingly rejected. Therefore, the estimation of equation (1) and (2) should be immune from the problems associated with non-stationary series.

3.2. Results of the Basic Estimation

Estimation results of equation (1) are presented in Table 3. The first three columns show the OLS, WITHIN (i.e., fixed-effects, FE, model specification) and GLS (i.e., random-effects, RE, model specification) estimates respectively, under the assumption of no correlation between individual-factor variables $x_{i,t}^{e}$, $x_{i,t}^{n}$, $x_{i,t}^{a}$, $x_{i,t}^{l}$, $x_{i,t}^{s}$ and $x_{i,t}^{d}$, and the disturbance term, $\tilde{e}_{i,t}$. In

[6] On this subject, see, Quah (1994), Levin and Lin (1993), Pedroi (1995), Im, Pesaran and Shin (1997),

addition, the OLS and RE estimates assume no correlation between $X_{i,t}$ and a_i, and the OLS estimates assume $a_i = a$ for all *i*. The next three columns of the table show the GMM, FEGMM (i.e., GMM in FE model specification) and REGMM (i.e., GMM in RE model specification) estimates respectively, which allow correlation between individual-factor variables $X_{i,t}$ and $\tilde{e}_{i,t}$. As do the OLS and RE estimates, the GMM and REGMM estimates also assume no correlation between $X_{i,t}$ and a_i, and then the GMM estimates assume $a_i = a$ for all *i*. These GMM estimates take into account the heteroskedasticity of an unknown form in $\tilde{e}_{i,t}$ and autocorrelation, in which case we specify a second-order moving average process. Bartlett kernels were specified for the kernel density to insure positive definiteness of the covariance matrix of the orthogonal conditions, when the number of autocorrelation terms is positive. We assume that stock prices and the individual factors are endogenous variables, so that the common-factor variables on the current day and the individual-factor variables in the previous account year, such as r_t^e, $x_{i,t-1}^e \cdot r_t^e$, $x_{i,t-1}^n \cdot r_t^e$, r_t^m, r_t^c, $x_{i,t-1}^s$ and $x_{i,t-1}^d$, are chosen as instruments.

These six estimation methods bring about similar estimates, thus comparable conclusions apply, independent of the estimation methods; however, it is still worth finding which are the most statistically valid results of these six estimates. Comparing the OLS and GMM estimates using a Hausman specification test (Hausman 1978), we test the null hypothesis that the individual-factor variables, such as $x_{i,t}^e \cdot r_t^e$, $x_{i,t}^n \cdot r_t^e$, $x_{i,t}^s$ and $x_{i,t}^d$, are uncorrelated with $\tilde{e}_{i,t}$. Because the specification test statistic is 16.44 which is distributed as c_6^2 under the null hypothesis, we can reject the null hypothesis at a 5 % level, but we cannot reject it at a 1 % confidence level.

As for the comparison of the FE and FEGMM, and RE and REGMM estimates, we get the

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McCoskey and Kao (1998) and Kao (1999).

same results as those in the comparison of the OLS and GMM estimates. The null hypothesis is rejected at a 5 % significance level, implying that the OLS, WITHIN and GLS estimators are not consistent

Constructing the F statistic of the GMM and FEGMM estimates, we also test the null hypothesis that the individual-effect parameters are identical (i.e., $a_i = a$ for all i), and get the result that the null hypothesis is not rejected at all significance levels. This result suggests that the individual-factor variables are adequate proxies for any individual-specific factor in each stock return. This also support the assumption that g_1 and g_2 are independent of i. Taking these results into account allows us to concentrate our attention on the GMM estimates.

An important consequence is that both the coefficients b_2 of $x_{i,t}^e \cdot r_t^e$ and b_3 of $x_{i,t}^n \cdot r_t^e$ are significantly positive. This confirms our basic hypothesis that Japanese investors are alert to the effect of the change in the exchange rate on the individual firm value. The result suggests that investors adequately consider the characteristics of the firms, such as their net foreign position.

