Do Speculative Bubbles Crowd Out International Equity Flows? – Some Empirical Evidence for South-East Asia

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Abstract

We analyzed the links between international equity flows and speculative bubbles in the equity markets of six South-East Asian countries over the period 1991–2006. Based on a cointegration analysis, we found significant equilibrium cointegration links between international equity flows and speculative bubbles. Before the Asian economic and financial crisis, an increase in speculative bubbles was accompanied by a decrease in net equity outflows. Our results are consistent with theories that predict that speculative bubbles absorb domestic savings and, thereby, crowd out capital outflows from financially underdeveloped countries.

JEL classification: F37, G15
Keywords: Speculative bubbles; International equity flows; South-East Asia; Cointegration analysis

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1 Introduction

A key manifestation of the globalization of the world's economy and the increasing international interdependence of financial markets is the significant increase in international capital flows since the mid 1990s. International investments offer investors the possibility to invest in a rich portfolio of international securities, and to diversify the risk of such investments. Recent economic and financial crises, however, have led to concerns that international capital flows may foster speculative asset price bubbles in underdeveloped financial markets, and that capital flow reversals may contribute to economic and financial fragility. In case of the Asian economic and financial crisis of 1997, the potentially vicious interplay of reversible international capital flows, underdeveloped financial markets, and speculative asset price bubbles has been analyzed by Jones (1999), Sarno and Taylor (1999b), and Edison et al. (2000), to name just a few.

Our research contributes to the literature on the sources of the Asian economic and financial crisis. The focus of our research is on the equilibrium relation between U.S. international equity flows and speculative bubbles in the equity markets of South-East Asian countries during the sample period from 1991 to 2006. While recent developments of asset prices and capital flows to South-East Asian countries have been analyzed in earlier literature (Kim and Yang 2009a, 2009b), we go beyond earlier literature by focusing on speculative bubbles. Sarno and Taylor (1999b) report strong evidence of speculative bubbles in East-Asian equity markets. In order to measure speculative bubbles in equity markets, we estimated an empirical model that allows equity market indexes to be decomposed into fundamentals and speculative bubbles (Wu 1995, 1997). We then used our estimates of speculative

bubbles in a cointegration analysis to analyze the significance and sign of a potential equilibrium cointegration relation between speculative bubbles and international equity flows. We also analyzed how the equilibrium cointegration relation changed from the pre-crisis to the post-crisis subsample period. Our focus on an equilibrium cointegration relation between speculative bubbles and international equity flows adds a new aspect to the large and significant earlier literature on dynamic links between international equity flows, equity returns, and other economic and financial variables (Choe et al. 1999, Froot et al. 2001, Bekaert et al. 2002, and Lin and Swanson 2004). Taylor and Sarno (1997) and Mody et al. (2001) show that a cointegration analysis provides a useful framework to model international capital flows.

We analyzed data for six South-East Asian countries (Indonesia, South Korea, Malaysia, the Philippines, Singapore, and Thailand). For the pre-crisis subsample period, the results of our cointegration analysis suggest that, net capital outflows tended to decrease when speculative bubbles in South-East Asian equity markets gathered steam. This negative correlation between speculative bubbles and net capital outflows is consistent with predictions of a model recently developed by Caballero and Krishnamurthy (2006). In their model of a financially underdeveloped emerging market economy, a stochastic rational speculative bubble provides agents with a store of value and solves a dynamic inefficiency problem. Because a speculative bubble absorbs domestic savings, net capital outflows decrease.

In sum, our research goes beyond earlier literature because (i) we studied the correlation between international equity flows and speculative bubbles rather then the correlation between international equity flows and equity market

indexes, (ii) we studied the long-run equilibrium cointegration relation between speculative bubbles and international equity flows, and, (iii) we used the model developed by Caballero and Krishnamurthy (2006) to motivate our empirical analysis and to put our empirical results into perspective.

We organize the remainder of this paper as follows. In Section 2, we describe the theoretical background for our empirical research in more detail and derive the hypothesis we tested in our empirical research. In Section 3, we describe the empirical model that we used to identify speculative bubbles. We also present the estimated speculative bubbles. In Section 4, we describe how we used the techniques of cointegration analysis to test for a potential equilibrium cointegration relation between speculative bubbles and international equity flows, and we present our empirical results. In Section 5, we offer some concluding remarks.

2 Theoretical Background

Why should one be interested in the equilibrium relation between speculative bubbles and international equity flows? A useful theoretical model to think about this question has been developed recently by Caballero and Krishnamurthy (2006). They consider an overlapping generations model of a fast-growing emerging market economy. Young agents are endowed with an internationally traded good, which they can invest abroad at a low world interest rate. Old agents act as entrepeneurs or bankers. Bankers lend the international good to entrepreneurs. Entrepeneurs instantaneously repay loans in terms of a perishable domestic good, which implies that neither young agents nor foreign investors participate in the loan market. Lending

takes place only between old contemporaneous market participants. The economy thus is financially underdeveloped.

In a fast-growing emerging market economy, the growth rate of young agents' endowment exceeds the low world interest rate. With regard to economic developments in South-East Asia before the economic and financial crisis of 1997, this fast-growth scenario is empirically plausible. In the fast-growth scenario, the economy is dynamically inefficient and young agents invest too much of their endowment abroad. Net capital outflows are inefficiently high. It would be socially optimal if young agents would lend at a high interest rate their fast-growing endowment of the international good directly to old agents, with the promise to receive, when being old, the endowment from the then young agents. Given the overlapping generations structure of the model, such an intergenerational contract is not enforceable.

Caballero and Krishnamurthy (2006) then introduce an unproductive and irreproducible asset into their model. The unproductive nature of the asset implies that any positive price of this asset is a speculative bubble. The rational equilibrium price of the unproductive asset hinges on agents expectations that future generations also will demand the asset. In case this coordination across generations fails, the rational speculative bubble bursts and the young invest their endowment abroad. Net capital outflows increase after the crash, domestic credit collapses, and investment by entrepeneurs falls. In contrast, as long as the coordination across generations continues, the speculative bubble provides young agents with a domestic store of value, and net capital outflows decrease. The model thus predicts a negative equilibrium relation between speculative bubbles and net capital outflows. In our empirical analysis, we used the techniques of cointegration analysis to analyze whether data for six South-East Asian countries are consistent

with such a negative equilibrium relation and, if so, whether the equilibrium cointegration relation was stable over time.

