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Contagion and the Role of Market Development: the Case of the Malaysian Futures Market During the East Asian Crisis of 1997

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ABSTRACT

In looking to explain the possible transmission and causal flows in volatility between financial markets during an economic crisis and the impact of possible contagion, we examine the specific circumstances surrounding the role of the development of futures index trading in Malaysia in relation to the East Asian (or Asian) crisis of the late 1990's. Specifically, our main contribution is to assess whether an undeveloped and subsequently developing futures market had the 'efficiency capacity' to transmit fair prices and, failing that, whether price contagion was spread via futures index trading.

1. INTRODUCTION

The Asian crisis that began in 1997 has been well-documented in a number of articles (for example, Masih and Masih 1999; Reside and Gochoco-Bautista, 1999; Nagayasu 2001; De Gregario and Valdes 2001; In *et al*, 2001; Khalid and Kawai, 2003; Sander and Kleimeier, 2003; and Dungey *et al*, 2005) although there has been no published work on the role of futures markets in the potential propagation of contagion between Asian financial markets. We would argue that this is an important omission on two grounds. First, derivatives markets came under significant scrutiny as to their role in the development of the 1987 stock market crisis, but the work relating to the Asian crisis remains limited in scope.[2] Second, our investigation of the Malaysian futures market addresses the potential impact of immature financial operations that have been associated with greater volatility in previous work, but not in relation to futures markets specifically.[3] Our work is therefore motivated to address what we consider to be a gap in our understanding of contagion propagation from a futures market perspective. Moreover, in developing our methodological approach, we respond specifically to the difficulties in identifying possible contagion effects over and above *additional* correlation which has been the source of significant difficulty in understanding

contagion propagation (see Forbes and Rigobon, 2002; Billio and Pelizzon, 2003). In so doing, we define and account explicitly for price transmission mechanism changes that might reflect conditions that promote contagion propagation. Finally, our analysis is conducted over three different economic environments (pre-crisis, crisis and post-crisis) and thus we are able to comment on how potentially different economic regimes related to stages of market development which, as we go on to argue, are important in understanding the propagation of contagion in the context we study.

In adopting a case approach, we examine comprehensively the pricing efficiency of two futures markets before, during and after the 1997 Asian crisis.[4] Our approach is to benchmark the performance of a developing market, Malaysia, against a geographically close, established market, Singapore. We do not replicate the studies that have established the degree of spread of the crisis in stock markets (Corsetti *et al*, 2001, review this comprehensively), but look to assess how two futures markets possibly interacted over the full crisis spectrum.[5] Our motive in choosing the Malaysian case is to examine the elements of the crisis that relate specifically to the development of a futures market in an attempt to understand the relationship between market development, market fragility and crisis economic conditions. To this end, we outline in the next section some economic background of the impact of the crisis with a particular focus on Malaysia and then detail our proposed methodology. In the section following we present our results and interpretation of the evidence. Conclusions are then drawn.

2. Economic Background, Methodological Approach and Empirical Tests

2.1 Economic background

The issues and causes of the Asian Financial Crisis were reflected initially in the currency markets and had a particularly heavy impact on US Dollar trading. In Malaysia, the Ringitt depreciated against the US Dollar by about 50 per cent and stabilised subsequently (March 1999), largely as a result of a control regime put in place in September, 1998.[6] Additionally, the banking sector across the region suffered from an absence of liquidity which, in turn, impacted on the funding for business operations. For example, loan growth rates fell sharply to virtual stagnation and non-performing loans rose sharply. What began as a currency crisis transformed into a more widespread problem as stock markets experienced significant price reductions, with sovereign debt downgrades experienced across the region.

The impact on Malaysia was severe given its preceding sharp development. There had been a dramatic increase in the growth of the equity market in Malaysia during the 1990's: market capitalisation increased from RM245.70 billion in 1993 to RM844.48 billion by 1997, which made Malaysia the 4th largest stock market in Asia and 13th in the world. Trading volume and the number of companies listed during that time also increased substan-

tially. In 1996, the total volume traded was 66.46 billion shares valued at RM463.27 billion, an increase of 95 per cent and 158 per cent over 1995's volume and value respectively. The number of companies listed in 1997 increased nearly two-fold from that in 1995. By April 1997, there were 641 companies listed on KLSE's Main Board and Second Board. The success of the stock market led, in 1995, to the introduction of trading of futures and other derivatives when the KLSE began trading the Composite Index Futures.[7]

