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Currency Exposure, Second-Moment Exchange Rate Exposure and Asymmetric Volatility of Stock Returns: The Effects of Financial Crises on Taiwanese Firms

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Abstract

Over the last two decades, a number of financial disasters have occurred due to failure in risk management procedures. If some, as the Asian financial crisis, had a very much more muted global impact (even though they sent shock waves through global financial markets, the main damage were fairly contained), the global financial crisis we are witnessing since 2007 is in many respects unparalleled. Compared to many other countries, we could observe that Taiwan performed better. But it does not mean that structural changes did not affect individual firms. This study investigates (i) the impact of first- and second-moment exchange rate exposure on individual firm value and the stock return volatility underlying exchange rate fluctuation, (ii) the time-varying exchange rate exposure following the 1997 Asian financial turmoil and the global financial crisis which started in 2007. We find a high percentage of exposed firms before the two crises but if this percentage decreases dramatically after, the exposure level is much larger. The two crises affect also the asymmetric profile of the firms and volatilities. Finally, when we study the breakdown between systematic and diversifiable risks, we find that the market risk of the Taiwanese firms decreases after the 1997 crisis but is higher after the 2007 crisis increasing thus their equity financing cost.

JEL Classification: C22, F31, G12, G15, G31
Keywords: Exchange Rate Exposure, Asymmetric Currency Exposure, Financial Crises, Asymmetric volatility, GJR GARCH-M

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1 Introduction

Financial theory holds that exchange rate movements significantly affect firm value via their effects on the competitiveness of the firm's products, the cost of its inputs, the value of its foreign assets, its sensitivity to short-term cash flows (i.e. the probability of financial distress) and its cost of capital (i.e. growth opportunity).

But there is also much evidence from practitioners that exchange rate movements affect firms. Hung [41] estimates for example that due to a strong dollar during the 1980s American manufacturers lost annually about USD23 billion, representing 10% of their gross profits. Rosenberg [64] mentioned another survey which indicates that more than 45% of American companies are adversely affected by a strong dollar and later when the dollar weakened around 2002, various industries experienced higher exports and earnings. This indicates that exchange rate movements affect both small and large firms. Without any doubt, similar observations have been made all around the world. The foreign exchange rate is even becoming a political tool.

Academics and practitioners, all agree that fluctuations in foreign exchange rate are a source of uncertainty for the firm, regardless its size and whether the firm is domestically or internationally oriented. Empirical studies already document significant impacts of these fluctuations on firm cash flows, sales and competitive positions in product markets (Hung [41], Williamson [69]). Similarly, theoretical models predict that firms should display a significant exchange rate exposure (see for example Bodnar, Dumas and Marston [14]).

A firm's exchange rate exposure refers to the sensitivity of its economic value (or stock price) to exchange rate changes (Heckman [39]) or as stated by Adler and Dumas [1], its economic exposure to exchange risk. If the volatility of exchange rates affect firm value (stock price), the question is to know how sensitive is the value of the firms to exchange rate movements. In another word, it means how the market prices the currency risk.

However, empirical studies have tended to document weak relations between exchange rate changes and firms' stock prices, if any at all. These studies include Jorion [44] and [45], Amihud [5], Bodnar and Gentry [15], Bartov and Bodnar [9], Griffin and Stuls [37] or Dominguez and Tesar [30], just to name some. In most of the studies, the percentage of firms displaying statistically significant exposures tends to be only about twice the chosen level of statistical significance, hence the term "exposure puzzle".

Bartram and Bodnar [11] argue that the puzzle is mostly the result of "*overly optimistic prior assumptions of the part of the researcher about the extent of significant exposures within a population of firms*". They explain that low percentages of exposed firms are the result from "exposure reducing actions" which include both financial and operational hedging activities. Bartram, Brown and Minton [12] show empirically that firms pass through part of currency changes to customers, which combined with operational hedging, each reduce firms' exposure by 10% to 15%; moreover, financial hedging with foreign debt decreases exposure by about 40%.

Nevertheless, it seems that small and open economies may be a better laboratory to explore the exposure puzzle, see for example Moran [57].

Varga [68] studied the currency exposure of Taiwanese firms. Taiwan is clearly an open economy according Friberg and Nydahl [33] criteria. He found that almost 89% of his sample (107 firms using daily data) is exposed to exchange rate fluctuations. Moreover, all the concerned firms are negatively exposed: they benefit from an appreciation of the domestic currency (TWD).

The purpose of this paper is to increase our understanding of the relationship between exchange rates changes and stock returns at the individual firm level. More specifically, we want to investigate if this relationship is time-varying by focusing on the potential impacts on it from the 1997 financial Asian and the 2007 global financial crises. In other words, the question we want to address is not if Taiwanese firms are or not exposed (they are, see Varga [68]), but to see how (if) financial crises affect exchange rate exposures, exchange rate volatility and individual stock returns.

On July 2nd, 1997 the financial Asian crisis started to spread in a larger way than most of the previous crises. Asian stock markets were affected as well worldwide economic growth. The wide foreign exchange fluctuations which followed increased the currency risk for most of the firms in the world. The Asian crisis seems to be more caused by financial imbalances in the private sector than in the public sector. So even though Taiwan was less impacted than other Asian countries, we can reasonably believe that vulnerability of Taiwanese firms to currency risk has increased.

Then, ten years later, we have to face a financial tsunami. The global financial crisis of 2007 (-?) is in many aspects unparalleled. Compared to this tsunami, previous crises such as the Asian crisis or the Russian bond default had a very much more muted global impact, with fairly contained damages.

In the early summer of 2007, fixed income markets were under considerable stress and then in July, equity markets experienced high volatility while currency markets were not affected yet. But with this uncertain environment, a major unwinding of the carry trade occurred on August 16 and many currency actors suffered huge losses. It marked the beginning of the crisis in the foreign exchange markets. The one-day change of the AUD/JPY was this day -7.7% compared to the average 0.7% one day earlier.

Even with periods of time calmer than others, we started to experience a much higher volatility in the exchange rates.

As for the 1997 East Asian crisis, the 2007 crisis cannot be without any consequences on Taiwanese firms and their vulnerability to currency risk.

Using a sample of 107 Taiwanese firms, we find a high percentage of exposed firms before the two crises but if this percentage decreases dramatically after (from 70% to about 20%) the exposure level is much higher. All the concerned firms are negatively exposed (they benefit from an appreciation of the domestic currency). The two crises affect also the asymmetric profile of the firms: sign asymmetries are more pronounced after than before the crises (and inversely for the magnitude asymmetries). Volatilities are also greater after than before the crises. Finally, when we study the breakdown between systematic and diversifiable risks, we find that the market risk of the Taiwanese firms decreases after the 1997 crisis (-13%) but increases after the 2007 crisis (+21%).

