Inflation Risk, Exchange Rate Risk, And Asset Returns: Evidence From Korea, Malaysia, And Taiwan

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ABSTRACT

In this paper we investigate whether inflation and currency risks are priced in the Korean, Malaysian and Taiwan stock market using conditional international asset pricing models. We take the view of a US investor. The estimation is conducted using a modified version of the multivariate GARCH framework of De Santis and Gérard (1998). We use a sample period from 1988 to 2009. The results show that the world market risk is priced on Korean, Malaysian, Taiwan and US stock markets. We find the currency and inflation risk to be also priced on Korean, Malaysian and Taiwan market.

Keywords: Foreign Exchange Risk; Inflation Risk; ICAPM; Emerging Markets; Multivariate GARCH

1 INTRODUCTION

During the last decade stock markets throughout the world have become increasingly integrated, if world markets are fully integrated, the expected return on all assets should be the same after adjusting for exposure to global sources of risk (e.g., Grauer *et al.* 1976). By financial market integration we understand that assets in all markets are exposed to the same set of risk factors with the risk premia on each factor being the same in all markets. In this case, e.g., Adler and Dumas (1983) have shown that the global value-weighted market portfolio is the relevant risk factor to consider. However, if some assets deviate from pricing under full integration, their risk-adjusted return will differ from the global CAPM. If this is the case, Errunza and Losq (1985) suggest that the local market portfolio as a source of local market risk should also be considered (see also Chaieb and Errunza, 2007)

On the other hand, any investment in a foreign asset is always a combination of an investment in the performance of the asset itself and in the movement of the foreign currency relative to the domestic currency. Adler and Dumas (1983) show that if the purchasing power parity (PPP) does not hold, investors view real returns differently and they want to hedge against exchange rate risks.¹ Specifically, the risk induced by the PPP deviations is measured as the exposure to both the inflation risk and the currency risk associated with currencies.

Most of earlier studies assume that the domestic inflation is non-stochastic over short-period of times (e.g., Solnik, 1974; Sercu, 1980; Stulz, 1981; Stulz, 1995). Most recently, among others De Santis and Gérard (1998) show that the PPP risk contains only the relative change in the exchange rate. However, international investors are more concerned about the real asset returns, hence; it seems unrealistic to assume that the dynamics of inflation are constant over time and neglect the potentially important source of risk, inflation risk, along with exchange rate risk (e.g., Moerman and Van Dijk, 2010).

Inflation risk have very important implications for the portfolio management, cost of capital of a firm, asset pricing and currency hedging strategies, as any source of risk which is not compensated in terms of expected returns

¹ Moreover, currency risk may enter indirectly into asset pricing, if companies are exposed to unhedged currency risk for example through foreign trade and/or foreign debt. Empirical evidence has found conflicting support for the pricing of the foreign exchange rate risk (e.g., Jorion 1990, 1991; Roll, 1992; De Santis and Gérard, 1997, 1998; Doukas, Hall, and Lang, 1999; De Santis et al. 2003; Dumas and Solnik, 1995).

should be hedged (e.g., Brennan and Xia, 2002; Campbell and Viceira, 2001; Campbell *et al.* 2003). Therefore, it is very important to examine whether inflation risk is priced in international stock markets and particularly in the context of emerging market frame work, since their inflation rates dynamics often differ, e.g., for that of developed markets.

In this paper, we extend the framework of De Santis and Gerard (1998) to study the pricing of global and local market risks, as well as, inflation risk and currency risk on three Asian emerging stock markets namely, Korea, Malaysia and Taiwan, using data from 1988 to 2009. The purpose of this study is twofold, first, to inspect the controversial issues of market segmentation and integration in an emerging market setting, i.e., to analyze whether US investor should take in to account the local risk factors on the three Asian emerging stock markets. Second, we study the issue of currency risk and inflation risk pricing in Taiwan, Malaysian and Korean stocks. These markets are interesting from the point of view of inflation and currency risks, since their currencies has undergone several currency regimes (multiple cases of devaluations and revaluations, periods of fixed and floating exchange rates, etc.) and the dynamics of inflation during the period studied show a significant variation over time (e.g., Jongwanich and Park, 2009). Moreover, as mentioned by Kevin Brown (March 18, 2010 – Financial Times) “*Asia’s inflation genie leaps out of the bottle*” high inflationary trend in Asia, after the recent financial crisis in US (Subprime crisis 2007-2009), certainly threaten the economic development of emerging markets of Asia and have raised the concerns about the inflation and inflation uncertainty in developing Asia (e.g., Jiranyaku and Opiela, 2010). Besides all, there exist a large amount of studies that focus on the inflation risk pricing in developed markets, such as, Bodie (1976), Fama and Schwert (1977), Evans (1998), Buraschi and Jiltsov (2005), Vassalou (2000), Ang and Bekaert (2008) and Joyce *et al.* (forthcoming), work on emerging financial markets is still very scarce.