A number of authors have concluded that the Asian crisis was not one that was linked to fundamentals, but was a reflection of a relatively weak financial sector. The coincident and perhaps contradictory evidence relating to Malaysia of exposure to economic disruption arising from currency fluctuations, coexisting with strong fundamentals has consistently been reported as a feature of the Asian crisis more broadly. Stiglitz (1998) attributed the Asian financial crisis to a combination of effects arising from a weakening financial sector, a high debt-to-equity ratio, a large amount of short-term foreign liabilities and a lack of transparency in the lending industry. These effects are likely to be compounded, or localised, when economies are geographically proximate, giving rise naturally to close trading relationships (Fratszer, 1998). Glick and Rose (1998) also confirm that financial crises tend to be regional. White (1998) reports that the combination of competitive currency devaluation and unhedged currency positions led to capital withdrawals within the Asian region which underpinned the strength of the crisis. In a different crisis but related market, Cifarelli (1998) considers the circumstances of the 1992 ERM currency crisis on the relationship between futures contracts on long term bonds issued by the Italian Treasury and futures contracts on offshore Eurolira deposits traded in LIFFE. He finds increased volatility in the pricing of bond futures due to intra-national effects (Italian Treasury credibility), but increased efficiency in the pricing of Eurolira futures during the crisis, which is suggestive of a containment of domestic aspects of the crisis to *within* national borders. The factual and counterfactual tests involved in this study provide firm evidence as to the role of futures trading and are indicative of their importance; a view we confirm in relation to the markets under study in this paper.

2.2 Methodological approach

Broadly, we specify and test the cointegrating relationships between related futures and spot markets to ensure that both markets are acting in the coordinated manner that is to be expected of a derivative and its underlying. We then proceed to assess the scope, scale and causality relating to possible contagion between futures markets by i) testing to see if the cross-border cointegration in futures markets alter during the full crisis economic cycle as an indication of contagion,[8] ii) establishing the potential scale of transmission via the calculation of cross border correlations in futures markets volatility, and iii) assessing causality in an attempt to specify the direction of transmission.

2.3 Futures and spot market cointegration

Our analysis is in three stages. First, we employ price related tests to examine efficiency that emerges from the relationship between stock index futures and the spot price, and may be motivated in terms of arbitrage behaviour (Stoll and Whaley, 1990), and expressed as:

$$F_t^* = S_t e^{(r-d)(T-t)} \tag{1}$$

where F_t^* is the fair or theoretically correct stock index futures price quoted at time t; S_t is the value of the underlying stock index; r is a risk-free rate of interest and d is the yield on dividends over the period until the contract matures, which is defined as $(T-t)$, the time to expiration for futures contracts. At time T, the futures price settles at (converges to) the stock index level, so that $F=S$. An appropriate efficiency test would be to estimate the following regression:

$$S_t = \alpha + \beta F_{t-n} + e_t \tag{2}$$

For the markets to be efficient the testable restrictions $\alpha = 0$ and $\beta = 1$ must be met and if the series are cointegrated, the residuals from et must be stationary. We adopt the Johansen vector autoregression model to assess the degree of cointegration (see also Lai and Lai, 1991).

Second, if two variables are cointegrated then according to the Granger Representation Theorem (Engle and Granger, 1987), there must also be an error correction representation:

$$Z_t = f_t - \alpha s_t \tag{3}$$

The error correction has the following form in our context:

$$\Delta s_t = -\rho_1 Z_{t-1} + \sum_{j=1}^{n} \alpha_i \Delta s_{t-i} + \sum_{j=1}^{n} \beta_j \Delta f_{t-i} + \varepsilon_t \tag{4}$$

$$\Delta f_t = -\rho_2 Z_{t-1} + \sum_{j=1}^{n} \gamma_i \Delta f_{t-i} + \sum_{j=1}^{n} \lambda_j \Delta s_{t-i} + \varepsilon_2 \tag{5}$$

where $\rho_1 + \rho_2 \neq 0$ and ε_1 and ε_2 are finite order moving averages. Variables s and f are the logs of spot prices and futures prices respectively. Thus, we report if changes in the variables s_t and f_t are partly driven by the previous value of Z_t. Z_{t-1} must be present in a significant manner in at least one direction if the series are cointegrated. This methodology has now a long pedigree in futures markets research, beginning with Quan (1992).

