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Export Promotion through Exchange Rate Policy: Exchange Rate Depreciation or Stabilization?

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Abstract

Exchange rate movements affect exports in two ways – its depreciation and its variability (risk). A depreciation raises exports, but the associated exchange rate risk could offset that positive effect. The present paper investigates the net effect for eight Asian countries using a dynamic conditional correlation bivariate GARCH-M model that simultaneously estimates time varying correlation and exchange rate risk. Depreciation encourages exports, as expected, for most countries, but its contribution to export growth is weak. Exchange rate risk contributes to export growth in Malaysia and the Philippines, leading to positive net effects. Exchange rate risk generates a negative effect for six of the countries, resulting in a negative net effect in Indonesia, Japan, Singapore, Taiwan and a zero net effect in Korea and Thailand. Since the negative effect of exchange rate risk may offset, or even dominate, positive contributions from depreciation, policy makers need to reduce exchange rate fluctuation along with and possibly before efforts to depreciate the currency.

Journal of Economic Literature Classification: F14, F31

Keywords: exports, exchange rate policy, net effect, DCC bivariate GARCH-M model

Export Promotion through Exchange Rate Policy:

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1. Introduction

Exchange rate movements affect exports in two ways -- its depreciation and its volatility (risk). The two effects have received considerable attention, since the collapse of fixed exchange rates in the early 1970s. But, no research considers the net (total) effect on exports of the two potentially offsetting effects. This paper investigates the net effect for eight Asian countries with Engle's (2002) dynamic conditional correlation (DCC) bivariate GARCH-M model that simultaneously estimates time varying correlation and exchange rate risk. The net effect relates to the goal of a foreign exchange intervention.

Depreciation lowers the foreign currency price of exports, and probably increases the quantity of exports and export revenue in domestic currency. Conditions may exist, however, where export revenue falls. Highly inelastic foreign import demand leads to falling export revenue. Ambiguity also arises if export production incorporates high import content, since the domestic cost or price of exports rises with depreciation. During periods of appreciation, exporters might price to market, lowering their domestic currency price to maintain export market share.

Theory and empirical evidence exhibits ambiguity as to the effect of the exchange rate on exports and export revenue. Junz and Rhomberg (1973) and Wilson and Takacs (1979) find that devaluation increases exports for developed countries with fixed exchange rates, and Bahmani-Oskooee and Kara (2003) find similar results with flexible rates. In contrast, Athukorala (1991), Athukorala and Menon (1994), Abeysinghe and Yeok (1998), and Wilson and Tat (2001) find that appreciation does not lower exports in some Asian countries.

With fluctuations in the exchange rate, exchange rate risk could theoretically lower exports due to profit risk as developed by Ethier (1973). De Grauwe (1988) suggests, however, that exporters might increase volume to offset potential revenue loss. Broll and Eckwert (1999) note that the value of the real option to export might increase with risk depending on the risk aversion of exporters. Klaassen (2004) argues that the effect of exchange rate risk is an empirical issue.

The empirical evidence on the effects of exchange rate risk is also mixed. Pozo (1992) uncovers a negative effect on U.K. exports to the US. Chowdhury (1993) and Arize (1995, 1996, 1997) find negative effects on US, European, and G7 exports. Weliwita, Ekanayake, and Tsujii (1999) report negative effects for Sri Lanka's exports to six developed countries. Fang, Lai, and Thompson (2004) discover negative effects for Japan, Singapore, and Taiwan. Arize, Osang, and Slottje (2000) and Arize, Malindretos, and Kasibhatla (2003) identify negative effects on LDC exports using a moving sample standard deviation model. In contrast, Asseery and Peel (1991) detect positive effects for Australia, Japan, Germany, the U.S. and a negative effect for the UK; Kroner and Lastrapes (1993) uncover positive effects for France, Germany, and Japan, but negative effects for the U.K. and the U.S.; McKenzie and Brooks (1997) uncover positive effects for Germany and the US; Klaassen (2004) discerns no effect on monthly bilateral U.S. exports to the other G7 countries.

These contrary results motivate the present paper, the first to examine the net effect of depreciation and exchange rate risk using the DCC bivariate GARCH-M model. Even if exchange rate depreciation positively affects exports, the associated exchange rate risk effect could offset the positive effect, leading to a negative net effect. Our empirical results address the goal of a foreign exchange intervention. That is, does intervention stimulate exports by depreciating the currency or by reducing exchange rate fluctuations. The conventional view argues that exchange rate depreciation stimulates exports. The more recent view argues that exchange rate risk hampers exports, providing the rationale for foreign exchange policies to reduce exchange rate fluctuations. Both arguments appear in the present paper. The policy issue involves examining the net effect. Assuming a positive correlation between exchange rate depreciation and exchange rate risk, a positive net effect supports a depreciation policy, while a negative net effect supports reducing exchange rate fluctuation.

To measure the net effect, we employ monthly time-series data on bilateral exports from eight Asian countries, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand, to the U.S. from 1979 to 2003. Strong reasons exist to examine Asian bilateral exports. First, Klaassen (2004) shows that exchange rate risk exhibits too little variability for developed countries to elicit an effect on exports, and proposes studying the exchange rate risk effect using data on developing countries. Fang, Lai, and Thompson (2004) provide evidence that some Asian countries experience more volatile exchange rates than certain EMS currencies. Second, Table 1 shows that the U.S. accounts for a substantial portion of exports from these Asian countries. The average U.S. share of total exports over our sample period ranges from 16 percent for Indonesia to 34 percent for Philippines. The bilateral approach avoids asymmetric responses across exchange rates in highly aggregated data, bringing more focus to the net effect of the exchange rate movement. Exports in these countries respond differently to exchange rate depreciation and risk.

Our use of the bivariate GARCH-M model differs from previous techniques in several ways. Bahmani-Oskooee and Kara (2003) and Wilson and Tat (2001) use cointegration to examine the effect of depreciation on exports and the trade balance. Arize, Osang, and Slottje (2000) show that this technique overestimates the effect of depreciation when a negative exchange rate risk effect exists. The present paper simultaneously estimates the effects of exchange rate depreciation and risk. Moving standard deviations of the exchange rate maintain the hypothesis of homoskedasticity while serving as a proxy for heteroskedastic risk in Chowdhury (1993) and Arize, Osang, and Slottje (2000). Our present method improves on those models examining the relationship between means and variances, as in Engle, Lilien, and Robins (1987) and Bollerslev, Chou, and Kroner (1992). Exchange rate risk is conditional and time varying, as shown by Hodrick and Srivastava (1984). GARCH methods allow time dependence as in Pozo (1992), McKenzie and Brooks (1997), and Weliwita, Ekanayake, and Tsujii (1999), but their two-step procedure may produce inefficient estimates as noted in Klaassen (2004). The present paper uses simultaneous bivariate estimation. The effects of exchange rate changes depend on the export adjustment speed. Time structure is an important characteristic of international trade as argued by Goldstein and Khan (1985) and Klaassen (2004). Dynamic features of our present distributed lag export model and the DCC estimator distinguish it from one-period adjustment multivariate GARCH-M models assuming a constant correlation between the exchange rate and exports over time such as Kroner and Lastrapes (1993) and Fang, Lai, and Thompson (2004). The present DCC estimator improves estimation efficiency over the constant correlation models as noted in Engle (2002), Tse and Tsui (2002), and Tsay(2002).

The rest of this paper unfolds as follows. Section 2 specifies the elements of the DCC bivariate GARCH-M model to examine the net effect of exchange rate depreciation and its risk on exports. Section 3 describes the data, presents empirical results, and derives the net effects. Section 4 analyzes quantitatively the net effects of exchange rate changes. Section 5 summarizes the empirical findings and provides concluding remarks.

