Assessing Business Cycle Synchronisation – Prospects for a Pacific Islands Currency Union*

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Abstract

On-going debate of a Pacific Islands currency union has rekindled the argument on whether Pacific Island Countries (PICs) demonstrate symmetric behavior in their business cycles as a precondition for a union according to the OCA theory. Unfortunately for the PICs, there are no empirical studies undertaken involving the analysis of business cycle synchronization. This paper measures business cycles for PICs employing a number of techniques and using newly constructed quarterly GDP data by Lahari et al. (2011), including Australia and New Zealand, and evaluates their degree of synchronization. The results showed that it was not feasible for the PICs as a group to form a union. Although, further analysis showed mixed results for the Melanesian sub-group, the argument for a Melanesian union was based on similar positive directions in their business cycles. Further structural adjustments and policy harmonization are still required for all PICs including the Melanesian sub-group.

1. INTRODUCTION

According to the Optimal Currency Area (OCA) theory, when countries within a geographical region or zone (e.g., the South Pacific Island region) experience symmetric shocks, then the impact of these shocks can be mitigated if these countries enter into a currency or monetary union (Mundell, 1961; McKinnon, 1963; Kenen, 1969).[1] Such a scenario would be conducive for a union-wide common monetary policy, regulated by a common central monetary authority that is likely to be more effective in counteracting the effects of symmetric shocks facing member countries. Hence, such a currency union setup would lead to reduced costs (e.g., reduction in exchange rate volatility) and increase inter-country trade and competition, and thus lead to stability in output and prices within the union area.

Moreover, shocks generally consist of permanent and transitory components. While the former often relates to long-term supply factors (e.g., technological innovations), the latter may refer to short-term factors (e.g., changes in consumer demand) and is often associated with movements in business cycles. Hence, if business cycles were synchronised, it would be less costly to engage a common union-wide counter-cyclical monetary policy in a currency union. This paper is motivated by the concerns raised at a regional meeting on Pacific Island regional integration and governance (Chand, 2005). In particular, Duncan (2005) argued that the key issue for prospects for a currency union among PICs is whether there is evidence that the economies of PICs demonstrate similar business cycles. Unfortunately, no empirical study on business cycle synchronisation has been undertaken involving PICs. This paper makes a first attempt to fill this void and contribute to the ongoing debate on prospects for a Pacific Islands currency union. For the general purpose of this analysis, the term 'currency union' will be used interchangeably to refer to either a currency or monetary union, or both, unless otherwise specified.

The remaining paper provides an overview of the business/growth cycles in section 2. Section 3 reviews selected empirical studies. Section 4 discusses the data and methodology where the applications of the various techniques are employed to in deriving business cycles. Section 5 discusses the empirical findings and section 6 summarises and concludes this analysis.

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[1] Generally, a currency union refers to a zone consisting of several countries or regions where a single exchange rate regime prevails, a single currency circulates, and where a single monetary authority implements a common monetary policy. A monetary union refers to a group of countries that agree to permanently fix their exchange rates under centralisation of monetary authority. A monetary union may not necessarily be fully centralised or have formal integration but there are commitments for monetary policy coordination among members through arrangements such as currency boards.

2. OVERVIEW OF BUSINESS/GROWTH CYCLE

There is on-going debate within the business cycle literature on conceptualising the business cycle. Earlier researchers (e.g., Mintz, 1974) and New-Classical theorists (e.g., Lucas, 1977; Hodrick and Prescott, 1980; Kydland and Prescott, 1990), refer to *business cycles* within the context of *growth cycles* (or deviation cycles). Generally, cycles derived by deducting the growth trend from the original series, whatever the method may be, is referred to as a growth cycle. On the other hand, Burns and Mitchell (1946) proposed a definition of the classical business cycle in terms of the turning points in the level of aggregated economic activity during a given period. These turning points categorised time series into phases called expansions and contractions.[2] Instead of the absolute expansions/contractions as suggested by Burns and Mitchell (1946), there were instances of cyclical slowdowns or retardations other than rapid declines, as growth slackened.[3] Burns and Mitchell's (1946) definition, adopted by the NBER, judged a cycle by assessing specific turning points that consisted of expansions occurring around the same time as many other economic activities followed by similar recessions, contractions and recoveries, which then develop again into the expansion phase for the next cycle.[4]

