Patterns of Exchange Rates and Current Accounts: The East Asian Waltz

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Abstract

The East Asian economies (Indonesia, Malaysia, the Philippines, Singapore, Thailand, Japan, Korea, China, Hong Kong) have highly benefited from the process of regionalism based on the US dollar as the anchor currency for at least for the past four decades. Regionalism has also given new life to East Asia, as these countries have become more integrated. However, integration through regionalism has also created market distortions in the foreign exchange markets and the current accounts imbalance. This study attempts to capture these distortions of these nine East Asian economies using the Phasor Analysis of the circuit/network theory of engineering. The method used also adopts Williamson's fundamental equilibrium exchange rates. The findings strongly show that for the last decades or two, these East Asian economies have already engaged in a grand Waltz.

Key words: Regionalism, Centripetal/Centrifugal Force, Feedback Mechanism

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Accounts: The East Asian Waltz

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1. Introduction

1997/1998 and 2008/2009 are remembered as two defining moments that gripped Asia. 1997/1998 saw worldwide economic meltdown due to financial contagion which started in Thailand with the financial collapse of the Thai Baht caused by the floatation of the Baht. As the financial crisis spread, most of Southeast Asia and Japan also saw slumping currencies, devalued stock markets and other asset prices, and a precipitous rise in privated debt. 2008/2009 saw again a repeat of the 1997/98 fear. However, this fear is different as the impact is felt worldwide and is transmitted via many routs - began since Lehman Brothers filed for bankruptcy in September 2008, Merrill Lynch bought over by Bank of America, and AIG rescued by the US Government bailouts via TARP I, TARP II (troubled assets relief programme), and other relief programmes, *e.g.* TALF (Term Asset-Backed Securities Loan Facility). This global financial crisis, originated by the US subprime crisis that impacted the East Asian economies in a systemic manner, saw Strauss-Kahn Dominique, managing director of IMF, coining it as the Great Recession. The reverberation of this systemic crisis saw also stock markets plunged sharply (50-80%), substantial depreciation of the Asian currencies (except Yen) against the US dollar, and increased widening of risk in debts (5%-10%).

This study attempts to understand these systemic patterns using the Phasor Analysis as in the network theory of electronic engineering. This phasor analysis would enable us to measure the centripedal/centrifugal force that pushes the East Asia financial and exchange rate arrangements into a certain trajectory path. One of these forces is stemmed largely through the process of regionalism since the formation of the Asian Global Supply Chain in the 1970s. Like the Akamatsu Japanese Flying Geese Theory of East Asian growth model, the pattern of production network and emergence of the supply chain saw Japan first emerging into the industrial world and helped create the Asian Global Supply Chain to meet US and global demand for consumer goods by investing in the rest of Asia. This process was helped by the usage of the US dollar as the key currency that lowered transaction costs and risks. De facto pegs against the dollar gave the rest of Asia the fiscal, monetary and trade disciplines that forced structural adjustments for them to benefit from joining the supply chain.

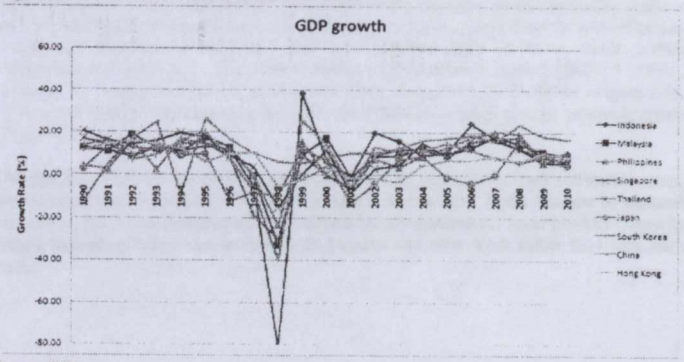
methodology using the Phasor Analysis. This analysis maps the phase or the position of economic variables in two-dimension represented in terms of angel θ in radians and radius. Section 4 shows the computation of Williamson's fundamental equilibrium exchange rates. These variables will be used in charting of the phasor diagrams. Section 5 gives the results, and Section 6 draws some conclusions.

2. East Asian Economic Flight

The East Asian growth model had become a widely celebrated model even till today (World Bank, 1993, and ADB, 2008). After Japan emerged as a highly industrialized nation after World War II, Japan's exports that shifted to the US markets offered new opportunities for other East Asia's newly industrializing economies like South Korea, Hong Kong, Singapore and Taiwan to be part of the production network and the global supply chain. Like the Akamatsu's Japanese Flying Geese Theory, the success of Japan uplifted the rest of East Asia's economies. The success and rise of the highly industrialized South Korea, Hong Kong, Singapore and Taiwan later became known as the Asian tigers.

In the last 60 years (between the early 1960s and 1990s), East Asia economies have grown not only richer by also closer. ASEAN-5's growth rates also moved broadly in a synchronized pattern with the advanced East Asia countries (Figure 2.1). Clearly, in the process of industrializing, each of these economies became more complexly integrated into the global supply chain and the production network through the process of regionalism.

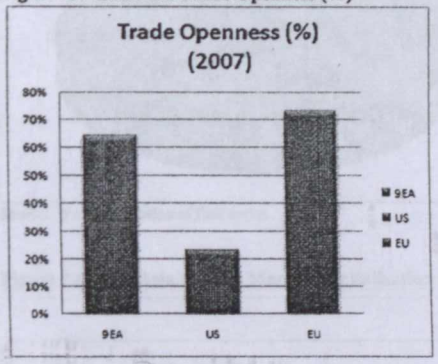
Figure 2.1 GDP Growth Rates for East Asia



Source: EIU
Note: 2010 data are projections by EIU

dependence. East Asia's export-led nations are also proving to be extremely vulnerable to a synchronized global trade, as East Asia accounts for 64% of trade openness to world trade (Figure 2.2) and consisting of 64% of world trade (double the amount of US) (Figure 2.3). It is not surprising then that should the world suffers a recession, East Asia would also be affected, as synchronized downturn in advanced economies would certainly add pressure on East Asia's trade.

Figure 2.2 East Asia Trade Openness (%)



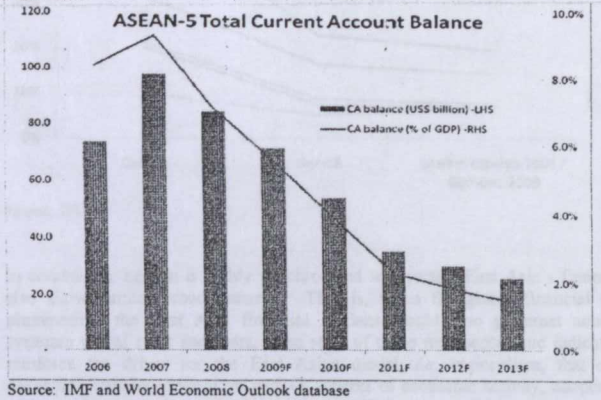
Source: IFS and COMTRADE database

Figure 2.3 Percentage of East Asia Trade from Global Trade

Source: IFS and COMTRADE database

suffer from the slowing exports and manufacturing production when demand from major advanced countries contracts. ASEAN-5's current account balance would decline sharply, and IMF projected that the ASEAN-5 total current account would decline by 70% by 2013 (Figure 2.4).

