A Dynamic Analysis of the Impact of Uncertainty on Import and/or Export-led Growth: The Experience of Japan and the Asian Tigers

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Abstract

Increasing integration of the Asian Tigers with the world economy through trade has exposed their income and trade to greater uncertainty and volatility. This paper models uncertainty in trade and income and re-examines the stability of the trade-growth nexus for Japan and the Asian Tigers in a dynamic framework. We find that in a volatile environment Japan's GDP growth is only import-led while Hong Kong's GDP growth is both export- and import growth-led. On the other hand, incorporating uncertainty breaks the causal link between Korea's GDP growth and trade but it does not affect Taiwan's mutually causative relationship between GDP growth, with exports and imports. Lastly, the varied qualitative and quantitative impact of volatility in imports and exports on income growth among the Asian Tigers provides further thought for policy making.

1. Introduction

The debate about the role of exports in stimulating economic growth has generated considerable interest in the last three decades but has produced little consensus among researchers. Proponents of the export-led growth hypothesis explain that exports contribute positively to economic growth by, facilitating the exploitation of economies of scale, especially in small economies; relieving the binding constraint to allow increases in the imports of capital and intermediate goods; enhancing efficiency through increased competition; and promoting the diffusion of technical knowledge through learning by doing. At the same time, economic growth via productivity improvements or reduction in unit costs has stimulated exports in some countries. Thus some studies have found bidirectional causality between exports and economic growth while others have found no such relationship. The latter is possible if output and export growth result from the same forces so that the correlation between the two may be strong but there may not be any causal relationship between them.

Giles and Williams (2000) provide a comprehensive survey on the evidence of the export-growth nexus from cross-sectional and time series studies as well as discuss the methodologies employed which range from bivariate Granger and Sims tests to bivariate and multivariate Vector Autoregressive Regression (VAR), Vector Error Correction Models (VECM), and the relatively recent Toda and Yamamoto (1995) causality tests. Interestingly, Lee and Pan (2000) use nonlinear causality tests to explain the relationship between exports and GDP but Diks and Panchenko (2005) show that these nonlinear tests have a consistency problem and the rejection rate of non-causality is high as the sample size increases.

Since the evidence is at best mixed and often contradictory, rigorous empirical analysis assumes great importance and this study seeks to overcome a number of problems in the existing literature. First, most studies on the export or import-led growth hypothesis have not considered or sufficiently checked for robustness with regard to the stability of the estimated parameters underlying the hypotheses. For example, some studies use dummy variables to account for specific events while others have used the cumulative sum and cumulative sum of squares (CUMSQ) based on the estimated residuals to obtain critical bounds at 5% significance level. The problem with using dummy variables lies in the implicit assumption that events which could change responses are known before hand but this is not necessarily true. With the CUMSQ test, not only are the correct critical values difficult to calculate, they are also likely to induce low power (Hendry 1995). Furthermore, the use of dummies is static as it only accounts for specific events. They do not incorporate the lagged effects of the events or any other form of volatility arising from unknown events within the economy and/or related to the external trade and economic environment. This is especially important given the increasing levels of integration of economies into the global economy via trade and investment.

To deal with this, the present study considers an alternative but more robust method of detecting instability by considering possible impacts of uncertainty in exports, imports and income in a dynamic framework. In essence, this is a test of volatility as well as the hysteresis effect, an effect which persists after its cause has been removed, and it measures the associated risk in trade variables and output changes in an economy. If these effects are found to be significant, they are explicitly incorporated in the model to establish causality for accurate policy formulation. This avoids misspecification which in part may explain differences in the results of previous empirical studies.

The second contribution lies in the multicountry nature of the study which enhances our understanding of the trade-growth relationship in a broader context. The unprecedented success stories of the East Asian tigers make a good case study for this exercise. Here, quarterly time series data on Hong Kong, South Korea, Taiwan and Japan are used for the separate analysis of the economies given the inappropriateness of drawing statistical inferences from cross-country and pooled panel data studies.[1] Table 1 provides trends on the real GDP growth and exports and imports share of GDP for the selected sample countries. Apart from Japan, which has had slow output growth, the other three economies show strong GDP growth and a rising trend in their trade ratios to GDP.

[Table 1]

Figure 1, on the other hand, shows the varying degrees of volatility in GDP, export and import growth of the four economies. It can be seen that Hong Kong has the largest fluctuations in output growth due to being the most open of the economies while Japan, the least open, exhibits relatively smaller fluctuations.[2] Also, the smaller economies of Taiwan and Hong Kong experienced greater trade volatility than the larger economies. Finally, the delayed effects of the second oil crisis for Japan, and the first oil crisis and impact of the 1997/98 Asian financial crisis on Korea's export growth are notable.

[Figure 1]

We estimate a trivariate ECM to investigate the export-led growth hypothesis by including imports.[3] Reizman et al. (1996) argue that imports are crucial in testing this hypothesis as they found imports played the role of a confounding variable in causal ordering; that is, imports affect both income and exports. They argue that omitting imports can result in both type I and type II errors, that is, spurious rejection of the export-led growth hypothesis as well as spurious detection of it (ibid). If imports are a channel via which exports affect GDP, then not considering imports would overstate the importance of exports in their effect on GDP growth**.** Based on this argument, one ought to include other factors such as terms

[1] The term "Asian Tigers" refers to the four economies, namely, Hong Kong, South Korea, Taiwan and Singapore. Our analysis excludes Singapore, but for ease of exposition, we refer to the other three economies as the Asian Tigers.
[2] One common measure of openness is the ratio of the sum of exports and imports to GDP. Based on this measure, Japan appears to be the least open when compared with the Asian Tigers (see Table 1).
[3] A bivariate ECM is also estimated to make a comparison of the results.

of trade or exchange rate that can be expected to affect the export-led growth hypothesis but this is beyond the scope of this paper for the following reasons.

First, a change in these other factors is a source of volatility in the variables (export, import and GDP). Such an investigation of the determinants of volatility and the impact on the export and/or import led growth hypothesis calls for a paper on its own as it requires a fully modified model to be estimated. This paper's objective is to provide a first step towards studying the hypothesis by incorporating volatility without identifying what causes it. Second, adding any one extra factor would require the estimation of another 41 parameters in addition to the 60 that are estimated using the current model. This would result in a considerable loss in the degrees of freedom which may affect the statistical validity of the model. Nevertheless the omission of variables is not a major concern.[4] Although the ECM results are known to be sensitive to the chosen variables and the problems inherent in the pretesting of unit roots and cointegration, the critics point out that the usefulness lies in '… the generation of stylized facts about the behaviour of the elements of the system which can be compared with existing theories or can be used in formulating new theories, and testing of theories that generate Granger causality implications' (McMillin 1988).

The paper is organised as follows. The next section details the two aspects of uncertainty while section 3 provides the data sources. Section 4 discusses the models used and the empirical results obtained from them. Section 5 concludes.