Our results show that the world market risk is priced on Korean, Malaysian, Taiwan and US stock markets, which is in line with De Santis and Gérard (1998). As local market risk, we find the currency and inflation risk to be also priced on Korean, Malaysian and Taiwan market which is in line with Moerman and Van Dijk (2010). Finding the local sources of risk, particularly, inflation risk relevant for the pricing of Korean, Malaysian and Taiwan stocks suggests that investors demand a risk premium for their exposure to inflation risk. Moreover, our results give further evidence that one should consider partially segmented asset pricing models for emerging stock markets.

The remainder of the paper is as follows. Section 2 explains the research methodology and theoretical background of the international asset pricing models. Section 3 presents the data in this study. Section 4 shows the empirical results. Section 5 concludes.

2 RESEARCH METHODOLOGY

2.1 Theoretical background

The classical CAPM of Sharpe (1964), Lintner (1965) and Black (1972) suggests that the expected equity returns are a function of only the country-specific local risk, if stock markets are fully segmented. However, if markets were complete integrated the international version of the CAPM by Adler and Dumas (1983) suggests that the only systematic source of risk is global market risk, also called the world price of covariance risk (e.g., Harvey, 1991). In line with their suggestion we begin our examination with the conditional international capital asset pricing model which implies the following restriction for the nominal excess returns².

$$E[r_{i,t+1}|\Omega_t] = \beta_{i,t+1}(\Omega_t) E[r_{m,t+1}|\Omega_t] \quad (1)$$

where $E[r_{i,t+1}|\Omega_t]$ and $E[r_{m,t+1}|\Omega_t]$ are expected returns on asset i and the global market portfolio conditional on investors' information set Ω_t available at time t . Both returns are in excess of the local riskfree rate of return r_{ft} for the period of time from t to $t+1$.

Since the conditional beta is defined as $\text{Cov}(r_{i,t+1}, r_{m,t+1}|\Omega_t) \text{Var}(r_{m,t+1}|\Omega_t)^{-1}$, we can use equation (1) to define the ratio $E[r_{m,t+1}|\Omega_t] \text{Var}(r_{m,t+1}|\Omega_t)^{-1}$. It can be considered as the conditional price of global market risk $\lambda_{m,t+1}$,

² Originally, the restriction implied by the ICAPM holds for the real excess returns.

conditioned on information available at time t .³ It measures the compensation the representative investor must receive for a unit increase in the variance of the market return (e.g., Merton, 1980). Now the model gives the following restriction for the expected excess returns for any asset i :

$$E[r_{i,t+1}|\Omega_t] = \lambda_{m,t+1} \text{Cov}(r_{i,t+1}, r_{m,t+1}|\Omega_t) \quad (2)$$

where the price of market risk should be positive if investors are risk-averse.

However, if some assets deviate from pricing under full integration, partially segmented model by Errurza and Losq (1985) suggests that both local and world factors should influence equilibrium asset returns. So, the pricing equation can be written as follows:

$$E[r_{i,t+1}|\Omega_t] = \lambda_{m,t+1}^w \text{Cov}(r_{i,t+1}, r_{m,t+1}^w|\Omega_t) + \lambda_{m,t+1}^l \text{Cov}(r_{i,t+1}, r_{m,t+1}^l|\Omega_t) \quad (3)$$

where $\lambda_{m,t+1}^w$ and $\lambda_{m,t+1}^l$ are the conditional prices of world and local market risk.

However, if the purchasing power parity (PPP) does not hold, investors view real returns differently and they want to hedge against exchange rate risks (e.g., Rogoff, 1996). Specifically, the risk induced by the PPP deviations is measured as the exposure to both the inflation risk as suggested by Moerman and Van Dijk (2010) and the currency risk (e.g., De Santis and Gérard, 1998). In this case the conditional asset pricing model for partially segmented markets implies the following restriction for the expected return of asset i in the numeraire currency

$$E_t[r_{i,t+1}] = \lambda_{m,t+1}^w \text{Cov}_t(r_{i,t+1}, r_{m,t+1}^w) + \sum_{c=1}^C \lambda_{c,t+1} \text{Cov}_t(r_{i,t+1}, f_{c,t+1}) + \lambda_{m,t+1}^l \text{Cov}_t(r_{i,t+1}, r_{m,t+1}^l), \quad (4)$$

$$E_t[r_{i,t+1}] = \lambda_{m,t+1}^w \text{Cov}_t(r_{i,t+1}, r_{m,t+1}^w) + \sum_{c=1}^C \lambda_{inf,t+1} \text{Cov}_t(r_{i,t+1}, f_{c,t+1}) + \lambda_{m,t+1}^l \text{Cov}_t(r_{i,t+1}, r_{m,t+1}^l), \quad (5)$$

where $\lambda_{c,t+1}$ and $\lambda_{inf,t+1}$ is the conditional price of exchange rate risk and inflation risk respectively. $\text{Cov}_t(\cdot)$ is short-hand notations for conditional variance and covariance operators, all conditional on information Ω_t . Note that the price of exchange rate risk and inflation risk is not restricted to be positive.