As long as there is a positive probability that coordination across generations fails, the presence of the unproductive asset not only gives rise to a rational speculative bubble, but to a *stochastic* rational speculative bubble. Consistent with the theoretical model, we used an empirical model of stochastic rational speculative bubbles to decompose South-East Asian equity markets indexes into "fundamentals" and speculative bubbles. Our empirical model parallels the theoretical model in that our empirical model assumes absence of arbitrage opportunities. Also in line with the theoretical model, the empirical model assumes that market participants form rational expectations.

Finally, it should be mentioned that, in the model developed by Caballero and Krishnamurthy (2006), a speculative bubble comes at a cost. In case a speculative bubble bursts, the economy experiences a sharp capital flow reversal, a collapse of domestic credit, and a drop of investment. A fragile speculative bubble thus can be welfare reducing, where preemptive government policies can force optimal investment in the bubble asset. One such policy is capital inflow sterilization, provided the government has enough tax power. The model developed by Caballero and Krishnamurthy (2006) shows that limited tax power implies that the government can only implement small sterilizations. Alternatively, the government can only use low-returns bonds to implement sterilizations, where a higher return on the bubble asset inflates the required taxes.

3 Speculative Bubbles in South-East Asia

In Section 3.1, we lay out the empirical model that we used to decompose equity market indexes into fundamentals and speculative bubbles. In Section 3.2, we present the estimation results.

3.1 Modeling Speculative Bubbles

Modeling speculative bubbles in stock markets is a delicate and controversial task. In the earlier literature, several empirical models have been developed that render it possible to test for speculative bubbles (for a recent survey, see Gurkaynak 2008). We used in our empirical analysis a model suggested by Wu (1995, 1997). This model is well-established in the literature on speculative bubbles, and it is easy to implement and provides time-series estimates of speculative bubbles. In addition, the estimated speculative bubbles are consistent with the absence of arbitrage opportunities and with rational expectations on the side of market participants. The estimated speculative bubbles follow an asymptotically explosive process, but also feature a stochastic disturbance term. The presence of the stochastic disturbance term implies that the model can be used to measure stochastic rational speculative bubbles, as in the theoretical model described in Section 2. In contrast to the trajectories of explosive deterministic speculative bubbles, the trajectories of stochastic rational speculative bubbles feature phases of extensive growth, occasional eruptions, and periods of collapses. Another attractive feature of the empirical model is that it renders it possible to apply the simple textbook present-discounted value model of stock price determination to decompose stock prices into fundamentals and speculative bubbles.

The present-discounted value model implies that the real stock price, P_t, can be expressed as the expected present value of next period's real stock price and real dividends, D_t. The model gives rise to the following valuation equation:

$$P_t = \mathbb{E}_t \left(P_{t+1} + D_t \right) / \left(1 + R \right), \tag{1}$$

where $\mathbb{E}_t$ denotes the conditional expectations operator and R denotes the required real rate of return. Upon letting lowercase letters denote the natural logarithm of a variable, a loglinearized version of Equation (1) is given by (Campbell et al. 1997):

$$p_t = \kappa - r + \phi \mathbb{E}_t \left(p_{t+1} \right) + (1 - \phi) d_t, \tag{2}$$

where $\kappa = -\log(\phi) - (1-\phi)\log(1/\phi - 1)$ and $\phi = 1/\left(1 + \exp(\overline{d-p})\right)$. The term $\overline{d-p}$ denotes the steady-state log dividend-price ratio. The current real stock price thus is a weighted average of the expected next-period real stock price and real dividends, plus a constant.

The fundamental rational expectations stock price, p_t^f, can be derived upon invoking a transversality condition. Forward-iteration of Equation (2) then yields the following solution:

$$p_t^f = (\kappa - r)/(1-\phi) + (1-\phi)\mathbb{E}_t \sum_{j=0}^{\infty} \phi^j d_{t+j}, \tag{3}$$

The fundamental rational expectations stock price is determined in terms of the present-discounted value of the expected stream of dividends, plus a constant. In the remainder of this paper, we use the term "fundamentals" to denote the fundamental rational expectations stock price. Computation of

the expected future stream of real dividends is made possible by assuming an autoregressive model for the dynamics of demeaned real dividends:

$$\Delta d_t = \sum_{j=1}^{n} \varphi_j \Delta d_{t-j} + u_t, \tag{4}$$

where $n = 1, 2, ...$, and the normally distributed mean-zero stochastic disturbance term, u_t, has variance σ_u^2. We used the first-difference operator, Δ, to express the model in first differences because real stock prices and real dividends are nonstationary. We found that a parsimonious AR(2) model suffices to capture the main elements of the dynamics of real dividends.

The actual real stock price can differ from fundamentals in case the transversality condition does not hold. If the transversality condition does not hold, a rational speculative bubble, b_t, can arise. The resulting equilibrium real stock price then can be expressed as the sum of fundamentals and the speculative bubble, $p_t = p_t^f + b_t$. The speculative bubble is consistent with rational expectations and the absence of arbitrage opportunities provided it satisfies the condition $\mathbb{E}_t b_{t+j} = (1/\phi)^j b_t$. The following standard parameterization of a stochastic rational speculative bubble satisfies this condition:

$$b_t = (1/\phi)\, b_{t-1} + \epsilon_t, \tag{5}$$

where $0 < \phi < 1$ and ϵ_t denotes a normally distributed mean-zero stochastic disturbance term with variance σ_ϵ^2. The stochastic disturbance terms, ϵ_t and u_t, are mutually independent. Upon inserting Equation (5) into Equation (2) and noting that the actual real stock price is the sum of fundamentals and the speculative bubble, it is straightforward to show that the speculative bubble constitutes a rational-expectations solution to the present-discounted value model of stock price determination.

The set of parameters to be estimated contains the autoregressive parameters in Equation (4), the parameter, ϕ, that governs the dynamics of the speculative bubble, and the variances of the disturbance terms in Equations (4) and (5). The parameters can be estimated by writing the model in state-space form (Wu 1995, 1997, Bhar and Hamori 2005, Chapter 12). Kim and Nelson (2000, Chapter 3) describe how the parameters of a model written in state-space form can be estimated by means of the Kalman-filter model.