2. The Dynamics of Uncertainty

The literature on hysteresis has seen many different applications to describe the persistence phenomenon in micro and macroeconomics. Here, we test the hysteresis hypothesis to see if there is time path dependence between trade and GDP growth, given that a large element of persistence shocks was identified to be due to other shocks (Lee et al. 1992). One reason

[4] The Ramsey Reset test for functional form misspecification did not show serious problems for the VECM results.

for such temporal dependence between trade and GDP can be drawn from Krugman's (1986) argument that dynamic economies of scale are a possible explanation for the existence of hysteresis in trade. Göcke (2002) on the other hand discusses hysteresis based on decreasing unit costs in the course of former production activity due to learning effects. Learning effects could have resulted from within the domestic economy due to research and development (R&D) or improvement in labour skills, and the fall in costs may then enable a gradual expansion in exports. In addition, the importance of hysteresis in trade that is related to the presence of sunk costs is evidenced in Giovannetti and Samiei (1996). In macroeconomic dynamics too, business fluctuations exhibit hysteresis if an asymmetry of effective demand such as a recession or boom is taken into account (Franz 1990). Also, it can be expected that in the presence of two-way causality effects between trade variables and output, hysteresis in one will feed through to give hysteresis in the other.[5]

The testing of the hysteresis hypothesis has taken many forms in the economics and finance literature, depending on the objectives of the study. Our choice of the formal econometric test rests on the role of uncertainty (and hence delayed response) in the dynamics of economic activity and exports. While Japan became more open much later, the Asian Tigers have been open and export-driven from as early as the 1970s, and thus we should expect that volatility in trade and the associated risks could have been major determinants of their export and import behaviour, and output expansion for these decades. Events such as the oil price shocks in the 1970s, the world recession in the mid 1980s, the early 1990s world-wide slump in the electronics market, and more recently, the 1997/98 Asian financial crisis would have an effect on trade volatility. Thus the scope for relying on exports to lead such economies in long-term economic growth is governed to a large extent by the unpredictability and uncertainty in the world market and/or in these economies' trade partners. In a model explaining economic activity, hysteresis and volatility are captured by the variance of the variables concerned.

[5] McCausland (2002) discusses a similar feedback effect from trade account hysteresis to exchange rate hysteresis.

3. Data

Quarterly data on value added GDP, exports and imports as well as GDP deflators and import and export price indices are downloaded from *Datastream International*. All variables are in constant 2000 prices and the natural logarithm of the variables is used. The sample data run from 1957:1 to 2005:2 for Japan, 1970:1 to 2005:2 for Korea, 1961:1 to 2005:2 for Taiwan and 1973:1 to 2005:2 for Hong Kong.

4. Models and Empirical Results

We first discuss the theoretical models to be estimated with and without uncertainty and then move on to the interpretation of the empirical results.

Without Uncertainty

Prior to estimation, all variables are tested for stationarity and the results are reported in table 2. Unit roots property of the data are established by both the Augmented Dickey-Fuller (ADF) and Kwiatkowski et al. (1992) (henceforth KPSS) tests for robustness.[6] The latter tests for a stationary null hypothesis as opposed to the null of a unit root in the ADF tests. The ADF tests when applied with an intercept and trend indicate that all the series are non-stationary in levels. These results are confirmed by the KPSS tests.[7]

[Table 2]

Based on the evidence that the data series were all integrated processes of order one, the cointegration test of Johansen-Juselies (1990) was used to test for the existence of a long-run relationship between the trade variables and real income using the maximum eigenvalue and trace statistics reported in table 3. The lag length is determined by the Akaike's Information Criterion and Schwartz Criterion. It can be seen that there is a long-

[6] To test for the existence of structural breaks and account for major events specific to the economies (see appendix for details), the Perron (1997) test was used. However, these were found to be insignificant and hence not reported.

[7] The choice of an intercept and a trend in the unit root test specification is consistent with the data plots that reveal all data series have non-zero mean and display a trend.

run relationship between real income, exports and imports for all countries. We then estimate the cointegration relationship by regressing real income (y_t) on a constant, exports (x_t) and imports (m_t) for each country. The one-period lag of the resulting residual from the cointegrating regression is employed as the error-correction regressor (ECT_{t-1}) in the VEC model. The VEC model is formulated as follows

$$
\begin{aligned}
\Delta y_t &= \mu_y + \sum_{i=1}^{p-1} \Gamma_{i,y}^{(y)} \Delta y_{t-i} + \sum_{i=1}^{p-1} \Gamma_{i,x}^{(y)} \Delta x_{t-i} + \sum_{i=1}^{p-1} \Gamma_{i,m}^{(y)} \Delta m_{t-i} + \alpha_y ECT_{t-1} + \varepsilon_{y,t} \\
\Delta x_t &= \mu_x + \sum_{i=1}^{p-1} \Gamma_{i,y}^{(x)} \Delta y_{t-i} + \sum_{i=1}^{p-1} \Gamma_{i,x}^{(x)} \Delta x_{t-i} + \sum_{i=1}^{p-1} \Gamma_{i,m}^{(x)} \Delta m_{t-i} + \alpha_x ECT_{t-1} + \varepsilon_{x,t} \qquad (1) \\
\Delta m_t &= \mu_m + \sum_{i=1}^{p-1} \Gamma_{i,y}^{(m)} \Delta y_{t-i} + \sum_{i=1}^{p-1} \Gamma_{i,x}^{(m)} \Delta x_{t-i} + \sum_{i=1}^{p-1} \Gamma_{i,m}^{(m)} \Delta m_{t-i} + \alpha_m ECT_{t-1} + \varepsilon_{m,t}
\end{aligned}
$$

where the residuals $\varepsilon_{y,t}$, $\varepsilon_{x,t}$ and $\varepsilon_{m,t}$ may be correlated but they follow a Gaussian white noise process. Referring to the first regression above, the coefficients, $\Gamma_{i,y}^{(y)}$, $\Gamma_{i,x}^{(y)}$ and $\Gamma_{i,m}^{(y)}$ measure the impacts of real income, export and import growth at period i on current real income growth (y) respectively. Note that α denotes the speed of adjustment towards the long-run equilibrium for the error-correction term, ECT_{t-1}, in each of the regressions.

With the inclusion of the error-correction term in the specification, the causality test can be formalized in two different ways. First, short-run non-causality can be tested under the joint null hypothesis that all the lagged difference right-hand-side variables are zero. For example, in the case that the null of $\Gamma_{1,x}^{(y)} = \Gamma_{2,x}^{(y)} = 0$ fails to be rejected, the test implies that export growth does not Granger cause income growth. Second, the impact of the error-correction term captures the extent to which the variables are out of equilibrium and this is a test for long-run non-causality. When combined with the short-run test of non-causality, the long-run non-causality test yields a strong exogeneity test in a VEC model. In such a case, the null hypothesis of $\Gamma_{1,x}^{(y)} = \Gamma_{2,x}^{(y)} = \alpha_y = 0$ is equivalent to testing for both long- and short-run non-causality from export to income growth. The results for short-run and strong exogeneity non-causality tests are reported in table 4. An overall summary of the causality results with and without uncertainty is presented in table 5.

[Tables 4 and 5]

With Uncertainty

An assessment of the relationship between trade and income growth is not complete if the model fails to capture the dynamics in periods when trade patterns and output growth are volatile. Factoring in the effects of uncertainty or volatility makes it possible to investigate whether output growth slowdown results from volatile trade patterns. The uncertainty surrounding output and the trade variables is captured by the conditional variance of the variables concerned using a generalised autoregressive conditional heteroskedastic (GARCH) model. This way of modeling uncertainty is established in other areas of applied macroeconomics literature such as Henry and Olekalns (2002), Grier and Perry (1998) and Fountas et al. (2001). The GARCH model has the advantage of allowing current conditional variance to be correlated with past ones and therefore captures persistence in uncertainty. Based upon the VEC model discussed above, we express the conditional variance-covariance matrix as follows