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[2] The Burns and Mitchell (1946) definition was later propagated by the NBER. This led to the emergence of the business cycle theoretical and empirical investigations mainly among economists of the Classical School (now New-Classical School) such as Lucas (1977) in the wake of declines in global economic output and employment during the 1970s. The New-Classical School argued that real business cycles (RBC) represented the economy's best response to disturbances in production and spending.

[3] The business cycle as specified by Burns and Mitchell (1946) cyclical components lasted no less than six quarters (1.5 years) and no more than 32 quarters (eight years) in duration. The approach of Burns and Mitchell/NBER has declined in popularity although various organisations such as the Organisation of Economic Corporation and Development (OECD) and International Monetary Fund (IMF) still follow the definition, using various parametric and non-parametric models to locate turning points in the series.

[4] The NBER defines a *recession* as a significant decline in economic activity across the whole economy, lasting more than a few months. It is observed in real GDP, real income, employment, industrial production, and wholesale-retail sales. The NBER does not define a recession as two or more consecutive quarters of negative growth as often referred to by a number of researchers and the media. On the other hand, the NBER suggests that an *expansion* is two or more months of a rise in economic activity across the economy seen in real GDP, real income, employment, industrial production, and wholesale-retail sales. The *peak* of an expansion is the point in time where the level of GDP reaches its maximum before it starts to decline, thus dating the start of a recession. Similarly, the *trough* of a recession is the point in time at which GDP falls to its lowest level before it rises again. Hence, a trough dates the start of an expansion. These are known as *turning points* in the sample path of the series and often called *specific cycles*.
A *contraction* is a mild recession (below zero growth but less than two consecutive quarters of negative growth). A *recovery* is when growth is rising above the zero level towards its trend. The features of business cycles describing the cycle phases are the *duration* and the *amplitude*. The former refers to expansion in the frequency of periods of time from trough to the next peak. The latter measures the change (or percentage change) in the series from trough to the next peak.

The emerging interest centred on the deviations from long trends, above trend or below-trend growth-phases that appeared to have varying forms (Mintz, 1974). This caused enormous interest that led to attempts to define cycles as growth cycles. Hence, the changing characteristics and features of business cycles evolved to gain much interest.[5] Although many economists concentrate on the dynamics of expansions (or booms) and contractions (or recessions) of the classical business cycles, others discuss the growth cycles. Often, economists do not distinguish between these two categories (Zarnowitz, 1984). The basic arguments emanate from the relationship between economic theory, statistical theory and measurement (Canova 1998a, 1998b). Given the controversies over the definition, numerous studies (e.g., Christodoulakis et al. 1995; and Massmann and Mitchell, 2002) have often used the broad term business cycle while also referring to a growth cycle.

Measuring business cycles is critical in determining the stylised facts of the business cycle regarding aggregate macroeconomic behaviour over time. Since there are no studies undertaken in the past on business cycles for the PICs, there is currently no specific evidence of business cycle stylised facts (e.g., whether business cycles among PICs are synchronised or whether PICs have different business cycle phases etc.) to compare outcomes. Further, the measurement of the business cycle is debateable given the varying decomposing/de-trending methods employed to separate the cycle from the growth trend. This controversy has also led to proliferations in measurement techniques. Given that there is currently no consensus on how to extract the cycle from the growth trend, this implies that the business cycle facts are dependent on the type of techniques employed. This does not exclude the fact that the choice of the method itself is sensitive to the objectives of the research, and variables employed. Hence, a pragmatic solution is to evaluate the robustness of the business cycle outcomes by using a number of appropriate methods (Canova, 1998a, 1998b; and Woitek, 1998).