3.2 Estimated Speculative Bubbles

In order to estimate the parameters of the state-space model, we retrieved from Thompson Financial Datastream monthly data on equity market indexes and dividend yields for the sample period from 1991 to 2006. Because of the U.S. subprime mortgage crisis, we deliberately kept out from our analysis data since 2007. Our choice of sample period also ensures that our analyses of the pre-crisis subsample period (before the Asian economic and financial crisis of 1997) and the post-crisis subsample period (Section 4) can be based on a comparable number of observations. We computed dividends by multiplying the Datastream-estimated dividend yield with the lagged stock market index. We converted all national equity market indexes and dividends to U.S. dollars. In order to compute real equity market indexes and real dividends, we used the U.S. consumer price index as a deflator. In order to make cross-country comparisons possible, we scaled the equity market indexes to assume the value 100 at the beginning of the sample period.

– *Include Figure 1 about here.* –

Figure 1 shows that the equity market indexes substantially increased in the years before the Asian economic and financial crisis. The equity markets of

Thailand and the Philippines experienced the largest increases. The Asian economic and financial crisis of 1997 led to a sharp collapse of the equity market indexes. While the equity market indexes partially recovered after the crisis, their performance was much worse than before the crisis. Only the equity market indexes of Singapore and South Korea again reached levels that are comparable to the levels before the Asian economic and financial crisis, but only at the end of the sample period.

Table 1 summarizes the estimation results for the state-space model. We present results for the six South-East Asian countries and for the United States. We estimated the state-space model for the United States because the speculative bubble for the United States served as a control variable in the cointegration analysis we shall present in Section 4. The parameters of the AR(2) process that captures the dynamics of real dividends are statistically significant. The estimation results further show that the parameter ϕ exceeds unity in all South-East Asian countries, where the model of speculative bubbles implies that the parameter ϕ should satisfy the restriction $0 < \phi < 1$. The estimated parameter ϕ satisfies this restriction only in case of the United States. In order to account for the restriction on the parameter ϕ implied by our model of stochastic rational speculative bubbles, we estimated a restricted version of the model in which this restriction by construction always holds. We invoked the restriction by using the transformation $\phi = 1/(1 + \exp(-\mu))$, where μ denotes an auxiliary parameter to be estimated. The restricted parameter ϕ is always close to unity.

– Include Table 1 about here. –

Figure 2 summarizes the estimated speculative bubbles in terms of the Kalman-filtered (log) bubble-price ratios, which approximate the information available to an investor at the time an investment decision must be

reached. The bubble-price ratios start at zero in all countries because, for both the estimated speculative bubbles and the equity market indexes, we chose a base level of 100 in 1991/3. We present the bubble-price ratios because our model of speculative bubbles implies that fundamentals are, by definition, equal to the real stock price minus the estimated speculative bubble. The autoregressive process given in Equation (4) implies that fundamentals have a unit root. It then follows that the bubble-price ratio also has a unit root. The unit-root property of the bubble-price ratio is useful for the cointegration analysis we shall present in Section 4. The cointegration analysis requires that all variables under consideration have the same degree of integration.

– *Include Figure 2 about here.* –

A perhaps surprising result shown in Figure 2 is that the bubble-price ratios showed no signs of a sharp drop during the months of the crisis. In fact, the bubble-price ratios on average *increased* in 1997 and 1998. In order to understand the dynamics of the bubble-price ratios, it should be recalled that, in the context of our model of speculative bubbles, speculative bubbles are defined in terms of the difference between the actual equity market index and the estimated fundamentals. The dynamics of the bubble-price ratios during the Asian economic and financial crisis, therefore, are a mirror image of the deterioration of fundamentals. The deterioration in fundamentals, in turn, reflects the economic turmoil caused by the financial market jitters that were characteristic of the crisis months.

Another important result conveyed by Figure 2 is that the bubble-price ratios in Indonesia, South Korea, and Thailand substantially increased after the Asian economic and financial crisis and peaked in 1999. South Korea, Indonesia and Thailand are also known as the "KIT economies", and studies

of the Asian economic and financial crisis often focus on one or the other of these "core" countries (see, for example, Edison et al. 2000). The increase in the bubble-ratios in the KIT economies reflect that, in terms of fundamentals, these countries were hit particularly hard by the crisis. The bubble-price ratios in Malaysia, Singapore, and the Philippines increased to a lesser extent.

It should be emphasized that increases in the bubble-price ratios do not imply that speculative bubbles did not burst during the Asian economic and financial crisis. In fact, speculative bubbles in South-East Asian equity markets did burst during the crisis. For example, our model implies that the speculative bubbles in the three KIT economies decreased from January 1997 to December 1997 by -56%, 70%, and 61%, respectively. In order to understand these numbers, it should be recalled, once again, that the bubble-price ratio is a ratio, and its dynamics reflect the dynamics of its constituents. The bubble-price ratio increases if the nominator (speculative bubbles) decreases to a lesser extent than the denominator (equity market index). An increase in the bubble-price ratio is, therefore, compatible with a decrease in speculative bubbles during the Asian economic and financial crisis.

It should also be recalled that we converted the data to real dollars. Because the exchange rates of the South-East Asian countries depreciated during the Asian economic and financial crisis (beginning with the collapse of the dollar peg of the Thai baht in July 1997), movements of the bubble-price ratios also reflect a valuation effect caused by exchange-rate depreciation. Because exchange rates stabilized and even started appreciating in the years after the Asian economic and financial crisis, a valuation effect also explains in part the decreases in the bubble-price ratios that are characteristic of

the post-crisis period. The decreasing bubble-price ratios of the post-crisis period, however, also reflect overall economic recovery and recovery of local-currency dividend yields, resulting in a strengthening of fundamentals in the context of our model of speculative bubbles.

4 Cointegration Analysis

In Section 4.1, we describe the methodology that we used to test for equilibrium cointegration relations. In Section 4.2, we briefly describe the data on international equity flows. We also describe the control variables that we used in our empirical analysis. In Section 4.3, we present the estimation results. In Section 4.4, we summarize the results of some robustness checks.

4.1 Methodology

We used the methodology developed by Johansen (1988, 1991) to analyze the equilibrium cointegration relation between stochastic rational speculative bubbles and international equity flows in a multivariate vector error correction (VEC) model. A multivariate VEC model has the advantage that one can control for the impact of several potentially important economic variables on the equilibrium cointegration relations to be estimated. We considered the following multivariate VEC model:

$$\Delta x_t = \mathbf{K} + \sum_{j=1}^{w} \mathbf{L}_j \Delta x_{t-j} + \mathbf{F} x_{t-1} + \epsilon_{t,x}, \tag{6}$$

where $w = 1, 2, ...$ and $\epsilon_{t,x}$ denotes a vector of mean-zero white-noise disturbance terms, and $\mathbf{K}$, $\mathbf{L}_j$, and $\mathbf{F}$ denote matrices of coefficients to be estimated. The vector of n endogenous variables, x_t, should include variables

that have the same degree of integration. One of the endogenous variables is the bubble-price ratio. The bubble-price ratio is integrated of order one. Accordingly, the other endogenous variables should also be integrated of order one. The VEC model features a constant as deterministic component.

