The Co-movement of Financial Market Volatility in Key Asian Economies:
The Contagious Effect of Asian Financial Crisis

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ABSTRACT: This paper aims at investigating the source of the co-movement of financial market volatility in key Asian economies during the period of 1980 to 1998. Moreover, effort is made to identify that, to what extend, the Asian financial crisis was fulfilled through the channels of contagion transmission. The study covers Singapore, Malaysia, Indonesia, the Philippines, Thailand, Hong Kong, Korea and Japan. Although these countries and region have had different currency systems to some extend, their financial markets are considered to be linked through capital and money markets. Hence, 'crisis" index of financial market is created for the 8 Asian countries by considering volatility in foreign exchange rate and interest rate. After verification of the possible co-movement of financial market volatility from the derived "crisis" index, we then employ OLS regression from the view of Singapore taking into account macroeconomic variables. The objective of testing the transmission of contagion through macro similarities is achieved with the inclusion of weights for the crisis variable. Our results show some evidences of contagion between countries with macroeconomic similarities. However, further testing with the inclusion of weights for trade linkages and macroeconomic similarities shows that contagion is more prevalent between countries that engage extensively in trade rather than having similar macroeconomic fundamentals.

1. Introduction

Similarities in weak macroeconomic fundamentals has often been cited as the underlying reason for the speculative attacks spillovers (contagion) in the Asian Currency Crisis. Nonetheless, economies with relatively strong fundamentals such as Taiwan, Hong Kong and Singapore were subjected to speculative pressure on their currencies and stock markets. Notably, the New Taiwan dollar and Singapore dollar has depreciated by 17.6%[1] and 18.8%[2], respectively vis-a-vis the US dollar.

This suggests an alternative channel for the transmission of contagion. One plausible explanation is the degree of trade competition, in which one country's devaluation depresses the trade competitiveness of it's trading partners. In order to maintain trade competitiveness, the trading partner is likely to devalue itself or worst - have it's currency speculated, thus realizing the currency fall. This view has provided the impetus for this study to gain better understanding and insights into the Asian financial crisis.

The objective of this paper is to verify that trade provides a channel for the transmission of contagion, above and beyond macroeconomic factors. A two-step empirical strategy is developed in the paper. First, we determine the pressence and magnitude of contagion from neighbouring countries to Singapore. Second, we determine the role of trade linkages versus macroeconomic similarities in explaining contagion to Singapore. Though the focus of this study is on Singapore, the study covers the 8 East Asian nations. They are the 5 ASEAN countries - that is Indonesia, Philippines, Malaysia, Singapore and Thailand, and regional countries like Hong Kong, Japan and South Korea. These countries are chosen to facilitate the empirical work of defining contagion in Singapore from these countries.

The paper is organized as the follows. Section 2 has brief discussion on the theories of contagious currency crisis in the respective of the Asian currency crisis. Section 3 studies the sources of the contagious currency crisis. Section 4 discusses the model of analyzing the contagion of currency crisis through the method of exchange market pressure. Section 5 presents the empirical results and finally a conclusion of this study is given in Section 6.

2. The Contagion Effect in Asian Currency Crisis

Currency crises are characterized by a drastic fall in the exchange rate, usually accompanied by the simultaneous depletion of the foreign reserves and sharp increase of short-term interest rates[3], as governments respond and defend their currencies. While studying the Asian financial crisis, Paul Krugman (1997)[4], identified currency crises with a defining feature of expectations. The expectation that a currency is about

[1] From June 97 to April 98, IMF, Direction of Trade Statistics (DOTS) and Information Notice System (INS) Databases; WEFA, inc.; and IMF Staff Calculation.
[2] From June 97 to 24 January 98, Montes (1997): Montes, Manuel F(1997): "The Currency Crisis in South-East Asia (Updated Edition)", Institute of South-East Asian Studies.
[3] Eichengreen, Rose & Wyplosz (1996) created a crisis index which has the exchange rate, reserves and interest rates as components.
[4] Krugman (1997): "Currency Crisies", prepared for NBER Conference, unpublished.

to devalue would be the drive for investors to abandon a currency. This translates into greater pressure for the currency to devalue which further weakens investor confidence.

A smattering of various explanations have been suggested for reasons why crises happen. They can be broadly grouped into three categories: 1) Information effects, 2) Government credibility and 3) Moral hazard. Information effects on currency crises include financial panics and herding behavior. Shiller (1989)[5] did a study on the 1987 October stock market crash and concluded that the frenzied selling was fueled mostly by falling prices. People saw stock prices going down and interpret the information as the indicator of future prices. Hence in response they sold. The selling further reduced stock prices which in turn caused further selling. Applied in the context of a currency crisis, a massive fall in the exchange rate would provoke bearish sentiments on the exchange rate itself. Information effects can therefore be a reason for market pessimism. Tavlas (1997) in his book "Collapse of Exchange Rate Regimes" suggested that the collapse of one currency might convey information regarding the impending collapse of another. This concept of information effects can apply in the context of multiple equilibria in self-fulfilling crises. If we were to consider an exchange rate in equilibrium, informational inputs may alter this equilibrium by affecting the contributors such as government policy tendencies. The result is that a new equilibrium in which currency devaluation is necessary may be created. Sachs, Tornell and Velasco (1996) argued a multiple equilibria case for self-fulfilling panic, which could help explain Mexico's 1994 debt crisis.

The credibility of the government and the soundness of their policies may also contribute to negative sentiments, which then leads to a crisis. In his paper entitled "The Logic of Currency Crisis", Obstfeld (1994) brought to attention the importance of government response to a crisis. Drazen et al. (1993)[6] proposed that the credibility of a government in carrying out its policies is a determining factor in the forming of investor expectations. Thus, a policy maker taking a tough stance (on the exchange rate) may in fact increase investor expectations of a collapse when other indicators show that the policy is not credible. When the Malaysian ringgit was attacked in September 1997, the Prime Minister of Malaysia Dr Mahathir was very vocal in blaming Market manipulators, especially the prominent hedge funds manager George Soros. In theory, certain individuals having considerable influence in the exchange market may be able to trigger an attack. If an influential investor perceives an imbalance in fundamentals, he may be able to profit from a crisis by quietly and gradually taking up a short position and then precipitate the attack with conspicuous and deliberate selling. While it is often that governments blame these external agents, Krugman (1996) argued that such agents merely serve to advance the date of the attack. The basis of the attack remains in the inadequate policies and fundamentals, such that the exchange will eventually collapse even in the absence of these agents.

Moral hazard induced crises can present themselves when fund managers act in their own interests against that of their principal. As the performance of fund managers are assessed with respect to that of others, when faced with uncertainty, these agents tend to follow market sentiments. As Krugman (1997) explained a fund manager has far

[5] Shiller (1989) : "Market Volatility".

[6] Drazen and Masson (Sep 1993) argued that the tough stance of the policy makers may not be the best option.

more to lose from taking a position counter to that of the market than from sticking with the market position. By following market trends, such agents exhibit herding and exacerbate the behavior when the common investors take cue from their actions. A moral hazard induced crisis can also arise in the banking system when governments provide guarantees either implicitly or explicitly for the liabilities of banks. This will lead to less stringent criteria and hence excessive borrowing without adequate loan assessments. This was the case in Thailand before the crisis; banks were lending out to real estate projects in an already saturated market[7]. Indeed, Krugman (1997) has argued that the Asian Crisis has its roots in the weak banking sectors that engaged in excessive lending.

The Asian currency crisis, to a large extend, was similar to the Mexican crisis in that, the crisis was preceded by a period of rapid economic expansion[8]. The period from the 80s till 1993 was termed "the Asian Miracle" by the World Bank. Beginning 1995 however, problems emerged. A key feature was the emergence of large current account deficits in the region. The Mexican collapse led to an excess of investment funds, which found its way to Asia. Countries in Asia have enjoyed large capital inflows in the growth years and have come to rely on it. The "twin liberalization policies" which Asian countries favor was successful. The freeing up both the financial system and the capital account meant that the private sectors huge demand for funds was being met by foreign sources, which were actively seeking investment ventures. But the zealousness of borrowers and the overtly-willingness to lend compromised regulatory policies. The freedom of investment in Asia also meant that foreign investors had greater access to financial instruments, which were liquid, such as deposits, bonds and equities. This made sharp withdrawal of investments more costly to the domestic economy and increased chances of a credit crunch. Domestically, the easy access of funds led to risky investments into the property sectors financed by foreign denominated debt, which were at a lower lending rate. The decline of exports in 1996 was the first sign of imminent trouble. The global electronics slump caused the electronics exporting Asian countries to experience an economic slow down. Overtly aggressive in the property sectors led to a property bubble in Thailand which was showing signs of bursting.

The Thai government like many Asian countries adopted liberal policies, which included giving guarantees to non-residents on the withdrawal of their investments easily. Speculators were however beginning to see the decline in domestic growth and increased possibility of default in debt obligations. The appreciating US dollar and growing export competition from China further convinced speculators that Thai authorities might devalue to re-inflate the economy. On 2 July, Thailand gave in to speculative pressures and floated the baht. Success of the attack soon led to speculation on regional currencies. From early July 1997 till January 1998, regional currencies depreciated a minimum of 19% to a maximum of 83%. Chart 1 shows the extent of the currency depreciation.