Given the above discussion, this empirical study will apply the term business cycle interchangeable to also refer to the growth cycle for simplicity and to avoid confusion. This practise is common in the business cycle literature (e.g., Christodoulakis et al. 1995; Artis and Zhang 1997, 1999; Massmann and Mitchell, 2002). Further, to assess the reliability of our business cycle results, a number of selected methods are applied as proposed by Canova (1998a,

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[5] For instance, the Keynesian School assumed that periods of recession or depression were economic maladies and that fluctuations were not just concerned with the general equilibrium. In particular, New Keynesians argue that wages and prices were 'sticky', meaning that wages and prices adjusted slowly and that disturbances in production and spending may cause the economy to deviate from its optimal level of output and employment.

1998b). It is important to note that the discussion of related economic theories is limited in this analysis as the focus of this analysis is on the OCA theory of currency unions.

3. SELECTED EMPIRICAL STUDIES

The review of literature will focus on selected empirical studies on business cycle synchronisation within the context of a currency or monetary union. The review will concentrate on selected studies mainly in the euro area due to the enormous volume of research undertaken while highlighting studies from other regions such as the Africa, Asia and the Pacific. In the euro area, the Center for Economic Policy and Research (CEPR) Dating Committee[6] undertook the first attempt to assess classical business cycles assuming the euro area as a single economy with data from 1970 to 2003. The study was based on indirect and subjective analyses. This work was later expanded by Artis et al. (2003) where the authors applied a modified version of the Hodrick and Prescott (1980) and the Baxter-King (1999) filters, and compared alternative measures for dating euro area business cycle such as the concordance index. They found that the euro area recessions were similar to the US recessions although the euro area turning points lagged by a quarter.

Although the findings by Artis et al. (2003) were supported by earlier studies such as Agresti and Mojon (2001), others such as Artis and Zhang (1997, 1999) disputed the findings, fully or partially. Agresti and Mojon argued that the US business cycles were very similar to the euro area although there were some differences, especially in how certain variables, such as consumption, affected GDP. Artis and Zhang (1997, 1999) analysed the exchange rate mechanism (ERM) and business cycles of participating countries of the European Monetary System (EMS) with those of the UK and the US. They applied several techniques such as the phase average trend (PAT) technique, the HP filter and a linear trend method. They also derived a cyclical index to assess cyclical behaviour. Using monthly industrial production data from 1961 to 1993, they found that during the ERM period (1979:4–1993:12) business cycles for countries participating in the ERM were becoming more synchronised with the German cycle. This was not the case in the pre-ERM period (1961:1–1979:3).

The findings by Artis and Zhang (1997, 1999) supports other earlier studies such as Christodoulakis et al.(1995). Christodoulakis et al. (1995) compared business cycles of former European Community (EC) economies. They applied a real business cycle (RBC) model

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[6] CEPR website: http://www.cepr.org/data/Dating/info1.asp.

following from Lucas (1977), and Kydland and Prescott (1990), and assessed turning points while also using the HP filter to compare cyclical features of the EC economies. Their study applied quarterly/annual GDP including other related indicators such as the money supply. They found remarkable similarities among the business cycles of the EC economies despite some policy differences, although the business cycles of the euro area countries had diverged considerably in the past. Artis and Zhang (1997, 1999) also found that the UK cycle was more in line with the US than with the euro area countries, evidence also supported by studies such as Artis (2003), and Massmaan and Mitchell (2002). Artis (2003) undertook a review of empirical literature on business cycles mainly among the UK, euro area and the US, and concluded that the UK cycle was strongly correlated with the US while suggesting that regional fluctuations indicated no UK region was connected with the euro area business cycle. In addition, Massmaan and Mitchell (2002) investigated the correlation between UK and euro area business cycles and engaged several multivariate methods such as the unobserved components model, a linear regression model, and univariate methods such as the HP filter, Baxter-King filter and PAT. They argued that there was no sustained evidence of increased correlation between the UK and the Euro zone business cycles. However, the UK business cycle showed similar behaviour with those of Germany and the US.

