Regional Vulnerability: The Case of East Asia

Ashoka Mody and Mark P. Taylor

No 776

WARWICK ECONOMIC RESEARCH PAPERS

DEPARTMENT OF ECONOMICS

THE UNIVERSITY OF WARWICK

Regional Vulnerability: The Case of East Asia

Ashoka Mody
International Monetary Fund

Mark P. Taylor
University of Warwick
and
Centre for Economic Policy Research

(Forthcoming, Journal of International Money and Finance)

Abstract

In a case study of six East Asian economies, we use dynamic factor analysis to estimate a regional component of the exchange market pressure index (EMPI) as a measure of regional financial stress. The extent to which this indicator is explained by regional economic and financial factors is interpreted as regional vulnerability to crisis. We find that regional external liabilities and exuberance in domestic stock and credit markets, as well as the US high yield spread, were positively correlated with regional vulnerability. Individual country EMPIs are also explained by regional factors, with country-specific factors and trade linkages playing little role.

Keywords: currency crisis; contagion; vulnerability; dynamic factor analysis.
JEL classifications: F31, F32, F36.

1. Introduction

The financial crises of the 1990s differed from those of the 1970s in a fundamental way: they tended to strike several countries simultaneously. The domino collapse of the European Exchange Rate Mechanism in 1992-1993, the "Tequila effect" of the Mexican crisis in 1994, the "Asian flu" of 1997-1998 and the turmoil in emerging and global financial markets following the August 1998 Russian crisis all illustrate the coincidence of financial crises in the last decade of the twentieth century. Such coincidence of crises has brought to the fore a vigorous enquiry into the extent and reasons for interconnections between economies.

The starting point of the analysis in this paper is the observation that crises have tended to be regional. While the events surrounding the Russian crisis in 1998 reverberated throughout the world, the evidence is persuasive that countries within a geographical region are jointly vulnerable (Glick and Rose, 1999; Eichengreen, Hale, and Mody, 2001; Kaminsky and Reinhart, 2001).

In this paper we suggest a method of determining the degree of common susceptibility or vulnerability to crisis that may characterize a region, using six Asian economies and their behavior before, during and after the East Asian crisis of the late 1990s as a case study.[1] In particular, we pursue the idea that a region such as East Asia largely presents a common "prospectus" to international investors. This may be because countries within a region follow similar development strategies and economic policies (Rigobon, 1998). Combined with investors' need to economize on information gathering, as implied by models such as those presented by Calvo and Mendoza (2000), groups of countries in a particular region may come to represent a single corporate entity, e.g., "East Asia, Inc."

Our research may be viewed in a broad sense as a contribution to the literature on contagion. We prefer, however, to use the term "vulnerability" for two reasons. First, as noted by Dungey and Tambakis (2003), the term "contagion" has proved to be something of an elusive concept, with no single received usage (see e.g. Masson, 1999; Edwards, 2000; Kaminsky and Reinhart, 2000; Forbes and Rigobon, 2001; Corsetti, Pericoli and Sbracia, 2002). More importantly, however, we see vulnerability and contagion as two components that together form an index of common regional exchange market stress. The component that is explained by movements in regional macroeconomic and financial variables we term *vulnerability*.

---

[1] Choosing these countries as representative of the region of East Asia immediately raises fundamental issues as to what constitutes a region. For example, if this were defined purely geographically, then our analysis ought to include other countries such as Vietnam, Cambodia, Hong Kong, etc. To include *all* countries in the geographical region would, however, lead to difficulties in empirical work because it would involve the estimation of very large dynamic systems. Hence, we have restricted ourselves to an examination of just six countries, but acknowledge that our research therefore can only be interpreted as a case study of those countries.

The component that is unexpected, based on the explanatory regional variables, could be thought of as *contagion*, following, for example, Masson (1999) and Edwards (2000). Vulnerability and contagion are thus related and, indeed, contagion may occur because of non-linear effects or structural shifts when vulnerability levels reach certain thresholds (Jeanne, 1997; Masson, 1999).

The remainder of the paper is structured as follows. In Section 2 we discuss the dynamic factor analysis that we use to construct a regional stress index. Section 3 presents the empirical results of our case study, reporting both the determinants of regional vulnerability and those of country-specific EMPIs. A brief summary of the case study findings and the implications for policy and future research are presented in a final section.

2. Methodological Issues

The construction of our measure of regional vulnerability proceeds in three steps. First we construct an index to capture the idea of devaluation probability and financial stress for each country, using the well known exchange market pressure index (EMPI). Second, we employ dynamic factor analysis in order to extract the component of the EMPI that is common to all six countries under examination in our case study, which can therefore be treated as a measure of *regional* stress. Finally, we extract the component of the regional stress index that can be explained by measures of macroeconomic and financial similarity among the six countries, and interpret this explained component as our measure of regional vulnerability. We provide a more extensive discussion of the final step, including the choice of variables to use in extracting the regional vulnerability component, in our empirical section. In this section we describe in more detail first the construction of the EMPI (although only briefly, since this measure is well known) and then the dynamic factor analysis that we use to extract the regional stress index.

2.1 The Exchange Market Pressure Index

As is standard in studies of international financial crises, we begin with the well known exchange market pressure index originally proposed by Girton and Roper (1977) in order to capture the idea of devaluation probability and financial stress. The EMPI is a weighted sum of exchange rate depreciation, loss of reserves, and rise in interest rates. It measures the pressure on the exchange rate that may in part be absorbed by a decline in reserves or through an increase in domestic interest rates. Thus, an increase in the value of a country's EMPI indicates that the net demand for that country's currency is weakening and hence that the currency may be liable to a speculative attack or that such an attack is already under way.

Formally, for a country i at time t the EMPI, denoted E_{it}, is given by:

$$\mathrm{E}_{it} = \alpha \frac{\Delta e_{it}}{e_{it}} - \beta \frac{\Delta r_{it}}{r_{it}} + \lambda \Delta i_{it}, \tag{1}$$

where e_{it}, r_{it} and i_{it} denote, respectively, the nominal exchange rate (domestic price of foreign currency), level of foreign exchange reserves and short-term interest rate for country i at time t, and Δ denotes the first-difference operator. The weights α, β and λ are chosen such that each of the three components on the right-hand side of (1) has a standard deviation of unity, in order to preclude any one of them from dominating the index.

2.2 Extracting the Common Factor: Dynamic Factor Analysis

Having constructed the EMPI series, we wish to extract a factor that is common to the EMPI for each of the countries under examination as a measure of regional stress. In order to do this we employ an "unobserved components," dynamic factor analysis approach based on maximum likelihood Kalman filtering (Engle and Watson,1981; Harvey,1989; Cuthbertson, Hall and Taylor, 1992). Let E_{it} be the EMPI at time t for country i, i=1,2,3,4,5,6, and let κ_t be the unobserved factor common to the EMPI of all of the crisis countries. Then the general statistical system we postulate is of the form:

$$\mathrm{E}_{it} = \gamma^{(i)}\kappa_t + n_{it}, \quad i = 1,2,3,4,5,6, \tag{2}$$
$$\Phi(L)\kappa_t = \omega_t, \tag{3}$$
$$\Psi^{(i)}(L)n_{it} = \varepsilon_{it}, \quad i = 1,2,3,4,5,6, \tag{4}$$
$$(\omega_t, \varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \varepsilon_{4t}, \varepsilon_{5t}, \varepsilon_{6t})' \sim \mathrm{N}[\mathrm{O}, \mathrm{diag}\{1, \sigma_1^2, \sigma_2^2, \sigma_3^2, \sigma_4^2, \sigma_5^2, \sigma_6^2\}], \tag{5}$$

where $\Phi(L)$ and $\Psi^{(i)}(L)$ denote polynomials in the lag operator L, O denotes a (7×1) column vector of zeroes, and diag$\{\cdot\}$ denotes a square symmetric matrix with the elements of main diagonal given in parentheses and zeroes elsewhere. Equation (2) partitions the EMPI for country i at time t, E_{it}, into a factor common to all six countries, κ_t, which we can think of as the regional stress index, plus a country-specific or national factor, n_{it} . Note that κ_t, is scaled by a country-specific parameter $\gamma^{(i)}$ in (2), so that the *degree* of influence of the regional stress index on the EMPI may vary from country to country. According to equations (3) and (4) respectively, the regional stress and national factors are each assumed to have a finite-order autoregressive representation. This is reasonable so long as the determinants of these components are stationary and, therefore, by Wold's decomposition theorem, admit a moving average representation that may be approximated by a finite-order autoregression. Below, we shall investigate further the probable major determinants of the vulnerability factor. In (5), the distribution of the disturbance terms is assumed to be Gaussian and the variance of innovations driving the ω_t term is normalized to unity in order to identify the vulnerability factor.