Third, an Error Correction Model (ECM) that incorporates errors from a cointegration regression in the bivariate case must possess temporal 'causality' in the Granger sense at least in one direction (Granger, 1988). Thus, for a pair of series to have an attainable equilibrium, there must be some causation between them to provide the necessary dynamics. In a world with no differential transactions costs across markets and no restrictions on borrowing or short selling, we would expect the spot market and the futures market to be equally accessible to all traders. Investors who have collected and analysed new information would be indifferent about transacting in one market over the other, and new information would tend to be revealed simultaneously in the prices of both markets. If the conditions tend to favour transactions in a particular market, then new information may be processed more rapidly in one market than the other. In other words, prices in one market may lead prices in the other market. The direction of causality that results in cointegrating markets should be bi-directional if the same information sets are available to both sets of market participants. If there is a superior information set or processing ability in either market, we might anticipate a unidirectional response. This is particularly important in developing markets where the *modus operandi* may have robust financial architecture but fragile confidence, and particularly so during the stress testing that was the Asian crisis. We therefore test and report on causality between spot and futures markets. Early work has established this approach as an informative one (Kawaller *et al* 1987; Stoll and Whaley 1990; and Chan 1992).

2.4 What is meant by contagion?

Within the contagion literature the principal debate has concerned the distinction between contagion and correlation. Contagion, above and beyond simple correlation (or *interdependence*) may arise if associated with a structural break or regime change. Thus, Corsetti *et al* (2001) argue in relation to stock markets in countries i and j, that stock market returns are assumed to be determined by the following processes:

$$r_i = \alpha_i + \gamma_i g + \varepsilon_i \quad (6)$$

$$r_j = \alpha_j + \gamma_j g + \varepsilon_j \quad (7)$$

where $r_{i,j}$ are the returns to countries i and j; γ are the factor loadings that relate global events to country returns; g is the global factor and ε are the unsystematic returns to the country.

That is, the processes comprise both country specific (unsystematic, risk adjusted) elements and global (or systematic) elements. The correlation in returns between r_i and r_j obviously contain variance of returns from both r_i and r_j and, hence, it is impossible to determine if a change in observed correlation arises from a change in var(r_i), or var(r_j), or both. Corsetti *et al* argue

that changes in correlation arising from var(r_i), or var(r_j), or both, are not contagion since they are consistent with the return generating processes described in (6) and (7). This is *interdependence*. If contagion was present, they argue, the return generating process would no longer function as an accurate process since it would become dominated by a different process. The return generating process would become dominated by a crisis regime (and become 'too strong' in relation to the usual return generating process). This is *contagion*. In essence, contagion is a result of a discontinuity in the transmission mechanism (see also Wang, 2004). The transmission mechanism we test as an indicator of contagion is the cross-border cointegrating relationship between futures markets, premised on an efficient within-border cointegrating relationship existing between spot and futures for each country.

2.5 Contagion analysis: transmission mechanism

We assess the cross-border cointegration mechanisms between Malaysia and Singapore futures markets in an analogous approach to that discussed in section 2.3, premised on the basis of geographic and, hence, economic proximity as outlined in the Introduction. Cointegrating relations are specified below. We then go on to examine cross-border error correction and the results of causality tests. A cointegrating relationship then provides the base against which regime change may be assessed in a sub-sample analysis over pre-crisis, crisis and post-crisis periods and which forms the basis of structural break tests that are now commonly employed (Campos *et al* 1996 and Johansen *et al* 2000). Thus, should the cointegrating relationship change over the full crisis economic cycle, then evidence exists of a regime change and the potential for contagion.

2.6 Contagion analysis: scale

Next, we look to determine if there was an increase in correlation during the crisis period, compared to the pre- and post-crisis periods. This is not a contagion test, as we have explained, but a supplemental to the cross-border cointegration tests that assess the potential scale of impact of spillovers. The two part analysis to contagion is thus, first, to identify regime change via alterations in the cross border cointegrating relationship and then, second, to establish the degree of change in the correlating relationship between the two markets. Our statistical approach is to derive a measure of correlation after stripping-out systematic national factors, as represented by national risk premia for holding futures and any possible non-synchronous trading effects. In detail, we regress futures prices against own past prices to account for the effect of possible nonsynchronous trading. We then incorporate Treasury-bill (the risk free rate proxy in the cost of carry model) and bond rates to account for risk premia. Thus, futures prices are conditioned according to:

$$f_{t,i} = \alpha_0 + \alpha_1 f_{i,t-1} + \alpha_2 TB_{i,t} + \alpha_3 B_{i,t} \qquad (8)$$

where f_{t-1} are past prices of futures, TB_t are monthly Treasury Bills rates and B_t are monthly bonds rates. We use a multivariate GARCH specification to model the futures prices and the national risk premium variables. Based on the constant-conditional correlation model of Bollerslev (1990), the model is presented in the following equation.