With increased interest and research on the topic of business cycle synchronisation, criticisms also surfaced. For example, in studies related to the euro area, Inklaar and de Haan (2001) and de Haan et al. (2002) criticised the findings of Artis and Zhan (1997, 1999). Inklaar and de Haan (2001) and de Haan et al. (2002) followed similar methods and used similar data as in Artis and Zhan (1997, 1999), and argued that there was no evidence of a strong relationship with increased exchange rate stability and increased business synchronisation. Subsequently, they also found mixed evidence of synchronisation among the EMU countries and the US. However, other studies such as Luginbuhl and Koopman (2003), Darvas and Szapary (2005) and Fidrmuc and Korhonen (2006) supported the evidence of synchronisation of business cycles among members of the euro area.

Other recent studies such as Harvey and Mills (2005) used common and co-dependent cycles method (Vahid and Engle 1993, 1997) to analyse G7 countries (Canada, France, Germany, Italy, Japan, UK, US). They found evidence of common and co-dependent cycles. Applying similar methods, as in Harvey and Mills (2005), with extensions to others techniques, Chen and Mills (2009) assessed growth cycle synchronisation of seven European countries (Austria, Belgium, France, Germany, Italy, Netherlands and Spain). They applied a number of univariate and

multivariate decomposition methods such as the Beveridge-Nelson approach. The common cycle and co-dependence econometric testing approach by Vahid and Engle (1993, 1997) was also applied. Other univariate techniques applied included the Butter/worth filters (Harvey and Trimbur, 2003). Their findings revealed some presence of common and co-dependent features in the data but mixed evidence from the univariate approaches. Another earlier study by Cheung and Westermaan (2003) also applied the common cycle test (Engle and Vahid, 1993) in assessing the Austrian, Germany and the US business cycles. They found non-synchronised business cycles among the three countries.

Other studies such as Sato and Zhang (2007) and Tapsoba (2008) covered Asian and African regions respectively. Sato and Zhang (2007) investigated prospects for an East Asian monetary union. They applied the Blanchard and Quah (1989) decomposition technique and tested for business cycles using common cycle features tests (Vahid and Engle, 1993). They concluded that the business cycles of Japan, Korea, Singapore and China were synchronised but their results needed further sensitivity tests due to the small sample used. Tapsoba (2008) investigated the relationship between trade and business cycles using Baxter and King's (1999) band-pass filter and correlation analysis. Tapsoba found that trade intensity increases synchronisation of business cycles but the 'endogenous effect' is small. His work followed the work of Frankel and Rose (1998) and Rose (2000) who assessed the 'endogeneity of the OCA' by investigating the effect of trade on business cycles.

Returning to the Pacific region, we find, apart from no studies regarding PICs, limited studies on business cycle synchronisation in connection to currency union between Australia and New Zealand. This could be due in part to the already numerous studies that have analysed Australia and New Zealand as part of the OECD group of countries or other regional blocks such as the Asia-Pacific group. More specifically, one study by Grimes (2005) analysed regional industrial cycles of Australia and New Zealand. Grimes derived measures for decomposing cycles, computed similarity indices and also utilised the HP and Baxter-King filters. Grimes assessed the degree of similarity of industry effects across the regions of Australia and New Zealand, and concluded that the industrial structure has been an insignificant factor in causing New Zealand's cycles to deviate from other regions of Australia. Grime's findings also showed that the industry cycle effect for NZ alluded to domestic factors, or unusual movements in NZ's cycles that were responsible for deviations between NZ and Australia's cycles.

In summary, and in retrospect, it is difficult to draw strong consensus from the findings of the above studies given the mixed results. It is also difficult to identify what would be deemed as the most appropriate method to apply in measuring business cycles in view of the varying methods employed in the various studies. Again, as reiterated by many economists and researchers, the outcomes of business cycle facts are largely determined by the aims of the research, methods used, variables employed and measure of synchronisation applied. As noted earlier, applying a number of appropriate methods would be a pragmatic solution in assessing the robustness of the business cycle outcomes (Canova, 1998a, 1998b; and Woitek, 1998).