If we assume that $\Phi(L)$ and $\Psi^{(i)}(L)$ are at most first-order,[2] then the system (2)-(4) may be cast into state space form as follows:

$$\begin{bmatrix} E_{1t} \\ E_{2t} \\ E_{3t} \\ E_{4t} \\ E_{5t} \\ E_{6t} \end{bmatrix} = \begin{bmatrix} \gamma^{(1)} & 1 & 0 & 0 & 0 & 0 & 0 \\ \gamma^{(2)} & 0 & 1 & 0 & 0 & 0 & 0 \\ \gamma^{(3)} & 0 & 0 & 1 & 0 & 0 & 0 \\ \gamma^{(4)} & 0 & 0 & 0 & 1 & 0 & 0 \\ \gamma^{(5)} & 0 & 0 & 0 & 0 & 1 & 0 \\ \gamma^{(6)} & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \kappa_t \\ n_{1t} \\ n_{2t} \\ n_{3t} \\ n_{4t} \\ n_{5t} \\ n_{6t} \end{bmatrix}, \tag{6}$$

$$\begin{bmatrix} \kappa_t \\ n_{1t} \\ n_{2t} \\ n_{3t} \\ n_{4t} \\ n_{5t} \\ n_{6t} \end{bmatrix} = \begin{bmatrix} \phi & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \psi^{(1)} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \psi^{(2)} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \psi^{(3)} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \psi^{(4)} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \psi^{(5)} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \psi^{(6)} \end{bmatrix} \begin{bmatrix} \kappa_{t-1} \\ n_{1t-1} \\ n_{2t-1} \\ n_{3t-1} \\ n_{4t-1} \\ n_{5t-1} \\ n_{6t-1} \end{bmatrix} + \begin{bmatrix} \omega_t \\ \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix}, \tag{7}$$

or, more compactly as:

$$\Xi_t = \Gamma F_t, \tag{8}$$

$$F_t = \Lambda F_{t-1} + \zeta_t, \tag{9}$$

where:

$$\zeta_t \sim N\,[O, \Sigma], \tag{10}$$

$$\Sigma = \mathrm{diag}\{1, \sigma_1^2, \sigma_2^2, \sigma_3^2, \sigma_4^2, \sigma_5^2, \sigma_6^2\}. \tag{11}$$

Once the system is in state space form, the Kalman filter recursions can be used to produce optimal estimates of the unobservable elements of the state vector F_t, conditional on maximum likelihood estimates of the state space parameters (Harvey, 1989).

[2] Experiments with higher-order specifications in our empirical work led to qualitatively identical and quantitatively virtually identical results.

3. Case Study: Six East Asian Economies

3.1 Data

The data set is monthly for the period January 1990 through December 2001 for six East Asian countries—Indonesia, Korea, Malaysia, Philippines, Singapore and Thailand—and was gathered from the *International Financial Statistics* data base published by the International Monetary Fund (IMF), supplemented by *Global Data Source*, an IMF Research Department data base that draws on both IMF and commercial sources. The series gathered included, for each country, the nominal (end-period) US dollar exchange rate, the level of foreign exchange reserves, nominal GDP, money supply (M2), consumer price index, a stock market index, a short-term interest rate (the interbank call-loan rate), the level of total foreign liabilities outstanding, and the level of domestic credit outstanding. In addition, a series on the US high-yield interest rate spread was obtained from Bloomberg as the difference between the yield on US high yield bonds and the yield on the ten-year US Treasury bond; it thus measures the risk premium on less-than-investment-grade (or "junk") bonds over the "riskless" interest rate. Finally, a data series on the spot price of oil (West Texas Intermediate) was also gathered. The reasoning underlying the choice of these variables and their use in our analysis is discussed below. All the series were expressed in mean-deviation from prior to the analysis.

3.2 Exchange Market Pressure Indices

Figure 1 shows the EMPIs of the six countries under examination, constructed as in equation (1), for the period 1990-2001. Larger values of the EMPI suggest higher stress. Negative EMPIs indicate speculators' expectations of currency appreciation rather than depreciation. High EMPIs in some countries prior to the 1997 Asian crisis indicate that these countries had in fact been exposed to the danger of crisis but that attacks had been staved off. Figure 1 also shows the common or regional component of the EMPI across the six countries

3.3 The Regional Stress Factor

The maximum likelihood estimates of the parameters of the state space form (2)-(5) are reported in Table 1 and the implied level of common or regional stress is displayed in Figure 1.[3] The regional stress level is especially high during the height of the crisis, June 1997 to January 1998. The index remains near zero or negative in most other periods except for a

[3] We used the unsmoothed Kalman filter estimates of the unobservable factors, since using the smoothed estimates would introduce additional moving average structures into the factors.

slight increase during the Mexican crisis in 1994. Negative values of the stress index may be interpreted as indicating regional optimism from the point of view of international investors.

The charts in Figure 1 and the estimation results in Table 1 reveal that the regional stress factor plays an important role in driving the exchange market pressure indices of all of the East Asian countries examined. In particular, the estimated $\gamma^{(i)}$ parameters, which measure the importance of common regional stress in driving the EMPI in each country, are in every case strongly significantly different from zero at conventional nominal test sizes. The degree of variation in each country's EMPI explained by the regional stress factor alone (the R^2 statistics shown in the final column) ranges from 21 percent for Thailand, to 70 percent for the Philippines.[4]

3.4 Analyzing the sources of vulnerability

What factors contribute to the predictable component of κ_t and hence drive regional vulnerability? In this connection, it is worth recalling that, in contrast to previous balance of payments-cum-currency crises where economic misalignment had resulted in either large fiscal deficits or gross misalignment of exchange rates, the macroeconomic performance of most of the East Asian economies prior to the 1997-98 crisis was exemplary.[5] Most of the countries concerned ran either balanced or surplus fiscal accounts, and high private sector savings funded internationally exceptional rates of investment. Even where rising investment surpassed savings, driving the current account into deficit, the fact that current account deficits appeared to be investment driven rather than consumption driven appeared comforting. Similarly, East Asian monetary policies appeared to be coping well before the crisis, with reported inflation rates tightly under control and strong levels of economic activity. Thus, "first-generation" and "second-generation" currency crisis models (Flood and Marion, 1999) were not seen as appropriate indicators of the range of fundamental variables to consider.
Instead, therefore, our choice of potentially influential fundamental variables was largely informed by the literature on the widely held "moral hazard" or "third generation" view of

---

[4] These R^2 statistics were conducted as the coefficient of determination in a regression of the EMPI of each country onto the extracted regional stress index. Given that the regional and national components of the EMPI were constructed to be orthogonal, this gives an accurate measure of the degree of variation of the country EMPI explained by the regional factor.

[5] Chinn (2000) examines a group of East Asian currencies immediately prior to the 1997-98 crisis and concludes that only that only the Thai baht shows evidence of external overvaluation relative, based on traditional purchasing power parity and monetary fundamentals, whilst Chinn (1999) and Chinn and Dooley (1999) find slightly more mixed results.

the underlying causes of the East Asian crisis (see e.g. McKinnon and Pill, 1996; Krugman, 1998; Corsetti, Pesenti and Roubini, 1999; Kaminsky and Reinhart, 1999; Agénor, Miller and Vines, 1999; Sarno and Taylor, 1999a).[6] According to the "moral hazard" view, a crucial role in the East Asian crisis was played by financial intermediaries whose liabilities were perceived as having an implicit government guarantee, but which were essentially unregulated. This therefore created a moral hazard problem, in which financial intermediaries were able to raise money at low rates of interest and then lend it at much higher rates to finance risky investments, thereby generating strong asset price inflation, sustained by a circular process in which the proliferation of risky lending drove up the prices of risky assets, making the financial condition of these institutions appear to be sounder than it actually was. At some point, however, the bubble bursts and the mechanics of the crisis is then described by the same circular process in reverse: asset prices begin to fall; making the insolvency of financial intermediaries highly visible; forcing them to cease operations and generating increasingly fast asset price deflation; leading to actual or incipient capital flight as asset prices collapse.

This description appears to fit the facts of the East Asian crisis well (Sarno and Taylor, 1999a), and suggests that movements in asset prices and measures of financial imbalance would be strong candidates to explain regional vulnerability. Indeed, financial imbalances in many of the crisis countries had created increasingly illiquid and insolvent corporate and banking sectors.