Hence, although the crisis still has its effects felt, the general consensus seems to classify the crisis as canonical in nature: policies were overtly expansionary and

[7] A summary regarding Thailand's causes for the collapse can be found in Montes (1997).
[8] Kindleberger (1978) theorized that a financial crisis is preceded by a period of "euphoria". In Asia's case, this euphoria was the "Asian Miracle".

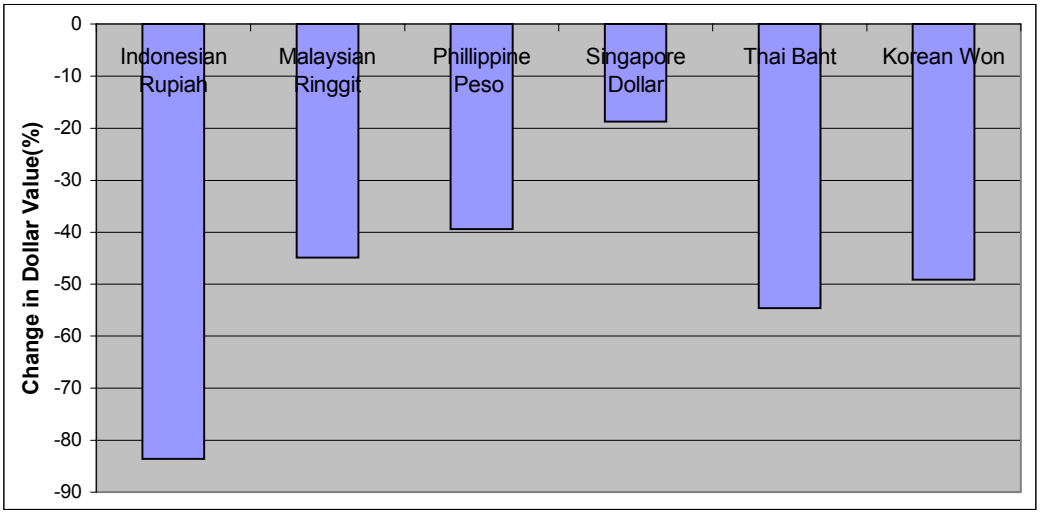
together with weak domestic banking sectors led to excessive lending of short term loans for longer-term investment projects. Such policies are unsustainable with a fixed exchange rate regime. Speculators saw the fundamental inconsistency and attacked the currency. Fears of devaluation led to withdrawal of funds from the region and pressured the collapse of a controlled exchange rate in Thailand.

A contradictory point in the experience was that countries, which were viewed as being cautious and prudent, were not spared the attack. Singapore, Hong Kong[9], Taiwan all seemed to have sound fundamentals yet were also subjected to attacks. A better explanation would be a combination of the canonical model for fundamentally distressed countries (for example Thailand, Indonesia, Korea) and financial panics, including herding behavior, for others stronger in fundamentals (Singapore, Hong Kong, Taiwan). Griffin-Jones (1997)[10] contributed crises to the herding behavior, which may be why countries with sound fundamentals get attacked when a wave of over-pessimism takes over.

By and large, a significant portion of the crisis could be attributed to contagion, where the over-pessimism led to fears of attacks and investors over-react by abandoning the region. The role of contagion has been suggested by Krugman (1997) and Kruger et al (1998). As stated previously, perplexity with regards to why Singapore, Hong Kong and Taiwan are attacked can be explained by contagion. Figure 1 shows the extent which, these three fundamentally stronger East-Asian countries have had its currency and equity prices affected during the period beginning 1996 to April 1998.

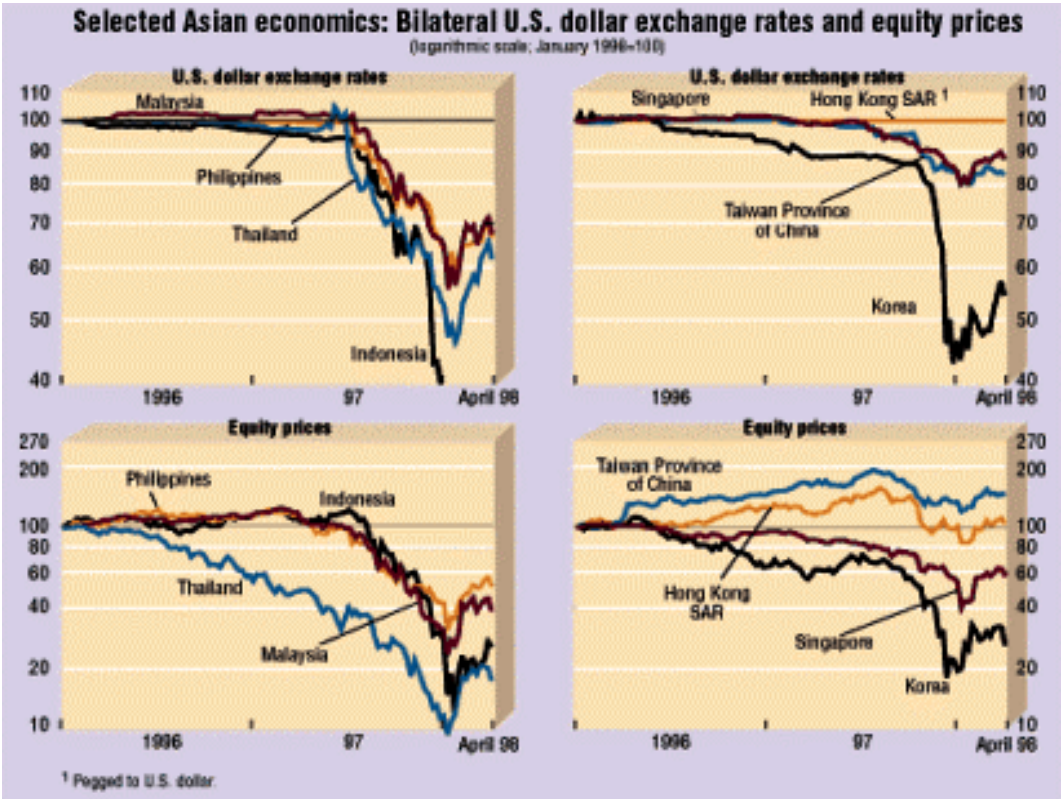
[9] Hong Kong's case is perhaps weaker since their Peg to the appreciating US dollar caused stress on their exports, although China's Pledge to support the currency should negate some negative sentiments.
[10] Griffith-Jones (1997): "Causes and Lessons of the Mexican Peso Crisis".

CHART 1: DEPRECIATION OF SELECTED ASIAN CURRENCIES
(1 July 97 to 24 January 98)



Source: Montes, Manuel F (1997): "The Currency Crisis in South-East Asia (Updated Edition)", Institute of South-East Asian Studies, Singapore.

FIGURE 1: VOLATILITY OF EXCHANGE RATE AND EQUITY PRICES



Sources: Bloomberg Financial Markets, LP, International Finance Corporation and Reuters.

If we were to suppose the cause of this was indeed contagion, the presence of contagion may mean that any one country on its own is incapable of ensuring a complete deterrence of currency speculation. This may be despite the very sound

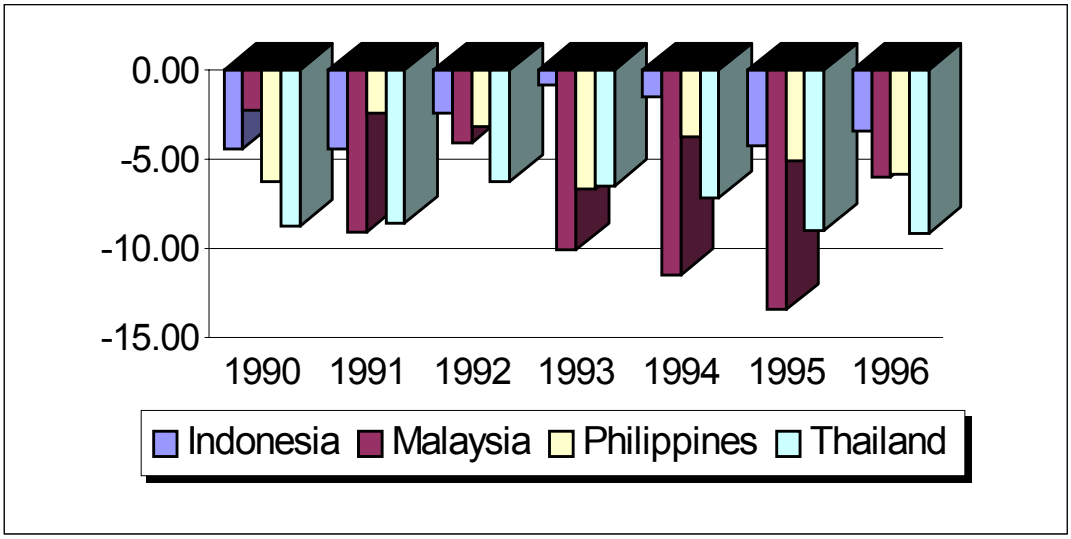
fundamentals of a country. Seen in this way, all countries will always have a risk or threat of being affected by currency crisis.

3. The Source of Contagious Currency Crisis

The literature of currency crisis suggests two broad classifications on contagion[11]. They are warranted contagion and unwarranted contagion. Warranted contagion refers to currency crisis spillovers justified by economic fundamentals. For instance, if currencies crisis spreads from one country to another due to macroeconomic similarities, it is classified as warranted contagion. On the contrary, unwarranted contagion refers to currency crisis spillovers to other countries without apparent deterioration in the fundamentals of the infected countries.