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon_{t-1}^{/}A + B'H_{t-1}B \qquad (2)$$

$$\text{where} \quad H_t = \begin{bmatrix} h_{y,t} & h_{y,x,t} & h_{y,m,t} \\ h_{y,x,t} & h_{x,t} & h_{x,m,t} \\ h_{y,m,t} & h_{x,m,t} & h_{m,t} \end{bmatrix}$$

and $\varepsilon_{j,t} \mid \Omega_{t-1} \sim N(0, H_t)$ with Ω_{t-1} is defined as the information set at time period *t-1* and $\varepsilon'_t = [\varepsilon_{y,t} \quad \varepsilon_{x,t} \quad \varepsilon_{m,t}]$. Note that C is a 3×3 upper-triangular parameter matrix with six constant terms $\{C\} = c_{ij}$ for all *i,j* = 1, 2 and 3 while $c_{21} = c_{31} = c_{32} = 0$. The restrictions on the C matrix ensure that equation (2) is identified. Here, A and B are 3×3 parameter matrix with $\{A\} = a_{ij}$ and $\{B\} = b_{ij}$ for all i,j = 1,2 and 3.[8] The conditional variance-covariance specification in equation (2) also takes into consideration the effect of the conditional covariance between output (y), export (x) and import (m) growth (i.e. $h_{y,x,t}, h_{y,m,t}$ *and* $h_{x,m,t}$). In addition, equation (2) is incorporated into the mean specification equation (1) via the conditional variances of output, export and import growth so as to quantify the impact of output and trade growth uncertainty on the dependent variable.[9] In so doing, the lead-lag relationships between output, export and import growth are more accurately reflected by the model estimates having factored in the effects of uncertainty. The resulting model known as VECM-GARCH-M is as follows

$$\Delta y_t = \mu_y + \sum_{i=1}^{p-1}\Gamma_{i,y}^{(y)}\Delta y_{t-i} + \sum_{i=1}^{p-1}\Gamma_{i,x}^{(y)}\Delta x_{t-i} + \sum_{i=1}^{p-1}\Gamma_{i,m}^{(y)}\Delta m_{t-i} + \alpha_y ECT_{t-1} + \phi_y^{(y)} h_{y,t} + \phi_x^{(y)} h_{x,t} + \phi_m^{(y)} h_{m,t} + \varepsilon_{y,t}$$
$$\Delta x_t = \mu_x + \sum_{i=1}^{p-1}\Gamma_{i,y}^{(x)}\Delta y_{t-i} + \sum_{i=1}^{p-1}\Gamma_{i,x}^{(x)}\Delta x_{t-i} + \sum_{i=1}^{p-1}\Gamma_{i,m}^{(x)}\Delta m_{t-i} + \alpha_x ECT_{t-1} + \phi_y^{(x)} h_{y,t} + \phi_x^{(x)} h_{x,t} + \phi_m^{(x)} h_{m,t} + \varepsilon_{x,t}$$
$$\Delta m_t = \mu_m + \sum_{i=1}^{p-1}\Gamma_{i,y}^{(m)}\Delta y_{t-i} + \sum_{i=1}^{p-1}\Gamma_{i,x}^{(m)}\Delta x_{t-i} + \sum_{i=1}^{p-1}\Gamma_{i,m}^{(m)}\Delta m_{t-i} + \alpha_m ECT_{t-1} + \phi_y^{(m)} h_{y,t} + \phi_x^{(m)} h_{x,t} + \phi_m^{(m)} h_{m,t} + \varepsilon_{m,t} \quad (3)$$

All the above variables are defined in the same way as in the VEC model while the coefficient $\phi_i^{(j)}$ measures the impact of uncertainty arising from variable i on the variable j. Equations (2) and (3) are jointly estimated using the quasi-maximum likelihood method with two lags as optimally chosen by the Akaike and Schwarz information criteria. The tests for Granger causality between the variables proceed in the same way as in the VEC model. These numerical results are reported in table 4 under the heading VECM-GARCH-M. A summary of the results are reported in table 5.

[8] The conditional variance-covariance specification follows the model developed by Engle and Kroner (1995) that ensures a positive definite H_t.

[9] Models that quantify the impact of conditional volatility on the dependent variable in the mean specification originate from the work of Engle et al. (1987).

Interpretation of Empirical Results

This section provides the discussion for each of the economies.

Japan

With reference to tables 4 and 5, under the heading of strong exogeneity test, it can be seen that imports and exports are mutually causative (possibly via their effect on GDP growth) but only in the long run regardless of uncertainty in the economic environment. This result is supported by Lawrence and Weinstein's (1999) findings of a strong positive impact of imports on productivity growth, and the latter is a source of output growth. This was explained to have stemmed more from the contribution of imports to competition than to intermediate inputs. The competitive pressure and potentially learning from foreign rivals allowed Japan to compete in world markets to enjoy export growth (ibid). But evidence also suggests that imports have led to export growth through intermediate and semi-finished products being sent back to Japan from its foreign direct investment (FDI) activities around Asia (Bayoumi and Lipworth 1998; Morikawa 1998; and Morikawa and Shone 2000).

When uncertainty is not considered (as in most studies), GDP growth is export and import growth-led. However, when uncertainty is factored into the model, there is no relationship between GDP and exports in the long run, although a bicausal relationship holds in the short run. This could partly explain why Japanese growth has been slow since 1990 despite the general economic progress in the world economy. In the short run, an increase in GDP growth leads to an increase in imports as indicated by the positive marginal propensity to import although the causality is marginally significant at the 10% level. This could reflect Japanese preference for Japanese products. The causation from output growth to import growth is reversed in the long run, possibly due to the impact of intermediate inputs in the form of imports[10] on production and hence GDP growth.

[10] Table 6 shows that there has been a rapid rise in imported machinery since the early 1990s.

Taiwan and Korea

If uncertainty is not factored in, there is bidirectional causality between exports and GDP growth in the long run for both Taiwan and Korea. The results are consistent with the ways in which market practices promote growth. For instance, Fields (1995) explains how networks and institutional environment among enterprises in Korea's *chaebol* and Taiwan's *guanxi qiye* (related enterprises) have softened the possibly destructive competition among associated partners and instead fostered a giant association of production, market and financial partners to provide a competitive edge in the international field. Thus the internally generated hypothesis put forth by Jung and Marshall (1985) is supported by the evidence of GDP growth led exports due to domestic efforts, R&D, and the accumulation of human capital, positively impacting on productivity growth.

For example, unlike most developing economies which depend on FDI for technology, Korea's restrictions on inward FDI made her rely on foreign licensing and patents to gain access to foreign technology. Consequently, much of the technological upgrading in Korea was undertaken by domestic firms (Kim 2003). By 2002, Korea's R&D expenditure as a proportion of GDP had reached about 2.6%, surpassing many Western European countries. In the case of Taiwan, Aw (2003), and Gee and Kuo (1998) provide evidence of how FDI and a high level of technology acquisition and development have taken place in the small and medium enterprises in the domestic economy which have helped improve productivity growth significantly and spurred GDP growth. Also, Taiwan's R&D expenditure is not particularly low as it was 2.3% of its GDP in 2002.

In addition, since the early 1960s, Korea and Taiwan's export-oriented industrial policies have been instrumental in making these economies competitive, thus advancing up the technology ladder in their involvement in high value added manufacturing activities.[11] The move from traditional exports such as exports of primary commodities to manufactured

[11] It must be noted that the opinion on how successful industrial policies and state intervention have been in the East Asian economies remains divided among researchers.

exports constitutes a change in the structural transformation in export composition which is a vital determinant of the export-led GDP growth hypothesis. Several studies have highlighted the importance of export composition (Balaguer and Cantavella-Jorda 2004, Lall 2000). The effect on the domestic economy via specialization and utilization of economies of scale, productivity, reallocation of resources, easing foreign exchange constraints, and spillovers are expected to be significantly greater for manufacturing exports than for traditional sectors. The intensity of high technology exports is also a conduit for GDP growth as they are more productive and more intensive in their use of modern technological inputs and therefore have a strong positive influence on the rest of the economy (Sengupta 1993). While Korea's share of high-tech manufacturing exports has almost doubled in the last 15 years to 32% of total manufactured imports in 2003, Taiwan's high technology intensity of input factor has increased from 26.6% to 46% in the same period.[12] Interestingly, in the short run the causality from GDP growth to exports is reversed when uncertainty is incorporated for Taiwan.