The reminder of this paper is organized as follows. The next section presents related papers. Methodology and sample selection are respectively described in sections 3 and 4. Section 5 reports the main empirical findings and section 6 concludes the paper.

2 Exposure to Exchange Rate Risks: Related Papers

An extensive literature followed the paper of Adler and Dumas [1] which introduced a simple model with the stock return as the dependant variable and the change in the exchange rate as the explanatory variable. The resulting coefficient is the sensitivity of the firm to exchange rate movements. In a seminal paper, Jorion [44] investigates it using a

sample of 287 American multinational firms and an augmented market model (See Jorion [44] and Bodnar and Wong [17] for a discussion of why it is important to include the market return in equation (1)):

$$R_{i,t} = \beta_{o,i} + \beta_{1,i} Rm_t + \beta_{2,i} FX_t + \varepsilon_{i,t} \quad (1)$$

with $R_{i,t}$ denoting the stock return, Rm_t the return on the market index and FX_t the change in the exchange rate. More specifically, Jorion [44] used an exchange rate index. The author finds that only 15 firms, i.e. 5.23% of the sample, display a significant exposure at the 5% level of significance, even though the firms have been selected due to their consequential international activities. Amihud [5] does not succeed too even after using as his sample, 32 companies listed in the Fortune magazine's "50 Leading Exporters" list. Bodnar and Gentry [15], in a multi-country study, find that 21% to 25% of the firms in USA, Japan and Canada display an exposure to exchange rate changes, percentage significantly higher than the ones obtained by Choi and Prasad [23] who used an American dollar index for their US multinational firms: 14.9% at the firm level and 10% at the industry level. Considering the special situation of American companies and currency, authors start to extend their studies outside the USA but with very mixed results. For example, He and Ng [38] find that 26.3% of their Japanese sample is exposed to an exchange rate index while Bartram [10] obtains only 7.5% of his German sample. Nydahl [60] documents a higher level of exposure for his Swedish sample (17%). Dominguez and Tesar [29] analyze exposure in different open, mature and developing countries at the firms and industry level. According the country, they find that between 14% and 26% of the firms are exposed, but one could have expected different results: only 14% of the Chilean sample is exposed, compared to the 47% obtained by Moran [57]. Among authors who do not document exposure at all, Priestley and Odegaard [63] investigate without success seven industries in Norway and none was exposed to the USD or ECU.

Several authors choose to study firms' exposure across many countries as for example Bartram and Karolyi [13] who study the impact of the introduction of Euro and Doidge et al. [28] who use a large sample of firms around North America, Europe and Asia. Both find results in conformity with Griffin and Stulz [37]: the exposure to exchange rate movements is small, not only statistically, but also economically. Many studies use an exchange rate index rather than a bilateral exchange rate, which can explain some mixed results. An index is not representative for an individual firm and can imply a diversification effect across currencies. However, it does not seem that using a bilateral exchange rate improves notably the measure of exposures as showed by Bartram [10]. Another change in the methodology is the use of orthogonalized models. Again, the results were not very different as for example Choi and Prasad [23] and Choi et al. [22]. Nevertheless some authors using orthogonalized model succeed to obtain better results, as Glaum et al. [36] – 49% of the sample being exposed, Priestley and Odegaard [62] – 69% exposed to the JPY and 40% to the ECU, Kiymas [48] – 62% or Chen et al. [21] – 24%.

Exposure is a complex concept to measure, especially if we take into account the time the firm needs to adjust its financial management to exchange rate fluctuations or the fact that company information is only disclosed at regular moments in the year hence the time also needed by the market to adjust its valuation process. These facts may lead to mispricing of currencies movements, and push some authors to introduce one more change in the methodology: the lag effect. So, beside contemporaneous exchange rate fluctuations, authors use lagged exchange rate too. Bartov and Bodnar [9] find some evidence at the one-month lag level, but with a very low adjusted R^2 (0.2%). Frazer and Pantzalis [32]

obtain some mixed results, with only 9% of their American sample being exposed. Di Iorio and Faff [26] find non significant lag effects.

Another change in methodology has also been proposed to improve the measurement of firms' exposure: time varying factors, by using sub-periods analysis. The problem is that it is not always easy to explain the time variation of the exposure which may have different economic sources or could even been caused by some estimation errors. There are studies that provide evidence that exposure is more generally time dependant. Brunner et al. [19] find that exposure coefficients are not stable over time for their German sample. Moreover, several studies assert that long-horizon regressions more readily detect significant exposure see for instance Chow et al. [24], [25] and Bodnar and Wong [18]. Muller and Verschoor [59] find considerable evidence of long-term exposure, the short-term seeming to be well hedged. As the horizon increases, the estimation of the exposure improves, especially if the horizon is at least between 3 to 5 years. Chow et al. [24], [25] assert that market participants may wrongly assess the exchange rate risk on the long run. Some authors try to explain the source of the time variation of the exchange rate exposure. Allayannis and Ihrig [3] identify industry markups, Williamson 69] concludes that exposure of his automotive sample changes with market share while pass-through is the main factor for Bodnar and Marston [16]. Patro et al. [61] find that exposure of their OECD sample, varies particularly with import and export. Ihrig and Prior [43] find that some multinationals companies display significant exposure only during crisis periods. Koutmos and Martin [51] find that the variability in the time-varying exposure is smaller (larger) for the largest (smallest) firms and for industrial (technology) firms. The size effect is also confirmed by Hunter [42].

Another explanation of mixed results in measuring exchange rate exposure is related to the fact that most studies only assess the linear component of the exposure, ignoring the nonlinear (asymmetric) exposure. Financial theory indicates that exposure should be at least for one part nonlinear, knowing that cash flows are a nonlinear function of the exchange rates. Several authors investigate asymmetric response to appreciations and depreciations, as Koutmos and Martin [50], Bartram [10], Carter et al. [20] and Tai [67]. If the measurement of the exposure is better when taking into account the nonlinear component, most of the studies display a low marginal improvement. Bartram [10] using a German sample, finds that 14.5% of the firms display a nonlinear exposure (more specifically, a convex exposure – U form) compared to 8.3% for linear exposure. Results are also mixed for Di Iorio and Faff [26]. But most of the authors agree that using an exchange rate index obscures somehow the detection of exposure. Hsu et al. [40] find that asymmetric exposures are based on industry characteristics. Rossi [66] studies a Brazilian sample of 196 firms and finds that at the 10% level of significance, 38% of the firms display a nonlinear exposure, compared to 29% showing a linear exposure.

According several authors such as Koutmos and Martin [50] or Muller and Verschoor [58], various reasons can generate a nonlinear relationship between the value of the firm and the exchange rate movements, mainly asymmetric hedging, incorrect pricing of assets, hysteresis for firms involved in international trade, magnitude of exchange rate fluctuations, pricing policies and market structures, and government interference.

Other authors as for instance Kanas [46] and Giurda and Tzavalia [35] cite evidence for the existence of volatility asymmetry in stocks returns, related to currency changes.