Countries with similar weak fundamentals have often been cited as the proximate cause in the Asian Contagion. The view holds that currency crisis spreads from one country to another if countries share similar economic characteristics. According to second-generation models of currency crisis, a country's mismanaged fiscal and monetary policies is reflected in weak fundamentals of budget deficits, rapid growth of domestic credit, overvalued currencies and persistent current account deficits. Weak fundamentals thus signal to speculators and hedgers on the country's unsustainable economic performance, and consequently trigger the currency speculation and collapse. The essence of this view is that markets will start to conjecture and expect a similar currency crisis in those countries with similar macroeconomic features. Thus, speculative pressure on these countries' currencies if successful, would result in a proliferation of the crisis in other countries, and hence the contagion effect. A glance at the fundamentals of the East Asian nations does suggest the validity of this theory. Chart 2 shows the current accounts, percentage of GDP of selected East Asian nations in chronic deficit since 1994.

CHART 2: CURRENT ACCOUNTS, PERCENTAGE OF GDP
(Selected Asian Nations)

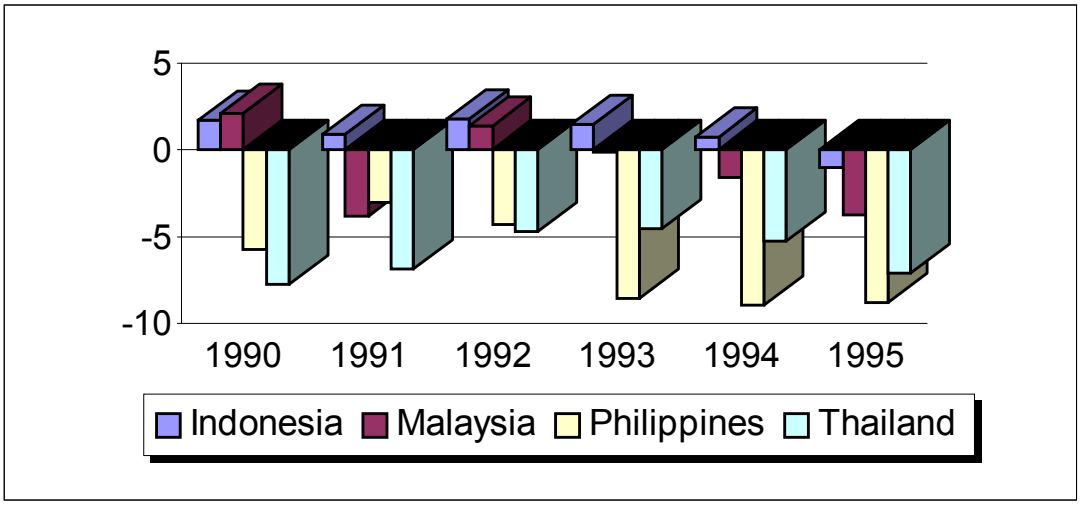


Source: Datastream

[11] We adopted Krueger, Osakwe and Page (1998) definition of contagion.

However, current account deficits need not necessarily be a bad thing as long as the countries concerned have the ability to service these deficits in the future. In this respect, the trade balance is a good indicator on the sustainability of the current account deficit. Chart 3 indicates that there were some considerable worrying signs of both the current account deficit and trade balance deficit in the selective Asian countries.

CHART 3
TRADE BALANCE, PERCENTAGE OF GDP
(Selected Asian Nations)



Source: Datastream.

There are three known channels for the transmission of such unwarranted contagion[12]. They are 1) Trade competitiveness and 2) Financial linkages and 3) Herding behaviour. Briefly, the intuition behind trade competitiveness purports that devaluation will hurt the export competitiveness of a country's trading partners, thus leading to a subsequent devaluation on the trading partner's currencies. Gerlach and Smets (1994) emphasized trade linkages as a channel for the transmission of contagion. In their two-country model, they argued that a speculative attack leading to a devaluation of a country's currency threatens the trading partners trade competitiveness. Since prices are normally sticky in the short run, the devaluation will boost the country's exports whilst depressing the trading partner's exports as the market substitutes to the cheaper exports. The theory of financial linkages holds the view that, markets with extensive cross-country financial linkages are subjected to the contagion effects if a sudden liquidation of other assets by the source country of crisis leads to a subsequent sell-off in other markets. In the Asian Financial Crisis, Korean bank's sales of substantial Brazilian and Russian debt instruments lead to a sharp deterioration in these countries asset prices, thus leading to a financial crisis through a severe depressed stock market. A certain degree of unwarranted contagion can be attributed to market participants herding behaviour. The currencies of fundamentally

[12] See IMF Report, Adams et al. (19998) for an explanation on the 3 channels of contagion.

sound economies such as Singapore Dollar and New Taiwan Dollar would not have depreciated by at least 17% if not for market's financial panic, which only serves to perpetuate a self-fulfilling prophesy.

A review of contagious currency crises shows the salient features. A first condition for contagion to be possible requires infected countries to be relatively open economies, without any capital controls. This is essential. Otherwise, speculators will not be able to bet against the country's currency. A good example is China, where the capital controls prevent speculators from betting against the Renminbi (RMB)[13]. A second feature of contagion is the sudden and concerted withdrawal of funds and investments in the infected countries. This can be seen from the rapidity of depreciation in the Asian countries' exchange rate and the general loss of confidence in these countries. As suggested by Glick and Rose (1998), a third feature of contagion is it's regional nature. The history of currency crises bears testament to this point. The ERM Crisis was concentrated in Europe; The Latin Crisis centred the countries in South America and the latest Asian Contagion which revolves chiefly the East Asian economies.

What is distinct in this view from that of the macroeconomic similarities - is that contagion can still be potentially high even if the economy does not exhibit symptoms of budget deficits, rapid current account deficit or substantial reserve losses. In other words, even countries with sound fundamentals will be subjected to speculative attack spillover - contagion if there is a high degree of trade competition between countries.

The two theories on the transmission of contagion - that is macroeconomic similarities and trade competitiveness has it's own support and merits. The implication of the former theory highlights the role of prudent fiscal and monetary policies in deterring one from speculative attacks. The latter theory extols the old adage, "Beggar thy neighbour" in international economics - that is a devaluation will only spark off seemingly endless devaluation spiral between trading partners. The explanation on macroeconomic similarities however was inconsistent for economies such as Hong Kong, Taiwan and Singapore, who had strong fundamentals, reflected in their current account surplus, budget surplus and substantial foreign exchange reserves. These economies came under speculators wrath, notably in October 1997[14]. This suggests the alternative channel for contagion - trade competitiveness.

The first lead came from academics claim to China's Renminbi (RMB) devaluation on 1 January of 1994 which was seen as a proximate cause for the Asian Financial Crisis[15]. This is a plausible argument since the dynamism of East Asia growth for the past 2 decades has been strong export-orientation. China's export expansion as a result of the devaluation means that it is harder for the rest of Asian exporters like Thailand and Philippines to compete with China for the electronics market. What is more subtle and important in this argument is the inevitable depreciation/ devaluation of the emerging economies in order to compete in the export market.

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[13] A note here must be made that speculators have tried to bring down the China Renminbi via the Hong Kong Dollar. See JETRO China Newsletter No. 133 1998 Vol. 2.

[14] See IMF Report, Adams et al. (1998) for a detailed explanation.

[15] See JETRO, China Newsletter (1998), Liu et al. (1998) and Edison et al. (1998) for empirical evidence.

Recent studies by Eichengreen, Rose and Wyplosz (1996), Glick and Rose (1998) and Goldstein (1998) support this thought too. They investigated the regional nature of contagion transmission, with different samples and periods of speculative attacks. They concluded that trade linkage is an important channel for contagion, after accounting macroeconomic factors in their regression. Evidence came from secondary sources too. However, Eichengreen and Rose (1998) study of industrial countries in post 1979 data found both macroeconomic similarities and trade channels of transmission in contagion to be relevant, albeit the relative significance of trade competition. Thus, it is not clear which view the contagion transmission in the Asian Currency Crisis subscribes to.

Contagion in currency crisis is a recognized phenomenon in many theoretical literatures, though past empirical models on contagion were few. Past empirical models on contagion were few. The first empirical work was by Calvo and Reinhart (1995). In investigating the contagion effect on the Latin American countries, they constructed a contagion proxy of capital flows in and out of the affected countries, in addition to standard macroeconomic indicators of weak fundamentals like rapid domestic credit growth and current account deficits. Their evidence of contagion, however was subjected firstly to the sample bias of the study and secondly, the variable capital flow being an inadequate proxy of speculative attack.

Schumkler and Frankels' (1996) model provided an indirect method for investigating contagion. Using level of stock prices as the dependent variable, they analyzed the effect of contagion transmission through stock market. The reasoning behind is that interest rate increase required to fend off a speculative attack tends to result in a depressed stock market. Their findings show that in the short run, a depressed Mexican market provokes a similar sell-off in other markets; while in the long run, there is positive correlation between Latin American stock markets and Asian stock markets. However, the correlation between interest rates and stock prices is not strictly causal.

Sachs, Tornell and Velasco (1996) investigated affected countries in the period after the Mexican peso collapse. In their model, they constructed a crisis index, which is a weighted average of percentage change in reserves and devaluation with respect to the US dollar. Their findings showed that macroeconomic features such as high current account deficits, excessive capital inflows and liberal fiscal policies do not contribute to vulnerability in speculative attacks. Instead, the affected countries shared similar weak macroeconomic characteristics of rapid domestic credit growth, over-valued exchange rates and low level of reserves. Their findings, however was inconclusive as they were not able to explain why some countries with weak macroeconomic characteristics were not subjected to contagion. In addition, macro-economic factors were not taken into account in explaining contagion.