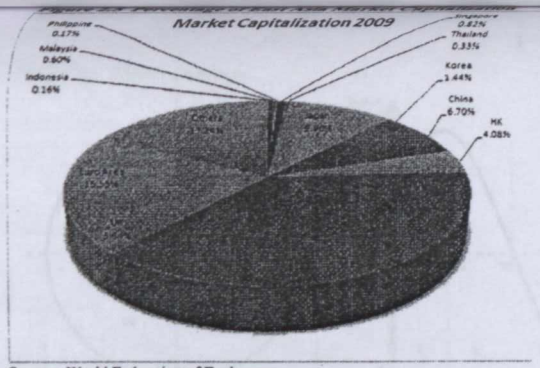
Figure 2.4



Source: IMF and World Economic Outlook database

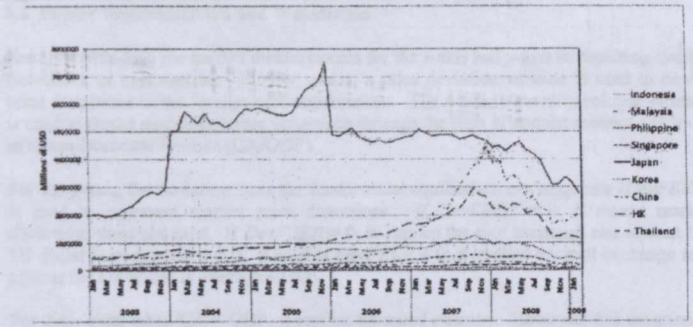
Unfortunately, Asian capital markets (bond and equity markets) remain relatively shallow and less attractive relative to the US and Europe as centres for savings despite efforts to deepen and broaden the markets. East Asia accounts only 14.3% of world market capitalization (Figure 2.5). The largest market capitalization is Japan US$276.5 trillion, followed by Singapore US$232 trillion and Hong Kong US$119.7 trillion (Figure 2.6). In terms of market capitalization to GDP, the ASEAN-5 ratios remain relatively small (Figure 2.7).

The real issues are the under-development of financial institutions, high transaction costs, and mindset barriers to deliver value to investors and savers. Partly because of national turf issues, the Asian financial markets remain largely pockets of "local markets", loosely linked through efficient connections with London and New York rather than with each other.

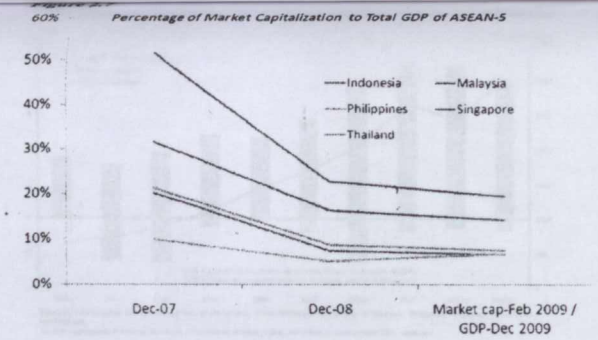


Source: World Federation of Exchanges

Figure 2.6 East Asia Capital Market Capitalization (2003 – 2009)



Source: COMTRADE database



Source: IFS

In conclusion, against a highly synchronized real sector, East Asia's financial markets also show similar broad patterns. That is, when the global financial markets are plummeting, the East Asia financial markets would also plummet amid spreading systemic global risks and fears. The state of these macroeconomic indicators seem to reinforce the driver for the East Asian model, *i.e.* regionalism, that encompasses deepening interdependence on various spheres of economic activity, cooperative efforts and growing commitment to international collaboration. In the following section, we apply an engineering tool, *i.e.* network/circuit theory, to measure the degree of market-network amongst these East Asian economies, that is to what extent are these markets synchronized?

3. Methodology: The Phasor Analysis

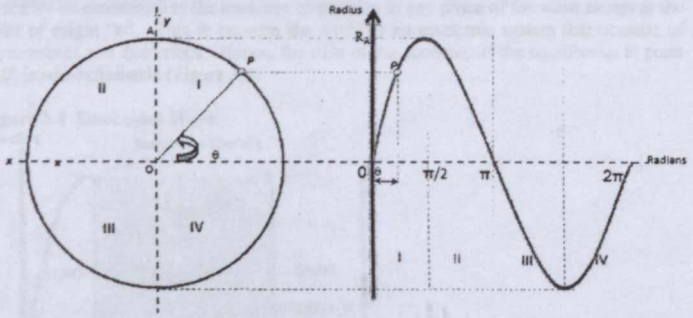
3.1 Phasor Diagram

The world is an economic system that consists of asymmetries. The fact that our world does not behave perfectly symmetrically is due to deviations from symmetry or equilibriums. This study attempts to transform the asymmetrical realities back into symmetrical spaces measured in shapes of circles and cycles of sinusoidal or sine waves. In the electrical engineering literature, sinusoidal waves using phasor diagrams are most frequently used to measure circuits or networks (circuits and networks are used synonymously in the engineering terminology).

In the analysis of circuits or networks, it is necessary to know the position of the phasor representing that alternating quantity at a particular instant. In economic system, the "alternating quantity" is translated as market distortions from a point of reference or "a particular instant". The position P in the phasor is represented in terms of angle θ in radians or degrees, measured from reference (o). The phase measured in anticlockwise

3.1 maps any two dimensional point on the circle from a Cartesian space into a sine wave.

Figure 3.1 Phasor Diagram



3.2 Phasor Representation and Waveforms

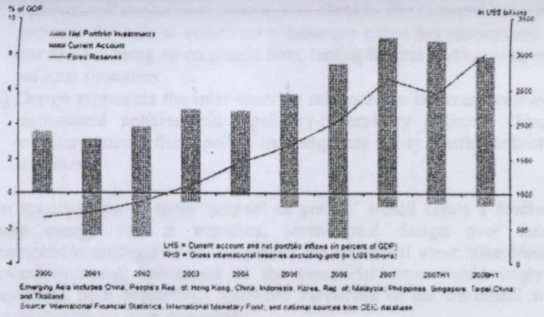
Next, we introduce the market measurements for the *x*-axis and *y*-axis in depicting market distortions or asymmetries. For the *y*-axis, a price deviation variable is used to depict price distortions in the foreign exchange markets. The *x*-axis, a quantity/volume variable is used to depict macroeconomic imbalance through the ratio of current account and level of Gross Domestic Product (CA/GDP).

For the *y*-axis, the deviation from the fundamental equilibrium exchange rate (*DevFEER*) is used to represent market price distortions. If *DevFEER* = 0, it means market distortions does not exist. If *DevFEER* > 0, it implies the spot exchange rate against the US dollar is undervalued (U). And if If *DevFEER* < 0, it implies the spot exchange rate against the US dollar is overvalued (O).