2.1 Asymmetric Hedging

One of the main factors to cause nonlinearity in the exchange rate exposure is the risk management chosen by the firm, through the use of hedging or financial derivatives. Firms always try to exploit opportunities and avoid adverse effects from macroeconomic changes, behavior which is reflected in their hedging strategies. It can generate nonlinear payoffs caused by the exchange rate movements leading to a nonlinear fluctuation of the cash flow and consequently the value of the firm.
Options allow the company to make asymmetric gains (for example an importer will hedge against the depreciation of the domestic currency while making eventually a "profit" if the local currency appreciates) and the firm's exposure will also be influenced by the magnitude of the currency fluctuation, see Miller and Reuer [56], Allayannis and Ofek [4] or Rossi [65]. The use of real or financial options means that market-value exposures is larger to beneficial macroeconomic changes than to adverse ones since this kind of hedging allows to protect the firm against adverse changes and exploit beneficial fluctuations, see Andren [6] for more details.

2.2 Errors in Assets' Pricing

Actors of the market may find uneasy to measure the consequences of an exchange rate movement on the firm's value especially in case of shocks. Indeed, it is difficult to identify if a shock is permanent of just temporary hence the problem to measure the real impact on the firm. Moreover, the way firms disclose their financial information (hedging policies…) is not always totally transparent thus creating the risk to mislead investors in their valuation process. Muller and Verschoor [58] argue that may push investors into a "safe behavior" by ignoring lower magnitude of exchange rate movements and reacting more strongly to greater magnitude especially in case of "bad news", hence emphasizing the nonlinear component of the exposure.

2.3 Hysteretic and Magnitude of Exchange Rate Change Asymmetries

Another important source of asymmetry is the hysteretic behavior. If the depreciation of domestic currency persists, a number of new exporters may enter the market to benefit from the exchange rate movement. Therefore, the profits of the existing exporters may not increase as more firms are sharing the market. If the depreciation of the domestic currency is followed by a period of appreciation it is not sure that companies are in position to just quit the market, given the sunk costs the new comers had to pay. They are more likely to stay in the market with a lower profit or even losses in such a period. In these cases, the exchange rate fluctuations have a negative impact on the firm's value. This creates an asymmetry in exchange rate exposure. The decrease in profits during appreciations is larger than the increase in profits during depreciations. The phenomenon of hysteresis is logically supposed to occur after greater magnitude exchange rate movement, since small fluctuations will not influence companies in their entry or exit decisions. Therefore, magnitude of exchange rate changes is also a source of asymmetry in the firms' exposure. The magnitude leading to a response from the firm may depend on the company size, its industry, its past experience or macroeconomic factors. Thus the different responses of the firms to small and large exchange rate fluctuations give birth to the magnitude asymmetry of exchange rate exposure. The question remains in knowing for which

threshold firms will start to respond and how long is supposed to be the period to attract new comers. See Baldwin [8] and Dixit [27] who describe hysteresis models.

2.4 Pricing-to-market

There are several studies describing pricing-to-market behavior of companies which is too, an important source of asymmetry of exchange rate exposure, see for example Froot and Klemperer [34], Marston [54] or Knetter [49] who study this particular behavior which may take either two forms: pricing-to-market in view to maintain or improve the market share and pricing-to market under volume constraints. As Knetter [49] states, the former form assumes that the firms' goal is to maximize their market share. So if the local currency appreciates, the exporter will not pass on the impacts to buyers by increasing the foreign prices of their products, to avoid the risk of losing market share to competitors from other countries. They may even be prone to reduce their export prices. On the contrary, if the domestic currency depreciates, exporters will maintain their mark-up at the same level, letting the export prices unchanged. Thus, they will not pass the benefits of depreciation by reducing the foreign prices of their goods. Consequently, exporters' profits may increase to a lesser degree during depreciation periods than decrease in appreciation periods. Pricing-to-market under volume constraints occurs because quota or wrong investment in marketing capacity (bottlenecks). On contrary to the previous behavior, the mechanism works in the other direction. In the case of a depreciation of the domestic currency exporters will not be able to increase their sales volume, because the volume constraints. Therefore, they may increase their foreign price to clear the market, being not interested in passing the benefit of depreciation to the buyers.
In the opposite situation, if the domestic currency appreciates, exporters may let the foreign prices reflect the fluctuations and may not use the pricing-to-market: they will not reduce the foreign prices.

2.5 Asymmetries due to Government Interference

Government interference in the foreign exchange market may also be a source of asymmetry by indirectly helping domestic firms. If the exchange rate exceeds a certain level, the government may intervene to reduce the currency volatility and hence the firms' exposure. By limiting the appreciation of the domestic currency, it may help exporters and by controlling the depreciations of the local currency, it will help companies holding debts in foreign currencies.

2.6 Asymmetry in Volatility of Stock Returns Underlying Exchange Rate Exposure

The main explanation of the asymmetry in volatility of stock returns is the leverage effect, common concept in finance, through the leverage ratio debt / equity. Resulting from bad news, the negative return shock increases the leverage ratio and the volatility while good news will generate a positive return shock and a lower leverage ratio and volatility. But if we analyze the volatility of stock returns underlying exchange rate exposure, the picture is not so clear. When a domestic currency appreciates or depreciates, we cannot state that we are facing good or bad news. It will depend on the situation of the market participants (exporter, importer etc…) as mentioned by Bodnar and Gentry [15]. But a firm can play more than one role like for instance exporter and internationally priced input user. As

Maghrebi et al. [52] state, "*whether depreciation of domestic currency should be viewed as good news or bad news is an open question*". Other authors cite evidence for the existence of volatility asymmetry in stock returns related to exchange rate fluctuations as for instance Kanas [46] and Giurda and Tzavalia [35] so it seems that this volatility asymmetry is one of the exposure components we need to take into account, even though its mechanism is unclear.

3 Methodology

3.1 Orthogonalized Model

There is a drawback of the above mentioned augmented CAPM models (Eq. 1). We cannot estimate the total impact of the exchange rate changes on stock returns as a single coefficient with this specification. Since market returns and exchange rate fluctuations are correlated, the influence of the latter on the firm value can be divided into two components: the direct exposure effect contained in $\beta_{2,i}$ and the indirect effect included in $\beta_{1,i}$. Alone, $\beta_{2,i}$ may under/overestimate the firm's true exposure to currency fluctuations. Moreover, these two effects may reinforce or offset each other. Under (Eq. 1) if exposure is zero, it does not mean that the firm has no exposure but just that its exposure is the same as the market. To address this issue, various authors as for instance Entorf and Jamin [31] use an auxiliary regression between market returns and exchange rate changes in order to avoid a possible multicollinearity which is usually more frequent when one uses a bilateral exchange rate instead of a trade weighted exchange rate index.