The rank of the matrix $\mathbf{F}$ is equal to the number of independent cointegration vectors. If the matrix $\mathbf{F}$ has reduced rank, the number of cointegration vectors can be determined by testing for the significance of the eigenvalues of the matrix $\mathbf{F}$. To this end, the λ_{trace} and λ_{max} statistics can be used. The definitions of the statistics are $\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \lambda_i)$ and $\lambda_{max}(r, r+1) = -T \ln(1 - \lambda_{r+1})$, where T denotes the number of usable observations and λ denotes the estimated eigenvalues of the matrix $\mathbf{F}$. The null hypothesis of the λ_{trace} statistic is that there are at most r cointegration vectors, where the general alternative hypothesis is that the number of cointegration vectors is larger than r. The null hypothesis of the λ_{max} statistic is that there are r cointegration vectors, and the alternative hypothesis is that there are $r + 1$ cointegration vectors (for further details, see Enders 1995).

4.2 Data and Model Specification

In order to estimate the VEC model and to test for equilibrium cointegration relations, we collected monthly data on U.S. international equity flows to the South-East Asian countries from the U.S. Treasury International Capital (TIC) reporting system. The TIC data have been used by many other authors to study international equity flows (for example, Bekaert et al. 2002). A detailed description of the data can be found in Griever et al. (2001).

We compiled TIC data for the period from 1991/1 to 2006/12 for six South-East Asian countries (Indonesia, South Korea, Malaysia, the Philippines,

Singapore, and Thailand) to compute *net international equity inflows.* Net international equity inflows are defined as the difference between gross sales of foreign stocks by foreigners to U.S. residents and gross purchases of foreign stocks by foreigners from U.S. residents. We used the U.S. consumer price index to compute real net international equity inflows. Unit-root tests showed that net international equity flows are integrated of order zero. For this reason, we defined the *net international investment position* to estimate our VEC model. The net international investment position is defined as the accumulated sum of net international equity inflows. Against the background of the theoretical model described in Section 2, we expect a positive equilibrium cointegration relation between the net international investment position and the bubble-price ratio (i.e., a negative relation between changes in the bubble-price ratio and net international equity outflows).

– *Include Figure 3 about here.* –

A large range of variables may potentially affect international equity flows, implying that one must find a reasonable balance between the number of endogenous variables included in the VEC model and degrees of freedom. We included five endogenous variables in the vector x_t of our VEC model. The VEC model contains as endogenous variables the net international investment position, the (log) U.S. industrial production index, the real U.S. short-term interest rate (Federal funds rate), the bubble-price ratio in the local equity market, and the bubble-price ratio in the U.S. equity market. The U.S. industrial production index accounts for results reported by Mody et al. (2001) that U.S. economic activity may be an important determinant of international capital flows. Similarly, Chuhan et al. (1998) and Kim (2000) argue that output fluctuations in industrialized countries are an important determinant of international capital flows. We included the U.S. short-term

interest rate as a measure of the world interest rate to control for the effect of exogenous global determinants of equity flows (Fernandez-Arias 1996, Taylor and Sarno 1997, Chuhan et al. 1998, Bekaert et al. 2002). We included the bubble-price ratio in the U.S. equity market to account for the possibility that the speculative bubbles in the U.S. equity market may be an important "push" factor of international equity flows.

Table 2 summarizes the results of unit-root tests. We applied the DFGLS unit root developed by Elliott et al. (1996) to test whether the endogenous variables included in our VEC model are integrated of order one. The null hypothesis of the DFGLS test is that the time series being analyzed features a unit root, where all variables were measured in levels. As expected, the results imply that the bubble-price ratios in the South-East Asian countries and in the United States have a unit root. The results further imply the U.S. real interest rate and the U.S. real industrial production can be treated as unit-root variables. The net international investment position also has a unit root. For a further analysis of the properties of accumulated net capital inflows, see also Froot et al. (2001).

– Include Table 2 about here. –

Economic and financial crises may disrupt cointegration relations (Jochum et al. 1999). In order to account for the possibility that the Asian economic and financial crisis of 1997 changed the equilibrium cointegration relation between the bubble-price ratio and the net international investment position, we subdivided the sample period into two subsample periods. The pre-Asian crisis subsample period ends in December 1996, and the post-Asian crisis subsample period starts in January 1998. We deliberately kept out of the analysis observations for the year 1997, when the Asian crisis occurred and the equity markets of the East-Asian countries collapsed.

– Include Table 3 about here. –

Table 3 summarizes the results of model diagnostics for the VEC model. Standard lag-length selection criteria imply that a reasonable choice is to include two lags of the endogenous variables in the VEC model. Results of applying a Portmanteau test for autocorrelation show that this choice leaves hardly room for remaining residual autocorrelation. White's test in general yields no evidence of residual heteroskedasticity.

4.3 Results of the Cointegration Analysis

Tables 4 and 5 summarize the results of the cointegration tests. The results of the λ_{trace} and λ_{max} statistics provide evidence of cointegration among the five variables in the VECM models. In the case of the λ_{trace} statistic, there is some evidence of more than one cointegration relation in some countries. The λ_{max} statistic, however, implies that at most only one cointegration relation existed in the pre-crisis subsample period. The λ_{max} statistic yields evidence of only one cointegration relation also for the post-crisis subsample period, where there is evidence of two cointegration relations only in the case of South Korea. We conclude that there is robust evidence of one cointegrating relation.

– Include Tables 4 and 5 about here. –

In order to test whether the Caballero and Krishnamurthy (2006) hypothesis holds in terms of an equilibrium cointegration relation, we also analyzed the cointegration coefficients. Table 6 summarizes the cointegrating coefficients of the bubble-price ratios, where we normalized to unity the coefficient of the net international investment position. If the Caballero and Krishnamurthy (2006) hypothesis holds in terms of an equilibrium cointegration relation, the

coefficient that captures the equilibrium cointegration relation between the net international investment position and the bubble-price ratio should be positive. In other words, net equity outflows should decrease when a speculative bubble gathers steam. In the pre-Asian crisis subsample period, we found the expected significant positive relation between the net international investment position and the bubble-price ratio. The only country in which the sign of the coefficient is negative is South Korea. In the pre-crisis subsample period, the net internal investment position of South Korea showed a clear upward tendency, but the bubble-price ratio started to decrease in 1994, thereby generating the observed negative relation. It thus seems that economic and financial developments in South Korea before the South-East Asian economic and financial crisis differed from developments in the other KIT economies.