When uncertainty is incorporated in the model for Korea, the short- and long-run bidirectional relationship between export and import growth no longer holds. In the same way, when uncertainty is incorporated in the model for Taiwan, there exists no common pattern between export and import growth in both the short and long run. As far as the relationship between import and GDP growth is concerned, the short-run relationship is mixed for both Korea and Taiwan as seen in the second and fourth columns of tables 5 and 6. However, in the long run, GDP growth in Taiwan is import-led while Korea's GDP growth is not affected by exports or imports in a volatile environment. This result is supported by Frankel et al. (1996) who show that the contribution of openness measured by the total of export and import on GDP was small for Korea but large for Taiwan.

[12] See *Human Development Report 2005 and Taiwan Statistical Data Book 2004.*

Foreign trade has been an important source of foreign technology via the importation of intermediate and investment goods that embody new technology. Reverse engineering is one way of assimilating technology from such imports for countries that have the capability to carry out this complex task. Mody and Yilmaz (2002) show that imported machinery is crucial for export competitiveness as it reduces the cost of production for export-oriented economies such as the Asian Tigers. Table 6 shows that Korea's import share of machinery has not changed much over time while that of Taiwan shows a consistent upward trend.

[Table 6]

Hong Kong

Without taking account of uncertainty, export growth is led by GDP growth in the long run and this could be driven by the impact of imports on exports via Hong Kong's strong entrepôt trade role. Such a role started with China as the hinterland and progressed to FDI in China when the latter started opening up in 1979. This resulted in increasing imports from China with most of the imports being processed and re-exported. Since the 1990s, this entrepot role has taken the form of outward trading and shipping industries to South China, which has led to a rise in transshipment activities and other indirect trade between China and Taiwan via Hong Kong (Tuan and Ng 1998).

With uncertainty factored in, the relationships between exports and imports, and between export and GDP are reversed and stable in the short- and long run.[13] A small open city-state such as Hong Kong would to a large extent rely on external demand and thus exports can be expected to affect imports which essentially consist of imported machinery, or unfinished products pertaining to its entrepot role. The slow but steady rise in the latter as seen in table 7 could partly explain why imports lead to GDP growth in a volatile or non-volatile environment.

[13] Tuan and Ng (1998) show that exports lead GDP growth even when exports are decomposed into domestic exports and re-exports.

Although Hong Kong's share of high technology exports in manufactured exports in 2003 is 13% and is much lower than Korea and Taiwan (*Human Development Report 2005*), its export composition is sufficiently diversified as its service exports are a lot higher than the other two economies. Also, given the strong linkages that exist between manufacturing and services in Hong Kong (Berger and Lester 1997), the causality between export and GDP growth is stable.

Overall Summary

In general, differences in the results on the causative relationships between export, import and output growth illustrate the importance of modelling uncertainty and exercising caution against drawing inference from models that fail to take into account uncertainty. This may potentially lead to a less informed understanding of the dynamics underlying the relationships and consequently, a false prescription of certain trade policies.

For the sake of brevity, the detailed results for the bivariate model are not provided but are available upon request from the authors. The reported results for the bivariate model have also been confined to the relationship between exports and GDP growth only. Interestingly, there is no cointegration for some of the economies although when imports are considered in the trivariate model, all economies exhibit a long run relationship between the variables. The results are however similar for Taiwan and Hong Kong while those for Korea and Japan are reversed, showing that exports and GDP growth are mutually causative under uncertainty.

Impact of Uncertainty on Output and Trade Growth

The estimates of the VECM-GARCH-M model for output and the trade variables are presented in table 7.

[Table 7]

With reference to the mean specification and judging by the significance of the coefficients in the parameter matrix Γ, it can be seen that the past period's impact of the variables themselves has a negative impact on current period's growth for exports, imports and output for all the economies. The sign and the relative size of the coefficient $\phi_i^{(j)}$ for *i,j = x, y,* and *m* on the other hand measure the direction and magnitude of impact on the growth of the variable *j* due to an increase in one standard deviation of the variable *i*'s growth volatility. The empirical evidence generally supports the notion that volatility in output impedes output growth. The greatest impact of output growth volatility on output growth is documented for Korea, where a one standard deviation increase in the volatility of output growth causes a fall in output growth by approximately 0.48%. In contrast, the volatility reduces Japan's output growth by only 0.15%.

In the relatively smaller economies of Hong Kong and Taiwan, the impact of trade volatility significantly impedes GDP growth, but there was no impact on output growth in the larger economies of Korea and Japan. In terms of magnitude, export growth volatility affects GDP growth more than import growth volatility for Hong Kong while the reverse is true for Taiwan. In particular, for Hong Kong, a one standard deviation rise in export growth volatility decreases output growth by about -0.51%. Also, between Taiwan and Hong Kong, the latter's GDP growth is more adversely affected than the former due to export growth volatility. This could partly be attributed to a higher measure of export product variety in Taiwan than in Hong Kong. This is drawn from Funke and Ruhwedel's (2001) computed measures using data from 1989 to 1996. They stress the importance of improvements in horizontal and vertical variety of exports as an explanation of trade flows.

Among the four countries, only Hong Kong's imports growth is affected by volatility in its export, import and output growth. We perform a joint test to determine the joint significance in the growth volatility for export, import and income in impacting the growth of export, import and output. The results unanimously report the significance of export, import and output volatility in explaining growth. An exception is the case of Taiwan where import growth appears to be independent of export, import and output volatility.

Referring to the estimates of the variance specification in table 7, the coefficient estimates of the conditional variances given by a_{ij} and b_{ij} for $i,j=1,2$ and 3 in equation (2) are by and large significant, implying that there is dependence with the conditional variance and covariance of output and trade variables. Two tests are employed to further confirm the nature of dependence in the volatility structure. First, we test for the presence of GARCH effect which amounts to testing if all the elements of the *A* and *B* matrices are zero under the null hypothesis of no GARCH effects. This hypothesis is easily rejected at all levels of significance suggesting that it is necessary to model volatility with a GARCH process. Second, we determine whether the conditional variance of output and trade is only dependent on their own one-period lagged conditional variances but not on their conditional covariance. Such a hypothesis can be tested under the null that the *A* and *B* matrices are diagonal, that is, $a_{ij}= b_{ij} =0$ for $i \neq j$, and that there is no interaction between output and trade volatility. This hypothesis too is rejected in all cases. Finally, we test if the VECM-GARCH-M is an adequate model for capturing the dynamic relationships between output and all the trade variables. This is determined conventionally by testing for serial correlation in the standardised residuals and squared standardised residuals. The diagnostic results report no such evidence, suggesting that our models adequately characterise the relationships of interest.

5. Conclusion

In the wake of globalization, economies have become increasingly integrated with the world economy. While this has enabled more trade in general, it has also increased uncertainty and volatility in the trading environment. This paper tests for these effects for

Japan and the Asian Tigers in a dynamic setting to determine if GDP growth is export or import growth-led or vice versa. The empirical results show that uncertainty matters for drawing accurate inference about the causal relationships between growth of GDP, exports and imports. The short- and long-run results also differ depending on whether a bivariate or trivariate model incorporating imports is used.

In particular, when uncertainty is incorporated in the trivariate model, Korea's GDP growth is not significantly affected by imports or exports (and vice versa) while Japan's GDP growth is import but not export growth-led. This is not to say that export promotion policies were not instrumental in the stimulation of GDP growth, but in a volatile environment, they may not have been effective. For the most and least open economies of the sample (i.e. Hong Kong and Japan respectively), uncertainty in GDP growth adversely affects export and import growth. This indicates the importance of domestic policies in fostering stable GDP growth for positive import and export growth.

In light of the results obtained, the issue of testing and incorporating uncertainty in the study of trade-output growth relationship merits further investigation as there are ramifications for both developed and developing economies. This calls for a reassessment of the effectiveness of trade policy as a strategy for economic development. Possible extensions are to consider the effects of uncertainty on another important relationship of trade with productivity growth, namely labour productivity and total factor productivity growth. A similar exercise may be undertaken on the manufacturing sector (which is an engine of growth in most rapidly developing economies) to unmask economy-wide relationships between GDP growth and trade. Lastly, as discussed earlier, various sources of volatility can be factored into the model and empirically tested to see if the export and/or import led growth hypothesis is supported.