It may explain why some authors do not find that orthogonalizing the market portfolio has an effect on their results, see for example Allayannis [2]. The auxiliary regression is described as:

$$R_{m,t} = \delta_0 + \delta_1 FX_t + \delta_{m,t} \tag{2}$$

with $\delta_{m,t}$, the orthogonalized market returns, representing the component of market returns that is uncorrelated with exchange rate changes.
We replace Rm_t in (1) by $\delta_{m,t}$. Substituting (Eq. 2) into (Eq. 1) and rearranging, we obtain the orthogonalized model:

$$R_{i,t} = \beta^*_{0,i} + \beta_{1,i}\delta_{m,t} + \beta^*_{2,i} FX_t + \varepsilon_{i,t} \tag{3}$$

where:

$$\beta^*_{0,i} = \beta_{0,i} + \beta_{1,i}\delta_0 \tag{4}$$

$$\beta^*_{2,i} = \beta_{2,i} + \beta_{1,i}\delta_1 \tag{5}$$

$\beta_{o,i}$ $\beta_{1,i}$ and $\beta_{2,i}$ are from the unorthogonalized model $R_{i,t} = \beta_{o,i} + \beta_{1,i} Rm_t + \beta_{2,i} FX_t + \varepsilon_{i,t}$

Under (3), $\beta^*_{2,i}$ is supposed to show the total impact of exchange rate fluctuations on the firm value. It contains the direct effect $\beta_{2,i}$ as well as the indirect effect $\beta_{1,i}\delta_1$.
The indirect effect is also a firm-specific component of the exposure (as the direct effect)

in the sense that $\beta_{1,i}$ varies across firms: each company may have a specific relationship with the market portfolio. This process is just an auxiliary step aiming to measure the component of market returns that is uncorrelated with exchange rate changes in view to obtain an orthogonalized model. So, it is related to the main model to be tested, but not to any sub period.

3.2 Multiple Asymmetries

The model captures both, sign asymmetry (responses from the firms after depreciation or appreciation of the domestic currency) and magnitude asymmetry (firms' reaction to small and large exchange rate fluctuations by distinguishing asymmetric and exposure coefficients. We use dummy variables to measure the effects of an appreciation of the domestic currency (sign asymmetry) and a change in the exchange rate greater (magnitude asymmetry) than a specified filter (threshold).
In order to take into account specificities of financial time series as the time-varying volatility, we add a GARCH specification, more precisely a GJR GARCH-M (1,1) which is able to accommodate asymmetry in volatility of stock returns which is as mentioned above, a stylized facts related to the exposure mechanism. The GARCH in Mean specifications allow to analyze the impact of the exchange rate volatility on firm return.

The model is described as:

$$\begin{aligned} R_{i,t} &= \beta^{*}_{0,i} + \beta_{1,i}\delta_{m,t} \\ &+ (\beta^{*}_{2,i} + \beta_{3,i}D_{sign,i,t} + \beta_{4,i}D_{amp,i,t})s_t \\ &+ \beta_{5,i}h_{s,t} + \varepsilon_{i,t} \end{aligned} \tag{6}$$

where:
s_t = the unexpected change in the exchange rate
$D_{sign,i,t}$ = 1 if s_t < 0 and 0 otherwise
$D_{amp,i,t}$ = 1 if $|s_t|$ > x and 0 otherwise
x = 0.5%
$h_{s,t}$ = the time-varying exchange rate volatility
$\varepsilon_{i,t}$ = error term which follows a GJR GARCH (1,1) process as:

$$\varepsilon_{i,t} = \mu_{i,t}\sqrt{h_{\varepsilon,i,t}} \tag{7}$$

and

$$h_{\varepsilon,i,t} = \omega_{\varepsilon,i} + \alpha_{\varepsilon,i}\varepsilon^2_{t-1} + \gamma_i D_{i,t-1}\varepsilon^2_{t-1} + \beta_{\varepsilon,i}h_{\varepsilon,i,t-1} \tag{8}$$

where $D_{i,t-1}$ is equal to 1 if $\varepsilon_{i,t}$ is negative and 0 otherwise.
$h_{\varepsilon,i,t}$ denotes the conditional variance of the residuals and $\mu_{i,t}$ the white noise error term. The usual constraints related to GARCH models apply.

In this model, it is associated to good news when $\varepsilon_{i,t}$ > 0 and bad news when $\varepsilon_{i,t}$ < 0. Both outcomes have differential effects on the conditional variance: good news has an impact on α_i, while the bad news has an impact on (α_i + γ_i). If γ_i > 0, bad news

increases volatility (we say there is a "leverage effect"). If γ_i is statistically significant, it implies the existence of an asymmetric volatility of stock returns underlying exchange rate exposure even though the mechanism through which it comes into being still remains unresolved. Depreciation or appreciation of the domestic currency is not automatically a good or bad news.

The last step is to define the exchange rate dynamics. Many previous studies as for example Meese and Singleton [55], find that exchange rates follow martingale processes, so the best forecast for time t+1 is the value at time t. Therefore, changes in FX_t follow a martingale of the form:

$$FX_t = \theta + FX_{t-1} + s_t \tag{9}$$

where s_t is the unexpected change in the exchange rate (innovation) used in equation (6).

The conditional variance of s_t follows a GARCH (1,1) process defined as:

$$s_t = \rho_{i,t}\sqrt{h_{s,t}} \tag{10}$$

and

$$h_{s,t} = \omega s_{,i} + \alpha_{s,i} s_{t-1}^2 + \beta_{s,i} h_{s,t-1} \tag{11}$$

$h_{s,t}$ denotes the conditional variance of s_t and $\rho_{i,t}$ the white noise error term.

The usual constraints related to GARCH models apply. The time-varying exchange rate volatility $h_{s,t}$, is used as variable in equation (6). [We tested the residuals before this stage (not reported here). At 5% significance, the White test confirms the existence of heteroskedasticity.] The parameters concerning the firm return and the exchange rate changes are estimated using the nonlinear numerical optimization method of Berndt, Hall, Hall and Hausman (BHHH), assuming that $\varepsilon_{i,t}$ and s_t are normally distributed with zero means and conditional variances given respectively by equations (7) and (10).

The model is estimated using a two-step procedure: s_t and $h_{s,t}$ are estimated via maximum likelihood and then their values are used as variables in the estimation of equation (6).

Table 1 summarizes the possible exposure coefficients according the various sign and magnitude changes in the exchange rate.

$\beta_{2,i}^*$ and $\beta_{3,i}$ may be positive or negative according the position of the firm (exporter, importer, etc…) and we do not set constraints for the sign of $\beta_{4,i}$ which means that an exchange rate exposure associated with large fluctuations may be greater or lower than that of small changes.

Indeed, Taiwanese firms may be more accustomed to relatively limited changes in the domestic currency (compared for instance to the JPY) given the Taiwan central bank policies.

