

# When China sneezes, does Australia need to catch a cold?

James Laurenceson\* and Kam Ki Tang, When China sneezes, does Australia need to catch a cold? East Asia Economic Research Group Discussion Paper No. 19, February 2009, School of Economics, The University of Queensland. Queensland.

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## ***Abstract***

*Australia's macroeconomic dialogue is replete with references to the economy's fortunes being crucially linked to China. While previous studies have investigated the extent to which Australia's business cycle is synchronized with those of other countries, notably the US and Japan, none have considered China, despite this being a matter of policy importance. This paper seeks to address this gap in the literature. The main finding is that while there is evidence of increased business cycle synchronization between Australia and China during the 2000s, perspective is called for because the period of investigation is limited in duration and measures of synchronization remain lower than what has been recorded previously vis-à-vis other countries, especially the US. The paper concludes by briefly discussing the likelihood that Australia's business cycle will become increasingly synchronized with China's in the future.*

**JEL classifications** – E32, F15

**Keywords:** Australia, China, Business Cycle synchronization

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## 1. Introduction

“It used to be said that when the US economy sneezed, the rest of the world caught a cold. That is no longer the case. While still the world's biggest economy, the US is just not that important any longer, particularly not for Australia. We are now a Sino-economy. That is, our economic fortunes are now dependent upon China, not the US. And should China sneeze, then we will really know it.”

*The Courier Mail (2008)*

As a medium-sized economy that is open to international trade and capital flows, economists have long considered Australia's economic fortunes to be crucially linked to developments abroad. The fact that during 2008 growth in Australia fell below trend in response to a credit crisis born in the US and to those origins Australia had little direct exposure served as another reminder of Australia's international interdependency. Such observations have given rise to the hypothesis that Australia's business cycle might in fact to a large extent reflect developments amongst its leading trade and investment partners. Empirical studies that have investigated this hypothesis have found that Australia's business cycle is particularly synchronized with the US's, although this is not a static state of affairs. For example, Andrews and Kohler (2005) found that over the period 1983Q1-2001Q4, the correlation coefficient between the cyclical component of GDP in Australia and the US was extremely high at 0.82. However, over the period 1963Q1-1982Q4, it was equal to just 0.02. The opposite is evident in relation to Japan; in the earlier period the correlation coefficient was equal to 0.49, while in the latter period it was just 0.07. One does need to be cautious in interpreting findings of synchronization as being the outcome of a causal relationship. For example, Crosby and Bodman (2005) argue that the high level of synchronization between Australia and the US during the 1980s and 1990s was most likely the result of coincident shocks, particularly the two monetary policy-induced recessions in the early 1980s and 1990s. Therefore, they saw no particular reason why it would persist in the future. Whatever the drivers were, Andrews and Kohler (2005) observe that by the 2000s, the high level of synchronization vis-à-vis

the US had come to be viewed by many economists as a stylized fact and it was exploited in numerous macroeconomic models of the Australian economy (see, amongst others, Dungey and Pagan, 2000).

While the US still looms large in Australia's macroeconomic dialogue, its influence is no longer viewed as being singularly preeminent. There have been suggestions that the US's role in deciding Australia's economic fortunes has come to be rivaled, or perhaps even surpassed, by China. During the 1980s, some economists, such as Garnaut (1989), claimed that the economic reforms that began in China in 1979 had the potential to have a profound impact on the Australian economy. However, the view that Australia might actually have become "coupled" to China only really began to gain in popularity in 2001. It was in that year that the Australian economy shrugged off a recession in the US. This was noteworthy because on the previous two occasions the US had gone into recession, respectively in the early 1980s and the early 1990s, Australia was quick to follow. Since then, China's stature in the Australian economy has grown immensely. China is now Australia's number one trading partner with the value of exports to China being more than two and a half times the value of exports to the US (Table 1). China currently still trails Japan as an export destination, although given current growth rates it seems likely that China will overtake Japan within the next five years. China's rise has been significant not only in the Australian context, but also in the global context; in 2008, China overtook Germany to become the world's third largest economy, following only the US and Japan.

### **Table 1 here**

In stark contrast to the prominence China receives in Australia's macroeconomic dialogue, which will be reviewed in the following section, is the fact that it has yet to be included in empirical studies that investigate the extent to which Australia's business cycle is synchronized with other countries. For example, Andrews and Kohler (2005) and Crosby and Bodman (2005) focused solely on synchronization vis-à-vis other OECD

economies with particular attention given to the US.<sup>1</sup> Given that until the 2000s OECD economies dominated global economic output and were Australia's leading export destinations and sources of foreign investment, this is perhaps understandable. However, in light of China's emergence, the time is ripe to address this gap in the literature. Understanding the extent to which Australia's business cycle is synchronized with China's is of policy importance. Specifically, it would help to gauge whether a policy response will be needed in the face of changing economic conditions in China. It is also useful in estimating the risk exposure of the Australian economy to country specific shocks and the possibility of diversifying this risk.

The rest of the paper is organized as follows. Section 2 highlights the prominence China receives in Australia's macroeconomic dialogue. Section 3 presents the methodology and data used to investigate the extent to which Australia's business cycle is synchronized with China's. Section 4 presents and discusses the results. Section 5 concludes by way of briefly commenting on the likelihood that Australia's business cycle will become increasingly synchronized with China's in the future.

