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Abstract

This paper investigates asymmetric exchange rate exposure on Indonesia industry's stock returns in both (non)linear specifications and different setting in exchange rate regimes and sub-sample periods using the EGARCH model. The results reveal that negative exchange rate exposure dominates over positive exposure in the linear exposure setting, but there is no dominance sign in nonlinear exposure effect specification. The negative exchange rate exposure is more pronounced in the episodes of Asian and Global financial crisis and largely reduces in tranquility period. In relation to exchange rate arrangements, many industries experience statistically significant negative exposure to the US dollar with managed floating exchange rate regime than flexible regime.

Keywords: exchange rate exposure, industry-level exposure, exponential GARCH-type model, Indonesia
JEL-code: C22, F31, G15

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1. Introduction

Exchange rate exposure that measures the sensitivity of firm's value to exchange rate changes is a crucial issue in financial management, because unexpected exchange rate changes may affect a firm's pricing decisions, future cash flows, and firm valuation as well as risk management. Over the past three decades, firms and industries that were once national have become more global resulting in large increases in international activity. This in turn makes exchange rate exposure management a key component of corporate strategy. The challenges for investors, creditors, and managers alike is then accurately access the size and direction of this exposure, since quite basically the problem must be accessed before it can be managed. Consequently, many theoretical models and empirical studies on the exchange rate exposure on firm's or industrial's valuation in both industrial and developing countries have been published over the last decades. Koutmos and Martin (2003), Bartram, Dufey, and Frenkel (2005), and Muller and Verschoor (2006) provide reviews.

Most empirical studies of exchange rate exposure to date have focused on western industrial countries and Asian emerging markets, and most have found only modest exposure. In this paper, we focus solely on Indonesia industrial sectors. We stress on how the returns for Indonesian industrial sectors respond to exchange rate returns after taking into account of returns on a market index. This paper extends the existing literature in several important ways. We investigate whether the exchange rate arrangement can impact exchange rate exposure and whether the exchange rate exposure differs across industrial sectors in terms of how they experienced the Asian and Global financial crises. In addition, we use the EGARCH (Exponential Generalized Autoregressive Conditional Heteroskedastic) model with (non)linear exposure specifications which is enable us to reveal important properties of high frequency data of financial markets instead of using the simple regression model.

Using a sample of ten Indonesia industrial sectors for the period May 29, 1996 to March 3, 2012, our findings can be summarized as follows. First, many Indonesia industries experience statistically significant negative exposure to fluctuations in the US dollar. Second, we find that the number of industries exhibited significant negative exposure increases from tranquility periods to the onset of Asian and Global financial crisis. Finally, we find that industries under managed floating exchange rate regime are more exposed to foreign currency movements than under floating regime.

The remainder of the paper is organized as follows. Section 2 briefly highlights the literature of exchange rate exposure both theoretically and empirically. Section 3 presents model specification and then it outlines estimation method for uncovering the relation between industry value and exchange rate exposure. Section 4 discusses the data and its properties. Section 5 reports the empirical results. Section 6 reveals the sensitivity and stability of exchange rate exposure in the present of exchange rate regime changes and the Asian financial crisis 1997-1998 and Global crisis 2007-2009. Section 7 concludes.

2. Literature review

In the theoretical literature the concept of foreign exchange rate exposure describes the impact of foreign exchange rate changes on corporations. More precisely, economic foreign exchange rate exposure represents the sensitivity of firm value in national currency reflected by changing the present value of its expected future cash flows with regard to unexpected foreign exchange rate changes (Adler and Dumas 1984). There are a number of channels through which the exchange rate might affect the value of a firm. Some theoretical models put forward a role of international trade as channel of exchange rate exposure. Shapiro (1975), among others, concludes that a depreciation of the domestic currency leads to an increase in sales revenue and profits as well as to higher production of a multinational firm. The degree of exposure may also relate to the level of foreign competition and the degree of substitutability between local and imported factors of production. Levi (1994) and Marston (2001) support that the profitability of sales in foreign country and net foreign revenues are the main channel for a firm's exchange rate exposure. Griffin and Stulz (2001) and Williamson (2001) argue that the industry competition level play key roles in exchange rate exposure, whilst Allayannis and Ihrig (2001) emphasize the role of industry markup besides competition level. Bodnar, Dumas, and Marston (2002) demonstrate that an exporting firm's exchange rate exposure relates with the extent it pass-through exchange rate changes to prices. Even firms that do no international business, O'Brien (1994) and Marston (2001) stress that these type of firms may be influenced indirectly by foreign competition and therefore they may have exchange rate exposure. This may happen in case of international market leaders located abroad are able to contest the local market with imports (import competition). Muller and Verschoor (2006) provide further detailed on the theoretical foundations of exchange risk exposure.

Empirical studies to investigate exchange rate exposure are quite diverse in terms of geographical covered, factors determined sign and size of the exchange rate exposure estimates, aggregation level in terms of firm- or industry-level, and model specification and estimation method used to relate exchange rate and firm value. Most empirical exposure studies focus on U.S. firms (*e.g*. Jorion 1990; Bartov and Bodnar 1994; Fraser and Pantzalis 2004; Pritamani, Shome, and Singal 2005; Kolari, Moorman, and Sorescu 2008; Du and Hu 2012; Chaieb and Mazzotta 2013) or international industries (*e.g*. Bodnar and Gentry 1993; Griffin and Stulz 2001; Bodnar, Dumas, and Marston 2002; Bredin and Hyde 2011). A potential problem with examining only U.S. firms is that they may differ widely in their exposure even after controlling for the level of foreign sales. Indeed, recent studies show more evidence of exposure in industries and firms for developed countries outside the U.S. (*e.g*. He and Ng 1998; Griffin and Stulz 2001; Apergis, Artikis, and Sorros 2011; Agyei-Ampomah, Mazouz, and Yin 2012). More recent studies emphasise on emerging and developing countries (*e.g*. Dominguez and Tesar 2001, 2006; Doidge, Griffin, and Williamson 2006; Muller and Verschoor 2007; Chue and Cook 2008; Aysun and Guldi 2011).

In terms of relation between exchange rate exposure and its determinants, the studies show a quite mixed result. Jorion (1990) and He and Ng (1998) find foreign sales to be an important determinant of exposure for US and Japanese multinationals. However, Bartov and Bodnar (1994) conclude that no evidence of contemporaneous exposure for U.S. multinationals, although they do show that U.S. firms respond to past quarterly exchange rate movements, and Koch and Saporoschenko (2001) indicate that Japanese keiretsu financial firms have higher than average market risk but insignificant exposure to exchange rate changes. Dominguez and Tesar (2001, 2006) find a link between foreign activity and exposure in a sample of firms from eight non-U.S. countries, including Japan. Using firm-level data from 18 countries (developed and emerging markets), Doidge, Griffin, and Williamson (2006) show that firm size, the level of international sales, foreign income, and foreign assets are all significantly negatively related to exposure. Chue and Cook (2008) reveal that depreciations for 15 emerging markets tend to have a negative impact on emerging market stock returns in the pre-Asian financial crisis episode, but this tendency has largely disappeared in the post-Asian crisis. Focusing on firm-level data of seven Asian markets, Muller and Verschoor (2007) find that about a quarter of Asian firm experienced economically significant exposure effects to the US dollar and the Japanese yen. The overall extent of exposure is not sample dependent; a depreciating (appreciating) Asian currency against foreign currencies has a net negative (positive) impact on stock returns. Recent study by Lin (2011) concludes that exchange rate exposure in the Asian emerging markets exists during sample period, especially the exposure more intense during the outbreak of the 1997-1998 Asian financial crisis and the 2008 global crisis.