$$h_t^i = a_i + b_i e_{t-1}^2 + c_i h_{t-1}^i \tag{9}$$

The variance term for each market is assumed to be a function of the past squared errors $e_t^2{}_{-1}$ and its past conditional variance, $h^i{}_{t-1.}$ The covariance between the markets is then:

$$h_t^{M,S} = r^{M,S}\sqrt{h_t^M h_t^S} \tag{10}$$

Where, h_t^M and h_t^S are the conditional variances of the Malaysian and Singapore markets, respectively; $h_t^{M,S}$ is the conditional covariance between Malaysia and Singapore, and $r^{M,S}$ measures the correlation between the markets. The conditional correlation coefficient is compared over the 3 sub periods to assess the degree of change in the correlation between the two markets.

2.6 Contagion analysis: causality

Our final test assesses causality between national markets using the following ECM:

$$\Delta f_{Mt} = \alpha_3 + \beta_3 Y_{t-1} + \sum_{i=1}^{k}\gamma_3 \Delta f_{Mt-i} + \sum_{i=1}^{k}\theta_3 \Delta f_{St-i} + \varepsilon_3 \tag{11}$$

$$\Delta f_{St} = \alpha_4 + \beta_4 Y_{t-1} + \sum_{i=1}^{k}\gamma_4 \Delta f_{Mt-i} + \sum_{i=1}^{k}\theta_4 \Delta f_{St-i} + \varepsilon_4 \tag{12}$$

where f_{mt} is the Malaysia futures index price and f_{Si} is the Singapore futures index price, ε_{it} is joint white noise and Y_{t-1} represents the error correction term:

$$Y_t = f_{Mt} - \beta_1 f_{St} \tag{13}$$

The two markets are cointegrated when at least one of the coefficients on Y_{t-1} are different from zero with a significant error correction term providing information on the speed of adjustment between the two markets. The short-run component is represented by the summation terms on the right hand side of Equations 11 and 12.

3. ANALYSIS

3.1 Basic data

Closing price, daily data are used and are obtained from Data Stream except KLCI futures data which were gathered from KLOFFE. The whole sample period extends from 1st January 1996 to 31st December 2004. The sample is subdivided to identify the crisis period from the pre-and post-crisis periods. The pre-crisis period is from 1st January 1996 to 30th June 1997, the crisis period is from 1st July 1997 to 31st December 1998,[10] and the post-crisis period from 1st January 1999 to 31 December 2004. We do not distinguish post-crisis transition and post-crisis stable periods as in Yang *et al* (2003) since our motivation is specifically to identify contagion during the crisis period as opposed to transient conditions that may not be robustly defined.[11] The beginning of the Asian crisis is widely agreed to have begun with the Thai Bhat devaluation in June 1997, although the end of the crisis is arguable. We extend our second sub-sample period to a period longer than Corsetti *et al* (January 1998) to account for the specific Malaysian factors already outlined. In any case, devaluations are easily identifiable events, structural change is likely to be a process that may take some time. Researchers may only hope to capture the existence of contagion, not necessarily its exact start or end point. Furthermore, the whole sample period is restricted to the dates chosen, which are largely consistent with other researchers, to reduce the possible impact of structural breaks not related to the Asian crisis. This will be important in relating correlation changes to contagion, as explained above.

Table 1: Johansen tests of cointegration between spot and futures markets for Malaysia and Singapore over 3 sub-sample periods

Sub-sample period	Hypotheses		Maximum eigenvalue	
	H0	H1	Malaysia	Singapore
Pre-crisis	r=0	r=1	**21.03**	**49.39**
	r=1	r=2	2.77	2.22
Crisis	r=0	r=1	15.95	66.20
	r=1	r=2	**2.53**	**2.75**
Post-crisis	r=0	r=1	247.9	212.3
	r=1	r=2	**3.17**	**1.09**

Notes: the table reports Johansen's test for cointegration using maximum eigenvalues that test specific nulls against specific alternatives, as shown in the hypotheses columns. Critical values are 14.26 for r=0, r=1 and 3.84 for r=1, r=2. These results are also confirmed using the trace eigenvalues that test against more general alternatives. Items in bold denote rejection of null.

