3. Exchange-rate exposure of individual firms

An unexpected appreciation of the NT (New Taiwan) dollar influences a Taiwanese exporting firm with profits in foreign currencies, in spite of possible adjustments in exporting prices measured in foreign currencies, as long as the firm's cost structure is not affected by the fluctuations in the NT dollar. Therefore, without any appropriate hedging, an appreciation of the NT dollar causes damage to the firm through the reduction in its profits which is measured as the foreign currency price in NT dollars. On the other hand, for the importing firm, an appreciation of the NT dollar will decrease its importing costs. Consequently, whether the firm is positively or negatively exposed to exchange-rate fluctuations mainly depends on the relative values of its exports and imports.

In this part, we narrow our focus only on Taiwan electronic firms which are the major exporting firms in Taiwan to make our discussions more specific. Besides, we expand some hypotheses and set up the corresponding empirical models to examine the effects of exchange-rate fluctuations on stock returns.

3.1. Corresponding model of the exchange-rate exposure

A. The basic regression of exchange-rate exposure

Adler and Dumas (1984) note that economic exposure can be measured through a simple regression with the change in firm value as the dependent variable and the exchange rate changes as the regressor. According to previous studies, we use the following equation to examine the existence of exchange-rate exposure of individual exporting firms:

$$R_{i,t} = \alpha + \beta_{1,i} \times \Delta e_t + \beta_{2,i} \times R_{m,t} + \varepsilon_{i,t}\,, \qquad (1)$$

where $R_{i,t}$ is the return on stock i at time t, $R_{m,t}$ is the return on the market index TAIEX (TSEC Capitalization Weighted Index), Δe_t is the change in the exchange-rate, measured as the price of NT dollar against foreign currencies, and $\varepsilon_{i,t}$ is the random error. $\beta_{1,i}$, the slope coefficient of the regression, is defined as the exchange-rate exposure and captures the sensitivity of stock returns to the contemporaneous changes in the exchange-rate.

B. The lagged response hypothesis

Bartov and Bondar (1994) first documented that lagged exchange-rate have significant effects on stock returns. Later, some economists, such as Amihud (1994) and He and Ng (1998) also agreed with their argument and also found out the significant effects of lagged exchange-rate return. They regard the information lag as the main reason to explain the lagged reaction of stock returns to exchange-rate fluctuations. Generally, determining the impact of a change in the dollar on firm performance is complicated by the fact that investors are not aware of the activities which firms engage in to hedge foreign currency exposures, how the firms' real internal activities will be altered in response to the new competitive conditions, or whether the currency movement will result in a change in the strategic behavior of firm. All the information of mentioned activities is available only after firm' financial reports are released and such events cause information lag.

Now we take the effects of the lagged exchange-rate return into consideration and further use the following equation to estimate exchange-rate exposure:

$$R_{i,t} = \alpha + \beta_{1.i} \times \Delta e_t + \beta_{1,i}^{L} \times \Delta e_{t-1} + \beta_{2,i} \times R_{m,t} + \varepsilon_{i,t}, \qquad (2)$$

where $R_{i,t}$ is the return on stock i at time t; $R_{m,t}$ is the return on the market index TAIEX; Δe_t is the change in the exchange-rate and Δe_{t-1} is the change in the exchange-rate in the last period, measured as the price of NT dollar against foreign currencies ; and $\varepsilon_{i,t}$ is the random error. $\beta_{1,i}^{L}$, the slope coefficient of the regression, is defined as the lagged exchange-rate exposure and captures the sensitivity of stock returns to the lagged changes in the exchange-rate.

C. Nonlinear exposure

Most previous studies applied trade-weighted exchange rate as the measures of exchange rates. Since the electronic goods traded in the world market are often priced in US dollars, we use only the exchange rate of NT dollar against US dollar as the measure in earlier studies. However, we found some key components of electronic products in Taiwan still depend on importing abroad, especially from Japan. Therefore, in current empirical analysis, we also take the exchange rate of NT dollar against Japan Yen into consideration and add another variable which represent cross changes between these two exchange rates. The corresponding nonlinear exposure model is:

$$R_{i,t} = \alpha + \beta_{i,USD} \times \Delta e_{USD,t} + \beta_{i,JPY} \times \Delta e_{JPY,t} + \beta_{i,USD\times JPY} \times (\Delta e_{USD,t} \times \Delta e_{JPY,t}) + \beta_{i,m} \times R_{m,t} + \varepsilon_{i,t} \quad (3)$$