2. The DCC Bivariate GARCH-M Model and the Net Effect

The nonstructural reduced-form export equation of Rose (1991), Pozo (1992), and Klaassen (2004) from the two-country imperfect substitutes model provides the building block of our empirical analysis, which examines the net effect of exchange rate movement on Asian bilateral exports to the United States. Real export revenue (x) depends on real foreign income (y), the real exchange rate (q), and real exchange rate risk (h_q). Real export revenue equals nominal export revenue in domestic currency deflated by the consumer price index (CPI). Our maintained hypotheses include the following. Foreign income, the U.S. industrial production index, should exhibit a positive effect on real export revenue. The real exchange rate, the domestic currency price of the U.S. dollar times the ratio of U.S. to domestic CPIs, should also exhibit a positive effect on real export revenue. The real exchange rate eliminates potential ambiguity from adjusting price levels. The effect of exchange rate risk proves uncertain theoretically and empirically.

To capture short-run adjustments of the variables, the following eclectic dynamic conditional correlation bivariate GARCH-M model provides the framework for investigating the net exchange rate effect.

$$\Delta lx_t = a_0 + \sum_{i=1}^{2} a_i \Delta lx_{t-i} + \sum_{i=0}^{2} b_i \Delta ly_{t-i} + \sum_{i=0}^{2} c_i \Delta lq_{t-i} + \sum_{i=0}^{2} d_i h_{q,t-i}^{1/2} + \varepsilon_{x,t} \tag{1}$$

$$\Delta lq_t = s_0 + s_1 \varepsilon_{t-1} + \sum_{i=1}^{2} \gamma_i MD_i + \varepsilon_{q,t} \tag{2}$$

$$\varepsilon_t \mid \Psi_{t-1} \sim Student - t(v) \tag{3}$$

$$h_{x,t} = \alpha_0 + \alpha_1 \varepsilon_{x,t-1}^2 + \alpha_2 h_{x,t-1} \tag{4}$$

$$h_{q,t} = \beta_0 + \beta_1 \varepsilon_{q,t-1}^2 + \beta_2 h_{q,t-1} + \sum_{i}^{2} \lambda_i VD_i \tag{5}$$

$$D_t^2 = \begin{bmatrix} h_{q,t} & 0 \\ 0 & h_{x,t} \end{bmatrix} \tag{6}$$

$$\eta_t = D_t^{-1} \varepsilon_t \tag{7}$$

$$Q_t = \bar{\rho}_{xq}(1 - \theta_1 - \theta_2) + \theta_1 \eta_{t-1}\eta'_{t-1} + \theta_2 Q_{t-1} \tag{8}$$

$$R_t = diag\{Q_t\}^{-1} Q_t \, diag\{Q_t\}^{-1} \tag{9}$$

where $\Delta lx_t \equiv 100\times(\ln x_t - \ln x_{t-1})$, $\Delta ly_t \equiv 100\times(\ln y_t - \ln y_{t-1})$ and $\Delta lq_t \equiv 100\times(\ln q_t - \ln q_{t-1})$. The lag structure of the mean equation of Δlx_t is selected by AIC. The MA component picks up serial dependence of Δlq_t. And, thus, $\varepsilon_{x,t}$ and $\varepsilon_{q,t}$ are white noise. We assume that the residual matrix, ε_t, conditional on the information set Ψ_{t-1} available at time $t-1$ follows a bivariate Student-t distribution with degrees of freedom v. Our sample includes the Asian financial crisis in 1997, which exhibited dramatic movements in exchange rates in most Asian countries. The dummy variables MD_i and VD_i capture extraordinary exchange rate changes in the mean and the variance equations of Δlq_t. Conditional variances are $h_{x,t}$ and $h_{q,t}$ measured by the GARCH(1,1) process, respectively, for exports and the exchange rate. The presence of the square root of $h_{q,t}$, $h_{q,t}^{1/2}$, in the mean equation of Δlx_t makes the system a bivariate GARCH-M model. Conditions, α_i >0, β_i >0, λ_i >0, $\alpha_1+\alpha_2<1$ and $\beta_1+\beta_2<1$, ensure positive and stable conditional variances of $\varepsilon_{x,t}$ and $\varepsilon_{q,t}$. If α_2 or β_2 equal zero, the process reduces to ARCH(1). The matrix D_t^2 contains $h_{x,t}$ and $h_{q,t}$ along the principle diagonal and η_t is the standardized residual matrix. Q_t is the covariance matrix of η_t, following a GARCH(1,1) process. $\bar{\rho}_{xq}$ is the unconditional correlation of exports and the exchange rates over the sample period. θ_1 and θ_2 must exceed zero and their sum ($\theta_1+\theta_2$) must fall below one to ensure Q_t is positively defined and mean-reverting. R_t is the conditional correlation matrix composed of time varying correlations. Equations (1) to (9) constitute the dynamic conditional correlation (DCC) estimator proposed by Engle (2002). When θ_1 and θ_2 both equal zero, the model reduces to the Bollerslev (1990) constant conditional coefficient estimator.

Let Φ denote the parameters in D_t^2 [that includes all parameters in equations (1) to (5)] and Θ the parameters in R_t (that includes θ_1 and θ_2), then the log likelihood function of the bivariate t-distribution in the maximization procedure is given as follows:

$$L(\Phi,\Theta)=\sum_{t=1}^{T}L_t(\Phi,\Theta) \tag{10}$$

where $L_t(\Phi,\Theta)=\ln\Gamma(\frac{v+2}{2})-\ln\Gamma(\frac{v}{2})-\ln\left[\pi(v-2)\right]-\frac{1}{2}\ln\left|D_t R_t D_t\right|-\frac{v+2}{2}\ln(1+\frac{\eta_t' D_t^{-1}R_t^{-1}D_t^{-1}\eta_t}{v-2})$ and $\Gamma(\bullet)$ is the Gamma function.

The model focuses on the effects of exchange rate movement on exports in equilibrium. The reduced-form export equation includes exchange rate depreciation and risk as well as the rate of change of foreign income as explanatory variables. The sign and significance of the estimated coefficients ($\hat{c}_i$) in equation (1) provide a straightforward test of the relationship between exports and depreciation, where their sum ($\sum\hat{c}_i$) should exceed zero. That is, exchange rate depreciation improves exports. Of particular interest are the signs and magnitudes of the estimated coefficients of exchange rate risk ($h_{q,t}^{1/2}$) in equation (1). If exporters cut their exports to minimize profit uncertainty of their export revenue when exchange rate risk rises, then the sum of the $\hat{d}_i s$ ($\sum\hat{d}_i$) should fall below zero. If, however, exporters intend to offset potential losses or to use options markets to hedge, then the sum ($\sum\hat{d}_i$) should exceed zero. In the dynamic adjustment process, both positive and negative transitory effects may exist, causing the sum ($\sum\hat{d}_i$) to equal zero.

To assess the net effects, we evaluate the total contribution of exchange rate depreciation and its risk on export growth. That is, we consider the sign and significance of the net effect ($\sum \hat{c}_i \Delta lq_{t-i} + \sum \hat{d}_i h_{q,t-i}^{1/2}$) in equation (1), which depends on each of the estimates and the magnitudes of Δlq_t and $h_{q,t}^{1/2}$. Since $\varepsilon_{x,t}$ in the estimated export equation (1) is white noise, the calculated sum is appropriate to be interpreted as the net effect of exchange rate depreciation and its risk on actual export growth. The net effect exceeds zero, if the positively estimated depreciation contribution ($\sum \hat{c}_i \Delta lq_{t-i}$) dominates the negatively estimated exchange risk effect ($\sum \hat{d}_i h_{q,t-i}^{1/2}$), or the latter is positive. The net effect falls below zero when the negative risk effect dominates. Either a positive or a negative net effect can occur. If the net effect does not differ statistically from zero, then changes of the exchange rate exhibit no net effect on exports.