2.2 Empirical formulation

To model the investors' conditional expectations we utilize the framework of De Santis and Gérard (1998), with the exception that we use constant price of risk specification instead of time varying, for simplicity and to attain convergence in the estimates (e.g., Saleem and Vaihekoski, 2008). The variance and covariance processes, however, are assumed to be time-varying. Our investigation proceeds from the point of view of an US investor, investing both in the domestic stock market, and emerging economies of Asia — in this case Korea, Malaysia and Taiwan. We estimate the model originally using five test assets: world equity market and equity market indices for the US, Korea, Malaysia and Taiwan. The currency returns and inflation differentials are also modelled. The full empirical model for excess returns in USD is the following:

$$r_{m,t+1}^w = \lambda_{m,t+1}^w h_{t+1}^w + e_{m,t+1}^w, \quad (6)$$

$$r_{m,t+1}^{US} = \lambda_{m,t+1}^w h_{t+1}^{US,w} + \lambda_{m,t+1}^{US} h_{t+1}^{US} + e_{m,t+1}^{US}, \quad (7)$$

³ The price of risk is sometimes also called as reward-to-risk, compensation for covariance risk, or aggregate relative risk aversion measure.

$$r_{m,t+1}^{K,M,T} = \lambda_{m,t+1}^w h_{t+1}^{K,M,T,W} + \lambda_{m,t+1}^{K,M,T} h_{t+1}^{K,M,T} + \lambda_{t+1}^{FX} h_{t+1}^{K,M,T,FX} + e_{m,t+1}^{K,M,T}, \quad (8)$$

$$r_{m,t+1}^{K,M,T} = \lambda_{m,t+1}^w h_{t+1}^{K,M,T,W} + \lambda_{m,t+1}^{K,M,T} h_{t+1}^{K,M,T} + \lambda_{t+1}^{INF} h_{t+1}^{K,M,T,INF} + e_{m,t+1}^{K,M,T}, \quad (9)$$

$$r_{t+1}^{FX} = \lambda_{m,t+1}^w h_{t+1}^{FX,w} + \lambda_{t+1}^{FX} h_{t+1}^{FX} + e_{m,t+1}^{FX}, \quad (10)$$

$$r_{t+1}^{INF} = \lambda_{m,t+1}^w h_{t+1}^{INF,w} + \lambda_{t+1}^{INF} h_{t+1}^{INF} + e_{m,t+1}^{INF}, \quad (11)$$

$$\boldsymbol{\varepsilon}_{t+1} \sim \text{IID}(\mathbf{0}, \mathbf{H}_{t+1}).$$

where lambdas are the conditional prices of risk and $\boldsymbol{\varepsilon}_{t+1}$ is a vector of stacked innovations, i.e., $\boldsymbol{\varepsilon}_{t+1} = [e_{m,t+1}^w, e_{m,t+1}^{\text{US}}, e_{m,t+1}^{K,M,T}, e_{m,t+1}^{FX}, e_{m,t+1}^{INF}]'$. $\mathbf{H}_{t+1}$ is the variance-covariance matrix. W stands for world, US, K, M and T represent US, Korean, Malaysian and Taiwan stock markets, while FX and INF stands for currency and inflation risk respectively. Equations (6)–(11) are the empirical counterparts to equations (1) to (5). In order to simplify the estimation process of $\boldsymbol{\varepsilon}_{t+1}$, we adopt the covariance stationary specification of Ding and Engle (1994), which has been utilized for example by De Santis and Gérard (1997, 1998):

$$\mathbf{H}_{t+1} = \mathbf{H}_0 \times (ii' - \mathbf{a}\mathbf{a}' - \mathbf{b}\mathbf{b}') + \mathbf{a}\mathbf{a}' \times \varepsilon_t \varepsilon_t' + \mathbf{b}\mathbf{b}' \times \mathbf{H}_t, \quad (12)$$

where $\mathbf{a}$ and $\mathbf{b}$ contain the diagonal elements of $\mathbf{A}$ and $\mathbf{B}$, respectively. $\mathbf{H}_0$ is the unconditional variance-covariance matrix. The parameters are estimated by maximum likelihood. Assuming conditional normality, and defining the residuals from equations (6)–(11) which yields the following time t log likelihood function (omitting the constant):

$$\ln L_t = -\frac{1}{2} \ln |\mathbf{H}_t| - \frac{1}{2} e_t' \mathbf{H}_t^{-1} \mathbf{e}_t. \quad (13)$$

Although asset returns are often non-normal, we choose the normal distribution. However, we use the quasi-maximum likelihood (QML) approach of Bollerslev and Wooldridge (1992) to calculate the standard errors. Given that the conditional mean and conditional variance are correctly specified, QML yields consistent and asymptotically normally distributed parameter estimates. Further, robust Wald statistics can straightforwardly be computed. We use the Berndt–Hall–Hall–Hausman (BHHH, 1974) algorithm for the optimization.