where $\Delta e_{USD,t}$ is the change in the exchange rate, measured as the price of NT dollar against U.S. dollar; $\Delta e_{JPY,t}$ is the change in the exchange rate, measured as the price of NT dollar against Japan Yen ; $\beta_{i,USD}$ is defined as the exchange rate exposure and captures the sensitivity of stock returns to changes in the exchange rate measured as the price of NT dollar against U.S. dollar; $\beta_{i,JPY}$ is defined as the exchange rate exposure and captures the sensitivity of stock returns to changes in the exchange rate measured as the price of NT dollar against Japan Yen ; $\Delta e_{USD,t} \times \Delta e_{JPY,t}$ is the cross change between the exchange rates ; $\beta_{i,USD\times JPY}$ captures the sensitivity of stock returns to nonlinear effect, and $\varepsilon_{i,t}$ is the random error.

A potential problem with using the results from the estimation of equation (3) is that $\beta_{i,USD}$ and $\beta_{i,JPY}$ are not the total exposure of stock i to the exchange rates, but rather the exposure of stock i over and above that of the market portfolio. If the stock has the same exposure as the marker portfolio then estimating (3) would result in the conclusion that the exposures of stock i are zero since $\beta_{i,USD}$ and $\beta_{i,JPY}$ would be estimated as zero. However, because the market return contains the currency exposure, this would be incorrect. It is essential to address this issue given the evidence on the relationship between cross-country aggregate stock returns and currencies.

The exposure of the stock market index to the exchange rate can be estimated

as:

$$R_{m,t} = a_{USD} \times \Delta e_{USD,t} + a_{JPY} \times \Delta e_{JPY,t} + U_{m,t} \quad (4)$$

Where $U_{m,t}$ is an error term which is defined as the orthogonal market return, that is to say; this part of the market return is uncorrected with changes in the exchange rate. To orthogonalize the market return we reformulate equation (3) as:

$$R_{i,t} = \alpha + \beta_{i,USD} \times \Delta e_{USD,t} + \beta_{i,JPY} \times \Delta e_{JPY,t} + \beta_{i,USD \times JPY} \times (\Delta e_{USD,t} \times \Delta e_{JPY,t}) + \beta_{i,m} \times U_{m,t} + \varepsilon_{i,t} \quad (5)$$

3.2. Data descriptions and empirical results

Ⅰ. Data descriptions

In this study, the electronic industry in Taiwan is selected to test the hypotheses of the currency exposures. This industry is characterized by high export sales. It also has high degree of international dependence for both production inputs and exports of finished products. Thus, the firms of electronic industry in Taiwan are likely to be sensitive to exchange-rate fluctuations. To estimate exchange-rate exposure of individual firms, the data we used is monthly stock returns, monthly market returns, and monthly exchange-rate fluctuations, which are described as below.

Stock and market returns

The stock returns[1] of 74 individual firms and market returns[2] from January 1998 to December 2003, are collected from a popular database – Taiwan Economic Journal Database. The sample firms selected in this study are listed in Table 1. Besides, we use market index-TSEC Capitalization Weighted Index (TAIEX) and transform it to represent market returns which is viewed as an important variable when estimating exchange-rate exposure.

Exchange-rate fluctuations[3]

The raw data of exchange rates are from Foreign Exchange Statistics of Central Bank of China. Most previous studies applied trade-weighted exchange rate as the measures of exchange rates. Because the US is the largest trade partner of Taiwan and the traded goods, especially the electronic goods, are often priced in US dollars no matter which countries firms traded with. Furthermore, the electronic firms in Taiwan do not only export their products. In fact, some key components in the process of production still depend on importing abroad, especially from Japan, for some Taiwanese electronic firms. We use the exchange rates of NT dollar against US dollar and of NT dollar against Japan Yen as the measures. Because we quote the exchange

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[1] If $P_{i,t}$ is the stock price of firm i at time t, we transform $P_{i,t}$ to $R_{i,t}$, where $R_{i,t}$ is the stock returns for firm i at time t and equals $\log P_{i,t} - \log P_{i,t-1}$.

[2] If $P_{m,t}$ is TAIEX at time t, we transform $P_{m,t}$ to $R_{m,t}$, where $R_{m,t}$ is the market returns at time t and equals $\log P_{m,t} - \log P_{m,t-1}$.