The various combination of the exposure and sign coefficients (respectively $\beta_{2,i}^*$ and $\beta_{3,i}$) mean different sources of asymmetry as mentioned above.

Table 1: Impacts of various sign and magnitude fluctuations

Changes in exchange rate	**Exposure coefficients**
Appreciation lower than the filter: $s_t < 0$ and $\lvert s_t \rvert < x$	$\beta^*_{2,i} + \beta_{3,i}$
Appreciation greater than the filter: $s_t < 0$ and $\lvert s_t \rvert > x$	$\beta^*_{2,i} + \beta_{3,i} + \beta_{4,i}$
Depreciation lower than the filter: $s_t > 0$ and $\lvert s_t \rvert < x$	$\beta^*_{2,i}$
Depreciation greater than the filter: $s_t > 0$ and $\lvert s_t \rvert > x$	$\beta^*_{2,i} + \beta_{4,i}$

x = 0.5%

In view to address this issue, we adopt the classification of Koutmos and Martin [50] as described in the table 2.

Table 2: Possible sources of sign asymmetry of exchange rate exposure

	$\beta^*_{2,i} > 0$	$\beta^*_{2,i} = 0$	$\beta^*_{2,i} < 0$
$\beta_{3,i} > 0$	#Net Exporters #Pricing-to-Market With Market Share Objective #Hysteresis	#Net Exporters #Pricing-to-Market With Market Share Objective #Hysteresis	#Net Importers #Pricing-to-Market With Market Share Objective
$\beta_{3,i} = 0$	#Net Exporters #Symmetric Exposure	#Net Exporters or Importers #No Exposure	#Net Importers #Symmetric Exposure
$\beta_{3,i} < 0$	#Net Exporters #Pricing-to-Market Under Volume Constraints #Asymmetric Hedging	#Net Importers #Pricing-to-Market Under Volume Constraints #Asymmetric Hedging	#Net Importers #Asymmetric Hedging

In section 2, we describe possible sources of asymmetric behavior, mainly asymmetric hedging, hysteresis and pricing-to-market (with market share objective or volume constraints). In the above table 2, Koutmos and Martin [50] show how different combinations of sign asymmetry coefficient ($\beta_{3,i}$) and currency exposure ($\beta^*_{2,i}$) relate to symmetric or asymmetric exposure. For example, positive $\beta^*_{2,i}$ and $\beta_{3,i}$ are usually associated to exporters who are supposed to benefit from a depreciation of the TWD,

which means an appreciation of the other currency. That will illustrate the price-to-market case with market share objective: the exporters may not pass on the impacts to buyers by increasing the foreign prices of their products, to avoid the risk of losing market share to other competitors. In another example, a positive $\beta_{2,i}^{*}$ means that firms suffer from an appreciation of the TWD, while they benefit from it when $\beta_{3,i}$ is negative: that describes the case where firms are encouraged to use financial derivatives to cover their risks (asymmetric hedging). By using similar reasoning, we can complete the above Table 2.

4 Sample selection

All data are obtained from Taiwan Economic Journal Data Bank (TEJ). We only focus on non-financial Taiwanese companies listed on the Taiwan Stock Exchange (TSE).
Financial institutions are not included due to their different asset characteristics and objectives with regard to financial risks. This restriction makes also the sample comparable to the ones used in most of the previous studies. As a starting point, we use our previous research based on a sample of Taiwanese non-financial firms from June 6th 1990 to July 14th 2010, see Varga [68].
This sample is designed to investigate the exchange rate exposure on the longest possible period of time, starting from 1990 (financial liberalization began mid of 1987 so we disregard the last years of the 1980s to avoid a structural break). At the time of sampling, 741 companies are listed on the TSE (199 firms in 1990) but after eliminating companies with unavailable information and financial firms, the final sample consists of 107 firms with data starting on June 6 1990 and finishing on July 14 2010. This period of time covers almost 22 years.
The sample selection may introduce a survivorship bias in the results. Since all these firms have survived during the sample period, they are likely to be the ones that have effectively managed various risk exposure. It means that the bias is against finding significant exposure coefficient.
In view to investigate the impacts from the 1997 Asian financial turmoil and the global financial crisis which started in 2007, we define 4 sub-samples: The first panel analyzes the impact of the Asian financial crisis using two sub-samples (before and after): from June 6th 1990 to June 30th 1997 and from July 1st 1997 to July 31st 2001. The second panel studies the consequences of the global financial crisis using also two sub-samples (before and after): from August 1st 2001 to July 31st 2007 and from August 1st 2007 to July 14th 2010.
To verify that time points are statistically significant, we used a structural test, more precisely a stability test based on the Chow Breakpoint Test (not reported here). The breakpoints are: 7/01/1997, 8/01/2001 and 8/01/2007. For 89% of our sample, we reject the null hypothesis (no break at specified breakpoints). Thus, we may consider that the choice of the 4 sub periods is statistically significant.
This study is at the firm level and we use daily adjusted stock prices, supplied by TEJ. We decide to select the firm as the unit of analysis for several reasons. Firstly, firms within the same industry are not homogenous and hence may display different exposure coefficients. Thus, individual exposure effects may be averaged out at the industry level. Secondly, industry return indices are often value-weighted, advantaging large firms.

As Dominguez and Tesar [29] say, if small firms are more exposed to exchange rate fluctuations, analysis at the industry level will misjudge the true level of exposure. Thirdly, asymmetry effects can best be captured at the firm level since an industry can include both exporters and importers. Finally, if this study provides interesting conclusions, they may have a more practical impact and be more useful in exchange rate and assets management at the firm level.

As a proxy for the returns on the market portfolio, we use the TAIEX which is the main index in the Taiwan stock exchange. We choose to employ a bilateral exchange rate instead of an exchange rate index to avoid its aggregated effects issues. Moreover, an exchange rate index is not always relevant for a firm. Currency changes may be measured in nominal and real terms. We choose to use the nominal exchange rate firstly because it avoids the trouble to adjust the other variables of our regressions for consistency purposes (Khoo [47]) and secondly, Mark [53] finds that nominal and real changes are almost perfectly correlated for the seven countries used in his study. His conclusion is also shared by Atindehou and Gueyie [7].

The American dollar is the currency mostly used by Taiwanese firms so as the nominal bilateral exchange rate we employ the direct quote USD / TWD (amount of Taiwanese dollar for one unit of American dollar). If the exchange rate change is negative (positive), the domestic currency (TWD) is appreciating (depreciating). If the firm displays a negative exposure coefficient, it will benefit from an appreciation of the TWD and if the exposure coefficient is positive, the firm will benefit from a depreciation of the domestic currency.

We have 5245 individual observations representing 561,215 daily data. Table 3 provides the repartition of the firms per industry and table 4 gives the list of companies constituting our sample.

