ABSTRACT

We consider whether there has been a gradual decoupling of the Australian business cycle from its trading partners in Europe and North America and a closer convergence towards its trading partners in Asia. We set up a dynamic latent factor model to estimate common dynamic components or factors for the real GDP growth rate of 19 countries. From variance decomposition over the 1991 to 2009 sample, we find that a global factor contributed the most in explaining Australian output growth variations, followed by a European factor, an Asian factor and finally a North American factor. However the correlation between Australian output growth movements and the Asian business cycle factor evolved from negative and small to positive and large after 2002. The European and North American factors were negatively correlated with Australian output growth for most of the sample period before turning positive in the global financial crisis of 2007-8. This evidence supports the hypothesis that the Australian economy has decoupled to some extent from Europe, was not much coupled with North America except insofar as the U.S. drove the global factor, and has increasingly become positively coupled with Asia.

JEL Classification: E32, C32

KEYWORDS: international business cycle, decoupling, dynamic latent factor model, Kalman filter, dynamic correlation, variance decomposition

† Email: c.leu@latrobe.edu.au
* Email: jsheen@efs.mq.edu.au
1. Introduction
In this paper, we examine the evolving business cycle linkages between Australia and key regional groupings. We test to see whether Australia’s links with Asian economies have become more intense in recent years, relative to Europe and North America. Using dynamic factor analysis, we find evidence to support this hypothesis, thus going a long way to understanding why Australia’s performance was relatively robust in the recent global financial crisis and the ensuing global recession.

The financial turmoil that began in 2007 and peaked in September 2008 in the U.S. led to perhaps the most severe global financial and real crisis since the Great Depression. This financial malfunction spread quickly to the real global economy by impacting the costs and confidence of consumers and firms, thus severely reducing the level of economic activity. Aggregate demand, global industrial production and trade volumes fell rapidly, unemployment rose almost everywhere, and as a result, most countries experienced one of the worst recessions in the post-war era. Against this difficult backdrop, the Australian economy was remarkably resilient. Amongst the main developed economies in the world, Australia is the only country that did not register negative year-end output growth during this global downturn. In addition, it did not record a drop in export volume during that period, and its terms of trade began to increase early in the piece. Unemployment did rise, but only to reach its long-run average. There are several factors that contributed to this remarkably robust performance. First, the large and timely monetary and fiscal stimulus measures of the central bank and the federal government were important in supporting aggregate demand. However, most other countries also responded with quite similar stimulus packages. Second, the banking sector in Australia was in a healthier state compared to some other advanced economies, with minimal exposure to the sub-prime debt problems originating in the U.S. Even so, there were a number of other developed countries with a similar low financial exposure whose economies performed much worse. Third, the Australian dollar depreciated in trade-weighted terms by 15% in the six months after September 2008, which helped to support exports. Nevertheless, a number of countries also experienced depreciation over that period, but performed worse. Fourth, increasing trade links over the decade with Asian economies, in particular China and India, which rebounded quickly in the crisis, provided an important driver for the relatively robust growth that Australia continued to enjoy through the crisis. It is this last point that might be the one that distinguished Australia’s response to the crisis, and it is the one that we test in this paper.

Few doubt that Australia has benefited from the resource boom arising from its Asian trading partners. Lowe (2009), the assistant governor of the Reserve Bank of Australia, was optimistic that this shift of economic weight to Asia not only had positive effects for the Australian economy in the short run but will also be sustained in the medium run. We therefore ask the following question: “For the last twenty years, has there been a degree of
decoupling of the Australian business cycle from its trading partners in Europe and North America, and greater coupling with its trading partners in Asia?"

We proceed to answer this question by drawing from the literature that examines the key characteristics of international business cycles. Using pairwise correlations, Backus et al. (1995) and Baxter (1995) found that the business cycles in major industrialized countries are similar. In Mendoza (1995) and Kose (2002), the business cycles of emerging market economies were found to share many similar features to those of the advanced countries. Gregory et al. (1997) employed the Kalman filter and dynamic factor analysis to identify common macroeconomic fluctuations across G7 countries. Using a VAR factor model, Clark and Shin (2000) studied the importance of common and country-specific shocks in accounting for variation in industrial production in European countries. Lumsdaine and Prasad (2003) developed a weighted aggregation procedure to examine the correlations between the industrial output fluctuations of 17 OECD countries. They found evidence for a world business cycle and a European business cycle. While most of these studies focus on smaller groups of countries, Kose et al. (2003) used a sample of 60 countries to estimate a world factor that could represent the common business cycle factor for all countries, a set of regional factors that could be common to countries within their regions, and country-specific factors that could capture fluctuations of individual countries. Kose et al. (2008) categorized a sample of 106 countries into developed countries, emerging markets, and other developing economies for the estimation of global, region-specific, and country-specific factors. This large literature, although spanning a variety of techniques, datasets and sample periods, has provided strong evidence of cross-country links for macroeconomic fluctuations in the context of international business cycles.