– Include Table 6 about here. –

In the post-crisis subsample period, the evidence in favor of a negative equilibrium cointegration relation between the bubble-price ratio and the net international investment position is weaker than in the pre-crisis subsample period. This is not surprising as it may simply be the case that, after the crisis and after the collapse of equity markets in South-East Asia, the mechanism that led to the crisis became weaker and lost significance in the post-crisis subsample period. Only for the Philippines, and to some extent for Singapore, there is evidence that an increase in the bubble-price ratio was accompanied by international net equity inflows. In the other South-East Asian countries, the bubble-price ratio and the net international investment position were negatively correlated in the equilibrium cointegration relation estimated for the post-crisis subsample period.

During the the last two decades, there has been a substantial upward trend

in capital inflows to Asia (Kim and Yang 2009b). Importantly, as Figure 3 indicates, the long-run upward trend in the net international investment position was not fully reversed by the Asian economic and financial crisis for the majority of countries in our sample, although the crisis certainly triggered sudden stops and temporary reversals of equity flows. At the same time, the bubble-price ratio showed a trend to decrease due to deflating speculative bubbles, on the one hand, and other factors including strengthening economic fundamentals, on the other hand (Kim and Yang 2009b). These opposing trends resulted in the observed negative relation between the net international investment position and the bubble-price ratio.

4.4 Robustness Checks

A natural question is whether our results are robust to changes in the specification of our VEC model. For the sake of brevity, we summarize the results of the robustness checks in this section but do not report the results. The results are available upon request.

As a robustness check, we reduced the number of lags of our VEC model from two lags to only one lag. We performed this robustness check because the results of applying lag-selection criteria summarized in Table 2 indicate that using only one lag may be a reasonable choice. We found evidence of a positive equilibrium cointegration relation between the bubble-price ratio and the net international equity position before the Asian economic and financial crisis in five South-East Asian countries, where South Korea is an exception. The positive equilibrium cointegration turned out to be significant in four out of the five countries. Only Singapore is an exception.

As another robustness check, we estimated a VEC model that features an intercept (no trend) in the cointegration equation and, in addition, a linear trend in the data. Our baseline VEC model only featured an intercept in the cointegration equation as deterministic component. We found that the results for the extended VEC model corroborate the results for the baseline model.

As a further robustness check, we replaced in our VEC model the bubble-price ratios with the estimated stochastic rational speculative bubbles. The bubble-price ratio captures the magnitude of the speculative bubbles relative to the magnitude of an equity market index and, as argued in Section 3.2, does not necessarily move one for one with changes in the speculative bubbles. While the speculative bubbles are not strictly difference stationary, their explosive root is in general close to unity. Again, we found evidence of a positive cointegration relation between speculative bubbles and the net international investment positions for the pre-crisis subsample period, where the evidence is strongest in the cases of Malaysia, Philippines, and Singapore. The cointegration coefficient in the case of South Korea also becomes positive, but its significance depends on the specification of the VEC model.

As a yet another robustness check, we compiled data for Australia and Japan. If the Caballero and Krishnamurthy (2006) model helps to explain how the Asian economic and financial crisis gathered steam, then the predictions of the model should have less explanatory power in the pre-crisis subsample period in case of economies that were not hit by the "storm" as hard as, for example, the KIT economies. In fact, Sarno and Taylor (1999b) report that developments in Australia and Japan were quite different from developments in other Asian countries. For example, they report that, in contrast to other Asian countries, there is no evidence of speculative bubbles in the case of

Australia. In addition, they report that the the permanent component of international capital flows to Australia and Japan was substantially larger than in those Asian countries that were hit particularly hard by the Asian economic and financial crisis.

We estimated the restricted state-space model for Australia and Japan and used the estimated bubble-price ratios in our VEC models. Using VEC models with one and two lags and with and without a deterministic trend in the data, we found that the coefficients of cointegration between the bubble-price ratios and the net international investment positions were negative in all specifications in the pre-crisis subsample period. If the Caballero and Krishnamurthy (2006) hypothesis holds in terms of an equilibrium cointegration relation, in contrast, one would expect a positive coefficient of cointegration. In addition, the coefficient of cointegration turned out to be insignificant in some VEC models estimated on Japanese data. When we replaced the bubble-price ratios with the speculative bubbles, we found hardly any evidence of an equilibrium cointegration relation in the pre-crisis subsample period.

As a final robustness check, we changed the definition of the net international investment position. In the baseline model, the net international investment position comprises accumulated sales and purchases of foreign stocks by foreigners. Focusing on trading in local stocks is one possibility to empirically approximate the structure of the Caballero and Krishnamurthy (2006) model, in which speculative bubbles provide local agents with a store of value. But another possibility is to account also for sales and purchases of U.S. corporate stocks by foreigners. Accordingly, we defined the modified net international investment position as consisting of the accumulated sales and purchases of foreign and U.S. corporate stocks by foreigners.

For the pre-crisis subsample period, we found evidence of a positive equilibrium cointegration relation between the bubble-price ratio and the modified net international investment position in the cases of the Phillipines, Malaysia, and Indonesia. For Thailand, the equilibrium cointegration relation was positive, and it was significant if we used one lag of the endogenous variables to estimate our VEC model. For Singapore, the cointegration coefficient was insignificant. For South Korea, the equilibrium cointegration relation was always significantly negative. As expected, for Australia and Japan the equilibrium cointegration relation was negative. In the case of Japan, the coefficient of cointegration was insignificant in three out of four VEC models. In sum, when we used the modified net international investment position to estimate our VEC models, the results corroborated the results for the baseline model.

5 Concluding Remarks

Our results contribute to develop a better understanding of the links between speculative bubbles and international equity flows. Our results imply that the equilibrium cointegration relation between the bubble-price ratios and the net international investment positions of South-East Asian countries before the Asian economic and financial crisis is consistent with predictions of a model that recently has been developed by Caballero and Krishnamurthy (2006). Their model predicts that speculative bubbles should crowd out net international outflows from financially underdeveloped countries. Results of a cointegration analysis support this prediction. In terms of an equilibrium cointegration relation, increases in the bubble-price ratios were

negatively correlated with net international equity outflows from South-East Asian countries in the pre-crisis subsample period.