4. DATA AND METHODOLOGY

The discussion on the data includes the type of variable, data source, and the proposed grouping of the PIC data for the analysis. The methodology section will cover three appropriate and fundamentally different techniques to compare the reliability and robustness of the business cycle outcomes.

4.1 DATA

This analysis uses the newly constructed quarterly real GDP for the PICs by Lahari et al. (2011), including quarterly GDP data for Australia and New Zealand from 1980:1 to 2006:4. All series are seasonally adjusted and expressed in logarithms. The series for New Zealand covers the period from 1987:2 to 2006:4. The cyclical component of real GDP as a proxy for aggregate output is a useful measure of the overall business cycle (Stock and Watson, 1998). The NBER has also expressed its preference for using GDP for business cycle analysis at the quarterly or annual frequencies. Many studies often use industrial production data because the data are available at a monthly frequency. Also, industrial production appears to be the most cyclical component of GDP and holds a relatively high proportion of share in GDP. However, for many PICs, industrial production data are not often available. In cases where industrial production data are compiled, these represent a relatively small fraction of GDP where as the services sector (mainly tourism) accounts for 50-90% of GDP. All real GDP series are found to be $I(1)$ as showed in the unit roots tests by Lahari et al. (2011). Table 1 in the Appendix shows summary statistics for real GDP growth for the PICs, Australia and New Zealand.

Cluster of Potential Currency Union Groupings

The Pacific Island region is represented by the six fully independent PICs (Fiji, Papua New Guinea (PNG), Samoa, Solomon Islands, Tonga and Vanuatu). The analysis will include Australia and New Zealand, the closest neighbouring metropolitan countries given their historical and commercial links with PICs mainly in trade, aid and military support. In addition, all countries are clustered into potential union blocks on the basis of their prevailing trade agreements, culture, language and historical connections. Hence, the following potential groups are proposed: Group 1: Pacific only (Fiji, PNG, Samoa, Solomon Islands, Tonga and Vanuatu). Evaluating initial prospects for uniting the PICs would help distinguish possible prospects for PICs (least developed/developing economies) prior to further assessment with Australia and/or New Zealand (advanced/developed economies). If this is feasible for Group 1 to form a union, then the analysis will extend to include either Australia (Group 2A) or New Zealand (Group 2B) respectively. If this is not feasible, then out from Group 1 countries, a sub-group of Melanesian countries (Group 2) consisting of Fiji, PNG, Solomon Islands and Vanuatu is evaluated. Further investigation on whether Melanesian countries can form a union with either Australia or New Zealand depends on whether Melanesian countries fully meet the conditions (synchronised business cycles) for a currency union.

4.2 METHODOLOGY

As discussed earlier, to ensure that the extracted business cycles are reliable and robust, comparing the outcomes from a number of filtering or decomposition methods is considered (Canova, 1998a, 1998b; and Woitek, 1998). The methods applied here include a non-parametric univariate filter, namely Baxter and King's (1999) band-pass filter, a parametric (model-based) decomposition procedure by Beveridge-Nelson (1981) following the state-space approach by Morley et al. (2003), and a common cycles approach based on an econometric testing methodology by Vahid and Engle (1993). These three methods are fundamentally different and are discussed separately.