3. Data and Empirical Results

For the eight countries studied, the bilateral export variable equals monthly seasonally adjusted real export revenue from the U.S. between January 1979 and April 2003 with a base year of 1995. All data come from the *International Financial Statistics and Direction of Trade* of the IMF, the *Main Economic Indicators* of the OECD, and the *AREMOS* data set of Taiwan. Table 2 reports preliminary statistics for logarithmic differences of real export revenue and the real exchange rate. In the sample, every country experienced depreciation and export growth, on average. Thailand experienced the highest average export growth at 1.031% with a depreciation of 0.196%. Indonesia experienced the highest monthly depreciation at 0.336% with an export growth of 0.486%. It appears that depreciation encourages exports, on average, but with different effects.

Using standard deviations as the measure of unconditional risk, Indonesia exhibits the most volatile export revenue and real exchange rate, while Japan and Singapore exhibit the least volatile export revenue and real exchange rate. Real export revenue volatility exceeds exchange rate volatility in every country. Indonesia's standard deviation of Δlq_t is about 4.5 times of that of Singapore, but the two countries have almost the same rate of export growth. For other countries, standard deviations of Δlq_t are close, but apparently with different rates of export growth. A general impression of how real exchange rate volatility affects exports does not emerge from standard deviations and extreme values.

Skewness statistics reject Δlx_t symmetry at the 5-percent level for Taiwan and Δlq_t symmetry for every country except Singapore and Taiwan. Kurtosis statistics for Δlx_t and Δlq_t imply that all series show leptokurticity with fat tails. Jarque-Bera tests reject normality for all variables and countries, suggesting the use of the Student-t distribution in model estimation.

The Ljung-Box Q statistic tests for autocorrelation and the number of lags (k) affects its performance. Tsay (2002) suggests choosing $k = \ln(T)$, where T equals the number of observations (291), implying that k equals 5.67, and the autocorrelations tests run to 6 lags. Ljung-Box statistics indicate autocorrelation in Δlx_t and Δlq_t for all countries. Ljung-Box statistics for squared Δlx_t and Δlq_t suggest time-varying variance for both series in all countries except for Δlq_t in Taiwan. To capture the dynamic structure and to generate white-noise residuals, we specify AR(2) and MA(1) processes for the mean equation of Δlx_t and Δlq_t, respectively, and GARCH(1,1) for the two variance equations.

Valid inference in GARCH models requires stationary variables. After selecting lag lengths by the AIC, the augmented Dickey-Fuller (ADF) test indicates that Δlx_t and Δlq_t individually exhibit stationary [I(0)] series at the 5-percent level.

The correlation coefficient between the two monthly logarithmic differenced series ranges from 0.018 in Taiwan to 0.259 in the Philippines. Figure 1 shows the sample correlation coefficient, using a moving window of 12 observations (i.e., 1 year). The horizontal line denotes the correlation coefficient. The correlation changes over time, appearing to increase in recent years for most countries. Thus, the DCC estimator proves appropriate to assess the net effect in that it captures time-varying correlation between export revenue and the real exchange rate.

In the DCC estimator each conditional variance term follows a univariate GARCH formulation. Preliminary analysis shows that the standard univariate GARCH(1,1) model for Δlx_t performs adequately for all countries. For Δlq_t, not surprisingly, unstable variance processes emerge in Indonesia, Korea, Malaysia, the Philippines, and Thailand because the Asian financial crisis that began in Thailand during July 1997 increased exchange market volatility immediately. Neglecting structural breaks may bias upward GARCH estimates of persistence in variance, vitiating the use of GARCH to estimate the mean equation. Perron (1989, 1997) suggests identifying breaks by examining data and using dummy variables to capture shifts in mean or variance processes. Figure 2 shows time plots of the eight exchange rates, marking the break dates.

One-time shocks appear as a single pulse in the exchange rate depreciation series and as a mean shift in volatility. Dummy variables enter the mean equations for Indonesia and Thailand and the variance equations for Indonesia, Korea, Malaysia, the Philippines, and Thailand to capture their particular patterns. In the mean equation, the two dummies for Indonesia are $MD_1=1$ for t=1983:04, $MD_2=1$ for t=1986:09, and 0 otherwise; for Thailand, $MD_1=1$ for t=1981:07, $MD_2=1$ for t=1984:11, and 0 otherwise. In the variance equation, for Indonesia dummies are $VD_1=1$ for $t \geq 1997{:}07$, and 0 otherwise; for Korea $VD_1=1$

for t$\geq$1997:07, and 0 otherwise; for Malaysia VD_1=1 for 1997:07≤t≤1998:12, and 0 otherwise; for the Philippines VD_1=1 for 1983:01≤t≤1984:12, VD_2=1 for 1997:07≤t≤1998:12, and 0 otherwise; for Thailand VD_1=1 for t$\geq$1997:07, and 0 otherwise. The 1997 Asian crisis raised exchange rate volatility in Indonesia, Korea, Malaysia, the Philippines, and Thailand. The Philippines also experienced another volatile period from 1983 through 1984.

Properties of the time-varying variance and correlation in export revenue and the exchange rate suggest the DCC bivariate GARCH(1,1)-M model specified in equations (1) to (9) to investigate the net effect of exchange rate movement. We estimate the general model first. Although neither autocorrelation nor heteroskedasticity exist, insignificant coefficients make it difficult to gauge the net effect. Table 3 reports estimated coefficients and standard errors for a parsimonious version with insignificant variables deleted. The advantages of parsimony include higher precision of estimates from reduced multicollinearity, increased degrees of freedom, more reliable estimates, and greater power of tests. The insignificant likelihood ratio statistic, LR(k), at the 5-percent level suggests no explanatory difference between the general and the parsimonious models for each country.

All estimates of ARMA components and dummy variables in the mean equations (1) and (2) prove significant. The parameters in the two variance equations (4) and (5) of Δlx_t and Δlq_t exceed zero. Every country exhibits time-varying variances in either GARCH(1,1) or ARCH(1) form except Taiwan, which has a constant variance for export revenue. These findings support the use of the bivariate GARCH model for all countries. Although Taiwan experiences a constant variance of exports, the information matrix of the system is not block diagonal and joint estimation is efficient as noted by Kroner and Lastrapes (1993). The significance of λ_1 and λ_2 in equation (5) supports the introduction of dummy variables to stabilize the effect of structural breaks. Volatility persistence for Δlx_t varies from 0.182 in Japan to 0.983 in Indonesia and the estimated volatility for Δlq_t varies from 0.164 in Taiwan to 0.887 in Thailand. These GARCH estimates correspond to the earlier observation that Japan and Indonesia exhibit the lowest and the highest standard deviations of Δlx_t, and Taiwan and Thailand exhibit relatively low and high standard deviations of Δlq_t (see Table 2). The two variance processes converge. Joint estimates of the degrees of freedom of the t-distribution prove significant. We cannot reject the hypothesis of bivariate Student-t distribution.