Various types of model specifications and estimation methods exist in the literature used to relate exchange rate and firm value. The studies differ in terms of (non)linear treatments of exchange rate exposure, (a)symmetric exposure, estimation method, and relation to risk management strategies. The majority of empirical studies test for a constant linear relationship between stock returns and exchange rate changes, for instance, Jorion (1990), Bodnar and Gentry (1993), Griffin and Stulz (2001). In contrast, the theoretical literature on the relationship between the value of a firm and the exchange rate generally posits a nonlinear relationship, among others, outlined by Kogut and Kulatilaka (1994), Bartram (2004), Priestley and Ødegaard (2007), and Aysun and Guldi (2011). Several arguments have been put forward to explain the existence of nonlinear exposure. Future corporate cash flows are uncertain as reflected in the way prices and quantities of sales changes to adjust exchange rate changes. Nonlinear exchange rate exposures result when corporations react to exchange rate movements by be able to shift manufacturing or sourcing in different countries or by their flexibility in production and export or import decisions. In addition, a nonlinear exposure can also stem from the result of asymmetric reactions of firm value to exchange rate changes. Asymmetric exposure is implied in theoretical models purporting to describe actual corporate behavior, such as, pricing-to-market (Marston 1990; Knetter 1994), hysteresis (Baldwin 1988), and asymmetric hedging (Miller and Reuer 1998). Koutmos and Martin (2003, 2007) provide more detailed review on asymmetric exchange rate exposure. Most of empirical studies use linear regression model both in panel data setting and using instrumental variable to uncover firm value and exchange rate exposure (*e.g*. Jorion 1990; Dominguez and Tesar 2001, 2006; Chue and Cook 2008; Agyei-Ampomah, Mazouz, and Yin 2012). Some studies employ event study, such as, Dewenter, Higgins, and Simin (2005). Recent studies use a variant type of GARCH models both in bivariate and multivariate setting in investigating sensitivity in both changes and volatility of stock returns to changes and volatility of exchange rate changes and the correlation between volatilities of stock returns and exchange rate changes. Those studies, among others, are Koutmos and Martin (2003), Muller and Verschoor (2007), Jayasinghe and Tsui (2008) and Gounopoulos et al. (2013).

In terms of risk management strategies to deal with exchange rate fluctuations, Levi (1994) and Marston (2001) argue that cash flows of specific commercial transactions that have already been booked is relatively easy to identify through accounting systems over a given time period. Exchange rate exposure to these transactions can be effectively managed by well-structured hedging strategies. Hagelin and Pramborg (2006) and Bartram, Brown, and Minton (2010) reveal that a large global manufacturing firms may be able to use pass-through, operational hedging, and financial hedging to reduce their foreign exchange exposure. These strategies represent only a part of the relevant economic foreign exchange rate exposure of the firm. While exchange rate movements affect contractually fixed transactions directly, there are additional effects on future cash flows related to the competitive position of the firm, which can manifest themselves in price as well as quantity effects. Consequently, Stulz and Williamson (1997) emphasize that economic foreign exchange rate exposure provides significant variability in cash flows for most firms worldwide, and therefore it is quite difficult to hedge efficiently. In relation to effects of different setting of exchange rate regime to firm's hedge incentives, Kamil (2012) finds that corporations may be able to diminish negative exchange rate exposure by hedging in environment of flexible exchange rate regime than pegged regime.

3. Model specification and estimation method

Since its introduction, the GARCH model, devised by Bollerslev (1986), has been applied in countless empirical studies. The GARCH model and its subsequent extension has turned out to be particularly useful for modeling conditional volatility in a wide variety of financial market data. Bollerslev, Chou, and Kroner (1992) and Bollershev, Engle, and Nelson (1994) provide reviews. In spite of the GARCH models elegantly capture fat tails and volatility clustering (highly persistent periods of volatility and tranquility) in asset returns, this feature of GARCH models neglect asymmetric conditional variance function that may be appropriate for modeling the volatility of asset returns because it can represent a phenomena knows as leverage effect, which is the negative correlation between volatility and past returns.[1] This is not only observed for individual assets, but volatilities of asset market also exhibit this behavior over time. Many variants of GARCH-type models that are capable of

[1] The asymmetric volatility phenomenon explained by leverage effect is put forward by Black (1976) and Christie (1982). Other explanations of the phenomenon are the volatility feedback effect (Pindyck 1984; French, Schwert, and Stambaugh 1987; Campbell and Hentschel 1992; Bekaert and Wu 2000) and an increasing correlation of stocks in down-markets (Conrad, Gultekin, and Kaul 1991; Longin and Solnik 2001; Ang and Chen 2002).

capturing volatility asymmetry have been developed. A widely accepted variant of such models that allows for asymmetric effects is the Exponential GARCH (EGARCH) model introduced by Nelson (1991). In this paper, we adopt an univariate EGARCH(1,1) model to capture the exchange rate exposure on industrial sector returns. We specify the mean and variance structures in details below.

We use a commonly adopted formula for measuring economic exposure, that is, an asset pricing equation, which is usually the market model, a variation of the Capital Asset Pricing Model (CAPM), augmented by the foreign exchange rate variable, as follows:

$$R_{i,t} = \beta_{0,i} + \beta_{1,i} R_{m,t} + \beta_{2,i} R_{f,t} + u_{i,t} \qquad (1)$$

where $R_{i,t}$ is the daily return on the stock of industrial sector *i* on day *t*; $R_{m,t}$ is the return on a Indonesia market index on day *t*; $R_{f,t}$ equals the change on the exchange rate in period *t* expressed in Indonesia rupiahs per unit of US dollar; and *u* is a random error term. An intercept is $\beta_{0,i}$. The sensitivity of the return on industry *i* to the market return is denoted by $\beta_{1,i}$ and $\beta_{2,i}$ is the sensitivity of the return on industry *i* to foreign exchange rate changes or return on foreign exchange. In order to take into account nonlinear structures in the foreign exchange rate exposure, we follow Priestley and Ødegaard (2007) by adding the squared values of the exchange rate changes to the linear exposure framework specified in Equation (1):

$$R_{i,t} = \phi_{0,i} + \phi_{1,i} R_{m,t} + \phi_{2,i} R_{f,t} + \phi_{3,i} R_{f,t}^2 + u_{i,t} \qquad (2)$$

where $R_{f,t}^2$ are the squared values of exchange rate changes, and $\phi_{3,i}$ measure the sensitivity of stock *i* to nonlinear effects.[2]

[2] $R_{f,t}$ and $R_{f,t}^2$ are by construction to be highly correlated. One may orthogonalize the exchange rate changes to avoid multicollinearity. However, Sercu and Vandebroek (2006) claim that this method is defected, in terms of the drop of the estimator's standard error is misleading and the significance tests

The specification for the conditional variance of EGARCH model is:

$$\log(\sigma_{i,t}^2) = \omega_i + \alpha_i g(z_{i,t-1}) + \beta_i \log(\sigma_{i,t-1}^2) \quad (3)$$

$$g(z_{i,t}) = \theta_i z_{i,t} + \gamma_i (|z_{i,t}| - E[|z_{i,t}|]) \quad (4)$$

where the terms θ_i and γ_i are real constants. The terms $\sigma_{i,t}^2$ is the conditional variance, $u_{i,t}$ is the innovation at time *t*, and $z_{i,t}$ is the standardized innovation (i.e. $z_{i,t} = u_{i,t} / \sigma_{i,t}$). It is assumed that $z_{i,t}$ has Generalized Error Distribution (GED) with mean zero and variance (σ_t^2) and $u_{i,t}$ ~ N(0, $\sigma_{i,t}^2$). Substituting Equation (4) into Equation (3), the conditional variance of EGARCH model is given by

$$\log(\sigma_{i,t}^2) = \omega_i + \delta_i z_{i,t-1} + \varphi_i (|z_{i,t-1}| - E[|z_{i,t-1}|]) + \beta_i \log(\sigma_{i,t-1}^2) \quad (5)$$

where $\alpha_i \theta_i = \delta_i$ and $\alpha_i \gamma_i = \varphi_i$. An important advantage of EGARCH specification is that since the equation uses the log of $\sigma_{i,t}^2$, the variance itself will always be positive. Therefore, unlike the GARCH model, no restrictions are imposed on the parameters in Equation (5) to ensure that the conditional variances are non-negative. The coefficient for $z_{i,t-1}$, δ_i, is the sign effect whereby asymmetric effects are present in response to a shock when $\delta_i \neq 0$ and the positive coefficient of δ_i means the non-existence of asymmetric volatility (leverage effect), while a negative δ_i, which is also statistically significant, represents the presence of leverage effect. The leverage effect asserts that negative shocks to the conditional mean equation tend to have a larger effect on volatility than positive shocks. The usual interpretation of the leverage effect is that a lower stock price reduces the value of equity relative to corporate debt and a sharp decline in stock prices increases corporate leverage and therefore the risk of holding stocks.