On the empirical research frontier, an open question is which short-run adjustment processes foster convergence towards the long-run equilibrium cointegration relation between the bubble-price ratio and the net international investment position. One can think of various mechanisms that trigger short-run adjustment to the long-run cointegration equilibrium: mechanisms assuming return chasing of international investors and portfolio-rebalancing effects, machanisms assuming momentum trading of international investors, mechanisms highlighting the effect of international equity flows on the cost of equity capital, mechanisms that emphasize the informational content of international equity flows, and mechanisms emphasizing the role of liquidity effects and attempts of monetary authorities to sterilize international capital inflows. The relative importance and time-varying nature of such mechanisms has been studied in earlier literature, albeit the focus of earlier literature has been on equity returns rather than on speculative bubbles (see, for example, Bekeart et al. 2002).

Another question open to debate is to what extent the short-run adjustment mechanisms influence the long-run equilibrium cointegration relation. In other words, it would be interesting to explore whether short-run adjustment mechanisms have had permanent effects. If such permanent effects can be recovered, factors other than those captured by the Caballero and Krishnamurthy (2006) model may have contributed to the equilibrium cointegration relation between the bubble-price ratio and the net international investment position. In this respect, the informational content of international equity flows for local equity market returns and the degree of reversibility of international equity flows deserve special attention.

With regard to informational content, international equity flows may forecast local equity market returns because international investors have superior information about "fundamentals", or because of a price-pressure effect. Depending on whether information about fundamentals or a price-pressure effect are at work, international equity flows may have a permanent or a transitory effect on local equity markets. Both information about fundamentals and a price-pressure effect, however, should give rise to a positive correlation between equity returns and international equity flows. Froot and Ramadorai (2008) find that that international institutional cross-border flows are linked to fundamentals. Lin and Swanson (2004) find that international equity flows mainly have a short-term effect on local equity markets.

With regard to reversibility, Sarno and Taylor (1999a, 1999b) report that international equity flows feature a large temporary component. An interesting avenue for future research would be to develop an empirical model in which the interaction between speculative bubbles, various competing adjustment mechanisms, and the reversible component of international equity flows can be analyzed in a unified framework. Such research may help to improve early-warning indicators of financial crises.

Finally, it would be interesting to go in future research beyond our analysis by exploring whether speculative bubbles in South-East Asian countries were "contagious". Although no generally accepted definition of the concept contagion has emerged in the literature, many authors have applied this concept to study how spillover effects caused the Asian economic and financial crisis to spread from country to country. In a recent study, Ito and Hashimoto (2005) have reported interesting results on contagion effects among Asian countries during the Asian economic and financial crisis.

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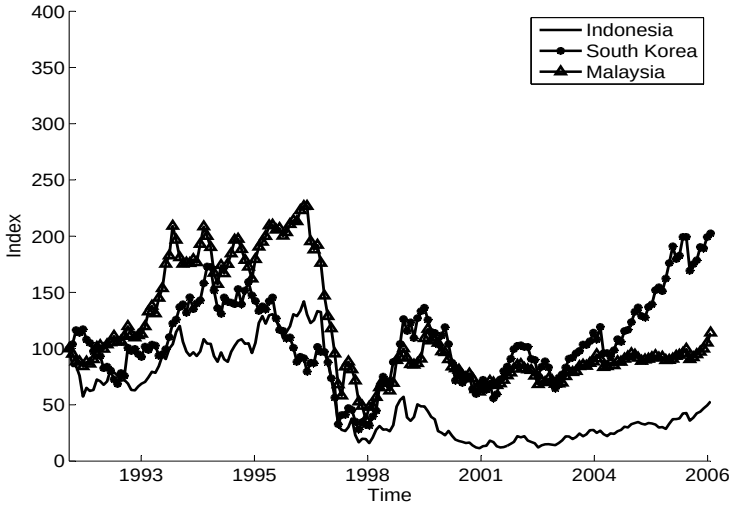
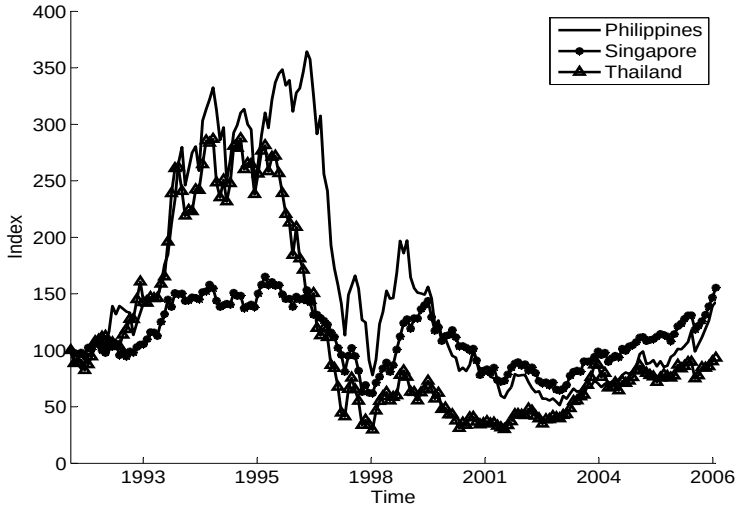
Figure 1: Equity Market Indexes