[3] If e_t is the exchange rate at time t, we transform e_t to Δe_t, where Δe_t is the exchange-rate fluctuations at time t and equals $e_t - e_{t-1}$.

rates in this study as units of NT dollar per US dollar and of NT dollar per Japan Yen, a depreciation of NT dollars is portrayed as a rise in exchange rates. We transform the raw data of exchange rates to exchange rate fluctuations to proceed with the following analysis.

Table 1.Sample firms of Taiwan electronic industry

This table lists the sample firms which are selected to test the existing of exchange-rate exposure in this study. We list all the sample firms in the order of company ID.

2301	Lite-On Technology	2333	Picvue	2364	Twinhead
2302	Rectron	2335	CWI	2365	KYE Systems
2303	UMC	2336	Primax	2366	Askey
2305	Microtek	2337	MXiC	2367	Unitech PCB
2308	Delta	2338	Taiwan Mask	2368	Gold Circuit
2311	ASE	2340	Opto Tech	2369	Lingsen
2312	Kinpo	2341	Behavior Tech	2371	Tatung
2313	Compeq Mfg.	2342	MVI	2373	Aurora
2314	MTI	2343	Systex	2374	Ability
2315	Mitac	2344	Winbond	2378	Potrans
2316	Wus PCB	2345	Accton	2379	Realtek
2317	Hon Hai	2347	Synnex	2383	Elite Material
2318	Megamedia	2348	Veutron	2389	Luxon
2319	FIC	2349	Ritek	2390	Everspring
2321	Tecom	2350	Universal Scientific	2391	ZyXEL
2323	CMC	2354	Foxconn	2393	Everlight
2324	Compal	2355	Chin-Poon	2401	Sunplus
2325	SPIL	2356	Inventec	2404	UIS
2326	CIS Technology	2357	Asustek	2420	Zippy
2327	Yageo	2358	MAG	2425	CT
2328	Pan International	2359	Solomon	2430	TKE
2329	OSE	2360	Chroma	2431	Lien Chang
2330	TSMC	2361	Mustek Systems	2436	Weltrend
2331	Elitegroup	2362	Clevo	2438	Enlight
2332	D-Link	2363	Silicon Integrated		

Ⅱ. Empirical results

A. Results of the basic regression[4]

We use monthly stock returns of 74 electronic firms, monthly market returns and monthly exchange-rate fluctuations from January 1998 to December 2003 to examine whether these 74 firms are significantly exposed to exchange rate fluctuations. The corresponding empirical results are showed in Table 2.

Our results can be compared with the results from Jorion (1990) for U.S. firms, where only 15 out of 287 firms (about 5%) showed a significant exposure at 5% level.

Table 2.Distribution of estimated exchange-rate exposure ($\beta_{1,i}$) of 74 firms using monthly returns, 1998/01-2003/12

Model 1: $R_{i,t} = \alpha + \beta_{1,i} \times \Delta e_t + \beta_{2,i} \times R_{m,t} + \varepsilon_{i,t}$.

Statistics	$\beta_{1,i}$	percentage
Average	-0.015	
Variance	0.002	
Standard deviation	0.041	
Max	0.089	
Min	-0.174	
Number of total firms	74	
Number of firms of 74 total with significant exposure at 5%(10%) level	3(7)	4(9)
Number of firms with positive exposure at 5%(10%) level	0(1)	0(1)
Number of firms with negative exposure at 5%(10%) level	3(6)	4(8)

[4] From Durbin-Watson d Test, we safely accept the null hypothesis that there is no first-order serial correlation in the random error $\varepsilon_{i,t}$

Interestingly, the percentage of firms with significant exposure in our Taiwan electronic sample is about 4% at 5% level, which is much lower than the 25% found in He and Ng (1998) for Japan.

B. Results of the lagged response hypothesis[5]

Observing the empirical results of exchange-rate exposure in the last part, we found only 4% of our sample showed significant exposure to exchange-rate fluctuations. Bartov and Bondar (1994) explained the existence of mispricing may cause from systematic error when investors estimate the correlation between stock returns and exchange-rate fluctuations. Therefore, it seems reasonable to examine whether there is significant correlation between stock returns and one period lagged fluctuation in exchange rates.

Now we take lagged fluctuations in exchange rate into account and change the model into model 2. The empirical results are showed in Table 3. According to our empirical results, we found 5 out of 74 firms (about 6.7%) at 5% level with significantly lagged exchange-rate exposure - $\beta_{1,i}^{L}$. Besides, there seem no significant differences in $\beta_{1,i}$ as compared to the empirical results of earlier analysis.