## **2. China in Australia's macroeconomic dialogue**

One might think that the events of 2008 would have had the effect of focusing attention on the US in the discussion of Australia's international interdependencies. However, a reading of the economic commentaries over the past year suggests that the global credit crisis has, at least in the case of Australia, served to heap attention on China in equal measure. According to the National Bureau of Economic Research, the US entered 2008 in recession. Yet, into the second quarter of 2008, Australia stood out amongst OECD economies in having a government and a central bank that were concerned with an inflation outbreak. In April, it was reported that Reserve Bank of Australia (RBA) board member, Warwick McKibbin, and Australian Commonwealth Government Treasury Chief Economist, David Gruen, contended that in their estimation the biggest challenge

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<sup>1</sup> Crosby and Bodman (2005) mention the rise of China and the possibility of business cycle synchronization by way of closing. However, China does not feature in their empirical analysis.

the economy would face in 2008 was not a recession in the US but rather how the inflationary effects of the rising terms of trade resulting from China's demand for Australia's resources exports should best be managed (*The Australian*, 2008). This view was echoed by the Governor of the RBA, Glenn Stevens, in a speech to Australian Commonwealth Government Treasury officials:

“We have been living through one of the largest transformations in the structure of the global economy, as far as Australia is concerned, for a century. The rise in the terms of trade over the past five years is the biggest such event since the Korean War boom in the early 1950s. But while the Korean War event was a temporary one, all the indications are that the rise of China is not just a cyclical event, but a structural change of the first order...In essence, we are seeing a very large change in relative prices in the world economy, and a relative price change that is more important to Australia, in particular, than to almost any other country....Because the event is, overall, *very expansionary* [emphasis added], it was always likely to be associated with some risk of higher inflation.”

Stevens (2008)

By mid-2008, the US had been joined in recession by Japan and the EU. A decade earlier, the US, Japan and the EU simultaneously being in recession would have been considered entirely fatal for the Australian economy. Yet, in their mid-year *Economic Outlook*, the OECD considered that,

“...the weakening economic situation in the OECD should be cushioned in Australia's case by the persisting strength of the Chinese economy”.

OECD (2008)

GDP growth in China had slowed in 2008, but even by the third quarter it remained at a relatively robust rate of 9.0 percent (in year on year terms). In their subsequent end-of-year *Economic Outlook*, the OECD was still forecasting Australia's real GDP to grow by 2.5 percent in 2008 and 1.7 percent in 2009 (OECD, 2008). Such forecasts were clearly far more in keeping with the growth slowdown being experienced in China than the recession being experienced in the US, the EU and Japan.

The first negative growth forecast for Australia from a peak institution came at the end of January 2009 with the IMF predicting -0.2 percent growth for the year. This forecast came on the back of the release of China's fourth quarter GDP growth figure, which fell to 6.8 percent. As *The Economist* (2009b) noted, while still sounding relatively robust, this year on year growth figure implied that China's economic growth between the third and fourth quarters on a seasonally adjusted basis was virtually zero. Also, new trade data revealed China's imports to have fallen by 21 percent in the 12 months to December (*The Economist*, 2009a). In responding to the new data, Australian Commonwealth Government Treasurer, Wayne Swan, commented:

“What Australia now faces is the prospect of a shrinking US economy and China not growing anything like it was expected to...China is absolutely critical to our economic fortunes and the outlook now certainly is of concern.”

*The Weekend Australian* (2009)

Before moving on to an empirical analysis of business cycle synchronization between Australia and China, it is helpful to consider what transmission channels might be involved. In contrast with the US, shocks in China can realistically pass through to Australia mainly via the channel of exports. At the end of 2007, Australian Bureau of Statistics data show that China's share of the stock of foreign investment in Australia stood at just 0.38 percent of the total. While the US significantly lags China as an export destination, it is Australia's leading source of foreign investment, accounting for 28.87 percent of the total. Besides, the fact that the capital accounts of Australia and the US are fully convertible means that capital movements in and out of Australia are much more responsive to changes in interest rates and other financial parameters in the US than those in China, whose capital account is still characterized by tight controls. Given a reliance on the export channel, synchronization between Australia and China should not simply be assumed based on a compelling narrative. If exports were important as a channel for business cycle transmission, then one might expect to find particularly strong evidence of synchronization vis-à-vis Japan given that it has been Australia's number one export

destination for many decades.<sup>2</sup> In fact, exports to Japan are also dominated by natural resources, as they are to China (Table 1). As noted earlier however, while Australia's business cycle showed signs of being synchronized with Japan during the 1970s, this all but disappeared during the 1980s and 1990s. Studies that have used international cross-sectional data to shed light on the factors that result in business cycle synchronization between countries also suggest that once other factors are controlled for, such as industrial structure, the effect of inter-industry trade – the type of trade that takes place between Australia and China – on synchronization appears to be positive, but modest in magnitude (e.g., Imbs, 2004).

### 3. Methodology and data

There are several measures of synchronization that can be found in the literature. In this paper we use two of the most popular. The first one calculates the extent of correlation between the cyclical components of aggregate output series. The second one calculates the extent of co-movement in cycles based on the phase switching points of the cycles.

For the first method, the cyclical component of aggregate output series is typically extracted using some sort of data filter. In this paper we use the Hodrick-Prescott (H-P) filter. The H-P filter is a smoothing algorithm whereby the smoothed component of the series is taken to represent the trend. The cyclical component of aggregate output series can then be expressed in the form of output gaps, i.e., the percentage deviation from the trend. Ideally, aside from the H-P filter, we would also like to extract the cyclical component of aggregate output series using alternative filters in order to test the robustness of the results to the de-trending procedure. However, another popular filter used in the literature, the band-pass frequency filter, requires that both ends of the sample be truncated. Given that our period of investigation is not overly long to begin with (discussed below), truncation is best avoided.<sup>3</sup>

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<sup>2</sup> According to ABS data, as of 2007, Japan also held a 3.47 percent share of the total stock of foreign investment in Australia. Thus, shocks in Japan might also pass through to Australia via financial channels.

<sup>3</sup> We did, however, extract the cyclical component of aggregate output series using a Baxter-King band-pass filter and calculate the correlation coefficient between the band-pass filtered series and the H-P filtered series during the period for which estimates were available from both filters (1998Q1-2005Q3). The

Largely for theoretical reasons, although also for reasons of data availability, we limit our analysis to the period 1995Q1 to 2008Q3, a total of 55 quarters. Prior to 1995, China's share of Australia's exports was less than 5 per cent of the total. Moreover, there was almost a complete absence of any financial linkages between the two countries. Thus, undertaking an empirical analysis of business cycle synchronization prior to 1995 would be lacking in theoretical justification. The full period of investigation (1995Q1-2008Q3) is also divided into two sub-periods (1995Q1-2001Q4 and 2002Q1-2008Q3) in a bid to shed light on whether there have been any changes in synchronization over time. Given the rise of China as an export destination for Australia, one might expect to see evidence of stronger synchronization in the second sub-period. While not being overly long, the period 1995Q1-2008Q3 includes several notable macroeconomic events, including the Asian financial crisis in 1997-1998, China's growth surge following its WTO entry in 2001, as well as most recent growth slowdown consequent to the global credit crunch.