However, an interesting related question has resurfaced recently\(^1\), which asks whether the emerging market economies of Asia have decoupled from the business cycles of the advanced economies. In recent years the impressive growth performance of emerging market economies, especially China and India, seems to have been only mildly affected by growth slowdowns in industrial countries. This has led to suggestions that the international channels of business cycle transmission might have weakened, with some even conjecturing that these emerging markets have “decoupled” from industrial economies, in the sense that their business cycle dynamics are no longer tightly linked to industrial country business cycles.

The decoupling hypothesis challenges the alternative view that increasing globalization through inter-country trade and financial linkages increases output co-movement by widening the channels for external shocks to spill across countries. However economic theory is ambiguous about the impact of greater international linkages on cross-country output co-movements. Stronger financial linkages may increase cross-country co-movements via the correlated wealth effects of external shocks. However, they may also reduce these output

\(^1\) See for example, “The Decoupling Debate” The Economist, March 6, 2008.
co-movements by encouraging specialization in production consistent with countries’ comparative advantage arising from international capital diversification. Greater trade linkages generate both demand- and supply-side spillovers across countries, which can result in more highly correlated output fluctuations. On the other hand, if stronger trade linkages facilitate greater specialization of production across countries, and if sector-specific shocks are dominant, then the degree of output co-movement could fall (see Baxter and Kouparitsas, 2005). Thus the degree of business cycle coupling across countries may be different in the short term (due to wealth effects and activity spillovers) than in the longer term (insofar as forces for specialization take root).

With Australia’s exports now more closely aligned with its Asian trading partners, the question arises whether its business cycle is now driven more (positively) by an Asian economic factor, than by other regional or global factors. To answer this question, we set up a dynamic latent factor model to estimate common dynamic components for the real GDP growth rate of 19 countries. Australia is viewed as the home country and the remaining 18 countries are divided into three regions: Asia, Europe, and North America. Apart from Australia, real GDP growth of each country is decomposed into two factors: (1) a global factor, which picks up fluctuations that are common to all countries; and (2) a region-specific factor, which captures fluctuations that are common to countries within each of the three regions. Since the objective of the study is to investigate the evolution of Australian business cycles and its correlation with that of the rest of the world, Australia is classified as a ‘member’ for all three regions and hence the decomposition of its output growth involves the global factor and the three regional factors.

To estimate the dynamic latent factor model, we use maximum likelihood with quarterly data over the period 1991Q1 to 2009Q1, and extract the latent (or unobservable) factors with the Kalman filter. We obtain the following main findings. First, the fluctuations of the global factor are found to be highly persistent. The movements track the major economic events of the past two decades quite closely and possibly represent the influences of coordinated policy responses across countries. In contrast, the fluctuations of the region-specific factors exhibit lower persistence and their higher-frequency cyclicality may be capturing real exchange rate variations between the regions, or uncoordinated policy responses across countries. Second, our estimated regional factors suggest that the negative impact of the global recession from 2008 was transmitted to the three regions at different speeds. The growth rates of most Asian economies were amongst the earliest to fall below zero and registered the largest decrease. The negative impact on North America started in late 2008 delivering three quarters of (small) negative growth. The European region seemed to weather the storm by producing positive (but low) growth throughout 2008 before turning negative in 2009. Third, we perform variance decompositions to determine the relative contributions of the latent factors to Australian output growth variations. The global factor is found to be the most important
external driver, explaining 11% of the variations. Of the regional factors, the European one ranks first with a contribution of 5.7%, the Asian factor picks up 2.3%, while the North American factor contributes 1.1%. Fourth, the correlation between the Australian and Asian business cycles changed from negative to positive after 2002, and then increased significantly after the 2007-8 global financial crisis. The European and North American factors were negatively correlated with the Australian cycle for most of the sample period, turning positive only at the onset of the global financial crisis in 2007-8. When the global crisis finally subsides, these results suggest that Australia will return to a negative relation with the European and North American factors, but remain positively connected to Asia. This provides support for the hypothesis that the Australian economy has decoupled to some degree from the idiosyncratic component of European and North American business cycles, and enhanced its coupling with Asia.

The paper is organized as follows. Section 2 describes the data and lays out the dynamic latent factor model. In section 3, we present the empirical results that include the parameter estimates, variance decomposition of Australian output growth, the estimated latent factors, and the dynamic correlations between Australian output growth and the latent factors. We close this section with a brief discussion of robustness checks on model specification. Section 4 concludes.

2. Data and methodology

2.1 Data
The primary data is real GDP for the 19 countries in the sample, which we extracted from three different sources—Datastream, the IFS and the OECD databases (see Data Appendix for more information). The sample period is quarterly and covers 1990Q1 to 2009Q1. Given our focus on Australia and its cyclical output linkages with its trading partners, we chose 18 countries that were among its top 27 export trading partners during the sample period. With Australia as the home country, the 18 foreign countries are divided up into three international regions: 9 countries in the Asian region that includes China, Hong Kong, India, Indonesia, Japan, Korea, New Zealand, Singapore, and Taiwan; 7 countries in the European region that includes Belgium, France, Germany, Italy, Netherlands, Spain, and the United Kingdom; and the North American region comprising Canada and the United States. The global economy is proxied by the ‘aggregate’ of all the countries in the sample. We compute year-end output growth rates from the real GDP data and remove the mean for each country for the empirical analysis.