For the *x*-axis, when CA = GDP, it implies balanced quantity. However, this situation is impossible to achieve in economic realities. If CA > GDP, it implies current account surplus (S), and if CA < GDP, it implies current account deficit (D).

See Appendix for an explanation on the computation of Cline and Williamson (2008) fundamental equilibrium exchange rates. The current account is chosen as a quantity for the *x*-axis because the amount of current account in East Asia is relatively large compared to the portfolio investments in the financial account (Figure 3.2).

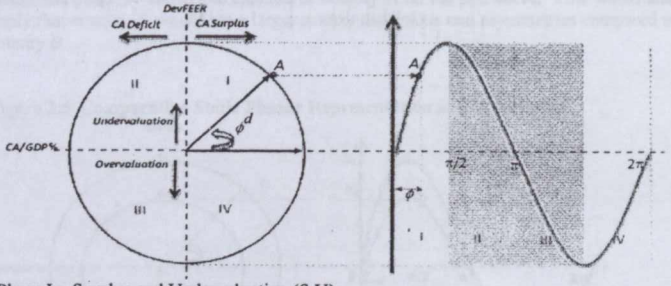
Figure 3.2
Net Portfolio Investments, Current Account and Forex Reserves



x-axis (Current account as a percent of GDP): Phases I and IV are the region of excessive current account surplus as a percent of GDP. Phases II and III are the regions of excessive current account deficit. Origin "o" means current account balance.

y-axis (FEER deviation index): This index reflects the deviation of country's bilateral exchange rates to fundamental equilibrium exchange rates (FEERs) which are based on the international current account imbalances. Thus, Phases I and II are undervaluation and Phases III and IV are overvaluation (Figure 3.3).

Figure 3.3 Phasor Representation and Waveforms

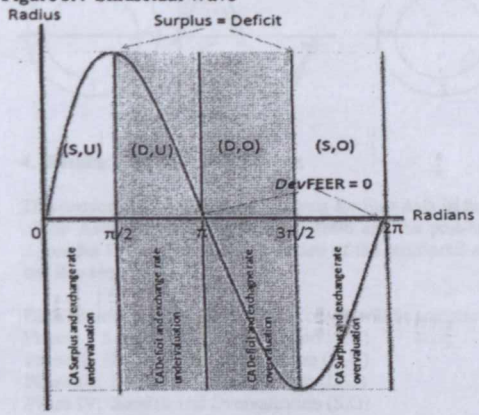


Phase I : Surplus and Undervaluation (S,U)
Phase II: Deficit and Undervaluation (D,U)
Phase III: Deficit and Overvaluation (D,O)
Phase IV: Surplus and Overvaluation (S,O)
The distance '*d*' measures how far away from the origin 'o'.
The distance '*d*' is calculated by using the Pythagoras theorem:

$$d = \sqrt{x^2 + y^2} = \sqrt{\left(\frac{CA}{GDP}\right)^2 + (devFEER)^2}$$

In reality an economy has the tendency to position in any phase of the wave except at the point of origin "o". This is because the world is an economic system that consists of asymmetries and distortions. Hence, the state of the economy at the equilibrium at point (0,0) is non-achievable (Figure 3.4).

Figure 3.4 Sinusoidal Wave



3.3 Feedback Loop

3.1 Introduction

Within the engineering circuits or networks, there exist resistances and sources of energy. Transporting this analysis into our Phasor analysis, we postulate that the economic system also consists of resistances (frictions) and sources of energy. Expanding this concept into a microscopic level, we can express these sources of energy as particles of energy network. These three difficult or non-quantifiable sources of energy are:

(1) *Impulses* (external forces or stochastic shocks like a banking crisis/contagion);
(2) *Inertia* (resistance to change in a state of "motion"); and
(3) *Design* (regulation changes, government intervention, other institutional factors).

(1) *Impulses* are external shocks to the economic system. For example, the 2008 global financial crisis is another example of external shock to the recessionary growth rates in Asia.

(2) *Inertia* is the resistance to change in a state of "motion". If the growth of GDP is measured as the state of the economy (Kwek and Cho, 2006), then inertia is caused by political and institutional resistance to change. For example, the debate for a common currency for Asia to enter into a monetary union has encountered many resistances due to Asia being an enigmatic bloc, having diverse institutional, economic and geo-political structures.

(3) *Design* represents the inter-weaving relationships between macroeconomic policies, institutional policies and regulatory-supervisory policies. Some examples are monetary policy, fiscal policy, exchange rate policy, market infrastructure, and legal conditions.

An accumulation of these 'sources of energy' would create a feedback loop, because these energy that is impulses, inertia and design over time would create centripetal/centrifugal force that pushes the sinusoidal wave inward/outward. Over time inward (outward) movement of the sinusoidal wave would imply smaller (larger) deviations from symmetry. Outward movement of the sinusoidal wave would imply larger deviations from symmetry.

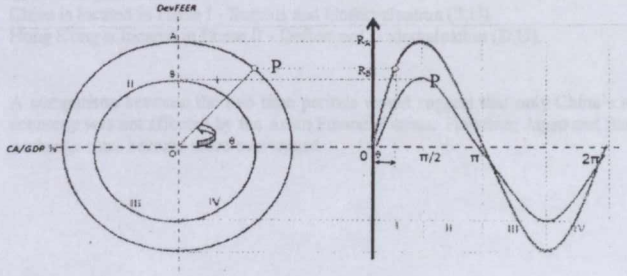
3.2 Centripetal or Centrifugal Force

Consider two countries (A and B) having same time period but having different maximum values that is R_A and R_B, where,

$A = R_A \sin\theta$ and,
$B = R_B \sin\theta$.

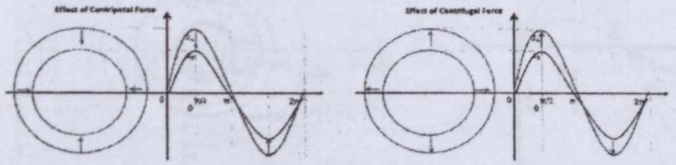
If $R_A > R_B$, then a comparative static phasor representation and waveforms of both the quantities are shown in Figure 3.5. The phasors OA (country A) = R_A and OB (country B) = R_B. The OA and OB phasor achieve their maximum deviation from *FEER* at $\pi/2$ radian and point 'P' shows the location of country A on the sine curve. This would also imply that country A would have larger market distortions and asymmetries compared to country B.

Figure 3.5 Comparative Static Phasor Representation and Waveforms



country is given in Figure 3.6. The figure shows the impact of centripetal or centrifugal force on the phasor diagram and the sine wave. Country A's radius will be reduced by the centripetal force, but it can also get larger in size if it is caused by the centrifugal force.