3.2 Price related futures market efficiency in relation to its underlying and causality tests

We confirm that both spot and futures markets are I(1) processes employing Dickey-Fuller tests for spot and futures for both Singapore and Malaysia over all sub-sample periods.[12] Table 1 reports Johansen cointegration tests for Malaysia and Singapore that confirm unit roots in levels between futures and spot markets, which is the usual result, and at most one cointegrating factor for both Malaysia and Singapore in all sub-sample periods, thus confirming no changes in cointegration properties over the duration of the full sample period. The confirmation of no change in cointegrating relationship supports, at least, a weak form efficiency between spot and futures.

Table 2: Tests for causality between futures and spot markets: estimation results of equations 4 and 5

		Malaysia		Singapore	
Sub sample period	Variable	Future causes spot Δs_t	Spot causes future Δf_t	Future causes spot Δs_t	Spot causes future Δf_t
Pre-crisis	Z_{t-1}	-0.894	-0.567	-0.200	-0.172
	Δs_{t-1}	0.523	0.257	0.467	0.421
	Δs_{t-2}	0.013	-0.231	-0.212	-0.229
	Δs_{t-3}	-0.132	-0.321	0.540	0.460
	Δf_{t-1}	-0.091	-0.082	-0.622	-0.312
	Δf_{t-2}	-0.095	0.059	0.339	0.520
	Δf_{t-3}	0.022	0.002	-0.209	-0.201
	Adj R^2	0.876	0.835	0.821	0.851
Crisis	Z_{t-1}	-0.215	-0.325	-0.224	-0.201
	Δs_{t-1}	-0.398	-0.299	0.414	0.314
	Δs_{t-2}	0.102	-0.326	-0.124	-0.201
	Δs_{t-3}	-0.320	-0.201	0.217	-0.115
	Δf_{t-1}	0.296	0.131	-0.422	-0.644
	Δf_{t-2}	0.112	0.103	0.172	0.159
	Δf_{t-3}	0.236	0.199	-0.010	0.132
	Adj R^2	0.870	0.886	0.887	0.883
Post-crisis	Z_{t-1}	-0.198	-0.621	-0.091	-0.200
	Δs_{t-1}	0.328	0.321	0.509	0.347
	Δs_{t-2}	0.220	0.052	0.273	-0.321
	Δs_{t-3}	0.005	0.034	-0.302	-0.301
	Δf_{t-1}	-0.032	-0.062	-0.351	-0.254
	Δf_{t-2}	-0.091	0.002	-0.258	0.315
	Δf_{t-3}	-0.010	-0.329	0.220	0.019
	Adj R^2	0.813	0.828	0.781	0.812

Notes: Dst are spot price changes and Dft are futures price changes. The lags are chosen using the Schwarz criterion. Only the first 3 lags are reported. Bold figures indicate rejection of the null hypothesis of zero coefficient at 5% significance level.

3.3: Causality tests between the futures and its underlying

Causality is examined by employing an ECM estimation and the results are reported in Table 2. The ECT (Z_{t-1}) is significant in a bidirectional sense over all periods and confirms the cointegration results of Table 1. In all sub-periods there is also evidence to suggest that short term factors have played a role in determining spot and futures prices for Singapore. The evidence for Malaysia is not as firm, with only lagged futures prices impacting on current spot and futures prices in the post crisis period.

3.4 Cross border cointegration

Table 3 contains the results of the Johansen cointegration tests used to examine the cross border cointegration between futures markets. The results suggest that we cannot reject the null hypothesis of no cointegrating vector in the pre-crisis and crisis periods. This implies no relationship between Malaysia and Singapore during these periods, although there is a change in the relationship in the post crisis period. We take this as evidence of regime change from a position of no significance in cross-border linkages in the pre-crisis and crisis periods, to a position of significant linkage in the post crisis period. This result is consistent with Kallberg *et al* (2002) who argue that regime change follows a crisis period. In their study of the relation between currency and equity markets for 6 Asian countries, including Malaysia but excluding Singapore, they find that currency volatility precedes shifts in equity returns, with shifts in the returns regime taking place up to a year following the currency crisis. They conclude that the sequential nature of the structural breaks between currency and equity market returns is consistent with information spillover effects. In our context, one possible explanation for this difference rests with the development of the Malaysian market in terms of volume. During the crisis period, volume and open interest doubled by comparison with the pre-crisis period and this trend continued for a period thereafter. Thus, as volume has developed over the full crisis cycle, a level of cross-border cointegration has been achieved (see, for example, Kasa, 1992). Moreover, the maturing of the Malaysian market over this time and the onset of the crisis is suggestive of a positive correlation between the volume and volatility in the futures market, which has been well documented elsewhere for equity markets[13] and indicates, we would argue, that only in the period that linked high volume with high volatility was cross-border cointegration achievable (ie in the post crisis period). We develop this point in relation to correlation between markets in the next section.