Surprisingly, we found most firms are negatively exposed to exchange-rate fluctuations no matter contemporaneously or with a lag. Since we quote the exchange rates in this study as units of NT dollar per US dollar, so that a depreciation of NT dollars is portrayed as a rise in exchange rates. As earlier section mentioned, exporting electronic firms are expected to benefit from an effective depreciation of

[5] From Durbin-Watson d Test, we safely accept the null hypothesis that there is no first-order serial correlation in the random error $\varepsilon_{i,t}$

NT dollars and hence have positive exposure. Therefore, our empirical results are not consistent with our expectations. In next section, we will further model the nonlinear equation to reexamine the exchange rate exposure in the Taiwanese electronic firms.

Table 3.Distribution of estimated exchange-rate exposure with one lag ($\beta_{1,i}^{L}$) of 74 firms using monthly returns, 1998/01-2003/12

Model 2: $R_{i,t} = \alpha + \beta_{1.i} \times \Delta e_t + \beta_{1,i}^{L} \times \Delta e_{t-1} + \beta_{2,i} \times R_{m,t} + \varepsilon_{i,t}$.

Statistics	$\beta_{1,i}$	percentage	$\beta_{1,i}^{L}$	percentage
Average	-0.001		-0.025	
Variance	0.003		0.002	
Standard deviation	0.049		0.045	
Max	0.117		0.127	
Min	-0.203		-0.138	
Number of total firms	74		74	
Number of firms of 74 total with significant exposure at 5%(10%) level	3(5)	4(6.7)	5(9)	6.7(12)
Number of firms with positive exposure at 5%(10%) level	2(2)	2.7(2.7)	0(0)	0(0)
Number of firms with negative exposure at 5%(10%) level	1(3)	1.4(4)	5(9)	6.7(12)

C. Results of nonlinear exposure

In this section, in doing our empirical analysis, we work with nonlinear model. Besides, using the orthogonalized market return, we will reexamine the exchange-rate

Table 4.Distribution of estimated exchange-rate exposure of 74 firms using monthly returns, 1998/01-2003/12

Model 5:

$$R_{i,t} = \alpha + \beta_{i,USD} \times \Delta e_{USD,t} + \beta_{i,JPY} \times \Delta e_{JPY,t} + \beta_{i,USD\times JPY} \times (\Delta e_{USD,t} \times \Delta e_{JPY,t}) + \beta_{i,m} \times U_{m,t} + \varepsilon_{i,t}.$$

Statistics	$\beta_{i,USD}$	percentage	$\beta_{i,JPY}$	percentage
Average	-0.103		-5.262	
Variance	0.002		3.519	
Standard deviation	0.048		1.876	
Max	0.028		-1.529	
Min	-0.239		-10.352	
Number of total firms	74		74	
Number of firms of 74 total with significant exposure at 5%(10%) level	53(55)	72(74)	52(61)	70(82)
Number of firms with positive exposure at 5%(10%) level	0(0)	0(0)	0(0)	0(0)
Number of firms with negative exposure at 5%(10%) level	53(55)	72(74)	52(61)	70(82)

exposure of the Taiwanese electronic firms.

Observing the sign of coefficient $-\beta_{i,USD}$, which we view as the exporter's exchange-rate exposure in model (5), we found almost all sample firms are with negative signs and 74% of total firms are significantly negative at 5% significant level, a much higher percentage than the results we examined via model (2). However, traditional wisdoms suggest that exporting firms are beneficial from a depreciation of domestic currency, our empirical results significantly reject this hypothesis.

Further observing the sign of coefficient $-\beta_{i,JPY}$, which we view as the importer's exchange-rate exposure in model (5), we found every firm is with negative sign and 70% of total sample firms are with significantly negative signs at 5% significant level. This seems provide strong evidence to support the idea that importing firms are harmful to a depreciation of domestic currency.

Our empirical results can be compared to the results from Nydahl (1999).He fist of all studied firms in a small open economy- Swedish and found about 26% firms in the sample have significant exposure to exchange-rate fluctuations. According our empirical results, we found Taiwanese electronic firms are highly sensitive to exchange-rate fluctuations on matter on importing or exporting aspects.[6]

[6] The empirical results are listed in detail in Appendix.