Figure 3.6 Feedback Mechanism in Phasor Representation and Waveforms

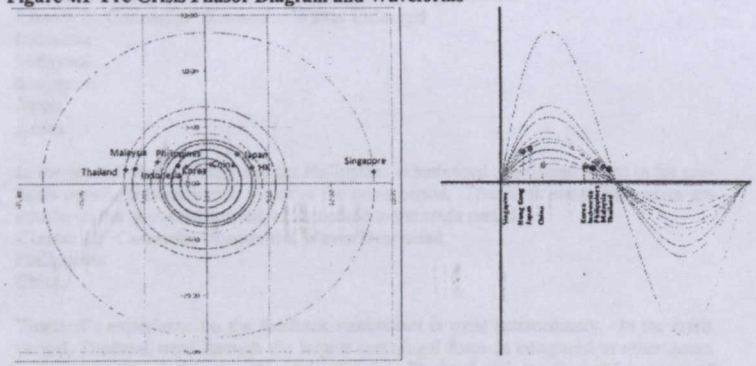


4. Results: The East Asian Waltz

This section shows the phasor analysis for East Asia in the pre-crisis period (1992-1996) of the Asian Financial crisis of 1997/98 and the post-crisis period (1998-2007). See Appendix II for a detailed calculation of the centripetal and centrifugal force in radians and degrees.

Each country's position on the sine waves will be summarized by the following phases:
Phase I : Surplus and Undervaluation (S,U)
Phase II: Deficit and Undervaluation (D,U)
Phase III: Deficit and Overvaluation (D,O)
Phase IV: Surplus and Overvaluation (S,O)

Figure 4.1 Pre-Crisis Phasor Diagram and Waveforms



In the pre-crisis period, Figure 4.1 suggests that we can differentiate two clusters of countries, namely, Indonesia, Malaysia, the Philippines, Thailand and South Korea in Cluster I. Cluster II would include Singapore, Japan, China and Hong Kong.

Cluster I pre-crisis
Indonesia is located in Phase II - Deficit and Undervaluation (D,U).
Malaysia is located in Phase II - Deficit and Undervaluation (D,U).
Philippines is located in Phase II - Deficit and Undervaluation (D,U).
Thailand is located in Phase II - Deficit and Undervaluation (D,U).
Korea is located in Phase II - Deficit and Undervaluation (D,U).

Cluster II pre-crisis
Singapore is located in Phase I - Surplus and Undervaluation (S,U).
Japan is located in Phase I - Surplus and Undervaluation (S,U).
China is located in Phase I - Surplus and Undervaluation (S,U).
Hong Kong is located in Phase I - Surplus and Undervaluation (S,U).

However, in the post-crisis Figure 4.2, the diagrams suggest that we can differentiate again into two clusters of countries, namely, Indonesia, Malaysia, the Philippines, Thailand and South Korea in Cluster I. Cluster II would include Singapore, Japan, China and Hong Kong.

Cluster I post-crisis
Indonesia is located in Phase IV - Surplus and Overvaluation (S,O).
Malaysia is located in Phase IV - Surplus and Overvaluation (S,O).
Philippines is located in Phase IV - Surplus and Overvaluation (S,O).
Singapore is located in Phase IV - Surplus and Overvaluation (S,O).
Thailand is located in Phase IV - Surplus and Overvaluation (S,O).
Korea is located in Phase IV - Surplus and Overvaluation (S,O).
Japan is located in Phase IV - Surplus and Overvaluation (S,O).

Cluster II post-crisis
China is located in Phase I - Surplus and Undervaluation (S,U).
Hong Kong is located in Phase II - Deficit and Undervaluation (D,U).

A comparison between the two time periods would suggest that only China's market or economy was not affected by the Asian Financial crisis. However, Japan and Singapore's exchange rates became more overvalued.

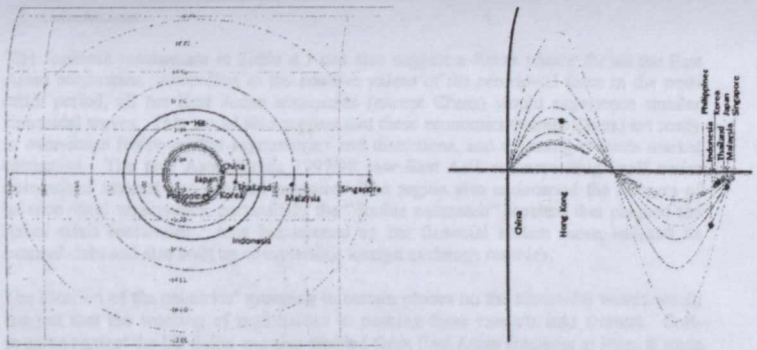


Table 4.1 gives the comparison of the phasor analysis between the pre-crisis, crisis and post-crisis periods. It computes also the feedback mechanism measured as centripetal and centrifugal forces. If in the pre-crisis period, country "A" experiences a centripetal force (value is positive), then in the next period the radius of the sinusoidal wave for country "A" should be smaller. However, when country "A" experiences a centrifugal force (value is negative), then in the next period the radius of the sinusoidal wave for country "A" should be larger.

From the pre-crisis and crisis periods, Indonesia, Malaysia, Singapore, Japan, and South Korea have experienced centrifugal forces that pushed the sinusoidal waves outward in the next period. This explains that any external shocks to an economy would enlarge market distortions and most of the time they are quite permanent.

Cluster I: Countries' Sinusoidal Waves Enlarged

Indonesia
Malaysia
Singapore
Japan
Korea

In the second cluster, China and the Philippines experienced centrifugal forces in the pre-crisis period, but centripetal forces in the crisis period. Thus their sinusoidal waves are smaller in the post-crisis period, as compared to the crisis period.

Cluster II: Countries' Sinusoidal Waves Decreased

Philippines
China

Thailand's experience on the feedback mechanism is most extraordinary. In the crisis period, Thailand went through the largest centrifugal force as compared to other Asian economies. This is because the crisis started in Thailand with the financial collapse of

the Thai Baht caused by the decision of the Thai government to float the Baht. At the time, Thailand had acquired a huge burden of foreign debt (like Ireland's in the current global financial crisis) that made the country effectively bankrupt even before the collapse of its currency. In conclusion, these clusters in Figures 4.1 and 4.2 strongly suggest that these East Asian economies were already dancing in a grand waltz, called the '*East Asian Waltz*'.