2.2. A dynamic factor model

---

2 We excluded countries in this set for which there were data availability problems and which were unlikely to be contributing drivers of the Australian economy (e.g. Papua New Guinea, and the Philippines).
For the set of output growth rates, we construct a dynamic factor model that allows for the identification of one global factor and three regional factors as drivers of cyclical output fluctuations, and accounts for their dynamic persistence. We cast the model into a state-space representation and estimate the parameters by maximum likelihood, using the Kalman filter to extract the global and regional latent factors. Modeling common fluctuations of a set of macroeconomic variables using a dynamic factor model approach has become popular recently. One reason is that this approach can characterize the degree and source of synchronization in various dimensions without having to make strong identifying assumptions to disentangle the different types of common shocks. The factor structure is motivated by general equilibrium models as shown in Altug (1989). The factors are interpreted as capturing the effects of many types of common shocks, including technology shocks and monetary policy shocks, rather than just representing specific types of shocks.

In the international business cycle literature, the estimated factors can capture common fluctuations across the entire dataset (which represents the ‘world’) and across subsets of the data (which represents a particular grouping of countries). Examples of studies that have applied this technique, for example, are Stock and Watson (1989), Monfort et al. (2003), and Kose et al. (2003, 2008). Another common approach in the literature to measuring the level of co-movement is to calculate a set of bivariate correlations for all variables in the dataset, e.g. Backus et al. (1995), Baxter (1995), and more recently Doyle and Faust (2002). There are two advantages of using the dynamic factor model rather than the bivariate correlation approach. First, the analysis of simple correlation cannot allow for the separation of idiosyncratic components from the common source of joint co-movements. Second, static correlation analysis cannot capture dynamic persistence in the data as well as common fluctuations.

In our implementation, the real GDP growth rate for each country, denoted by $y_{it}$ and indexed by $i = 1,\ldots,19$, is assumed to evolve according to an AR(1) process. There is an unobservable global factor ($f_t$) that is common to all 19 countries in the sample. For the regional groupings, the three unobservable factors are the Asian factor ($n_A$), the European factor ($n_E$), and the North American factor ($n_{NA}$), which are indexed by $j = A, E, \text{and } NA$. Hence each observable output growth series is decomposed as:

$$y_{ij} = \alpha_i y_{i,j-1} + \beta_i f_t + \gamma_i n_{ij} + \epsilon_{ij},$$

where the parameters $\beta$ and $\gamma$ are the factor loadings that capture the sensitivity of individual output growth rates to the latent factors. The estimated factor loadings quantify the extent to which output growth moves with the global factor and the regional factors respectively.

---

$^3$ Two other measures are: (1) the concordance statistic by Harding and Pagan (2002), which measures the synchronization of turning points; and (2) the measurement of coherences, which is the equivalent of correlations in the frequency domain; unlike static correlations, this can allow for lead-lag relationships between variables.
idiosyncratic shocks are assumed to be normally distributed and serially uncorrelated, \( \varepsilon_{i,t} \) is distributed \( \text{NID}\left(0, \sigma^2_{\varepsilon_i}\right) \), and are uncorrelated with each other, \( E(\varepsilon_{i,t}\varepsilon_{k,t-1}) = 0 \) for \( i \neq k \) and \( s \geq 0 \).

Since the focus is on the business cycle synchronicity between Australia as the home country and the rest of the world, we allow the global factor and all three regional factors to enter into the Australian output growth equation:

**Australia**

\[
y_{i,t} = \alpha_i y_{i,t-1} + \beta_i f_{i,t} + \gamma_{A_i} n_{A,t} + \gamma_{E_i} n_{E,t} + \gamma_{NA} n_{NA,t} + \varepsilon_{i,t}
\]

As a result, we can compute the dynamic correlations between Australian output growth and the estimated latent factors. The correlation statistics can shed light on the degree and evolution of synchronization between the Australian business cycle and the global and regional factor cycles. It is worth noting, for example, that the U.S. economy’s business cycle will impact on Australia’s cycle via both the global factor and the idiosyncratic North American factor.

For the remaining countries in the sample that are classified into one of the three regions, the global factor and only the assigned regional factor enter into their output growth equations:

**Asian Region, \( i = 2, \ldots, 10 \)**

\[
y_{i,t} = \alpha_i y_{i,t-1} + \beta_i f_{i,t} + \gamma_{A_i} n_{A,t} + \varepsilon_{i,t}
\]

**European Region, \( i = 11, \ldots, 17 \)**

\[
y_{i,t} = \alpha_i y_{i,t-1} + \beta_i f_{i,t} + \gamma_{E_i} n_{E,t} + \varepsilon_{i,t}
\]

**North American Region, \( i = 18, 19 \)**

\[
y_{i,t} = \alpha_i y_{i,t-1} + \beta_i f_{i,t} + \gamma_{NA} n_{NA,t} + \varepsilon_{i,t}
\]