For these reasons, we examined external and domestic financial variables that could reflect such regional vulnerabilities. The corporate and financial sector imbalances developed due to the nexus of three factors: the inflow of reversible foreign capital, which created both maturity and currency mismatches; the accumulation of domestic private debt; and weak financial regulation and opaque reporting practices, which contributed to excessive investment in unproductive assets. Capital inflows *per se* do not create financial instability, but when these inflows serve as a main source by which to fund high levels of domestic credit, reliance on them could render the market vulnerable because of the high degree of reversibility of portfolio flows and bank lending (Sarno and Taylor, 1999a, 1999b). Thus, a growing stock of external liabilities is clearly a source of concern to investors. Second, domestic credit growth, and in particular real domestic credit growth, can be associated with unproductive investments and, thus, viewed as unsustainable. There appears to be some empirical support for this view; Kaminsky and Reinhart (1999), for example, show that rapid growth of domestic credit helps predict financial crisis, and rapid domestic credit growth also

---

[6] The "insurance model" of crisis due originally to Dooley (1997) and analyzed empirically by Chinn, Dooley and Shrestha (1999) also suggests that asset market booms are likely to be followed by capital flight and that rapid expansion of domestic credit and foreign liabilities will tend to be associated with currency crises.

finds a role in various post-mortem accounts of the Asian crisis (e.g. Bank for International Settlements 1998, Chapter VII).[7]

Similarly, to the extent that a boom in stock market prices, adjusted for inflation, is not based on fundamentals, it could similarly raise concerns with respect to future vulnerability. Kaminsky, Lizondo and Reinhart (1998) and Sarno and Taylor (1999a), for example, provide strong empirical evidence that stock market booms tend to precurse future exchange rate crises for a number of East Asian countries.

We also include a "global" risk factor, the US high-yield spread, on the basis that this is not only is a proxy for international investors' attitude towards risk, but is also a leading indicator of US economic activity (Gertler and Lown, 1999; Mody and Taylor, 2003, 2004). Gertler and Lown (1999), reasoning on the basis of the theory of the "financial accelerator", argue that a rise in the spread (and, hence, in the external costs of borrowing) reflects a lowering of the collateral value that borrowing firms can offer. In turn, this reduced collateral results from downgrading of growth prospects. Since exports to the United States play an important role in East Asian economic activity, it is not surprising that the prospect of a slowdown in the US reduces the net demand for East Asian currencies. Mody and Taylor (2002) find that a rise in US high yield spread leads to a significant curtailment of capital flows to emerging markets (and, indeed, its influence overshadows that of US interest rates).

In short, therefore, the final set of macroeconomic and financial variables that we settled on as potential drivers of the degree of vulnerability for these six East Asian economies included percentage monthly changes in the real (consumer price index-deflated) stock market index, the level of total foreign liabilities as a proportion of GDP, the ratio of M2 money supply to GDP (inverse velocity), and percentage monthly changes in the level of domestic credit outstanding in real terms. In order to obtain a measure of regional similarity in these macroeconomic fundamentals, we used the Kalman filtering method outlined above to extract a regional common factor for each of these series, and the results of this dynamic factor analysis are given in Tables 2-5. In addition, we included the US high yield spread as well as an interaction term involving the product of the change in the high yield spread and the regional component of growth in the real value of domestic credit and, as a further global factor, the monthly change in the spot oil price.

[7] Chinn and Dooley (1997) find some evidence that rapid expansion of bank lending increases the riskiness of marginal projects for a set of Pacific Rim countries. In an analysis of EMPI movements for several emerging market economies, Tanner (2001, p. 318) finds that growth of domestic credit and a rise in the EMPI have gone together. He notes, for example, that starting around mid-1997, both the EMPI and domestic credit rose in Thailand, Indonesia, and Korea, "suggesting that the crises were foreshadowed by a period of loose monetary policy."

Having extracted the regional common factor of each of these series (except for the global variables) across the six countries concerned, we then regressed the common regional stress factor onto the current value and three lagged values of each of the macro fundamental common factors.[8] Interestingly, all of the current values of the macro common factors appeared significant in the regression, although of the lagged common factors, only the first lag of the change in the real stock market index was significant and the oil price term did not yield an estimated coefficient significantly different from zero at even the ten percent level.

The resulting estimated regression equation was therefore of the form:

$$\hat{\kappa}_t = -\underset{(1.4762)}{5.2263}\ \mu 1_t - \underset{(1.4420)}{3.3046}\ \mu 1_{t-1} + \underset{(2.7365)}{6.6139}\ \mu 2_t + \underset{(0.1162)}{0.2101}\ \mu 3_t + \underset{(0.2017)}{0.4288}\ \mu 4_t + \underset{(1.8841)}{4.8224}\ \mu 5_t$$

$$R^2 = 0.26,\ DW = 1.17,\ Chow(>6/97) = 0.4216,\ Hausman = 0.2812, \qquad (12)$$

where figures in parentheses denote estimated standard errors and where:

$\hat{\kappa}_t$ = explained component of the regional stress index (i.e. regional vulnerability),
$\mu 1_t$ = common factor of monthly log-change in real value of the stock market index,
$\mu 2_t$ = common factor of logarithm of ratio of total foreign liabilities to GDP,
$\mu 3_t$ = common factor of logarithm of ratio of M2 to GDP,
$\mu 4_t$ = common factor of monthly log-change in real value of domestic credit,
$\mu 5_t$ = monthly change in the U.S. high-yield spread multiplied by $\mu 4_t$,
R^2 = coefficient of determination,
DW = Durbin-Watson statistic,
Chow(>6/97) = p-value of a Chow test for a structural break in the parameters after June 1997,

[8] Note that the estimated standard errors in these equations are conditional on the estimated state space parameters as the extracted common factors are generated regressors. In principle, this could have been avoided by combining the state space form for the EMPIs and for the each of the macro fundamental variables into a single state space form and estimating all of the state space parameters and the factor loadings in a single step. (This system could also be extended to allow for a common shock that impacts upon all markets—see Dungey, Fry, Gonzàlez-Hermosillo and Martin, 2002.) Indeed, we did spend some time in attempting to estimate this system. The problem with this approach in practice is that it involves extremely high dimensionality of the resulting state space form and a very large number of unknown parameters to be estimated simultaneously (approximately one hundred). This initially generated a severe problem with available computer memory; this was eventually overcome but the maximum likelihood Kalman filtering estimation procedure did not prove stable with such a high-dimensional system. This remains a possible avenue for future research, however.

Hausman = p-value of a Hausman (1978) test for exogeneity of the current-dated regressors.[9]

It is interesting to note that similarity in financial indicators is capable of explaining 26 percent of the variation in the regional stress index, and that indicators such as the ratio of total foreign liabilities to GDP, inverse velocity and changes in the level of real domestic credit enter with significant and positive coefficients.[10] Note also, that a test for a structural break after June 1997 (the onset of the East Asian crisis) is insignificant. Most interestingly, the interaction of the change in real domestic credit and the US high-yield spread enters positively and significantly. Thus, to the extent that credit growth *in excess of inflation* implies a loose monetary policy, as suggested by Tanner (2001), or is associated with likelihood of unproductive investments, the implication is that such domestic vulnerability is aggravated by the joint effects of a larger premium being required by international investors for holding risky assets, and by the prediction of poorer export prospects on account of slower expected US growth which a rise in the high-yield spread predicts. The fitted values from this estimation seem to track well the actual values of the regional stress index (Figure 2 panel a). Note also that there does not appear to be any strong evidence of endogeneity of the right-hand-side regressors on the basis of a Hausman (1978) specification test. This is important because one might suspect that causality may at times run from, say, a rise in regional stress to movements in the stock market or even in the US high-yield spread, rather than vice versa. However, these reverse-causation effects do not appear to be strongly statistically significant.

One shortcoming of this estimated equation, however, is the evidence of first-order serial correlation, as shown by the low value of the Durbin-Watson statistic, even though we included lagged values of the macro fundamental variables. Accordingly, we re-estimated the equation with one lag of the dependent variable on the right-hand side. This led to the lagged change in the real stock market index and the inverse velocity factor becoming insignificant, so that the resulting final equation was:

$$\hat{\kappa}_t = -\underset{(1.3072)}{3.4443}\ \mu 1_t + \underset{(2.3456)}{5.6152}\ \mu 2_t + \underset{(0.0918)}{0.2012}\ \mu 4_t + \underset{(1.7651)}{5.1735}\ \mu 5_t + \underset{(0.0729)}{0.5169}\ \kappa_{t-1}$$

$$R^2=0.43,\ h=0.74,\ Chow(>6/97)=0.5357,\ Hausman=0.2134. \qquad (13)$$

---

[9] The Hausman test for exogeneity of the regressors was constructed using the method suggested by Davidson and MacKinnon (1993), with two lagged values of all variables in (12) (or, below, (13)) used as the instrument set.

