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PACIFIC RIM BUSINESS CYCLE ANALYSIS:

DATING, VOLATILITY and SYNCHRONISATION

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Abstract

We report preliminary results from analytical work on business cycle turning points, volatility, and synchronisation for New Zealand and its major (Pacific Rim) trading partners. Principal conclusions are that: New Zealand's (real GDP) business cycles have been synchronised primarily with those of the "Pacific Rim" countries of Australia and the United States of America, rather than with any "European cycle" associated with (West) Germany or with Japanese cycles. It seems too soon to be able to establish meaningful business cycle synchronisations between New Zealand and any of China, Korea, Taiwan, Hong Kong and Singapore, despite the current importance of the latter countries as trading partners for New Zealand. There was a clear disturbance during the mid- to late-1980s of New Zealand's strong procyclical business cycle synchronisation with both Australia and the US. The fast growing Asian economies of China, Hong Kong, Korea and Singapore have displayed the highest business cycle volatilities; New Zealand and Taiwan have also recorded high volatility on average; while Australia, the US, West Germany and Japan have displayed relatively lower average volatility. With the possible exception of New Zealand (and Japan), this is consistent with the high growth rate countries exhibiting high business cycle volatility and our lower growth rate countries displaying relatively lower volatility. Business cycle volatility has varied over time for all countries, with the possible exception of Japan. The volatilities of China, Korea, Taiwan and Singapore having been moving steadily lower over time.

Key words: Business cycles, New Zealand, Pacific Rim countries, volatility, synchronisation.

Journal of Economic Literature Classification: E32

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Pacific Rim Business Cycle Analysis: Dating, Volatility and Synchronisation

Viv B. Hall, Kunhong Kim and Robert A. Buckle

1. Introduction

In a review of recent research on business cycles and international trade, Baxter (1995, p.1) states that "...there is a definite tendency for the business cycles of developed countries to move together..." She also observes (p. 4) that "A large and growing literature on the statistical properties of international business cycles finds that fluctuations across countries and across time periods display a remarkable consistency in the key stylised facts." One of those stylised facts (p. 4 and Table 1D) is that "Across countries, cyclic movements in output tend to be positively correlated...".

Moreover, recent research centred on countries of the European Community seems to be consistent with these findings. Christodoulakis, Dimelis and Kollintzas (1995) find that real GDP cycles are positively correlated across all European countries except Denmark, and the duration and volatility of their business cycles are similar, while Artis and Zhang (1995) have found a marked shift in business cycle affiliation of these countries from the United States to Germany, implying that the formation of the ERM may have led to a European business cycle centred on Germany.

Turning more specifically to Pacific Rim countries, in APEC (1995, pp 19-21) it was argued that the economies of the APEC region had "...experienced a deepening of economic interdependence as a result of trade and direct investment...[and that] this deepening could act to increase synchronisation in the business cycles of the economies concerned." Their preliminary research findings, based on deviations of annual real GDP data from linear trends for the period 1980-1993, were that synchronisation could be observed "... only in sub-regions, and not in the APEC region as a whole." They termed this phenomenon "semi-synchronization of business cycles".

New Zealand's economic and international trading environment has changed significantly since the advent of the European Community (see Brownie and Dalziel, 1993), and as the result of more than a decade of significant economic reforms (see Bollard and Buckle, 1987, and Silverstone, Bollard and Lattimore, 1996). Almost all of New Zealand's major trading partners are now key Pacific Rim countries rather than European. A key issue, therefore, is the extent to which New Zealand's aggregate business cycle is primarily synchronised with individual Pacific Rim or European countries or with a European cycle centred on Germany, and the extent to which any synchronisations have changed over time.

The Pacific Rim business cycle analysis presented in this paper is therefore essentially from the perspective of New Zealand and its current major trading partners. It also develops further the APEC (1995) analytical work, by utilising quarterly data wherever possible, by employing modern business cycle detrending and dating methods, and by paying particular attention to the extent to which "average" volatility and synchronisation relationships have been changing over time. This "identification of key relationships" stage is seen as logically prior to in depth examination of the roles of specific trade, investment, financial, structural change and economic reform influences on Pacific Rim business cycle relationships over time.

Principal specific aims of the paper are therefore:

- to establish primarily computer-generated "benchmark" **business cycle turning points** for each country, and hence **summary duration and amplitude characteristics**;

- to summarise the **relative positioning** of these countries within "Pacific Rim business cycles";

- to establish the **relative volatility** of each country's cycles, and the extent to which these have varied over time; and

- to establish the **degree of synchronisation** of these cycles, including the changing nature over time of any robust associations.

Section 2 identifies New Zealand's fourteen major trading partners, and from them defines the ten countries chosen for our business cycle analysis. It also sets out some annual average growth rates and volatility measures for the period 1960 to 1994. The latter is essentially so as to provide some perspective on the relative role of China, for which quarterly GDP data are not yet available. Section 3 presents quarterly business cycle turning points, durations and amplitudes, based on three well-established detrending methods and associated transparent rules (see Kim, Buckle and Hall, 1995; and Canova, 1994). In section 4, there is an illustrative summary positioning of "benchmark" cycles for the nine individual countries. In section 5, we present measures of average and relative volatility, and establish the extent to which these have moved over time. Similarly, section 6 focuses first on identifying any robust average synchronisations between countries, before examining how these average relations may have varied over time. Conclusions are presented in section 7.

2. New Zealand's Major Trading Partners, and a Preliminary Growth Rates Perspective

Countries Chosen for Analysis

New Zealand's principal major trading partners for 1994 are summarised in Table 1. With two exceptions, we chose the countries for our analysis on the basis of rankings in that Table. (West) Germany was chosen instead of the United Kingdom as the sole European representative, because of its probably dominant role in driving business cycles in Europe. And Singapore (ranked 13) was included instead of Malaysia (ranked 11 or 10) because of the more ready availability of its quarterly real GDP data.

So, the countries chosen, approximately by region, are:

New Zealand and Australia,
United States of America,
Japan, Korea, China, Taiwan, Hong Kong, and Singapore, and
(West) Germany

Annual Growth Rates

Because comprehensive quarterly real GDP data are not yet available for China, it is useful to start with a preliminary perspective, based on annual data from 1960 to 1994. Annual percentage growth rates for all ten countries are presented in Figure 1. The corresponding mean growth rates for 1960-94 and 1970-94 appear in Table 2. Modern business cycle analysis defines aggregate cycles in terms of deviations from trend real GDP, so the volatility measures presented in Table 2 are percentage deviations from Hodrick-Prescott (1980) (HP) trends, with common λ values of 100.

Figure 1, with countries grouped approximately by range of growth rates, and recent growth rate behaviour, and Table 2 show that:

- New Zealand, Australia and the United States have had relatively low mean growth rates of between 2.7 and 3.8 percent. Individual year rates have varied within the range, -3 to 8 percent. Directions of movement of their growth rates have been broadly similar over the past decade, i.e. growth in these three countries has been broadly synchronised.

- Japan's average growth rate of 5.7 percent has been somewhat higher, although only 3.8 percent for the 1970-1994 period. Over the past decade, movements in direction of Japan's growth rates have been rather different from the US, Australia and New Zealand, but not dissimilar to West Germany.

- The five Northeast and Southeast Asian countries, Taiwan, Singapore, Korea, China, and Hong Kong, dominate the growth rate rankings, averaging 7.5 percent per annum or better over both sample periods. Their growth rate maxima vary from around 14 percent to as much as 23 percent for China for 1970.

Business Cycle Volatility
Three features stand out:

- The fast growing Asian economies have also displayed high volatilty in their GDP fluctuations, with China having by far the highest volatility for the full 1960-1994 period. Its full sample figure of 5.9 percent is still highest at 4.3 percent when its particularly volatile 1960s observations are excluded. The movements over time in its percentage standard deviations are depicted in Figure 2.

- The volatility of New Zealand's real GDP fluctuations, at 2.6 percent on average, is similar to that of Taiwan and Japan over 1960-1994, but substantially above that of the US, Australia and West Germany. This is consistent with New Zealand's volatility being high by OECD country standards (as found using a different quarterly data set in Kim, Buckle and Hall, 1994), but it is lower than at least four of our faster growing Asian economies.

- With the possible exception of New Zealand, which has recorded low growth and relatively high business cycle volatility, the evidence from Table 2 seems consistent with our high growth rate countries exhibiting high volatility and our lower growth rate countries displaying relatively lower volatility.

3. Business Cycle Turning Points, Durations and Amplitudes

Turning Points
Business cycle turning points have been derived for the nine countries for which sufficiently long periods of quarterly data are available, i.e. New Zealand, Australia, the United States, West Germany, Japan, Korea, Taiwan, Hong Kong and Singapore. This involved first computing three sets of "deviations from trend" business cycle series, from procedures in the now well-known Bry and Boschan (BB) (1971), Henderson Moving Average (HMA), and Hodrick Prescott (HP) computer-based methods. "Transparent rules" of the type set out in Canova (1994) and Kim, Buckle and Hall (KBH) (1995) were then used to select turning points from the relevant deviations from trend series.

"Deviations from Trend" Series

The BB, HMA and HP methodologies have previously been used with success on New Zealand data (KBH, 1995), and HMA methods are used for business cycle analysis in Australia (Salou and Kim, 1992). Further details on each method are available in KBH, Salou and Kim, and their original sources. Some key attributes of each, particularly pertinent to this study, are as follows.

The BB algorithm was developed in the early 1970s when the NBER sought to automate their method of dating turning points in individual data series. It involves searching for turning points in (moving average and Spencer curve) smoothed versions of a seasonally adjusted series, so as to avoid being misled by so-called "erratic" movements. In its form originally developed for monthly data (but which is easily adapted for use with quarterly data), lower bound restrictions imposed on the selection procedure are that the BB business cycles must be no less than 15 months

long, and that all expansion and contraction phases must be at least five months in duration. No upper bound restrictions seem to have been explicitly imposed. BB turning points underpin the "benchmark" turning points suggested in KBH (1995, Table 5) for New Zealand's production-based real GDP series from the second quarter of 1977 (1977:2).

The detrending method using HMA filters, as reported in Salou and Kim (1992), involves computing a "business cycle component" as the deviation of a "smoothed series" from a "long-term trend". They obtained their "smoothed series", designed to eliminate irregular short-term movements, from a 7-term HMA. Their "long-term trend" is based on a 33-term HMA, This 7-term/33-term HMA choice essentially bounds empirical cycles to between 2 and 8 years, and for convenience at this stage we have retained those values, as well as making due adjustment for the "end point problem" referred to in KBH (1995, pp 157-158).

The HP detrending method has been used frequently in recent years for work on establishing "key business cycle characteristics" or "stylised facts", generally with a value of 1600 for the smoothing parameter λ, e.g. Kydland and Prescott (1990) for the US, KBH (1994) for New Zealand, and Fisher, Otto and Voss (1996) for Australia. HP filtering requires computation of the trend component of a (seasonally adjusted) variable, from a minimisation problem involving degree of fit and smoothness terms, and an imposed value for λ. The advantages and disadvantages of using the HP method are now relatively well-known, including the fact that the cyclical observations obtained from HP filtering could well be more volatile and quite erratic compared with those obtained from the HMA method. The latter is because HP cyclical components can include significant irregular movements as well as the cyclical movements. For such reasons (see also King and Rebelo, 1993, Cogley and Nason, 1995), comparatively little attention has been paid to how useful HP filters could be for business cycle dating purposes, and their use in this latter context remains far from non-controversial. Neverthess, Canova (1994) and KBH (1995) have produced credible dating results when HP deviations from trend data are combined with suitably transparent rules for turning point selection. No bound on the cycle length, such as 2 to 8 years, is implicitly or explicitly imposed by the HP filter, but both the "eyeballed" and Canova "Rule 1" based turning points reported for New Zealand in KBH (1995, Table 3, Figure 4) were very similar, whether taken from results using the HMA or the HP methodologies.

Dating Rules

To assign suitably consistent turning points to the HMA and HP deviations-from-trend series, it is necessary for us to assign an appropriately transparent selection criterion or "rule". In KBH (1995), we investigated the relative efficiency of "eyeballing" the peaks and troughs, against use of Canova's Rule 1 (1994, p 618). His rule utilises four successive quarterly observations, and defines a trough in quarter t if $c_{t-2}>c_{t-1}>c_t<c_{t+1}$, where c_t is the deviation from trend value for quarter t, for the logarithms of seasonally adjusted data. The inequality signs are reversed to define peaks. In KBH, we found that results calculated from the use of Rule 1 were very little different from those obtained much more quickly by eyeballing. For the two data sets for nine countries considered here, we obtained initial peaks and troughs from eyeballing points which obviously satisfied Rule 1, and then checked carefully for any

additional points satisfying slightly modified Rule 1 conditions (i.e. peaks and troughs must alternate, and be above and below the trend line by a non-trivial magnitude such as .005). The latter modification was found helpful at the margin for a few countries in rejecting excessive HMA and HP turning points.