The aggregate output series used for Australia is seasonally adjusted, quarterly real GDP. This series is drawn from the database, *SourceOECD*. For China, two aggregate output series are used. The first is seasonally adjusted, quarterly real GDP. The second is seasonally adjusted, quarterly real industrial output. The latter series is included because it could be argued that GDP is too broad a measure of aggregate output, particularly in terms of Australia's connectedness to China. Specifically, growth in China's agricultural or services sectors might not spur growth in the demand for Australia's exports to nearly the same extent as growth in the industrial sector given that most of Australia's exports to China are resources used as inputs in industrial processes. Unlike OECD economies, China does not have long history of publishing GDP data at a quarterly frequency. Estimates from China's National Bureau of Statistics are available since 1999 and are reported in various publications such as *China's Monthly Statistics* and *China Data Online*. Data for the period 1995-1998 is taken from Abeysinghe and Rajaguru (2004), who source it from publications such as *The People's Bank of China Quarterly Statistical*

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correlation coefficient between the filtered series for Australia's GDP, China's GDP, China's industrial output, US GDP and Japan's GDP was 0.92, 0.86, 0.95, 0.97 and 0.91, respectively. Thus, we do not anticipate any significant bias in our results as a result of using the H-P filter.

*Bulletin*. Prior to 1995, Abeysinghe and Rajaguru (2004) construct a GDP series for China at a quarterly frequency using a modified version of the Chow-Lin procedure. However, in view of its constructed nature, and the fact that there is little theoretical justification for investigating business cycle synchronization between Australia and China prior to the mid-1990s, we elect not to use this data. GDP data for China is originally in seasonally unadjusted form and so we adjust it using the US Census Bureau's X12 technique. China's quarterly real industrial output series is obtained from two sources. The IMF publication, *International Financial Statistics* (line 66), provides the growth rate in industrial output (at comparable prices), while the level of industrial output (at current prices) can be found in *China's Monthly Statistics* and *China Data Online*. Once the real series is constructed, it is then also seasonally adjusted using the X12 technique.

In interpreting estimated correlation coefficients, there is a challenge of finding appropriate benchmarks, i.e., how high does the correlation coefficient need to be in order to be indicative of meaningful synchronisation? We use two benchmarks. The first one is whether the correlation coefficient is statistically different to zero. The second one is how the value of the correlation coefficient between Australia and China compares with those between Australia and the US, and Australia and Japan, respectively. The aggregate output series used for the US and Japan are the same as that used for Australia, i.e., seasonally adjusted, quarterly real GDP, and are also drawn from the database, *SourceOECD*.

The second measure of synchronization we use is Harding and Pagan's (2002) concordance index. The concept of concordance relates to the extent of co-movement in cycles by focusing on the phase switching points. Business cycles consist of two phases - periods above and below a trend, respectively.<sup>4</sup> This allows them to be represented using a binary series whereby a value of 1 is assigned to periods (quarters) when aggregate

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<sup>4</sup> This is the "modern" conceptualization of the business cycle. The alternative is the "classical" conceptualization. The classical conceptualization also features two phases but without reference to the trend. The first phase consists of periods of positive growth. The second phase consists of periods of negative growth (see Harding and Pagan, 2002)

output is above the trend and a value of 0 when it is below the trend.<sup>5</sup> The mean of the binary series therefore shows the proportion of sample periods that the series is in an above-trend state, which will tend to 0.5 over a sufficiently long time horizon if the cycle phases are symmetric. If the binary series for two countries,  $X$  and  $Y$ , are denoted by  $S_{X_t}$  and  $S_{Y_t}$ , then a concordance index,  $\hat{I}$ , can be calculated as:

$$\hat{I} = 1 + 2\hat{\sigma}_{S_X S_Y} + 2\hat{\mu}_{S_X}\hat{\mu}_{S_Y} - \hat{\mu}_{S_X} - \hat{\mu}_{S_Y} \quad (1)$$

where  $\hat{\mu}_{S_X}$  is the mean of  $S_{X_t}$ ,  $\hat{\mu}_{S_Y}$  is the mean of  $S_{Y_t}$ , and  $\hat{\sigma}_{S_X S_Y}$  is the covariance between  $S_{X_t}$  and  $S_{Y_t}$ . This index is bounded between zero and one: a value of 0.9 means that two countries are in the same cycle phase for 90 percent of the periods in the sample. Periods above and below the trend are identified using the H-P filter. In addition to calculating the concordance index value we also calculate a benchmark value. The benchmark value is calculated by setting the covariance in the above equation equal to zero. Thus, if the business cycle phases are symmetric and so  $S_{X_t}$  and  $S_{Y_t}$  had means of 0.5, then the benchmark value would be equal to 0.5. If  $X$  and  $Y$  are independent of each other, they would by pure chance be in the same cycle phase for 50 percent of the periods in the sample. In this case, the benchmark value for no synchronization would be 0.5. If  $S_{X_t}$  and  $S_{Y_t}$  had means different from 0.5, the benchmark value would change accordingly. In light of this, a concordance index value of, say, 0.52 would not provide convincing evidence of synchronization when it is benchmarked against a value of 0.5. On the other hand, a concordance index value of, say, 0.8, would be far more convincing.

## 4. Results

### 4.1 Correlation

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<sup>5</sup> Other requirements could also be imposed on the binary series. For example, one could require that a cycle phase must consist of at least  $n$  consecutive periods of aggregate output being above or below the trend. This paper simply uses an unadjusted binary series.