The other estimates also take on sensible values. The coefficient g_1 of r_t^m is highly significant and is close to unity. This suggests that r_t^m is a good variable representing the return of the market portfolio. The coefficient g_2 of r_t^c is negative, as is consistent with the notion that a rise in the interest rate will raise the subjective discount rate of the future values. The constant coefficient b_1 of r_t^e is negative, which implies a rise of the exchange rate tends to lower the stock prices through effects other than a firm's exporting characteristics and foreign net position. We are not certain why, but the following may be a reason for this result. We do not include the amount of the import goods used as the input for production in explanatory variables because of the data availability. This information is not readily available to researchers, but it may be accessible to investors.[7] If this is the case, then the value of firms using more imported goods should see prices of the input factors falling when the yen is depreciated. The negative impact on stock prices due to a devaluation is included in the information set controlling the constant coefficient b_1 of the r_t^e. In the current case, the variable of import intensity is excluded, so that b_1 takes on a negative value.[8]

The coefficients d_1 and d_2 of the other individual firm variables, $x_{i,t}^s$ and $x_{i,t}^d$, are not significant. The coefficient on the debt-asset ratio implies that the two effects explained above have similar strength, so that they either offset each other, or that both effects are negligible. The constant term a is insignificant, suggesting that there are no important variables missing in equation (1) that have strong systematic explanatory power. Adjusted R^2 is 0.285, which is very high considering that the rate of change of stock prices is the dependent variable and that the sample size is quite large.

3.3. *Effects of Foreign Assets and Liabilities*

The estimates of equation (2) are presented in Table 4. Table 4 is different from Table 3 in that both b_4 and b_5 are reported. In Table 3 as well, we report the OLS, FE, RE, GMM, FEGMM and REGMM estimates. The GMM, FEGMM and REGMM estimates take account of heteroskedasticity and autocorrelation by the same procedures as in Table 3. The

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[7] As we argued in footnote 6, correct information is not available. However, we know that some industries depend heavily on imported goods, e.g. oil.

[8] Assume that true relation is not equation (1), but the one that includes the import intensity, $x_{i,t}^m$, that is $r_{i,t}^s = a_i + (b_1 + \ldots + b_6 \cdot x_{i,t}^m) \cdot r_t^e + \ldots$, where $b_6 < 0$. Estimating this relation excluding the variable $x_{i,t}^m \cdot r_t^e$, the estimate of b_1 has a bias of $b_6 \cdot \left[\operatorname{cov}\left(r_t^e, x_{i,t}^m \cdot r_t^e\right) \big/ \operatorname{var}\left(r_t^e\right) \right]$ (Green, 1997). Considering that $x_{i,t}^m$ is annual data and almost behaves like a constant, we get $\operatorname{cov}\left(r_t^e, x_{i,t}^m \cdot r_t^e\right) \approx x_{i,t}^m \cdot \operatorname{var}\left(r_t^e\right) > 0$. Therefore, the bias is negative.

instrumental variables are r_t^e, $x_{i,t-1}^e \cdot r_t^e$, $x_{i,t-1}^a \cdot r_t^e$, $x_{i,t-1}^l \cdot r_t^e$, r_t^m, r_t^c, $x_{i,t-1}^s$ and $x_{i,t-1}^d$.

The specification test statistics are respectively 17.58 (OLS vs. GMM), 17.58 (FE vs. FEGMM) and 15.00 (RE vs. REGMM) which are distributed as c_7^2, c_8^2 and c_5^2 under the null hypothesis that the individual-factor variables, such as $x_{i,t}^e \cdot r_t^e$, $x_{i,t}^a \cdot r_t^e$, $x_{i,t}^l \cdot r_t^e$, $x_{i,t}^s$ and $x_{i,t}^d$, are uncorrelated with $\tilde{e}_{i,t}$. Thus we can reject the null hypothesis at a 5 % significance level. This implies that the OLS, WITHIN and GLS estimators would be inconsistent. In addition, the null hypothesis that the individual-effect parameters are identical is not rejected at any significance levels. Hence, we focus on the GMM estimates.

Inspection reveals that all the coefficients except b_4 and b_5 are almost equivalent to those in Table 3. Although b_5 is negative and takes on a similar value to the coefficient b_3 of $x_{i,t}^n$, b_4 is also negative and insignificant by GMM estimation, contradicting our expectations.

b_4 could be negative for a couple of economic reasons: for example, there may be some elements common to the firms that have foreign assets or liabilities, which affect the stock prices downward. The problem is that dummy variables cannot correct the sign of the coefficient. Inclusion of a dummy variable representing the possession of foreign position does not bring about a positive b_4.