Empirical Results

BB, HMA and HP business cycle turning points for each country are presented in Table 3. The sample of detrended observations from which they have been drawn is the 1977:2 to 1995:1 sub-period of the maximum sized sample available for each country. "Initial turning point problems" were therefore able to be avoided for all countries except Singapore. Its quarterly observations were available only from 1980:1. Because of the well-known potential end-point problems associated with the HMA and HP detrending methods, the latest turning points have been treated with caution. The 1977:2 start point was chosen, partly because New Zealand's preferred production based real GDP data are available only from that date, and partly because Osada and Hiratsuka (1991, p.x) have suggested that "The Asian NIEs began to exhibit business cycles, originating from the manufacturing sector, in the early 1970s...Rapidly industrialising ASEAN countries likewise began to experience business cycles in the late 1970s".

The general conclusions drawn from Table 3 are that:

- The BB method produced far fewer turning points for all countries than did HMA and HP, and this was especially so for Japan, Korea, Taiwan, Hong Kong and Singapore. While the BB turning points presented for New Zealand, Australia and the US could legitimately be interpreted as a genuinely parsimonious set of cycle points for those countries, this method (which was originally designed to mimic NBER-type cycles) does seem unsuitable for use on the data of all five of our Asian countries. We have therefore not used the BB points further in this work.

- The HMA and HP1600 methods have produced broadly similar numbers of turning points for each of New Zealand, Australia, the US and Hong Kong, and somewhat fewer HP than HMA points for each of West Germany, Japan, Korea, Taiwan and Singapore. Also, the number of turning points these two methods have produced in common for each country is exceptionally high.

Durations and Amplitudes

Definitions

Measures of duration (in quarters), calculated for each of "Trough-Peak-Trough (T-P-T) Total Cycle", "Expansion" and "Contraction" Phases, follow logically from turning points set out in Table 3. The amplitudes for the HMA and HP data need to be presented in equivalent measurement units, to assist meaningful comparison of their results, and so are presented in Table 4 in "per cent deviation from trend" form. One would, nevertheless, expect the HP percentage deviations to be greater than those from HMA series, as while the HP deviation is defined as ((actual - trend)/trend), the HMA is (as presented in Salou and Kim, 1992, Table 1) is the less volatile ((smoothed 7-term HMA - trend)/ trend) measure.

Empirical Results

Detailed duration and amplitude results for each country's HMA and HP individual cycles are available on request from the authors. Averaged cycle results for each country, and mean results for all countries are presented in Table 4.There is a full set of results for the HMA data, but there are too few expansion, contraction and therefore total cycle HP observations for Japan, Singapore, West Germany and Taiwan to provide meaningful averages for those countries.

However, there remain more than sufficient in the way of meaningful results for us to observe that while the HP data provide a mean total cycle of 14.4 quarters which is longer than the 12.6 mean from HMA data, the individual country mean HMA durations do not vary widely around 12.6 quarters. Taiwan and NZ display the shortest average total cycle duration of around 10.5 quarters, with Hong Kong having clearly the longest average of 14.7 quarters.

The amplitude results are, however, much more striking. We first note that, consistent with our theoretical priors expressed above, the individual country and mean total cycle amplitudes from HP data are between 1.5 and 2 times those for the corresponding HMA data. But more importantly, Hong Kong has displayed by far the highest average total cycle amplitude, ahead of Korea, Singapore, Australia, NZ and Taiwan. Relatively low average amplitudes are recorded for West Germany and Japan. The HMA average peak, trough, expansion, contraction and total cycle amplitudes presented in Table 4 for Australia are very close to the average amplitude figures presented in Salou and Kim (1992, Table 2) for Australian data from the much longer period, 1959:3 to1992:2.

4. Illustrative Positioning of Individual Country Business Cycles

A summary positioning for all nine country's individual business cycles is not easy to present succinctly. So two different forms of illustration are provided, utilising just the HMA data. Cycle turning points are grouped by common dates in Table 5, and deviations-from-trend movements over the 1977:2 to 1995:1 sample period, with appropriately marked "eyeball/rule-based" turning points are presented in Figure 3.

Table 5 displays alternating troughs and peaks, with countries grouped around approximately common dates. For example:

- The recent business cycle troughs of the early 1990s have been spread quite widely over time, and can be grouped around four separate dates. These are:

Taiwan	1990:3
NZ, Australia, the US	1991:2/1991:3
Singapore, Korea	1992:3/1992:4
West Germany, Japan	1993:2/1993:4

- The preceding peaks were also spread over four separate sets of dates, but with countries still grouped as above.

- But for some much earlier peaks and troughs, e.g. the trough around 1982:4/1983:1, the countries were much more closely concentrated.

- For latest tentatively recorded dates, peaks could well be established around the 1994:3/1994:4 period for NZ, Australia, the US, Singapore and Taiwan.

These observations, together with the visual evidence shown in Figure 3, seem to provide evidence that there has been far from perfect synchronisation of business cycle turning points over time for these nine countries. However, consistent with the preliminary annual data analysis presented in the APEC (1995) study, we can suggest synchronisation amongst certain sub-groups of countries over certain time periods. These include: NZ, Australia and the US (except for the second half of the 1980s); West Germany and Japan from 1987:2 onwards; and Singapore, Korea, Hong Kong (and Taiwan) for almost the whole of the 1980s. But in contrast for the latter four countries, in both the late 1970s and the early 1990s, there seem to have been significant variations in possible synchronisations.

This *prima facie* evidence of shifts in synchronisations and semi-synchronisations over time therefore justifies further investigation. Accordingly, the next two sections present evidence on whether credible patterns can be established for each country's "cycle risk" (i.e average and moving windows volatility) and "degrees of synchronisation" (i.e average and moving windows bivariate cross correlations).

5. Volatility

In recent years, a number of business cycle papers (Gerlach, 1988, Baxter and Stockman, 1989, Razin and Rose, 1992, and Ramey and Ramey, 1995) have been concerned with possible associations between output or business cycle volatility and factors such as degree of openness of an economy, any change in a country's exchange rate regime, the removal of international barriers to trade and capital flows, and differing economic growth rates. But as indicated in the introduction, we confine our attention here to the initial task of presenting measures of average volatility over time for individual countries, the relative rankings of these measures, and the extent to which the average values have varied over time.

Average Volatility

First, though, recall from the annual data analysis presented in section 2 that China displayed by far the highest business cycle volatility over the 1960-1994 period, and that this continued to be the case even when its particularly volatile observations for the 1960s were excluded.

A more detailed picture, especially for the past two decades, can be established from analysis of our quarterly data set. For nine countries, Table 6 presents sample average values for volatility (expressed as percentage standard deviations from trend), their

corresponding GMM standard errors as a guidance to reliability, and rankings of the countries according to degree of volatility. Our findings on relative volatility do not vary in any meaningful way between the HMA and HP data sets, despite HP data providing consistently the higher absolute values for the reasons explained in section 3. It can also be noted that results do not vary in a major way between the "full" and "post-1977:2" sample periods, except that West Germany and Japan (and Taiwan and Hong Kong) record somewhat lower average volatility when the 1960:1 to 1977:1 observations are not included. So, for the recent 1977:2 to 1995:1 sample period, it can be concluded that:

- Hong Kong, Korea, and Singapore are the countries with the highest average business cycle volatility;

- New Zealand and Taiwan have also displayed high average volatility; and

- in descending order, relatively lower average volatility is shown by Australia, the US, West Germany and Japan.

These rankings for quarterly data are consistent with those displayed in Table 2 for annual data.

Variability over Time

Preliminary evidence has already been gained from the lower average volatilities recorded for four countries when a substantial number of observations for the 1960s and 1970s are ignored. But much more meaningful evidence can be provided from examining average percentage standard deviations calculated as 2.5 year (11 quarter) moving windows. The corresponding HMA data outcomes, for the 1977:2 to 1995:1 period, are presented in Figure 4. Similar directions of movement are displayed by our HP data. Key findings are that:

- Business cycle volatility has varied over time for all countries, with the possible exception of Japan. There have, however, been a number of different types of variation;

- NZ, Australia and the US displayed above average volatility prior to the mid-1980s, and below average volatility thereafter. Their movements from above to below average volatility took place over broadly the same period of time in the mid-1980s. But while volatility has since remained consistently below average for Australia and the US, New Zealand's volatility has recently been rising again;

- West Germany has reverted to above average volatility after a lengthy "U-shaped" period of below average values; and

- the volatilities of the other four countries, starting with Korea and followed by Hong Kong, Taiwan and Singapore have been moving lower over time.

There are possible economic explanations for each of these observed movements over time, and the next research step would be to conduct formal tests for them.

6. Degree of synchronisation

There has been a small body of work on degree of synchronisation of business cycles amongst the nine countries for which we have quarterly data, and somewhat less work on exploring reasons for constant- or varying-over-time business cycle relationships. The APEC (1995) "semi-synchronisation" work has been referred to above, and one can extract selected findings on synchronisation from Wells, Magill and Felmingham (1978), Magill, Felmingham and Wells (1981), Blyth (1992), KBH (1994) and Selover and Round (1995) for New Zealand; from Boehm and Liew (1994), Gruen and Shuetrim (1994), Debelle and Preston (1995), and Selover and Round (1995) for Australia; and from Baxter (1995) for the US, Australia, Germany and Japan.

Our preliminary work, aimed at establishing reliable average and moving bivariate cross correlations between pairs of countries, has focussed on two aspects: the degree of synchronisation of New Zealand's aggregate business cycle with those of its eight selected major trading partners; and any notably robust synchronisations between the eight. Again, particular attention is paid to statistical reliability when identifying the most appropriate average cross correlations, leads or lags in the relationships, and the extent to which relations are pro- or countercyclical (see KBH, 1994, for further methodological details). The moving windows outcomes are capable of providing *prima facie* evidence for subsequent more rigorous testing on: the extent to which there have been "trend movements" in relations over time, and whether "special factors" (such as New Zealand's extensive economic reforms from the mid-1980s and/or the change to floating exchange rates in March 1985) should also be tested for.

New Zealand and Selected Major Trading Partners

For the 1977:2 to 1995:1 sample period, preferred bivariate cross correlations are presented in Table 7. The most robust results are consistent across the two deviations-from-trend data sets and for the annual percentage change data at quarterly intervals.

Average degree of synchronisation varies considerably across trading partners, though some broad groupings are possible. For example, from HMA data:

- there is strong procyclical synchronisation, contemporaneously with Australia (.69), and after a two quarter lag with the United States (.68);

- there is statistically significant, but much weaker, countercyclical synchronisation with West Germany (-.29, leading NZ by 5 quarters) and Japan (-.28, leading NZ by 3 quarters); and

- due to somewhat inconsistent results between data sets, there seems to be no clear degree of synchronisation with our other four key Asian countries. The possible exception is a countercyclical relationship with Singapore (-.49, lagging NZ by 6 quarters).

The **moving windows** cross correlations shown in Figure 5 shed further light on the average relations. They suggest possible reasons for the varying degrees of reliability of the average results, and point towards some time periods when relationships may have changed in major ways. Perhaps the most prominent amongst these are:

- New Zealand's procyclical relationship with Australia has often been much stronger, at around .9, than the sample average of .69. This is because, during the latter half of the 1980s, there was a lengthy period with synchronisation well below average. This corresponds broadly with the period in New Zealand when substantial structural economic reforms were being carried through and major macroeconomic imbalances were being tackled;

- A very similar pattern is observed for New Zealand's degree of synchronisation with the US, except that moving cross correlations for the 1990s have returned only to between .5 and .7, rather than to around .9;

- No significant periods of procyclicality are evident for cross correlations with Japan, and the degree of countercyclicality has varied widely over time between zero and around -.75; and

- Possible synchronisation with Singapore has varied widely, from strong countercyclically in the first half of the 1980s to gentle fluctuations around "no association" in the latter part of the 1980s and the 1990s.

An obvious general implication from these results is that Baxter's summary conclusions (from quarterly data over the period 1970:1 to 1990:1 for ten industrialised countries), of "business cycles of developed countries moving together" and "cyclical movements in output tending to be positively correlated across countries", need appropriate qualification for New Zealand and its major trading partners over the 1977:2 to 1995:1 sample period.

Amongst Selected Major Trading Partners of New Zealand

Relatively few results are presented in Table 8, as even fewer reliable results were identified.

Not surprisingly, in view of the results in Table 7 and previous Australian research, the most robust sample average result is the **US** leading **Australia** by one quarter in a strongly procyclical manner, i.e .74 for HMA data. Figure 6 shows that the average has been maintained quite consistently over the (centred) 1977:2 to 1995:1 time period, except for a period around the mid-1980s when the moving value declined to

around .5. The average cross correlation has been higher for this more recent period than over the full 1960:1 to 1995:1 sample period.