4. The Model of Analyzing the Contagion of Currency Crisis through Exchange Market Pressure

Contagion in currency crisis is a recognized phenomenon in many theoretical literatures, though past empirical models on contagion were few. The first empirical work was by Calvo and Reinhart (1995). In investigating the contagion effect on the Latin American countries, they constructed a contagion proxy of capital flows in and

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The inadequacies of past empirical models make establishing the pressence and channel of contagion a problem[16]. More importantly, a *priori* in establishing contagion is to determine *quantitatively* whether speculative attacks on a country's currency have occurred. Speculative attacks, however, cannot be associated singly by pre-actual devaluation, revaluation or instances of speculative attack in which a currency is floated[17] (for instance Thailand's abandonment of the Thai baht peg to US dollar on 2 July 1997). First, not all speculative attacks will result in "successful" devaluation[18]. A currency may be supported by a range of policies such as expense of foreign exchange reserves to fend off the attack, increase in interest rates (as seen in Hong Kong's defend of the Hong Kong dollar at 7.80 to the US dollar in October 1997) or a combination of both. Alternatively, besides foreign exchange market intervention, the central bank can intervene in the forward or derivatives markets to influence the demand for and supply of the domestic currency. Second, the central bank may deliberately re-aligned the official exchange rate during periods of no-attack so as to ward off further speculative attack.

[16] Meese and Rogoff (1983) pointed out the inadequacy of structural models linking macroeconomic variables.
[17] This is the view maintained by Eichengreeen, Rose and Wyplosz (1996).
[18] Successful speculative attack here refers to substantial actual devaluation from the perspective of the speculators.

An ideal model to determine speculative pressure would be one that reflects the demand and supply forces of a currency as well as the volume of intervention to fend off an attack. This is the simple yet appealing intuition behind Girton and Roper's (1977) Exchange Market Pressure (EMP) analysis - that is the pressure on exchange rate, interest rate and foreign exchange reserves when there exists excess demand over supply for foreign exchange. A speculative attack when successful, should result in significant currency devaluation or depreciation. On the other hand, a speculative attack can be defended by central bank's reserves expense or interest rate increase. Thus to determine speculative pressure, an index is constructed, on a weighted average of percentage changes on exchange rate, interest rate and reserves. Hence, the index would not only indicate speculative pressure on the currency, but also depict realistically successful as well as unsuccessful speculative attacks. In short, a higher value of EMP means greater probability of speculative attack(s).

Adapting the model from Eichengreen, Rose and Wyplosz (1996), the EMP index is:

$$EMP_{i,t} = [(\alpha \%\Delta e_{i,t}) + (\beta\Delta (i_{i,t} - i_{G,t})) - (\gamma (\%\Delta r_{i,t} - \%\Delta r_{G,t}))]^{19},$$

where $e_{i,t}$ denotes the price of a US$ in i's currency at time t; i_G denotes the short US interest rate; r denotes the ratio of international reserves; and α, β and γ are weights. Crisis is defined by the following decision rule on the index:

$$Crisis_{i,t} = 1 \text{ if } EMP_{i,t} > 1.5\sigma_{EMP} + \mu_{EMP},$$
$$= 0 \text{ otherwise,}$$

where μ_{EMP} and σ_{EMP} are the sample mean and standard deviation of EMP respectively.

With crisis defined, the next question must be the measurement of contagion. Using the Crisis index constructed from the sample studied (8 Asian nations, in this context), we define a *contagion variable* for Singapore. This *contagion variable* takes a value 1 if there is at least 1 crisis in the same period other than Singapore. Otherwise, the contagion variable takes a value of zero. In short, the contagion variable $D(Crisis_{j,t})$ is defined as follows:

$$D(Crisis_{j,t}) = 1 \text{ if } Crisis_{j,t} = 1, \text{ for any } j \neq i$$
$$= 0 \text{ otherwise}$$

With the contagion variable constructed, we determine the effect of contagion using Ordinary Least Squares (OLS) method, taking into account the effect of macroeconomic factors. OLS allows us to assess empirically the significance of contagion, after accounting for macroeconomic variables. A positive coefficient on a regressor indicates an increased probability of that variable contributing to Singapore's speculative attack and conversely for a negative coefficient.

The OLS model is as follows:

[19] This makes good economic sense since a measure of speculative pressure must be gauged against a supposedly safe country. Refer to Eichengreen, Rose and Wyplosz (1996), pp. 267-68.

$$Crisis_{i,t} = \omega D(Crisis_{j,t}) + \lambda I(L)_{i,t} + \varepsilon_{i,t} \text{ where}$$
$$D(Crisis_{j,t}) = 1 \text{ if } Crisis_{j,t} = 1, \text{ for any } j \neq i$$
$$= 0 \text{ otherwise}$$

where: "$I(L)_{i,t}$ is a set of contemporaneous and/ or lagged macroeconomic variables; λ is the corresponding vector of nuisance coefficients; and ε is a normally distributed disturbance representing a host of omitted influences which affect the probability of a currency crisis"[Eichengreen, Rose and Wyplosz (1996)]. The focus of the regression is to test Ho: ω=0. Thus, we interpret rejection of the null as evidence of contagion. Hence, with this basic analytical framework, we can define speculative attacks and contagion succinctly and test the significance of contagion in Singapore.

To determine the significance of contagion via trade or macro-economic similarities, we estimate the extended model as follows:

$$Crisis_{i,t} = \omega W_{ij,t}(Crisis_{j,t}) + \lambda I(L)_{i,t} + \varepsilon_{i,t} \text{ where}$$

$$W_{ij,t}(Crisis_{j,t}) = w_{ij,t} \text{ if } Crisis_{j,t} = 1, \text{ for any } j \neq i$$
$$= 0 \text{ otherwise}$$

where : " $w_{ij,t}$ is a weight which corresponds to the relevance at time t of country j for country i"[Eichengreen, Rose and Wyplosz (1996)]. The hypothesis of interest is still Ho: ω=0. We interpret evidence of the null as being inconsistent with existence of contagion.

The first weighting scheme tests the channel of contagion via trade. In order to capture the significance of trade between Singapore and the 7 regional countries, we construct a weight based on the percentage of trade between Singapore and these 7 Asian nations against Singapore's total trade. Using data from Singapore's Yearbook of Statistics (various years from 1980-1996), we compute this weight using a combination of bilateral imports value and exports value.

Thus our trade-weight is defined as follows:

$$w_{ij,t} = \frac{[\text{Imports}_{\text{ from 7 Asian nations}} + \text{Exports}_{\text{ to 7 Asian nations}}]}{[\text{Imports}_{\text{ from the world}} + \text{Exports}_{\text{ to the world}}]}$$

With the computed trade-weights, we generate a trade-weighted contagion variable which is a product of the dummy contagion variable $D(Crisis_{j,t})$ and trade-weight $w_{ij,t}$. Thus we estimate the extended model, with the trade-weighted contagion variable replacing the unweighted contagion variable.

The second weighting scheme tests the channel of contagion via macroeconomic similarities. Countries are considered similar in their macroeconomic factors for instance if they displayed similar rates of growth in domestic credit. To reveal this intuition of macro-similarity, we standardize the variables by subtracting the sample means and dividing the result by the same standard deviation. There are two approaches for this standardization: 1) Country-specific standardizations and 2) Time-specific standardizations. The country-specific approach is appropriate when a

country's macroeconomic fundamentals is compared with itself over time. That is speculators judge a country's macroeconomic fundamentals in a quarter to its past. The time-specific is appropriate when a country's fundamentals (that is Singapore) at a point in time is compared with other countries (7 Asian countries) at the same point in time. Thus the macro-weights for country-specific and time-specific are in the following order:

$$w_{ij,t} = \Sigma_j (1-\{\Phi[(x_{jt} - \mu_i)/\sigma_i] - \Phi[(x_{it}-\mu_i)/\sigma_i]\})/n$$
$$w_{ij,t} = \Sigma_j (1-\{\Phi[(x_{jt} - \mu_t)/\sigma_t] - \Phi[(x_{it}-\mu_t)/\sigma_t]\})/n$$

for any $j \neq i$, n = number of regional countries

where "$\Phi(.)$ is the cumulative distribution function of the standardized normal function , $\mu_i(\mu_t)$ is the country-specific (time-specific) sample averages of variable x, $\sigma_i(\sigma_t)$is the country-specific (time-specific) standard deviation of variable x, x's are the seven macroeconomic 'focus' variables, and n=7 in this context (all Asian nations other than Singapore)" [Eichengreen, Rose and Wyplosz (1996)]. The reasoning for this specification is that if country i is attacked and is similar to country j in the standardized macroeconomic variables, the weight on the contagion variable is high. Specifically, the more similar country j and country i are in their macroeconomic features, the greater the weight skews towards unity. Conversely, the more dissimilar countries are in their macroeconomic features, the more the weight tends towards zero.

In a similar manner, we generate a country-specific weighted contagion variable and a time-specific weighted contagion variable. This is obtained as a product of the dummy contagion variable D(Crisis $_{j,t}$) and the respective macro-weights $w_{ij,t}$. Thus in this case, we estimate the extended model, with the macro-weighted contagion variable in place of the unweighted contagion variable.