[10] The estimated standard errors in this equation should be treated with caution since they are conditional on the estimates of the parameters of the state space form that was used to construct the generated regressors. See footnote 8.

The increase in the goodness of fit and the improved dynamic correspondence between the fitted estimates (i.e. the vulnerability index) and the actual values of the regional stress index is perhaps not surprising, (Figure 2 panel b); the first-order serial correlation has, however, disappeared (the statistic $h=0.74$, is Durbin's h statistic[11]) and again there is no sign of a structural break post-June 1997 on the basis of Chow test and the Hausman test does not reject exogeneity of the regressors.[12] Also, we once more see that the interaction term involving the product of the US high-yield spread and changes in the real level of domestic credit enters strongly significantly.[13]

In Figure 2 panel c we have graphed the contribution of the interaction term in equation (13) (i.e. $5.1735\mu 5_t$) together with the regional stress index itself: clearly, the interaction term tracks the regional stress index well, especially around the 1997-98 crisis period. Growth in the real value of domestic credit clearly had a strong influence on regional financial stress, especially in combination with a rising value of the US high yield spread.

3.5 The dynamic interaction of regional stress and common macro fundamentals

We next investigated the dynamic interaction between the regional stress index and the macro similarity variables by estimating small vector autoregressions (VARs). Our investigation of the relationship between macroeconomic and financial similarity and vulnerability (i.e. the component of regional stress which could be explained by the fundamentals) indicated the importance of the interaction between domestic credit and changes in the US high-yield spread. In estimating a VAR, however, since our ultimate aim was to produce impulse-response functions for the regional stress index in response to shocks to the macroeconomic and financial similarity variables, we were reluctant to include *both* changes in domestic credit *and* the interaction term in the same VAR since this would make interpretation of the impulse-response functions problematic because of the nonlinear relationship between these two variables. Accordingly, we estimated two systems: System 1,

---

[11] Durbin's h statistic, which is valid in the presence of a lagged dependent variable, is distributed as standard normal under the null hypothesis of no first-order serial correlation of the residuals.

[12] It is interesting to note that the estimated coefficient on the lagged dependent variable (0.5169) is much higher than the estimated simple first-order autocorrelation coefficient resulting from the dynamic factor analysis reported in Table 1 (0.1846). On reflection, however, the fact that the two coefficients differ is not surprising since, given (12) and the autocorrelation of the regional stress index, the lagged dependent variable is clearly correlated with the other regressors in (13).

which included the regional stress index (κ_t) and the regional common factors of the changes in the real stock market index ($\mu 1_t$), of the ratio of total foreign liabilities to GDP ($\mu 2_t$), and the interaction between changes in the high-yield spread and the common factor of changes in real domestic credit ($\mu 5_t$); and System 2, which included κ_t, $\mu 1_t$, $\mu 2_t$ and the regional common factor of changes in real domestic credit, $\mu 4_t$.[14]

We estimated a first-order VAR for both systems.[15] We then used the estimated VARs to construct impulse-response functions.[16] We have graphed the response of the regional stress index to shocks to itself and to each of the three macro similarity variables derived from Systems 1 and 2 in Figure 3. These impulse-response functions can in fact be interpreted as the response of *regional vulnerability* to innovations in each of the fundamentals variables since, by definition, movements in the regional stress index which are explained by movements in the fundamentals are in fact the same as movements in vulnerability.

Interestingly, the impulse-responses of regional stress with respect to shocks to itself and to $\mu 1_t$ and $\mu 2_t$ seem little affected by the choice of VAR and, moreover, each of the impulse-response functions show an interesting pattern capable of entirely intuitive interpretation. The impulse-response of the regional stress index to own shocks mean reverts toward zero with a half-life of between two and three months. Since this movement is conditional on holding the macro similarity variables constant, this may be interpreted as a measure of the degree to which pure market sentiment, independent of the fundamentals, affects the regional stress index.

---

[14] In fact, we found that the impulse-response functions obtained with all the variables, including both $\mu 4_t$ and $\mu 5_t$, in the VAR were qualitatively extremely similar to those we report below for the two separate systems, which is not surprising since $\mu 4_t$ and $\mu 5_t$ do not have a high degree of *linear* dependence. Nevertheless, we prefer to report the results obtained using the two systems, in order to make clear the interpretation of the impulse-response functions.

[15] The first-order VARs appeared adequate in the sense that there was no evidence of remaining serial correlation in the residuals, although the Akaike information criterion (AIC) did in fact suggest a third-order VAR in both cases. The tendency of the AIC to overparameterize and choose higher-order VARs is, however, well known, and a first-order system did seem more consistent with the dynamic factor and regression analysis reported elsewhere in the paper. However, as a check, we also carried out the impulse-response analysis with the third-order systems and this resulted in almost identical results.

[16] We used an orthogonalization of the VAR innovations based on a standard Cholesky decomposition, with the variables in the ordering κ_t -$\mu 1_t$- $\mu 2_t$-$\mu 5_t$ for System 1 and κ_t-$\mu 1_t$- $\mu 2_t$-$\mu 4_t$ for System 2, although alternative orderings (with κ_t first) did not materially affect the results.

The impulse response of regional stress (and hence vulnerability) to movements in the stock market index is also very interesting: although the effect for the first few periods is to reduce vulnerability—consistent with our single-equation regression results—the net long-term effect is in fact to *raise* regional vulnerability. As would be expected, an increase in total foreign liabilities as a proportion of GDP raises vulnerability in both the short run and the long run.

Shocks to the interaction between domestic credit and changes in the high-yield spread also tend to raise the vulnerability index in both the short run and the long run. Comparing Figures 3(a) and 3(b), however, it is interesting to note that shocks to the interactive term indicate a much more acute effect on regional vulnerability in the short run than do shocks to domestic credit alone.

3.6 The role of macro similarity in explaining individual country EMPIs

The next step in our investigation was an analysis of the extent to which the common factors in the macro fundamentals are capable of explaining movements in individual country EMPIs. We did this by regressing the individual country EMPIs onto the same set of variables as in regression equation (13), except that the individual country lagged EMPI replaces the lagged regional stress index. The results are given in Table 6. Interestingly, in most cases the variables enter with strongly significant coefficients which are the same sign as those reported in equation (13).

Columns 8 and 9 of Table 6 report the marginal significance level, or p-value, of an F-test of the significance of adding in the country-specific components of the macro fundamental variables into the regression, both for the post-1998 (i.e. post-crisis) period and for the pre-1999 period. In nearly every case, these p-values indicate that the national factors are insignificant in explaining movements in individual country EMPIs, although the marginal significance levels do appear to shrink post 1998, perhaps indicating a move towards greater importance of national factors. This is especially evident in the case of Thailand, which in fact has a p-value for the post-1998 period significantly less than 5 percent. Closer examination of the Thai regression reveals that it is the national component of the change in real domestic credit that is strongly significantly different from zero, with a marginal significance level of the t-ratio of the estimated coefficient of 0.0003. Testing for the significance of the remaining three national factors yielded a marginal significance level of 0.20.

3.7 The role of trade linkages

Finally, we examined the importance of trade linkages in explaining individual country EMPIs, once the influence of macro similarity had been accounted for, since there has been some debate in the literature as to whether contagion may be linked to the degree of trade integration among countries (see e.g. Glick and Rose, 1999; Taylor, 1999; Van Rijckeghem and Weder, 2001; Forbes, 2001). To do this, we constructed measures of trade integration suggested by Fratzscher (1999).[17] This variable was constructed on a monthly basis for each of the six countries under investigation, with respect to each of the other five countries, for our sample period. We then added the five trade linkage variables together for each country to provide and overall measure of trade linkage of each of the countries under examination with the other five countries over the sample period.[18]

In the final column of Table 6, we report the p-value resulting from a t-test of the significance of this variable when it is added into the EMPI regression for each of the individual countries, controlling for the international common components of the macro fundamental series. In each case, the marginal significance levels indicate that the variable is not significant at standard significance levels.

The fact that trade linkages do not appear significant in explaining movements in the EMPI over time should not, however, be taken as contradicting the findings of Glick and Rose (1999), who find that trade linkages are significant in explaining contagion. As noted earlier in our discussion, the "contagious crises" literature asks a different question from that posed in the present analysis, namely, given that a crisis has occurred, who else is most likely to be affected? In the present study, we are primarily examining the vulnerability of a region to the occurrence of a crisis.