Panel A



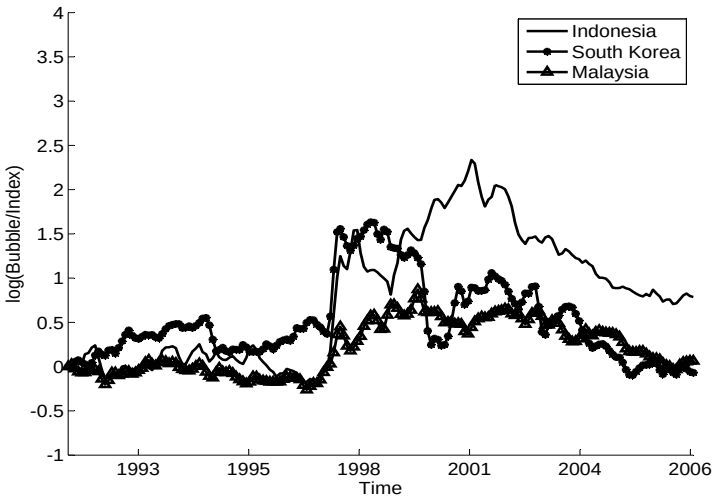
Panel B



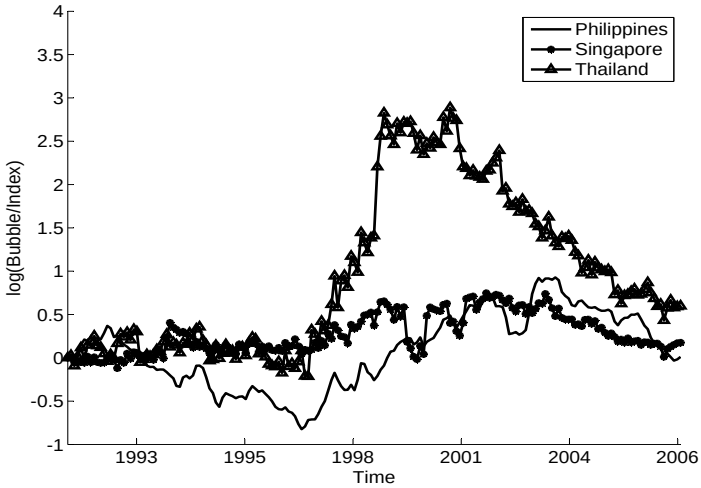
Note: This figure plots monthly equity market indexes. The equity market indexes were scaled to assume the value 100 at the beginning of the sample period. The equity market indexes were converted to U.S. dollars and then deflated with the U.S. consumer price index. The data are from Thompson Financial Datastream.

Figure 2: Bubble-Price Ratios

Panel A

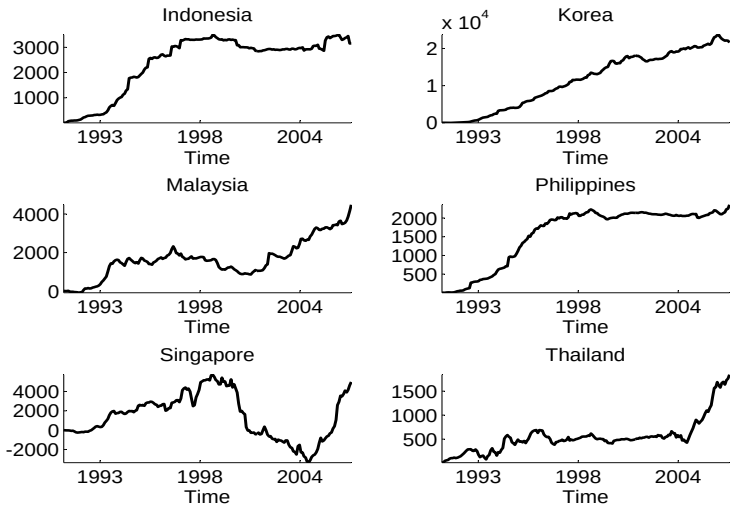


Panel B



Note: This figure plots the (log) bubble-price ratios for the restricted model. The restricted model is a model in which the parameter ϕ was not estimated directly, but a transformation $\phi = 1/(1 + \exp(-\mu))$ was being used and the auxiliary parameter μ was estimated. We used this transformation to ensure that the parameter ϕ assumes point estimates strictly smaller than unity.

Figure 3: Net International Investment Position



Note: This figure plots the net international investment position defined as the accumulated sum of net international equity inflows, measured in terms of millions of U.S. dollars. We used the U.S. consumer price index to deflate the data.

Table 1: Estimation Results for the State-Space Model

	φ_1	φ_2	ϕ		σ_ϵ^2	σ_u^2
Indonesia						
Coefficient	-0.1378	-0.3455	1.1873	[0.9009]	194.668	190.845
Std. Error	0.0600	0.0569	0.0512		10.3430	10.1699
South Korea						
Coefficient	-0.3858	-0.3053	1.0555	[0.9583]	211.396	207.383
Std. Error	0.0631	0.0624	0.0253		11.5844	11.3853
Malaysia						
Coefficient	-0.3198	-0.3315	1.0492	[0.9540]	109.883	142.777
Std. Error	0.0637	0.0632	0.0228		5.8758	7.6422
Philippines						
Coefficient	-0.5399	-0.2741	1.0467	[0.9559]	146.632	154.158
Std. Error	0.0637	0.0638	0.0222		7.9625	8.3745
Singapore						
Coefficient	-0.5222	-0.1875	1.0335	[0.9991]	115.854	117.444
Std. Error	0.0629	0.0618	0.0191		6.3411	6.4297
Thailand						
Coefficient	-0.5022	-0.2392	1.0215	[0.9973]	206.927	213.794
Std. Error	0.0637	0.0635	0.0137		11.3870	11.7662
United States						
Coefficient	-0.7884	-0.4907	0.9993	[0.9896]	55.7358	67.2943
Std. Error	0.0640	0.0640	0.0049		2.9933	3.6136

Note: This table summarizes estimation results for the state-space model. The parameters φ_1 and φ_2 denote the autoregressive parameters of the $AR(2)$ model that describes the dynamics of real (demeaned) dividends. The parameter ϕ denotes the parameter of the model that describes the dynamics of speculative bubbles. The numbers in brackets are the point estimates of ϕ estimated from a restricted model. In the restricted model, we used the transformation $\phi = 1/(1+\exp(-\mu))$ and estimated the auxiliary parameter μ. We used this transformation to ensure that, in line with the theoretical model described in Section 3.1, the parameter ϕ assumes point estimates strictly smaller than unity. The parameter σ_u^2 denotes the variance of the error term of the $AR(2)$ model that describes the dynamics of real (demeaned) dividends. The parameter σ_ϵ^2 denotes the error term of the model that describes the dynamics of speculative bubbles.

Table 2: Results of Unit Root Tests

	Indonesia	South Korea	Malaysia	Philippines	Singapore	Thailand	United States
Net international investment	1.1127	2.2128	1.9821	1.3584	-0.6044	1.9668	–
Bubble-price ratio	-0.8998	-1.3993	-1.0940	-1.5991	-1.8826	-0.8658	-1.5846
U.S. real short-term interest rate	–	–	–	–	–	–	-1.8698
U.S. industrial production	–	–	–	–	–	–	0.2797

Note: This table summarizes the results of DFGLS unit root tests (Elliott et al. 1996). The 95% critical value of the test is -1.9426. We used the full sample of data to implement the tests.