3.5 Tests of correlation changes over the crisis

Results for the estimation of equations 8, 9 and 10 are reported in Table 4. In the pre-crisis and crisis periods, lagged futures prices are significant at the 5% level, which indicates that the futures prices are correlated over time. In the

Table 3: Johansen tests of cointegration between futures markets for Malaysia and Singapore over 3 sub-sample periods

Sub-sample period	Hypotheses H0	Hypotheses H1	Maximum eigenvalue
Pre-crisis	r=0	r=1	9.36
	r=1	r=2	2.77
Crisis	r=0	r=1	5.17
	r=1	r=2	2.66
Post-crisis	r=0	r=1	**21.73**
	r=1	r=2	1.10

Notes: the table reports Johansen's test for cointegration using maximum eigenvalues that test specific nulls against specific alternatives, as shown in the hypotheses columns. Critical values are 14.26 for r=0, r=1 and 3.84 for r=1, r=2. These results are also confirmed using the trace eigenvalues that test against more general alternatives. Items in bold denote rejection of null.

case of the T-Bill and bond rates for the pre-crisis period, the coefficients are not significant. In the crisis period, the coefficients for T-Bill and bond rates in the Malaysian markets increase and are significant, which accords with the positive relationship between interest rates and equity volatility previously discussed. For Singapore, the coefficients for these two rates are only marginally changed.

Lagged futures price effects are significant in all periods for both markets as are, for the most part, Treasury Bill effects. The influence of Bond rates are only significant in both markets during the post crisis period. We also report significant past error and conditional variance effects for almost all periods. The final column reports the results for the correlations between the markets. We find that the correlation (r) is higher in the crisis period compared to the pre-crisis period and this confirms Longin and Solnik's (1995) observation concerning greater correlation in times of market turbulence.

Thus, the results reported in Table 4 suggest that conditional variances change over time, as correlation is higher in the crisis period compared with the pre- and post-crisis periods. We argue that efficiency increased in the crisis period because of the growing volume and open interest during this time, supported by the earlier results that provided no indication that the market transmission mechanism between spot and futures markets functioned inefficiently during times of high volatility. However, the question remains as to whether higher correlation represents contagion across borders. We observe in the crisis period higher correlations in volatility between futures

markets that are not explained by contemporaneous cross border cointegration. In the period following, however, we observe that the nature of cross border cointegration has changed and, according to Forbes and Rigobon (*op cit*), this fact is indicative of contagion. As it happens, and as we discuss further below, the emergence of cointegration during the post crisis period is one in which it might be argued that greater efficiency has arisen and that the futures markets, having experienced greater volume and volatility during the crisis period, are now exhibiting their mature characteristics. The point arises, however, whether this change is structural and, in combination with higher correlations, could be argued to be contagion under the definitions offered by Forbes and Rigobon. We would suggest not, on the grounds that the change represented a natural development and was one that would almost certainly have arisen, in due course, without the pressure of the Asian crisis. This view is consistent with the evidence reported in Yang *et al* (2003), who suggest that crises can lead to greater market integration. Thus, ostensibly whilst satisfying the conditions laid down for contagion, structural change in combination

Table 4: Correlation analysis over sub-sample periods, including national risk premium estimates, conditional variance and correlations

Sub-sample period		α_1	α_2	α_3	*a*	*b*	*c*	Correlation
Pre-crisis	Malaysia	**0.684**	**0.241**	0.029	0.000	**0.284**	**0.609**	**0.298**
	Singapore	**0.675**	**1.258**	0.124	**0.502**	**0.225**	**0.898**	
Crisis	Malaysia	**0.716**	**0.642**	0.451	**0.000**	**0.273**	**0.655**	**0.523**
	Singapore	**0.694**	0.008	0.085	**1.905**	**0.090**	**0.855**	
Post-crisis	Malaysia	**0.878**	**0.186**	**0.243**	0.018	**1.720**	0.001	**0.324**
	Singapore	**0.531**	**0.992**	**0.832**	0.022	**0.323**	**0.297**	

Notes: the table reports coefficient estimates for equations 8 and 9. Correlation coefficients are reported in the final column (equation 10). Values for the constant, a0, in equation 8 are not reported (they are all insignificant). Bold figures are significant at 5%.

with higher correlation, of itself, cannot be a defining characteristic of contagion in the case of Malaysia: it is a necessary but not a sufficient condition.