The constant coefficient b_1 of the exchange rate may represent the effect of the evaluation of importing firms. If so, b_1 should be different between industries depending on their intensity of importing because investors know which industries are more import-intensive. Following this idea, we adopt the industry dummies instead of constant coefficient.[9] The estimation

[9] Industry numbers $j\ (=1,\cdots,47)$ denote, respectively, livestock processing, beer and liquor, bread and confectionery, other food, synthetic fiber, cotton, knitwear, pulp and paper making, printing, plastic, other organic chemistry, petrochemistry, grease and soap, drug, other chemistry, glass, ceramic, carbon steel, alloy steel, ferroalloy, bronze, smelting and refining of copper, lead and zinc, telegraph wire and cable, boiler and motor, office machine, general industry machine, electric power machine and equipment, computer, radio and television, sound machine and equipment, other electric machines and

results are presented in Table 5. Since the results of the specification test are essentially the same as those in Tables 3 and 4, we concentrate our attention on the GMM estimates.[10] Considerable numbers of coefficients, $b_{1,j}$ ($j = 1,...,47$), of industry dummies, DI_j ($j = 1,...,47$), are significant: 26 coefficients at a 10 % significance level, of which some take positive and the other take negative values, suggesting that the specification is reasonable (estimates of industrial dummies are not shown in the Table to save space). The coefficients of r_t^m and r_t^c are very similar to those in Tables 3 and 4, while that of export b_2 gets smaller. Most importantly, b_4 takes on a positive value, though not significant, and b_5 is negative. The results confirm our supposition, even if there still remains a need of further investigation.

In the next section, we present the results of conducting analyses with divided sample periods. These results clarify why b_4 does not systematically show the sign we expect with the whole samples.

3.4. Change of the Market Efficiency

Because of our rather long estimation period, it should seem reasonable to assume there are heterogeneous phases within the period. There is no reason to believe that the model structure is unchanged over the whole period, thus it is interesting to see whether the market efficiency changes over this period.

Looking at the $TOPIX_t$ in Figure 1, there seems to exist three phases: normal period before 1986, the bubble period between 1986 and 1990, and a stagnant period thereafter. The stagnant

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equipment, wagon, automobile parts, ship building and repairing, optical machine and equipment, clock and it's parts, fishery, oil and natural gas, civil architecture, trading company and wholesale, other retail, real estate rental, installment sale, railroad, auto truck, air service, electric power supply, and town gas.

[10] $DI_j \cdot r_t^e$ ($j = 1,\cdots,47$), $x_{i,t-1}^e \cdot r_t^e$, $x_{i,t-1}^a \cdot r_t^e$, $x_{i,t-1}^l \cdot r_t^e$, r_t^m, r_t^c, $x_{i,t-1}^s$ and $x_{i,t-1}^d$ are chosen as instruments in GMM estimation.

period may be divided at the point that the $TOPIX_t$ takes on the lowest value, that is August 4 1992. Before this date, $TOPIX_t$ rapidly fell, while it stayed at the low level thereafter. If one looks at the transition of the exchange rate in Figure 1, it seems reasonable to divide the period into three sub-periods. While the middle period from March 3 1985 to the Black Monday is characterized as a rapid appreciation of the yen, in the earlier period until March 3 1985 and the later period after the Black Monday, the exchange rate is relatively stabilized.

In sum, the whole period is divided into the following five sub-periods.

Period Ⅰ: January 5, 1983 to March 8, 1985,

Period Ⅱ: March 11, 1985 to October 19, 1987,

Period Ⅲ: October 20, 1987 to December 12, 1989,

Period Ⅳ: January 4, 1990 to August 4, 1992,

Period Ⅴ: August 5, 1992 to March 29, 1996.

In Table 6, the GMM estimates of equation (1) are presented because they turned out to be the best of six estimation methods with the same specification tests in the former section. Most importantly, the estimates of the key coefficients, b_2 and b_3, are drastically changed over the period. In period I, b_2 is negative and b_3 is not significant. They show expected only for periods Ⅳ and Ⅴ. It is apparent that they increasingly show the correct signs in the later periods. This strongly suggests that the market efficiency of the semi-strong form has improved throughout these fourteen years.