Table 4.1 Summary of Phasors and Feedback Mechanisms

Country	Period	FEER	CA/GDP%	Radius	Centripetal(+)/Centrifugal(-) force*	Degree	Radians(π)
Indonesia	Pre-crisis	1.58	-2.30	2.79	-3.96	145	0.808
	Crisis	1.59	-2.27	2.77	-25.33	145	0.805
	Post Crisis	-7.15	4.64	8.53	10.22	303	1.683
Malaysia	Pre-crisis	1.33	-5.68	5.83	-5.19	167	0.927
	Crisis	1.29	-5.93	6.06	-3.43	168	0.932
	Post Crisis	-1.26	12.17	12.24	3.52	354	1.967
Philippines	Pre-crisis	1.94	-3.90	4.36	-3.87	154	0.853
	Crisis	1.99	-5.28	5.64	1.89	159	0.886
	Post Crisis	-2.73	1.79	3.26	1.50	303	1.685
Singapore	Pre-crisis	1.01	13.50	13.54	-5.66	4	0.024
	Crisis	1.75	15.64	15.74	-9.00	6	0.036
	Post Crisis	-0.66	21.66	21.67	6.44	358	1.990
Thailand	Pre-crisis	1.21	-6.50	6.61	8.42	169	0.942
	Crisis	0.48	-2.00	2.06	-88.92	167	0.925
	Post Crisis	-0.92	5.16	5.24	4.17	350	1.944
Japan	Pre-crisis	2.78	2.60	3.81	-1.59	47	0.261
	Crisis	2.49	2.31	3.39	-0.26	47	0.262
	Post Crisis	-0.46	3.57	3.60	2.33	353	1.959
Korea	Pre-crisis	1.56	-1.64	2.26	-11.81	136	0.757
	Crisis	1.32	-1.62	2.09	-151.38	141	0.783
	Post Crisis	-1.60	3.29	3.66	2.28	334	1.856
China	Pre-crisis	2.03	0.40	2.07	-1.44	79	0.438
	Crisis	0.46	3.75	3.78	0.01	7	0.039
	Post Crisis	0.29	3.75	3.76	-2.91	4	0.025
HK	Pre-crisis	1.48	3.67	3.95	0.75	22	0.122
	Crisis	0.44	3.21	3.24	2.80	8	0.043
	Post Crisis	-7.02	-0.66	7.05	117.71	95	0.530

Note: * Negative values means centrifugal force
Positive values means centripetal force.

5. Conclusions

The feedback mechanism in Table 4.1 can also suggest a future phasor for all the East Asian economies. According to the positive values of the centripetal force in the post-crisis period, all the East Asian economies (except China) would experience smaller sinusoidal waves. This would also suggest that these economies (except China) are ready to over-come future market asymmetries and distortions, and adjusting towards market correction. The post Asian Crisis 1997/98 saw East Asia reconstructing itself under tremendous internal and external pressure. The region also understood the dangers of balance sheet weaknesses, particularly the "double mismatch" problem that plagued the Asian crisis economies. Asia has opened up her financial system more, reduced its external debt and also built up considerable foreign exchange reserves.

The location of the countries' grouping in certain phases on the sinusoidal waves would suggest that the working of regionalism in pushing these markets into clusters. Soft-pegging against the US dollar has also enabled these East Asian countries to learn to trade and coordinate production and distribution chains in Asia. Through such soft-pegging, these regional currencies were already "flying-in-unison" formation. This flight path for the Asian currencies can be seen as an informal monetary arrangement that was adjusting to the needs of the Asian supply chain, without unfortunately fully realizing the implications of the volatility of the dollar yen relationship.

In conclusion, by focusing on the real side of development, and not paying sufficient attention to underdevelopment of their financial systems, the Asian economies will become vulnerable again to the subsequent external shocks. The Global Financial Crisis 2008/09 that started in the US has spread into recessionary systemic risks in most of the economies around the world. It is inevitable this time that China would be struck by this great tsunami.

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APPENDIX 1
Estimating Williamson's Fundamental Equilibrium Exchange Rate

This appendix applies the fundamental equilibrium exchange rate (FEER) method of Cline and Williamson (2008).

Define the parameter γ that indicates the change in a country's current account balance as a percent of GDP that takes place in response to a change in the country's real effective exchange rate by 1 percent. Such a relationship is to be expected from the influence of the relative price variable in determining demand and supply of exports and imports. This price variable can be seen as one of the arguments in the equations for imports and exports, with the other main argument being the income variable, or the rate of growth in the domestic economy (for the import equation) or the foreign economies trade weighted (for the export equation).

From the national accounts identity it will also be necessary that the trade deficit (goods and services) equals the excess of investment over domestic saving (including saving by the government). In this general equilibrium system it will be necessary by implication that changes in domestic absorption occur in parallel to the changes directly predicted from the export and import equations in response to exchange rate and activity changes.

For the 9 countries the respective changes in current account as a percent of GDP will be:

$$\begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \\ c_5 \\ c_6 \\ c_7 \\ c_8 \\ c_9 \end{bmatrix}_{(9x9)} = \begin{bmatrix} \gamma_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \gamma_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \gamma_3 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \gamma_4 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \gamma_5 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \gamma_6 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \gamma_7 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \gamma_8 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \gamma_9 \end{bmatrix} \begin{bmatrix} \dot{r}_1 \\ \dot{r}_2 \\ \dot{r}_3 \\ \dot{r}_4 \\ \dot{r}_5 \\ \dot{r}_6 \\ \dot{r}_7 \\ \dot{r}_8 \\ \dot{r}_9 \end{bmatrix}$$

where c is the desired change in the current account as a percent of GDP to attain fundamental equilibrium, γ is the current impact parameter and $\dot{r}$ is the proportionate change in the real effective exchange rate. In order to translate the changes in real effective exchange rates into the corresponding changes needed in what markets and policymakers actually observe bilateral exchange rates against the numeraire (dollar) the system must identify the relationships between bilateral exchange rate changes real effective exchange rate changes. Abstracting from any induced changes in inflation, these will depend on trade patterns and the extent of appreciation of partners. If the numeraire exchange rate is that of country 1 (the deficit country) or for simplicity, the dollar, the set of effective exchange rate will be:

$$\dot{r}_1 = -\phi_{12}z_2 - \phi_{13}z_3 - \phi_{14}z_4 - \phi_{15}z_5 - \phi_{16}z_6 - \phi_{17}z_7 - \phi_{18}z_8 - \phi_{19}z_9 - \phi_{110}z_{10}$$

$$\dot{r}_2 = \phi_{21}z_2 + \phi_{23}(z_2 - z_3) + \phi_{24}(z_2 - z_4) + \phi_{25}(z_2 - z_5) + \phi_{26}(z_2 - z_6) + \phi_{27}(z_2 - z_7) + \phi_{28}(z_2 - z_8) + \phi_{29}(z_2 - z_9) + \phi_{210}(z_2 - z_{10})$$

$$\dot{r}_3 = \phi_{31}z_3 + \phi_{32}(z_3 - z_2) + \phi_{34}(z_3 - z_4) + \phi_{35}(z_3 - z_5) + \phi_{36}(z_3 - z_6) + \phi_{37}(z_3 - z_7) + \phi_{38}(z_3 - z_8) + \phi_{39}(z_3 - z_9) + \phi_{3,10}(z_3 - z_{10})$$

$$\dot{r}_4 = \phi_{41}z_4 + \phi_{42}(z_4 - z_2) + \phi_{43}(z_2 - z_3) + \phi_{45}(z_4 - z_5) + \phi_{46}(z_4 - z_6) + \phi_{47}(z_4 - z_7) + \phi_{48}(z_4 - z_8) + \phi_{49}(z_4 - z_9) + \phi_{4,10}(z_4 - z_{10})$$