Both θ_1 and θ_2 in the GARCH(1,1) process of Q_t significantly exceed zero and their sum ($\theta_1 + \theta_2$) falls below one, except Malaysia in which θ_1 is insignificant. The sum ($\theta_1 + \theta_2$) lies between

0.645 in the Philippines and 0.984 in Malaysia. Table 4 reports the statistics for the conditional correlation coefficients between Δlx_t and Δlq_t estimated by the DCC model. The mean value of the correlation ranges from 0.013 in Taiwan to 0.175 in the Philippines. Generally, the calculated mean value falls below the correlation in Table 2. The maximum value, the minimum value, and the standard deviation indicate that the correlation coefficient varies. Figure 3 displays the fitted conditional correlation coefficient between Δlx_t and Δlq_t. The plot shows that the correlation coefficient fluctuates over time, similar to that of Figure 1. This characteristic along with the non-zero estimates for θ_1 and θ_2 suggests the use of the time-varying correlation coefficient model for each country.

Bivariate Ljung-Box $Q_2(k)$ statistics (Hosking, 1980) for standardized residuals and squared standardized residuals of Δlx_t and Δlq_t, up to six lags, do not detect remaining autocorrelation or conditional heteroskedasticity at the 5-percent level. The DCC bivariate GARCH-M model proves adequate for each country.

In Table 3, the estimated coefficients of U.S. manufacturing income on export revenue significantly exceeds zero, as expected, for all countries. Seven of the eight Asian countries experience contemporaneous effects and Malaysia experiences only a one-month-lagged effect. In addition, the Philippines and Taiwan also exhibit a one-month-lagged effect and Japan, a two-month-lagged effect. Exchange rate depreciation significantly increases export revenue for all countries. Each country experiences a one-month-lagged effect along with a contemporaneous or a two-month-lagged effect. Longer lagged effects exist for exchange rate depreciation than for foreign income, a characteristic of trade emphasized in Klaassen (2004). Exchange rate risk affects exports significantly for all countries except Korea. The estimates differ among countries. Indonesia, Malaysia, the Philippines, and Singapore show positive contemporaneous effects, but negative lagged effects. Japan, Taiwan, and Thailand show only negative lagged effects. In Korea the negative estimate proves insignificant. We keep this variable as a comparison with other countries. There is no change of our conclusions at all when we omit the risk variable in estimation.

Table 5 reports the cumulative effects of Δly_t, Δlq_t, and $h_{q,t}^{1/2}$. The likelihood ratio (LR) statistic with χ^2 distribution and one degree of freedom tests whether each of the cumulative effects differs from zero. U.S. income shows significant effects on exports across all countries. The effect varies from 1.521 in Korea to 3.118 in Taiwan. The foreign income effect is consistent with Klaassen's (2004) evidence that the significant estimate for foreign industrial production of monthly bilateral U.S. exports to the other G7 countries ranges from 1.19 in Italy to 4.22 in France. Foreign income effect on exports is larger than one in both developed and developing countries.

All countries exhibit significant cumulative exchange rate depreciation effects at the 5-percent level, except Singapore. The LR test provides a more powerful test than asymptotic t-test as pointed in Kroner and Lastrapes (1993). Abeysinghe and Yeok (1998) find that exchange rate appreciation does not diminish Singapore's exports due to their high import content. Lower import prices lower the cost of export production. The depreciation effect ranges from 0.380 in Malaysia to 1.739 in Thailand. Every country exhibits a lower depreciation effect than the U.S. income effect. Klaassen (2004) reports similar evidence, where the range of the cumulative depreciation effect runs form 0.49 in Canada to 0.95 in Japan, lower than the effect of foreign income. The depreciation effect of 0.95 from the U.S. to Japan is close to that of 1.076 from Japan to the U.S. in this study.

Regarding exchange rate risk, mixed estimates emerge, making the cumulative effect less significant in some countries and more significant in others. Only Indonesia, Japan, and Taiwan possess significant negative risk effects. The evidence of the negative risk effect supports the common argument that exchange rate risk hampers international trade. That finding differs from Klaassen (2004), who finds no risk effect for bilateral U.S. exports to the other G7 countries. He argues that the exchange rate risk does not exhibit enough variability to uncover an effect on export revenue. He suggests using data on developing countries with more volatile exchange rates. Ignoring the sign and the significance, the range [-6.932, 0.227] of the exchange rate risk effect in our eight Asian countries is close to the range [-0.17, 6.44] in Klaassen's (2004) six G7 countries. The high negative risk effect in Taiwan suggests that the forward exchange rate cover proves incomplete (Fang and Thompson, 2004).

4. Quantitative analysis of depreciation and risk

To assess the net effect, we observe the sign and the significance of the sum ($\sum \hat{c}_i \Delta lq_{t-i} + \sum \hat{d}_i h_{q,t-i}^{1/2}$). The combined contribution of the two variables – exchange rate depreciation and its risk -- depends on their estimated coefficients and the magnitudes of the variables themselves. Insignificance (significance) of the cumulative effect in Table 5 does not necessarily imply absence (existence) of contribution to the export growth. Table 6 reports the contribution shares of Δly_t, Δlq_t, and $h_{q,t}^{1/2}$, their standard errors, and the associated p-values for significant effects.

U.S. income uniformly contributes significantly to export growth for the Asian countries. Its contribution falls within a narrow range from 0.275 in Korea to 0.561 in Taiwan. Low standard errors and p-values strongly suggest that U.S. economic activity influences Asian bilateral exports. In contrast, exchange rate depreciation exhibits weak contributions to export growth. Only Malaysia and Thailand show significant positive contributions. In Japan, the contribution is negative, although nearly zero. Athukorala and Menon (1994) argue that in the period of massive appreciation since the Plaza Accord in 1985, Japanese exporters maintain competitiveness in world markets by reducing their profit mark-up and by the cost lowering effect of exchange rate appreciation due to the heavy reliance on imported inputs across all export industries. Finally, exchange rate risk significantly affects all countries. Negative exchange rate risk effects emerge in six countries and positive effects in two countries, ranging from -10.177 in Taiwan to 0.320 in Malaysia. Table 7 reports the results of the net effect tests.

The net effect, the sum of the contribution shares of exchange rate depreciation and its risk, ranges from -10.144 in Taiwan to 0.474 in the Philippines. At the 5-percent level, six countries exhibit sums differing significantly from zero. The evidence suggests that exchange rate movement causes a negative net effect on exports in Indonesia, Japan, Singapore, and Taiwan and a positive net effect in Malaysia and the Philippines. For the countries with a negative net effect, a significant negative effect of exchange rate risk exists while the exchange rate effect proves insignificant. In contrast, the two countries with the positive net effect exhibit significant positive effects of exchange rate risk with a significant or insignificant contribution of their depreciations. Korea and Thailand possess a zero sum, meaning that the net effect of exchange rate changes on export revenue equals zero. In these two countries, the Ljung-Box statistics for the series of the sum and the squared sum prove highly significant. Thus, if we omit exchange rate depreciation and its risk, the estimation of the model becomes a problem. In other words, each variable exhibits significant effects. But the negative exchange rate risk effect offsets exactly the positive exchange rate depreciation effect.

The size of the risk estimate, risk contribution and the net effect appear related to the standard deviation of time-varying exchange rate volatility. Table 8 summarizes relevant statistics and estimates. As can be seen, in most countries the exchange rate risk estimated by GARCH(1,1) model is lower than the standard deviation of depreciation in Table 2, and they are close and consistent. For example, Indonesia and Singapore still have the highest and the lowest exchange rate risk measured by the GARCH process, respectively.