The $\overline{R}^2$'s of periods Ⅰ and Ⅱ are quite low, taking the value of around 0.1; however, since period Ⅲ, they have been in excess of 0.3. This confirms that the multi-factor model applies well after the Black Monday. Closer inspection of the estimates of period Ⅴ reveals that they are very similar to those of the whole period, except that b_3 more than doubles.

In Table 7, the results of equation (2) are presented. In this Table, the coefficients of foreign assets and foreign liabilities, b_4 and b_5, are shown instead of the coefficient of net foreign position, b_3. Except for b_4 and b_5, the results are quite similar to those in Table 6. The coefficients b_4 and b_5 satisfy the correct signs only for periods Ⅳ and Ⅴ, though b_4 is not very significant in period Ⅳ. In period Ⅴ, both b_4 and b_5 are significant and they take on similar values consistent with our expectation.

These results suggest that stock investors correctly evaluate the foreign asset position of firms and appropriately respond to a change in the exchange rate since 1992. In contrast, b_2, the coefficient of the export intensity, takes on the correct positive sign since 1985, suggesting that investors began to pay attention to exporting firms much earlier than to firms' foreign assets and liabilities.

Incidentally, the coefficient b_2 of period Ⅱ is more than double of those in the later periods. Noticing that the yen rapidly appreciated from 260 to 120 against the dollar during period Ⅱ and kept that level thereafter, the result implies that the effect of the change of the exchange rate is larger during the volatile period than during the stabilized period. This makes intuitive sense; investors should be more concerned with the exchange rate when there is high variation, rather than when things are stable.

4. Concluding Remarks

In this paper, we have explored whether export intensity and net foreign position of the Japanese firms are carefully watched by investors and are properly reflected in the stock prices. By estimating a multi-factor model including the TOPIX, the call rate, the exchange rate, and other variables representing the characteristics of individual firms, we have examined the market efficiency of the Japanese stock market.

Our main results are as follows.

(i) Japanese investors adequately consider the characteristics of the firms, such as the exporting behavior and net foreign position.

(ii) The market efficiency of the semi-strong form has been improved throughout the period.

(iii) Stock investors correctly evaluate firms' foreign asset position and appropriately respond to the change of the exchange rate after 1992. In contrast, investors began to pay attention to exporting firms much earlier, that is, since 1985.

This paper has some limitations, while it retains some novelty. First, the yen-dollar exchange rate represents the various exchange rates for Japan in this paper. Consideration of the other exchange rates is a necessary future task. Second, assumption of the constant coefficients of common factors might be restrictive, though the estimation results suggest the opposite. Third, we concentrate on investigating the effect of the exchange rate on stock prices from the point of view of the market efficiency. From the perspective of the APT, our analysis corresponds to an estimation of the data generating process. Examination of the validity of the international APT will be an interesting future work.

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Table 1 Data Description

Symbol	Variable	Definition, frequency and Source
$SP_{i,t}$	Stock price	Closing price; daily; *Domestic Stock Prices*, Nomura Research Institute
Common factor		
ER_t	Exchange rate	Yen-dollar mean rate among banks; daily; *Call*, Nikkei Inc.
$TOPIX_t$	Market portfolio index	Tokyo Stock Exchanges; daily; *Call*, Nikkei Inc.
$CALL_t$	Call rate	Secured overnight rate; daily; *Call*, Nikkei Inc.
Individual factor		
$x^e_{i,t} \equiv ES_{i,t}/TS_{i,t}$	Rate of exporting sales	Exporting sales / total sales; account year; *Financial Data of Corporations*, Development Bank
$x^a_{i,t} \equiv FA_{i,t}/TA_{i,t}$	Rate of foreign assets	Foreign assets / total assets; account year; *Financial Data of Corporations*, Development Bank
$x^l_{i,t} \equiv FL_{i,t}/TA_{i,t}$	Rate of foreign liabilities	Foreign liabilities / total assets; account year; *Financial Data of Corporations*, Development Bank
$x^n_{i,t} \equiv \left(FA_{i,t} - FL_{i,t}\right)/TA_{i,t}$	Rate of net foreign assets	$x^a_{i,t} - x^l_{i,t}$; account year; *Financial Data of Corporations*, Development Bank
$x^s_{i,t} \equiv TA_{i,t}/\left(\sum_i \sum_t TA_{i,t}\right)$	Normalized total assets	Total assets / sum of all samples; account year; *Financial Data of Corporations*, Development Bank
$x^d_{i,t} \equiv TL_{i,t}/TA_{i,t}$	Debt-asset ratio	Debt / total assets; account year; *Financial Data of Corporations*, Development Bank
Sample period	January 5, 1983 to March 29, 1996	
Selection criterion of stock prices	The closing price is bidden at all days in the sample period.	
Number of individuals	114	
Minimum time periods	2336	
Maximum time periods	3067	
Number of observations	335392	