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doubtful. One may capture the essence of exchange rate exposure non-linearity by testing the joint effect of $R_{f,t}$ and $R_{f,t}^2$ on the market returns.

The coefficient on $(|z_{i,t-1}| - E[|z_{i,t-1}|])$, φ_i, represents the size effect which indicates how much volatility increases irrespective of the direction of the shock. A coefficient value for $\varphi_i > 0$, implies that conditional volatility would tend to rise (fall) when the absolute value of the standardized residual is larger (smaller). The conditional variance specification of EGARCH model captures the degree of volatility persistence measured by β_i. The unconditional variance is finite if $\beta_i < 1$. If $\beta_i = 1$, then the unconditional variance does not exist and the conditional variance follows an integrated process of order one. A significant β_i suggests that the effects of an information shock persist for some time. The persistence of volatility may also be quantified by an examination of the half life (HL), which indicates the time period required for the shocks to reduce to one half of their original size. Following Koutmos, Lee, and Theodossiu (1994), the HL of the volatility persistence can be calculated as HL = $\ln(0.5)/\ln|\beta_i|$.

The z_t is assumed to follow the Generalized Error Distribution (GED) with probability density function

$$f(z_t) = \frac{v\exp(-(1/2)|z_t/\lambda|^v)}{2^{(1+v)/v}\Gamma(1/v)\lambda\sigma_t}, -\infty < z_t < \infty, 0 < v \le \infty$$

where $\Gamma(\bullet)$ is the gamma function, v is a tail-thickness parameter, and λ is defined as

$$\lambda = \left(\Gamma(1/v)/(2^{2/v}\Gamma(3/v))\right)^{1/2} \qquad (6)$$

Under the GARCH specification, the contribution of a single observation to the sample loglikelihood and its analytical scores are given as

$$L = \log(v) - (1/2)|z_t/\lambda|^v - \log\left(2^{(1+v)/v}\Gamma(1/v)\lambda\right) - (1/2)\log(\sigma_t^2) \qquad (7)$$

Substituting Equation (6) into Equation (7) and using the fact that $z_{i,t} = u_{i,t}/\sigma_{i,t}$, the simplified loglikelihood function is given by

$$L = (1/2)\log(v^2\Gamma(3/v)/4\Gamma(1/v)^3) - \left|u_t^2\Gamma(3/v)/\sigma_t^2\Gamma(1/v)\right|^{v/2} - (1/2)\log(\sigma_t^2)$$

4. Data sources and properties

We use daily data covering the period from May 29, 1996 to March 3, 2012 consisting of 4,122 observations for investigating the potential exchange rate exposure at the industry level in Indonesia. All data are collected from Thomson-Datastream. Sample periods cover the Asian financial crisis and the recent Global crisis. We employ country-specific market portfolio returns proxied by Jakarta stock exchange (JSX) composite price index, an overall stock index in Indonesia. Foreign exchange rates are quoted in terms of domestic currency per unit of US dollar.[3] Our choice of the exchange rates is supported by the fact that the US is one of the most important trading partners of the Indonesia market. In addition, using bilateral rates may facilitate the detection of exposures. Bartov and Bodnar (1994) and Koutmos and Martin (2003) emphasize that it may be more difficult to detect exposure to an exchange rate index, such as a trade-weighted rate or a weighted average of multiple bilateral exchange rate, if firms or industries have different relative linkages than those reflected in the index. Our dataset on the stock of industrial sectors focuses on the three-digit industry level. It comprises the daily industrial indexes of ten sectors in Indonesia. The industrial sectors include agriculture, basic industry, consumer goods, finance, manufacture, mining, miscellaneous industries, construction and property, trade and service, and utility infrastructure. We include all industries in our empirical work without limiting to industries that actively engage in international trade or have multinational operation. This empirical strategy allows the data to inform us about

[3] We use nominal exchange rate for a number of reasons. We deal with monetary assets in which its value of home currency is sensitive to changes in the nominal exchange rate. Unlike non-monetary assets varies with changes in the real rate. By using the nominal rates we assume that participants in financial markets cannot instantaneously observe the inflation rates (which is likely to be the case). In addition, it is well documented in the literature that a high correlation between the changes in nominal and real exchange rates exists.

which industries are more or less likely to be exposed. Figure 1 plots the returns (daily differences of natural logarithms) on the industrial sectors, the market index, and on the exchange rate. The figure clearly highlights that most of the returns have a huge variability during the Asian financial crisis 1997-1998 and relatively modest variability during the Global crisis 2007-2009.

[Figure 1 about here]

Table 1 presents the descriptive statistics of daily stock individual industry and market returns, and exchange rate returns. The table shows that all of series have positive average returns. The table implies that the changes in the exchange rates and the stock returns of financial sector exhibit the lowest and the highest dispersion (measured as the absolute value of the percentage coefficient of variation). The sample skewness coefficients indicate that all of the series are positively skewed, except for basic industries, mining, and market stock returns yield negative skewness. All returns are leptokurtic (peaked relative to the normal distribution and fat tails). Consequently, all series display strong evidence of non-normality as is also illustrated by the Jarque-Bera statistic.

[Table 1 about here]

Table 2 reports test results of serial correlation and ARCH effects for all series at 12 and 24 lags. The Ljung-Box Q-statistics at 12 and 24 lags are computed for both the series and squared series. The results of the Q tests show that there is significant autocorrelation in the residuals. This is seen as evidence for linear and nonlinear dependencies. Linear dependencies may be caused by some form of market inefficiency or market structure, and nonlinear dependencies may lead to autoregressive conditional heteroscedasticity. The ARCH tests also indicate that the null hypothesis of no autoregressive conditional heteroscedasticity is rejected at the 5% significance level.

[Table 2 about here]

5. Empirical results

The estimation results of EGARCH(1,1) model outlined in Equation (1) or (2) and (5) with the Generalized Error Distribution (GED) are shown in Table 3. Two specifications of exchange rate exposure, linear and nonlinear, are estimated. Table 3 reveals that two of the 10 industrial sectors for both linear and nonlinear exposure specification exhibit statistically significant leverage effects, making other industries with $\delta_i > 0$ better investment in anticipation of bad news for risk-averse investors. The leverage effects for the linear exposure model are exhibited in industrial sectors, i.e., consumer goods and construction and property. For non linear exposure model, manufacture, and construction and property industries show the same effect. The leverage effect seems more pronounced for manufacture industry. The stronger leverage effect might be due a greater concentration on commercial activities that have greater implications for the volatility of those industry's stock prices.

[Table 3 about here]

All industries exhibit a significant positive φ_i. This implies positive relation between conditional volatility and the absolute value of the standardized residual. The persistence in volatility is measured by the parameter β_i. The values of β_i are less than one for all industries, which is a necessary condition for the volatility process to be stable. The magnitudes of the β_i parameter are close to unity for all industries in both (non)linear specification showing evidence of a high level of persistence of volatility shocks over time which in turn might have been due to the use of daily data.