4. Conclusion

In this paper, we have presented a case study of the six Asian countries most severely affected by the1997 currency crisis—Thailand, Indonesia, the Philippines, Malaysia, Singapore and Korea—in an analysis of the *vulnerability* of a region to exchange rate crisis. Our ultimate aim has been to contribute to an understanding of how crises may be prevented, rather than an understanding of how they spread.[19]

---

[17] See Fratzscher (1999) for details. Fratzscher's index is designed to capture both the degree of competition in third markets—which here includes industrialized countries (US, Europe and Japan), developing countries (Africa, Asia, Eastern Europe, Middle East and Western Hemisphere), and other regions—as well as the degree of bilateral trade between countries. The first factor captures the exposure of a country to a competitor's devaluation in selling to a third market, while the second factor captures the more direct effects of devaluation on bilateral trade.

[18] Trade data was obtained from the International Monetary Fund's *Direction of Trade Statistics*. We are grateful to Jung Yeon Kim for help in constructing these indices.

[19] See Goldstein, Kaminsky and Reinhart (2000) for a similar notion of "vulnerability."

In particular, we constructed a measure of regional financial stress for these countries using dynamic factor analysis which partitions the EMPIs of the six countries into a common or regional component and a country-specific, idiosyncratic component. We have also shown how this regional stress index can be further partitioned into a component that is predictable given the underlying regional measures of macro and financial similarity (leading to a measure of regional vulnerability) and a part that is unexpected based on the fundamentals (a residual measure that could be interpreted as regional contagion).

To summarize our empirical results briefly, regional vulnerability in these six East Asian countries appeared to arise in the context of regional accumulation of foreign liabilities and the rapid growth of domestic credit and stock market prices. Global, or "monsoonal," effects were proxied by the rise in risk premia in financial markets, which signal also a slowdown in US growth, amplifying the vulnerabilities on account of credit growth. There was no evidence of a structural change in the sources of vulnerability following the Asian crisis. Our results also suggest that individual country EMPIs are also explained by the common regional factors that drive the level of regional vulnerability. Country-specific factors played almost no role, with the exception of Thailand and, to a lesser extent, Singapore (both in the post-crisis period).

Our case study therefore reveals that the six countries in question were indeed characterized by a pre-existing degree of common vulnerability prior to the 1997-98 crisis. This is of interest for at least two reasons. First, it aids in our understanding of the East Asian crisis. Second, if this finding generalizes to other crises and geographical regions (and perhaps also to a wider definition of a geographical region), then the implications for policymakers in any particular country are that they need to be concerned not only about their own level of vulnerability, but should also monitor and, possibly safeguard against, financial imbalances in the rest of the region. For international financial institutions, multilateral surveillance takes on greater importance.

We end, therefore, with a call for further work on this issue. We have been careful to stress that the research reported in this paper can only be interpreted as a case study of six particular East Asian economies and the East Asian crisis of the late 1990s. Although the results of this case study are illuminating and suggest that our approach is potentially of policy significance, further research is necessary in order to establish the general applicability and usefulness of these methods. In particular, further work might usefully test the dynamic common factor approach in the context of other geographical regions (e.g. Latin America) or in the context of expanding the number of countries examined.

Acknowledgements
The research reported in this paper was undertaken while Mark Taylor was a Visiting Scholar at the International Monetary Fund. The authors are grateful to the editor—James Lothian—to three anonymous referees and to Kristin Forbes, Antu Murshid, and Carmen Reinhart for helpful and constructive comments on a previous version. We also thank Young Kim for assistance with the data. Any errors that may remain, however, are strictly the responsibility of the authors. In particular, the views expressed here are the authors' own private views and should not be attributed to the International Monetary Fund or to any of its member countries.

References

Agénor, P.-R., Miller, M., Vines, D., Weber, A. (Eds.), 1999. The Asian Financial Crisis: Causes, Contagion and Consequences. Cambridge University Press; Cambridge, New York and Melbourne.

Bank for International Settlements, 1998. Annual Report. Bank for International Settlements, Basel.

Calvo, G.A., Mendoza, E., 2000. Rational Contagion and the Globalization of Securities Markets. Journal of International Economics 51, 79-113.

Chinn, M.D., 1999. On the Won and Other East Asian Currencies. International Journal of Finance and Economics 4, 113-127.

Chinn, M.D., 2000. Before the Fall: Were East Asian Currencies Overvalued? Emerging Markets Review 1, 101-126.

Chinn, M.D., Dooley, M.P., 1997. Asia–Pacific Capital Markets: Measurement of Integration and the Implications for Economic Activity. In: Ito, T., Krueger, A.O. (Eds.), Regionalism Versus Multilateral Trading Arrangements. Chicago University Press, Chicago.

Chinn, M.D., Dooley, M.P., 1999. International Monetary Arrangements in the Asia-Pacific Before and After. Journal of Asian Economics, 10, 361-84.

Chinn, M.D., Dooley, M.P., Shrestha, S., 1999. Latin America and East Asia in the Context of an Insurance Model of Currency Crises. Journal of International Money and Finance, 18, 659–81.

Corsetti, G., Pericoli, M., Sbracia, M., 2002. Some Contagion, Some Interdependence: More Pitfalls in the Tests of Financial Contagion. Unpublished Working Paper, Yale University, New Haven, CT.

Corsetti, G., Pesenti, P., Roubini, N. 1999. The Asian Crisis: An Overview of the Empirical Evidence and Policy Debate. In: Agénor, P.-R., Miller, M., Vines, D., Weber, A. (Eds.), 1999. The Asian Financial Crisis: Causes, Contagion and Consequences. Cambridge University Press; Cambridge, New York and Melbourne.

Cuthbertson, K., Hall, S.G., Taylor, M.P., 1992. Applied Econometric Techniques. University of Michigan Press, Ann Arbor.

Davidson, R., MacKinnon, J.G., 1993. Estimation and Inference in Econometrics. Oxford University Press, Oxford and New York.

Dooley, M.P. 1997. A Model of Crises in Emerging Markets. International Finance Discussion Paper no. 630. Board of Governors of the Federal Reserve System, Washington, DC.

Dungey, M., Fry, R., Gonzàlez-Hermosillo, B., Martin, V.L. 2002. International Contagion Effects from the Russian Crisis and the LTCM Near-Collapse. International Monetary Fund Working Paper no. 02/74.

Dungey, M., Tambakis, D.N. 2003. International Financial Contagion: What Do We Know? Unpublished Working Paper, Australian National University, Canberra, ACT.

Edwards, S. 2000. Contagion. World Economy 23, 873-900.

Eichengreen, B., Hale, G., Mody, A. 2001. Flight to Quality: Investor Risk Tolerance and the Spread of Emerging Market Crises. In: Claessens, S., Forbes, K.J. (Eds.), 2001. International Financial Contagion. Kluwer Academic, Boston, MA.

Engle, R.F., Watson, M.F. 1981. A One-Factor Multivariate Time-Series Model of Metropolitan Wage Rates. Journal of the American Statistical Association 76, 774-781.

Flood, R.F., Marion, N. 1999 Perspectives on the Recent Currency Crisis Literature. International Journal of Finance and Economics 4, 1-26.

Forbes, K.J. 2001. Are Trade Linkages Important Determinants of Country Vulnerability to Crises? National Bureau of Economic Research Working Paper no. 8194. Cambridge, MA.

Forbes, K.J., Rigobon, R. 2001. Measuring Contagion: Conceptual and Empirical Issues. In: Claessens, S., Forbes, K.J. (Eds.), 2001. International Financial Contagion. Kluwer Academic, Boston, MA.

Fratzscher, M. 1999. What Causes Currency Crisis: Sunspots, Vulnerability or Fundamentals? Unpublished Working Paper. European University Institute, Florence.

Gertler, M., Lown, C. 1999. The Information in the High-Yield Bond Spread for the Business Cycle: Evidence and Some Implications. Oxford Review of Economic Policy 15, 132-50.

Girton, L., Roper, D. 1977. A Monetary Model of Exchange Market Pressure Applied to the Postwar Canadian Experience. American Economic Review 67, 537-548.

Glick, R., Rose, A. 1999. Contagion and Trade: Why are Currency Crises Regional? Journal of International Money and Finance 8, 603-617.

Goldstein, M., Kaminsky, G.L., Reinhart, C.M. 2000. Assessing Financial Vulnerability: An Early Warning System for Emerging Markets. Institute for International Economics, Washington, DC.

Haley, B. 1978. The Healthy Body and Victorian Culture. Harvard University Press, Cambridge, MA.

Harvey, A.C. 1989. Forecasting, Structural Time Series Models and the Kalman Filter. Cambridge University Press, Cambridge, New York and Melbourne.

Hausman, J. 1978. Specification Tests in Econometrics. Econometrica 46, 1251-71.

Jeanne, O. 1997. Are Currency Crises Self-Fulfilling? A Test. Journal of International Economics 43, 263-86.

Kaminsky, G.L., Lizondo, S., Reinhart, C.M., 1998. Leading Indicators of Currency Crises. International Monetary Fund Staff Papers 45, 1-48.