To test our hypothesis that trade is a dominant channel of contagion over macroeconomic similarities, we must do a joint test on the explanatory power of each contagion variable. To avoid the problem of multicollinearity, this requires us to do construct a single contagion variable for the macro weights. The single contagion variable is constructed as an average of the seven macroeconomic weights. Since there are two definitions of macro weights, we compute two single contagion variables for the country-specific and time specific standardization. Hence, with these single macro-weighted contagion variables, we can test the dominance of trade over macroeconomic similarities by estimating the trade-weighted contagion variable and macro weighted contagion variable simultaneously.

5. The Empirical Studies

The majority of cross-sectional data we use in the empirical work are from the CD-ROM version of the International Monetary Fund's International Financial Statistics (IFS). Using quarterly data, the sample size of our study spans from 1980:1 to 1998:2, accounting for 70 observations. The data collected are from Hong Kong, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Thailand and United States. They have been checked for transcription and erroneous errors. Given

constraints in some available data, we have supplemented missing data from resources such as Datastream.

For the computation of trade weights, we have utilised data from Singapore's Yearbook of Statistics. Due to the lack of published data, our computed trade weights apply the annual computed trade weights across the 4 quarters of a year. The following macroeconomic variables based on theoretical considerations and data availability are used in the regression. All variables are measured as deviations from US (reference country). This is because a measure of crisis must be gauged against a currency of no speculative attack[20]. The variables are transformed to differential percent changes by employing natural logarithms[21] - growth of domestic credit, output growth and money growth data. This step is necessary as the different magnitude and volatility of the variables makes analysis difficult.

Exchange Rate Exchange rate is included in for three reasons. First, the most obvious effect of the Asian Financial Crisis is the large fall in exchange rate. This variable is crucial in the construction of EMP in identifying successful speculative attacks. Second, the exchange rate is an indicator of external competitiveness and is essential in elucidating the theory of trade competitiveness. Third, by Interest Rate Parity Theory, there exist a long run equilibrium in the foreign exchange rate of a country. The implication in this context highlights the fact that if Asian currencies are appreciating (as seen in the 90s), a nominal depreciation or devaluation is expected for the exchange rate to align to it's 'correct' value. The official real exchange rates are used to account for the real changes in the exchange rate with respect to the US dollar.

Interest Rate Interest rate inclusion in the EMP construction is necessary for identifying unsuccessful speculative attacks. This is especially applicable when speculators lose confidence in the government's commitment to defend the currency peg, and the officials have to respond with an interest rate increase to reverse the excess demand for foreign exchange and stem the excess outflow of capital and funds. Studies by Eichengreen, Rose and Wyplosz (1995) showed that during periods of speculative attack where a stock market is typically down, both long term and short term interest rates rise dramatically. 3-months inter-bank rates are used for two reasons. First, reports on officials' response to speculative attacks typically name the dramatic rise of inter-bank rates overnight. Second, interest rates of more than 3 months (for example 6 months rate) may not fully reflect the actual pressure on foreign exchange market, due to short run deviations.

Growth of Domestic Credit and Money Growth: A central bank's balance sheet comprises of the following: M=D+R, where M= total supply of money, D= sum of domestic credit and R= reserves. Domestic credit represents the tool of monetary policy whereas reserves reflect the balance of payments surplus or deficit. In a fixed exchange rate regime, since the stock of reserves is determined exogenously, any

[20] It is instructive to note that United States was subjected to speculative attacks in the 70s. However, as our sample begins from 1980, we assume the lagged effect of the attack on the macroeconomic variables to be negligible.

[21] Changes in natural logarithm is useful because it prevents onerous results due to the base year and coefficients are interpreted easily as elasticity change, that is the unit change in X due to change in Y. See Pindyck, R.S and D.L. Rubinfeld (1991).

excess demand for foreign currency must be accommodated by the central bank's sale of foreign exchange. In other words, if the growth of domestic credit exceeds the growth in money demand, and left unchecked, this would lead to the exhaustion of reserves. Money growth is included as a variable to capture the liberal policies of the monetary authorities.

Inflation: Extensions to Krugman (1996) model shows that the cause of currency crisis can exist in the form of cost-push inflation. This theory claims that expectation of a future crisis leads workers to revise their nominal wages upwards. If prices are sticky, this would lead to higher real wages and lower competitiveness, thus indicating to speculators the insustainability of the country's economic health. We adopt Consumer Price Index (CPI) as a measurement of inflation.

Output and Unemployment Growth: Second generation of currency crisis attributes the conflict between internal and external goals as the cause of currency crisis. A case of this conflict arise when the government has to combat high unemployment yet is unable to adopt expansionary monetary policy because of fixed exchange rate. The cost to the economy in terms of sluggish output and mass unemployment indicates to speculators the credibility of the country's exchange regime, thus making it susceptible to attacks.

Budget Position, percentage of GDP: Krugman's first generation model points to excessively expansionary fiscal policy as the trigger of currency crisis, which is reflected in the budget deficit. It is worthwhile to note that prudent fiscal policy in terms of budget balance is itself a constrain and instills further discipline in a country's fiscal and monetary policies. However, counter-evidence by Frankel and Rose (1996) highlighted the inadequacy of budget surplus as a good indicator of currency crisis. Thus it is interesting to test the explanatory contribution of this variable in explaining currency crisis.

Current account, percentage of GDP: Current account reflects the external competitiveness of an economy. According to Sachs, Tornell and Velasco (1996) there are two broad schools of thought. One theory argues that in the absence of a creditor unwilling to extend credit, a large deficit leading to a large debt will rendered the country insolvent. Without a lender of last resort, the country in debt will have no incentive to service its obligation. The mounting debt continues until the country is financially drained and crisis strikes. The second theory argues that large deficit financed through capital flows (especially short term) makes an economy vulnerable to the rapid capital reversal. This gives rise to disruption in the economy such as unemployment and sluggish growth. These indicators of weak growth signal a potential crisis.

We construct the EMP index by considering only changes in exchange rate and interest rate. The exclusion official reserve from the index are for a number of reasons . First, there is no yardstick or criteria to differentiate crisis-stricken countries, based solely on high, low or zero reserves. Low reserves indicate potential vulnerability to crisis, not firm indications of crisis. Second, unrecorded transactions[22] and unpublished expend reserves (to defend a desired exchange target)

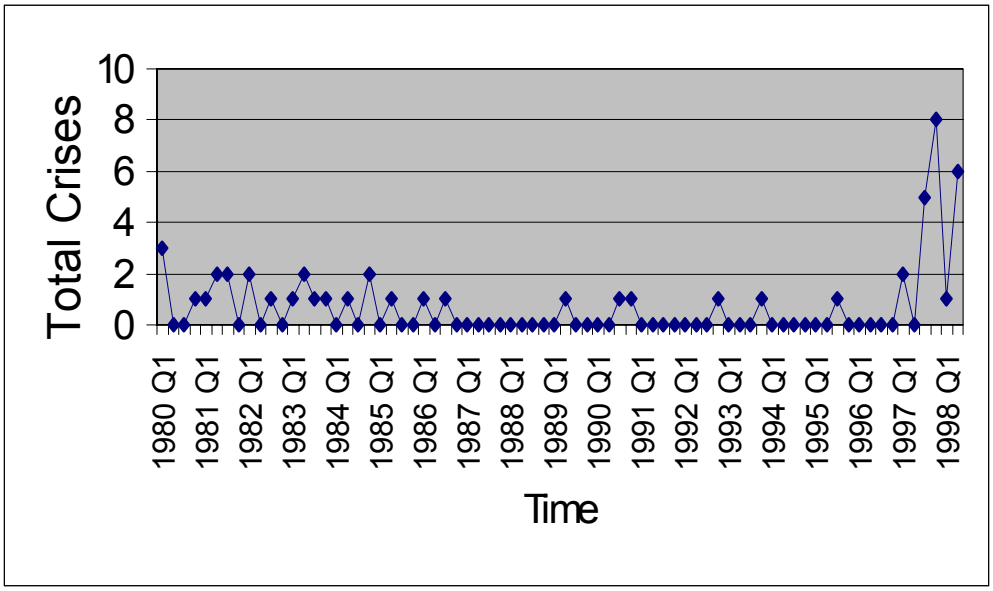
[22] Unrecorded transactions include off-balance sheet liabilities, third party intervention, stand-by credits and foreign liabilities.

overstate the true magnitude of reserves holding. The problem is accentuated when the majority of reserves are illiquid[23]. Thus, in our analysis, the EMP index is given as follows:

$$EMP_{i,t} = [(\alpha \%\Delta e_{i,t}) + (\beta\Delta (i_{i,t} - i_{G,t})],$$

where $e_{i,t}$ denotes the price of a US$ in i's currency at time t; i_G denotes the short US interest rate; α and β are weights. Using data from 8 Asian nations and regions, namely, Hong Kong, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea and Thailand, the crisis index is generated according to the definition defined in the above[24]. A time series plot of crises over the sample is displayed in Figure 2, showing the extent of the Asian Currency Crisis.