Table 2A *t*-bar Test of Stock Prices

Series	Test Statistic $\Gamma_{\bar{t}}$ (P-value)	*t*-bar Statistic $\bar{t}_{NT}$	Common Mean of t_{iT} $E(t_T \mid a_i = 1)$	Common Variance of t_{iT} $\mathrm{var}(t_T \mid a_i = 1)$	Number of Augmenting Lags K
$r_{i,t}^{s}$	3.524 (.00043)	-16.508	-16.713	.385	10

Note:

1. The number of stock prices N is 114. The t-bar statistic is obtained by $\bar{t}_{NT} \equiv \frac{1}{N}\sum_{i=1}^{N} t_{iT}$.
2. $E(t_T \mid a_i = 1)$ and $\mathrm{var}(t_T \mid a_i = 1)$ are computed via stochastic simulations with 50,000 replications. t_T is the t-statistic for testing $a = 1$ in the Augmented Dickey-Fuller regression with time trend,
$$x_t = a \cdot x_{t-1} + b + g \cdot t + \sum_{j=1}^{10} d_j \cdot \Delta x_{t-j} + e_t, \quad t = 1,2,\ldots,T; T = 3067 .$$
The observations x_t are generated as $x_t = e_t^x$, $e_t^x \sim N(0,1)$.
3. The test statistic is defined by $\Gamma_{\bar{t}} \equiv \frac{\sqrt{N} \cdot \{\bar{t}_{NT} - E(t_T \mid a_i = 1)\}}{\sqrt{\mathrm{var}(t_T \mid a_i = 1)}}$. Im, Pesaran and Shin (1997) showed that $\Gamma_{\bar{t}}$ converge weakly to a standard normal distribution as N and $T \to \infty$. Hence the inference can be conducted by comparing the obtained $\Gamma_{\bar{t}}$ statistic to critical values from the lower tail of the $N(0,1)$ distribution.

Table 2B Unit Root Tests of Common Factors

Series	Augmented Dickey-Fuller (P-value)	Weighted Symmetric (P-value)	Phillips-Perron (P-value)	Number of Augmenting Lags K
r_t^{e}	-23.434 (.000)	-23.464 (.000)	-3157.020 (.000)	5
r_t^{m}	-25.056 (.000)	-25.085 (.000)	-2602.624 (.000)	4
r_t^{c}	-17.782 (.000)	-17.818 (.000)	-2764.496 (.000)	11

Table 3 Estimation Results of Equation (1)