Using the HL (half-life) parameter, the volatility persistence can be expressed in day terms. Based on the HL results for linear exposure model, finance industry takes the longest to reduce the impact from its shocks by half (76.67 days) and agriculture sector takes the least time (18.38 days), which suggests that agriculture sector has the lowest level of volatility persistence out of all industries. For non linear exposure model, agriculture industry still has the shortest HL persistence in volatility (16.15 days), whilst finance and mining industries has the longest HL (76.69 days).

Table 3 reports the estimates of the exposure coefficients for the industries with linear and non linear exposure. The estimates of the linear exposure coefficients show that all of industries, except agriculture and mining industries, have a statistically significant exposure coefficient relative to the US dollar. Seven industries exhibit negative sign of the US dollar exposure with consumer goods sector yields the highest negative exposure (-1.17), only utility infrastructure industry have positive sign. The negative $\beta_{2,i}$ coefficient suggests that an appreciation of the US dollar against the rupiah has a negative impact on Indonesia's industrial sector returns. On the other hand, the positive $\beta_{2,i}$ coefficient obtained suggests that Indonesia industries experience a beneficial valuation effect when the US dollar appreciates. The negative exchange rate exposure dominates over positive exposure across industrial sectors which are consistent with Parsley and Popper (2006) and Muller and Verschoor (2007). This evidence indicates that most Indonesia industries experience gains (relative to the market) when their domestic currency appreciates the value of Indonesia industry share values benefits (is hurt) when the domestic currency appreciates (depreciates).

The effect of exchange rate to industry's stock returns may relate to the following channels: foreign-currency debt exposure, international trade exposure, and the depth of financial system (Chue and Cook 2008). Appreciation of US dollar may diminish firm's value in the presence of high foreign-currency dominated debt. As external debt in Indonesia markets is primarily denominated in foreign currencies, exchange rate devaluations (appreciations) lead to an increase (decrease) in foreign currency debt repayments, thereby causing negative exchange rate exposure. In the case of industries that actively engaged in international trade, exporters and domestic firms facing imported competition suffer under a large dollar appreciation against the rupiah. Operationally, this is consistent with a notion that Indonesia industries are net-importers, and/or have foreign operations for export to the world market. The appreciation US dollar that give a beneficial valuation effect to Indonesia industries would be the case if these industries are net-exporters, and/or if they set up foreign operations for the purpose of local sales. In terms of the depth of financial development channel, less-developed financial markets (especially with minor access to both financial and operational hedging strategies) should higher firms' cost of hedging and decrease their desire to hedge. On the other hand, the shorter range of available financial products may also decrease firms' desire to speculate in the foreign exchange market. The former effect tends to higher, while the latter effect tends to lower, the negative magnitude of a firm's exchange rate exposure.

The results from running nonlinear exchange rate exposure model for those industries reveals that four industrial sectors experience statistically significant nonlinear foreign exchange rate exposure based on *z*-statistic (individual effect). There are two industries that have negative and positive exposure coefficients, respectively, to the US dollar, that are statistically significant. Mining industry and trade and service sector have the highest positive (+0.47) and negative (-0.48) nonlinear exposure, respectively. The negative coefficient on the nonlinear effects would indicate that exporters are affected since as the US dollar appreciates stock returns will fall. However, given the convex relationship, the effect is reduced relative to the linear case. Recall that the linear coefficient was negative and suggested that exporters and domestic firms that have import competition suffered. The negative sign on the nonlinear term suggests that the loss they incur is offset as the exchange rate change gets larger. Many of not significant of individual effects may due to the existence of multicollinearity. When we test the joint effect of exchange rate changes and its squared values on the market returns using the Wald test based on *F*-statistic, we obtain all industries significantly exhibited non-linearity in terms of joint effect, except agriculture industry. This evidence shows us that together exchange rate changes and its squared values influence the market returns, but it is difficult to sort out the effect of each.

6. Exposure sensitivity and stability

Having gauged the foreign exchange exposure, we next examine its empirical link to structural change in the Indonesia industrial's exposure to exchange rate fluctuations during two major financial crisis, i.e. the Asian financial crisis 1997-1998 and the Global financial crisis 2007-2009; and exchange rate arrangements. We employ separately two estimations strategy to address the two issues.[4] First, in dealing with the first issue, we follow Muller and Verschoor (2007) to implement a subsample-based analysis in order to take account the importance of structural breaks owing to the Asian and Global crises. The sample is divided into five sub-periods: May 29, 1996 – May 30, 1997 (pre-crisis period); June 2, 1997 – December 31, 1999 (Asian crisis period and its aftermath); January 1, 1999 – July 31, 2007 (between crisis

[4] We focus only on linear exchange rate exposure specification for uncovering the relation of exchange rate exposure to exchange rate arrangement and the Asian and Global financial crisis. As noted in the previous section that nonlinear exposure is not decisive enough in terms of statistically significant of nonlinear exposure coefficients of individually effect.

period); August 1, 2007 – March 31, 2009 (Global crisis period and its aftermath); and April 1, 2009 – March 15, 2012 (post-crisis period).[5] We complement this analysis by introducing crises dummy variables both in mean and conditional variance equations of EGARCH(1,1) linear exchange rate exposure model specified in Equation (1) and (3), respectively. The dummy variable takes value of one to indicate the presence of the Asian and Global crises, and otherwise it equals zero. Next, we test joint hypothesis of the presence of the Asian and Global crises using the *F*-statistic based of Wald test.

Table 4 provides the estimated EGARCH(1,1) model with mean equation, as defined in Equation (1), for the five sub-sample periods. The table provides evidence in support of time-variation in exposure at the industrial level. The number of significant $\beta_{2,i}$ coefficients increases substantially from tranquility sub-sample periods (pre-crisis, between crisis, and post-crisis) to financial turmoil sub-periods (Asian financial crisis and Global crisis). It seems likely that the increase in exchange rate fluctuations during the period of Asian and Global financial crisis faced by Indonesia industries generally has led to a higher percentage of firms with significant exchange risk exposure. However, significant exchange exposure is higher during Asian financial crisis than Global crisis. Consistent with the results of Table 3, almost all Indonesia industries experience a predominantly negative foreign currency exposure effect. It should be noticed that the estimated β_i parameters are statistically significant and reveal a high degree of volatility persistence for all industries, except construction and property, utility infrastructure, and trade and service industries in the pre-crisis period. Based on the HL parameters, the longest HL persistence in volatility

[5] The crisis dating is based on official timelines for the Asian crisis dated by Baig and Goldfajn (1999) and Nagayasu (2001) and for the Global crisis by Federal Reserve Board of St. Louis (2009) and Filardo et al. (2010).

intensifies during the episode of Asian and Global crisis. Moreover, a number of industries that significantly have leverage effect escalate particularly in the onset of Asian crisis. Table 5 gives further evidence that joint hypothesis of the role of dummy variables of the crisis is not rejected for all industries. In addition, the dummy variables play a role in variance of exchange exposure model for all industries but not in the mean equation. Meaning that Asian and Global crisis intensify exchange risk exposure of all industries. Overall, the empirical results provided by Table 4 and 5 suggest that the Asian financial crisis in 1997-1998 has dramatically affected and altered the characteristics of Indonesia industries. This results also supports the fact that the spillovers from the Global financial turmoil originated from the United States are too strong to avoid by Indonesia, despite the fact that the region have an increased resilience relative to the Asian crisis.[6]

[Table 4 about here] [Table 5 about here]

Second, to link exchange rate arrangements and the foreign exchange exposure, we focus separately at exposure under the alternative arrangements that exist in our sample. Specifically, we look at the exposure under a managed float exchange rate regime, and we look at the exposure without one. To do so, we estimate EGARCH(1,1) model with the following mean equation:

$$R_{i,t} = \eta_{0,i} + \eta_{1,i} R_{m,t} + \eta_{m,i} D_{m,t} R_{f,t} + \eta_{n,i} D_{n,t} R_{f,t} + u_{i,t} \tag{8}$$

where $D_{m,t}$ equals one when the firm's home currency is managed float against another currency and equals zero otherwise, and $D_{n,t} = 1 - D_{m,t}$. The parameters $\eta_{m,i}$ and $\eta_{n,i}$ provide separate managed float and floating exposure estimates, respectively,

[6] Didier, Hevia, and Schmukler (2012), Gourinchas and Obstfeld (2012), and Frankel, Vegh, and Vuletin (2013) conclude that the strength of financial sector, ability to conduct countercyclical monetary and fiscal policies, and the role of flexible exchange rate regime adopted since the Asian crisis, are key reasons behinds relative resilience of Asia economies to the effects of the Global crisis.

for the industries that have had experience both with and without a managed float during the sample period. We test $H_0 : \eta_{m,i} = \eta_{n,i}$ in order to reveal whether information about the exchange rate regime is useful for asymmetric impacts of the exchange rate returns. The dates of the exchange rate managed float are identified by relying on the officially reported arrangement in which Indonesia announced to adopt floating exchange rate regime started from August 14, 1997.