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Table 1 Trends in GDP, Exports and Imports

	GDP Growth Rate			Export share of GDP			Import share of GDP		
	1973-85	1986-99	2000-04	1973-85	1986-99	2000-04	1973-85	1986-99	2000-04
Japan	3.74	2.60	1.59	58.51	69.43	75.94	64.66	68.86	73.21
Korea	16.03	5.53	1.42	66.68	75.86	92.36	77.56	79.90	88.80
Taiwan	7.54	7.12	3.27	89.99	93.74	96.88	89.85	93.36	95.76
Hong Kong	15.72	10.36	1.88	103.35	105.26	111.03	90.91	103.91	110.22

Note: Above figures are in percentages and have been averaged over the specified period.

Table 2 Unit Root Tests Results

	ADF(τ)	KPSS(τ)		ADF(τ)	KPSS(τ)
Japan					
y	-1.9923	0.3995	Δy	-5.2123	0.0721
x	-1.1443	0.4216	Δx	-7.8775	0.0816
m	-1.4098	0.3011	Δm	-10.4021	0.0583
Korea					
y	-0.2452	0.2363	Δy	-4.4956	0.1032
x	-2.8795	0.2193	Δx	-5.5165	0.0500
m	-3.1015	0.2232	Δm	-14.8424	0.0514
Taiwan					
y	0.7152	0.3781	Δy	-4.7667	0.0667
x	-2.1550	0.3945	Δx	-5.4968	0.0492
m	-0.2013	0.4262	Δm	-4.0427	0.0511
Hong Kong					
y	0.7568	0.3193	Δy	-5.7912	0.0566
x	-0.3843	0.3084	Δx	-4.1366	0.0929
m	0.2088	0.3144	Δm	-4.1231	0.0689

Note: y, x, m, denote logarithm of income, exports, and imports. The critical values for the KPSS(τ) unit root tests at 5% level of significance is 0.146 where τ denotes the regression includes an intercept and time trend. The critical values for the ADF tests are based on McKinnon (1996) and are generated by the EVIEWS package used for these tests.

Table 3 Johansen Test for Cointegration and the Cointegrating Relations

Country	Trace Test Statistics / Hypotheses			Maximal Eigenvalue Test Statistic / Hypotheses			Lags
	$r = 0$	$r \leq 1$	$r \leq 2$	$r = 0$	$r = 1$	$r = 2$	
Japan	50.2552*	15.4596	2.3148	34.7955*	13.1448	2.3148	4
Korea	41.9473*	16.1940	8.4400	20.7533***	12.7539	8.4400	5
Taiwan	50.3799*	14.5813	6.1070	35.7985*	8.4743	6.1070	4
Hong Kong	37.3570**	19.9364	6.1841	37.4206*	13.7522	6.1841	4

Cointegrating Relations

Japan
$$y_t = \underset{(0.7271)}{2.3592} + \underset{(0.0851)}{0.1695} m_t + \underset{(0.3415)}{1.0976} x_t$$

Korea
$$y_t = \underset{(1.3098)}{8.4219} - \underset{(0.1606)}{0.2329} m_t + \underset{(0.5659)}{3.0975} x_t$$

Taiwan
$$y_t = \underset{(0.7170)}{7.2622} - \underset{(0.3653)}{0.0325} m_t + \underset{(0.3231)}{0.5307} x_t$$

Hong Kong
$$y_t = \underset{(0.2397)}{1.0756} + \underset{(0.2845)}{1.9073} m_t + \underset{(0.3039)}{1.1392} x_t$$

Note: *, ** and *** denote 1%, 5% and 10% levels of significance respectively. The critical values for the Johansen tests are based on MacKinnon et al. (1999) and are generated by the EVIEWS package used for these tests. Standard errors are in brackets.

Table 4 Granger Causality Test Results

Null hypothesis	VECM		VECM-GARCH-M	
	Short-run causality test	Strong exogeneity test	Short-run causality test	Strong exogeneity test
Japan				
$y_t \rightarrow x_t$	2.8484 [0.1203]	2.4563 [0.1831]	5.1129 [0.0387]**	1.1766 [0.2402]
$x_t \rightarrow y_t$	13.3932 [0.0010]*	14.9943 [0.0008]*	4.9590 [0.0528]***	2.1675 [0.1987]
$y_t \rightarrow m_t$	4.1030 [0.0642]***	3.9620 [0.1095]	4.3374 [0.0571]***	2.5481 [0.1781]
$m_t \rightarrow y_t$	1.1132 [0.2865]	4.9727 [0.0740]***	2.9783 [0.1128]	5.0513 [0.0717]***
$x_t \rightarrow m_t$	7.9321 [0.0094]*	10.2111 [0.0077]*	2.2646 [0.1611]	5.3722 [0.0630]***
$m_t \rightarrow x_t$	2.4952 [0.1435]	10.3635 [0.0072]*	7.1702 [0.0138]**	9.3491 [0.0114]**
Korea				
$y_t \rightarrow x_t$	5.6926 [0.0290]**	5.6538 [0.0561]***	2.9021 [0.1172]	3.8700 [0.1133]
$x_t \rightarrow y_t$	7.7687 [0.0103]**	4.9754 [0.0739]***	2.1999 [0.1664]	3.7059 [0.1204]
$y_t \rightarrow m_t$	5.8692 [0.0265]**	3.3304 [0.1377]	7.5658 [0.0113]**	1.2989 [0.2375]
$m_t \rightarrow y_t$	5.1804 [0.0375]**	3.7966 [0.1165]	6.6991 [0.0176]**	3.6181 [0.1243]
$x_t \rightarrow m_t$	17.5717 [0.0000]*	17.2225 [0.0000]*	2.4588 [0.1462]	2.8278 [0.1631]
$m_t \rightarrow x_t$	13.4350 [0.0006]*	10.0061 [0.0034]*	3.1022 [0.1061]	5.0577 [0.0715]**
Taiwan				
$y_t \rightarrow x_t$	8.3238 [0.0078]*	16.6510 [0.0000]*	0.0326 [0.4919]	56.7556 [0.0000]*
$x_t \rightarrow y_t$	3.1759 [0.1051]	15.5094 [0.0007]*	19.9496 [0.0000]*	23.0032 [0.0000]*
$y_t \rightarrow m_t$	22.8885 [0.0000]*	26.6522 [0.0000]*	0.1553 [0.4626]	22.4859 [0.0000]*
$m_t \rightarrow y_t$	18.0230 [0.0000]*	22.8735 [0.0000]*	31.4657 [0.0000]*	34.8224 [0.0000]*
$x_t \rightarrow m_t$	12.6080 [0.0009]*	13.3557 [0.0018]*	0.6685 [0.3579]	16.2837 [0.0000]**
$m_t \rightarrow x_t$	3.1383 [0.1041]	2.0109 [0.2069]	7.0339 [0.0148]**	9.0464 [0.0130]**
Hong Kong				
$y_t \rightarrow x_t$	2.0186 [0.1822]	8.2864 [0.0182]**	2.6189 [0.1349]	3.0454 [0.1519]
$x_t \rightarrow y_t$	2.4748 [0.1451]	3.0739 [0.1504]	13.3048 [0.0006]*	14.7558 [0.0009]*
$y_t \rightarrow m_t$	15.0212 [0.0002]*	25.1112 [0.0000]*	8.9670 [0.0056]*	9.0395 [0.0131]**
$m_t \rightarrow y_t$	14.8006 [0.0003]*	20.7256 [0.0000]*	36.0884 [0.0000]*	36.1480 [0.0000]*
$x_t \rightarrow m_t$	2.3973 [0.1508]	1.2590 [0.2818]	10.0985 [0.0032]*	26.4420 [0.0000]*
$m_t \rightarrow x_t$	11.9513 [0.0013]*	21.9338 [0.0000]*	3.1929 [0.1013]	2.8787 [0.1605]

Note: → represents "does not Granger cause".
*, ** and *** denote 1%, 5% and 10% levels of significance respectively.
Figures in brackets are p-values.