The degree of synchronisation of the aggregate business cycles of the **US** and **Taiwan** has varied widely over time, despite recording impressive average procyclical cross correlations of between .56 and .69. The sample period shown in Figure 6 has the cross correlations moving from around .9 to around -.5, which follows on from countercyclical values in the range -.1 to -.5 in the 1960s and procyclical values of around .9 in for most of the 1970s.

For **Japan** and **West Germany,** statistically significant average relationships can be reported, but the magnitude of the procyclicality varies by data set and sample period. Moving windows illustrations for the full sample period show steadily stronger synchronisation in the 1960s and from the early 1980s onwards, but broadly declining procyclicality throughout the 1970s. Figure 6 shows the relation has been very strongly procyclical, at around .8, for the 1990s.

For the **US** and **Japan**, results do not seem robust enough for the full sample period. But for the shorter sample period, the average cross correlations in Table 8 are consistent with a countercyclical relationship. The corresponding moving windows illustration shows this to have varied considerably in strength over time.

Any potential countercyclical relation between **Australia** and **Japan** seems even weaker, and the length by which the Australian cycle lags Japan's seems not particularly robust.

So, these bivariate results involving the US, Japan, West Germany and Australia display both positive and negative average cross correlations between countries, and also demonstrate considerable variation over time. They therefore at least call into question Baxter's (1995) stylised fact of "cyclical movements in output tending to be positively correlated across countries".

7. Conclusions

We have conducted exploratory analytical work on business cycle turning points, volatility, and synchronisation for New Zealand and its major (Pacific Rim) trading partners.

We have established primarily computer- and rule-generated **"benchmark" turning points** from quarterly data for each of New Zealand, Australia, the United States, West Germany, Japan, Korea, Taiwan, Hong Kong and Singapore. The Bry and Boschan method, while appropriate in a parsimonious fashion for the US, Australia and NZ, does not seem suitable for the real GDP data of these five Asian countries. The Henderson Moving Average and Hodrick Prescott detrending methods, with the assistance of simple "transparent rules", produced broadly similar numbers of turning points for each of NZ, Australia, the US and Hong Kong, and somewhat fewer HP than HMA turning points for each of the other five countries.

Amplitude results computed from the illustrative "benchmark" turning points are quite striking. Hong Kong displayed by far the highest average total cycle amplitude, ahead of Korea, Singapore, Australia, NZ and Taiwan. Relatively low average amplitudes are recorded for West Germany and Japan.

Illustrative **positioning** of individual country business cycles provided preliminary evidence that there has been far from perfect synchronisation of business cycle turning points over time for all nine countries. Synchronisation is identifiable, though, amongst sub-groups of countries over certain time periods. These include: NZ, Australia and the US (except for the second half of the 1980s); West Germany and Japan from 1987:2 onwards; and Singapore, Korea, Hong Kong (and Taiwan) for most of the 1980s but not so tightly for the 1990s to date.

We have also found, from a combination of our quarterly and annual data results, quite clear evidence on relative business cycle **volatility**. China, Hong Kong, Korea and Singapore are the countries with the highest volatility; New Zealand and Taiwan have also displayed high volatility on average; while Australia, the US, West Germany and Japan have displayed relatively lower average volatility. This is broadly consistent (except for New Zealand, and possibly Japan) with our high growth rate countries exhibiting high volatility and the lower growth rate countries displaying relatively lower volatility. There have also been some particularly notable movements in volatility over time. For example, the volatilities of China, Korea, Hong Kong, Taiwan, and Singapore have been moving steadily lower over time. And while NZ, Australia and the US displayed above average volatility prior to the mid-1980s, and below average volatility thereafter, New Zealand's volatility has recently been rising again somewhat.

Our degree of **synchronisation** analysis has shown strong procyclical synchronisations between NZ and both Australia and the US. But there was a clear disturbance of the strength of the relationships during the mid- to late-1980s. New Zealand has shown much weaker degrees of countercyclical synchronisation with West Germany and Japan. There seems to be no clear degree of synchronisation between New Zealand and any of Korea, Taiwan, Hong Kong and Singapore, with the possible exception of Singapore. Not surprisingly, the strongest degree of synchronisation among New Zealand's trading partners is the procyclicality between the US and Australia. Other potentially strong associations, for example between the US and Taiwan, the US and Japan, and West Germany and Japan, varied too widely over time to be classified as robust.

Linking our synchronisation findings back to the APEC "semi-synchronisation", and the Baxter and European "moving together" concepts referred to in the introduction, we conclude that meaningful synchronisations can be established only for particular sub-groups of countries and sometimes then only for quite short time periods. New Zealand's business cycle synchronisation is primarily with the "Pacific Rim" countries of Australia and the US, rather than with any "European cycle" associated with (West) Germany. It seems too soon to be able to establish meaningful business cycle synchronisations between NZ and any of China, Korea, Taiwan, Hong Kong and Singapore.

Finally, it can be noted that "semi-synchronisation" for certain APEC sub-regions is additionally supported by some of our growth rate and business cycle volatility findings. For example, as well as having relatively well synchronised business cycles, New Zealand, Australia and the United States have had relatively low growth rates, relatively low business cycle volatility (with the exception of New Zealand), and a shifting of volatility from above to below average in the mid-1980s. Also, the high growth rate, high volatility countries of China, Korea, Taiwan, Hong Kong and Singapore have recorded high business cycle amplitudes on average, and have seen their business cycle volatility decline over time. And in many ways, except for its recent procyclical association with (West) Germany, Japan has perhaps displayed growth and cycle characteristics different from other sub-regions.

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Data Sources

Available on request from the authors

Table 1. New Zealand's Principal Merchandise Trading Partners, 1994
Millions of U.S. Dollars

Country	Exports from NZ	Rank	Exports + Imports	Rank
Australia	**2530**	**1**	**5092**	**1**
United States	**1311**	**3**	**3602**	**2**
Japan	**1873**	**2**	**3437**	**3**
United Kingdom	724	4	1461	4
Germany	**311**	**9**	**853**	**5**
Korea (ROK)	**585**	**5**	**777**	**6**
China, People's Rep.	**336**	**6**	**725**	**7**
Taiwan Province of China (Chinese Taipei)	**334**	**7**	**654**	**8**
Hong Kong	**312**	**8**	**442**	**9**
Italy	171	12	437	10
Malaysia	234	10	379	11
Canada	206	11	379	12
Singapore	**159**	**13**	**370**	**13**
France	133	14	339	14

Source: *Direction of Trade Statistics Yearbook, 1995*, International Monetary Fund

Table 2. Real GDP Growth Rates and Volatility
New Zealand and Selected Major Trading Partners, 1960-1994

Country	Av. Annual % Growth Rate				Volatility (% stand. devs. from HP trend)			
	1960-1994*		1970-1994		1960-1994*		1970-1994	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Taiwan	8.9	1	8.5	1	2.6	4	3.0	5
Singapore	8.5	2	8.2	3	4.2	2	3.5	2
Korea**	-	-	8.2	2	-	-	3.3	4
China	8.3	3	8.0	4	5.9	1	4.3	1
Hong Kong	7.9	4	7.5	5	3.9	3	3.3	3
Japan	5.7	5	3.8	6	2.6	5	2.7	7
Australia	3.8	6	3.2	7	1.9	9	2.0	10
West Germany	3.0	7	2.4	9	2.0	7	2.1	8
United States	3.0	8	2.6	8	2.0	8	2.1	9
New Zealand	2.7	9	2.2	10	2.6	6	2.7	6

* Sample period for China and for Hong Kong is 1961-1994
** Sample period for Korea is 1970-1994

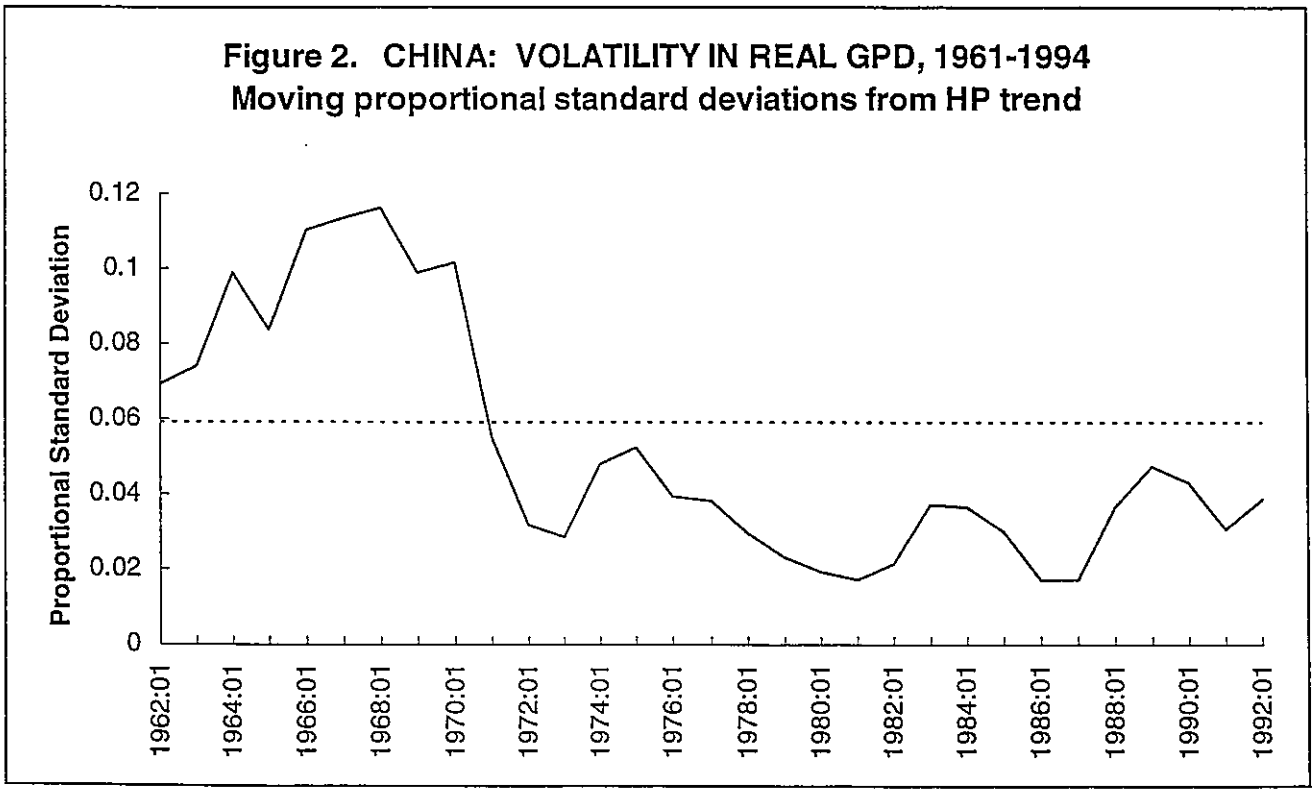


Table 3. Business Cycle Turning Points for New Zealand and Selected Major Trading Partners, 1977:2 to 1995:1*

Country		Dating Method		
		BB	HMA	HP1600
New Zealand	T	1977:4	1978:1	1978:2
	P	-	1979:1	1979:1
	T	-	1980:4	1981:1
	P	1982:2	1982:1	1982:2
	T	1983:1	1983:1	1983:1
	P	-	1984:2	1984:2
	T	-	1985:4	1986:1
	P	1986:3	1986:3	1986:3
	T	-	1988:3	1988:2
	P	-	1990:2	1989:2
	T	1991:2	1991:2	1991:2
	P	-	(1994:3)	(1994:3)
Australia	T	-	1977:4	1977:4
	P	-	1978:4	1979:1
	T	-	1980:2	1980:2
	P	1982:2	1981:4	1981:3
	T	1983:1	1983:1	1983:2
	P	-	1985:3	1985:3
	T	-	1986:4	1987:1
	P	1990:1	1990:1	1989:3
	T	1991:2	1991:3	1991:4
	P	-	(1994:3)	(1994:3)
United States of America	T	-	1977:4	-
	P	-	1978:4	1978:4
	T	-	1980:3	1980:3
	P	1981:3	1981:2	1981:1
	T	1982:3	1982:4	1982:4
	P	-	1984:2	1984:2
	T	-	1987:1	1987:1
	P	1990:2	1990:2	1989:1
	T	1991:1	1991:2	1991:4
	P	-	(1994:4)	(1994:4)
West Germany	T	-	1978:3	-
	P	1980:1	1979:4	1980:1
	T	1980:4	1980:4	-
	P	1981:3	1981:3	-
	T	1982:3	1982:4	1982:4
	P	-	1984:1	1984:1
	T	-	1987:2	1987:1
	P	-	1988:4	-
	T	-	1989:4	-
	P	1992:1	1992:2	1992:1
	T	1993:1	1993:2	1993:2
	P	-	-	-
Japan	T	-	-	-
	P	-	1979:3	1979:2
	T	-	1983:3	1983:2
	P	-	1985:3	1985:2
	T	-	1987:2	1987:2
	P	-	1988:3	-
	T	-	1989:4	-
	P	1992:1	1991:4	1991:4
	T	1993:4	1993:4	-
	P	1994:3	-	-