FIGURE 2: GRAPH SHOWING CRISES PER QUARTER



The first part of the regression tests the existence of contagion from other countries to Singapore, taking into account Singapore's macroeconomic variables. Following the method discussed in Section 4, the contagion variable is derived as the dummy values of EMP for the 8 Asian nations: the *contagion variable* takes a value 1 if there is at least 1 crisis in the same period other than Singapore and, otherwise, the contagion variable takes a value of zero. We determine the effect of contagion using OLS methods, taking into account the effect of macroeconomic factors. Specifically, we test the null hypothesis "that incidence of crisis elsewhere in the region at the same point in time does not affect the probability of a speculative attack on the Singapore

[23] This was the case in Korea where out of $24 billion reserves, only $6 billion reserves are "usable". See IMF Report, Adams et al. (1998) pp. 15 and Eichengreen, Rose and Wyplosz (1995) on the limitations of using reserves data.

[24] We only used 1.2 standard deviation as a benchmark to derive the index. Eichengreen, Rose and Wyplosz (1996) used 1.5 as a benchmark. We believe an appropriate definition is by examining the crisis index with the foreign exchange market developments during the periods of speculative pressure.

dollar" [Eichengreen, Rose and Wyplosz (1996)]. The following regressions are hence estimated:

$$Crisis_{i,t} = \omega D(Crisis_{j,t}) + \lambda I(L)_{i,t} + \varepsilon_{i,t} \text{ where}$$
$$D(Crisis_{j,t}) = 1 \text{ if } Crisis_{j,t} = 1, \text{ for any } j \neq i$$
$$= 0 \text{ otherwise,}$$

where: "$I(L)_{i,t}$ is a set of contemporaneous and/ or lagged macroeconomic variables; λ is the corresponding vector of nuisance coefficients; and ε is a normally distributed disturbance representing a host of omitted influences which affect the probability of a currency crisis" [Eichengreen, Rose and Wyplosz (1996)]. The following Singapore's macroeconomic variables are used: 1) growth of domestic credit (LDCSID), 2) inflation (CPISID), 3) output growth (LGDPSID), 4) unemployment rate (UPMSID), 5) budget balance (positive sign for surplus and negative sign for deficit), expressed as percentage of GDP (BSSID) and 6) the current account balance, percentage of GDP (same treatment as budget balance) (CASID). These variables are specified as deviations from United States values. For econometric analysis purpose, the estimation model is written as follows:

$$EMPSI^{25} = C_0 + C_1 D2EW + C_2 LDCSID + C_3 CPISID + C_4 LGDPSID + C_5 UPMSID + C_6 BSSID + C_7 CASID + \varepsilon \quad (1)$$

where C_0 is a constant and the other variables are defined as the above discussion.

Equation (1) regresses EMPSI against the contagion variable taking into account the significance of macroeconomic fundamentals. Essentially, the equation shows how the contagion variable and the macroeconomic variables increase the probability of a speculative attack to Singapore. A positive coefficient on a regressor indicates an increased probability of that variable contributing to Singapore's speculative attack and conversely for a negative coefficient. The focus of the regression is to test Ho: $\omega=0$ at 5% significance level. Thus, we interpret rejection of the null as evidence of contagion. To test the dynamic effects of the macroeconomic controls in the regression, we have further varied the estimation by eliminating the variables one at a time, and other insignificant variables (2 or more) in one go. The estimated equations lead to the results which are presented in Table 2 below.

From equation 1 to 7, all regressors have positive sign except for the ratio of budget position to GDP variable. This implies that the positively sign macroeconomic variables contribute to an increased probability in the attack of the Singapore dollar. The variable budget position to GDP is economically significant. This means that Singapore's strong budget position reduces the probability of a speculative attack. This is due to Singapore's perennial budget surplus since the 1970s. However, they are generally insignificant, except for unemployment rate, which registers significance (at 5 % level) throughout equation 1 to 7. The contagion variable is positive and statistically significant at 5% level. This is consistent with the view that

[25] We have used EMPSI instead of D2SI. This is because Singapore was mildly affected (17% depreciation vis-a-vis US$) despite it's strong fundamentals. Thus using D2SI would bias the results since we cannot firmly classified Singapore as a crisis-stricken country. Note too that the coefficient C has no theoretical underpinnings and is not a variable of interest.

there is strong contagion to Singapore despite her sound fundamentals. Since Table 2 presents in principle a static specification, we are prudent in the interpretation of the results.

TABLE 2: OLS RESULTS
(Contemporaneous Explanatory Variables Excluded One by One)

	Eqn 1	Eqn 2	Eqn 3	Eqn 4	Eqn 5	Eqn 6	Eqn 7
Crisis Elsewhere	**2.99** (2.61)	**2.72** (2.44)	**2.82** (2.50)	**2.33** (2.09)	**2.79** (3.21)	**1.99** (2.34)	**2.66** (2.28)
Credit Growth	0.09 (0.98)	-	0.08 (0.87)	0.09 (0.91)	0.35 (0.80)	0.05 (0.81)	0.10 (1.06)
Inflation Rate	0.05 (0.88)	0.04 (0.74)	-	0.05 (0.75)	0.13 (1.13)	0.03 (0.61)	-0.005 (-0.16)
Output Growth	0.02 (1.72)	0.02 (1.69)	0.02 (1.67)	-	0.11 (1.06)	0.01 (1.17)	0.02 (1.50)
Unemployment Rate	**1.41** (2.58)	**1.31** (2.43)	**1.26** (2.43)	**1.20** (2.18)	-	**0.94** (3.16)	**1.19** (2.16)
Budget Position/GDP	-0.08 (-3.36)	-0.12 (-0.55)	-0.04 (-0.17)	-0.05 (-0.21)	**-0.64** (-1.93)	-	**0.23** (1.58)
Current Account/GDP	**0.33** (1.74)	**0.34** (1.81)	0.24 (1.52)	0.29 (1.53)	**0.74** (2.33)	**0.21** (2.06)	-
R^2	0.28	0.25	0.26	0.21	0.45	0.28	0.21
Adjusted R^2	0.12	0.12	0.13	0.07	0.32	0.18	0.06

Note: a. Figures without parentheses refer to coefficient of corresponding variable.
b. Figures in parentheses refer to t-statistics.
c. Figures in bold mean variables significant at 5% level.

With the exception of the contagion variable, we lagged all the regressors - that is the 6 macroeconomic variables of moving averages[26]. This is important for two reasons. First, traditional models of currency crises tend to associate speculative attacks with persistent deterioration in fundamentals. This suggests some time is needed for the economic fundamentals to trigger the crisis. Second, using contemporaneous macro-economic variables do not indicate the causality direction. Thus, lagging the variables is necessary to pinpoint the effect of macroeconomic variables on contagious crises. Taking a general to specific approach on the time horizon of the equation specification, we lagged our contemporaneous macroeconomic variables by 2 years, 1 year and 2 quarters with contemporaneous. We also lagged our variables by 2 quarters without contemporaneous variables. The results of these estimated equations are presented in Table 3 below.

As expected, from the estimation of contemporaneous variables (column 1), all the seven variables have positive sign except for the ratio of budget position to GDP variable. The results show strong evidence of contagion. The contagion variable has a positive sign and is significant at 1 per cent level. A currency crisis in the region increases the probability of a speculative attack on the Singapore dollar by about 3

[26] According to Eichngreen, Rose and Wyplosz (1996), it is to conserve the degrees of freedom.

percent points. This is in addition to the relative high t-statistics, and the improved results with lagged macroeconomic variables.

TABLE 3: OLS RESULTS
(Contemporaneous and Lagged Variables)

	Contem-poraneous	MA of Contem + 2 lags	MA of 2 lags	MA of Contem + 4 lags	MA of Contem + 8 lags
Crisis Elsewhere	**2.99** (2.61)	**2.50** (2.30)	**2.80** (2.89)	**2.79** (2.78)	**1.97** (2.02)
Credit Growth	0.09 (0.98)	-0.21 (-1.10)	**-0.24** (-1.87)	0.35 (1.19)	1.06 (1.75)
Inflation Rate	0.05 (0.88)	0.03 (0.46)	0.02 (0.37)	0.13 (1.80)	0.22 (1.98)
Output Growth	0.02 (1.72)	0.05 (1.34)	-0.007 (-0.31)	0.11 (1.74)	0.15 (1.31)
Unemployment Rate	**1.41** (2.58)	1.15 (1.84)	0.92 (1.71)	**2.42** (3.38)	**3.31** (2.93)
Budget Position/GDP	-0.08 (-0.37)	-0.48 (-1.70)	**-0.53** (-2.15)	-0.64 (-1.73)	-0.18 (-0.22)
Current Account/GDP	0.33 (1.75)	**0.57** (2.48)	**0.58** (2.89)	**0.74** (2.78)	0.70 (1.24)
R^2	0.28	0.31	0.39	0.45	0.47
Adjusted R^2	0.12	0.14	0.24	0.32	0.31

Note: a. Figures without parentheses refer to coefficient of corresponding variable.
b. Figures in parentheses refer to t-statistics.
c. Figures in bold means variables significant at 5% level.

The macroeconomic variables show varying significance. The unemployment growth, which indicates falling economic performance, is significant at 1 per cent level. This result supports second generation models, where crises are triggered by inconsistency in domestic and external goals. The ratio of current account to GDP, which captures the external competitiveness of an economy though insignificant with contemporaneous estimation, gains increased significance with greater lags. This is in accordance with findings of Dornbush and Werner (1994) and Eichengreen, Rose and Wyplosz (1995) to current account as an indicator of currency crisis. The credit growth variable is insignificant, suggesting that rapid monetization may not need to be a leading indicator of crises. This is consistent with the view expressed in second-generation models that a currency crisis can occur without excessive monetary expansion. The inflation rate variable, output growth and ratio of budget position to GDP are also insignificant.