3.6: Tests of causality

The results in Table 5 report the cross-border ECM estimates and confirm the cross-border cointegration results reported in Table 3. In the relationship between Malaysia and Singapore, we reject the null hypotheses of no causality in the post-crisis period only. There is also some evidence of significant

Table 5: Tests for causality between Malaysian and Singaporean futures markets

Sub sample period	Variable	Malaysia future Δf_{Mt} caused by:	Singapore future Δf_{St} caused by:
Pre-crisis	Z_{t-1}	-0.012	-0.026
	Δf_{M-1}	0.083	-0.036
	Δf_{M-2}	0.012	-0.074
	Δf_{M-3}	-0.054	-0.001
	Δf_{st-1}	-0.033	**-0.201**
	Δf_{st-2}	0.026	-0.033
	Δf_{st-3}	0.051	0.000
	Adj R^2	0.042	0.067
Crisis	Z_{t-1}	-0.029	0.007
	Δf_{M-1}	**-0.133**	**0.046**
	Δf_{M-2}	-0.053	0.020
	Δf_{M-3}	-0.064	-0.001
	Δf_{st-1}	-0.101	**-0.158**
	Δf_{st-2}	0.127	-0.085
	Δf_{st-3}	0.210	0.011
	Adj R^2	0.047	0.054
Post-crisis	Z_{t-1}	**-0.025**	**-0.026**
	Δf_{M-1}	**-0.203**	-0.136
	Δf_{M-2}	**-0.112**	**-0.168**
	Δf_{M-3}	**-0.100**	**-0.101**
	Δf_{st-1}	**0.153**	**-0.201**
	Δf_{st-2}	**-0.234**	**-0.133**
	Δf_{st-3}	0.102	**0.198**
	Adj R^2	0.042	0.067

Note: Lags are chosen using the Schwarz criterion. Only the first 3 lags are reported. Bold figures indicate rejection of the null hypothesis of zero coefficient at 5% significance level.

cross-border effects in short term price corrections, bi-directionally, also for the post-crisis period. The evidence is consistent with the view that structural changed occurred, but there is no indication of causality.

4 Conclusions

In seeking to understand the role of futures markets during the Asian crisis of 1997 we have sought to respond to what we argued was an under-researched area. This was particularly relevant in the context of assessing how futures markets functioned during the crisis and in seeking to ascertain how contagion might manifest itself in a futures market within the context of a degree of market immaturity in the case of Malaysia. This led us to focus on the

Malaysian experience and how it compared to a developed market locally (Singapore). In so doing, we provided a set of limited benchmarks against which our testing methodology was developed and analysed. Our methodological approach was to ascertain that futures and spot markets functioned in accordance with equilibrium expectations and our results led us broadly to conclude that this was so. The equilibrium conditions that might be expected between a futures and spot market, as set out in our approach, existed during the period when the Asian crisis was at its height and, against this background, the potential for the transmission of contagion was tested.

Whilst a universally agreed definition of contagion remains unresolved, the characteristics employed in this paper are those that have been fairly widely used. In essence, contagion is reflected in increased market volatility, demonstrated in higher correlations between markets, combined with an element of structural change. In a futures market context, we identified significantly increased correlation between Malaysia and the benchmark market. We also argued that a degree of structural change had occurred in the cross-border relations between Malaysia and Singapore in the post-crisis period. Our assessment was that the realisation of a cointegrating relationship during the post-crisis period reflected an underlying structural change. Preceded by an increased correlation during the crisis, the two events appeared to satisfy the conditions widely used to identify the possibility of contagion arising, particularly in the context of information spillover effects previously discussed. However, we argue that these two conditions are necessary but not sufficient in a Malaysian context since the structural change, we suggested, arose as a consequence of increased trading volume in Malaysia during the full crisis cycle and which was a natural evolution that would almost certainly have taken place without the forcing events surrounding the Asian crisis. This view was supported by the evidence surrounding the brief but substantial history of growth in equity trading that was a characteristic of the Malaysian economy in the years leading up to the crisis. Moreover, at no time were the equilibrium characteristics of the relationship between futures and cash markets, for each of the markets examined, disturbed by the events of 1997, thus inevitably leading to the conclusion that futures markets functioned efficiently during the full crisis cycle.