Table 3: Sample: industries represented

Industry Code	Sample	%
1 Cement	5	4.67%
2 Foods	8	7.48%
3 Plastics	11	10.28%
4 Textile	17	15.89%
5 Elec. & Mach.	4	3.74%
6 Elec. Appliance & Cable	8	7.48%
7 Chemicals	11	10.28%
8 Glass & Ceramics	1	0.93%
9 Paper & Pulp	5	4.67%
10 Steel & Iron	6	5.61%
11 Rubber	4	3.74%
12 Automobile	1	0.93%
13 Electronics	5	4.67%
14 Construction	5	4.67%
15 Transportation	3	2.80%
16 Tourism	4	3.74%
17 Wholesale & Retail	7	6.54%
19 Others	2	1.87%
TOTAL	107	100.00%

Table 4: Sample list

Industry Code	Firm Code	Industry Code	Firm Code	Industry Code	Firm Code	Industry Code	Firm Code
1	1101	4	1418	7	1713	14	2540
1	1102	4	1419	7	1718	15	2601
1	1103	4	1423	8	1802	15	2603
1	1104	4	1434	9	1903	15	2605
1	1108	4	1435	9	1904	16	2701
2	1201	4	1441	9	1905	16	2702
2	1210	4	1436	9	1907	16	2704
2	1213	4	1437	9	1909	16	2705
2	1215	4	1439	10	2002	17	2915
2	1216	4	1440	10	2006	17	2913
2	1217	4	1443	10	2007	17	2901
2	1218	5	1503	10	2008	17	2903
2	1229	5	1504	10	2009	17	2904
3	1301	5	1506	10	2010	17	2905
3	1303	5	1507	11	2102	17	2906
3	1304	6	1605	11	2103	19	9904
3	1305	6	1608	11	2104	19	9902
3	1307	6	1609	11	2105		
3	1308	6	1611	12	2201		
3	1309	6	1603	13	2303		
3	1310	6	1604	13	2371		
3	1312	7	1701	13	2302		
3	1313	7	1702	13	2305		
3	1326	7	1704	13	2308		
4	1402	7	1707	13	2311		
4	1409	7	1708	13	2312		
4	1410	7	1709	14	2501		
4	1413	7	1710	14	2504		
4	1416	7	1711	14	2509		
4	1417	7	1712	14	2506		

5 Empirical Results and Major Findings

Tables 5-1 and 5-2 provide the main results for respectively the Asian Crisis and the 2007 Global Crisis. We find a high percentage of exposed firms (β_2^*) before the two crises: 68.2% (1997) and 72% (2007). All concerned firms are negatively exposed (they benefit from an appreciation of the TWD). The main difference between the two crises remains in the level of exposure which is almost 13% lower before the 2007 crisis compared to before the 1997 crisis.

In both cases, sign asymmetries (β_3) increase after the crises. They are mostly negative, increasing thus the exposure level. But if the sign coefficient is lower after the 1997 crisis,

it is much higher after the 2007 crisis. So in both crises, Taiwanese firms tend to benefit more from their sign asymmetric profile, especially after the 2007 crisis if we consider the level of the sign coefficient.

For the two crises, the number of magnitude asymmetries (β_4) cases decreases sharply after. For the 1997 crisis, the coefficient' sign is well distributed before, but it is mostly negative after, increasing thus the level of exposure. For the 2007 crisis, the sign is mostly positive (before and after), pushing down the level of exposure. It shows that Taiwanese firms suffer more from large currency changes during the 2007 crises than during the 1997 one.

The number of cases of asymmetric volatility of stock returns underlying exchange rate exposure (γ) decreases after the 1997 crisis by almost 60%. We observe the same trend for the 2007 crisis, but the change is less than 30%. Still, there are much more cases of asymmetric volatility before and after the 2007 crisis than for the 1997 crisis. The sign is mostly negative for both crises: bad news ($\varepsilon_{i,t} < 0$) decrease the volatility of the stock returns. But taking into account the number of cases, the impact on the volatility is much more accentuated in the 2007 crisis. Moreover, the positive impact on the volatility from the bad news (average γ) is the largest after the 2007 crisis. Nevertheless, the mechanism through which the asymmetric volatility comes into being still remains unresolved. Depreciation or appreciation of the domestic currency is not automatically a good or bad news.

The number of cases of exchange rate volatility impacting the stock returns increases after both crises. But for the 1997 crisis, the sign is mostly positive: Taiwanese firms benefit from the currency volatility. But given the fact that we excluded from our sampling financial firms, the explanation of the positive relation between exchange rate volatility and stock returns is not obvious.

Normally, we may observe for financial firms that volatility implies greater hedging and thus, revenues from for example the sale of currency derivatives should increase and thereby, a positive impact on the stock returns should be observed. But our sample only contains non-financial firms.

Before the 2007 crisis, the sign is mostly negative: firms suffer from the currency volatility. And it confirms our conclusions concerning the effect of the magnitude asymmetry. One possible reason for a negative relation between stock returns and exchange rate volatility is that the concerned firms are frequent users of expensive hedging tools (as for example currency derivatives) and then a greater volatility translates to greater costs of hedging. Thus, it is logical to think that cash flows and stock returns will be adversely affected. But after the 2007 crisis, the volatility signs are evenly distributed. If the number of positive cases is not very consequent, it is still too large to be ignored for both crises. Obviously, more tests should be conducted in view to explain the positive relation between exchange rate volatility and stock returns.

For Tables 5-1 and 5-2:

$$R_{i,t} = \beta^*_{0,i} + \beta_{1,i}\delta_{m,t} + (\beta^*_{2,i} + \beta_{3,i}D_{sign,i,t} + \beta_{4,i}D_{amp,i,t})s_t + \beta_{5,i}h_{s,t} + \varepsilon_{i,t}$$

where: s_t *= the unexpected change in the exchange rate,* $D_{sign,i,t}$ *= 1 if* $s_t < 0$ *and 0*

otherwise, $D_{amp,i,t} = 1$ *if* $|s_t| > x$ *and 0 otherwise;* $x = 0.5\%$. $h_{s,t}$ *= the time-varying exchange rate volatility [* s_t *follows a GARCH (1,1)];* $\varepsilon_{i,t}$ *= error term which follows a GJRGARCH(1,1) process:* $\varepsilon_{i,t} = \mu_{i,t}\sqrt{h_{\varepsilon,i,t}}$ *and* $h_{\varepsilon,i,t} = \omega_{\varepsilon,i} + \alpha_{\varepsilon,i}\varepsilon_{t-1}^2 + \gamma_i D_{i,t-1}\varepsilon_{t-1}^2 + \beta_{\varepsilon,i}h_{\varepsilon,i,t-1}$*:* $D_{i,t-1}$ *is equal to 1 if* $\varepsilon_{i,t}$ *is negative and 0 otherwise.* $h_{\varepsilon,i,t}$ *denotes the conditional variance of the residuals and* $\mu_{i,t}$ *the white noise error term.*