An observation across the time horizon shows generally the goodness of fit (indicated by R^2) and significance of all variables. This is supported from the R^2 value of 0.28 to 0.45, from contemporaneous variables estimation to Moving Average (MA) of contemporaneous variables and 4 lags estimation. This result shows that economic fundamentals have an effect on currency crisis. However, MA of contemporaneous variables and 8 lags reduced the significance of all macroeconomic variables rather

dramatically. This suggests that economic fundamentals have an explanatory power of one year at best in predicting currency crisis. Any inference beyond one year, as suggested by the data seems futile. The result is also consistent with Kaminsky, Lizondo and Reinhart (1997) findings that on average, macroeconomic factors indicates an imminent crisis between a year and a year-and -a-half.

To check for robustness, we also performed sensitivity analysis. First, we change the definition of EMP by emphasizing more weights on interest rate than exchange rate. This is in the ratio of 0.6 and 0.4 (represented by EMPSI1). Second, we change the definition of speculative pressure by varying the benchmark of 1.2. These variations comes in 3 graduations - 1.5 standard deviation, 1.0 standard deviation and 0.5 standard deviation, represented by D1EW, D3EW and D4EW (See Appendix 4, 5 and 6). Third, we drop post 1992 data so as to focus on pre-crisis period[27]. Similarly, we limit the sample from 1993:1 - 1998:2. The results of these estimated equations are represented in Table 4 below.

TABLE 4: SENSITIVITY ANALYSIS

	Increased Weight on Interest Rates	EMP at 1.5 Standard Deviation	EMP at 1.0 Standard Deviation	EMP at 0.5 Standard Deviation	Pre-1992	Asian Currency Crisis
Crisis Elsewhere	**1.24** (2.44)	0.97 (0.58)	**2.14** (2.08)	**2.44** (2.94)	**3.42** (2.24)	**2.50** (3.34)
Credit Growth	0.03 (0.86)	0.05 (0.48)	0.06 (0.67)	0.01 (0.16)	020 (1.63)	-0.15 (-2.10)
Inflation Rate	0.02 (0.73)	0.02 (0.37)	0.03 (0.59)	-0.02 (-0.32)	0.06 (0.66)	0.004 (0.05)
Output Growth	0.01 (1.71)	0.01 (0.89)	0.02 (1.46)	0.01 (1.01)	**0.04** (2.42)	-0.008 (-1.22)
Unemployment Rate	**0.65** (2.70)	0.98 (1.64)	**1.43** (2.43)	**1.23** (2.42)	**1.86** (2.89)	-23.31 (-1.39)
Budget Position/GDP	-0.07 (-0.76)	-0.05 (-0.20)	-0.05 (-0.21)	-0.19 (-0.86)	-0.40 (-0.90)	**-3.83** (-3.67)
Current Account/GDP	**0.17** (2.09)	0.24, (1.19)	0.29 (1.54)	0.31 (1.71)	0.80 (1.54)	-0.43 (-0.74)
R^2	0.30	0.13	0.23	0.31	0.47	0.91
Adjusted R^2	0.14	-0.06	-0.06	0.16	0.24	0.83

Note: a. Figures without parentheses refer to coefficient of corresponding variable.
b. Figures in parentheses refer to t-statistics.
c. Figures in bold means variables significant at 5% level.

Firstly, the increased weightage on interest rates in the EMP construction reduces the explanatory power of the contagion variable to 1.24 (though still significant at 2% level). One possible explanation is the passive role played by the monetary

[27] This is justified on the grounds that Asian currencies appreciate from the 90s with their ballooning current account deficits.

authorities since the Singapore economy was essentially strong. Thus there is no pressure for the authorities to defend the Singapore dollar by taking the drastic measure of increasing interest rates. The second analysis changes the definition of EMP. As expected, the results improved with the relaxed definition of EMP. However, we maintain that a better criteria of the EMP benchmark is to compare the computed readings with the actual developments in the foreign exchange during periods of speculative pressure as seen in the Asia Financial Crisis. The third analysis questions whether the inclusion of recent data (where there were heavy speculative pressures) bias the results. The pre-1992 sample shows the coefficient variable to increase further to 3.42 and is statistically significant. The contagion variable in the Asian Currency Crisis period, defined as 1993 to 1998 (second quarter) is significant at 1% level.

From the sensitivity analysis, we can confirm the first part of our hypothesis. That is, *a speculative attack elsewhere in the region at the same point in time increases the probability of a speculative attack on the Singapore dollar by 3 percent points*. This result however, does not distinguish the channels of contagion transmission; namely trade competitiveness versus macroeconomic similarities. We proceed to test these two theories individually by weighting the contagion variable accordingly.

Having established priori evidence of contagion, we extend our model as follows:

$$Crisis_{i,t} = \omega W_{ij,t}(Crisis_{j,t}) + \lambda I(L)_{i,t} + \varepsilon_{i,t} \text{ where}$$

$$W_{ij,t}(Crisis_{j,t}) = w_{ij,t} \text{ if } Crisis_{j,t} = 1, \text{ for any } j \neq i$$
$$= 0 \text{ otherwise}$$

where : " $w_{ij,t}$ is a weight which corresponds to the relevance at time t of country j for country i"[Eichengreen, Rose and Wyplosz (1996)]. The hypothesis of interest is still Ho: $\omega=0$. We interpret evidence of the null as being inconsistent with existence of contagion.

The first weighting scheme tests the channel of contagion via trade. In order to capture the significance of trade between Singapore and the 7 regional countries, we construct a weight based on the percentage of trade between Singapore and these 7 Asian nations against Singapore's total trade. Using data from International Monetary Fund's (IMF) Direction of Trade Statistics 1996, we compute this weight using a combination of bilateral imports value and exports value.

Thus our *trade-weight* is defined as follows (from Singapore's respective):

$$w_{ij,t} = \frac{[\text{Imports}_{\text{ from 7 Asian nations}} + \text{Exports}_{\text{ to 7 Asian nations}}]}{[\text{Imports}_{\text{ from the world}} + \text{Exports}_{\text{ to the world}}]}$$

Thus, a trade-weighted contagion variable (D2EWEER) is generated which is a product of the dummy contagion variable D2EW and trade weight EER. This trade-weighted contagion variable is used in the regressions to replace the original contagion variable D2EW used in the above regressions. The estimated results are presented in Table 5.

TABLE 5: OLS RESULTS WITH CONTAGION VARIABLE WEIGHTED BY INTERNATIONAL TRADE

	Contem-poraneous	MA of Contem + 2 lags	MA of 2 lags	MA of Contem + 4 lags	MA of Contem + 8 lags
Crisis Elsewhere	**6.25** (2.66)	5.23 (2.36)	**5.83** (2.89)	**5.83** (2.14)	**4.12** (2.99)
Credit Growth	0.09 (0.98)	-0.21 (-1.14)	**-0.24** (1.20)	0.35 (1.71)	1.06 (-1.92)
Inflation Rate	0.05 (0.88)	0.03 (0.46)	0.02 (1.82)	0.13 (2.03)	0.22 (0.34)
Output Growth	0.02 (1.74)	0.05 (1.34)	-0.007 (1.80)	0.11 (1.38)	0.15 (-0.32)
Unemployment Rate	**1.41** (2.57)	1.15 (1.82)	0.92 (3.41)	**2.42** (2.95)	**3.31** (1.68)
Budget Position/GDP	-0.08 (-0.38)	-0.48 (-1.71)	**-0.53** (-1.77)	-0.64 (-0.29)	-0.18 (**-2.15**)
Current Account/GDP	0.33 (1.74)	**0.57** (2.49)	**0.58** (2.82)	**0.74** (1.31)	0.70 (2.86)
R^2	0.28	0.31	0.39	0.45	0.47
Adjusted R^2	0.12	0.14	0.24	0.32	0.31

Note: a. Figures without parentheses refer to coefficient of corresponding variable.
b. Figures in parentheses refer to t-statistics.
c. Figures in bold means variables significant at 5% level.

In contrast with Table 2 (which reports the results of the unweighted contagion variable), the coefficient on the trade-weighted contagion variable has increased by a factor of 2. Since the trade-weighted contagion variable is now a product of the dummy and trade weights, the coefficient is not so easily interpretable. Nonetheless, the positive sign on the trade-weighted contagion variable indicates that a speculative attack elsewhere in the region increases the probability of a speculative attack on the Singapore dollar by a statistically significant amount. Hence we interpret the result to mean that contagion transmission is explained partially through trade linkages.

Our second weighting scheme tests the channel of contagion via macroeconomic similarities. Countries are considered similar in their macroeconomic factors for instance if they displayed similar rates of growth in domestic credit. To reveal this intuition of macro-similarity, we standardize the variables by subtracting the sample means and dividing the result by the same standard deviation. According to Eichengreen, Rose and Wyplosz (1996) there are two approaches for this standardization: 1) Country-specific standardization and 2) Time-specific standardization.

The country specific approach is appropriate when a country's macroeconomic fundamentals is compared with itself over time. That is speculators judge a country's macroeconomic fundamentals in a quarter to its past. The time specific is appropriate

when a country's fundamentals (that is Singapore) at a point in time is compared with other countries (7 Asian countries) at the same point in time.