3 DATA

Our sample period begins from January 1988 and ends in December 2009. The beginning of the sample period is dictated by the availability of the MSCI data for Korea, Malaysia and Taiwan. We take the view of a US investor. Thus, all returns are measured in US dollars. As a proxy for U.S. investors' risk-free return measured in USD for month $t+1$, we use a one-month holding period return on Eurodollar in London. We use continuously compounded asset returns throughout the paper, since these returns more accurately describe price changes during volatile periods. All returns in estimations are in percentage – not decimal – form.

We employ three types of risk factors in our international asset pricing model to represent economic risks. Our first risk factor is the global market risk measured using the global equity market portfolio. Global market portfolio returns are proxied by the total return on the Morgan Stanley Capital International (MSCI) world equity market index with reinvested gross dividends. It has been commonly used in earlier studies. Our second source of risk is related to exchange rate changes. As a proxy for the exchange rate risk, one can test either a global (trade-weighted) currency index or a single bilateral currency exchange rate. In this paper we choose the latter approach in order to detect if the USD/WON, USD/Ringgits and USD/NT\$ exchange rate is relevant for the pricing of Korean, Malaysian and Taiwan stocks. If the US investors price consider the value of WON, Ringgits and NT\$ as source for

the currency risk, the exchange risk premium should be significant in the estimation. We use continuously compounded change in the U.S. dollar value of WON, Ringgits and NT\$ as a measure of the currency risk. Figure 1 shows the dynamics of exchange rates during the sample period.

Figure 1. Development of the monthly exchange rates from 1988 to 2009.

Finally, our third source of risk is related to inflation rate changes. As a proxy for the inflation risk we use US–Korean, US-Malaysian and US-Taiwan inflation differentials. If the US investors consider the inflation dynamics of Korea, Malaysia and Taiwan as an important source of risk, the inflation risk premium should be significant in the estimation. Figure 2 shows the dynamics of inflation during the sample period.

Figure 2. Development of the monthly inflation rates from 1988 to 2009.

Initially, we test the model using two assets in addition to the global market portfolio, namely the U.S. and Korean market portfolios as well as, U.S. and Malaysian and U.S. and Taiwan market portfolios. The U.S., Korean, Malaysian and Taiwan stock market returns are calculated from the MSCI total return indices. Figure 3 shows their development during the sample period.

We can see from the Figure 3 how the world and US stock markets go almost hand in hand whereas the Korean, Malaysian and Taiwan stock market shows clearly different behavior. All the emerging market has much higher volatility and the peaks which do not seem to happen at the same time in the world market.

Figure 3. Development of global, US and Local MSCI equity market indices in USD terms from 1988 to 2009. All indices are scaled to start from 100 (December 1987).

The difference can also be seen when one calculates the correlation between the world equity market and the national markets (see Figure 4). Over the whole sample, the correlation coefficient between the world and the USA market returns is 0.88, whereas the same number for the Korea, Malaysia and Taiwan is only 0.52, 0.44 and 0.40 respectively.

Figure 4. 24-month rolling correlation between the world equity market return and the US, Korea, Taiwan, Thailand and Malaysian stock market returns respectively.

3.1 Descriptive statistics

Table 1 contains summary statistics for the monthly risk factor and test asset returns. Panel A in Table 1 reports mean, standard deviation, skewness and kurtosis. To check the null hypothesis of normal distribution we calculate Jarque-Bera test statistic. The p -values are presented in the Table. In addition, we calculate ARCH-LM test statistics to check the ARCH effect in all the series. Finally, to investigate whether the autocorrelation coefficients up to twelve lags are zero, we compute Ljung and Box (1978) test statistic for each return series.

The index of kurtosis demonstrates that the unconditional distribution of asset returns has thicker tails than the standard for all the risk factors in our sample. The Jarque-Bera test-statistics also specify that the hypothesis of normality is rejected in all cases. The lack of statistically significant autocorrelations in the return series and Ljung and Box (1978) test statistics, and ARCH –LM test statistics might lead us to believe that market indexes need not to correct for spurious autocorrelation and GARCH specification used in our study is warranted. Panel B reports pair wise correlations among asset returns. All correlations in the table are below 0.5 except the correlation between USA and world (the value is 0.88) and Korea and world (the value is 0.52). Further, we found very low correlations between the exchange rates and inflation differentials.