Parameters	OLS	Fixed effects (FE)	Random effects (RE)	GMM	Fixed effects GMM (FEGMM)	Random effects GMM (REGMM)
$a_i\,(=a)$	$-.734\times10^{-4}$ (-.56)	—	$-.613\times10^{-4}$ (-.43)	$-.660\times10^{-4}$ (-.50)	—	$.316\times10^{-5}$ ($.33\times10^{-1}$)
b_1	$-.591\times10^{-1}$ (-8.75)	$-.592\times10^{-1}$ (-8.76)	$-.591\times10^{-1}$ (-8.75)	$-.649\times10^{-1}$ (-8.76)	$-.651\times10^{-1}$ (-8.78)	$-.650\times10^{-1}$ (-8.77)
b_2	.680 (22.30)	.680 (22.30)	.680 (22.30)	.746 (21.08)	.746 (21.06)	.746 (21.08)
b_3	.824 (5.75)	.825 (5.75)	.824 (5.75)	1.131 (4.83)	1.129 (4.81)	1.130 (4.82)
g_1	1.054 (364.24)	1.054 (364.14)	1.054 (364.26)	1.054 (232.95)	1.054 (233.66)	1.054 (232.97)
g_2	$-.526\times10^{-2}$ (-4.53)	$-.525\times10^{-2}$ (-4.52)	$-.526\times10^{-2}$ (-4.53)	$-.525\times10^{-2}$ (-4.37)	$-.523\times10^{-2}$ (-4.36)	$-.524\times10^{-2}$ (-4.37)
d_1	-5.889 (-.71)	32.105 (.91)	-5.169 (-.57)	-4.225 (-.60)	55.053 (.29)	3.764 (.20)
d_2	$.278\times10^{-3}$ (1.42)	$-.480\times10^{-3}$ (-.74)	$.257\times10^{-3}$ (1.20)	$.260\times10^{-3}$ (1.26)	$-.767\times10^{-3}$ ($-.67\times10^{-1}$)	$.122\times10^{-3}$ (.69)
q	—	—	.811	—	—	.815
Adjusted R-squared	.285	.285	.285	.285	.285	.285
LM heteroskedasticity Test	2496.60 [.00]	2497.82 [.00]	2496.39 [.00]	—	—	—
Durbin-Watson	2.10	2.10	2.10	2.10	2.10	2.10

Note: 1. The numbers in parentheses represent estimated *t*-ratios.

2. The numbers in brackets represent estimated *p*-values.

3. $q \equiv s_W^2 \big/ \left(s_W^2 + T_M \cdot s_B^2\right)$, where T_M is the maximum number of time periods, s_W^2 is the variance of the basic error terms and s_B^2 is the variance of the individual-specific error terms. If $q=1$, RE (or REGMM) is the same as OLS (or GMM). If $q=0$, RE (or REGMM) is the same as FE (or FEGMM).

4. F test for equality with the OLS and WITHIN (FE) estimators .23 [1.00]
with the GMM and FEGMM estimators .22 [1.00]

5. Hausman test of H_0: RE vs. FE 3.39 [.85]
H_0: REGMM vs. FEGMM .54 [.97]
H_0: OLS vs. GMM 16.44 [.01]
H_0: FE vs. FEGMM 16.44 [.02]
H_0: RE vs. REGMM 16.79 [.01]

Table 4 Estimation Results of Equation (2)

Parameters	OLS	Fixed effects (FE)	Random effects (RE)	GMM	Fixed effects GMM (FEGMM)	Random effects GMM (REGMM)
$a_i\,(=a)$	$-.698\times10^{-4}$ (-.54)	—	$-.576\times10^{-4}$ (-.40)	$-.618\times10^{-4}$ (-.46)	—	$.352\times10^{-5}$ ($.37\times10^{-1}$)
b_1	$-.511\times10^{-1}$ (-7.30)	$-.511\times10^{-1}$ (-7.30)	$-.511\times10^{-1}$ (-7.30)	$-.561\times10^{-1}$ (-7.01)	$-.562\times10^{-1}$ (-7.02)	$-.561\times10^{-1}$ (-7.01)
b_2	.697 (22.68)	.698 (22.68)	.697 (22.68)	.765 (21.49)	.765 (21.48)	.765 (21.50)
b_4	-.832 (-2.04)	-.839 (-2.06)	-.833 (-2.05)	-.595 (-1.02)	-.604 (-1.03)	-.599 (-1.02)
b_5	-.884 (-6.13)	-.885 (-6.14)	-.884 (-6.13)	-1.230 (-5.21)	-1.229 (-5.20)	-1.230 (-5.20)
g_1	1.054 (364.13)	1.054 (364.03)	1.054 (364.14)	1.054 (232.80)	1.054 (233.52)	1.054 (232.83)
g_2	$-.524\times10^{-2}$ (-4.51)	$-.523\times10^{-2}$ (-4.51)	$-.524\times10^{-2}$ (-4.51)	$-.522\times10^{-2}$ (-4.35)	$-.521\times10^{-2}$ (-4.34)	$-.522\times10^{-2}$ (-4.35)
d_1	-5.879 (-.72)	33.210 (.94)	-5.140 (-.57)	-4.227 (-.60)	55.678 (.29)	3.818 (.20)
d_2	$.273\times10^{-3}$ (1.40)	$-.484\times10^{-3}$ (-.74)	$.252\times10^{-3}$ (1.18)	$.254\times10^{-3}$ (1.23)	$-.780\times10^{-3}$ ($-.69\times10^{-1}$)	$.121\times10^{-3}$ (.68)
q	—	—	.810	—	—	.815
Adjusted R-squared	.285	.285	.285	.285	.285	.285
LM heteroskedasticity Test	2491.86 [.00]	2493.08 [.00]	2491.65 [.00]	—	—	—
Durbin-Watson	2.10	2.10	2.10	2.10	2.10	2.10