Table 3 (continued)

Country		Dating Method BB	HMA	HP1600
Singapore**	T	-	-	-
	P	-	1981:3	-
	T	-	1982:4	-
	P	1985:1	1984:3	1984:1
	T	1985:4	1985:4	1985:4
	P	-	1988:2	1989:2
	T	-	1989:4	-
	P	-	1991:1	-
	T	-	1992:3	1992:2
	P	-	1994:3	1994:3
South Korea	T	-	-	-
	P	-	1977:4	-
	T	-	1978:2	-
	P	1979:2	1979:2	1979:1
	T	1980:4	1980:4	1980:4
	P	-	1981:3	-
	T	-	1982:2	-
	P	-	1984:1	1984:1
	T	-	1985:4	1985:3
	P	-	1988:2	1988:1
	T	-	1989:2	1989:2
	P	-	1991:3	1991:3
	T	-	1992:4	1992:4
	P	-	-	-
Taiwan	T	-	1977:3	-
	P	-	1978:3	1978:3
	T	-	1979:3	-
	P	-	1981:2	-
	T	-	1982:4	1983:1
	P	-	1984:2	1984:2
	T	-	1985:3	1985:3
	P	-	1987:2	1987:3
	T	-	1988:2	-
	P	-	1989:3	-
	T	-	1990:3	1990:2
	P	-	(1994:4)	-
Hong Kong	T	-	-	-
	P	-	1977:4	1978:1
	T	-	1978:4	1978:3
	P	-	1981:3	1981:4
	T	-	1983:1	1983:1
	P	1984:3	1984:2	1984:2
	T	1985:3	1985:4	1985:3
	P	-	1988:3	1988:3
	T	-	1989:4	1991:1
	P	-	-	-

* T and P denote troughs and peaks respectively: ( ) denotes a provisional turning point.

** Sample period for Singapore is 1980:1 to 1995:1.

Table 4. Mean Business Cycle Durations and Amplitudes 1977:2 to 1995:1*

HMA Deviations from Trend Data

Country	Duration (in quarters)			Amplitude (per cent deviation)				
	E	C	Total Cycle (T-P-T)	P	T	E	C	Total (E+C)
New Zealand	4.8	5.8	10.6	1.3	-1.7	3.0	2.8	5.8
Australia	8.3	5.5	13.8	1.6	-1.6	3.3	3.1	6.4
United States	6.5	7.0	13.5	1.3	-1.1	2.5	2.6	5.1
West Germany	5.8	6.0	11.8	0.8	-0.9	1.6	1.7	3.3
Japan	7.0	9.0	13.7	0.8	-0.7	1.6	1.5	3.2
South Korea	6.6	4.5	11.6	1.7	-1.7	3.4	3.3	7.0
Taiwan	5.8	4.6	10.4	1.6	-1.3	2.9	2.8	5.7
Hong Kong	9.0	5.3	14.7	2.8	-2.7	6.0	5.5	11.7
Singapore*	7.5	5.5	13.0	1.5	-1.6	3.2	3.1	6.5
Mean	6.8	5.9	12.6	1.5	-1.5	3.1	2.9	6.1

HP Deviations from Trend Data

New Zealand	3.8	6.6	10.4	1.9	-2.4	4.0	6.3	10.2
Australia	7.3	6.8	14.0	2.3	-2.3	4.5	4.5	9.0
United States	5.3	9.0	15.0	1.9	-2.0	3.4	3.9	7.1
West Germany	-	9.3	-	2.3	-1.8	-	4.2	-
Japan	-	-	-	1.6	-	-	-	-
South Korea	10.7	5.8	16.0	4.5	-4.0	8.1	8.5	13.7
Taiwan	-	11.3	-	2.8	-3.0	-	5.8	-
Hong Kong	10.0	5.5	16.7	4.2	-3.7	9.0	7.9	17.6
Singapore*	-	-	-	3.5	-	-	-	-
Mean	7.4	7.8	14.4	2.8	-2.7	5.8	5.9	11.5

* Sample period for Singapore is 1980:1 to 1995: 1. T and P denote troughs and peaks, E and C denote expansion and contraction phases of a total (T-P-T) business cycle. Results are presented only where there are at least 3 E, C, P or T observations or 3 complete T-P-T cycles.

Table 5. Business Cycle Turning Points Grouped by Dates: HMA Data

	New Zealand	Australia	USA	West Germany	Japan	Singapore **	South Korea	Taiwan	Hong Kong
P							1977:4		1977:4
T	1978:1	1977:4	1977:4					1977:3	
				1978:3			1978:2		1978:4
P	1979:1	1978:4	1978:4					1978:3	
				1979:4	1979:3		1979:2		
T								1979:3	
	1980:4	1980:2	1980:3	1980:4			1980:4		
P	1982:1	1981:4	1981:2	1981:3		1981:3	1981:3	1981:2	1981:3
T	1983:1	1983:1	1982:4	1982:4		1982:4	1982:2	1982:4	1983:1
					1983:3				
P	1984:2		1984:2	1984:1		1984:3	1984:1	1984:2	1984:2
		1985:3			1985:3				
T	1985:4					1985:4	1985:4	1985:3	1985:4
		1986:4							
				1987:2	1987:2				
P	1986:3								
								1987:2	
				1988:4	1988:3	1988:2	1988:2		1988:3
T			1987:1						
	1988:3							1988:2	
				1989:4	1989:4	1989:4	1989:2		1989:4
P								1989:3	
	1990:2	1990:1	1990:2						
						1991:1	1991:3		
				1992:2	1991:4				
T								1990:3	
	1991:2	1991:3	1991:2						
						1992:3	1992:4		
				1993:2	1993:4				
P	(1994:3)	(1994:3)	(1994:4)			1994:3		(1994:4)	

* T and P denote troughs and peaks respectively; ( ) denotes a provisional turning points.

** Sample period for Singapore is 1980:1 to 1995:1

Table 6. Volatility (Percentage standard deviations from real GDP trend)

Country	1977:2 to 1995:1*				Full sample**			
	HMA Data	Rank	HP Data	Rank	HMA Data	Rank	HP Data	Rank
New Zealand	1.17 (.11)	4	1.84 (.17)	4		6		6
Australia	1.04 (.10)	6	1.71 (.15)	6	1.03 (.07)	7	1.60 (.10)	8
United States	0.88 (.07)	7	1.56 (.12)	7	0.88 (.06)	8	1.62 (.10)	7
West Germany	0.72 (.05)	8	1.39 (.10)	8	1.42 (.19)	3	2.38 (.27)	4
Japan	0.45 (.03)	9	1.06 (.08)	9	0.85 (.06)	9	1.48 (.09)	9
South Korea	1.50 (.14)	2	2.50 (.30)	3	1.46 (.10)	2	2.63 (.24)	2
Taiwan	1.10 (.10)	5	1.75 (.16)	5	1.26 (.11)	5	2.25 (.18)	5
Hong Kong	1.65 (.14)	1	2.52 (.20)	2	1.99 (.15)	1	3.04 (.25)	1
Singapore	1.34 (.14)	3	2.59 (.23)	1		4		3

Numbers in parentheses are GMM standard errors

* Sample period for Singapore is 1980:1 to 1995:1

** 1960:1 to 1995:1, except for Taiwan (from 1961:1), South Korea (from 1970:1) and Hong Kong (from 1973:1)

Table 7. Degree of Synchronisation of New Zealand's real GDP with Selected Major Trading Partners Bivariate Cross Correlations, 1977:2 to 1995:1*

Country	Deviations from Trend Data				Annual% Change Data, at quarterly intervals	
	HMA		HP			
	Value	Lead/Lag**	Value	Lead/Lag	Value	Lead/Lag
Australia	.69 [8.9]	0	.59 [6.8]	0	.56	0
United States	.68 [5.8]	-2	.51 [5.0]	-2	.48	-2
West Germany	-.29 [3.6]	-5	-.34 [3.5]	-5	-.43	-5
Japan	-.28 [3.1]	-3	-.45 [4.5]	-1	-.47	-2
Korea	.45 [3.4]	-10	.32 [3.2]	10	.35	10
Taiwan	.53 [4.6]	-2	.34 [3.0]	10	.42	10
Hong Kong	-.52 [4.0]	5	-.28 [2.3]	5	.36	10
Singapore	-.49 [3.1]	6	-.28 [2.3]	6	-.36	6

* Sample period for Singapore is 1980:1 to 1995:1

** Negative value denotes the other country's real GDP leading New Zealand's, positive value denotes lagging, and zero indicates contemporaneous

[ ] denotes t-statistics calculated from GMM standard error

Table 8. Degree of Synchronisation of real GDP amongst Selected Major Trading Partners of New Zealand Bivariate Cross Correlations, Deviations from Trend Data

Country*	Other Country	1977:2 to 1995:1				Full Sample**			
		HMA Data		HP Data		HMA Data		HP Data	
		Value	Lead/Lag	Value	Lead/Lag	Value	Lead/Lag	Value	Lead/Lag
United States	Australia	.74 [8.9]	1	.77 [9.2]	1	.56 [6.5]	2	.48 [6.1]	2
United States	Taiwan	.57 [6.2]	0	.56 [6.5]	0	.69 [11.4]	0	.65 [9.3]	-1
Japan	West Germany	.55 [7.2]	0	.73 [13.8]	0	.23 [3.4]	-1	.54 [9.8]	-1
Japan	United States	-.34 [4.5]	3	-.46 [5.9]	5	.33 [3.9]	0	-.36 [5.1]	6
Japan	Australia	-.28 [3.5]	3	-.34 [3.7]	7	-.28 [4.3]	7	-.16 [2.3]	8

* Negative value for number of quarters' lead/lag denotes the "other country's" real GDP leading that of the "country", positive value denotes lagging, and zero indicates contemporaneous