In Table 8 Indonesia, the Philippines, Thailand, Malaysia, and Korea display high standard deviations of conditional exchange rate variance (larger than one), ranging from 1.292 in Korea to 4.513 in Indonesia. These same countries exhibit small cumulative risk estimates from -0.088 in Korea to 0.227 in Malaysia (less than one in absolute value), and only Indonesia's proves significant. In the Philippines and Malaysia exchange rate risk contributes export growth, leading to positive net effects. In Thailand and Korea negative risk contribution shares are less than one, no net effect emerge. In contrast, lower standard deviations of conditional variance in Singapore, Taiwan, and Japan (less than one) associate with higher negative risk estimates, risk contributions (both are larger than one in absolute value), and therefore negative net effects. An explanation is that exporters who face volatile exchange rates hedge or aggressively manage exchange risk, resulting in a positive or a small negative risk effect. As a result, positive net effects emerge in Malaysia and the Philippines and zero net effects, in Korea and Thailand. In Japan, Singapore, and Taiwan, low volatility lulls exporters into neglecting risk and leads to a significant negative net effect. The case of Indonesia proves noteworthy. While Indonesia experiences the highest depreciation rate among countries with a significant depreciation effect, it also exhibits the highest standard deviation of $h_{q,t}^{1/2}$ with a significant risk effect (see Table 5). The relatively high exchange rate risk effect (see Table 6) gives Indonesia a significant negative net effect (see Table 7). In the depreciation process Indonesia obtains no benefit from depreciation, but hurt from associated exchange rate risk. This finding compares with Chou and Chao (2001), who show that in Indonesia, both the long-run and the short-run, currency depreciation produces contractionary effects, mainly due to the negative exchange rate risk effect.

5. Conclusion

This paper empirically studies the net effect of real exchange rate changes on exports. The empirical results estimated by Engle's (2002) dynamic conditional correlation bivariate GARCH-M model employ monthly bilateral exports from eight Asian countries to the U.S. from 1979 to 2003. They demonstrate that U.S. income generates significant and quick positive effects on Asian exports. Real exchange rate depreciation displays the normal positive estimate. The depreciation effect proves significant for all countries, except Singapore. Exports react slowly to depreciation as compared to U.S. income. Real exchange rate risk produces significant estimates on exports for seven of the eight countries studied, either negative or positive. The cumulative risk effect proves negative and significant in three countries. In contrast, Klaassen (2004) finds no significant risk effect on monthly bilateral U.S. exports to the other G7 countries.

Ignoring exchange rate risk, depreciation typically stimulates exports across Asian economies. Including the effect of time varying risk, the net effects demonstrate less uniformity. High degrees of risk induce efforts to avoid its effect and thus, exchange rate risk stimulates exports in Malaysia and the Philippines, leading to positive net effects. Depreciation alone stimulates exports, but exchange rate risk displays a negative effect for six countries, resulting in negative net effects in Indonesia, Japan, Singapore, Taiwan and zero net effects in Korea and Thailand.

These results highlight several policy implications regarding exchange rate depreciation to stimulate exports. Generally, little guarantee exists that exchange market intervention will succeed, since exporters react differently to the exchange rate and its associated risk. Conditions vary across countries and each requires evaluation on its own merits. Exchange rate depreciation typically improves exports, but its contribution is generally small. Policy makers should carefully consider exchange market intervention, since the associated change in exchange risk may offset any positive effects of depreciation.

The evidence of negative net effects provides the rationale for foreign exchange policies to reduce exchange rate fluctuations such as in Indonesia, Japan, Singapore, and Taiwan. Indonesia produces a noteworthy example. It experiences the highest depreciation rate but also the highest standard deviation, where the negative effect of exchange rate risk overcomes the positive effect of depreciation, resulting in a negative net effect. Chou and Chao (2001) show that currency depreciation leads to a contractionary effect for Indonesia due mainly to foreign exchange market volatility. A zero net effect also suggests policies to stabilize the foreign exchange market as in Korea and Thailand since depreciation does not benefit exports. A positive net effect supports the conventional view that depreciation stimulates exports, as seen in Malaysia and the Philippines, where exchange rate risk reinforces the effect of depreciation.

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Table 1. U.S. share of total exports

INDONESIA	JAPAN	KOREA	MALAYSIA	PHILIPPINES	SINGAPORE	TAIWAN	THAILAND
16.00%	30.50%	26.50%	17.60%	34.10%	18.70%	32.80%	18.70%

Note: The data are obtained from *Direction of Trade* of the IMF, exports to the total U.S. exports.

Table 2. Preliminary statistics for exports and the exchange rate

	INDONESIA		JAPAN		KOREA		MALAYSIA	
	Δlx_t	Δlq_t	Δlx_t	Δlq_t	Δlx_t	Δlq_t	Δlx_t	Δlq_t
Sample size	291	291	291	291	291	291	291	291
Mean	0.486	0.336	0.218	0.020	0.542	0.123	0.617	0.254
SD	23.561	6.257	5.263	2.792	10.886	2.785	9.815	2.085
Maximum	112.428	56.678	15.506	6.801	41.158	34.325	36.894	14.890
Minimum	-120.641	-26.884	-18.577	-10.068	-42.280	-8.509	-32.974	-15.417
Skewness	-0.166	3.026*	-0.035	-0.609*	-0.186	6.678*	0.049	0.348*
	(0.144)	(0.144)	(0.144)	(0.144)	(0.144)	(0.144)	(0.144)	(0.144)
Kurtosis	8.475*	32.407*	3.787*	3.757*	5.013*	82.118*	4.118*	26.085*
	(0.287)	(0.287)	(0.287)	(0.287)	(0.287)	(0.287)	(0.287)	(0.287)
J-B N	364.801*	10929.82*	7.573*	24.945*	50.807*	78061.06*	15.278*	6467.65*
$Q(3)$	70.030*	11.934*	52.199*	27.323*	70.169*	59.985*	68.233*	13.182*
$Q(6)$	77.207*	29.785*	66.728*	28.284*	90.065*	64.426*	70.957*	14.315*
$Q^2(3)$	62.163*	55.883*	14.311*	8.800*	44.415*	13.136*	19.944*	139.630*
$Q^2(6)$	62.257*	87.651*	16.013*	17.596*	47.158*	13.622*	26.883*	188.000*
ADF(m)	-21.005*(1)	-14.494*(0)	-9.673*(2)	-12.641*(0)	-19.635*(1)	-12.047*(1)	-18.864*(1)	-13.875*(0)
ρ_{xq}	0.213		0.206		0.215		0.081	

	PHILIPPINES		SINGAPORE		TAIWAN		THAILAND	
	Δlx_t	Δlq_t	Δlx_t	Δlq_t	Δlx_t	Δlq_t	Δlx_t	Δlq_t
Sample size	291	291	291	291	291	291	291	291
Mean	0.622	0.186	0.487	0.095	0.283	0.053	1.031	0.196
SD	9.528	2.702	12.145	1.411	8.956	1.560	11.542	2.609
Maximum	35.601	21.006	55.490	6.380	37.592	9.020	49.175	16.295
Minimum	-38.113	-8.687	-54.574	-4.995	-25.208	-6.546	-43.237	-15.911
Skewness	-0.050	2.577*	-0.218	0.069	0.407*	0.109	-0.144	1.872*
	(0.144)	(0.144)	(0.144)	(0.144)	(0.144)	(0.144)	(0.144)	(0.144)
Kurtosis	5.418*	20.495*	6.618*	4.950*	4.645*	7.954*	6.404*	24.106*
	(0.287)	(0.287)	(0.287)	(0.287)	(0.287)	(0.287)	(0.287)	(0.287)
J-B N	71.019*	4033.18*	160.985*	46.330*	40.824*	298.168*	141.504*	5570.93*
$Q(3)$	64.406*	8.400*	100.780*	17.620*	89.918*	14.133*	38.784*	23.865*
$Q(6)$	66.996*	9.516	101.580*	20.500*	90.098*	22.365*	58.018*	28.645*
$Q^2(3)$	31.870*	6.203**	59.289*	48.710*	36.352*	3.324	53.417*	129.850*
$Q^2(6)$	35.351*	8.823	59.721*	86.074*	39.742*	6.538	109.77*	187.150*
ADF(m)	-18.787*(1)	-14.335*(0)	-19.291*(1)	-13.543*(0)	-20.683*(1)	-13.980*(0)	-14.982*(1)	-12.766*(0)
ρ_{xq}	0.259		0.046		0.018		0.110	