The evolution of the global factor and the regional factors is governed by the following first-order autoregressive process:

\[
f_{t} = \phi_{f,t} f_{t-1} + \eta_{f,t} \tag{2}
\]

\[
n_{j,t} = \phi_{n,j,t} n_{j,t-1} + \eta_{j,t} \tag{3}
\]

where \( \eta \) are assumed to be normally distributed and serially uncorrelated, \( \eta_{f,t} \) is distributed \( \text{NID}\left(0, \sigma^2_{\eta_f}\right) \) and \( \eta_{j,t} \) is distributed \( \text{NID}\left(0, \sigma^2_{\eta_j}\right) \), and the factor innovations are uncorrelated with each other. In addition, there is orthogonality between the idiosyncratic
shocks and the factor innovations, \( E(\eta_i, \epsilon_{i,s-t}) = E(\eta_i, \epsilon_{i,t-s}) = 0 \) for all \( i, j \), and \( s \). Thus all co-movement is driven by the latent factors, which in turn have autoregressive representations. The lag order for (1) through (3) can in principle be different to each other, however, for simplicity and parsimony, these are restricted to be AR(1). At the end of section 3, we will discuss the results of some robustness checks carried out on model specification.

To identify the scales of the factors and factor loadings we follow Sargent and Sims (1977) and Stock and Watson (1989) by assuming that the variances of factor innovations are constant. The constant is chosen based on the scale of the data so that the innovation variance is equal to the average innovation variance of a set of univariate autoregressions for each time series. In other words, we calibrate \( \sigma^2_{\eta} \) equal to the average innovation variance of the global set. For the regional innovation variances, \( \sigma^2_{\eta, A} \), \( \sigma^2_{\eta, E} \), and \( \sigma^2_{\eta, NA} \), these are calibrated to equal the average innovation variance of their respective regional groups. Note that in casting the model into state-space representation for the estimation of the parameters and latent factors, (1) can be viewed as the measurement equation and (2)-(3) make up the transition equation (see the Technical Appendix for the matrix representation).

3. Empirical results

We now present the estimation results of our global model (1)-(3). Since this paper focuses on the evolving linkages of the Australian business cycle with the rest of the world, our discussion will concentrate on the implications of the model estimates for Australia.

3.1. Parameter estimates

The parameter estimates of the model are given in Table 1. The estimates for the lagged dependent variables are all highly significant (at 1%), thus supporting the AR(1) specification. Apart from China, the impact coefficients for the global factor are positive and significant at 1% indicating a positive co-movement between individual output growth rates and global economic fluctuations. The global factor also exhibits a high and significant degree of autocorrelation, as indicated by the autoregressive parameter \( \phi_f = 0.72 \) that suggests a high persistence of global business cycle fluctuations, which then impact on individual output growth rates.

[--- insert Table 1 about here ---]

Looking at the impact coefficients for the regional factors, most are significant except for the Asian factor loading for New Zealand, the European factor loading for the UK, and the North American factor loading for Australia. Concentrating on the two significant regional factor loadings for Australia leads us to suggest that Australian business cycles co-move positively with the Asian regional cycles but in the opposite direction to the
European regional cycles. The regional factors also exhibit positive autocorrelation, however, these are lower than that of the global factor (which are $\phi_A = 0.41$, $\phi_E = 0.53$, and $\phi_{NA} = 0.35$). This result indicates that most of the persistent, or low-frequency, co-movement across economies is generated by the global factor. The higher-frequency fluctuations would seem to be better captured by the regional factors.

3.2. Variance decomposition

We decompose the variance of Australian output growth into the relative contributions that are due to each of the four latent factors and the idiosyncratic shock. Given the factors are orthogonal to each other by construction, the variance of the Australian output growth rate can be written as:

$$\text{var}(y_{t,t}) = \left(\frac{(\beta)^2}{1-(\alpha_t)^2}\right) \text{var}(f_t) + \left(\frac{(\gamma^A)^2}{1-(\alpha_t)^2}\right) \text{var}(n_{A,t}) + \left(\frac{(\gamma^E)^2}{1-(\alpha_t)^2}\right) \text{var}(n_{E,t}) + \left(\frac{(\gamma^{NA})^2}{1-(\alpha_t)^2}\right) \text{var}(n_{NA,t}) + \frac{1}{1-(\alpha_t)^2} \text{var}(\varepsilon_{t,t}) \tag{4}$$

Hence the shares of volatility due to each component are

- **Global factor:** $\left(\frac{(\beta)^2}{1-(\alpha_t)^2}\right) \text{var}(f_t) / \text{var}(y_{t,t})$
- **Asian factor:** $\left(\frac{(\gamma^A)^2}{1-(\alpha_t)^2}\right) \text{var}(n_{A,t}) / \text{var}(y_{t,t})$
- **European factor:** $\left(\frac{(\gamma^E)^2}{1-(\alpha_t)^2}\right) \text{var}(n_{E,t}) / \text{var}(y_{t,t})$
- **North American factor:** $\left(\frac{(\gamma^{NA})^2}{1-(\alpha_t)^2}\right) \text{var}(n_{NA,t}) / \text{var}(y_{t,t})$
- **Idiosyncratic Australian shock:** $\frac{1}{1-(\alpha_t)^2} \text{var}(\varepsilon_{t,t}) / \text{var}(y_{t,t}) \tag{5}$

Table 2 reports the relative contributions of the global and regional factors to variations in the Australian output growth rate over the whole sample period (since 1991). The global factor plays a major role and accounts for 11% of the output growth variation. From the regional factors, the European factor is the most dominant, accounting for 5.7%, while the Asian factor explains 2.3% and the North American factor contributes just 1.1% of the output growth variation.
growth variation. Over the whole sample then, we cannot conclude that the Asian region has played a significant role in Australian output growth variance. Nevertheless it may have begun to play an increasingly important role, something we will try to establish later.