Note: 1. See the Notes of Table 3.

2. F test for equality with the OLS and WITHIN (FE) estimators .23 [1.00]
with the GMM and FEGMM estimators .22 [1.00]

3. Hausman test of H_0: RE vs. FE 3.60 [.89]
H_0: REGMM vs. FEGMM .63 [.99]
H_0: OLS vs. GMM 17.58 [.01]
H_0: FE vs. FEGMM 17.58 [.02]
H_0: RE vs. REGMM 15.00 [.01]

Table 5 Estimation Results of Equation (2) adopted the Industry Dummies instead of β_1

Parameters	OLS	Fixed effects (FE)	Random effects (RE)	GMM	Fixed effects GMM (FEGMM)	Random effects GMM (REGMM)
$a_i\,(=a)$	$-.210\times10^{-4}$ (-.16)	—	$-.950\times10^{-5}$ ($-.67\times10^{-1}$)	$-.176\times10^{-4}$ (-.13)	—	$.626\times10^{-5}$ ($.66\times10^{-1}$)
b_2	.109 (1.44)	.109 (1.44)	.109 (1.44)	.384 (3.49)	.383 (3.47)	.384 (3.48)
b_4	.582 (1.17)	.570 (1.15)	.580 (1.17)	1.078 (1.28)	1.063 (1.26)	1.070 (1.27)
b_5	-.337 (-2.18)	-.339 (-2.19)	-.337 (-2.18)	-.405 (-1.46)	-.403 (-1.45)	-.404 (-1.46)
g_1	1.054 (364.62)	1.054 (364.52)	1.054 (364.66)	1.054 (233.15)	1.054 (233.87)	1.054 (233.17)
g_2	$-.530\times10^{-2}$ (-4.57)	$-.529\times10^{-2}$ (-4.56)	$-.530\times10^{-2}$ (-4.57)	$-.529\times10^{-2}$ (-4.41)	$-.528\times10^{-2}$ (-4.39)	$-.529\times10^{-2}$ (-4.41)
d_1	-7.331 (-.90)	33.034 (.93)	-6.612 (-.74)	-5.921 (-.86)	54.833 (.29)	1.902 (.10)
d_2	$.206\times10^{-3}$ (1.05)	$-.535\times10^{-3}$ (-.82)	$.186\times10^{-3}$ (.87)	$.195\times10^{-3}$ (.95)	$-.783\times10^{-3}$ ($-.69\times10^{-1}$)	$.126\times10^{-3}$ (.71)
q	—	—	.817	—	—	.832
Adjusted R-squared	.286	.286	.286	.286	.286	.286
LM heteroskedasticity Test	2497.19 [.00]	2497.78 [.00]	2496.98 [.00]	—	—	—
Durbin-Watson	2.10	2.10	2.10	2.10	2.10	2.10

Note: 1. See the Notes of Table 3.

2. F test for equality with the OLS and WITHIN (FE) estimators .22 [1.00]
with the GMM and FEGMM estimators .20 [1.00]

3. Hausman test of H_0: RE vs. FE 8.08 [1.00]
H_0: REGMM vs. FEGMM .16 [1.00]
H_0: OLS vs. GMM 333.78 [.00]
H_0: FE vs. FEGMM 172.51 [.00]
H_0: RE vs. REGMM 380.58 [.00]