Note: SD represents the standard deviation; J-B N denotes the Jacque-Bera normality test; $Q(k)$ and $Q^2(k)$ are Ljung-Box statistics for the level and squared terms for autocorrelations up to k lags; ADF(m) is the augmented Dickey-Fuller unit root test with lags m selected by the AIC criterion;

* denotes 5-percent significance level

** denotes 10-percent significance level

Table 3. Estimates for dynamic conditional correlation bivariate GARCH-M, equations (1) to (9)

	INDONESIA		JAPAN		KOREA		MALAYSIA		PHILIPPINES		SINGAPORE		TAIWAN		THAILAND	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
a_0	1.691 *	0.415	3.937 *	0.240	0.761 **	0.427	0.442	0.408	0.128	0.305	3.366 *	0.099	10.165 *	0.241	1.314 *	0.370
a_1	-0.643 *	0.048	-0.570 *	0.044	-0.577 *	0.049	-0.625 *	0.047	-0.617 *	0.042	-0.684 *	0.049	-0.736 *	0.070	-0.645 *	0.047
a_2	-0.353 *	0.047	-0.272 *	0.041	-0.277 *	0.042	-0.250 *	0.050	-0.230 *	0.043	-0.257 *	0.035	-0.324 *	0.047	-0.321 *	0.045
b_0	2.865 *	0.667	1.212 *	0.347	1.521 *	0.651			1.176 *	0.471	2.618 *	0.566	1.539 *	0.554	2.446 *	0.570
b_1							1.828 *	0.604	1.550 *	0.415			1.579 *	0.524		
b_2			1.066 *	0.336												
c_0			0.298 *	0.082	0.562 *	0.118			0.936 *	0.106					0.474 *	0.131
c_1	0.280 *	0.069	0.453 *	0.079	0.924 *	0.195	0.380 *	0.188	0.395 *	0.133	0.419 **	0.215	0.590 *	0.256	0.780 *	0.166
c_2	0.148 **	0.076	0.325 *	0.078											0.485 *	0.130
d_0	0.421 *	0.083			-0.088	0.229	1.189 *	0.188	0.664 *	0.122	1.579 *	0.071				
d_1	-0.653 *	0.086	-1.476 *	0.080					0.741 *	0.123			-1.959 *	0.097	-0.253 *	0.122
d_2							-0.962 *	0.199	-1.308 *	0.124	-3.804 *	0.084	-4.973 *	0.103		
s_0	0.072	0.056	0.174	0.189	0.033	0.069	0.117 **	0.063	0.004	0.094	0.037	0.088	0.106	0.093	-0.042	0.059
s_1	0.202 *	0.068	0.310 *	0.058	0.351 *	0.055	0.183 *	0.068	0.356 *	0.057	0.236 *	0.053	0.218 *	0.060	0.212 *	0.062
γ_1	30.258 *	1.483													6.065 *	1.206
γ_2	16.037 *	0.598													15.069 *	1.198
α_0	1.839 *	0.701	13.528 *	1.892	40.966 *	6.764	5.722 *	1.275	8.397 *	1.820	4.106 *	0.053	44.521 *	5.117	1.559 *	0.479
α_1	0.096 *	0.015	0.182 **	0.097	0.363 *	0.118	0.139 *	0.027	0.240 *	0.053	0.173 *	0.006	0.092	0.069	0.082 *	0.012
α_2	0.887 *	0.011			0.282 *	0.075	0.797 *	0.020	0.725 *	0.028	0.793 *	0.005			0.890 *	0.010
β_0	0.251 *	0.044	6.164 *	0.479	0.118 *	0.023	0.796 *	0.099	0.713 *	0.146	0.309 *	0.023	1.823 *	0.083	0.083 *	0.016
β_1	0.489 *	0.087	0.172 *	0.055	0.101 *	0.027	0.357 *	0.099	0.333 *	0.067	0.099 *	0.023	0.164 *	0.031	0.100 *	0.021
β_2	0.299 *	0.048			0.761 *	0.024			0.401 *	0.059	0.732 *	0.016			0.787 *	0.017
λ_1	10.869 *	4.018			0.799 *	0.307	34.865 *	15.375	16.632 *	5.160					10.868 *	3.659
λ_2									18.962 **	11.580						
ν	5.691 *	0.934	7.131 *	1.858	4.143 *	0.461	5.069 *	0.795	3.023 *	0.170	7.174 *	0.579	5.164 *	0.946	6.105 *	1.257
θ_1	0.160 **	0.082	0.057 **	0.032	0.099 *	0.030	0.011	0.018	0.204 **	0.110	0.061 **	0.034	0.049 *	0.023	0.050 **	0.027
θ_2	0.592 *	0.198	0.730 *	0.073	0.828 *	0.005	0.984 *	0.037	0.441 *	0.120	0.649 *	0.155	0.859 *	0.115	0.815 *	0.038
$Q_2(6)$	32.658		20.294		30.200		28.275		36.108		8.848		28.183		36.001	
$Q_2^2(6)$	13.299		20.950		14.066		10.643		15.949		20.672		16.552		23.231	
$LR(k)$	4.788 (4)		3.414 (5)		5.621 (5)		7.844 (5)		1.962 (2)		3.606 (5)		2.874 (4)		5.858 (4)	

Note: $Q_2(6)$ and $Q_2^2(6)$ are the bivariate Ljung-Box statistics (Hosking,1980) of the standardized and squared standardized residuals for autocorrelations up to 6 lags. $LR(k)$ is the likelihood ratio statistic following a χ^2 distribution with the degree of freedom k (in parentheses) that tests whether the restricted simple model exhibits the same explanatory power as the unrestricted general model when we eliminate the k insignificant estimates.

* denotes 5-percent significance level

** denotes 10-percent significance level

Table 4. Statistics for dynamic conditional correlations

	INDONESIA	JAPAN	KOREA	MALAYSIA	PHILIPPINES	SINGAPORE	TAIWAN	THAILAND
Mean	0.154	0.172	0.068	0.017	0.175	0.040	0.013	0.066
Median	0.147	0.176	0.088	0.014	0.187	0.053	-0.004	0.065
Maximum	0.775	0.645	0.406	0.094	0.817	0.225	0.308	0.656
Minimum	-0.448	-0.063	-0.431	-0.058	-0.349	-0.191	-0.203	-0.203
Std. Dev.	0.011	0.005	0.008	0.002	0.007	0.004	0.006	0.005

Table 5. Cumulative effect of Δly_t , Δlq_t , and $h_t^{1/2}$

	INDONESIA	JAPAN	KOREA	MALAYSIA	PHILIPPINES	SINGAPORE	TAIWAN	THAILAND
$\sum b_i$	2.865*	2.278*	1.521*	1.828*	2.725*	2.618*	3.118*	2.446*
LR	12.548	28.683	4.048	6.836	12.058	10.96	18.534	10.815
	(0.000)	(0.000)	(0.044)	(0.009)	(0.001)	(0.001)	(0.000)	(0.001)
$\sum c_i$	0.428*	1.076*	1.486*	0.380**	1.331*	0.419	0.590*	1.739*
LR	18.578	57.978	26.087	2.973	35.368	2.125	5.509	45.657
	(0.000)	(0.000)	(0.000)	(0.085)	(0.000)	(0.145)	(0.019)	(0.000)
$\sum d_i$	-0.232*	-1.476**	-0.088	0.227	0.097	-2.226	-6.932*	-0.253
LR	4.624	3.273	0.082	0.642	0.263	1.968	6.889	2.478
	(0.032)	(0.070)	(0.775)	(0.423)	(0.608)	(0.161)	(0.009)	(0.115)

Note: LR is the likelihood ratio statistic, following a χ^2 distribution with one degree of freedom that tests $\sum b_i = 0$, $\sum c_i = 0$, and $\sum d_i = 0$. P-$value$s are in parentheses.