Table 6 summarizes the findings from estimating Equation (8). As exhibited by $\eta_{m,i}$ and $\eta_{n,i}$, far more industries show statistically significant exposure to the US dollar with managed floating exchange rate regime than without one. Therefore, industries under dependent floating currencies may have to be accustomed to hedging, and hedging may be less costly if there is an access to both financial and operational hedging strategies. Most of industries exposed by the US dollar under managed floating regime yield negative exchange exposure. That is, in most of the industries, when the US dollar depreciates against the home currencies, returns go up, not down. One may argue that a dollar managed floating would discourage firms/industries into taking on too much dollar denominated debt, making them effectively more positive exposed by the foreign exchange rate movements. However, this effect does not seem to occur since there are so many of the industries are essentially negative exposed by the US dollar shown by Table 6. This evidence reveals that a managed floating exchange rate regime provides less beneficial environment for business in terms of providing stability and removing the need for expensive hedging.[7] It is interesting to note that only two industries (finance and utility infrastructure industries) shows

[7] Kamil (2012) reveals that freely floating exchange rate regime diminishes currency mismatches in corporate's balance sheet and transition from managed to a floating regime reinforces corporate to reduce portion of foreign currency dominated debt and use export revenues and foreign currency dominated asset to gradually eliminate unhedged foreign currency exposures and therefore offset risks of foreign currency dominated debt.

statistically significant evidence of leverage effect and all of industries exhibits relatively comparable magnitude of statistically significant persistence in volatility compared to the results without augmented exchange rate arrangements exhibited in Equation (1) and Table 3. The null hypothesis whether $\eta_{m,i}$ and $\eta_{n,i}$ are the same is rejected for more than a half of industries. This evidence reveals that asymmetric effects of exchange rate on those industries stock returns are significantly matter in different setting of exchange rate arrangement.

[Table 6 about here]

7. Conclusion

The purpose of this paper is to explore the level of exchange rate exposure on stock returns across Indonesia industrial sectors for the period from May 29, 1996 to March 3, 2012. The EGARCH model with (non)linear exposure specifications were used for the purpose of this study. In addition, the extension of the EGARCH model allow us to observe the stability and sensitivity of exchange rate exposure on industrial's value in different setting of exchange rate arrangements and sub-sample periods setting between tranquility and financial crisis.

Analyzing the (non)linear exchange rate exposure across Indonesia industrial's stock returns, we find that negative exchange rate exposure dominates over positive exposure across industrial sectors in the linear exposure setting. Nevertheless, there is no dominance sign in nonlinear specification. In both (non)linear models, only few industries exhibit statistically significant leverage effects, but all industries exhibit highly persistence in volatility. Using sub-periods analysis, we detect changes in the exchange rate exposure of Indonesia industrial's stock returns over time. In comparison to tranquility sub-periods (pre-crisis, between crisis, and post-Global crisis), immediately following the Asian and Global financial crises, Indonesia industries are mostly negatively exposed to exchange rate changes. This negative exposure is more frequent in the aftermath of Asian crisis than Global crisis. This result supports the evidence of relatively resilience of Asian emerging economies to Global crisis. We go on to investigate the exposure in different setting of exchange rate arrangements, managed float or floating regime. The results reveal that many industries experience statistically significant negative exposure to the US dollar with managed floating exchange rate regime than without one.

Finally, our empirical results lead to the following implications. The existence relationship between exchange exposure risks and firm value leads to even more crucial of the implications of risk management. Therefore, the exposure profile and behavior determine the choice of hedging tools in order to hedge properly. In the light of increased financial instability, it is important to account for reinforcing a sound flexible exchange rate regime, other than to maintain financial sector strength and sound countercyclical monetary and fiscal policy, to stabilize exchange rate and to manage crisis.

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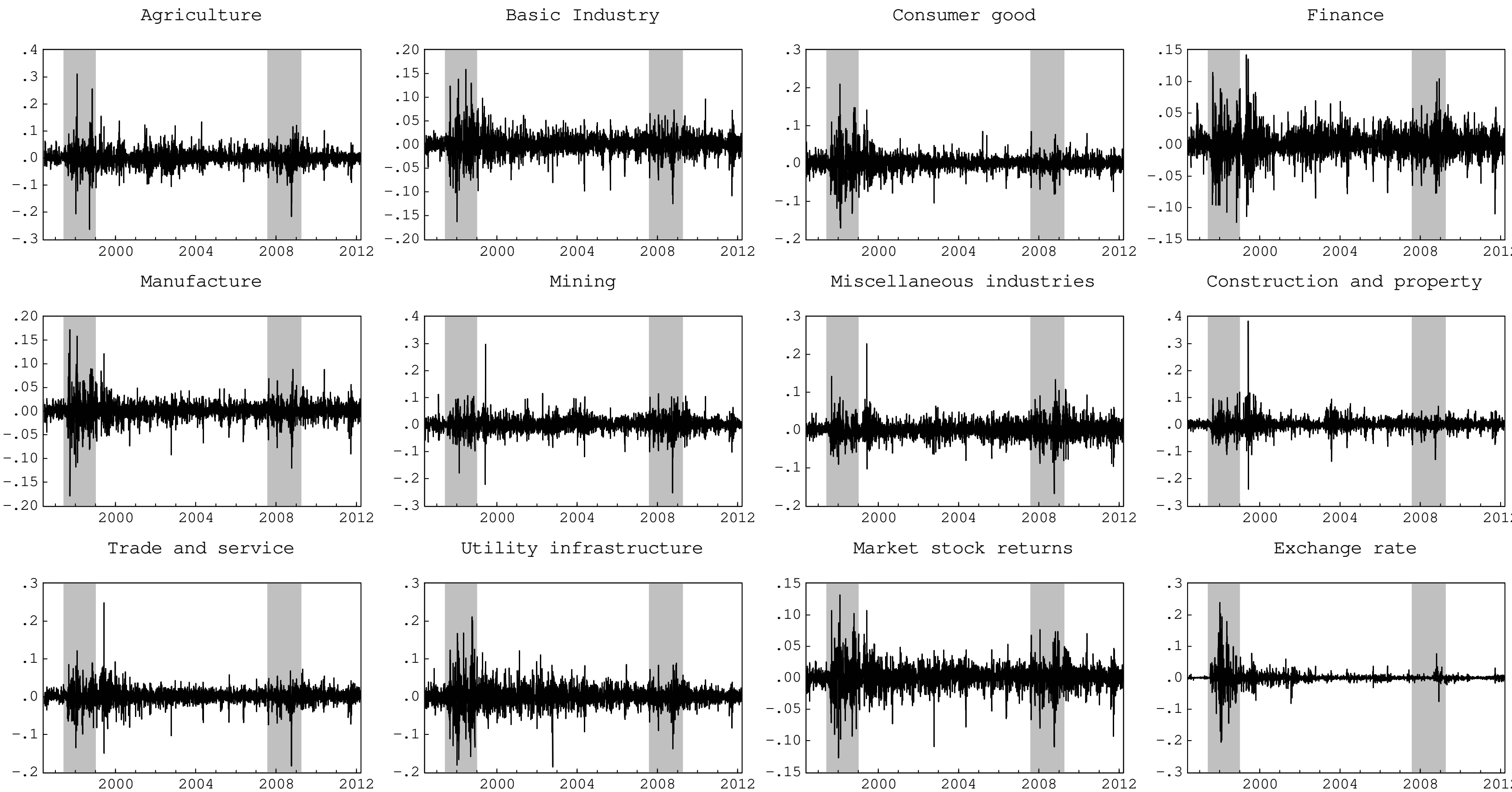
Figure 1. The underlying data



Note: Shading area shows the timing of the Asian financial crisis: June 2, 1997 to December 31, 1998; and the Global crisis: August 1, 2007 to March 31, 2009. The crisis dating is based on official timelines for the Asian crisis dated by Baig and Goldfajn (1999) and Nagayasu (2001) and for the Global crisis by Federal Reserve Board of St. Louis (2009) and Filardo et al. (2010).