[--- insert Table 2 about here ---]

3.3. Estimated factor roles

Figure 1 presents the estimated global factor and the three regional factors with Australian output growth. The fluctuations of the global factor reflect the major world economic events of the past two decades and perhaps the coordinated policy responses to them: the global recession in the early 1990s due to tight anti-inflationary policies of major industrialized countries and the uncertainty created by the first Gulf war; the 1997-98 Asian financial crisis that was followed by a quick recovery; the global slowdown associated with the first dot-com bubble in 2000 and then the terrorist attack in the U.S. in 2001; the beginning of the second Iraq war in 2004 that had a short impact with a subsequent economic turnaround; and the spectacular collapse of the world output growth associated with the global financial crisis that began in late 2007 and peaked in September 2008. According to the estimates, the global factor growth rate was -0.1% in December 2007, but fell to a dismal -8.3% in March 2009.

The region-specific factors are orthogonal to the global factor by construction and any common shocks affecting all countries will show up in the global factor, hence the region-specific factors capture the remaining, more high-frequency, co-movements among countries within each group. They may be capturing real exchange rate variations between the regions, or uncoordinated policy responses across countries. One interesting feature is that the Asian factor exhibits the most volatility with a standard deviation of 1.95, followed by 1.19 for Europe, and 0.41 for North America, while the global factor has a measure of 1.84. The fluctuations in the region-specific factors highlight some important cyclical episodes specific to each region. While the 1990-91 recession had a relatively mild effect on the Asian region, it was particularly hard hit by the Asian financial crisis that started in 1997 with the growth rate sinking to -5.7% in March 1998. Since most of the countries in the Asian region rely heavily on exports to drive their economic growth, the global collapse of industrial production and trade after the 2007-8 global financial crisis negatively affected the region with its factor growth rate falling rapidly to -2.9% in December 2008. This was followed by a rebound (although still with negative growth, -0.8%) in March 2009. The European regional factor started off with a 7.2% growth rate in June 1991, but this was followed by three extended periods of negative growth from 1992 to 2005. During the global financial crisis, according to the estimated factor, the European region managed to maintain positive but low growth rates throughout 2008. However, the regional economy could not sustain the performance and the growth rate dipped into the negative territory with -1.2% at the end of
the sample. The cyclical fluctuations exhibited by the North American factor broadly mirror most of the main economic events that we discussed for the global factor. Comparing the effect on the three regions during the height of the global financial crisis, the negative impact was transmitted faster to the Asian region and its growth rate suffered the deepest loss given that most of the countries are small open economies. The North American region experienced three quarters of (small) negative growth starting in September 2008. Displaying some economic resilience (although weak) in 2008, the spillover of the cyclical downturn was transmitted to the European region with a delay.

It is well-known that Australian output growth over a number of decades appears remarkably similar to that of the U.S. Given this fact, an interesting puzzle is why the North American factor had an insignificant effect on Australia. The resolution of this apparent puzzle is that the marginal effect of the global factor on Australia was large, positive and significant, and this global factor was heavily influenced by the largest economy in the world, the U.S.\(^4\) The global factor is likely to be picking up inter-country transmission channels beyond trade links. In particular, international financial integration is likely to go a long way in understanding its global characteristic.

--- insert Figure 1 about here ---

3.4. Dynamic correlations
Figures 2 to 5 plot the dynamic correlations with a 4-year rolling window between Australian output growth and the four latent factors—the global, Asian, European, and North American growth rates respectively. These results will help to answer whether there has been some decoupling of the Australian business cycles from the European and North American business cycles and an increasing convergence towards the Asian business cycles. Figure 2 shows that the degree of synchronization was high between the Australian business cycle and the global factor—the average dynamic correlation for the sample is 0.54. However there was a marked fall in the correlation which turned negative in 1999 to reach a low of -0.08. Since 2001 the correlation hovered around 0.67 but with substantial and increasing variability. At the start of the global financial crisis in late 2007, the correlation decreased. However, by the peak of the crisis in the second half of 2008, the correlation had risen rapidly, reaching a high of 0.85 in March 2009. At the height of the crisis, the global business cycle factor was an important driver in dragging down the Australian output growth, which supports the variance decomposition result that the global factor was the most important external driver in explaining the variations of Australian output growth.