Table 1. Descriptive statistics for the monthly asset returns.

Descriptive statistics are calculated for the monthly asset continuously compounded returns. The global market portfolio, US market return, Taiwan market return, Thailand market return, Korean market return and Malaysian market return are proxied by the Morgan Stanley Capital International (MSCI) world, and national market equity index. All returns are calculated in USD and they include dividends (i.e., total return). Exchange rates are the logarithmic difference in the USD value of every country's currency. Inflation differentials are the difference between US inflation and local market inflation rates. The risk-free rate is proxied by the one month Eurodollar rate. The mean and standard returns are annualized (multiplied with 12 and the square root of 12, respectively). The sample size is 264 monthly observations from January 1988 to December 2009. The *p*-value for the Jarque-Bera, ADF, Q-statistics and ARCH-LM test statistic of the null hypothesis of normal distribution, stationarity, autocorrelation and ARCH effects is provided in the table.

Panel A: Summary statistics

	Mean	Std. dev.	Skewness	Kurtosis	J-B test	ADF	Q-Stat	ARCH-LM
World market portfolio	6.938	7.293	-0.898	5.257	0.000	0.000	0.685	0.000
USA	9.232	7.192	-0.835	4.810	0.000	0.000	0.431	0.000
Taiwan	6.195	11.379	-0.080	4.259	0.000	0.000	0.081	0.013
Korea	7.003	11.478	0.190	5.629	0.000	0.000	0.866	0.000
Malaysia	7.895	10.136	-0.259	6.983	0.000	0.000	0.000	0.026
Korean won to 1 us \$	-0.018	0.693	-3.038	33.644	0.000	0.000	0.182	0.000
Malaysian ringgits to 1 us \$	-0.014	0.541	0.881	34.577	0.000	0.000	0.247	0.000
Taiwan \$ per us\$	-0.005	0.395	-0.503	7.623	0.000	0.000	0.000	0.005
Inflation differentials- US-Taiwan	0.111	0.442	-0.324	2.745	0.069	0.061	0.000	0.000
Inflation differentials- US-Korea	-0.201	0.499	-0.423	2.992	0.019	0.084	0.000	0.000
Inflation differentials- US-Malaysia	0.009	0.463	-0.497	3.037	0.004	0.077	0.000	0.000
Risk-free rate (Eurodollar)	3.838	1.299	-0.215	2.389	0.047	0.000	0.000	0.000

Panel B: Pairwise correlations - Equity

	World	USA	Taiwan	Korea	Malaysia
World market portfolio	1.000	0.879	0.401	0.524	0.440
USA		1.000	0.364	0.443	0.373
Taiwan			1.000	0.370	0.416
Korea				1.000	0.360
Malaysia					1.000

Panel B: Pairwise correlations – Exchange and inflation rates

	won	ringgits	Twon \$	us_twn	us_kor	us_mla
Korean won to 1 us \$	1.000	0.180	0.347	-0.029	-0.087	0.009
Malaysian ringgits to 1 us \$		1.000	0.390	-0.062	-0.028	-0.013
Taiwan \$ per us\$			1.000	-0.033	-0.040	0.068
Inflation differentials- US-Taiwan				1.000	0.390	0.444
Inflation differentials- US-Korea					1.000	0.371
Inflation differentials- US-Malaysia						1.000

In summary, the descriptive statistics of our data set suggest that emerging markets included in this study offer an attractive opportunity to U.S. investors to diversify their portfolios internationally and a GARCH parameterization might be appropriate to explain the different sources of risks associated with Korean, Malaysian and Taiwan stock market.

4 EMPIRICAL RESULTS

We begin our investigation by testing the international CAPM which assumes full integration between global and local stock markets. As a result, we have only one source of risk, the global market risk. This corresponds to equation (2). Next we modify our model to allow partial segmentation specification, where the U.S. and other markets are assumed to be partially segmented to the world market. This corresponds to equation (3). Finally, to test whether inflation risk and exchange rate risk, a source of local market risks, are priced in the Taiwan, Malaysian and Korean stocks we add the inflation risk and currency risk component into our partially segmented model, i.e. equation (5) and (4). The prices of risk are assumed to be constant, whereas the variance and covariance terms are time-varying⁴, meaning that even if the conditional risk free rate and conditional mean standard deviation frontier

⁴ This restriction has been imposed in many studies of the conditional CAPM (e.g., Giovannini and Jorion 1989; Chan *et al.* 1992).

can vary in every period, the slope of capital market line is fixed (e.g., De Santis and Imrohorglu, 1997). In practice, we test the model using three assets in addition to the global market portfolio, inflation differentials and bilateral exchange rates, namely the U.S. and Taiwan, Malaysian and Korean market portfolios. Table 2, 3 and 4 shows the results for Taiwan, Malaysia and Korea respectively.