Figure 1 shows the GDP output gap series for Australia and China. While not wanting to read too much into a simple eyeballing of the data, there do appear to have been periods of synchronous movements in business cycle phases. For example, in 1998, positive output gaps simultaneously opened in both countries, and again in 2007. Figure 1 also shows that despite the fact that the two sub-periods being analyzed are relatively short in duration, there is considerable volatility in both series, which is desirable in terms of assessing the extent of correlation, and with the exception of China in the second sub-period, there are also several phase switches in each sub-period, which is desirable in terms of assessing the extent of concordance. Table 2 shows the correlation coefficients between output gaps series. We calculate correlation coefficients both on a contemporaneous and lagged basis.<sup>6</sup> This is in recognition of the fact that output innovations in China, the US and Japan may not impact on Australia in the same period.

**Figure 1 here**

**Table 2 here**

For all three countries for all periods, with the exception of Japan during 1995Q1-2008Q3 and during 1995Q1-2001Q4, correlation coefficients appear higher on a contemporaneous than lagged basis and hence we focus our discussion on these. Two comments on the results in Table 2 seem particularly relevant. The first is that the degree to which Australia's business cycle is synchronized with China, the US and Japan varies markedly over the period of investigation. Existing studies mostly show that the degree of synchronization vis-à-vis the US and Japan also varied markedly in periods prior to 1995. Taking the US as an example, over the entire period the correlation coefficient is 0.41, which is significant at the 1 percent level. However, the correlation fell sharply from 0.54 in the first sub-period, which is significant at the 1 percent level, to 0.18 in the second sub-period, which is insignificant. When reading in conjunction with the findings of existing studies, the results in Table 2 suggest that it may be inappropriate to view Australia's economic fortunes as being predominantly linked to developments in any

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<sup>6</sup> Table 2 shows correlation coefficients allowing for lagged effects up to two quarters. Correlation coefficients were also calculated allowing for lagged effects up to four quarters. However, lags beyond two quarters did not show any evidence of increasing correlation and so are not reported.

single country, even ones as large as China, the US and Japan, over a long time horizon. This is perhaps not surprising given that Australia is a medium-sized economy with exports of goods and services only accounting for one quarter of GDP. In the case of economies such as Hong Kong, SAR and Singapore, the ratio is more than 200 percent. The second comment is that there does appear to be some evidence of greater synchronization between Australia and China in the second sub-period. During the first sub-period, the correlation coefficient between the cyclical component of Australia's GDP and China's GDP is 0.15, which is statistically insignificant. In the second sub-period, the degree of correlation more than doubled to 0.32, which is significant at the 10 percent level and only narrowly misses being significant at the 5 percent level. It is also higher than the corresponding figure for the US (i.e., 0.18). A similar story is evident between Australia's GDP and China's industrial output, except in this case the correlation coefficient in the second sub-period is statistically significant at the 5 percent level. This tentatively suggests that either China's GDP cycles are largely attributable to fluctuations of its industrial output rather than agricultural or services output, or the business cycles of the three sectors themselves are highly synchronized. The degree of synchronization vis-à-vis Japan changes even more dramatically. During the first sub-period, the correlation coefficient is actually negative and significant at the 1 percent level.<sup>7</sup> During the second sub-period, it is positive and significant at the 1 percent level, and higher in magnitude than the corresponding values for either China or the US.

While the results in Table 2 are indicative of the emergence of business cycle synchronization between Australia and China, some perspective regarding the extent of this synchronization is in order. Firstly, over the entire period of investigation, the correlation coefficient between Australia's GDP and China's GDP and industrial output is only statistically significant at the 10 percent level. The second sub-period, in which statistical significance approaches the 5 percent level, is relatively short, consisting of just 27 observations. Thus, the conclusion of an emergent synchronization begs re-examination as additional data becomes available. Secondly, while the correlation coefficient more than doubled between the first and second sub-periods, and was higher

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<sup>7</sup> The strong negative correlation between the business cycles of Australia and Japan during the 1990s has been noted in other studies such as Crosby and Bodman (2005) and defies any obvious explanation.

than the US in the latter period, its absolute value is still much lower than what has been observed vis-à-vis other countries in previous periods. As noted earlier, Andrews and Kohler (2005) found the correlation coefficient between the cyclical component of Australia's GDP and that of the US during the period 1983Q1-2001Q4 to be 0.82. Thus, the strength of synchronization vis-à-vis China that is implied by the likes of the quote that opens this paper appears somewhat exaggerated, at least for the time being.

#### *4.2 Concordance*

Table 3 shows the concordance index values. The benchmark values were either 0.5 or extremely close to 0.5 and hence these are not reported. The results using the measure of concordance are largely consistent with those in Table 2 based on correlation.

Concordance index values are again generally higher on a contemporaneous rather than lagged basis and so we focus on these. The concordance between Australia's GDP series and China's GDP and industrial output series rose from 0.54 and 0.57, respectively, in the first sub-period, to 0.70 in the second sub-period. The concordance vis-à-vis Japan rose from 0.32 to 0.70 during the two period, while that vis-à-vis the US fell from 0.68 to 0.41.

#### **Table 3 here**

#### *4.3 Discussion*

While Crosby and Bodman (2005) provide a possible explanation for the fall in business cycle synchronization between Australia and the US, how might the increase vis-à-vis China (and Japan) during the same period be explained? First of all, we can probably rule out the scenario that the change in synchronization between Australia on the one hand and China and Japan on the other is a result of global business cycles, because if that were the case, then we would expect to observe the same pattern between China, Japan and the US themselves and this is not the case (see referee's Appendix Table 1). As noted in section 2, in the absence of financial linkages any explanation of synchronization between Australia and China is likely to be related to the export channel. Figure 2 shows the value of Australia's exports to China and Japan, expressed as a percentage of nominal

GDP. It can be seen that the value of Australia's exports to China rose rapidly during the second sub-period, from 0.97 percent in 2002Q1 to 3.06 percent in 2008Q3.