Table 1. Descriptive statistics of daily stock returns and exchange rate returns: May 29, 1996 to March 3, 2012

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
Stock returns							
Agriculture	0.0005	0.31	-0.26	0.03	0.33	17.19	34644.53
Basic industries	0.0003	0.16	-0.16	0.02	-0.04	10.99	10956.25
Consumer goods	0.0006	0.21	-0.17	0.02	0.34	15.83	28329.28
Finance	0.0003	0.14	-0.12	0.02	0.05	9.00	6187.07
Manufacture	0.0005	0.17	-0.18	0.02	0.06	15.74	27877.00
Mining	0.0007	0.30	-0.25	0.02	-0.01	16.04	29194.52
Miscellaneous industries	0.0006	0.23	-0.17	0.02	0.45	11.81	13475.15
Construction and property	0.0002	0.38	-0.24	0.02	1.31	40.78	246298.80
Trade and service	0.0004	0.25	-0.18	0.02	0.10	19.55	47026.42
Utility infrastructure	0.0004	0.21	-0.19	0.02	0.20	12.81	16555.24
Market stock returns	0.0005	0.13	-0.13	0.02	-0.20	10.55	9811.35
Exchange rate returns	0.0003	0.24	-0.20	0.02	1.78	63.76	636186.20

Table 2: Serial correlation and ARCH effects tests for the changes in the exchange rate and the stock market returns: May 29, 1996 to March 3, 2012

	Ljung-Box Q-statistics				ARCH-LM test	
	Series		Squared series			
	12 lags	24 lags	12 lags	24 lags	12 lags	24 lags
Stock returns						
Agriculture	76.70	93.73	408.11	770.98	216.15	335.38
Basic industries	59.99	83.57	569.70	1064.90	291.78	397.66
Consumer goods	137.37	174.96	1995.00	3347.40	827.85	945.71
Finance	69.82	108.77	1230.80	1696.80	566.51	629.55
Manufacture	86.95	123.67	698.66	1327.90	483.67	627.24
Mining	45.27	74.36	501.80	638.30	394.29	428.78
Miscellaneous industries	54.96	76.24	507.61	815.64	316.99	386.98
Construction and property	55.14	98.14	588.58	799.08	470.67	535.24
Trade and service	90.13	138.50	394.95	573.59	284.83	329.14
Utility infrastructure	40.08	72.64	1325.00	2117.30	533.94	650.03
Market stock returns	121.34	165.38	784.29	1354.20	344.65	456.90
Exchange rate returns	205.44	265.58	3412.70	5736.90	1003.08	1365.76

Note: The Ljung-Box Q-statistic tests the null hypothesis of no autocorrelation; ARCH-LM (Lagrange multiplier) tests the null hypothesis of conditional homoscedasticity. All these test statistics are chi squared-distributed with the degrees of freedom equal to the number of lags. The critical values at the 5% level for these tests with 12 and 24 lags are 21.03 and 36.42, respectively.

Table 3. EGARCH(1,1) estimation with (non)linear exposure specifications

Linear exposure	Mean equation $\beta_{0,i}$	$\beta_{1,i}$	$\beta_{2,i}$	Variance equation ω_i	φ_i	δ_i	β_i	HL	$\bar{R}^2$	S.E.
Agriculture	-3.03×10^{-7}*	0.878*	-0.022	-0.475*	0.261*	0.011	0.963*	18.38	0.41	0.02
Basic industries	-8.06×10^{-5}	0.863*	-0.020**	-0.384*	0.188*	0.009*	0.972*	24.41	0.62	0.01
Consumer goods	-8.61×10^{-5}	0.854*	-1.170**	-0.205*	0.149*	-0.005*	0.989*	62.67	0.62	0.01
Finance	-4.20×10^{-5}	0.961*	-0.040*	-0.189*	0.158*	1.364	0.991*	76.67	0.54	0.01
Manufacture	-7.81×10^{-6}	0.920*	-0.013**	-0.219*	0.142*	0.006*	0.988*	57.41	0.80	0.01
Mining	-2.97×10^{-6}	0.996*	0.005	-0.179*	0.132*	0.010	0.989*	62.67	0.44	0.02
Miscellaneous industries	-1.26×10^{-5}	0.791*	-0.074*	-0.209*	0.140*	0.022**	0.987*	52.97	0.52	0.01
Construction and property	-1.30×10^{-5}*	0.652*	-0.062*	-0.373*	0.251*	-0.012*	0.977*	29.79	0.36	0.02
Trade and service	-2.32×10^{-7}*	0.769*	-0.109*	-0.263*	0.147*	-0.014	0.983*	40.43	0.60	0.01
Utility infrastructure	-2.07×10^{-5}*	1.456*	0.146*	-0.234*	0.156*	0.012	0.986*	49.16	0.68	0.01

Nonlinear exposure	$\phi_{0,i}$	$\phi_{1,i}$	$\phi_{2,i}$	$\phi_{3,i}$	ω_i	φ_i	δ_i	β_i	HL	$\bar{R}^2$	S.E.	F-statistic
Agriculture	-3.74×10^{-8}*	0.877*	0.011	-0.284	-0.518*	0.262*	0.010	0.958*	16.15	0.41	0.02	0.24
Basic industries	-7.81×10^{-5}	0.863*	-0.024**	-0.144	-0.380*	0.187*	-0.007	0.973*	25.32	0.62	0.01	7.21*
Consumer goods	-9.50×10^{-5}	0.851*	-0.015	-0.169	-0.204*	0.149*	-0.006	0.989*	62.67	0.61	0.01	13.00*
Finance	-4.15×10^{-5}	0.960*	-0.041*	-0.019	-0.189*	0.159*	0.014*	0.991*	76.69	0.54	0.01	18.81*
Manufacture	-9.99×10^{-6}	0.921*	-0.019*	0.060	-0.217*	0.141*	-0.050*	0.988*	57.41	0.80	0.01	19.41*
Mining	-3.38×10^{-7}*	0.995*	0.013	0.469*	-0.158*	0.126*	0.009	0.991*	76.69	0.44	0.02	8.54*
Miscellaneous industries	-1.61×10^{-5}	0.792*	-0.077*	0.148*	-0.233*	0.148*	0.022**	0.986*	49.16	0.52	0.01	4.52*
Construction and property	-1.72×10^{-5}	0.651*	-0.078*	-0.261*	-0.356*	0.243*	-0.013*	0.978*	31.16	0.36	0.02	18.30*
Trade and service	-1.62×10^{-8}	0.771*	-0.094*	-0.477*	-0.286*	0.152*	-0.012	0.980*	34.31	0.60	0.01	68.39*
Utility infrastructure	-2.08×10^{-5}	1.108*	0.145*	-0.022	-0.239*	0.156*	0.011*	0.986*	49.16	0.68	0.01	77.85*

Note: The mark * and ** indicate that the parameter is statistically significant at 5% and 10% level, respectively, based on z-statistic (individual effect) and F-statistic (jointly effect). The joint null hypothesis is $H_0 : \phi_{2,i} = \phi_{3,i} = 0$ with critical value of F-test at 5% level is 3.84. S.E. denotes the standard error of the regression. HL is half-life in days.