Kaminsky, G.L., Reinhart, C.M. 1999. The Twin Crises: The Causes of Banking and Balance-of-Payments Problems. American Economic Review 89, 473-500.

Kaminsky, G.L., Reinhart, C.M. 2000. On Crises, Contagion, and Confusion. Journal of International Economics 51 (1), 145-168.

Krugman, P. 1998. What happened to Asia? Unpublished Working Paper. Massachusetts Institute of Technology, Cambridge, MA.

Masson, P. 1999. Contagion: Monsoonal Effects, Spillovers, and Jumps Between Multiple Equilibria. In: Agénor, P.-R., Miller, M., Vines, D., Weber, A. (Eds.), 1999. The Asian Financial Crisis: Causes, Contagion and Consequences. Cambridge University Press; Cambridge, New York and Melbourne.

McKinnon, R., Pill, H. 1996. Credible Liberalizations and International Capital Flows: The Overborrowing Syndrome. In: Ito, T., Krueger, A.O. (Eds.), Financial Deregulation and Integration in East Asia. Chicago University Press, Chicago, IL.

Mody, A., Taylor, M.P. 2002. International Capital Crunches: The Time-Varying Role of Informational Asymmetries. International Monetary Fund Working Paper no. 02/43. Washington, DC.

Mody, A. Taylor, M.P. 2003. The High-Yield Spread as a Predictor of Real Economic Activity: Evidence of a Financial Accelerator for the United States. International Monetary Fund Staff Papers 50, 373-402.

Mody, A., Taylor, M.P. 2004. Financial Predictors of Real Activity and the Financial Accelerator. Economics Letters 82, 167-72.

Morck, R., Yeung, B., Yu, W. 2000. The Information Content of Stock Markets: Why Do Emerging Markets Have Synchronous Stock Price Movements? Journal of Financial Economics 58, 215-260.

Rigobon, R. 1998. Informational Speculative Attacks: Good News is No News. Unpublished Working Paper, Massachusetts Institute of Technology, Cambridge, MA.

Sarno, L., Taylor, M.P. 1999a. Moral Hazard, Asset Price Bubbles, Capital Flows and the East Asian Crisis: The First Tests. Journal of International Money and Finance 18, 637-57.

Sarno, L., Taylor, M.P. 1999b. Hot Money, Accounting Labels and the Permanence of Capital Flows to Developing Countries: An Empirical Investigation. Journal of Development Economics 59, 337-64.

Tanner, E. 2001. Exchange Market Pressure and Monetary Policy: Asia and Latin America in the 1990s. International Monetary Fund Staff Papers 47, 311-333.

Taylor, M.P. 1999. Contagion and Trade: Why are Currency Crises Regional?: Discussion of Glick and Rose. In Agénor, P.-R., Miller, M., Vines, D., Weber, A. (Eds.), 1999. The Asian Financial Crisis: Causes, Contagion and Consequences. Cambridge University Press; Cambridge, New York and Melbourne.

Van Rijckeghem, C., Weder, B. 2001. Sources of Contagion: Is It Finance or Trade? Journal of International Economics 54, 293-308.

Figure 1. Exchange Market Pressure Index

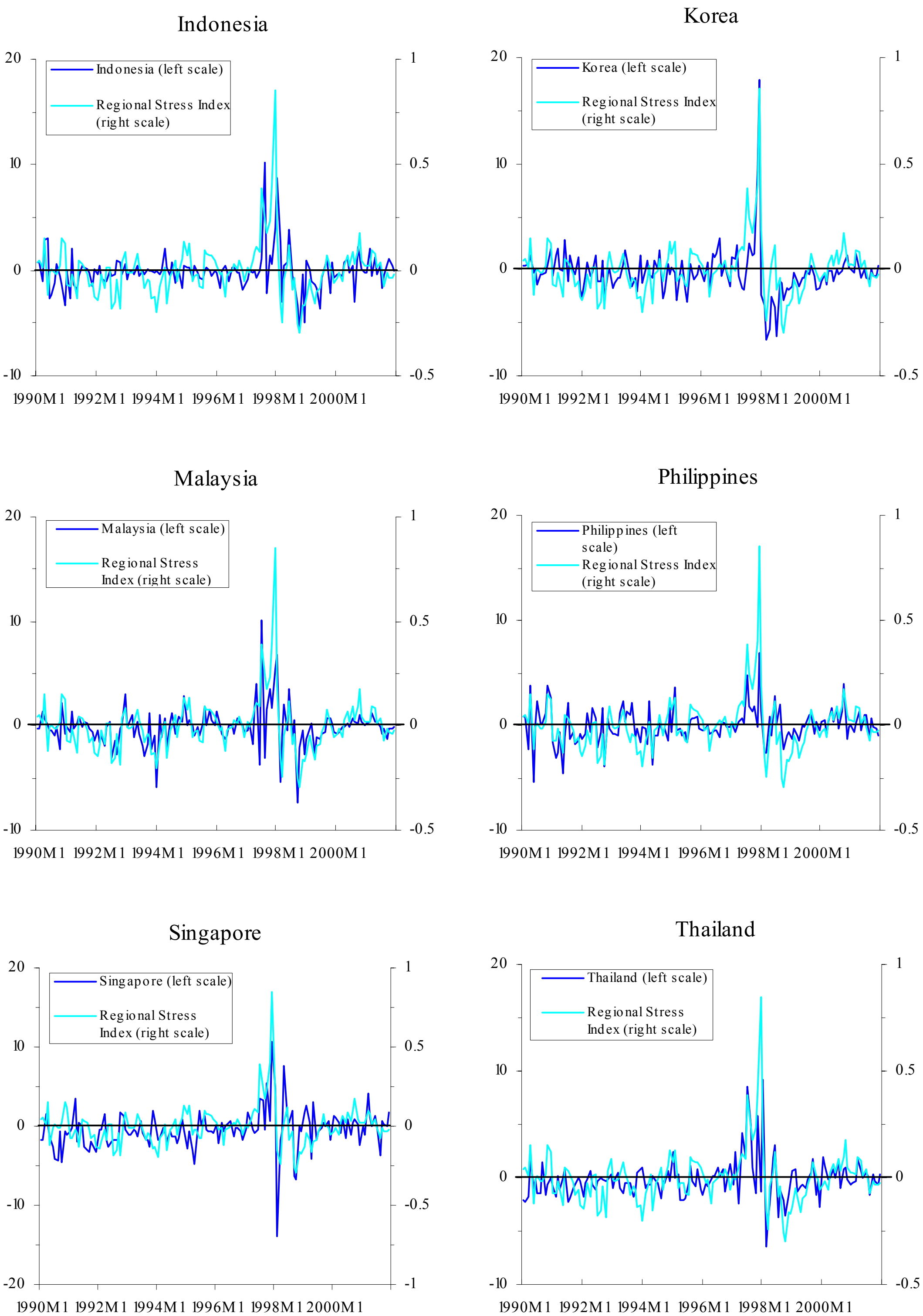
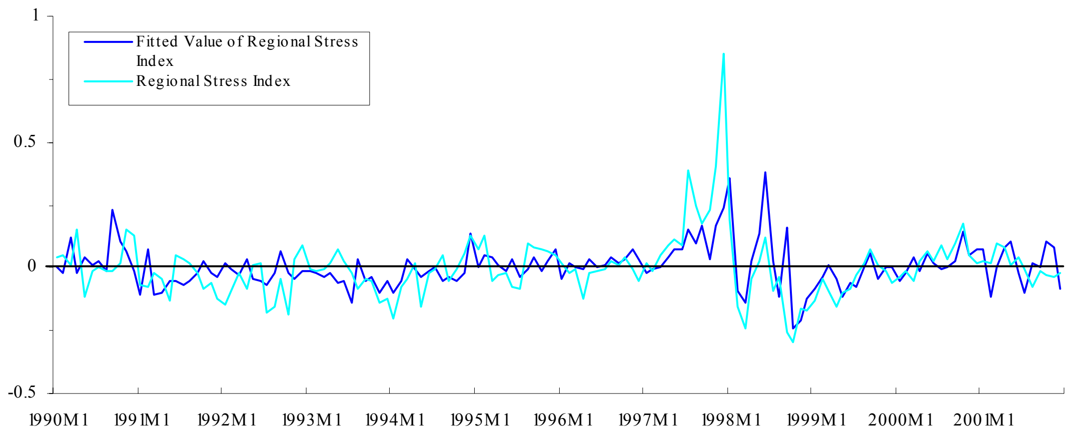
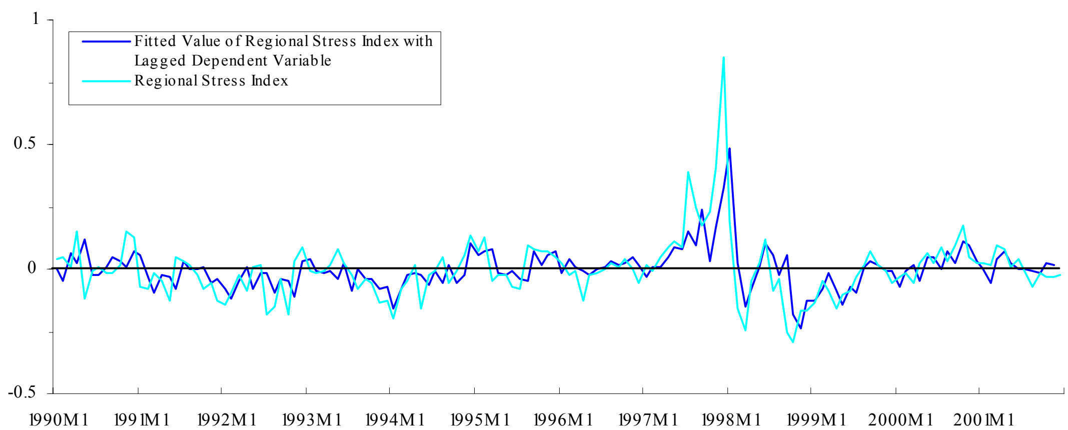