Table 5 Summary of Causality Results

Country	VECM (Without Uncertainty) Short-run causality	VECM (Without Uncertainty) Strong exogeneity	VECM-GARCH-M (With Uncertainty) Short-run causality	VECM-GARCH-M (With Uncertainty) Strong exogeneity
	Bivariate Model			
Japan	$y \leftrightarrow x$	n.a.	$y \leftrightarrow x$	n.a.
Korea	$y \leftarrow x$	n.a.	$y \leftrightarrow x$	n.a.
Taiwan	$y \leftarrow x$	$y \leftrightarrow x$	$y \leftrightarrow x$	$y \leftrightarrow x$
Hong Kong	$y \sim x$	n.a.	$y \leftarrow x$	n.a.
	Trivariate Model			
Japan	$y \leftarrow x$ $y \rightarrow m$ $x \rightarrow m$	$y \leftarrow x$ $y \leftarrow m$ $x \leftrightarrow m$	$y \leftrightarrow x$ $y \rightarrow m$ $x \leftarrow m$	$y \sim x$ $y \leftarrow m$ $x \leftrightarrow m$
Korea	$y \leftrightarrow x$ $y \leftrightarrow m$ $x \leftrightarrow m$	$y \leftrightarrow x$ $y \sim m$ $x \leftrightarrow m$	$y \sim x$ $y \leftrightarrow m$ $x \sim m$	$y \sim x$ $y \sim m$ $x \leftarrow m$
Taiwan	$y \rightarrow x$ $y \leftrightarrow m$ $x \rightarrow m$	$y \leftrightarrow x$ $y \leftrightarrow m$ $x \rightarrow m$	$y \leftarrow x$ $y \leftarrow m$ $x \leftarrow m$	$y \leftrightarrow x$ $y \leftrightarrow m$ $x \leftrightarrow m$
Hong Kong	$y \sim x$ $y \leftrightarrow m$ $x \leftarrow m$	$y \rightarrow x$ $y \leftrightarrow m$ $x \leftarrow m$	$y \leftarrow x$ $y \leftrightarrow m$ $x \rightarrow m$	$y \leftarrow x$ $y \leftrightarrow m$ $x \rightarrow m$

Note: The signs '$\sim$', '$\leftrightarrow$' and '$\rightarrow$' denote no relationship, mutually causative and causative in the direction of the arrow respectively. The "n.a." appears when there is no cointegration and hence only short-run results are available from the VAR estimation.

Table 6 Imports of machinery as a share of total imports

	1980	1990	1997	2003
Japan	0.089	0.174	0.305	0.318
Hong Kong	0.237	0.308	0.371	0.392
Korea	0.227	0.351	0.355	0.373
Taiwan	0.273	0.434	0.474	0.521

Source: World Development Indicators and Taiwan Statistical Data Book.

Table 7 Parameter Estimates of the VECM-GARCH-M Model

Mean Specification

Japan						Korea					
(3a)		(3b)		(3c)		(3a)		(3b)		(3c)	
μ_y	0.0099 (0.0062)	μ_x	0.0405* (0.0128)	μ_m	0.0180** (0.0085)	μ_y	0.0143 (0.0097)	μ_x	-0.0039 (0.0753)	μ_m	0.0190 (0.0301)
$\Gamma_{1,y}^{(y)}$	-0.0948** (0.0522)	$\Gamma_{1,y}^{(x)}$	0.0225** (0.0109)	$\Gamma_{1,y}^{(m)}$	-0.0606 (0.0467)	$\Gamma_{1,y}^{(y)}$	-0.3871* (0.1095)	$\Gamma_{1,y}^{(x)}$	-0.3495 (0.9928)	$\Gamma_{1,y}^{(m)}$	0.0807 (0.0567)
$\Gamma_{2,y}^{(y)}$	-0.0237 (0.0562)	$\Gamma_{2,y}^{(x)}$	-0.0002 (0.0243)	$\Gamma_{2,y}^{(m)}$	-0.0819** (0.0414)	$\Gamma_{2,y}^{(y)}$	-0.0091 (0.2835)	$\Gamma_{2,y}^{(x)}$	0.3402 (0.5268)	$\Gamma_{2,y}^{(m)}$	0.2617* (0.1088)
$\Gamma_{1,x}^{(y)}$	0.0225** (0.0118)	$\Gamma_{1,x}^{(x)}$	0.1721* (0.0499)	$\Gamma_{1,x}^{(m)}$	-0.0737 (0.0425)	$\Gamma_{1,x}^{(y)}$	0.0117 (0.1227)	$\Gamma_{1,x}^{(x)}$	-0.4390* (0.1353)	$\Gamma_{1,x}^{(m)}$	0.1465 (0.1517)
$\Gamma_{2,x}^{(y)}$	0.0243 (0.0265)	$\Gamma_{2,x}^{(x)}$	0.1313* (0.0551)	$\Gamma_{2,x}^{(m)}$	-0.0601** (0.0314)	$\Gamma_{2,x}^{(y)}$	0.0339 (0.1335)	$\Gamma_{2,x}^{(x)}$	-0.0104 (0.5073)	$\Gamma_{2,x}^{(m)}$	0.0478 (0.0331)
$\Gamma_{1,m}^{(y)}$	-0.0763* (0.0198)	$\Gamma_{1,m}^{(x)}$	0.1313* (0.0504)	$\Gamma_{1,m}^{(m)}$	0.1541** (0.0686)	$\Gamma_{1,m}^{(y)}$	-0.0078 (0.0548)	$\Gamma_{1,m}^{(x)}$	0.1078** (0.0623)	$\Gamma_{1,m}^{(m)}$	-0.1271 (0.3169)
$\Gamma_{2,m}^{(y)}$	-0.0117* (0.0038)	$\Gamma_{2,m}^{(x)}$	-0.0823* (0.0399)	$\Gamma_{2,m}^{(m)}$	0.1517* (0.0474)	$\Gamma_{2,m}^{(y)}$	-0.0354* (0.0112)	$\Gamma_{2,m}^{(x)}$	0.2352 (0.2468)	$\Gamma_{2,m}^{(m)}$	0.2017* (0.1030)
α_y	-0.0070 (0.0144)	α_x	0.0302 (0.0529)	α_m	0.0830* (0.0391)	α_y	-0.0024 (0.0020)	α_x	0.0482* (0.0218)	α_m	-0.0041 (0.0243)
$\phi_y^{(y)}$	-0.1553** (0.07312)	$\phi_y^{(x)}$	-0.1468** (0.0752)	$\phi_y^{(m)}$	-0.1068* (0.0191)	$\phi_y^{(y)}$	-0.4793** (0.2546)	$\phi_y^{(x)}$	-0.6113 (0.4731)	$\phi_y^{(m)}$	-0.1780 (0.2962)
$\phi_x^{(y)}$	-0.2676 (0.3009)	$\phi_x^{(x)}$	-0.2902** (0.1049)	$\phi_x^{(m)}$	-0.6592 (0.4553)	$\phi_x^{(y)}$	-0.2301 (0.1964)	$\phi_x^{(x)}$	-0.5180* (0.2244)	$\phi_x^{(m)}$	-0.1085 (0.1284)
$\phi_m^{(y)}$	-0.4325 (0.4989)	$\phi_m^{(x)}$	-0.1799* (0.1019)	$\phi_m^{(m)}$	-0.4174 (0.5102)	$\phi_m^{(y)}$	-0.1259 (0.1431)	$\phi_m^{(x)}$	-0.1893 (0.2795)	$\phi_m^{(m)}$	-0.0930** (0.0414)