\(^4\) Indeed the (static) correlation between the global factor and U.S. output growth is 0.8 and the global factor loading on the U.S. output growth is highly significant and large, \(\beta_{US} = 0.3\). Both of these facts support the hypothesis that the U.S. represents an important source of global economic fluctuations.
An interesting pattern emerges from the dynamic correlation between Australian output growth and Asian factor growth rates as shown in Figure 3. The correlation statistic suggests that there were two distinct phases of business cycle linkage. Before June 2002, the Australian business cycle moved in the opposite (or counter-cyclical) direction to that of the Asian factor. The correlation turned positive briefly around the 1997-98 Asian financial crisis, suggesting that Australia was not immune from this regional shock. However Australia re-oriented its trading relationships by boosting links with its Asian neighbors, and so we observe that the correlation became positive after June 2002 reaching a local peak of 0.72 in March 2005 before falling to 0.29 in September 2008. However, in the last two quarters of the sample, the correlation jumped up again, reflecting the additional importance of Asia for Australia in the latest global economic downturn. In fact, this meant that Australia actually benefited from the relatively quick recovery of Asia in 2009, so that its experience of the crisis was the most benign amongst rich industrialized countries.

Figures 4 and 5 show that Australian output growth movements have been negatively correlated with the European and North American factors throughout much of the sample period, except in the latest financial crisis. In both cases, the degree of synchronization increased with the onset of the global financial crisis, and turned positive at the end of the sample, reflecting the additional impact of the crisis on Australia in weighing down the growth rates of countries in these two regions. Although the correlations in March 2009 for Europe (0.38) and North America (0.06) took the highest values for the whole sample period, these were still lower than that for the Asian region (0.71) at the end date. While the level of synchronicity between Australia and North America fluctuated over time below zero, the correlation measure fell dramatically in 2001 and reached its lowest point in June 2003 at -0.80. This decrease in synchronicity evidences the fact that Australia was not as badly affected by the 2001 slowdown as Canada and the U.S. Inspecting the output growth rates we observe that they fell dramatically from 5.1% in 2000 to 1.8% in 2001 for Canada and from 3.6% to 0.8% for the U.S., while the Australian economy performed relatively well, with the growth rate falling from 3.4% to a mere 2.1%.
3.5. Some robustness checks

To check the robustness of the results, we estimated a dynamic factor model with an AR(2) specification in both the output growth and latent factor equations. Most of the second-order lagged autoregressive parameters for the output growth equations are not statistically significant. Figure 6 compares the estimated latent factors of the AR(1) and AR(2) models. The two series for each factor are very similar and the turning points match quite closely. However, the AR(2) model offers a more exaggerated amplitude for some end points and turning points of the latent factors. Inspecting the dynamic correlations shown in Figure 7, the basic story does not change between the two models, except in the correlation between Australia and North America where we do not observe the same decrease in the 2000-1 slowdown.

To what extent are our results driven by the specification that the Asian region is dependent on the global and only the Asian regional factor? Given many countries in the region are small open economies that rely heavily on the global export markets, it is plausible to modify our assumption that the Asian region is influenced also by European and North American factors. The estimated results of the latent factors and dynamic correlations from this ‘alternative’ model are included in Figures 6 and 7. In general, the result from the alternative model is not different qualitatively from our AR(1) model. Adding the European and North American factors to the Asian region does not change our conclusions in regard to the Australia-Asia business cycle evolution, which is the focus of this paper.

--- insert Figure 6 about here ---

--- insert Figure 7 about here ---

4. Conclusions

In the aftermath of the global financial crisis of 2007-8, it appears that emerging market countries recovered from the crisis sooner and faster than advanced economies in general. It has even been suggested that these emerging market countries are the “new engines of global growth”. This suggests that business cycles in emerging market economies have become less dependent on those of advanced economies. Amongst the developed economies in the world, Australia performed remarkably well in response to the global financial crisis of 2007-8. One contributing factor is the increasing trade links Australia has developed with Asian economies, in particular China and India, which has kept up its level and value of its exports and hence

--- insert Figure 6 about here ---

--- insert Figure 7 about here ---

5 We restrict our attention to AR(2) but acknowledge that in principle higher-order autoregressive specifications might also be considered. However, this increases dramatically the number of parameters to be estimated and we could not achieve numerical convergence during estimation. Further it is unlikely that such high-order models will be consistent with the univariate time-series process for GDP growth.
helped output growth.

We posed the question about whether there has been a gradual decoupling of the Australian business cycle from its trading partners in Europe and North America, and a closer convergence towards its trading partners in Asia. We set up a dynamic latent factor model to estimate common dynamic components or factors for the real GDP growth rate of 19 countries. We performed variance decomposition over the whole sample to examine the sources of Australian output growth variations and found that the global factor contributed the most to explaining the variations, followed by the idiosyncratic European factor, then the Asian factor and finally the North American factor in a distant last place. However we found that the correlation between Australian output growth movements and Asian business cycle factor evolved from being small and negative to positive and large after 2002. The idiosyncratic business cycle factors for Europe and North America were negatively correlated with Australian output growth for most of the sample period before turning positive owing to the intense effects of the global financial crisis of 2007-8. This evidence supports the hypothesis that the Australian economy has decoupled to some extent from Europe, was not much coupled with North America except insofar as the U.S. drove the global factor, and has increasingly and positively coupled with Asia.
Data Appendix

The table below displays the source of the real GDP series for the 19 countries in the sample and the regional classification of countries except for Australia which is set up as the home country.