Table 4. EGARCH(1,1) estimation across sub-periods

	Mean equation			Variance equation						
	$\beta_{0,i}$	$\beta_{1,i}$	$\beta_{2,i}$	ω_i	φ_i	δ_i	β_i	HL	$\bar{R}^2$	S.E.
Pre-crisis										
Agriculture	-3.82×10^{-6}	0.442*	-0.118	-0.691	0.291*	-0.127	0.929*	9.41	0.15	0.01
Basic industries	-1.05×10^{-3}*	0.719*	-0.422**	-3.319	0.104	-0.131	0.692*	1.88	0.46	0.01
Consumer goods	-5.74×10^{-4}	1.845*	-0.207	-0.951**	0.085	-0.021	0.908*	7.18	0.61	0.01
Finance	3.92×10^{-5}	0.840*	-0.402*	-2.137	0.336**	-0.064	0.800**	3.11	0.43	0.01
Manufacture	-4.23×10^{-4}**	1.015*	-0.247**	-4.109	0.268**	-0.024	0.642**	1.56	0.75	0.01
Mining	-7.52×10^{-9}	0.321*	-0.109	-4.177**	0.268*	-0.011	0.550*	1.16	0.66	0.02
Miscellaneous industries	3.03×10^{-5}	0.565*	-0.143	-4.048	0.566	0.145	0.587*	1.30	0.27	0.01
Construction and property	2.92×10^{-4}	0.486*	-0.417	-11.359*	-0.132	0.196	-0.135	0.35	0.29	0.01
Trade and service	2.21×10^{-4}	0.603*	-0.846*	-7.592	0.106	0.102	0.239	0.48	0.40	0.01
Utility infrastructure	6.35×10^{-5}	1.261*	0.572*	-8.999*	0.298*	-0.053	0.059	0.24	0.57	0.01
Asian Crisis										
Agriculture	1.77×10^{-3}*	0.914*	0.026*	-0.426*	0.257*	0.001	0.960*	16.98	0.45	0.03
Basic industries	1.14×10^{-3}*	0.866*	-0.073*	-0.660*	0.277*	-0.020*	0.943*	11.81	0.63	0.02
Consumer goods	-4.78×10^{-5}	1.132*	-0.034*	-0.627*	0.328*	0.006	0.949*	13.24	0.78	0.02
Finance	1.31×10^{-3}*	0.531*	-0.143*	-0.508*	0.172*	-0.124**	0.952*	14.09	0.41	0.02
Manufacture	2.87×10^{-4}	0.954*	-0.030*	-2.280*	0.490*	-0.074*	0.731*	2.21	0.72	0.02
Mining	2.29×10^{-4}	0.712*	0.076*	-0.424*	0.181*	0.040*	0.961*	17.42	0.44	0.02
Miscellaneous industries	-5.65×10^{-4}	0.520*	-0.087*	-4.255*	0.423*	-0.117*	0.520*	1.06	0.50	0.02
Construction and property	-1.25×10^{-3}*	0.584*	-0.067*	-0.541*	0.233*	-0.088*	0.952*	14.09	0.38	0.02
Trade and service	9.15×10^{-4}	0.769*	-0.096*	-0.551*	-0.229*	-0.079*	0.955*	15.05	0.65	0.02
Utility infrastructure	6.93×10^{-6}	1.355*	0.181*	-0.779*	0.313*	-0.027*	0.927*	9.14	0.73	0.02
Between-crisis										
Agriculture	-1.37×10^{-4}	0.844*	-0.041	-0.908*	0.271*	0.024	0.909*	7.26	0.31	0.02
Basic industries	-9.57×10^{-7}	0.846*	-0.883	-3.836*	0.387*	-0.035	0.719*	2.10	0.57	0.01
Consumer goods	-7.57×10^{-5}	0.867*	-0.010	-3.147*	0.082*	0.002	0.919*	8.21	0.67	0.01
Finance	-3.32×10^{-5}	0.952*	-0.029	-0.162*	0.121*	0.001	0.942*	11.60	0.54	0.01
Manufacture	-8.35×10^{-5}	0.900*	-0.015	-0.412*	0.107*	0.007	0.926*	9.02	0.86	0.01
Mining	-6.70×10^{-7}	0.843*	-0.026	-0.243*	0.119*	-0.004	0.928*	9.28	0.30	0.02
Miscellaneous industries	-8.12×10^{-5}	0.757*	-0.109*	-0.223*	0.118*	0.035*	0.914*	7.71	0.52	0.01
Construction and property	-7.69×10^{-7}	0.603*	-0.087*	-0.334*	0.206*	0.043*	0.940*	11.20	0.30	0.02
Trade and service	1.38×10^{-7}	0.741*	-0.118*	-0.345*	0.159*	-0.014*	0.951*	13.79	0.52	0.01
Utility infrastructure	-1.57×10^{-4}	1.252*	-0.121*	-0.253*	0.123*	-0.007*	0.917*	8.00	0.69	0.01

Note: The mark * and ** indicate that the parameter is statistically significant at 5% and 10% level, respectively, based on z-statistic. S.E. denotes the standard error of the regression. HL is half-life in days. Dating of pre-Asian financial crisis: May 29, 1996 to May 30, 1997; the Asian financial crisis: June 2, 1997 to December 31, 1998; between crisis: January 1, 1999 to June 31, 2007; the Global crisis: August 1, 2007 to March 31, 2009; and post-Global crisis: January 1, 2010 to March 15, 2012. The crisis dating is based on official timelines for the Asian crisis dated by Baig and Goldfajn (1999) and Nagayasu (2001) and for the Global crisis by Federal Reserve Board of St. Louis (2009) and Filardo et al. (2010).

Table 4. EGARCH(1,1) estimation across sub-periods (continued)

		Mean equation			Variance equation					
	$\beta_{0,i}$	$\beta_{1,i}$	$\beta_{2,i}$	ω_i	φ_i	δ_i	β_i	HL	$\bar{R}^2$	S.E.
Global-crisis										
Agriculture	-2.32×10^{-6}	1.084*	0.039	-0.386	0.135*	-0.004	-0.963*	18.38	0.67	0.02
Basic industries	-1.96×10^{-4}	0.846*	-0.144*	-6.936*	0.587*	0.234*	0.821*	3.51	0.69	0.01
Consumer goods	-4.23×10^{-7}	1.531*	-0.071*	-1.094*	0.307*	0.021	0.901*	6.65	0.57	0.01
Finance	-3.12×10^{-4}	0.929*	-0.167*	-0.372*	0.131*	0.018	0.969*	22.01	0.77	0.01
Manufacture	-1.28×10^{-5}	1.854*	0.076	-0.909*	0.237*	0.013	0.923*	8.65	0.81	0.01
Mining	4.70×10^{-7}	1.409*	0.207*	-2.103	0.296*	0.017	0.766*	2.60	0.75	0.02
Miscellaneous industries	3.22×10^{-7}	1.080*	-0.193*	-3.021*	0.426*	0.048	0.658*	1.66	0.60	0.02
Construction and property	-3.71×10^{-4}	0.659*	-0.102*	-1.285*	0.261*	0.063	0.883*	5.57	0.64	0.01
Trade and service	-1.66×10^{-6}	0.786*	-0.022*	-0.323*	0.072*	-0.057	0.971*	23.55	0.71	0.01
Utility infrastructure	-8.03×10^{-7}	0.958*	-0.186*	-0.807	0.194*	0.015	0.925*	8.89	0.76	0.01
Post-Global crisis										
Agriculture	-1.67×10^{-4}	0.881*	-0.194*	-0.594*	0.217*	-0.011	0.852*	4.33	0.60	0.01
Basic industries	3.04×10^{-7}	0.987*	-0.171	-0.296*	0.104*	0.008	0.927*	9.14	0.76	0.01
Consumer goods	1.26×10^{-4}	0.783*	0.227*	-0.434*	0.162*	0.006	0.867*	4.86	0.60	0.01
Finance	-1.29×10^{-4}	1.095*	0.134*	-0.168*	0.005*	-0.003	0.884*	5.62	0.85	0.01
Manufacture	2.51×10^{-4}	0.982*	-0.004	-1.140**	0.069*	0.014	0.892*	6.06	0.88	0.01
Mining	-6.92×10^{-4}	1.161*	-0.340*	-0.177*	0.110*	0.007	0.891*	6.01	0.76	0.01
Miscellaneous industries	-3.19×10^{-4}	1.141*	-0.130	-0.053*	-0.016	0.008	0.546*	1.15	0.67	0.01
Construction and property	-1.26×10^{-4}	0.844*	-0.075*	-4.561*	-0.393*	0.047	0.951*	13.80	0.65	0.01
Trade and service	-2.60×10^{-4}	0.807*	-0.164*	-0.054*	0.033*	-0.005	0.937*	10.65	0.70	0.01
Utility infrastructure	-5.44×10^{-4}	0.843*	-0.317	-0.403*	-0.105*	-0.041*	0.942*	11.60	0.69	0.01