* denotes 5-percent significance level
** denotes 10-percent significance level

Table 6. Contribution of Δly_t , Δlq_t , and $h_t^{1/2}$

		INDONESIA	JAPAN	KOREA	MALAYSIA	PHILIPPINES	SINGAPORE	TAIWAN	THAILAND
$\sum b_i \Delta ly_t$	Mean	0.511*	0.410*	0.275*	0.328*	0.490*	0.473*	0.561*	0.442*
	Std. Err.	0.109	0.070	0.058	0.069	0.084	0.099	0.095	0.092
	p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\sum c_i \Delta lq_t$	Mean	0.156	-0.001	0.205	0.097*	0.260	0.034	0.032	0.343**
	Std. Err.	0.125	0.124	0.209	0.047	0.171	0.035	0.055	0.188
	p-value	(0.213)	(0.992)	(0.327)	(0.040)	(0.130)	(0.333)	(0.557)	(0.069)
$\sum d_i h_t^{1/2}$	Mean	-0.628*	-3.986*	-0.133 *	0.320*	0.214*	-2.990*	-10.177*	-0.392*
	Std. Err.	0.087	0.028	0.007	0.063	0.077	0.038	0.076	0.029
	p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)	(0.000)	(0.000)

* denotes 5-percent level of significance.

Table 7. The net effect of exchange rate changes

	INDONESIA	JAPAN	KOREA	MALAYSIA	PHILIPPINES	SINGAPORE	TAIWAN	THAILAND
Mean	-0.472*	-3.987*	0.072	0.417*	0.474*	-2.956*	-10.144*	-0.050
Std. Err.	0.159	0.134	0.208	0.084	0.192	0.048	0.092	0.189
p-value	(0.003)	(0.000)	(0.728)	(0.000)	(0.014)	(0.000)	(0.000)	(0.793)

* denotes 5-percent level of significance.

Table 8. Standard deviation of exchange rate risk and net effects

	INDONESIA	PHILIPPINES	THAILAND	MALAYSIA	KOREA	JAPAN	TAIWAN	SINGAPORE
Std. Err. Of exchange rate depreciation	6.257	2.702	2.609	2.085	2.785	2.792	1.560	1.441
Exchange rate risk	5.256	3.093	2.492	2.117	1.980	2.719	1.486	1.361
(Std. Err.)	(4.513)	(2.075)	(1.957)	(1.549)	(1.292)	(0.327)	(0.236)	(0.229)
Risk effect	-0.232*	0.097	-0.253	0.227	-0.088	-1.476**	-6.932*	-2.226
Risk contribution	-0.628*	0.214*	-0.392*	0.320*	-0.133*	-3.986*	-10.177*	-2.990*
Net effect	-0.472*	0.474*	-0.050	0.417*	0.072	-3.987*	-10.144*	-2.956*