Diagnostic Tests

Japan			Korea		
Joint test for GARCH-in-mean H$_0$: $\phi_y = \phi_x = \phi_m = 0$			Joint test for GARCH-in-mean H$_0$: $\phi_y = \phi_x = \phi_m = 0$		
Output	Export	Import	Output	Export	Import
$\chi^2(3)$= 6.0985 [0.0466]	$\chi^2(3)$= 7.2683 [0.0284]	$\chi^2(3)$= 9.8567 [0.0091]	$\chi^2(3)$= 11.1573 [0.0050]	$\chi^2(3)$= 6.8424 [0.0341]	$\chi^2(3)$= 10.3413 [0.0072]

Table 7 (Continued)

Variance Specification											
Japan						Korea					
c_{11}	0.0025* (0.0009)	a_{11}	-0.7350* (0.0593)	b_{11}	0.7460* (0.1118)	c_{11}	-0.0041* (0.0020)	a_{11}	0.7322* (0.1100)	b_{11}	0.0119* (0.1221)
c_{12}	0.0090 (0.0094)	a_{12}	-0.0374 (0.0317)	b_{12}	-0.1575* (0.0475)	c_{12}	0.0206* (0.0015)	a_{12}	0.5411* (0.3049)	b_{12}	0.3337 (0.4606)
c_{13}	0.0189* (0.0013)	a_{13}	-0.0055* (0.0010)	b_{13}	0.1722* (0.0531)	c_{13}	0.0014 (0.0465)	a_{13}	0.1522 (0.2797)	b_{13}	0.0843** (0.0437)
c_{22}	-0.0032* (0.0012)	a_{21}	-0.0232 (0.0463)	b_{21}	-0.0459 (0.0385)	c_{22}	0.0106* (0.0050)	a_{21}	0.2593* (0.0736)	b_{21}	-0.0880* (0.0360)
c_{23}	-0.0181 (0.0144)	a_{22}	-0.5037* (0.1572)	b_{22}	0.2409* (0.0935)	c_{23}	0.0009 (0.0423)	a_{22}	-0.7146* (0.2292)	b_{22}	0.2035 (0.2301)
c_{33}	0.0021** (0.0010)	a_{23}	0.2927* (0.1100)	b_{23}	0.4715* (0.1201)	c_{33}	0.0023* (0.0005)	a_{23}	-0.0341 (0.2429)	b_{23}	0.3663** (0.1486)
		a_{31}	0.0674 (0.0548)	b_{31}	0.0115 (0.0232)			a_{31}	-0.0555* (0.0321)	b_{31}	0.0184 (0.0467)
		a_{32}	-0.5326* (0.1091)	b_{32}	0.1632** (0.0771)			a_{32}	0.3193 (0.6121)	b_{32}	0.5796*** (0.3258)
		a_{33}	0.0380* (0.0161)	b_{33}	-0.1899* (0.0484)			a_{33}	0.0200* (0.0101)	b_{33}	0.0902* (0.0103)

Diagnostic Tests

Japan						Korea					
Diagonal conditional variance model						Diagonal conditional variance model					
H_0: $a_{ij}=b_{ij}=0$ for $i \neq j$, and i,j=1,2 and 3				$\chi^2(12)$=307.12 [0.0000]		H_0: $a_{ij}=b_{ij}=0$ for $i \neq j$, and i,j=1,2 and 3				$\chi^2(12)$=286.3544 [0.0000]	
No GARCH effects						No GARCH effects					
H_0: $a_{ij}=b_{ij}=0$ for i and j =1,2 and 3				$\chi^2(18)$=4692.74 [0.0000]		H_0: $a_{ij}=b_{ij}=0$ for i and j =1,2 and 3				$\chi^2(18)$=4807.8058 [0.0000]	
Serial Correlation						Serial Correlation					
$\varepsilon_{y,t}/\sqrt{h_{y,t}}$	Q(4)=2.0131	$\varepsilon_{x,t}/\sqrt{h_{x,t}}$	Q(4)=2.4396	$\varepsilon_{m,t}/\sqrt{h_{m,t}}$	Q(4)=0.5148	$\varepsilon_{y,t}/\sqrt{h_{y,t}}$	Q(4)=2.1328	$\varepsilon_{x,t}/\sqrt{h_{x,t}}$	Q(4)=4.5103	$\varepsilon_{m,t}/\sqrt{h_{m,t}}$	Q(4)=3.8693
$\varepsilon^2_{y,t}/h_{y,t}$	Q(4)=1.9832	$\varepsilon^2_{x,t}/h_{x,t}$	Q(4)=1.0472	$\varepsilon^2_{m,t}/h_{m,t}$	Q(4)=2.4974	$\varepsilon^2_{y,t}/h_{y,t}$	Q(4)=3.4145	$\varepsilon^2_{x,t}/h_{x,t}$	Q(4)=2.7608	$\varepsilon^2_{m,t}/h_{m,t}$	Q(4)=5.5572

Note: Standard errors and p-values are reported in (.) and [.] brackets respectively. (3a), (3b) and (3c) correspond to the three mean regressions of the VECM-GARCH-M model (3) with real income, export and import growth being the dependent variable respectively.

Table 7 Parameter Estimates of the VECM-GARCH-M Model (Continued)

Mean Specification

Taiwan						Hong Kong					
(3a)		(3b)		(3c)		(3a)		(3b)		(3c)	
μ_y	0.0328* (0.0034)	μ_x	0.0193 (0.0133)	μ_m	0.0102 (0.0133)	μ_y	0.0182* (0.0054)	μ_x	0.0345* (0.0072)	μ_m	0.0509* (0.0075)
$\Gamma_{1,y}^{(y)}$	-0.3712* (0.0451)	$\Gamma_{1,y}^{(x)}$	0.0731 (0.4049)	$\Gamma_{1,y}^{(m)}$	0.0097 (0.2179)	$\Gamma_{1,y}^{(y)}$	-0.4255* (0.1578)	$\Gamma_{1,y}^{(x)}$	-0.6951* (0.1521)	$\Gamma_{1,y}^{(m)}$	-0.4694* (0.1956)
$\Gamma_{2,y}^{(y)}$	-0.4698* (0.0656)	$\Gamma_{2,y}^{(x)}$	-0.0035 (0.1908)	$\Gamma_{2,y}^{(m)}$	0.0994 (0.3090)	$\Gamma_{2,y}^{(y)}$	-0.1357 (0.2129)	$\Gamma_{2,y}^{(x)}$	-0.5704* (0.1031)	$\Gamma_{2,y}^{(m)}$	-0.6853* (0.0322)
$\Gamma_{1,x}^{(y)}$	0.0548* (0.0167)	$\Gamma_{1,x}^{(x)}$	-0.5578* (0.0582)	$\Gamma_{1,x}^{(m)}$	0.0380 (0.0645)	$\Gamma_{1,x}^{(y)}$	0.2653* (0.1038)	$\Gamma_{1,x}^{(x)}$	-0.0169* (0.0031)	$\Gamma_{1,x}^{(m)}$	-0.2041* (0.0442)
$\Gamma_{2,x}^{(y)}$	0.0585* (0.0167)	$\Gamma_{2,x}^{(x)}$	-0.1843** (0.0926)	$\Gamma_{2,x}^{(m)}$	0.0312 (0.1176)	$\Gamma_{2,x}^{(y)}$	-0.6000* (0.1781)	$\Gamma_{2,x}^{(x)}$	-0.9475* (0.0812)	$\Gamma_{2,x}^{(m)}$	-0.5190* (0.0536)
$\Gamma_{1,m}^{(y)}$	0.0862* (0.0174)	$\Gamma_{1,m}^{(x)}$	0.3406* (0.0834)	$\Gamma_{1,m}^{(m)}$	-0.2799* (0.0692)	$\Gamma_{1,m}^{(y)}$	0.1193 (0.1362)	$\Gamma_{1,m}^{(x)}$	0.2829* (0.0292)	$\Gamma_{1,m}^{(m)}$	0.2255 (0.0169)
$\Gamma_{2,m}^{(y)}$	0.0859* (0.0217)	$\Gamma_{2,m}^{(x)}$	0.3795* (0.0663)	$\Gamma_{2,m}^{(m)}$	0.1319 (0.0993)	$\Gamma_{2,m}^{(y)}$	0.5418* (0.1403)	$\Gamma_{2,m}^{(x)}$	0.1147 (0.3586)	$\Gamma_{2,m}^{(m)}$	0.9151* (0.0671)
α_y	-0.0173* (0.0018)	α_x	0.3115* (0.0441)	α_m	0.2339* (0.0618)	α_y	-0.0075* (0.0031)	α_x	0.1232* (0.0397)	α_m	0.1626* (0.0246)
$\phi_y^{(y)}$	-0.2648* (0.1140)	$\phi_y^{(x)}$	0.1651 (0.2720)	$\phi_y^{(m)}$	-0.1866 (0.1604)	$\phi_y^{(y)}$	-0.1077* (0.0517)	$\phi_y^{(x)}$	-0.1442** (0.0643)	$\phi_y^{(m)}$	-0.4600** (0.2331)
$\phi_x^{(y)}$	-0.1625*** (0.0914)	$\phi_x^{(x)}$	-0.3069** (0.1117)	$\phi_x^{(m)}$	0.3268 (0.2439)	$\phi_x^{(y)}$	-0.5140* (0.1810)	$\phi_x^{(x)}$	-0.2550* (0.0771)	$\phi_x^{(m)}$	-0.3709** (0.1958)
$\phi_m^{(y)}$	-0.2906* (0.0684)	$\phi_m^{(x)}$	-0.6057 (0.4632)	$\phi_m^{(m)}$	-0.0778 (0.1834)	$\phi_m^{(y)}$	-0.1819* (0.0478)	$\phi_m^{(x)}$	-0.3813* (0.05071)	$\phi_m^{(m)}$	0.3215* (0.04991)