**Figure 2 here**

However, business cycle synchronization does not automatically result from having reached some threshold level of export exposure to a particular country. Figure 2 shows that the value of Australia's exports to Japan was already equal to 3 percent of GDP at the start of the first sub-period and yet Table 2 and 3 show that Australia's business cycle was not synchronized with Japan's during this time. A more pertinent consideration might be as follows - after having reached some threshold level of exposure, how then does the value of exports *change* from period to period? It is, after all, the change in export value that contributes to the change in GDP. Changes in export value can be broken into volume and price changes. It is instructive to consider two product groups that are of particular relevance to Australia's exports: (1) metal ores and minerals, and (2) coal, coke and briquettes. In the latest month for which Australia Bureau of Statistics data are available, December 2008, these product groups accounted for 22.1 percent and 25.7 percent of the total value of Australia's merchandise exports. These two groups also dominate Australia's exports to China and Japan (Table 1). Figure 3 presents indices of the volume and price of metal ores and minerals exports and Figure 4 does likewise for coal, coke and briquettes exports. It can be seen that in both cases the volume of exports displayed a fairly steady rate of increase throughout the period of investigation. However, what changed in the second sub-period, particularly since 2005, was that prices increased at a far greater rate. It is worthwhile noting that at least in the case of metal ores and minerals, China's demand and the world price are not independent. China has, in the terminology of trade theory, taken on the "large country" status. For example, by 2007 China had become by far the world's largest importer of iron ore, accounting for 46 percent of the total, followed by the EU with 21 percent (RBA, 2009). This means that changes in China's demand can cause particularly large changes in the value of Australia's resources exports as rising / falling volumes will typically be associated with rising / falling world prices. Given that Australia's exports to Japan are also dominated by resources, the increase in world prices since 2005 also means that Japan's import

demand will give rise to a similar boosting effect to Australia's aggregate output. This may explain why the degree of synchronization vis-à-vis Japan made a 180 degree turn in the second sub-period compared with the first sub-period.

Another key element in understanding the synchronization of Australia's business vis-à-vis China's is the extraordinarily high level of resources intensity of China's industrial production. The World Bank (2009) notes that China's "metals intensity" – the quantity of metals used per unit of GDP – is 7.5 times as high as in high-income countries and 4 times as high as in other developing countries. This implies that, a one dollar increase in output in China will translate into a much greater rise in demand for Australia's exports than a one dollar increase in output in Australia's other trading partners.

**Figure 3 here**

**Figure 4 here**

The increase in world resources prices has been sufficiently large to drive Australia's overall terms of trade, which as of 2008 stood at heights unprecedented in the post-WW2 period. An increase in the terms of trade essentially constitutes an income transfer to Australia from the rest of the world. Given that exports account for around one fifth of GDP, each 10 percent increase in the terms of trade translates into a two percent increase in national income. Being a relative price measure, changes in the terms of trade have no direct impact on volume measures of aggregate output such real GDP. However, it can have significant indirect impacts. For example, economic activity in the resources sector might be invigorated as projects become viable due to higher world prices, or broader economic activity might be stimulated as a result of stronger income growth and greater government spending funded by higher resources royalties. However, as noted by RBA (2005), the impact of the terms of trade on economic activity will depend crucially on the response of the exchange rate. If the Australian dollar appreciates as the terms of trade increase, then the domestic currency price of total exports will be more or less unchanged. Any income gains to commodity exporters will be offset by income losses to other exporters. Since Australia floated the dollar in 1983, there has been a tendency for the

exchange rate and terms of trade to move in the same direction (De Roos and Russell, 2002). Figure 5 shows this tendency has continued into the 2000s, albeit since the middle of 2005 the increase in the terms of trade has been more dramatic than the increase in the exchange rate.

**Figure 5 here**

## **5. Conclusion**

This paper put the widely held perception that Australia's economic fortunes are significantly linked to developments in China to the empirical test. We assessed the extent of business cycle synchronization evident between Australia and China using two different measures – correlation and concordance – and compared the findings with the extent of synchronization displayed vis-à-vis the US and Japan. The investigation covered the period 1995Q1 to 2008Q3. Prior to 1995, there was a lack of theoretical channels through which business cycle synchronization between Australian and China might result and also no official estimates of GDP at a quarterly frequency for China. We found that the two measures of synchronization give very consistent results. Firstly, the synchronization between Australia on the one hand, and China, the US and Japan on the other, is stronger on a contemporaneous than lagged basis. This indicates that any shocks that are transmitted from these countries to Australia are transmitted quickly, if at all. Secondly, periods of synchronization or lack thereof are evident vis-à-vis China, the US and Japan over the full sample. This implies that suggestions that Australia's economic fortunes are crucially linked to developments in any single country over the longer time horizon should be viewed cautiously. Thirdly, there is some evidence of rising synchronization vis-à-vis China during the second half of the period of investigation. We provided other evidence suggesting that this finding is likely to be related to China's rising influence on world commodity prices and thus Australia's terms of trade, in conjunction with the growing volume of resources exports in the 2000s.

What does all this mean for the future of business cycle synchronization between Australia and China? Much depends upon whether the volume of resources exports will

continue to grow as it has during the 2000s and whether the prices of resources exports will remain at historically high levels. There are divergent perspectives on this. A study by Garnaut and Song (2006) contends that the trend rate of growth in China's demand for resources will remain high chiefly because of its stage of industrialization. Using international, cross-sectional data, they show that there is a positive correlation between steel consumption per capita and GDP per capita. Presently, China's GDP per capita and steel consumption per capita are still low compared with its neighbors, such as Japan, Korea and Taiwan. Thus, they also expect that the world price for resources will remain at historically high levels because of China's status as a large country in world resources markets, albeit increased supply might see prices fall from their recent highs. This view appears to accord with the contention by RBA Governor Glenn Stevens quoted earlier that China's industrialization has generated a structural change in the relative price of traded goods in favor of those countries that export resources such as Australia. If the above contentions are correct, they suggest that Australia's business cycle will become increasingly synchronized with China's. This is because booms in China will result in the volume of resources exports rising above their trend growth rates, and perhaps more importantly, resources prices also rising, thus leading to large increases in the value of Australia's exports. Slowdowns in China will be accompanied by modest, stagnant or negative growth in export volumes, and falling prices, thus likely resulting in falls in the value of Australia's exports. However, the World Bank (2009) notes that several other factors might moderate China's demand for resources in the future. In particular, the World Bank (2009) predicts that China's metal intensity is set to decline, notably because they expect investment rates to fall and market mechanisms to provoke an increase in efficiency in a similar fashion to that observed in other former centrally planned economies in Europe. In the longer term, another factor that might promote greater business cycle synchronization between Australia and China is the opening of China's capital account. While China's role as a source of capital for Australia is presently limited, in recent years there have been several high profile instances of Chinese entities seeking to bankroll projects in Australia's resources sector and there is good reason to think that China's role might grow given the global competition to secure stable supplies of resources (Laurenceson, 2008). Still, the large and frequent changes in the extent of

business cycle synchronization evident between Australia and the U.S and Japan suggest that one should be cautious in predicting that Australia's economic fortunes will predominantly be driven by any single country in the future, including China.