$$\dot{r}_5 = \phi_{51}z_5 + \phi_{52}(z_5 - z_2) + \phi_{53}(z_5 - z_3) + \phi_{54}(z_5 - z_4) + \phi_{56}(z_5 - z_6) + \phi_{57}(z_5 - z_7) + \phi_{58}(z_5 - z_8) + \phi_{59}(z_5 - z_9) + \phi_{5,10}(z_5 - z_{10})$$

$$\dot{r}_6 = \phi_{61}z_2 + \phi_{62}(z_6 - z_2) + \phi_{63}(z_6 - z_3) + \phi_{64}(z_6 - z_4) + \phi_{65}(z_6 - z_5) + \phi_{67}(z_6 - z_7) + \phi_{68}(z_6 - z_8) + \phi_{69}(z_6 - z_9) + \phi_{6,10}(z_6 - z_{10})$$

$$\dot{r}_7 = \phi_{71}z_7 + \phi_{72}(z_7 - z_2) + \phi_{73}(z_7 - z_3) + \phi_{74}(z_7 - z_4) + \phi_{75}(z_7 - z_5) + \phi_{76}(z_7 - z_6) + \phi_{78}(z_7 - z_8) + \phi_{79}(z_7 - z_9) + \phi_{7,10}(z_7 - z_{10})$$

$$\dot{r}_8 = \phi_{81}z_8 + \phi_{82}(z_8 - z_2) + \phi_{83}(z_8 - z_3) + \phi_{84}(z_8 - z_4) + \phi_{85}(z_8 - z_5) + \phi_{86}(z_8 - z_6) + \phi_{87}(z_8 - z_7) + \phi_{89}(z_8 - z_9) + \phi_{8,10}(z_8 - z_{10})$$

$$\dot{r}_9 = \phi_{91}z_9 + \phi_{92}(z_9 - z_2) + \phi_{93}(z_9 - z_3) + \phi_{94}(z_9 - z_4) + \phi_{95}(z_9 - z_5) + \phi_{96}(z_9 - z_6) + \phi_{97}(z_9 - z_7) + \phi_{98}(z_9 - z_8) + \phi_{9,10}(z_9 - z_{10})$$

$$\dot{r}_{10} = \phi_{10,1}z_{10} + \phi_{10,2}(z_{10} - z_2) + \phi_{10,3}(z_{10} - z_3) + \phi_{10,4}(z_{10} - z_4) + \phi_{10,5}(z_{10} - z_5) + \phi_{10,6}(z_{10} - z_6) + \phi_{10,7}(z_{10} - z_7) + \phi_{10,9}(z_{10} - z_8) + \phi_{10,9}(z_{10} - z_9)$$

where z is the percent rise in the bilateral exchange rate of the country against the dollar, and ϕ_{ij} is the share of country j in total trade turnover of country i. For country 1, in this case the United States, the effective exchange rate falls when the foreign exchange rates rise against the dollar; hence the negative signs on nominal exchange rates 2 to 10. There is no bilateral exchange rate change "z" for country1 because the numeraire currency (the dollar) does not change against itself. The system ultimately has only nine unknowns (z_2 to z_{10}) but ten independent equations and is hence over-determined.

It can be shown as:

$$\dot{r}_1 = \frac{c_1}{\gamma_1} = -\phi_{12}z_2 - \phi_{13}z_3 - \phi_{14}z_4 - \phi_{15}z_5 - \phi_{16}z_6 - \phi_{17}z_7 - \phi_{18}z_8 - \phi_{19}z_9 - \phi_{110}z_{10}$$

$$\dot{r}_2 = \frac{c_2}{\gamma_2} = \phi_{21}z_2 + \phi_{23}(z_2 - z_3) + \phi_{24}(z_2 - z_4) + \phi_{25}(z_2 - z_5) + \phi_{26}(z_2 - z_6) + \phi_{27}(z_2 - z_7) + \phi_{28}(z_2 - z_8) + \phi_{29}(z_2 - z_9) + \phi_{210}(z_2 - z_{10})$$

$$= z_2 - \phi_{23}z_3) - \phi_{24}z_4 - \phi_{25}z_5 - \phi_{26}z_6 - \phi_{27}z_7 - \phi_{28}z_8) - \phi_{29}z_9 - \phi_{210}z_{10}$$

$$+\phi_{38}(z_3 - z_8) + \phi_{39}(z_3 - z_9) + \phi_{3,10}(z_3 - z_{10})$$
$$= z_3 - \phi_{32}z_2 - \phi_{34}z_4 - \phi_{35}z_5 - \phi_{36}z_6 - \phi_{37}z_7 - \phi_{38}z_8 - \phi_{39}z_9 - \phi_{3,10}z_{10}$$

In matrix form,

$$\begin{bmatrix} \dot{r}_1 \\ \dot{r}_2 \\ \dot{r}_3 \\ \dot{r}_4 \\ \dot{r}_5 \\ \dot{r}_6 \\ \dot{r}_7 \\ \dot{r}_8 \\ \dot{r}_9 \\ \dot{r} \end{bmatrix} = \left(\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & & & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & & & & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & & & & & 1 & 0 & 0 & 0 & 0 \\ 0 & & & & & & 1 & 0 & 0 & 0 \\ 0 & & & & & & & 1 & 0 & 0 \\ 0 & & & & & & & & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} 1 & \phi_{12} & \phi_{12} & \cdot & \cdot & \cdot & & & & \phi_{1,10} \\ \phi_{21} & 1 & & & & & & & & \cdot \\ \phi_{31} & & 1 & & & & & & & \cdot \\ \phi_{41} & & & 1 & & & & & & \cdot \\ \cdot & & & & 1 & & & & & \\ \cdot & & & & & 1 & & & & \\ \cdot & & & & & & 1 & & & \\ & & & & & & & 1 & & \\ & & & & & & & & 1 & \\ \phi_{10,1} & \phi_{10,2} & \phi_{10,3} & \cdot & \cdot & \cdot & & & \phi_{10,9} & 1 \end{bmatrix} \right) \begin{bmatrix} z_1 \\ z_2 \\ \cdot \\ \cdot \\ \cdot \\ z_{10} \end{bmatrix}$$

Thus,

$R_{10x1} = (I_{10x10} - \phi_{10x10})Z_{10x1}$

$R_{10x1} = B_{10x10}Z_{10x1}$ where $B_{10x1} = (I_{10x10} - \phi_{10x10})$

It is necessary to delete one row from the vector of real exchange rate changes and the adjusted trade matrix: namely, the row for the country selected to be treated residually. The truncated adjusted trade share matrix will be B'.

The solution for the set of exchange rate changes against the dollar needed to arrive at FEERs is then obtained as follows,

$$Z_{9x1} = (B')^{-1}R_{10x1}$$

The vector of real effective exchange rate changes is determined exogenously and is equal to the set of country currency change targets (c_i) divided by the country adjustment impact parameters (γ_i).