<table>
<thead>
<tr>
<th>Australia</th>
<th>OECD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>Datastream</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>Datastream</td>
</tr>
<tr>
<td>India</td>
<td>Datastream</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Datastream</td>
</tr>
<tr>
<td>Japan</td>
<td>IFS</td>
</tr>
<tr>
<td>Korea</td>
<td>IFS</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Datastream</td>
</tr>
<tr>
<td>Singapore</td>
<td>Datastream</td>
</tr>
<tr>
<td>Taiwan</td>
<td>Datastream</td>
</tr>
<tr>
<td>Europe</td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>IFS</td>
</tr>
<tr>
<td>France</td>
<td>IFS</td>
</tr>
<tr>
<td>Germany</td>
<td>IFS</td>
</tr>
<tr>
<td>Italy</td>
<td>IFS</td>
</tr>
<tr>
<td>Netherlands</td>
<td>IFS</td>
</tr>
<tr>
<td>Spain</td>
<td>IFS</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>IFS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North America</th>
<th>OECD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>OECD</td>
</tr>
<tr>
<td>United States</td>
<td>OECD</td>
</tr>
</tbody>
</table>
Technical Appendix

The state-space representation is consisted of a measurement equation:

\[ w_t = z_t + F \tilde{\xi}_t + v_t \]

and a transition equation:

\[ \tilde{\xi}_t = G \tilde{\xi}_{t-1} + \nu_t \]

where \( w_t \) is the vector of observable variables (output growth rates), \( \tilde{\xi}_t \) is the vector of latent variables (the unobservable global and regional factors), and \( z_t \) is a vector of exogenous or predetermined variables (lagged output growth). \( v_t \) and \( \nu_t \) are white noise innovation vectors that are assumed to be uncorrelated at all lags, \( \mathbb{E}(v_t; \nu_{t'}) = 0 \) for all \( t \) and \( t' \).

Transforming equation (1) into the measurement equation yields:

\[
\begin{bmatrix}
y_{1,t} \\
y_{2,t} \\
\vdots \\
y_{10,t} \\
y_{11,t} \\
\vdots \\
y_{17,t} \\
y_{18,t} \\
y_{19,t}
\end{bmatrix} = \begin{bmatrix}
\alpha_{11} y_{1,t-1} \\
\alpha_{21} y_{2,t-1} \\
\vdots \\
\alpha_{10,1} y_{10,t-1} \\
\alpha_{11,1} y_{11,t-1} \\
\vdots \\
\alpha_{17,1} y_{17,t-1} \\
\alpha_{18,1} y_{18,t-1} \\
\alpha_{19,1} y_{19,t-1}
\end{bmatrix} + \begin{bmatrix}
\beta_{11} \gamma_{1}^E \\
\beta_{12} \gamma_{2}^E \\
\vdots \\
\beta_{10,1} \gamma_{10}^E \\
\beta_{11,1} \gamma_{11}^E \\
\vdots \\
\beta_{17,1} \gamma_{17}^E \\
\beta_{18,1} \gamma_{18}^E \\
\beta_{19,1} \gamma_{19}^E
\end{bmatrix} \begin{bmatrix}
f_t \\
n_{A,t} \\
n_{E,t} \\
n_{NA,t}
\end{bmatrix} + \begin{bmatrix}
ev_{1,t} \\
ev_{2,t} \\
\vdots \\
ev_{10,t} \\
ev_{11,t} \\
\vdots \\
ev_{17,t} \\
ev_{18,t} \\
ev_{19,t}
\end{bmatrix}
\]

(A.1)

where the top partition corresponds to Australia as the home country, and the other partitions correspond to the Asian, European, and North American countries respectively.

Combining equations (2) and (3) gives the transition equation:

\[
\begin{bmatrix}
f_t \\
n_{A,t} \\
n_{E,t} \\
n_{NA,t}
\end{bmatrix} = \begin{bmatrix}
\phi_{f,1} & 0 & 0 & 0 \\
0 & \phi_{A,t} & 0 & 0 \\
0 & 0 & \phi_{E,t} & 0 \\
0 & 0 & 0 & \phi_{NA,t}
\end{bmatrix} \begin{bmatrix}
f_{t-1} \\
n_{A,t-1} \\
n_{E,t-1} \\
n_{NA,t-1}
\end{bmatrix} + \begin{bmatrix}
\eta_{f,t} \\
\eta_{A,t} \\
\eta_{E,t} \\
\eta_{NA,t}
\end{bmatrix}
\]

(A.2)

The covariance matrix for \( v_t \) is

\[
\begin{bmatrix}
\sigma_{\epsilon_1}^2 & 0 & 0 & 0 \\
0 & \sigma_{\epsilon_2}^2 & 0 & 0 \\
\vdots & \vdots & \ddots & \vdots \\
0 & 0 & 0 & \sigma_{\epsilon_{19}}^2
\end{bmatrix}
\]