We find the global price of risk to be positive and statistically significant in all the markets under investigation, which is consistent with the theory of risk aversion and corresponds to De Santis and Gérard (1998) who also found the unconditional market price of risk to be positive. However, unlike them but similar to Saleem and Vaihekoski (2010), we found the price of world risk parameter to be significant⁵ which shows that the world market risk is priced using market data from the US and the emerging markets of Asia. Results from partial segmentation specification show that local market price of risk for Korea is highly significant (p -value 0.004), indicating that a partially segmented asset pricing specification is better suited for at least Korean market. In line with the previous research (e.g., De Santis and Gérard, 1998), the same parameter for the USA is negative and insignificant (p -value 0.612); indicating that the local risk is not needed to price US stocks. Interestingly the asset specific risk coefficients for both Taiwan and Malaysian market are found insignificant, 0.006 (p -value 0.215) and 0.003 (p -value 0.757) respectively. Thus, market specific risk does not seem to be priced on either of the markets using the unconditional approach. This suggests that one should treat inflation risk and/or currency risk as a separate local risk factors as recommended by Carrieri *et al.* (2006). As stated before, the inflation risk and exchange rate has played an important role in the Taiwan, Malaysian and Korean economy and their companies as well as for the investors. This suggests *a priori* that the inflation risk and currency risk may be priced in the Taiwan, Malaysian and Korean stock market. To test this, we add the inflation risk and currency risk component into our partially segmented model and found both inflation risk and currency risk priced and highly significant in all the markets. Indicating that both inflation risk and exchange rate exposure, to some extent, are non-diversifiable (systematic risk) and investors should be rewarded for bearing such risk. Thus, our results have direct implications for both investors and corporations interested to invest in emerging markets or diversify their portfolios internationally, by making hedging strategies inevitable. Since, any source of risk which is not compensated in terms of expected returns should be hedged.

Panel B of Table 2, 3 and 4 shows some diagnostic test statistics for the standardized residuals. The results show that simple ICAPM is misspecified and need to consider the local market effect as well. With the inclusion of inflation and currency risk as local market risk factors, the model performs better; one fact is the disappearances of misspecification in mean standardized residual for simple ICAPM (results not reported). This also indicates that the partially segmented model is better specified if market specific risk is included. The coefficients of skewness and excess kurtosis in all cases are lower than the corresponding values reported in Table 1, but still significant. The variance parameters (a_i , b_i) are highly significant, making the variance process clearly time-varying. Moreover, in line with earlier studies variance process exhibit high persistence and the estimates of the b_i coefficients (which connect second moments to their lagged value) are significantly larger than the resultant estimates of the a_i 's (which connect second moments to their past innovations). Same is true for Jarque-Bera statistic which rejects the normality of the residuals for all markets.⁶ Due to the fact that GARCH parameterization can accommodate some of the kurtosis in the data, we can use QML testing procedure as suggested by previous studies (e.g., De Santis and Gérard, 1998). We also compute the Ljung-Box portmanteau statistic for each series to test the hypothesis of absence of autocorrelation up to order 12. The tests show that the null hypothesis cannot be rejected and that the GARCH (1, 1) parameterization that we adopt is satisfactory.

⁵ De Santis and Gérard (1998) used 8 different country and forex indices, and mentioned that the little explanatory power of δ_m is due to the cross section of returns that they used in their study (page. 389).

⁶ As robustness check model is also estimated under the assumption of a multivariate t -distribution for the residuals. It allows for thicker-than-normal tails, and a higher excess kurtosis. The results are in line with those reported in Table 2,3 and 4.

Table 2. Conditional partially segmented world APM with constant prices of global, local currency, and inflation risk for Taiwan.

Quasi-maximum likelihood estimates of the conditional international CAPM with constant price of world covariance risk and constant price of currency and inflation risk where the U.S. and Taiwan are assumed to be partially segmented to the world market. $\lambda_{m,t+1}^w$ denote the price of world covariance risk, $\lambda_{m,t+1}^l$ price of local risk and $\lambda_{c,t+1}$ price of currency and inflation risk, a and b are 4×1 vector of constants and i is an 4×1 unit vector. The sample size is 264 monthly observations from January 1988 to December 2009. QML standard errors are provided in parentheses below parameter estimates. Coefficients significantly (10%, 5% different from zero are marked with (*), (**)).