Figure1 Bilateral Exchange Rates Index (1992 = 100)

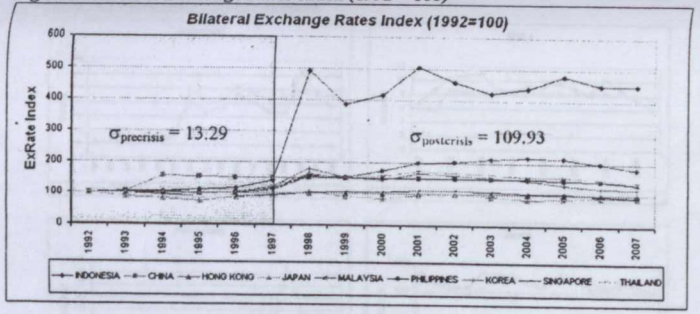
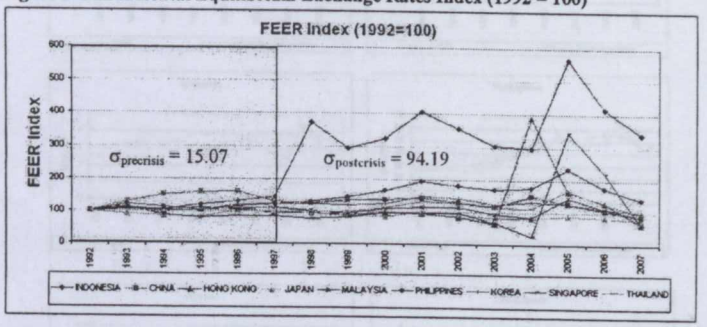


Figure 2 Fundamental Equilibrium Exchange Rates Index (1992 = 100)



In pre-crisis period, the standard deviation within the bilateral exchange rates index is very low, 13.29, compared relatively to the post-crisis standard deviation of 109.93 (Figure 2.1). In the post-crisis period, the standard deviation within the FEER index is 15.07, compared relatively to the post-crisis standard deviation of 94.19 (Figure 2.2).

When we examine the deviations of the fundamental equilibrium exchange rates (FEER) index, the plots show that in the pre-crisis period, all the Asian currencies were actually "flying-in-unison" with each other. However, after the crisis, these currencies were dispersed, as being attacked by a hawk, and began to deviate in a larger range (Figure 2.3).

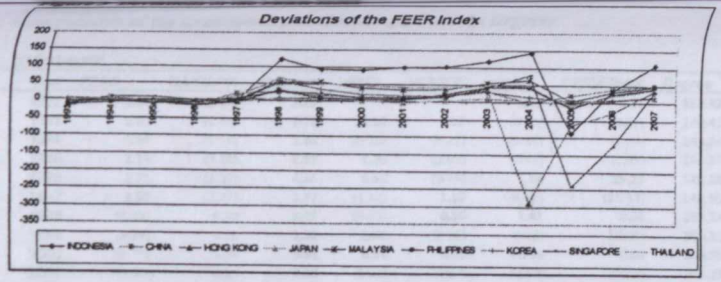
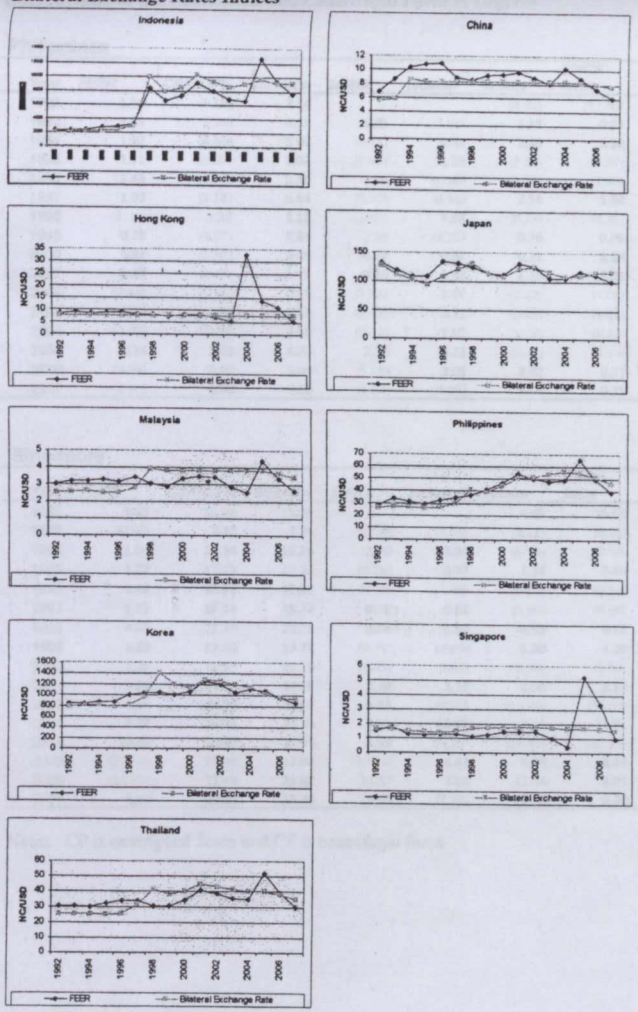


Figure 4 Comparing the Fundamental Equilibrium Exchange Rates and the Bilateral Exchange Rates Indices



Note: NC is national currency.

APPENDIX II
Computation of the Centripetal and Centrifugal Force in Degrees

Indonesia

Year	FEER	CA/GDP%	distance	1dFEER	1dCAGDP	velocity	CP/CF force	Degree
1992	1.00	(2.00)	2.23			0.51	0.17	153.42
1993	1.10	(1.33)	1.73	0.10	0.67	(0.11)	(2.07)	140.41
1994	0.94	(1.58)	1.84	(0.16)	(0.25)	(2.00)	(1.24)	149.24
1995	2.14	(3.18)	3.83	1.20	(1.60)	(0.49)	(1.09)	146.07
1996	2.71	(3.37)	4.33	0.57	(0.19)	1.56	15.25	141.18
1997	1.59	(2.27)	2.77	(1.12)	1.10	(6.56)	(25.33)	144.91
1998	(8.29)	4.29	9.33	(9.88)	6.56	1.81	0.36	297.38
1999	(6.29)	4.13	7.52	2.00	(0.16)	(0.02)	(0.01)	303.30
2000	(5.79)	4.84	7.55	0.50	0.71	0.26	0.08	309.93
2001	(5.95)	4.20	7.28	(0.16)	(0.64)	(0.50)	(0.16)	305.25
2002	(6.73)	3.91	7.79	(0.79)	(0.29)	(1.58)	(0.03)	300.14
2003	(8.72)	3.41	9.37	(1.99)	(0.50)	(2.02)	(0.14)	291.38
2004	(11.37)	0.61	11.39	(2.65)	(2.81)	(3.16)	(19.46)	273.06
2005	14.55	0.10	14.55	25.91	(0.51)	11.73	18.86	89.62
2006	0.72	2.73	2.82	(13.82)	2.63	(4.84)	(55.40)	14.83
2007	(7.56)	1.21	7.66	(8.29)	(1.51)	7.66	7.66	279.11