Figure 2. Explaining Common Regional Stress

(a) Fitted Value of Regional Stress Index



(b) Fitted Value of Regional Stress Index with Lagged Dependent Variable



(c) Contribution of Interaction Term in Explaining Regional Stress Index

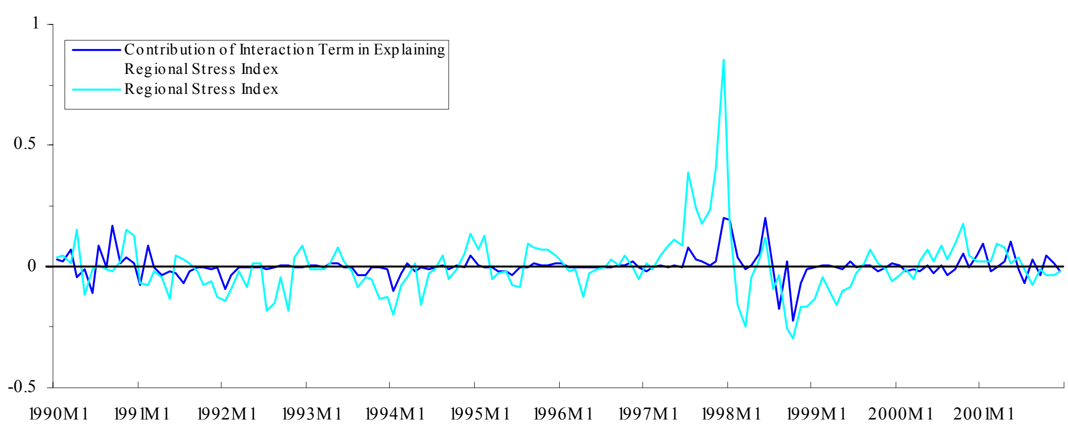
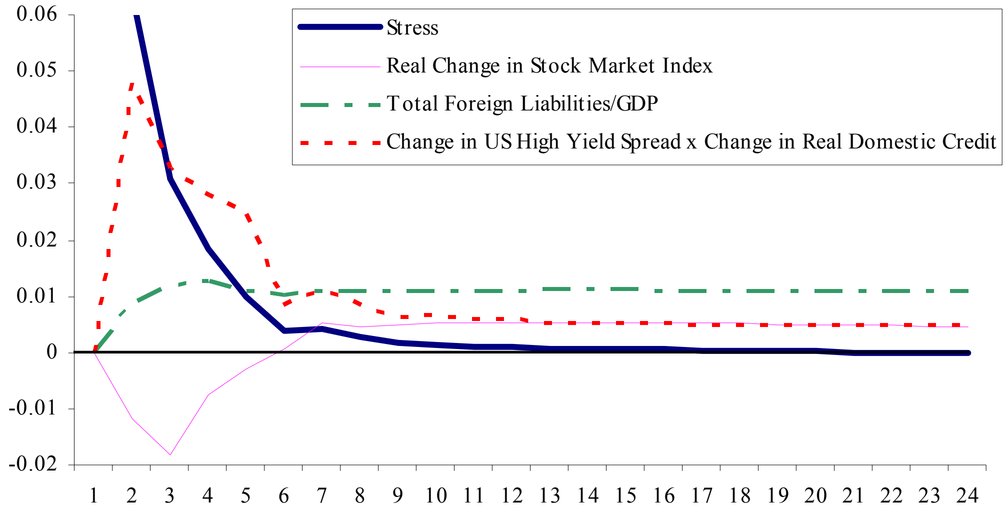


Figure 3. Impulse Response Functions of Regional Stress

(a) System 1



(b) System 2

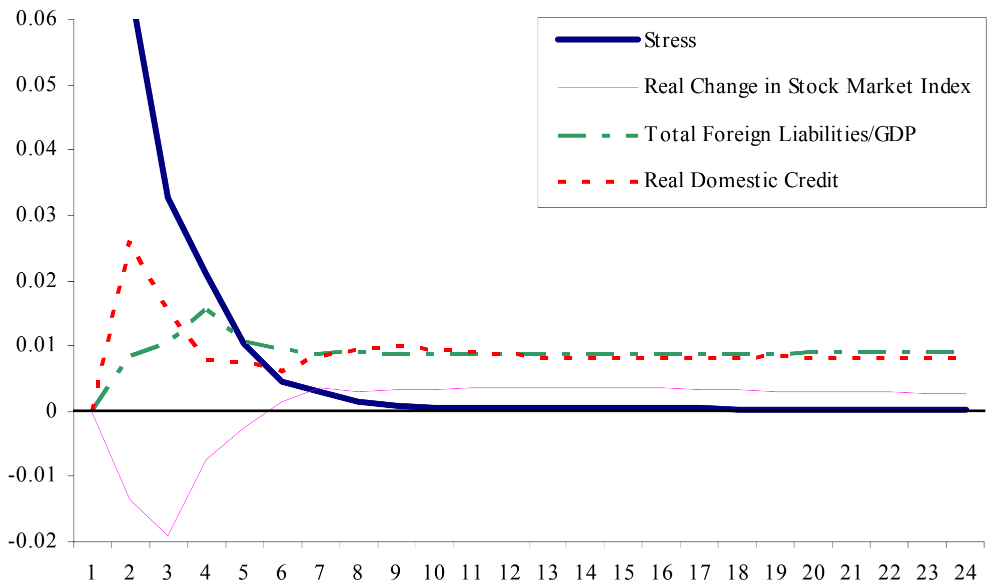


Table 1: State Space Parameter Estimation Results: Exchange Market Pressure Index

Param.	*Estimate*	*Stand. Error*	*Param.*	*Estimate*	*Stand. Error*	*Param.*	*Estimate*	*Stand. Error*	*R^2 of Common Component*	*R^2*
-	-	-	φ	0.1846	0.5143	-	-	-		
$\gamma^{(1)}$	0.4699	0.1034	$\Psi^{(1)}$	0.1151	0.3045	σ^2_1	2.8836	1.0032	R_1^2	0.29
$\gamma^{(2)}$	12.4633	2.3254	$\Psi^{(2)}$	0.1088	0.2098	σ^2_2	4.8749	1.9632	R_2^2	0.33
$\gamma^{(3)}$	10.5574	2.1194	$\Psi^{(3)}$	0.4059	0.1174	σ^2_3	2.1963	0.9053	R_3^2	0.40
$\gamma^{(4)}$	5.0734	1.0043	$\Psi^{(4)}$	0.5205	0.1947	σ^2_4	1.8764	0.8176	R_4^2	0.70
$\gamma^{(5)}$	3.7972	0.8521	$\Psi^{(5)}$	0.1430	0.0221	σ^2_5	1.4137	0.6542	R_5^2	0.25
$\gamma^{(6)}$	40.5731	3.8862	$\Psi^{(6)}$	0.3300	0.1241	σ^2_6	3.1115	0.6658	R_6^2	0.21

Note: R^2_i denotes the coefficient of determination in a regression of the country variable onto the extracted common factor for country i, with 1=Indonesia, 2=Korea, 3=Malaysia, 4=Philippines, 5=Singapore, 6=Thailand.