Table 6 Estimation Results of Equation (1) for divided periods

Parameters	GMM estimates				
	I 83.1.5 - 85.3.8	II 85.3.11 - 87.10.19	III 87.10.20 - 89.12.29	IV 90.1.4 - 92.8.4	V 92.8.5 - 96.3.29
a	$-.501\times10^{-3}$ (-1.03)	$-.190\times10^{-3}$ (-.46)	$-.856\times10^{-3}$ (-2.63)	$.897\times10^{-3}$ (3.13)	$.548\times10^{-4}$ (.31)
b_1	$.424\times10^{-1}$ (1.18)	-.112 (-4.64)	$-.707\times10^{-1}$ (-4.29)	$-.431\times10^{-1}$ (-2.52)	$-.497\times10^{-1}$ (-4.62)
b_2	-.479 (3.61)	1.405 (15.95)	.688 (8.43)	.700 (9.15)	.623 (11.18)
b_3	1.085 (.77)	.295 (.61)	.463 (1.00)	2.364 (4.69)	2.115 (3.42)
g_1	.939 (51.57)	.814 (66.04)	1.056 (82.37)	1.142 (143.69)	1.061 (144.68)
g_2	$-.245\times10^{-2}$ (-.38)	$-.101\times10^{-1}$ (-2.25)	$-.107\times10^{-1}$ (-2.71)	$-.673\times10^{-2}$ (-1.36)	$-.220\times10^{-2}$ (-1.60)
d_1	-65.158 (-2.40)	30.032 (1.10)	-30.937 (-1.75)	-2.874 (-.21)	5.407 (.56)
d_2	$.690\times10^{-3}$ (.98)	$.790\times10^{-3}$ (1.30)	$.173\times10^{-2}$ (3.39)	$-.829\times10^{-3}$ (-1.85)	$-.192\times10^{-4}$ ($-.68\times10^{-1}$)
Number of Observations	45,532	61,016	57,501	72,672	98,671
Adjusted R-squared	.079	.105	.306	.430	.360

Note: The numbers in parentheses represent estimated t-ratios.

Table 7　Estimation Results of Equation (2) for divided periods

Parameters	GMM estimates				
	I 83.1.5 - 85.3.8	II 85.3.11 - 87.10.19	III 87.10.20 - 89.12.29	IV 90.1.4 - 92.8.4	V 92.8.5 - 96.3.29
a	$-.482\times10^{-3}$ (-.99)	$-.104\times10^{-3}$ (-.25)	$-.858\times10^{-3}$ (-2.63)	$.898\times10^{-3}$ (3.13)	$.544\times10^{-4}$ (.31)
b_1	$-.588\times10^{-3}$ ($-.97\times10^{-2}$)	$-.731\times10^{-3}$ (-2.92)	$-.535\times10^{-3}$ (-3.01)	$-.339\times10^{-1}$ (-1.82)	$-.512\times10^{-1}$ (-4.52)
b_2	-.688 (-3.26)	1.581 (17.28)	.735 (8.83)	.708 (9.23)	.624 (11.20)
b_4	8.882 (1.18)	-7.876 (-5.46)	-1.543 (-2.13)	1.085 (1.02)	2.578 (1.88)
b_5	.264 (.14)	-.585 (-1.21)	-.704 (-1.47)	-2.483 (-4.84)	-2.074 (-3.33)
g_1	.939 (51.59)	.814 (66.08)	1.056 (82.42)	1.142 (143.68)	1.061 (144.67)
g_2	$-.244\times10^{-2}$ (-.38)	$-.102\times10^{-1}$ (-2.27)	$-.107\times10^{-1}$ (-2.72)	$-.671\times10^{-2}$ (-1.36)	$-.220\times10^{-2}$ (-1.60)
d_1	-65.788 (-2.42)	28.380 (1.04)	-30.563 (-1.73)	-2.971 (-.22)	5.412 (.56)
d_2	$.665\times10^{-3}$ (.94)	$.672\times10^{-3}$ (1.11)	$.173\times10^{-2}$ (3.39)	$-.829\times10^{-3}$ (-1.86)	$-.185\times10^{-4}$ ($-.65\times10^{-1}$)
Number of Observations	45,532	61,016	57,501	72,672	98,671
Adjusted R-squared	.078	.105	.306	.430	.360

Note: The numbers in parentheses represent estimated *t*-ratios.

FIGURE 1 Exchange Rate and Stock Prices in Japan
1983.1-1996.3