Malaysia

Year	FEER	CA/GDP%	distance	1dFEER	1dCAGDP	velocity	CP/CF force	Degree
1992	1.00	(3.66)	3.80			(0.87)	(0.11)	316.03
1993	1.33	(4.47)	4.67	0.33	(0.81)	(1.52)	(1.01)	316.22
1994	1.21	(6.07)	6.19	(0.12)	(1.60)	(3.69)	(12.93)	315.56
1995	1.73	(9.73)	9.88	0.52	(3.66)	5.25	4.52	315.45
1996	1.37	(4.42)	4.63	(0.36)	5.31	(1.43)	(7.37)	316.31
1997	1.29	(5.93)	6.06	(0.08)	(1.50)	(7.27)	(3.43)	315.66
1998	(1.91)	13.20	13.34	(3.20)	19.13	(2.72)	(6.51)	44.70
1999	(2.05)	15.92	16.06	(0.15)	2.72	6.60	1.86	44.76
2000	(1.02)	9.40	9.45	1.03	(6.53)	1.14	0.02	44.83
2001	(0.73)	8.28	8.31	0.29	(1.12)	0.72	4.59	44.89
2002	(0.82)	7.55	7.59	(0.08)	(0.73)	(5.45)	(4.90)	44.83
2003	(2.10)	12.87	13.04	(1.29)	5.33	0.65	0.64	44.62
2004	(2.74)	12.09	12.39	(0.64)	(0.78)	(2.23)	(0.02)	44.28
2005	1.29	14.57	14.62	4.03	2.48	(1.72)	(3.20)	44.89
2006	(0.70)	16.33	16.34	(1.99)	1.76	5.12	2.27	44.97
2007	(1.76)	11.08	11.22	(1.06)	(5.25)	11.22	11.22	44.64

Notes: CP is centripetal force and CF is centrifugal force

APPENDIX II (cont'd)
Computation of the Centripetal and Centrifugal Force in Degrees

Philippines

Year	FEER	CA/GDP%	distance	1dFEER	1dCAGDP	velocity	CP/CF force	Degree
1992	1.00	(1.89)	2.14			(4.05)	(12.85)	318.53
1993	2.75	(5.55)	6.19	1.75	(3.66)	1.19	0.09	318.13
1994	1.96	(4.60)	5.00	(0.78)	0.94	1.93	3.60	317.39
1995	1.51	(2.67)	3.07	(0.45)	1.93	(2.31)	(1.37)	318.97
1996	2.49	(4.77)	5.38	0.98	(2.10)	(0.26)	(1.46)	318.44
1997	1.99	(5.28)	5.64	(0.50)	(0.51)	2.54	1.89	316.89
1998	(2.01)	2.37	3.11	(3.99)	7.66	(0.73)	(0.72)	37.36
1999	0.70	(3.77)	3.84	2.70	(6.15)	0.76	0.05	315.48
2000	0.93	(2.93)	3.08	0.23	0.84	0.31	1.14	316.37
2001	1.29	(2.45)	2.77	0.36	0.48	2.18	7.01	318.48
2002	(0.46)	(0.36)	0.59	(1.75)	2.09	(2.22)	(4.01)	328.24
2003	(2.79)	0.36	2.81	(2.33)	0.72	(0.69)	(0.12)	7.33
2004	(2.95)	1.88	3.50	(0.17)	1.52	(1.28)	(0.27)	28.21
2005	4.34	2.01	4.78	7.29	0.13	(0.31)	(1.14)	22.81
2006	(0.84)	5.02	5.09	(5.18)	3.01	2.02	0.21	44.60
2007	(2.91)	0.96	3.06	(2.07)	(4.05)	3.06	0.35	17.45

Singapore

Year	FEER	CA/GDP%	distance	1dFEER	1dCAGDP	velocity	CP/CF force	Degree
1992	1.00	11.86	11.90			4.65	15.66	44.90
1993	(0.76)	7.22	7.26	(1.76)	(4.65)	(9.01)	(8.93)	44.84
1994	1.94	16.14	16.26	2.70	8.93	(0.96)	(0.59)	44.79
1995	1.77	17.13	17.22	(0.16)	0.98	2.14	0.46	44.85
1996	1.08	15.03	15.07	(0.70)	(2.09)	(0.67)	(2.64)	44.93
1997	1.75	15.64	15.74	0.68	0.61	(6.98)	(9.00)	44.82
1998	4.40	22.28	22.71	2.64	6.64	4.93	0.05	44.45
1999	3.68	17.40	17.78	(0.71)	(4.89)	6.00	4.03	44.37
2000	2.25	11.57	11.79	(1.43)	(5.83)	(2.46)	(0.60)	44.47
2001	2.63	14.01	14.25	0.38	2.44	0.20	8.63	44.50
2002	2.81	13.77	14.05	0.18	(0.24)	(10.89)	(12.09)	44.41
2003	6.13	24.18	24.94	3.31	10.41	2.14	11.92	44.11
2004	10.82	20.07	22.80	4.69	(4.11)	(15.10)	(21.21)	41.36
2005	(28.94)	24.48	37.91	(39.76)	4.41	6.89	0.57	32.85
2006	(14.37)	27.49	31.02	14.57	3.01	11.54	2.03	41.55
2007	4.68	18.91	19.48	19.05	(8.58)	19.48	3.24	44.15

Notes: CP is centripetal force and CF is centrifugal force

HK

Year	FEER	CA/GDP%	distance	1dFEER	1dCAGDP	velocity	CP/CF force	Degree
1992	1.00	4.25	4.37			(0.74)	(0.80)	44.23
1993	2.19	4.61	5.11	1.19	0.36	1.14	0.00	42.09
1994	0.90	3.87	3.97	(1.29)	(0.75)	1.00	0.47	44.24
1995	1.44	2.60	2.97	0.53	(1.26)	(0.38)	(0.08)	41.19
1996	1.78	2.84	3.35	0.34	0.24	0.11	2.38	40.31
1997	0.44	3.21	3.24	(1.34)	0.37	2.93	2.80	44.74
1998	0.30	(0.05)	0.31	(0.13)	(3.26)	(0.08)	(1.98)	351.11
1999	(0.38)	(0.06)	0.39	(0.69)	(0.01)	(0.86)	(6.20)	351.56
2000	0.43	(1.17)	1.24	0.81	(1.11)	(2.40)	(4.06)	316.85
2001	0.19	(3.64)	3.65	(0.24)	(2.48)	(0.16)	(0.02)	315.04
2002	(0.98)	(3.68)	3.81	(1.17)	(0.03)	(0.42)	(273.31)	315.98
2003	(3.54)	(2.32)	4.23	(2.56)	1.36	(32.68)	(864.48)	331.28
2004	36.90	(0.69)	36.91	40.44	1.63	27.79	15.87	358.93
2005	9.07	0.87	9.11	(27.83)	1.56	3.59	1.28	5.48
2006	4.80	2.74	5.52	(4.27)	1.87	0.17	4.87	26.39
2007	(3.63)	3.94	5.36	(8.42)	1.20	5.36	5.03	36.36

Notes: CP is centripetal force and CF is centrifugal force