Table 2: State Space Parameter Estimation Results: Real Stock Market Changes

Param.	*Estimate*	*Stand. Error*	*Param.*	*Estimate*	*Stand. Error*	*Param.*	*Estimate*	*Stand. Error*	*R^2 of Comm. Compt.*	*R^2*
-	-	-	Φ	0.4426	0.2033	-	-	-		
$\gamma^{(1)}$	0.9472	0.4176	$\Psi^{(1)}$	0.0855	0.0321	σ^2_1	0.0135	0.0052	R_1^2	0.35
$\gamma^{(2)}$	8.0237	2.3764	$\Psi^{(2)}$	0.0320	0.0118	σ^2_2	0.0090	0.0042	R_2^2	0.39
$\gamma^{(3)}$	9.9100	2.8345	$\Psi^{(3)}$	0.0847	0.0203	σ^2_3	0.0068	0.0033	R_3^2	0.55
$\gamma^{(4)}$	16.6847	6.3754	$\Psi^{(4)}$	0.2322	0.1008	σ^2_4	0.0052	0.0022	R_4^2	0.80
$\gamma^{(5)}$	6.8947	1.1435	$\Psi^{(5)}$	0.1090	0.0347	σ^2_5	0.1827	0.0662	R_5^2	0.55
$\gamma^{(6)}$	35.3404	9.7312	$\Psi^{(6)}$	0.2175	0.1020	σ^2_6	0.3077	0.1442	R_6^2	0.54

Note: R^2_i denotes the coefficient of determination in a regression of the country variable onto the extracted common factor for country i, with 1=Indonesia, 2=Korea, 3=Malaysia, 4=Philippines, 5=Singapore, 6=Thailand.

Table 3: State Space Parameter Estimation Results: Ratio of Total Foreign Liabilities to Nominal GDP

Param.	*Estimate*	*Stand. Error*	*Param.*	*Estimate*	*Stand. Error*	*Param.*	*Estimate*	*Stand. Error*	*R^2 of Comm. Compt.*	*R^2*
-	-	-	Φ	0.6034	0.2334	-	-	-		
$\gamma^{(1)}$	1.7771	0.5621	$\Psi^{(1)}$	0.2152	0.1123	σ^2_1	0.2123	0.1003	R_1^2	0.29
$\gamma^{(2)}$	3.2213	1.1331	$\Psi^{(2)}$	0.2981	0.1432	σ^2_2	0.2621	0.1326	R_2^2	0.26
$\gamma^{(3)}$	4.1239	2.0003	$\Psi^{(3)}$	0.2315	0.1183	σ^2_3	0.0981	0.0224	R_3^2	0.23
$\gamma^{(4)}$	8.9991	3.1123	$\Psi^{(4)}$	0.2411	0.1221	σ^2_4	0.0991	0.0221	R_4^2	0.11
$\gamma^{(5)}$	5.6673	2.1561	$\Psi^{(5)}$	0.2318	0.1010	σ^2_5	0.4146	0.2153	R_5^2	0.05
$\gamma^{(6)}$	9.8899	4.6391	$\Psi^{(6)}$	0.3159	0.1235	σ^2_6	0.4733	0.2236	R_6^2	0.20

Note: R^2_i denotes the coefficient of determination in a regression of the country variable onto the extracted common factor for country i, with 1=Indonesia, 2=Korea, 3=Malaysia, 4=Philippines, 5=Singapore, 6=Thailand.

Table 4: State Space Parameter Estimation Results: Changes in Real Domestic Credit

Param.	*Estimate*	*Stand. Error*	*Param.*	*Estimate*	*Stand. Error*	*Param.*	*Estimate*	*Stand. Error*	*R^2 of Comm. Compt.*	*R^2*
-	-	-	Φ	0.4510	0.2031	-	-	-		
$\gamma^{(1)}$	0.7018	0.3113	$\Psi^{(1)}$	0.1296	0.0431	σ^2_1	0.0130	0.0067	R_1^2	0.79
$\gamma^{(2)}$	10.0446	3.4221	$\Psi^{(2)}$	0.5063	0.2249	σ^2_2	0.3279	0.1432	R_2^2	0.11
$\gamma^{(3)}$	7.8648	2.6425	$\Psi^{(3)}$	0.2085	0.1127	σ^2_3	0.4740	0.2034	R_3^2	0.13
$\gamma^{(4)}$	7.9067	2.7447	$\Psi^{(4)}$	0.1083	0.0623	σ^2_4	0.8598	0.4256	R_4^2	0.17
$\gamma^{(5)}$	4.3942	1.2151	$\Psi^{(5)}$	0.2197	0.1134	σ^2_5	0.9364	0.3346	R_5^2	0.15
$\gamma^{(6)}$	12.4753	5.3344	$\Psi^{(6)}$	0.5359	0.2615	σ^2_6	0.5465	0.2352	R_6^2	0.32

Note: R^2_i denotes the coefficient of determination in a regression of the country variable onto the extracted common factor for country i, with 1=Indonesia, 2=Korea, 3=Malaysia, 4=Philippines, 5=Singapore, 6=Thailand.

Table 5: State Space Parameter Estimation Results: Ratio of M2 to GDP

Param.	*Estimate*	*Stand. Error*	*Param.*	*Estimate*	*Stand. Error*	*Param.*	*Estimate*	*Stand. Error*	*R^2 of Comm. Compt.*	*R^2*
-	-	-	Φ	0.6422	0.2270	-	-	-		
$\gamma^{(1)}$	0.8156	0.3416	$\Psi^{(1)}$	0.2153	0.1013	σ^2_1	0.0177	0.0061	R_1^2	0.73
$\gamma^{(2)}$	8.1952	3.9228	$\Psi^{(2)}$	0.5155	0.2413	σ^2_2	0.3142	0.1553	R_2^2	0.41
$\gamma^{(3)}$	8.1265	3.8873	$\Psi^{(3)}$	0.2144	0.1143	σ^2_3	0.4521	0.2152	R_3^2	0.66
$\gamma^{(4)}$	6.4432	2.9853	$\Psi^{(4)}$	0.1432	0.0631	σ^2_4	0.7861	0.3734	R_4^2	0.73
$\gamma^{(5)}$	2.1123	1.0338	$\Psi^{(5)}$	0.2248	0.1133	σ^2_5	0.8355	0.3124	R_5^2	0.21
$\gamma^{(6)}$	16.8913	4.3899	$\Psi^{(6)}$	0.6349	0.2816	σ^2_6	0.5671	0.2445	R_6^2	0.67

Note: R^2_i denotes the coefficient of determination in a regression of the country variable onto the extracted common factor for country i, with 1=Indonesia, 2=Korea, 3=Malaysia, 4=Philippines, 5=Singapore, 6=Thailand.

Table 6: Individual Country EMPI Regressions

Country	Lagged EMPI	Stock market change	Total foreign liabilities to GDP	Domestic credit change	Change in high-yield spread * domestic credit change	R^2	National Factors Pre-1999 p-value	National Factors Post-1998 p-value	Trade p-value
Indonesia	0.1727 (0.0912)	-14.0331 (6.4432)	0.2641 (0.0771)	9.5933 (3.6313)	48.3141 (16.5805)	0.18	0.8739	0.2012	0.6969
Korea	0.4597 (0.0833)	-66.6453 (26.1594)	2.2226 (1.6871)	7.1364 (3.1003)	38.3392 (20.7661)	0.23	0.9710	0.3142	0.1091
Malaysia	0.1297 (0.0817)	-66.2690 (23.0265)	1.9307 (0.9912)	11.5633 (3.9390)	18.8082 (8.4910)	0.15	0.7277	0.2561	0.7380
Philippines	0.3761 (0.1991)	-67.8627 (20.5311)	1.6647 (2.2349)	7.0759 (3.4568)	6.5373 (2.9810)	0.19	0.3841	0.1777	0.5049
Singapore	0.0336 (0.0890)	-32.7606 (12.3321)	7.4286 (3.3915)	18.1095 (5.1403)	10.0356 (4.05299)	0.18	0.1123	0.0914	0.5880
Thailand	0.0546 (0.0825)	-29.6951 (12.2843)	6.3382 (2.4313)	14.9619 (3.7293)	20.4199 (9.1238)	0.23	0.2300	0.003	0.1051

Note: Dependent variable is the individual country EMPI. Columns 2-5 give estimated coefficients for lagged EMPI and various extracted common macro factors, with standard errors given in parentheses; R^2 in column 6 gives the coefficient of determination of this regression. Column 7 gives the p-value of an F-test of the significance of adding the national components of each of the macro variables to the regression for the pre-1999 period, while column 7 gives the p-value of an F-test of the significance of adding the national components of each of the macro variables to the regression for the post-1998 period. Column 8 gives the p-value of a t-test of the significance of adding a trade linkage variable to the regression.