Table 5-1. Results for the financial Asian crisis

Before 1997 Crisis			**Sample Size**		107					
Firms Exposed at	$\beta_{2,i}^*$		**β3**		**β4**		**β5**		γ	
	Qty	**%**	**Qty**	**%**	**Qty**	**%**	**Qty**	**%**	**Qty**	**%**
10%	73	68.2%	3	2.8%	12	11.2%	11	10.3%	38	35.51%
	>0	**<0**	**>0**	**<0**	**>0**	**<0**	**>0**	**<0**	**>0**	**<0**
Firms Exposed (10%)	**0**	**73**	**0**	**3**	**6**	**6**	**11**	**0**	**12**	**26**
% of Exposed (10%)		**100.00%**		**100.0%**	**50.0%**	**50.0%**	**100.0%**		**31.58%**	**68.42%**
Mean		-0.03213		-0.03385	0.027354	-0.024	0.019768		0.055264	-0.05116
Mean β1		0.957884								
(persistence) $\beta_{\varepsilon,i}$		0.84792								

After 1997 Crisis			**Sample Size**		107					
Firms Exposed at	$\beta_{2,i}^*$		**β3**		**β4**		**β5**		γ	
	Qty	**%**	**Qty**	**%**	**Qty**	**%**	**Qty**	**%**	**Qty**	**%**
10%	19	17.8%	10	9.3%	5	4.7%	21	19.6%	16	14.95%
	>0	**<0**	**>0**	**<0**	**>0**	**<0**	**>0**	**<0**	**>0**	**<0**
Firms Exposed (10%)	**1**	**18**	**4**	**6**	**1**	**4**	**17**	**4**	**6**	**10**
% of Exposed (10%)	**5.26%**	**94.74%**	**40.0%**	**60.0%**	**20.0%**	**80.0%**	**81.0%**	**19.0%**	**37.50%**	**62.50%**
Mean	0.030092	-0.03424	0.027335	-0.02301	0.020724	-0.02562	0.084684	-0.09046	0.009184	-0.01992
Mean β1		0.830507								
(persistence) $\beta_{\varepsilon,i}$		0.773692								

Table 5-2. Results for the 2007 global financial crisis

Before 2007 Crisis			**Sample Size**		107					
Firms Exposed at	$\beta_{2,i}^*$		**β3**		**β4**		**β5**		γ	
	Qty	**%**	**Qty**	**%**	**Qty**	**%**	**Qty**	**%**	**Qty**	**%**
10%	77	72.0%	7	6.5%	13	12.1%	7	6.5%	47	43.93%
	>0	**<0**	**>0**	**<0**	**>0**	**<0**	**>0**	**<0**	**>0**	**<0**
Firms Exposed (10%)	**0**	**77**	**3**	**4**	**12**	**1**	**2**	**5**	**1**	**46**
% of Exposed (10%)		**100.00%**	**42.9%**	**57.1%**	**92.3%**	**7.7%**	**28.6%**	**71.4%**	**2.13%**	**97.87%**
Mean		-0.02764	0.046218	-0.02208	0.021691	-0.02033	0.030258	-0.04359	0.001948	-0.02206
Mean β1		0.778536								
(persistence) $\beta_{\varepsilon,i}$		0.841758								

After 2007 Crisis			Sample Size	107						
Firms Exposed at	$\beta^*_{2,i}$		β3		β4		β5		γ	
	Qty	%	Qty	%	Qty	%	Qty	%	Qty	%
10%	21	19.6%	8	7.5%	5	4.7%	16	15.0%	33	30.84%
	>0	<0	>0	<0	>0	<0	>0	<0	>0	<0
Firms Exposed (10%)		21	1	7	4	1	8	8	7	26
% of Exposed (10%)		100.00%	12.5%	87.5%	80.0%	20.0%	50.0%	50.0%	21.21%	78.79%
Mean		-0.03863	0.037915	-0.03884	0.025023	-0.03198	0.085102	-0.09752	0.097217	-0.1082

Mean β1		0.940581
(persistence)	$\beta_{\varepsilon,i}$	0.78018

Table 6-1 describes the possible sources of asymmetries, using the classification in Koutmos and Martin [50] for the 1997 crisis, table 6-2 describing the possible sources for the 2007 crisis with the same classification.

Table 6-1. Possible sources of asymmetries, for the 1997 crisis

BEFORE	$\beta^*_{2,i}>0$	$\beta^*_{2,i}=0$	$\beta^*_{2,i}<0$	AFTER	$\beta^*_{2,i}>0$	$\beta^*_{2,i}=0$	$\beta^*_{2,i}<0$
β3 > 0	#Net Exporters #Pricing-to-Market With Market Share Objective #Hysteresis **0 firm (0%)**	#Net Exporters #Pricing-to-Market With Market Share Objective #Hysteresis **0 firm (0%)**	#Net Importers #Pricing-to-Market With Market Share Objective **0 firm (0%)**	β3 > 0	#Net Exporters #Pricing-to-Market With Market Share Objective #Hysteresis **0 firm (0%)**	#Net Exporters #Pricing-to-Market With Market Share Objective #Hysteresis **3 firms (2.8%)**	#Net Importers #Pricing-to-Market With Market Share Objective **1 firm (1%)**
β3 = 0	#Net Exporters #Symmetric Exposure **1 firm (1%)**	#Net Exporters or Importers #No Exposure **32 firms (30%)**	#Net Importers #Symmetric Exposure **73 firms (72%)**	β3 = 0	#Net Exporters #Symmetric Exposure **1 firm (1%)**	#Net Exporters or Importers #No Exposure **79 firms (73.8%)**	#Net Importers #Symmetric Exposure **17 firms (16%)**
β3 < 0	#Net Exporters #Pricing-to-Market Under Volume Constraints #Asymmetric Hedging **0 firm (0%)**	#Net Importers #Pricing-to-Market Under Volume Constraints #Asymmetric Hedging **2 firms (1.9%)**	#Net Importers #Asymmetric Hedging **1 firm (1%)**	β3 < 0	#Net Exporters #Pricing-to-Market Under Volume Constraints #Asymmetric Hedging **0 firm (0%)**	#Net Importers #Pricing-to-Market Under Volume Constraints #Asymmetric Hedging **6 firms (5.6%)**	#Net Importers #Asymmetric Hedging **0 firm (0%)**

The classification confirms our results concerning the exposed firms before and after the

1997 crisis. But if we have much more less exposed firms after the crisis, asymmetric profiles are more pronounced even if Taiwanese firms are mostly symmetrically exposed.