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**Table 1. Australia's exports to China, the US and Japan (2007-2008)**

	China	US	Japan
Export value (\$A million) (percent annual growth)	26927 (18.1)	10604 (8.2)	34936 (7.1)
Export share (percent of total exports)	14.9	5.9	19.3
Top four merchandise exports (by \$A value) <sup>1</sup>	<ul style="list-style-type: none"> <li>• Iron ore &amp; concentrates,</li> <li>• Wool &amp; other animal hair,</li> <li>• Copper ores &amp; concentrates,</li> <li>• Manganese ores &amp; concentrates</li> </ul>	<ul style="list-style-type: none"> <li>• Beef</li> <li>• Crude petroleum</li> <li>• Alcoholic beverages</li> <li>• Passenger motor vehicles</li> </ul>	<ul style="list-style-type: none"> <li>• Coal</li> <li>• Iron ore &amp; concentrates</li> <li>• Beef</li> <li>• Aluminium</li> </ul>
Value of top four merchandise exports (percent of total export value to this country)	59.2	30.2	55.9

Notes –

1. Exports to China include \$A3.8 billion in confidential items, mainly alumina, wheat and sugar, 14percent of total exports. Exports to the US include \$A1.7 billion in confidential items, mainly alumina, 16percent of total exports. Exports to Japan include \$A6.7 billion in confidential items, mainly LNG, nickel, wheat, sugar, 19percent of total exports.

Source – Department of Foreign Affairs and Trade

**Table 2. Correlation Coefficients Between Output Gap Series**

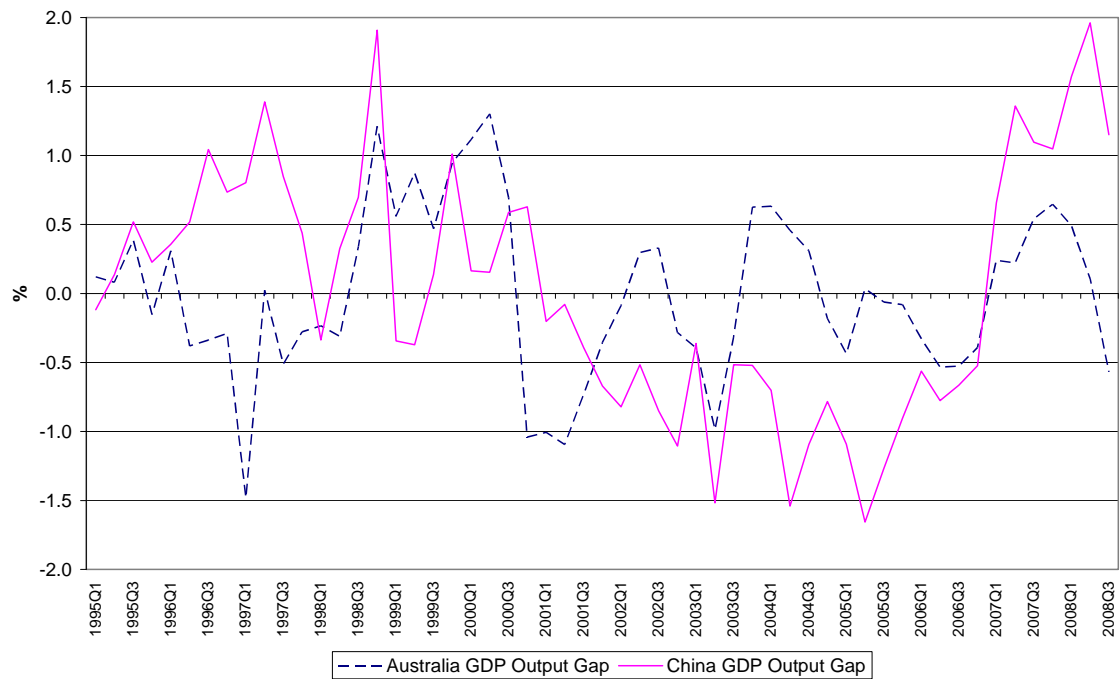
	China GDP	China industrial output	US GDP	Japan GDP
Lag = 0				
1995Q1-2008Q3	0.19*	0.21*	0.41***	(-)0.22
1995Q1-2001Q4	0.15	0.18	0.54***	(-)0.47***
2002Q1-2008Q3	0.32*	0.35**	0.18	0.54***
Lag = 1				
1995Q1-2008Q3	0.08	0.08	0.25**	(-)0.35***
1995Q1-2001Q4	(-)0.03	0.00	0.31	(-)0.59***
2002Q1-2008Q3	0.23	0.20	0.17	0.37**
Lag = 2				
1995Q1-2008Q3	0.07	0.06	0.07	(-)0.47***
1995Q1-2001Q4	(-)0.08	(-)0.03	0.11	(-)0.64***
2002Q1-2008Q3	0.25*	0.22	0.00	0.03

Note:

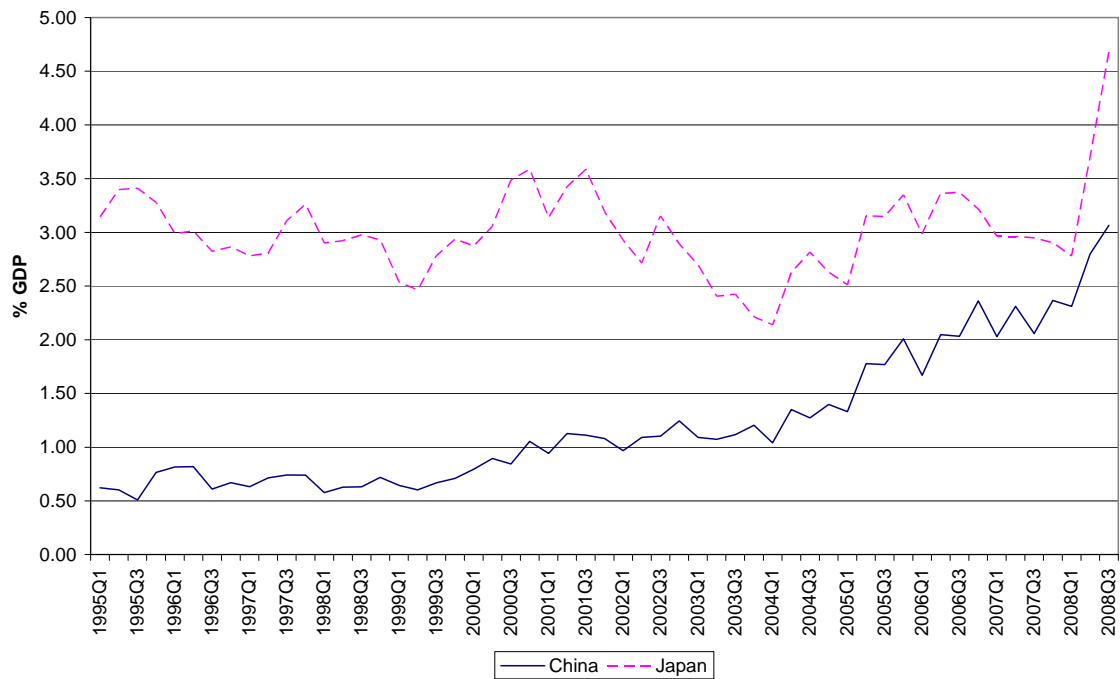
1. Statistical significance at the 10, 5 and 1 percent levels are denoted using \*, \*\* and \*\*\*, respectively.

**Table 3. Concordance Index for Aggregate Output Series**

	China GDP	China industrial output	US GDP	Japan GDP
Lag = 0				
1995Q1-2008Q3	0.62	0.64	0.55	0.51
1995Q1-2001Q4	0.54	0.57	0.68	0.32
2002Q1-2008Q3	0.70	0.70	0.41	0.70
Lag = 1				
1995Q1-2008Q3	0.57	0.59	0.52	0.44
1995Q1-2001Q4	0.48	0.52	0.63	0.26
2002Q1-2008Q3	0.67	0.67	0.41	0.63
Lag = 2				
1995Q1-2008Q3	0.53	0.58	0.53	0.38
1995Q1-2001Q4	0.42	0.54	0.58	0.19
2002Q1-2008Q3	0.63	0.63	0.48	0.56

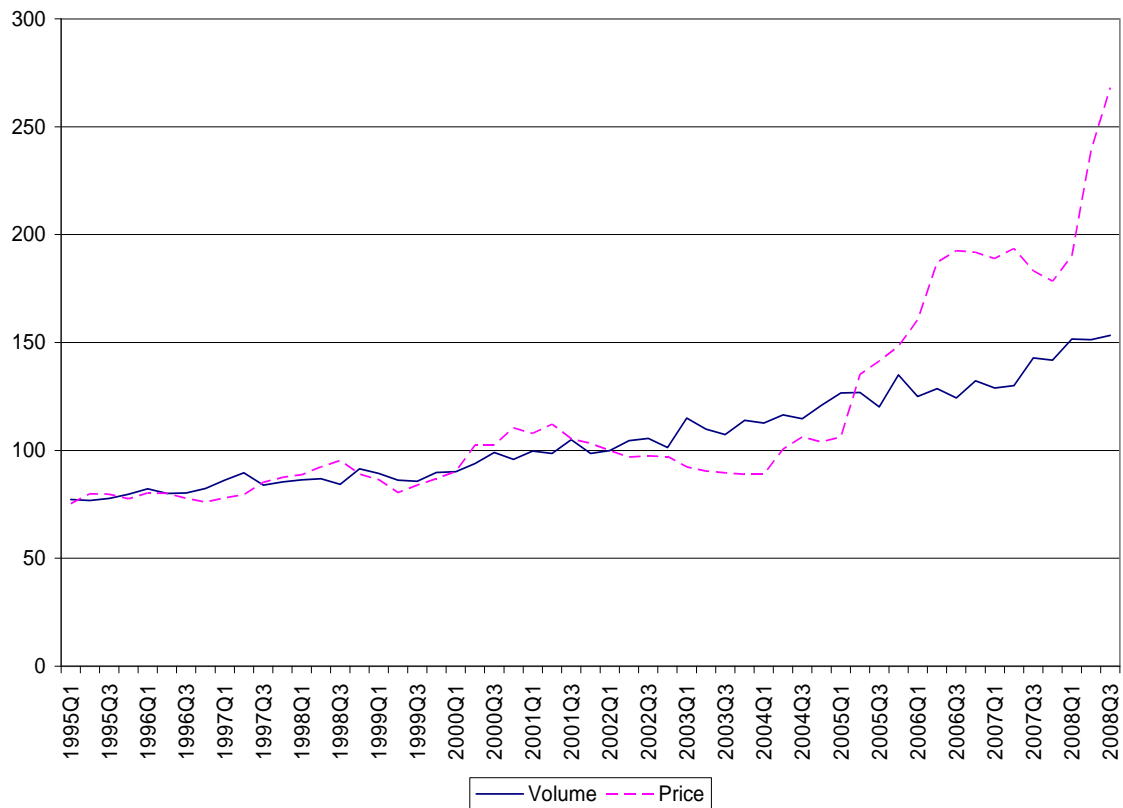
**Figure 1. GDP Output Gap – Australia and China**