The results of an analysis of the Asian crisis reported in Gong *et al* (2004) from the multiple perspectives of trade flows, currency fluctuations, transmissions mechanisms and investor cash flight (but not from a futures market perspective) concluded that the crisis, unlike previous episodes elsewhere (in a number of instances in Latin America, for example), was not related to fundamental macroeconomic weakness. They do suggest, however, and we concur, that there is evidence of the crisis being related to an incomplete regulatory and supervisory oversight which is consistent with our own view that market immaturity had a role to play. Thus, whilst futures markets became more connected over the full crisis cycle, it was entirely within the

context of an equilibrium relationship between the futures and the spot markets in both countries and at all times. In sum, the evidence of this paper suggests that the transmission of volatility did arise, as was seen in the context of higher correlations, but that this was not contagion. Although satisfying the accepted definition of contagion as reported elsewhere, we reject this notion in the context of the Malaysian market. Whilst market immaturity has been related to increased volatility, futures market operations as reported for the case of Malaysia did not give rise to any events outside of the normal equilibrium relationship. In sum, there was certainly higher volatility, but no contagion.

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ENDNOTES

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2. Zhong *et al* (2004) examine volatility spillover effects from futures to the spot in the case of Mexico but do not elaborate a methodology to examine futures market linkages between economies. This is addressed in this paper.

3. The Bank for International Settlements (BIS, 1998) noted that fragility in financial systems was arguably relevant in the propagation of the 1987 crisis in the context of those countries that were developing, at that time, new financial systems and markets, including futures markets. Also, Santis and Imbrohoglu (1997), found that emerging markets exhibit higher conditional volatility and conditional probability of large price changes than do mature markets.

4. Whilst price-only based studies ignore important relationships that may have arisen during a contagious period between volume and liquidity, for example (reported in Chung, 2005; Bailey *et al*, 2000), we focus on equilibrium pricing relationships to establish robust null hypotheses to test for contagion in the well-defined theoretical linkages between a futures market and the spot market.

5. Recent work on inter-regional effects has led to mixed results. Chung (2005) indicates that there is no evidence that the devaluation of the Thai bath in 1997 led to sell-offs of non-Asian mutual funds held outside the region although there is evidence, inevitably, of loss of confidence of Asian funds held outside the region.

6. The purpose of the exchange control policy was to eliminate offshore trading of the Ringgit to bring about financial stability and support recovery and expansion in economic activity. The Government also decided that capital flows into Malaysia should remain in the country for at least one year. Massive short-term flows were discouraged, both incoming and outgoing, to ensure stability in the financial markets. There was also a one year ruling applied to purchases of shares and securities, as well as placement of deposits in the Malaysian banking system. However, profits and dividends gen-

erated on such inflows could be taken out of the country. The capital control had a substantial impact in the futures industry in Malaysia, since the principal participants in KLOFFE were foreign investors who accounted for 53% of the total participation in the market. Since the implementation of capital controls, stock index futures contracts suffered a decline in volume and open interest. Open interest fell sharply from 32,000 to 2,200 contracts per day and volume declined from 5,000 contracts to 800 contracts per day. Foreign participation shrank to 4% from 50%.

7. The Kuala Lumpur Options and Futures Financial Exchange (KLOFFE) was incorporated in March 1992 but did not begin trading a futures index until 1995.

8. We develop this point below.

9. Such sample periods have previously been employed, as in Chung (2005).

10. Yang *et al* employ a slightly different sub-sample period than ours: pre-crisis (January 2, 1995 - December 31, 1996), crisis (July 1, 1997 - June 30, 1998), and post-crisis (July 1, 1998 - May 15, 2001) which is indicative of some debate about the *length* of crises.

11. Forbes and Rigobon (2002) test the sensitivity of their results in relation to stock market correlation and found no difference in an examination of different dates in relation to pre-crisis from the 'turmoil' period.

12. Results available on request.

13. For example, Kyle (1985), Jones *et al* (1994), Karpoff (1987), Schwert (1990) and Gallant *et al* (1992).

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