** Full sample is 1960:1 to 1995:1, except for Taiwan 1961:1 to 1995:1

[ ] denotes t-statistic calculated from GMM standard error

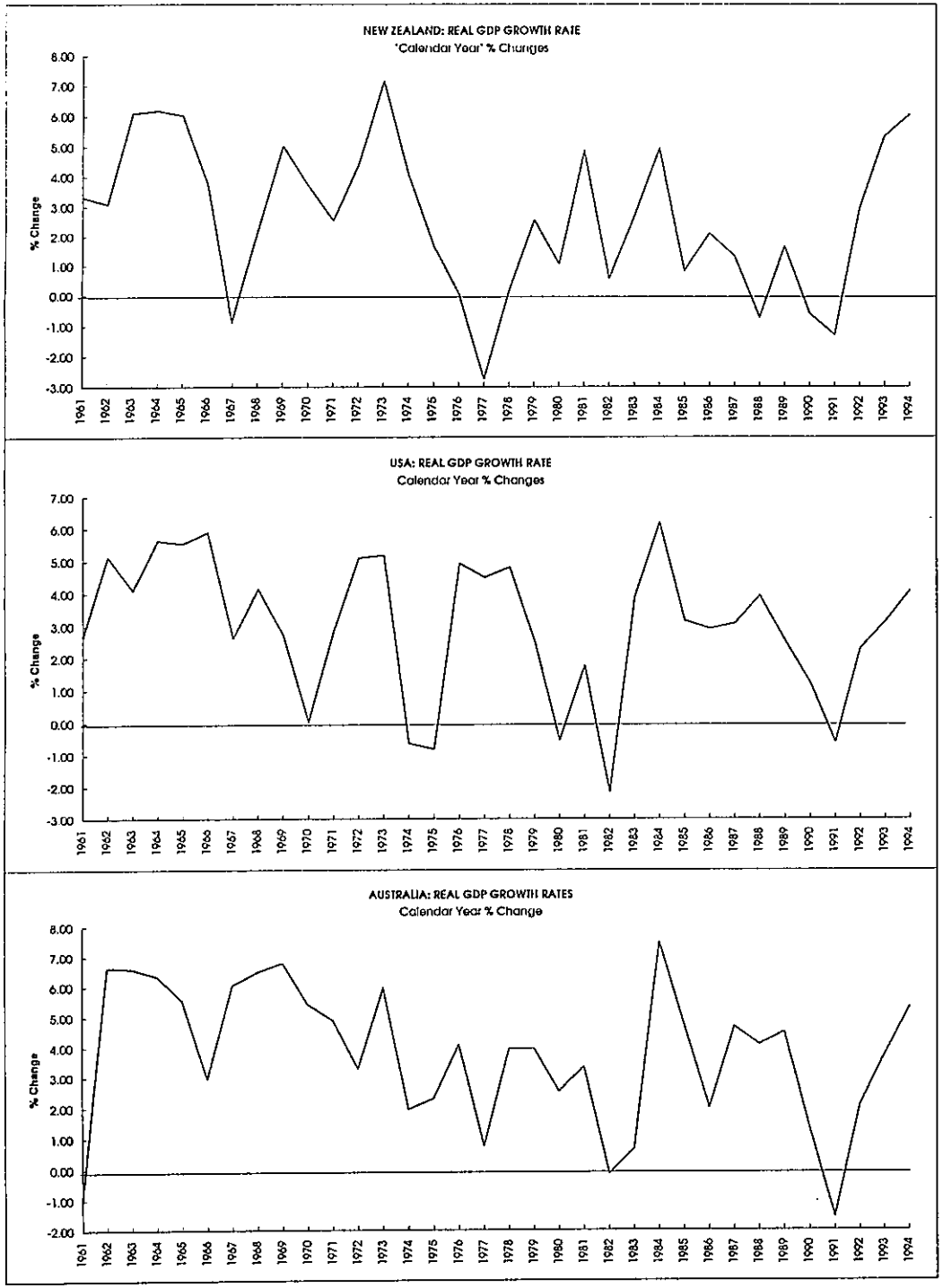
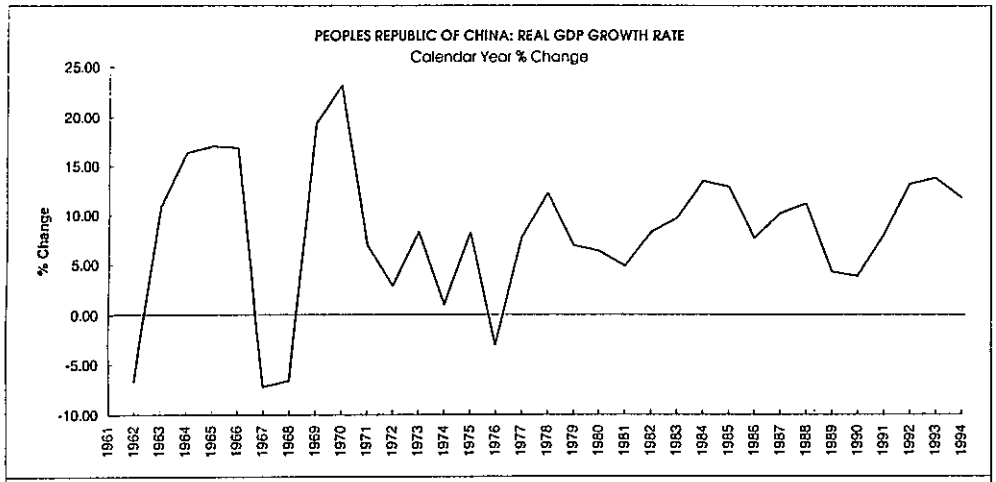
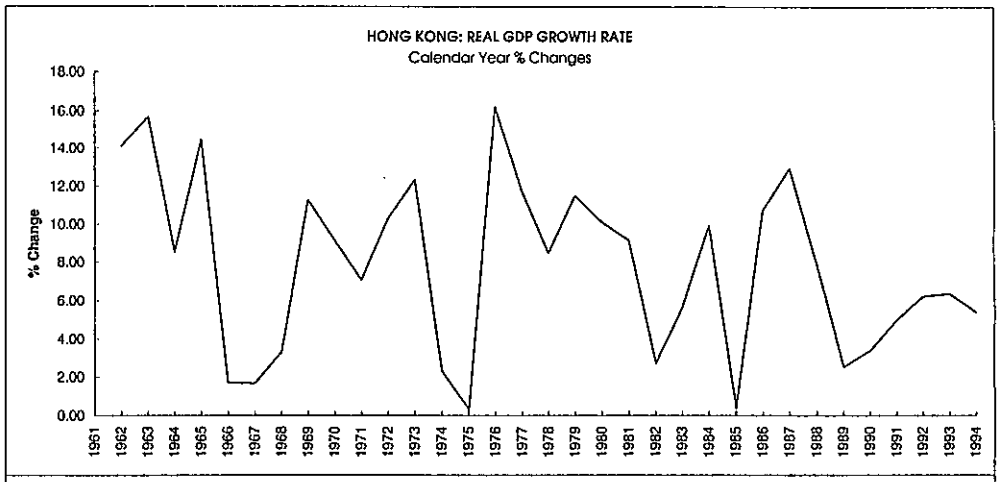
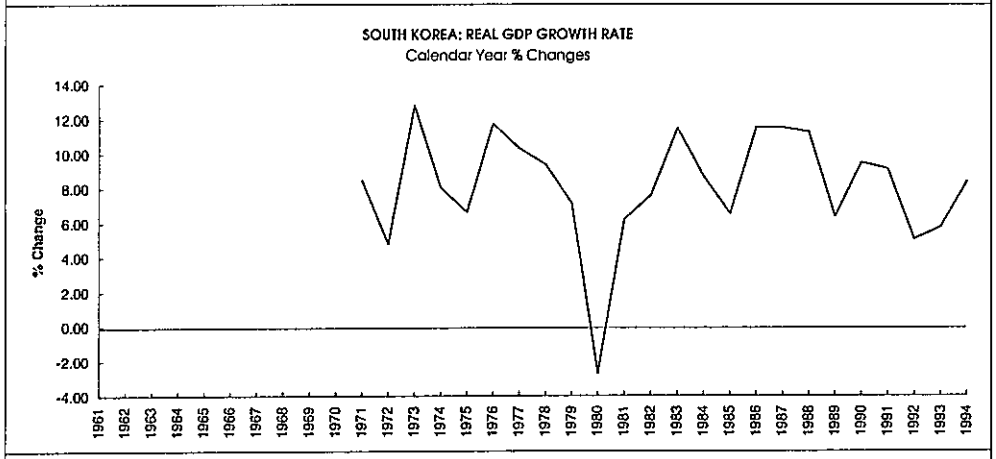
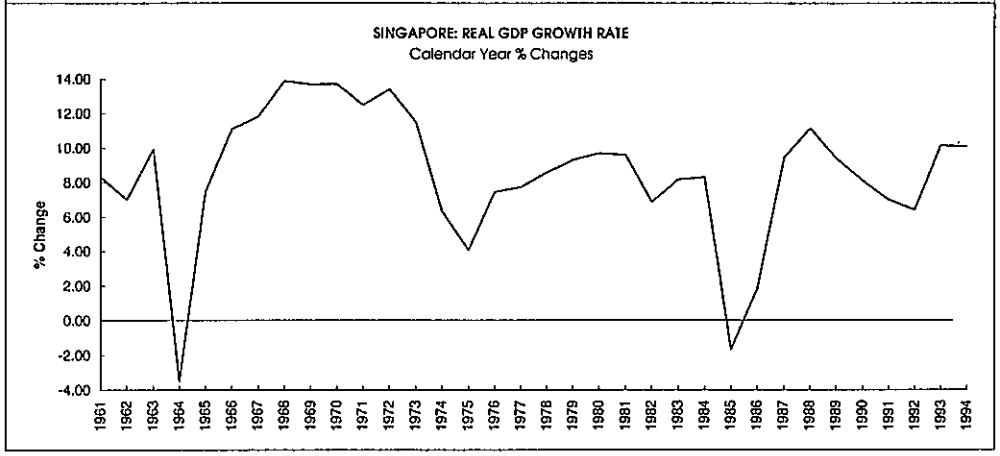


Figure 1. Annual Real GDP Growth Rates









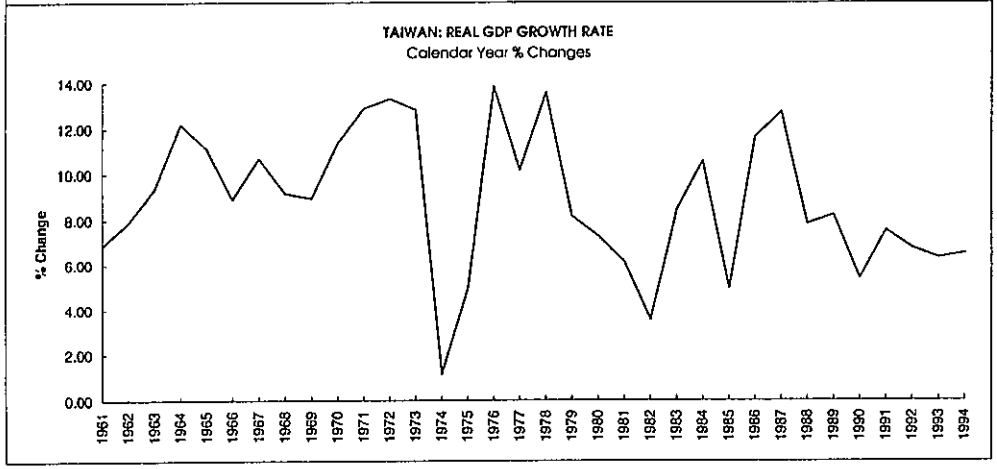
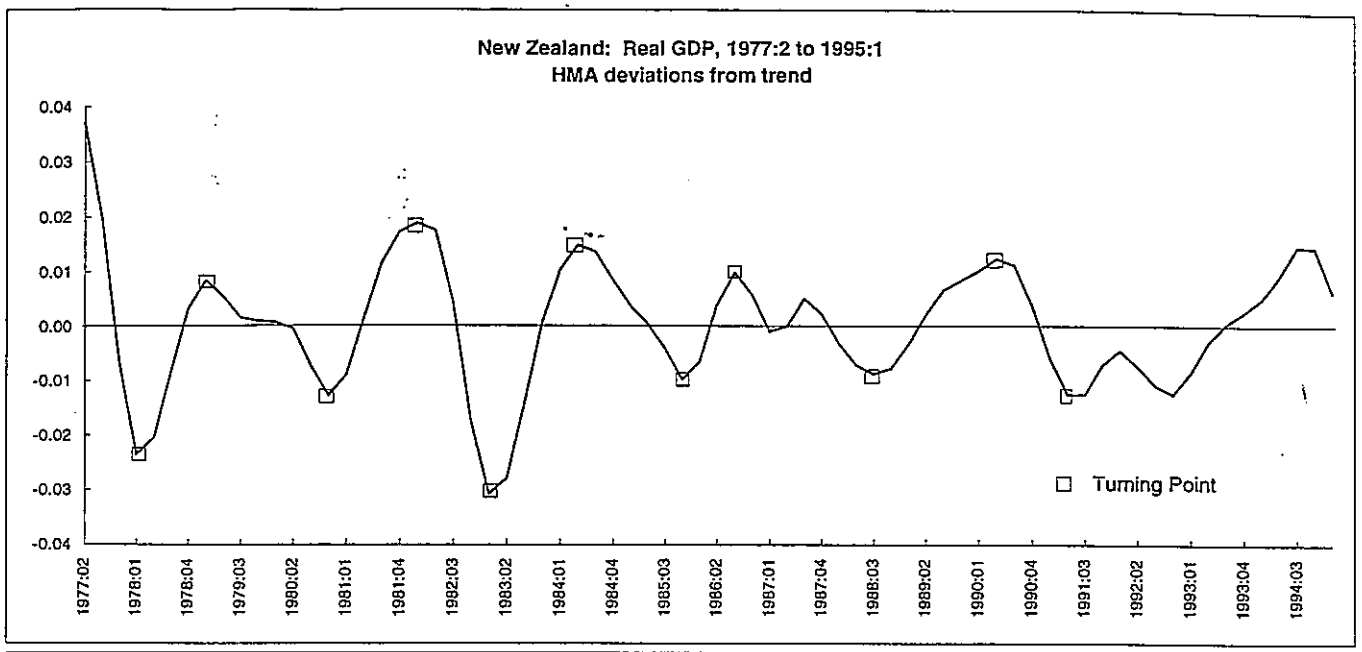
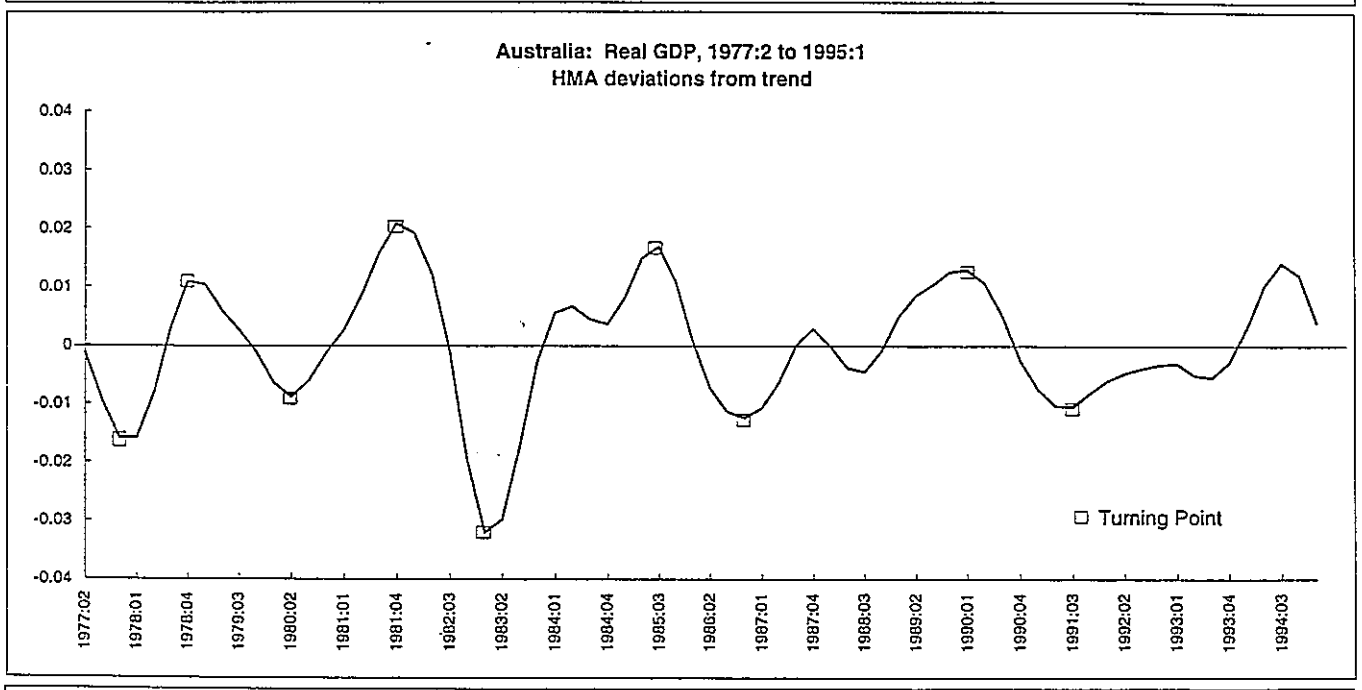