Following Eichengreen, Rose and Wyplosz (1996), we focus on the following seven variables[28], all computed as deviations from US values. They are: 1) domestic credit growth, 2) money growth, 3) CPI inflation, 4) output growth, 5) unemployment rate, 6) current account (% of GDP, nominal) and 7) government budget (% of GDP). For easier comparison, we multiply the rate of GDP growth, the current account and government budget by minus 1. This is because variables like domestic credit growth, money growth and inflation are associated with a higher probability in speculative attack. Thus, the above step ensures that all variables are associated with higher risk

With these standardized variables, we proceed with the computation of the macro-weights for country-specific and time-specific as follows:

$$w_{ij,t} = \Sigma_j (1-\{\Phi[(x_{jt} - \mu_i)/\sigma_i] - \Phi[(x_{it}-\mu_i)/\sigma_i]\})/n$$
$$w_{ij,t} = \Sigma_j (1-\{\Phi[(x_{jt} - \mu_t)/\sigma_t] - \Phi[(x_{it}-\mu_t)/\sigma_t]\})/n$$
for any $j \neq i$, n = number of regional countries

where "$\Phi(.)$ is the cumulative distribution function of the standardized normal function , $\mu_i(\mu_t)$ is the country-specific (time-specific) sample averages of variable x, $\sigma_i(\sigma_t)$is the country-specific (time-specific) standard deviation of variable x, x's are the seven macroeconomic 'focus' variables, and n=7 in this context (all Asian nations other than Singapore)" [Eichengreen, Rose and Wyplosz (1996)].

The reasoning for this specification is that if country i is attacked and is similar to country j in the standardized macroeconomic variables, the weight on the contagion variable is high. Specifically, the more similar country j and country i are in their macroeconomic features, the greater the weight skews towards unity. Conversely, the more dissimilar countries are in their macroeconomic features, the more the weight tends towards. With the computed series of macro-weights for country-specific and time-specific, we generate macro-weighted contagion variables, using again a product of the dummy contagion variable D2EW and the corresponding macroeconomic focus variables.

To avoid the problem of multicollinearity, we have included the macro-weighted contagion variables one at a time in the estimation. We lagged Singapore's macroeconomic variables by 2 quarters, 1 year and 2 years with the contemporaneous variables. The results of estimated equations using the country-specific weights and the time-specific weights are presented in Table 6 below. From Table 6, all macroeconomic variables have positive coefficients and are statistically significant (with the exception of inflation at a 2 year lag specification). That is a currency crisis in the region with macroeconomic fundamentals similar to that of Singapore raises the probability of an attack on the Singapore dollar. A comparision between country-specific weights and time-specific weights shows no discernible difference in the variables significance. Thus the results suggest that, besides the perceived

[28] According to Eichengreen, Rose and Wyplosz (1996), these variables are most-watched by foreign exchange market participants.

speculation on Singapore's dollar in comparision with the region's fundamentals, another channel of contagion or speculation exists when Singapore's macroeconomic fundamentals depreciate over time. Hence we interpret these evidence to mean that contagion can be transmitted through macroeconomic similarities.

TABLE 6: OLS RESULTS WITH CONTAGION VARIABLE WEIGHTED BY MACRO-SIMILARITY

(Contagion Variables Included One by One)

	---Country Specific Averages---			---Time Specific Averages---		
	Contem-poraneous	MA of 2 Lags	MA of Contem + 8 Lags	Contem-poraneous	MA of 2 Lags	MA of Contem + 8 Lags
Crisis*Credit Similarity	**4.48** (3.03)	**3.98** (3.14)	**3.32** (2.62)	**4.87** (3.00)	**4.41** (3.24)	**3.49** (2.49)
Crisis*Money Similarity	3.89 (2.82)	**3.58** (3.01)	**2.77** (2.34)	**4.38** (2.73)	**4.05** (2.97)	**2.99** (2.18)
Crisis*Inflation Similarity	**3.92** (2.52)	**3.62** (2.80)	2.42 (1.84)	**4.64** (2.53)	**4.35** (2.75)	2.99 (**1.92**)
Crisis*GDP Similarity	**3.20** (2.13)	**3.35** (2.68)	**2.62** (1.93)	**4.14** (2.59)	3.90 (2.84)	**2.75** (2.02)
Crisis*Unemp Similarity	**3.82** (2.66)	**3.61** (2.80)	**3.67** (2.14)	**3.84** (2.67)	**3.61** (2.94)	**2.59** (2.12)
Crisis* C/Acc Similarity	**6.19** (2.59)	**5.75** (2.83)	**2.33** (1.82)	**5.59** (2.43)	**5.26** (2.63)	3.57 (1.85)
Crisis*Budget Similarity	**3.48** (2.58)	**3.28** (2.76)	**4.87** (2.04)	**5.55** (2.24)	**5.07** (2.58)	3.40 (1.63)

Note: a. Figures without parentheses refer to coefficient of corresponding variable.
b. Figures in parentheses refer to t-statistics.
c. Figures in bold means variables significant at 5% level.

To determine the explanatory power of the trade-weighted and macro-weighted contagion variables, we construct firstly a single-contagion variable for the 7 macro weights (this is to avoid the problem of multicollinearity). The single contagion variable is an average of the seven macroeconomic weights. Since there are 2 macro weights, we compute two single contagion variable for the country-specific and time specific standardization, represented as D2EWWC_AVE and D2EWWT_AVE respectively. The single macro weights are computed and shown in Appendix 8 and 9 respectively. Regressions are hence implemented by simultaneously including the thus defined weights in the model and the results are presented in Table 7.

The trade-weighted contagion remains positive and statistically significant at the contemporaneous specification. This is consistent with the view of contagion through trade. In contrast to Table 6, the macro-weighted contagion (for both country-specific standardization and time-specific standardization) are negative and statistically insignificant. More importantly, the macro-weighted time-specific standardization is uniformly negative. This result is consistent with our belief that contagion in Singapore via macroeconomic similarities is a weak hypothesis. Thus our results

suggest that contagion in Singapore transmit mainly through regional trade competitiveness.

TABLE 7:OLS RESULTS WITH TWO DIFFERENT MEASURES OF CONTAGION

	---Country Specific Averages---			---Time Specific Averages---		
	Contem-poraneous	MA of 2 Lags	MA of Contem + 8 Lags	Contem-poraneous	MA of 2 Lags	MA of Contem + 8 Lags
Crisis Elsewhere: Int'l Trade Weights	**4.85** (2.26)	28.76 (1.67)	6.80 (0.04)	13.81 (0.76)	33.92 (1.80)	17.5 (0.77)
Crisis Elsewhere: Macro Factor Weights	1.56 (0.16)	-13.6 (-1.30)	2.66 (0.21)	-5.63 (-0.49)	-18.85 (-1.53)	-8.23 (-0.54)
Credit Growth	0.05 (0.84)	**-0.23** (-2.35)	**1.16** (3.59)	0.06 (0.91)	**-0.23** (-2.41)	1.16 (3.62)
Inflation Rate	0.04 (0.64)	-0.04 (-0.70)	**0.24** (2.57)	0.03 (0.65)	-0.04 (-0.69)	**0.24** (2.53)
Output Growth	0.01 (1.20)	-0.02 (-0.74)	**0.23** (2.25)	0.01 (1.27)	-0.02 (-0.76)	**0.23** (2.30)
Unemployment Rate	**0.95** (3.16)	0.42 (1.29)	**3.65** (4.69)	0.99 (3.20)	0.42 (1.29)	**3.61** (4.66)
Current Account/GDP	0.21 (1.91)	0.12 (1.06)	**0.68** (3.67)	0.20 (1.99)	0.12 (1.04)	**0.65** (3.51)
R^2	0.29	0.34	0.48	0.29	0.35	0.42
Adjusted R^2	0.16	0.22	0.37	0.17	0.23	0.37

Note: a. Figures without parentheses refer to coefficient of corresponding variable.
b. Figures in parentheses refer to t-statistics.
c. Figures in bold means variables significant at 5% level.

6. Conclusion

The trade-weighted contagion remains positive and statistically significant at the contemporaneous specification. This is consistent with the view of contagion through trade. In contrast to Table 6, the macro-weighted contagion (for both country-specific standardization and time-specific standardization) are negative and statistically insignificant. More importantly, the macro-weighted time-specific standardization is

uniformly negative. This result is consistent with our belief that contagion in Singapore via macroeconomic similarities is a weak hypothesis. Thus our results suggest that contagion in Singapore transmit mainly through regional trade competitiveness.

The above estimations have two important indications: First, not only did we established the pressence of contagion in Singapore, we found that a speculative attack elsewhere in the region increases the probability of a speculative attack on the Singapore dollar by 3 percent points. Second the transmission of contagion is stronger through trade channel than that of contagion through macroeconomic similarities, albeit the significant results of macro-weighted contagion tested individually.

In the empirical process, we found some other interesting results. Singapore's sound fundamentals, shown in it's budget surplus reduced the probability of a speculative attack on the Singapore dollar. The strong budget position could have explained the mild attack on the Singapore dollar. In addition we found that the efficiency of macroeconomic variables as a predictor of currency crisis falls beyond one year. Hence, macroeconomic fundamentals can only serve to indicate an imminent crisis within one year.

Trade has always played a key role in the economic growth of Asia. As Asia takes on an increase in trading partners, the possible sources of contagion also increases. Hence, a key issue with regards to Asia's future is the need to strike a balance between expansion into foreign markets and the increased exchange risks of contagion. A prudent risk assessment of these possible trading partners and the implementation of suitable regulatory policies to minimize exchange risk should be a priority for future study.

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