Diagnostic Tests

Taiwan			Hong Kong		
Joint test for GARCH-in-mean H0: $\phi_y = \phi_x = \phi_m = 0$			Joint test for GARCH-in-mean H0: $\phi_y = \phi_x = \phi_m = 0$		
Output	Export	Import	Output	Export	Import
$\chi^2(3)$= 29.7240 [0.0000]	$\chi^2(3)$= 22.4048 [0.0000]	$\chi^2(3)$= 2.5343 [0.1789]	$\chi^2(3)$= 36.2798 [0.0000]	$\chi^2(3)$= 27.4333 [0.0000]	$\chi^2(3)$= 23.7410[0.0000]

Table 7 (Continued)

Variance Specification

Taiwan						Hong Kong					
c_{11}	0.0011 (0.0018)	a_{11}	0.8206* (0.0610)	b_{11}	-0.4460* (0.0764)	c_{11}	0.0381* (0.0060)	a_{11}	-0.5376** (0.2596)	b_{11}	-0.0258 (0.0272)
c_{12}	0.0404* (0.0073)	a_{12}	0.0324* (0.0137)	b_{12}	0.5933* (0.2074)	c_{12}	0.0576* (0.0043)	a_{12}	-0.3632 (0.2861)	b_{12}	-0.3543** (0.2009)
c_{13}	0.0238* (0.0080)	a_{13}	-0.2813 (0.5026)	b_{13}	-0.4328 (0.6153)	c_{13}	0.0475* (0.0074)	a_{13}	-0.1010 (0.4685)	b_{13}	-0.3671 (0.2391)
c_{22}	-0.0023* (0.0011)	a_{21}	0.01968 (0.0366)	b_{21}	0.0482* (0.0107)	c_{22}	0.0108* (0.0018)	a_{21}	0.3611* (0.1090)	b_{21}	-0.3200* (0.0193)
c_{23}	-0.0132 (0.0144)	a_{22}	0.0715* (0.0327)	b_{22}	0.4482* (0.0744)	c_{23}	0.0137* (0.0019)	a_{22}	0.1306** (0.0607)	b_{22}	0.3380* (0.0567)
c_{33}	-0.0012* (0.0005)	a_{23}	-0.0003 (0.2089)	b_{23}	-0.1274 (0.0876)	c_{33}	0.0001 (0.0138)	a_{23}	-0.0758 (0.1251)	b_{23}	-0.7903* (0.0463)
		a_{31}	0.0476* (0.0132)	b_{31}	0.0242 (0.0467)			a_{31}	-0.2416*** (0.1262)	b_{31}	0.3926* (0.0278)
		a_{32}	0.1372 (0.2045)	b_{32}	0.0543* (0.0227)			a_{32}	0.3072* (0.0860)	b_{32}	-0.3400 (0.2075)
		a_{33}	0.9152* (0.0413)	b_{33}	0.4356* (0.0564			a_{33}	0.5514* (0.0495)	b_{33}	0.1012** (0.0599)

Diagnostic Tests

Taiwan						Hong Kong					
Diagonal conditional variance model						Diagonal conditional variance model					
H_0: $a_{ij}=b_{ij}=0$ for $i \neq j$, and i,j=1,2 and 3			$\chi^2(12)$=491.7531 [0.0000]			H_0: $a_{ij}=b_{ij}=0$ for $i \neq j$, and i,j=1,2 and 3			$\chi^2(12)$=220.5807 [0.0000]		
No GARCH effects						No GARCH effects					
H_0: $a_{ij}=b_{ij}$ =0 for i and j =1,2 and 3			$\chi^2(18)$=4384.1131 [0.0000]			H_0: $a_{ij}=b_{ij}$ =0 for i and j =1,2 and 3			$\chi^2(18)$=2892.1796 [0.0000]		
Serial Correlation						Serial Correlation					
$\varepsilon_{y,t}/\sqrt{h_{y,t}}$	Q(4)=1.8971	$\varepsilon_{x,t}/\sqrt{h_{x,t}}$	Q(4)=3.1566	$\varepsilon_{m,t}/\sqrt{h_{m,t}}$	Q(4)=2.1838	$\varepsilon_{y,t}/\sqrt{h_{y,t}}$	Q(4)=4.3676	$\varepsilon_{x,t}/\sqrt{h_{x,t}}$	Q(4)=3.1682	$\varepsilon_{m,t}/\sqrt{h_{m,t}}$	Q(4)=2.9593
$\varepsilon^2_{y,t}/h_{y,t}$	Q(4)=1.3785	$\varepsilon^2_{x,t}/h_{x,t}$	Q(4)=2.9829	$\varepsilon^2_{m,t}/h_{m,t}$	Q(4)=3.0189	$\varepsilon^2_{y,t}/h_{y,t}$	Q(4)=3.6742	$\varepsilon^2_{x,t}/h_{x,t}$	Q(4)=1.6731	$\varepsilon^2_{m,t}/h_{m,t}$	Q(4)=6.0678

Note: Standard errors and p-values are reported in (.) and [.] brackets respectively. (3a), (3b) and (3c) correspond to the three mean regressions of the VECM-GARCH-M model (3) with real income, export and import growth being the dependent variable respectively.

Appendix **Major Events**

Hong Kong

1973/74	: Oil crisis
1978/79	: Oil crisis
Oct 1987	: Stock market crash
June 1989-Dec 1989	: Effects of Tiananmen massacre
Jan 1990	: Exchange rate peg to the US$
1997/98	: Handover to China and the Asian financial crisis
1999	: Property market collapse

Korea

1973/74	: Oil crisis
1978/79	: Oil crisis
1997/98	: Asian financial crisis

Japan

1964	: Trade and capital liberalisation
1973/74	: Oil crisis
1978/79	: Oil crisis
1990/91	: Speculation bubble burst

Taiwan

1973/74	: Oil crisis
1978/79	: Oil crisis