Note: The mark * and ** indicate that the parameter is statistically significant at 5% and 10% level, respectively, based on z-statistic. S.E. denotes the standard error of the regression. HL is half-life in days. Dating of pre-Asian financial crisis: May 29, 1996 to May 30, 1997; the Asian financial crisis: June 2, 1997 to December 31, 1998; between crisis: January 1, 1999 to June 31, 2007; the Global crisis: August 1, 2007 to March 31, 2009; and post-Global crisis: April 1, 2009 to March 15, 2012. The crisis dating is based on official timelines for the Asian crisis dated by Baig and Goldfajn (1999) and Nagayasu (2001) and for the Global crisis by Federal Reserve Board of St. Louis (2009) and Filardo et al. (2010).

Table 5. EGARCH(1,1) estimation with dummy variables for crisis

	Mean equation				
	$\beta_{0,i}$	$\beta_{1,i}$	$\beta_{2,i}$	$\beta_{3,i}$	$\beta_{4,i}$
Agriculture	-2.94×10^{-4}	0.918*	-0.019	3.16×10^{-3}	8.63×10^{-4}
Basic industries	-3.34×10^{-4}*	0.868*	0.040*	9.44×10^{-4}	-6.48×10^{-5}
Consumer goods	-1.78×10^{-4}**	0.849*	-0.027*	3.67×10^{-4}	1.00×10^{-4}
Finance	-6.09×10^{-5}	0.959*	-0.062*	-2.05×10^{-4}	-4.66×10^{-5}
Manufacture	-5.85×10^{-5}	0.916*	-0.031*	0.67×10^{-4}	8.98×10^{-5}
Mining	-2.08×10^{-4}	1.005*	0.020	1.67×10^{-4}	6.24×10^{-4}
Miscellaneous industries	5.63×10^{-5}	0.816*	-0.078*	4.62×10^{-4}	1.91×10^{-4}
Construction and property	3.21×10^{-5}	0.682*	-0.097*	9.57×10^{-4}	1.23×10^{-3}*
Trade and service	1.43×10^{-4}	0.782*	-0.112*	-9.19×10^{-4}	-7.21×10^{-4}
Utility infrastructure	-3.71×10^{-4}	1.118*	0.162*	4.31×10^{-4}	7.32×10^{-5}

	Variance equation									
	ω_i	φ_i	δ_i	β_i	$\alpha_{1,i}$	$\alpha_{2,i}$	HL	$\bar{R}^2$	S.E.	F-statistic
Agriculture	-0.312*	0.172*	0.008	0.977*	0.032*	0.016*	29.79	0.41	0.02	6.68*
Basic industries	-1.245*	0.261*	-0.016	0.887*	0.143*	0.047*	5.78	0.63	0.01	5.43*
Consumer goods	-0.344*	0.134*	0.008	0.974*	0.054*	0.019*	26.31	0.62	0.01	7.92*
Finance	-0.231*	0.149*	0.011	0.987*	0.030*	0.010*	52.97	0.55	0.01	4.40*
Manufacture	-0.501*	0.131*	0.016*	0.962*	0.084*	0.041*	17.89	0.80	0.01	8.15*
Mining	-0.246*	0.151*	0.006	0.984*	0.017*	0.013*	42.97	0.45	0.02	4.52*
Miscellaneous industries	-0.232*	0.111*	0.031*	0.983*	0.018*	0.023*	40.43	0.56	0.01	4.99*
Construction and property	-0.369*	0.226*	0.017*	0.977*	0.037*	0.006*	29.79	0.37	0.01	8.29*
Trade and service	-0.202*	0.116*	0.003*	0.987*	0.016*	0.007*	52.97	0.60	0.01	5.65*
Utility infrastructure	-0.326*	0.140*	0.017*	0.975*	0.046*	0.009*	27.38	0.68	0.01	3.94*

Note: The mark * and ** indicate that the parameter is statistically significant at 5% and 10% level, respectively, based on z-statistic (individual effect) and F-statistic (jointly effect). The joint null hypothesis is $H_0 : \alpha_{1,i} = \alpha_{2,i} = \beta_{3,i} = \beta_{4,i} = 0$ stated that there is no effects of all dummy variables of crisis. The critical value of F-test at 5% level is 3.84. S.E. denotes the standard error of the regression. HL is half-life in days.

Table 6. Foreign exchange exposure and exchange rate arrangements

	Mean equation				
	$\eta_{0,i}$	$\eta_{1,i}$	$\eta_{m,i}$	$\eta_{n,i}$	F-statistic
Agriculture	-1.84×10^{-8}	0.875*	-0.033*	0.173*	2.64**
Basic industries	-8.83×10^{-5}	0.863*	-0.019*	-0.087	0.45
Consumer goods	-9.72×10^{-5}	0.851*	-0.017**	0.154**	4.26*
Finance	-4.34×10^{-5}	0.961*	-0.041*	0.037	1.24
Manufacture	-5.49×10^{-6}	0.919*	-0.014*	0.072**	3.91*
Mining	-1.33×10^{-7}	0.996*	0.002	0.111*	0.94
Miscellaneous industries	-1.26×10^{-5}	0.791*	-0.077*	0.062	1.93
Construction and property	-1.26×10^{-5}	0.652*	-0.065*	0.046	3.13**
Trade and service	-8.40×10^{-8}	0.769*	-0.110*	0.015*	2.68**
Utility infrastructure	-2.20×10^{-4}**	1.108*	0.141*	0.406*	4.32*
	Variance equation				
	ω_i	φ_i	δ_i	β_i	$\bar{R}^2$
Agriculture	-0.769*	0.315*	0.008	0.982*	0.42
Basic industries	-0.387*	0.189*	-0.009	0.972*	0.62
Consumer goods	-0.205*	0.149*	-0.006	0.989*	0.63
Finance	-0.189*	0.159*	-0.014**	0.992*	0.54
Manufacture	-0.220*	0.143*	0.004	0.988*	0.80
Mining	-0.172*	0.127*	0.010	0.991*	0.45
Miscellaneous industries	-0.211*	0.141*	0.022**	0.987*	0.51
Construction and property	-0.378*	0.253*	0.011	0.977*	0.36
Trade and service	-0.269*	0.148*	0.014**	0.982*	0.59
Utility infrastructure	-0.240*	0.156*	-0.010*	0.986*	0.68

Note: The mark * and ** indicate that the parameter is statistically significant at 5% and 10% level, respectively, based on z-statistic (individual effect) and F-statistic (jointly effect). The joint null hypothesis is $H_0 : \eta_{m,i} = \eta_{n,i}$.