Table 6-2. Possible sources of asymmetries, for the 2007 crisis

BEFORE	$\beta^*_{2,i}>0$	$\beta^*_{2,i}=0$	$\beta^*_{2,i}<0$	AFTER	$\beta^*_{2,i}>0$	$\beta^*_{2,i}=0$	$\beta^*_{2,i}<0$
β3 > 0	#Net Exporters #Pricing-to-Market With Market Share Objective #Hysteresis **0 firm (0%)**	#Net Exporters #Pricing-to-Market With Market Share Objective #Hysteresis **0 firm 0%)**	#Net Importers #Pricing-to-Market With Market Share Objective **3 firms (2.8%)**	β3 > 0	#Net Exporters #Pricing-to-Market With Market Share Objective #Hysteresis **0 firm (0%)**	#Net Exporters #Pricing-to-Market With Market Share Objective #Hysteresis **0 firm 0%)**	#Net Importers #Pricing-to-Market With Market Share Objective **1 firm (1%)**
β3 = 0	#Net Exporters #Symmetric Exposure **0 firm (0%)**	#Net Exporters or Importers #No Exposure **26 firms (24.3%)**	#Net Importers #Symmetric Exposure **74 firms (69.2%)**	β3 = 0	#Net Exporters #Symmetric Exposure **0 firm (0%)**	#Net Exporters or Importers #No Exposure **80 firms (74.7%)**	#Net Importers #Symmetric Exposure **20 firms (18.7%)**
β3 < 0	#Net Exporters #Pricing-to-Market Under Volume Constraints #Asymmetric Hedging **0 firm (0%)**	#Net Importers #Pricing-to-Market Under Volume Constraints #Asymmetric Hedging **4 firms (3.7%)**	#Net Importers #Asymmetric Hedging **0 firm (0%)**	β3 < 0	#Net Exporters #Pricing-to-Market Under Volume Constraints #Asymmetric Hedging **0 firm (0%)**	#Net Importers #Pricing-to-Market Under Volume Constraints #Asymmetric Hedging **7 firms (6.5%)**	#Net Importers #Asymmetric Hedging **0 firm (0%)**

As shown in the table 6-2, the conclusions are very similar for the 2007 crisis.

The number of firms exhibiting at least one form of asymmetry is lower after both crises (not reported here): 45% and 24% for 1997 and 61% and 38% for 2007. We can notice that asymmetric profiles are more pronounced before and after the 2007 crisis than for the Asian crisis.

For a consequent part of our sample, we observe the existence of an asymmetric volatility of stock returns (for both crises). But a large part of our sample which does not have an exchange rate exposure is also associated with this volatility asymmetry: 11% and 13% respectively before and after 1997 crisis and 13% and 22% respectively before and after the 2007 crisis (not reported). This phenomenon is more pronounced for the 2007 crisis. Nevertheless, the mechanism through which the existence of an asymmetric volatility of stock returns comes into being still remains unresolved.

Our study shows clearly that stock return volatilities are time dependant. Persistence, measured by $\beta_{\varepsilon,i}$, is quite high with an average of 0.848 / 0.774 before / after the 1997 crisis and 0.842 / 0.780 before / after the 2007 crisis. It suggests that there is a long memory in the stock return volatility process. So obviously, the time variance is an

important variable in the conditional variance. But numbers show that it is truer before than after the crisis, persistence being lower after the crises.
Finally, the two crises have different impacts on the market risk of Taiwanese firms. Surprisingly, it is lower by 13% after the 1997 crisis, but (more logically) it is higher by 21% after the 2007 crisis. Thus, the two crises have different consequences on the required rate of equity return from investors, to keep holding the firm's shares. If negative consequences from the 1997 crisis had a very more muted impact on Taiwanese firms, the 2007 global financial crisis increased their equity financing costs.
We conducted a test regression (not reported here), by adding dummy variables to our main model, in view to observe possible individual influences according the period of time:
D1: = 1 if the period is between 6/06/1990 and 6/30/1997 and 0 otherwise
D2: = 1 if the period is between 7/01/1997 and 7/31/2001 and 0 otherwise
D3: = 1 if the period is between 8/01/2001 and 7/31/2007 and 0 otherwise
The period from 8/01/2007 to 7/14/2010 will be the base category to interpret the results.
For 24% of our sample, we have statistically significant dummy variables (mostly at 5% level of significance). Respectively for D1, D2 and D3 we have 13, 18 and 13 cases. But what is interesting to note is that for almost 80% of the cases, the coefficient is negative. It means that on average (keeping other variables constant), the first three periods tend to lower the stock return, compare to the base category (the fourth period). It is consistent with our other findings: firms benefit from their asymmetric profile, especially after the 2007 crisis.

6 Concluding Remarks

This paper investigates whether the Asian crisis and the 2007 global crisis impacted Taiwanese exposure, volatilities and systematic risk with respect to the Taiwan equity market portfolio. We found that for both crises, the number of exposed firms decreased sharply after the crises, compared to the situation before the crises. We may explain it by the fact that following the consequences of the crises, Taiwanese firms are more engaged in hedging activities. The main difference between the two crises remains in the level of exposure which is almost 13% lower before the 2007 crisis compared to before the 1997 crisis, but 13% higher after the 2007 crisis, compared to after the 1997 crisis. Whatever the period of time or the crisis, all Taiwanese firms are negatively exposed, benefiting from an appreciation of the TWD.
For both crises, sign asymmetries increase after the crisis. Being mostly negative, firms benefit from their asymmetric profile, especially after the 2007 crisis.
Conversely, magnitude asymmetries decreased sharply after both crises, but for the 2007 crisis, the sign is mostly positive (before and after), pushing down the level of exposure. It shows that Taiwanese firms suffer more from large currency changes during the 2007 crisis than during the 1997 one.
The number of cases of asymmetric volatility of stock returns underlying exchange rate exposure is lower after both crises, but it is more pronounced for the 2007 crisis. The sign is mostly negative (bad news reduce the volatility of stock returns). But a large part of non-exposed firms is also associated to the volatility asymmetry, especially for the 2007 crisis (not reported here). Nevertheless, the mechanism through which the asymmetric volatility comes into being still remains unresolved. Depreciation or appreciation of the

domestic currency is not automatically a good or bad news.
The number of cases of exchange rate volatility impacting the stock returns increases after both crises. The sign is mostly positive for the 1997 crisis (before and after). Before the 2007 crisis, signs are mostly negative, and evenly distributed after. If financial theory clearly explains that cash flows and stock returns are adversely affected by the currency volatility, a positive relationship between exchange rate volatility and stock returns is not obvious, especially knowing that our sample does not include financial firms.
If Taiwanese firms are clearly symmetrically exposed, asymmetric profiles are more pronounced for the 2007 crisis.
Our study shows clearly that stock return volatilities are time dependant, even though persistence tends to decrease after both crises.
Finally, the two crises have different consequences on the market risk of Taiwanese firms. Surprisingly, it is lower after the 1997 crisis, but (more logically) is higher after the 2007 crisis. Thus, the two crises have different impacts on the required rate of equity return from investors, to keep holding the firm's shares. If negative consequences from the 1997 crisis had a very more muted impact on Taiwanese firms, the 2007 global financial crisis increased their equity financing cost.

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