(A.3)

and the covariance matrix for \( \nu_t \) is
\[
\begin{bmatrix}
\sigma^2_{\eta_j} & 0 & 0 & 0 \\
0 & \sigma^2_{\eta_A} & 0 & 0 \\
0 & 0 & \sigma^2_{\eta_E} & 0 \\
0 & 0 & 0 & \sigma^2_{\eta_{BA}} \\
\end{bmatrix}
\] (A.4)
References
(Eds.), Handbook of International Economics, volume 3, North-Holland, Amsterdam, pp.
1801-64.
Hess, G. and van Wincoop, E. (Eds.), International Macroeconomics, Cambridge
University Press, Boston, MA, pp.189-220.
Australia Inaugural Australian Investment Conference, Sydney – 19 October 2009,
Mendoza, E. (1995), “The terms of trade, the real exchange rate, and economic fluctuations”,
4119.
Sargent, T. and Sims, C. (1977), “Business cycle modeling without pretending to have too
much a priori economic theory”, in Sims, C. (Ed.), New Methods in Business Cycle
<table>
<thead>
<tr>
<th>Country</th>
<th>$\alpha_i$</th>
<th>$\beta_i$</th>
<th>$\sigma_e$</th>
<th>$\gamma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>0.58***</td>
<td>0.20***</td>
<td>0.67***</td>
<td>Australia</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Asia factor 0.06***</td>
</tr>
<tr>
<td>China</td>
<td>0.36***</td>
<td>0.29</td>
<td>2.71***</td>
<td>EU factor 0.27***</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>0.80***</td>
<td>0.78***</td>
<td>1.38***</td>
<td>NA factor -0.20</td>
</tr>
<tr>
<td>India</td>
<td>0.68***</td>
<td>0.52***</td>
<td>2.23***</td>
<td>Asia Region</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.90***</td>
<td>0.60***</td>
<td>3.65***</td>
<td>Japan 0.31***</td>
</tr>
<tr>
<td>Japan</td>
<td>0.75***</td>
<td>0.39***</td>
<td>0.94***</td>
<td>China 0.81***</td>
</tr>
<tr>
<td>Korea</td>
<td>0.68***</td>
<td>0.66***</td>
<td>1.94***</td>
<td>Hong Kong 0.51***</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.61***</td>
<td>0.41***</td>
<td>1.19***</td>
<td>India 0.14***</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.67***</td>
<td>1.01***</td>
<td>1.90***</td>
<td>Indonesia 0.38***</td>
</tr>
<tr>
<td>Taiwan</td>
<td>0.68***</td>
<td>0.84***</td>
<td>1.22***</td>
<td>Japan 0.48***</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.60***</td>
<td>0.52***</td>
<td>0.78***</td>
<td>New Zealand 0.01</td>
</tr>
<tr>
<td>France</td>
<td>0.79***</td>
<td>0.32***</td>
<td>0.48***</td>
<td>Singapore 0.59***</td>
</tr>
<tr>
<td>Germany</td>
<td>0.42***</td>
<td>0.44***</td>
<td>1.02***</td>
<td>Taiwan 0.48***</td>
</tr>
<tr>
<td>Italy</td>
<td>0.80***</td>
<td>0.42***</td>
<td>0.74***</td>
<td>EU Region</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.79***</td>
<td>0.40***</td>
<td>0.55***</td>
<td>Belgium 0.34***</td>
</tr>
<tr>
<td>Spain</td>
<td>0.80***</td>
<td>0.30***</td>
<td>0.71***</td>
<td>France 0.18***</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.78***</td>
<td>0.31***</td>
<td>0.37***</td>
<td>Germany 1.18***</td>
</tr>
<tr>
<td>Canada</td>
<td>0.70***</td>
<td>0.29***</td>
<td>0.00</td>
<td>Italy 0.30***</td>
</tr>
<tr>
<td>United States</td>
<td>0.66***</td>
<td>0.30***</td>
<td>0.52***</td>
<td>Netherlands 0.28***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Spain 0.22***</td>
</tr>
</tbody>
</table>

$\phi_y$ 0.72*** $\sigma_y$ 1.21 United Kingdom -0.03

$\phi_A$ 0.40*** $\sigma_A$ 1.78

$\phi_E$ 0.53*** $\sigma_E$ 0.66 NA Region

$\phi_{NA}$ 0.34*** $\sigma_{NA}$ 0.40 Canada -1.25***

Log-likelihood -2090 United States -0.25

Note: designates significance at 10%, ** at 5% and *** at 1%.
Table 2: Variance Decomposition of Australian Output Growth

<table>
<thead>
<tr>
<th>Factor</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global factor</td>
<td>0.11</td>
</tr>
<tr>
<td>Asian factor</td>
<td>0.02</td>
</tr>
<tr>
<td>European factor</td>
<td>0.06</td>
</tr>
<tr>
<td>North American factor</td>
<td>0.01</td>
</tr>
<tr>
<td>Idiosyncratic Australian shock</td>
<td>0.80</td>
</tr>
</tbody>
</table>
Figures

Figure 1: Australian output growth and dynamic latent factors
Figure 2: Dynamic correlation between Australian output growth and Global factor output growth

Figure 3: Dynamic correlation between Australian output growth and Asian factor output growth
Figure 4: Dynamic correlation between Australian output growth and European factor output growth

Figure 5: Dynamic correlation between Australian output growth and North American factor output growth
Figure 6: Comparison of estimated latent factors between the AR(1), AR(2), and alternative models
Figure 7: Comparison of dynamic correlations between the AR(1), AR(2), and alternative models