Figure 1. (continued) Annual Real GDP Growth Rates

Figure 3. Business Cycle Turning Points, HMA Data





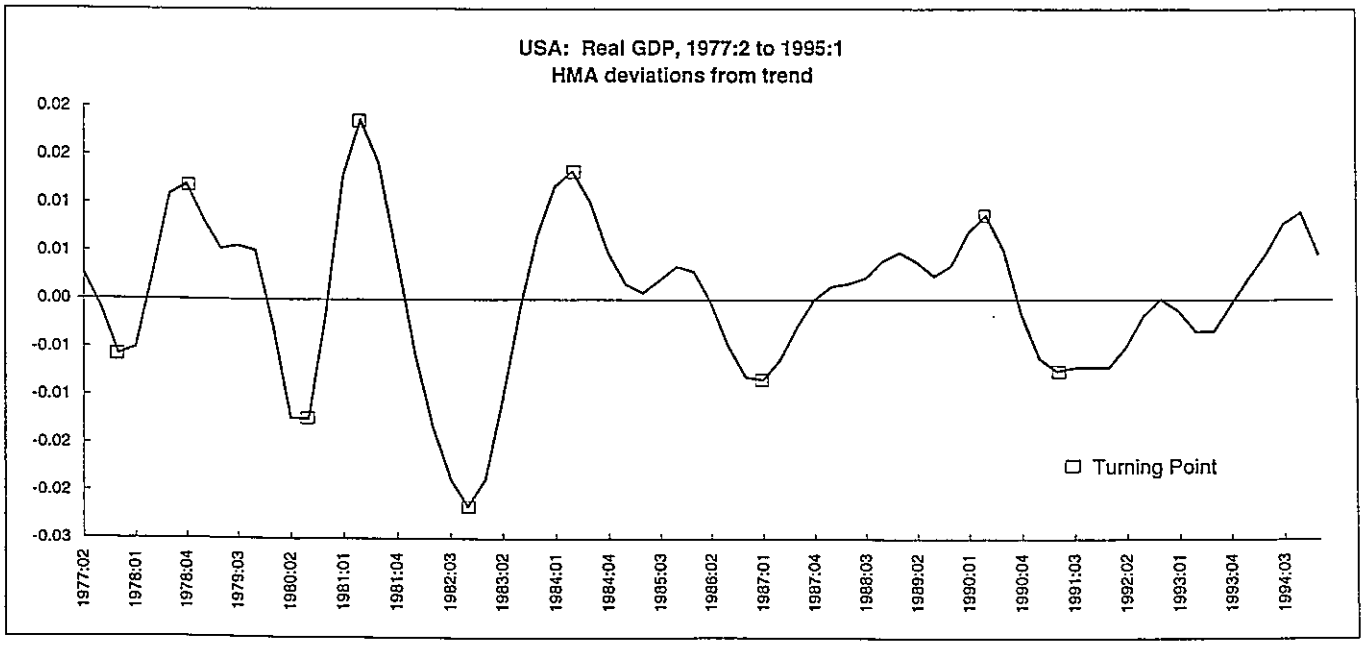


Figure 3. Business Cycle Turning Points, HMA Data

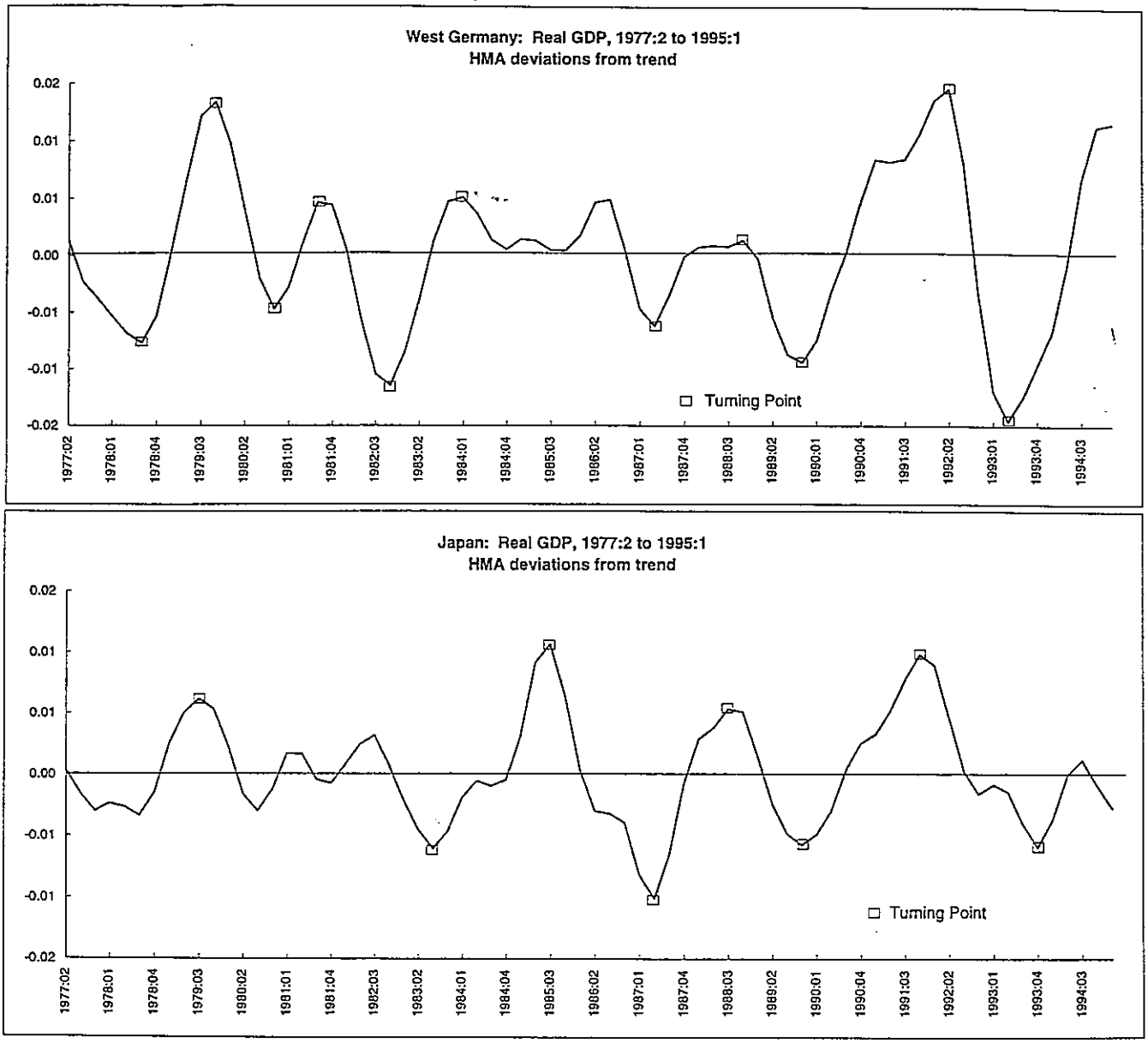
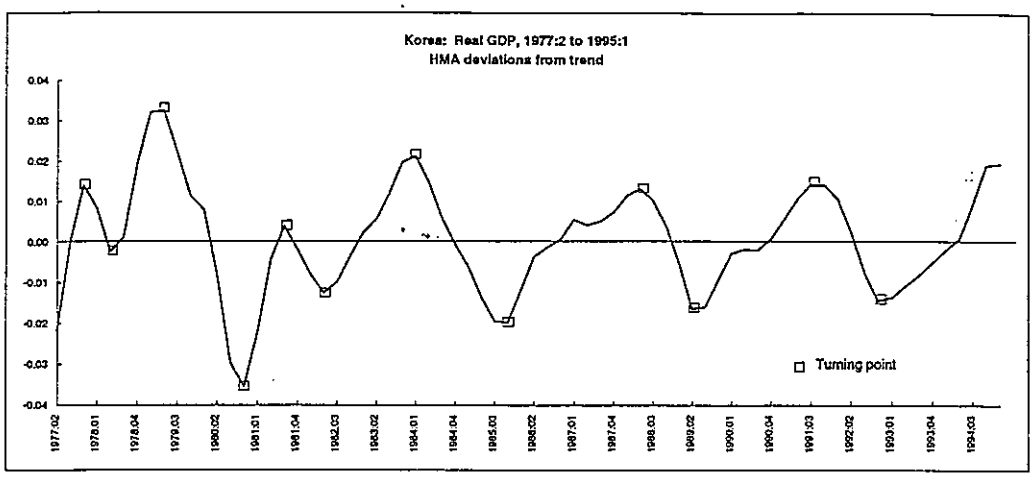
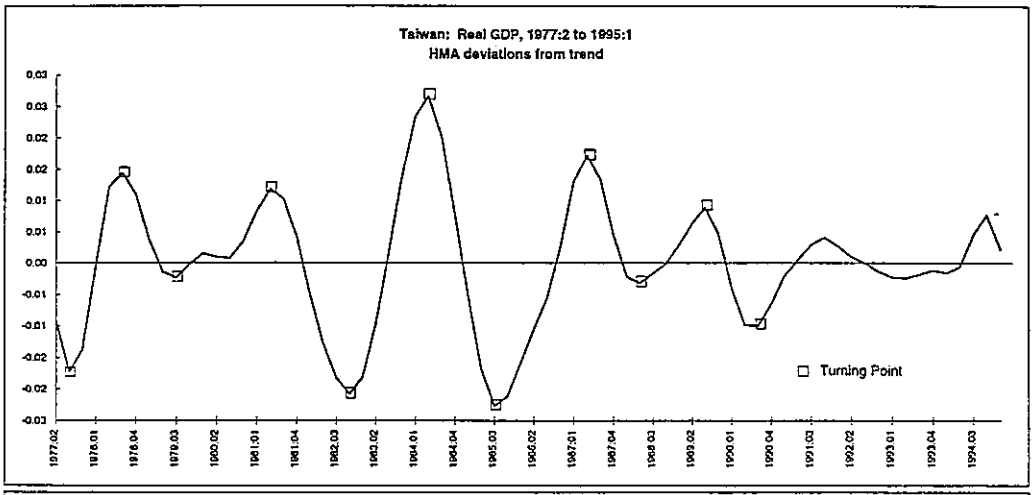
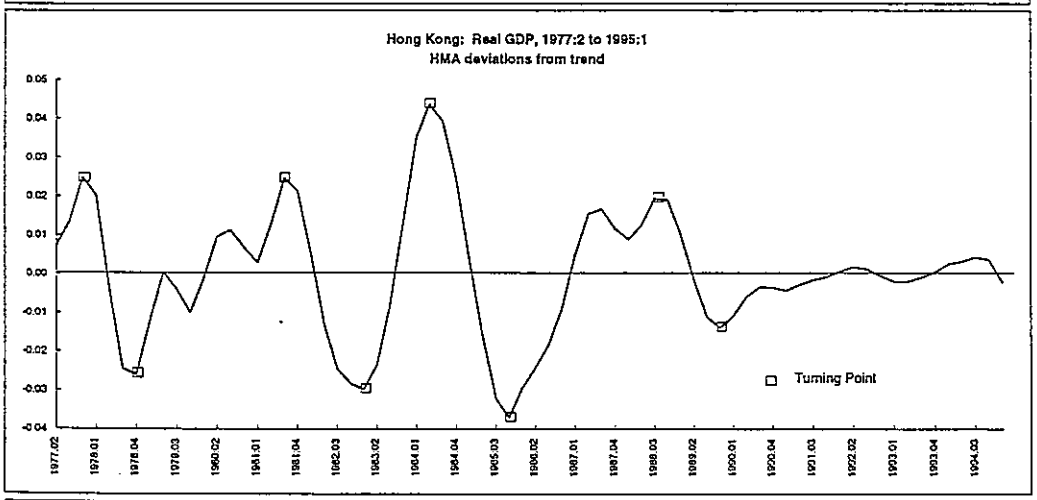