	currency risk				inflation risk			
	U.S.	Taiwan	Δ Twn \$/S	World	U.S.	Taiwan	INFD	World
<i>Panel A: Parameter estimates</i>								
World market price of risk, λ_w				0.037** (0.0120)				0.0262** (0.0115)
Price of currency risk, λ_{fx}			-0.187** (0.0430)					
Price of inflation risk, λ_{inf}							0.1622** (0.0425)	
Local market price of risk, λ_l	-0.0012 (0.0035)	0.0061 (0.0049)			0.0025 (0.004)	-0.0014 (0.0054)		
<i>ai</i>	0.291** (0.032)	0.195** (0.035)	0.399** (0.088)	0.258** (0.033)	0.299** (0.028)	0.224** (0.034)	0.549** (0.102)	0.278** (0.03)
<i>bi</i>	0.948** (0.011)	0.977** (0.009)	0.794** (0.077)	0.959** (0.011)	0.945** (0.01)	0.971** (0.01)	-0.366 (0.31)	0.953** (0.011)
<i>Panel B: Diagnostic tests</i>								
Average standardized residual	0.027	-0.034	-0.061	-0.042	0.038	-0.034	0.122	-0.029
Standard deviation of z	1.03	0.99	0.98	1.04	1.03	1.01	0.97	1.04
Skewness of z	-0.76**	-0.03	0.07	-0.85**	-0.78**	0	-0.26*	-0.82**
Excess kurtosis of z	1.34**	0.64**	2.47**	1.64**	1.42**	0.69**	-0.24	1.66**
J-B-test for normality	43.63**	4.02**	63.38	59.03**	46.94	4.73	3.68	58.11
Q(12)	31.58	35.9*	63.2**	23.9	32.22	36.74*	868.82**	24.93
Q ² (12)	18.67	20.68	25.51	16.14	18.75	18.33	33.74	13.64
Absolute mean pricing error	0.018	0.385	0.087	0.241	0.45	0.196	0.604	0.258
Likelihood function			-2648.3490				-2722.1646	

Table 3. Conditional partially segmented world APM with constant prices of global, local currency and inflation risk for Malaysia.

Quasi-maximum likelihood estimates of the conditional international CAPM with constant price of world covariance risk and constant price of currency and inflation risk where the U.S. and Malaysia are assumed to be partially segmented to the world market. $\lambda_{m,t+1}^w$ denote the price of world covariance risk, $\lambda_{m,t+1}^l$ price of local risk and $\lambda_{c,t+1}$ price of currency and inflation risk, a and b are 4×1 vector of constants and i is an 4×1 unit vector. The sample size is 264 monthly observations from January 1988 to December 2009. QML standard errors are provided in parentheses below parameter estimates. Coefficients significantly (10%, 5% or 1%) different from zero are marked with (*), (**) or (***)

	currency risk				inflation risk			
	U.S.	Malaysia	Δ Ringg/\$	World	U.S.	Malaysia	INFD	World
<i>Panel A: Parameter estimates</i>								
World market price of risk, λ_w				0.0252** (0.0124)				0.0191* (0.0101)
Price of currency risk, λ_{fx}				-0.046** (0.0131)				
Price of inflation risk, λ_{inf}							-0.031* (0.0169)	
Local market price of risk, λ_l	-0.0007 (0.0036)	0.0026 (0.0085)			-0.0008 (0.0045)	0.0061 (0.0121)		
<i>ai</i>	0.292** (0.03)	0.395** (0.046)	0.597** (0.067)	0.276** (0.03)	0.244** (0.027)	0.362** (0.036)	0.821** (0.07)	0.251** (0.026)
<i>bi</i>	0.945** (0.01)	0.887** (0.03)	0.776** (0.069)	0.951** (0.011)	0.961** (0.007)	0.906** (0.023)	0.365* (0.221)	0.961** (0.009)
<i>Panel B: Diagnostic tests</i>								
Average standardized residual	0.055	0.042	-0.207	-0.011	0.055	-0.007	-0.042	0.01
Standard deviation of z	1.02	0.98	0.9	1.03	1.02	0.96	0.96	1.04
Skewness of z	-0.76**	-0.43**	-1.03**	-0.8**	-0.83**	-0.53**	0.06	-0.87**
Excess kurtosis of z	1.28**	2.18**	9.03**	1.47**	1.7**	2.35**	-0.42	1.78**
J-B-test for normality	41.47**	57.26**	905**	50.07**	60.09**	69.49**	2.22	65.95**
Q(12)	30.94	39.23	57.85	23.94	29.36	42.99*	1081.8*	23.36
Q ² (12)	20.18	30.13	20.92	14.55	22.56	22.41	10.74	16.31
Absolute mean pricing error	0.149	0.138	-0.169	-0.117	0.17	-0.383	-0.159	-0.09
Likelihood function			-2576.3352				-2609.0373	

In summary, the empirical analysis suggests a partially segmented model with inflation and currency risk as a separate risk factor is best suitable for Taiwan, Malaysian and Korean stock market and a GARCH parameterization seems to be appropriate to explain the different sources of risks associated with these markets.