* denotes 5-percent significance level
** denotes 10-percent significance level

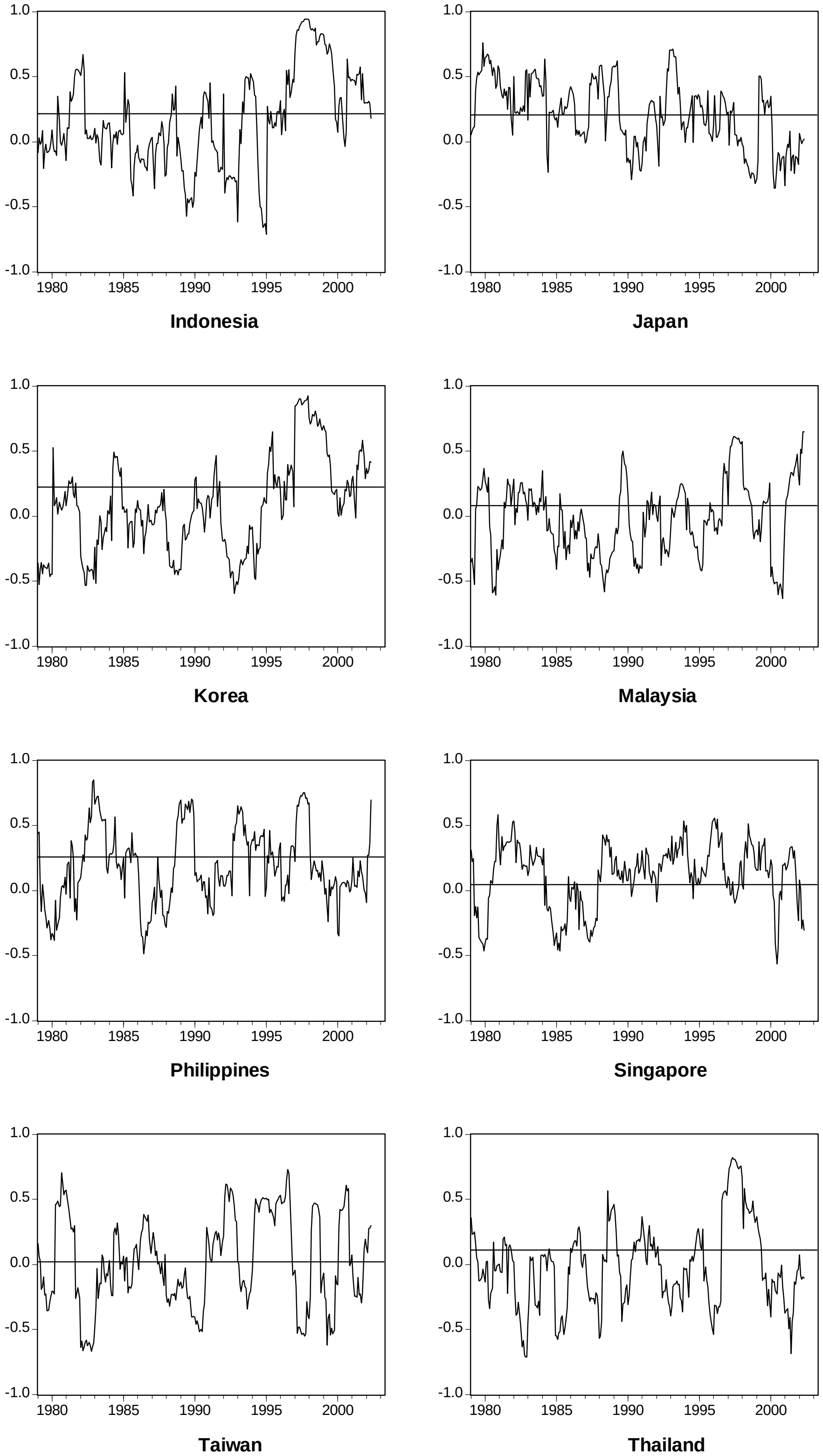

Figure 1. 12-period rolling correlations

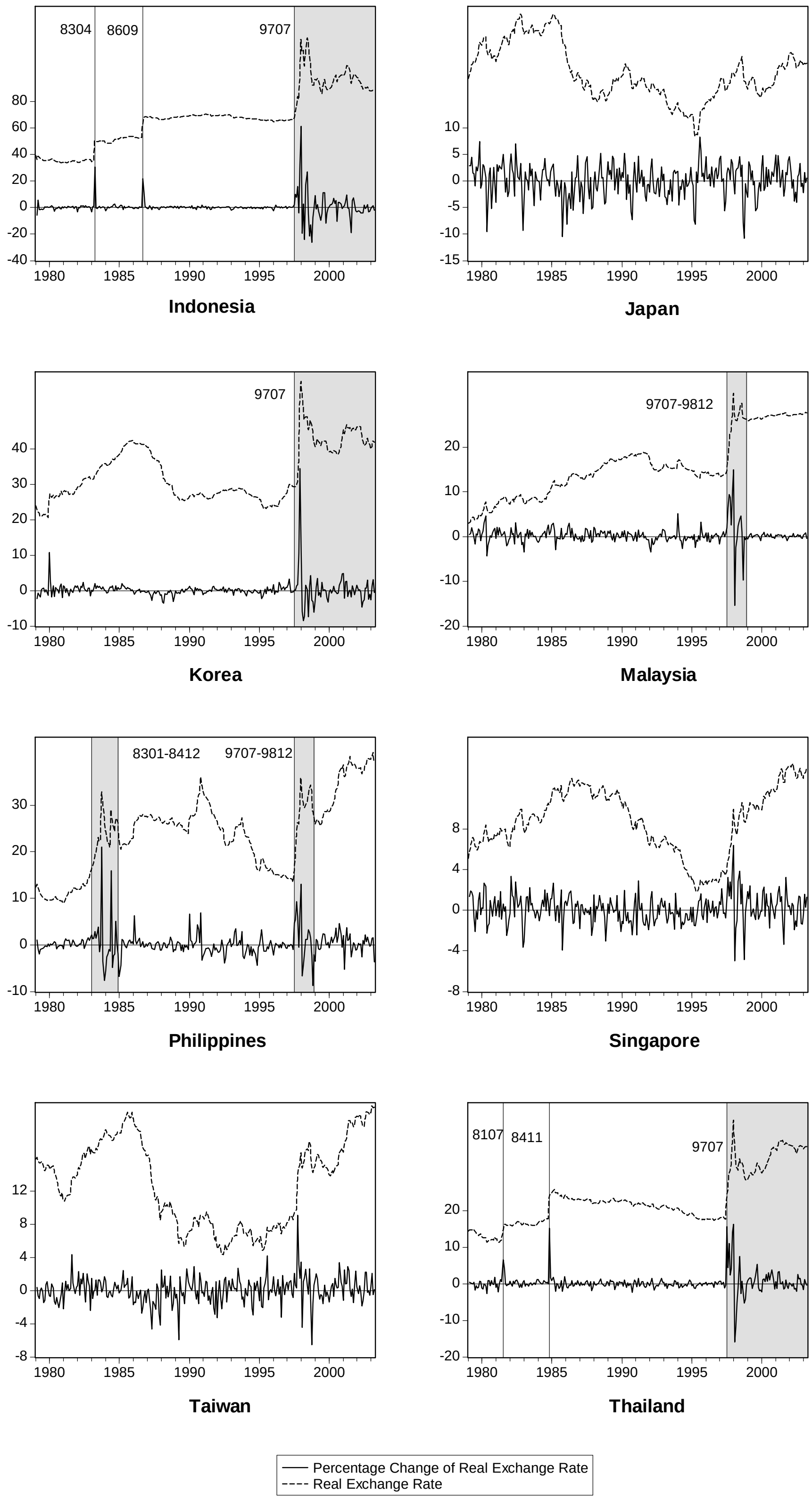

Figure 2. Structural changes for exchange rates

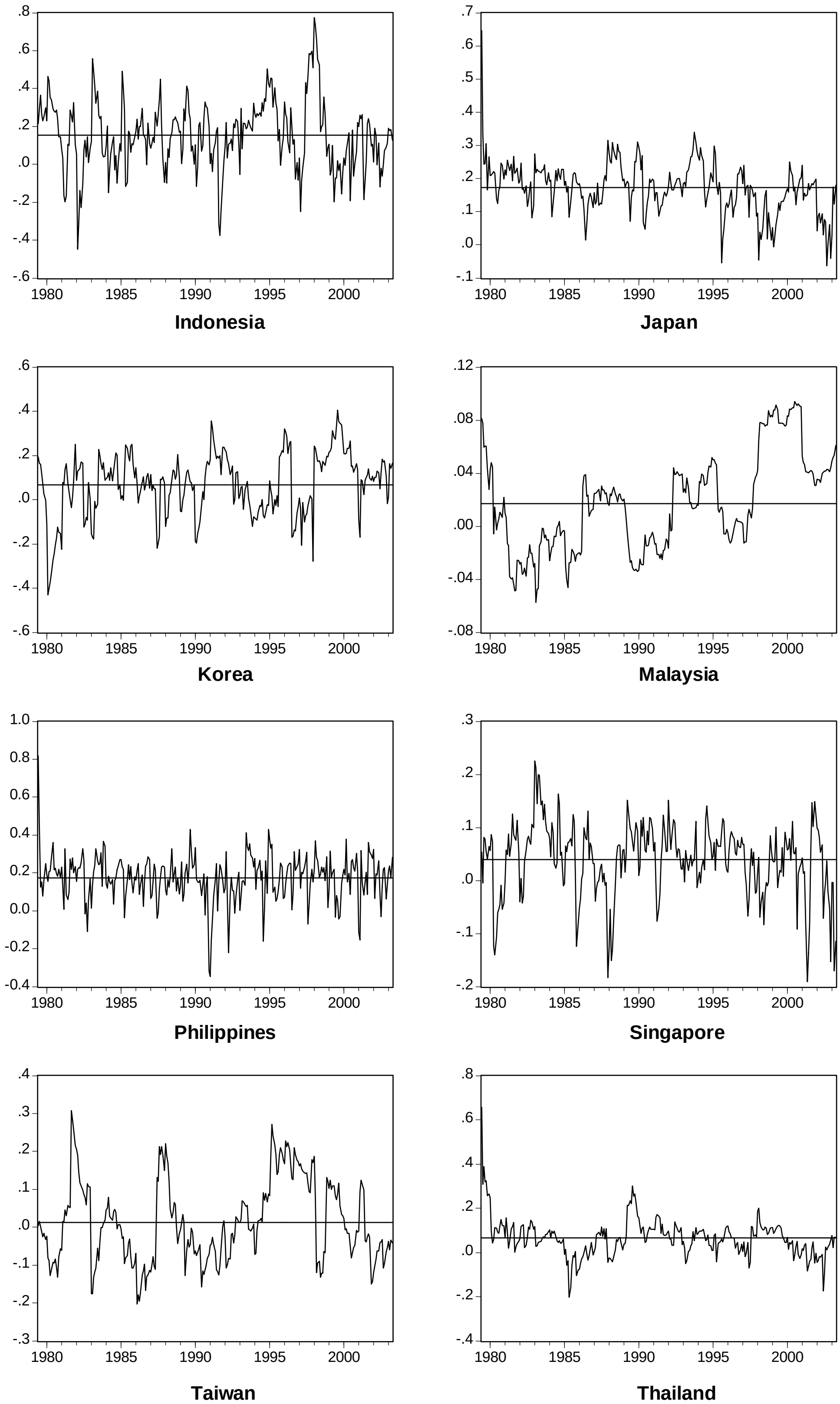

Figure 3. Dynamic conditional correlations