Figure 3. Business Cycle Turning Points, HMA Data







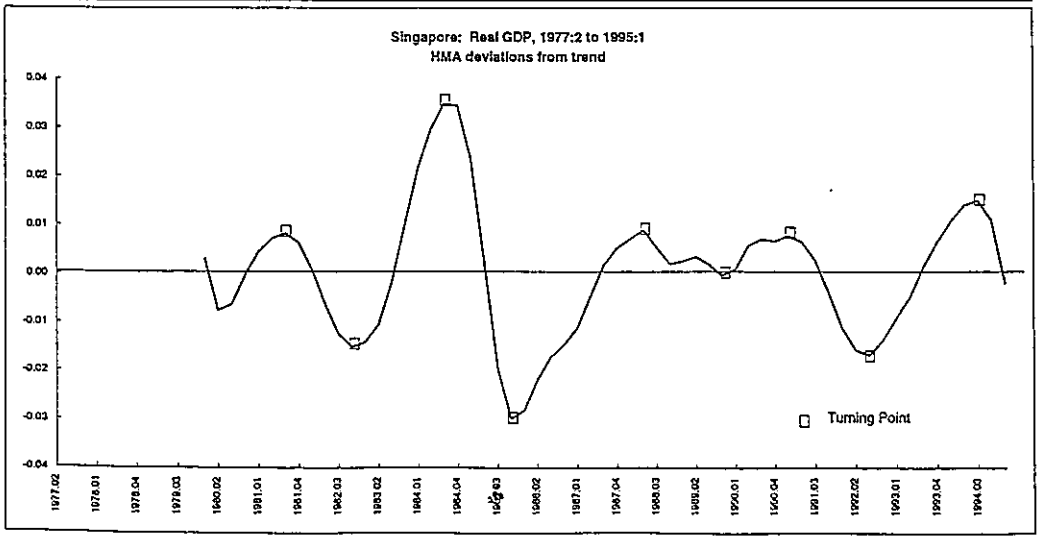


Figure 4. Moving Real GDP Volatility
Proportional deviations from HMA trend

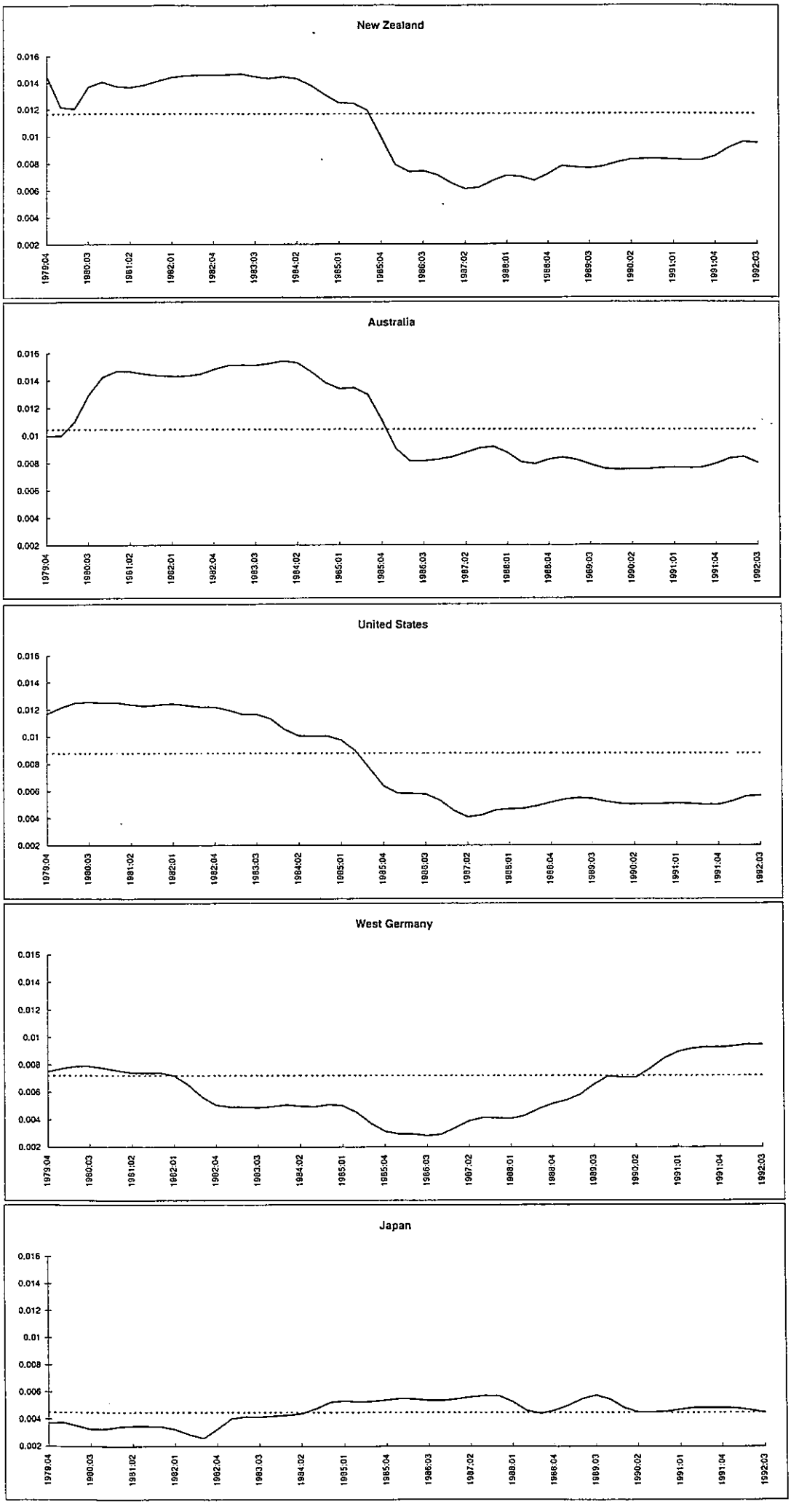
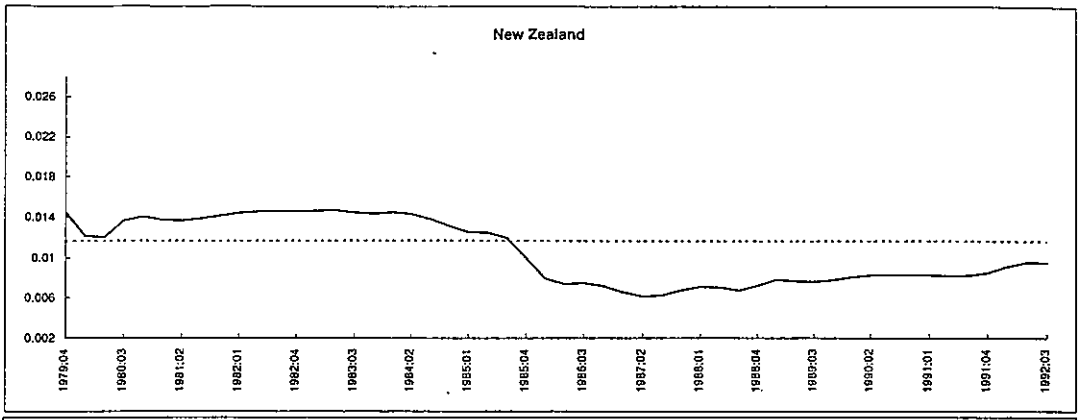
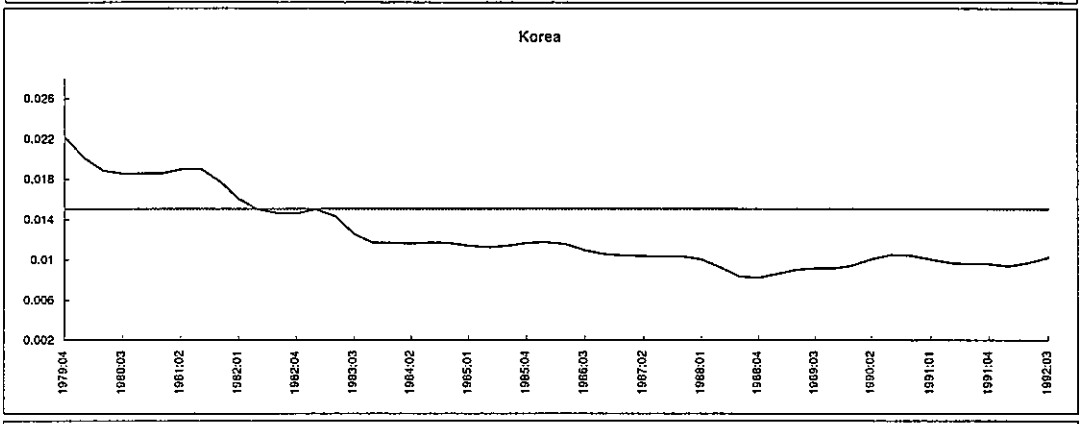
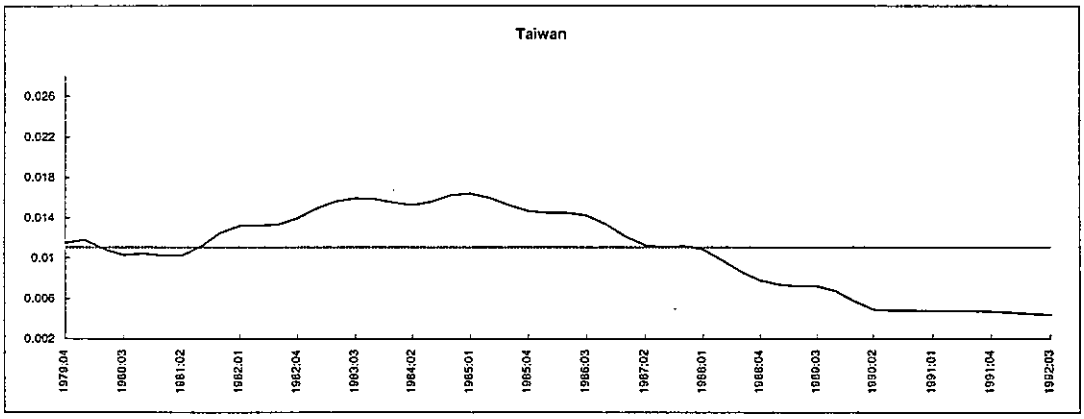
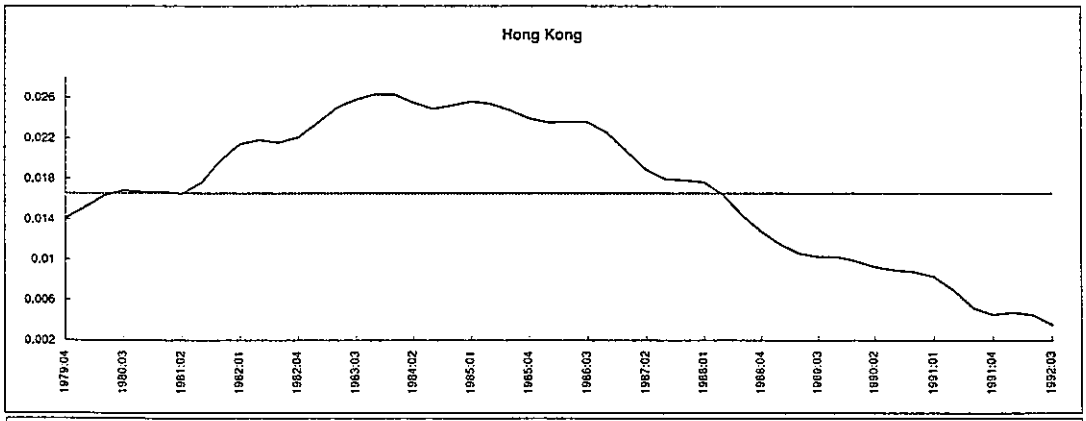


Figure 4. (continued) Moving Real GDP Volatility
Proportional deviations from HMA trend