Table 3: Model Diagnostics for the VEC Model

	Indonesia	South Korea	Malaysia	Philippines	Singapore	Thailand
Pre-Crisis Subsample Period						
AIC	1	1	2	3	1	2
SBIC	1	1	1	1	1	1
AR(3)	0.03	0.05	0.14	0.03	0.36	0.10
AR(6)	0.23	0.46	0.47	0.26	0.58	0.08
White	0.24	0.43	0.58	0.04	0.03	0.12
Post-Asian Crisis Subsample Period						
AIC	2	3	2	2	2	2
SBIC	1	1	1	1	1	1
AR(3)	0.06	0.05	0.06	0.54	0.18	0.43
AR(6)	0.78	0.11	0.61	0.79	0.26	0.34
White	0.11	0.41	0.73	0.21	0.83	0.42

Note: AIC = Akaike Information Criterion for lag selection. SBIC = Schwarz Bayesian Information Criterion for lag selection. AR(x) = VEC Portmanteau test for residual autocorrelations of order x. White = VEC test for residual heteroskedasticity (no cross terms). The results for the pre-Asian (post-Asian) crisis subsample period refer to the subsample period 1991−1996 (1998−2006). The VEC Portmanteau test for autocorrelation and the VEC test for residual heteroskedasticity apply to a VEC model with two lags.

Table 4: Cointegration Results (λ_{trace})

Null hypothesis	Indonesia	South Korea	Malaysia	Philippines	Singapore	Thailand
Pre-Crisis Subsample Period						
r = 0	0.0279	0.0030	0.0177	0.0030	0.0305	0.0422
r $\leq$ 1	0.0441	0.0412	0.2389	0.0492	0.0905	0.3146
r $\leq$ 2	0.0357	0.1146	0.2465	0.2333	0.3334	0.2031
r $\leq$ 3	0.0442	0.1402	0.2241	0.2398	0.3672	0.1073
r $\leq$ 4	0.0523	0.2865	0.5283	0.3382	0.3332	0.1009
Post-Asian Crisis Subsample Period						
r = 0	0.0001	0.0030	0.0000	0.0029	0.0002	0.0065
r $\leq$ 1	0.0153	0.0403	0.0153	0.0304	0.0523	0.1812
r $\leq$ 2	0.1245	0.4921	0.0344	0.0616	0.1083	0.3044
r $\leq$ 3	0.2970	0.5477	0.1466	0.3044	0.4779	0.5437
r $\leq$ 4	0.8176	0.5344	0.3006	0.8237	0.8234	0.4561

Note: This table summarizes MacKinnon-Haug-Michelis p-values for Johansen's (1988, 1991) λ_{trace} test for cointegration. The null hypothesis in the case of $r = 0$ ($r \leq 1$, $r \leq 2$, ...) is that there is no cointegration vector (one cointegration vector, two cointegration vectors,...). The alternative hypothesis stipulates $r > 0$ ($r > 1$, $r > 2$,...) cointegration vectors. In the first stage, the null hypothesis $r = 0$ is tested. If the null hypothesis of noncointegration cannot be rejected, there is no cointegration vector. If the null hypothesis can be rejected, in the second stage, the null hypothesis $r \leq 1$ is tested. If the null hypothesis cannot be rejected, there is one cointegration vector. If the null hypothesis can be rejected, in the third stage, the null hypothesis $r \leq 2$ is tested. If the null hypothesis cannot be rejected, there are two cointegration vectors, and so forth. The results for the pre-Asian (post-Asian) crisis subsample period refer to the subsample period 1991−1996 (1998−2006). The table summarizes the results for a VEC model with two lags.

Table 5: Cointegration Results (λ_{max})

Null hypothesis	Indonesia	South Korea	Malaysia	Philippines	Singapore	Thailand
Pre-Asian Crisis Subsample Period						
r = 0	0.0489	0.0375	0.0253	0.0295	0.2264	0.0531
r = 1	0.2872	0.2022	0.6258	0.1039	0.1376	0.8533
r = 2	0.3955	0.3868	0.5718	0.5172	0.5378	0.7343
r = 3	0.4387	0.1963	0.2008	0.3134	0.5027	0.3164
r = 4	0.5131	0.2865	0.5283	0.3382	0.3332	0.1009
Post-Asian Crisis Subsample Period						
r = 0	0.4131	0.0380	0.0006	0.0547	0.0010	0.0101
r = 1	0.5619	0.0202	0.2296	0.2696	0.2786	0.3831
r = 2	0.3078	0.5953	0.1006	0.0860	0.0946	0.3191
r = 3	0.2109	0.5852	0.1984	0.1848	0.3424	0.6368
r = 4	0.0523	0.5344	0.3006	0.8237	0.8234	0.4561

Note: This table summarizes MacKinnon-Haug-Michelis p-values for Johansen's (1988, 1991) λ_{max} test for cointegration. The null hypothesis in the case of $r = 0$ ($r = 1$, $r = 2$, ...) is that there is no cointegration vector (one cointegration vector, two cointegration vectors,...). The alternative hypothesis is that there are $r = 1$ ($r = 2$, $r = 3$,...) cointegration vectors. In the first stage, the null hypothesis $r = 0$ is tested. If the null hypothesis of noncointegration cannot be rejected, there is no cointegration vector. If the null hypothesis can be rejected, in the second stage, the null hypothesis $r = 1$ is tested. If the null hypothesis cannot be rejected, there is one cointegration vector. If the null hypothesis can be rejected, in the third stage, the null hypothesis $r = 2$ is tested. If the null hypothesis cannot be rejected, there are two cointegration vectors, and so forth. The results for the pre-Asian (post-Asian) crisis subsample period refer to the subsample period 1991−1996 (1998−2006). The table summarizes the results for a VEC model with two lags.

Table 6: Cointegration Vectors

Coefficient	Indonesia	South Korea	Malaysia	Philippines	Singapore	Thailand
Pre-Asian Crisis Subsample Period						
CE	20933 (5236.9)	-33405 (7466.1)	2959.8 (805.40)	3521.8 (1086.9)	1975.2 (643.33)	191.14 (140.01)
Post-Asian Crisis Subsample Period						
CE	-52.796 (93.039)	-6961.0 (2541.2)	-3137.0 (427.76)	684.33 (213.70)	5902.0 (2631.0)	-282.58 (82.224)

Note: The rows headed CE summarize the normalized cointegration coefficient of the local bubble-price ratio in the first cointegration vector (standard error in parentheses). The cointegration coefficient of the net international investment position has been normalized to unity (this coefficient and the coefficients of the control variables are not shown in the table). The results for the pre-Asian (post-Asian) crisis subsample period refer to the subsample period 1991−1996 (1998−2006). The test statistics λ_{trace} and λ_{max} yield identical cointegration coefficients. The table summarizes the results for a VEC model with two lags.