Table 4. Conditional partially segmented world APM with constant prices of global, local currency and inflation risk for Korea.

Quasi-maximum likelihood estimates of the conditional international CAPM with constant price of world covariance risk and constant price of currency and inflation risk where the U.S. and Korea are assumed to be partially segmented to the world market. $\lambda_{m,t+1}^w$ denote the price of world covariance risk, $\lambda_{m,t+1}^l$ price of local risk and $\lambda_{c,t+1}$ price of currency and inflation risk, a and b are 4×1 vector of constants and i is an 4×1 unit vector. The sample size is 264 monthly observations from January 1988 to December 2009. QML standard errors are provided in parentheses below parameter estimates. Coefficients significantly (10%, 5% or 1%) different from zero are marked with (*), (**) or (***)

	currency risk				inflation risk			
	U.S.	Korea	Δ Won/\$	World	U.S.	Korea	INFD	World
<i>Panel A: Parameter estimates</i>								
World market price of risk, λ_w				0.0253* (0.0136)				0.0147 (0.0106)
Price of currency risk, λ_{fx}			-0.0055 (0.0146)					
Price of inflation risk, λ_{inf}							-0.1009** (0.0311)	
Local market price of risk, λ_l	-0.002 (0.004)	0.0147** (0.005)			-0.0008 (0.0055)	0.031** (0.0098)		
ai	0.284** (0.03)	0.272** (0.119)	0.498** (0.151)	0.247** (0.034)	0.277** (0.026)	0.475** (0.079)	0.475** (0.052)	0.268** (0.025)
bi	0.949** (0.009)	0.929** (0.023)	0.818** (0.168)	0.958** (0.01)	0.945** (0.008)	0.787** (0.097)	0.849** (0.026)	0.948** (0.009)
<i>Panel B: Diagnostic tests</i>								
Average standardized residual	0.044	-0.192	-0.196	-0.032	0.05	-0.317	-0.310	0.003
Standard deviation of z	1.02	0.94	0.8	1.02	1.01	0.92	0.88	1.02
Skewness of z	-0.79**	-0.37**	-1.38**	-0.87**	-0.8**	-0.24	0.22	-0.83**
Excess kurtosis of z	1.46**	1.06**	7.97**	1.76**	1.53**	0.46	-0.92**	1.61**
J-B-test for normality	48.82**	17.13**	752.03**	65.09**	51.8**	4.53	11.56**	56.8**
Q(12)	29.74	24.23	54.95**	23.39	27.41	28.16	1229.1**	23.06
Q ² (12)	19.57	40.91	54.99	16.9	0.16	-3.757	-0.751	-0.05
Absolute mean pricing error	0.107	-1.991	-0.523	-0.186	27.41	28.16	1229.1	23.06
Likelihood function			-2792.8069				-2726.9552	

5 SUMMARY AND CONCLUSIONS

In this paper we study the international asset pricing models and the pricing of local market risks, particularly, inflation risk and currency risk in the Korean, Malaysian, and Taiwan stock markets using monthly data from 1988 to 2009. We take the view of a US investor investing both domestically and internationally. All returns are expressed in US dollars. The stock markets included in the study offer an interesting test laboratory for many aspects of the international asset pricing models. The sample period includes, for example, a gradual liberalization of the Korean, Malaysian, and Taiwan financial markets and several currency regimes, and the different episodes of financial crisis, such as, Asian financial crisis of 1997, Russian financial crisis of 1998 and more recently the subprime crisis in the US.

In our empirical specification, we utilize the multivariate GARCH-M framework of De Santis and Gerard (1998), allowing a time-varying variance-covariance process. We estimate the conditional fully integrated world CAPM and partially segmented asset pricing models with constant prices of global and local risk. Finally, we add inflation and currency risk, as local sources of risks to our model.

The results show that the world market risk is priced on Korean, Malaysian, Taiwan, and US stock markets, which is in line with De Santis and Gérard (1998). As local market risk, we find the currency and inflation risk to be also priced on Korean, Malaysian, and Taiwan market. Finding the local market risk relevant for the pricing of Korean, Malaysian, and Taiwan stocks gives further evidence that one should consider partially segmented asset pricing models for emerging stock markets.

The results show that the role and the modeling of the inflation risk and currency risk in open economies with emerging stock markets need further research. Moreover, when global asset pricing models are tested using data from countries with clear evidence of segmentation, it could be more appropriate to model the integration as a dynamic process with local influence. These questions are left for future study.

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