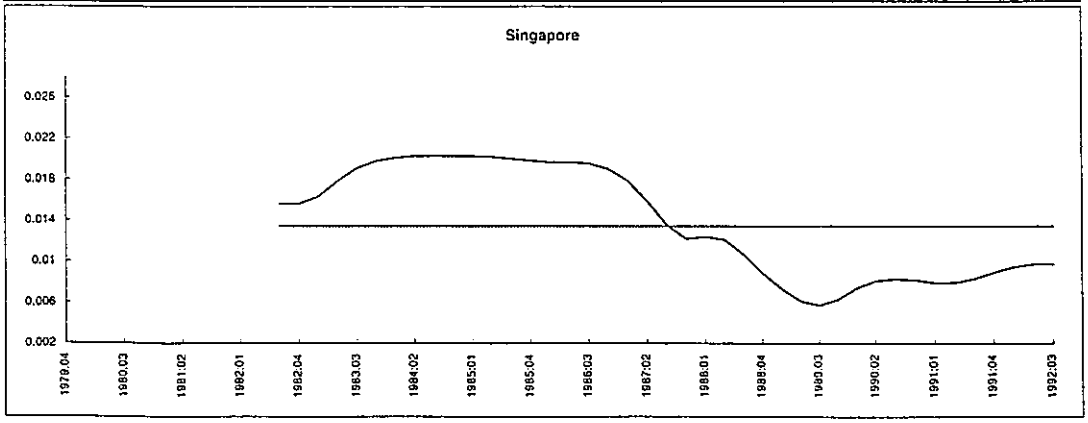


Figure 5. Moving Synchronisations of New Zealand's Real GDP
Cross correlations, HMA deviations from trend

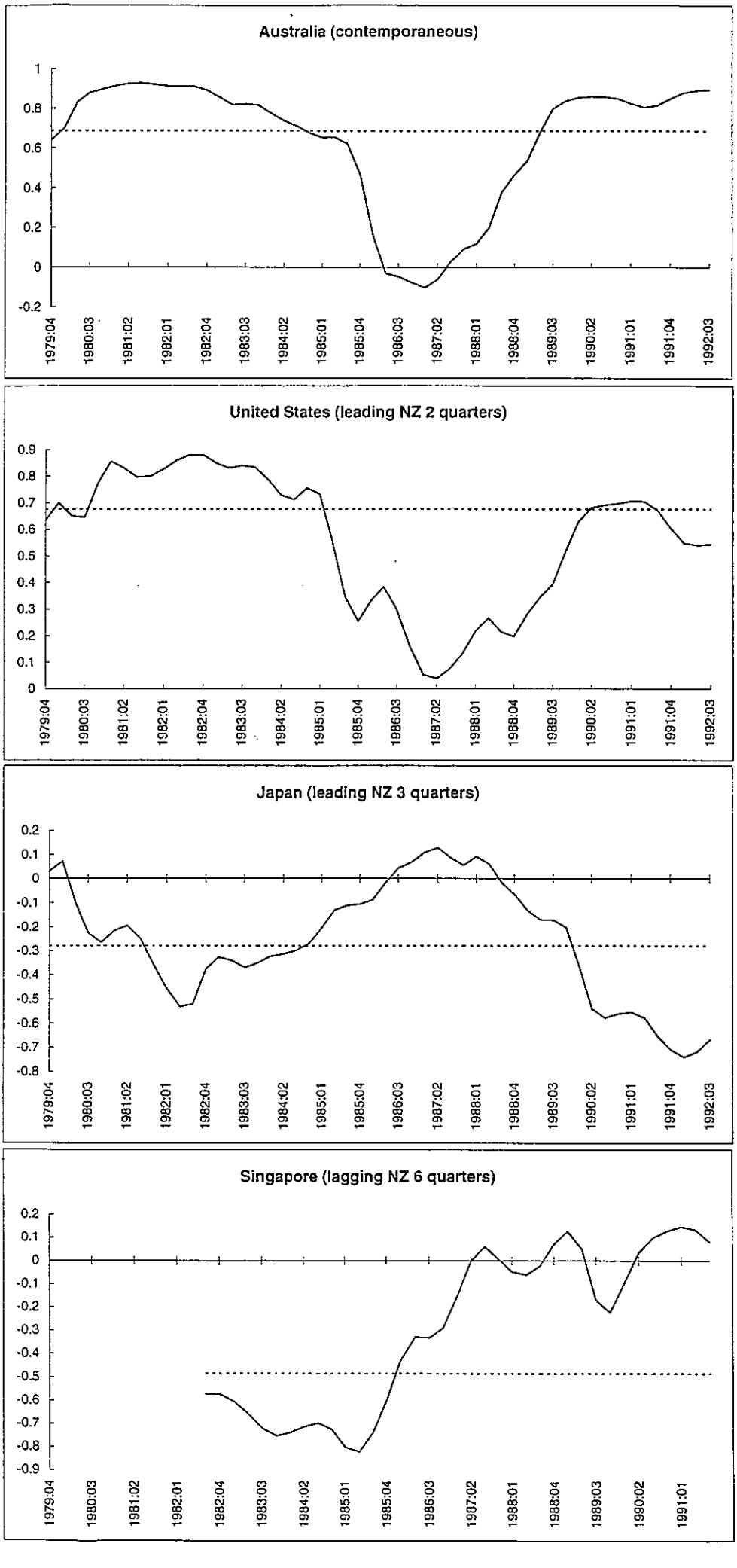
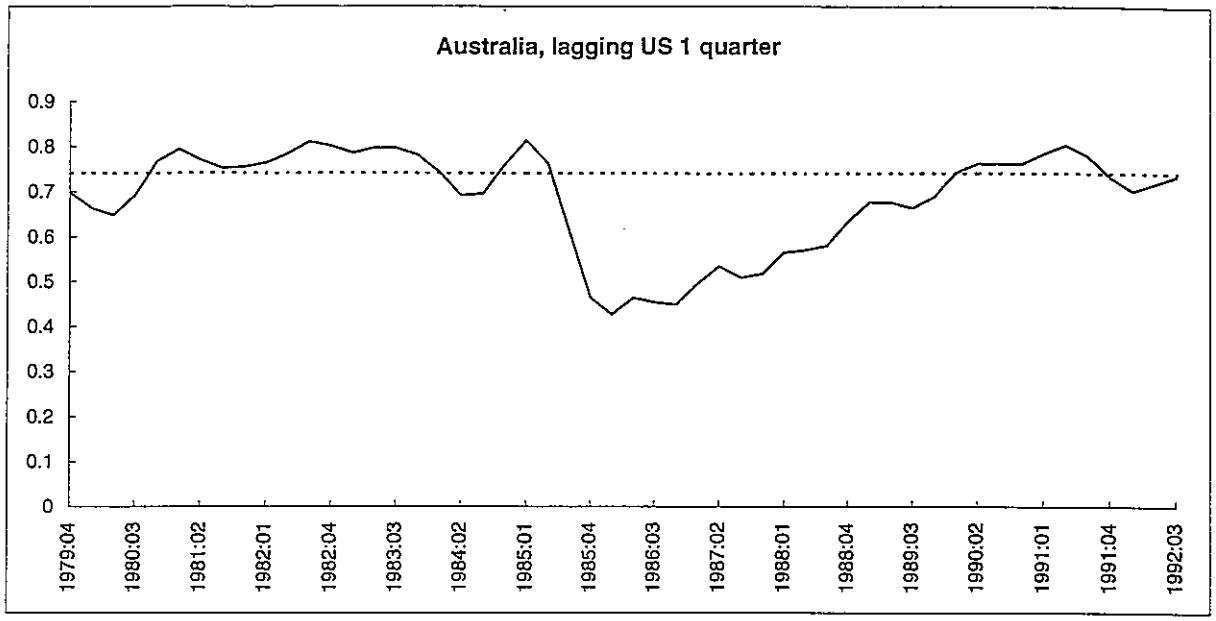
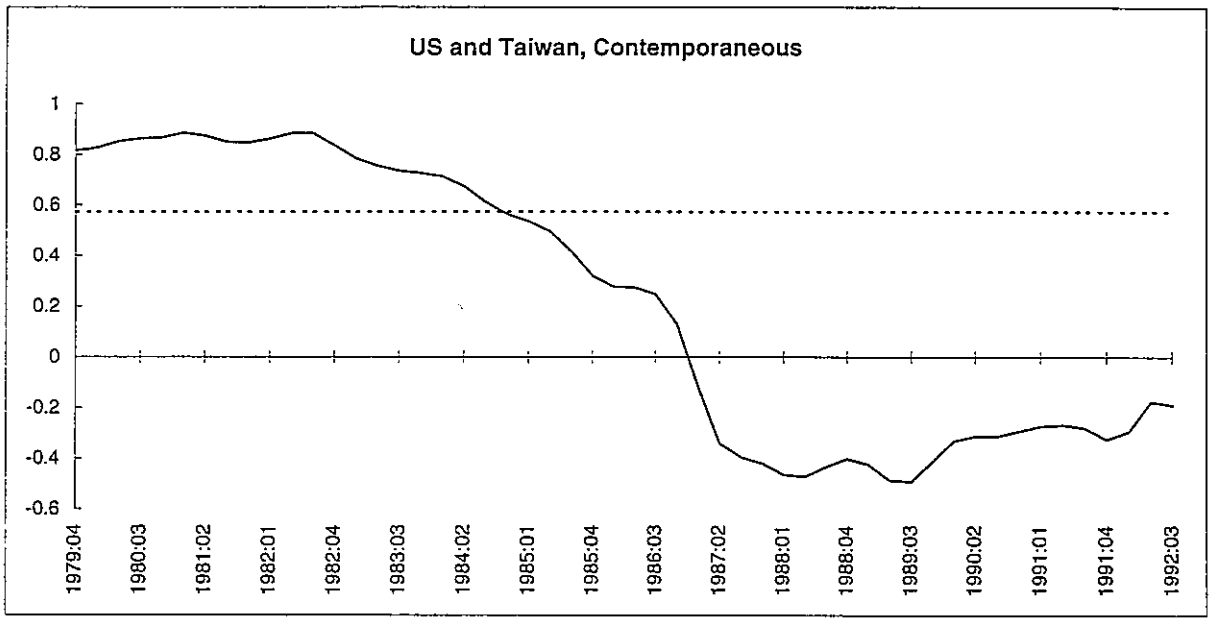
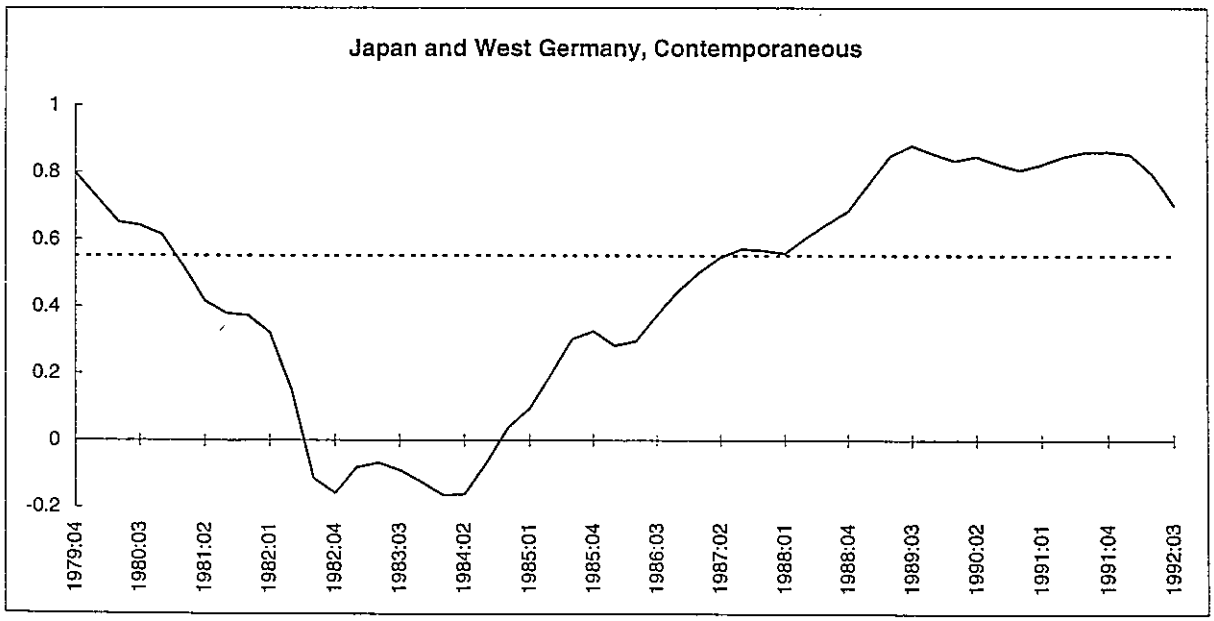


Figure 6. Moving Real GDP Synchronisations between Major Trading Partners of New Zealand
Cross correlations, HMA deviations from trend







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