**Figure 2. Australia's Exports to China and Japan (percent GDP), 1995Q1-2008Q3**



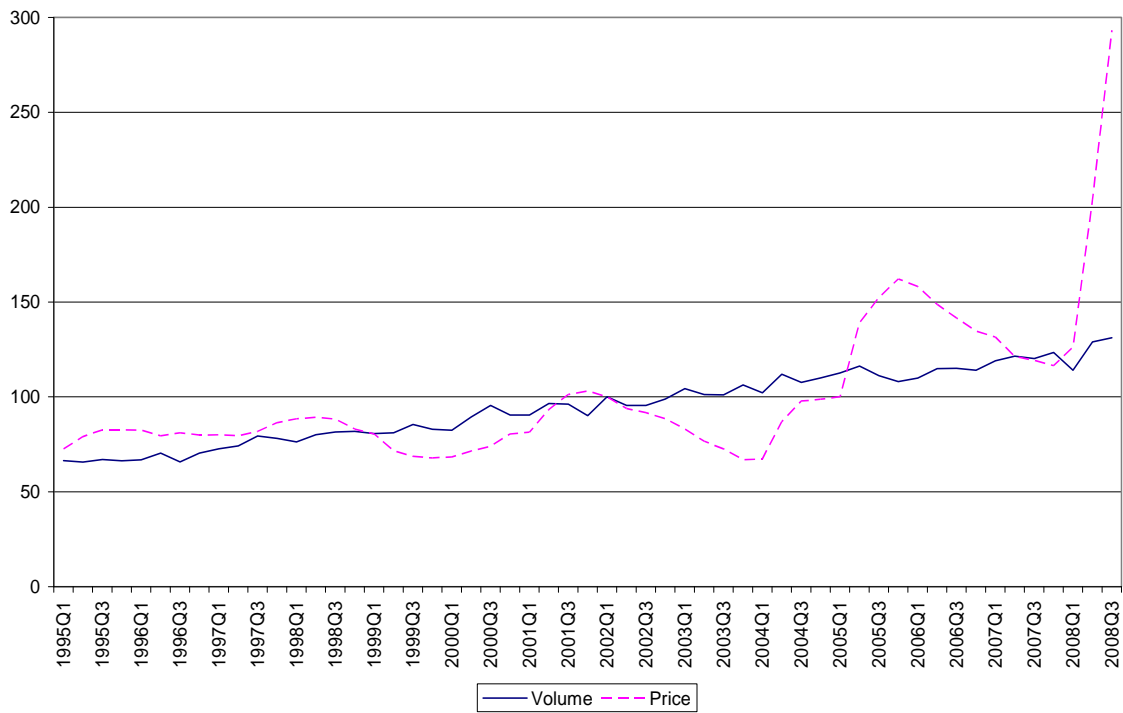
Source – Australian Bureau of Statistics

**Figure 3. Australia's exports of metal ores and minerals (2002Q1 = 100)**



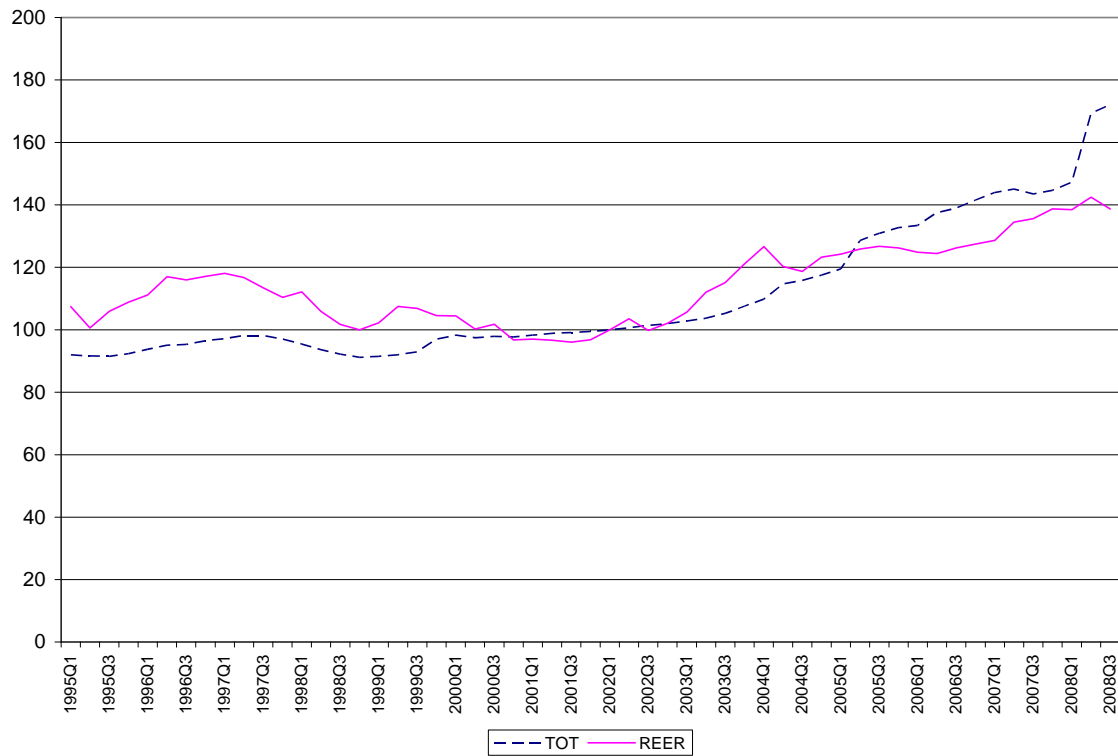
Source – Australian Bureau of Statistics

**Figure 4. Australia's exports of coal, coke and briquettes (2002Q1=100)**



Source – Australian Bureau of Statistics

**Figure 5. Australia's Terms of Trade (TOT) and Real Effective Exchange Rate (REER) (2002Q1=100)**



Source – Australian Bureau of Statistics and International Monetary Fund

**Referee's Appendix Table 1. Correlation Coefficients Between Non-Australian Output Gap Series**

	China GDP – US GDP	China GDP - Japan GDP	US GDP – Japan GDP
Lag = 0			
1995Q1-2008Q3	0.15	0.25**	0.13
1995Q1-2001Q4	0.04	0.40**	-0.10
2002Q1-2008Q3	0.08	0.14	0.63***

Note:

1. Statistical significance at the 10, 5 and 1 percent levels are denoted using \*, \*\* and \*\*\*, respectively.