Baxter-King filter

The choice of the Baxter-King filter was determined primarily on the basis of the definition of the business cycle. A central aspect of the Baxter-King filter was the adoption of the definition of business cycle proposed by Burns and Mitchell (1946) and popularised by the NBER. The specific range of the duration (periodicities) of the business cycles was defined within 6 to 32 quarters (i.e., 1.5 to 8 years). It was important to empirically integrate this definition in the

context of the PICs given the lack of research in this area. Analysis of the data set for PICs demonstrates that the specified range for business cycles fits well within the stated definition.[7] Moreover, the popularity of the Baxter-King filter was evident from the numerous empirical studies (e.g., Artis et al. (2003); Tapsoba, 2008) as noted in the literature review of selected studies. This analysis also draws insights from these studies.[8]

Apart from the choice of the specific range of the business cycle, the Baxter-King filter requires a choice for the order of the moving average, *K*. This allows the researcher to determine a specific target of frequency band to extract from the series of interest, keeping all the components within that band while discarding all the others. Although Baxter and King (1999) proposed that researchers choose *K* = 3 for annual data, we choose *K* = 3 but applied instead to quarterly data given our small sample and because larger values of *K* did not lead to any further noticeable changes in the filtered series. However, there is a trade-off in choosing *K,* where *K* observations are lost at either end of the series. This is a limitation of the Baxter-King approach. To implement the Baxter-King filter, a visual inspection of the real GDP time series for the PICs was undertaken. This was to determine the minimum and maximum duration of the growth cycles in line with the definition of a business cycle, given the lack of evidence or information on business cycle phases for the PICs. This revealed that the cycle phases for the Melanesian countries (Fiji, PNG, Solomon Islands and Vanuatu) were from 2 to 4 years. For Samoa, the cycle duration was from 2 to 5 years. The Tonga business cycle phase showed 2 to 6 years on average. For Australia, evidence from the Melbourne Institute of Applied Social and Economic Research (MIASER) showed a business cycle lasted 3 to 6 years on average.[9] This was also reflected in the real GDP data. From the OECD data, the Australian business cycle phase was about 1 to 6 years. The difference was due, in part, to differences in the variables used to construct leading indexes. For example, among other indicators, the OECD uses dwelling permits in contrast to the MIASER that uses manufacturing material price index. For the New Zealand economy, the business cycles from June quarter, 1987 to December quarter, 2006 showed about 1.5 to 6.5 years based on real

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[7] There are other commonly used filters such as the HP filter. The HP filter has been subject to some criticism especially where it is found to induce spurious cyclical behaviour in some cases of random walk models (see e.g., King and Rebelo, 1993; Cogley and Nason, 1995). However, such claims have been disputed by Pederson (2001) in terms of how the business cycle is defined and what is meant by the term 'spurious' (see also Haug and Dewald, 2004). The Baxter-King filter was widely preferred from a theoretical and definition point of view rather than from a trend-cycle decomposition perspective (Nelson and Plosser, 1982; Stock and Watson, 1999).

[8] There are other band-pass filters such as the Christiano and Fitzgerald (2003) filter that draws from the Baxter-King filter but assumes different optimising rules (see e.g., Haug and Dewald, 2004).

[9] See MIASER website: http://www.melbourneinstitute.com/research/macro/bcchronology.html

GDP data from Statistics New Zealand (Hall and McDermott, 2007, 2009). This appeared consistent with visual inspection of the real GDP data series. Moreover, the OECD data showed that the business cycle for New Zealand lasted 3 to 5 years. As in the Australian case, this was attributed to differences in variables as well as the different methods applied.[10] The Baxter-King procedure is presented in Appendix A.2.

BN Decomposition (State-Space Approach)

Secondly, the choice of the Beveridge-Nelson (BN) (1981) univariate procedure provides another dimension to evaluating the business cycles. In contrast to the cycles generated by the Baxter-King filter that are defined within a specific period and whose cycles appear relatively smooth and persistent, the BN cycles are normally short and noisy (Morley et al. 2003; and Nelson, 2008). Thus in retrospect, the BN generated cycles for the PICs should reflect to some extent the behaviour of inconsistent growth phases that have, over the decades, been predominantly impacted by transitory shocks (e.g., frequent cyclones and volatility of world export commodity prices). For the Baxter-King cycle and the BN cycles, the measure of synchronisation applied is the standard (Pearson) cross-correlation measure. This measure is used widely in empirical studies regarding business cycle synchronisation (see, e.g., Artis and Zhang, 1997, 1999; Massmann and Mitchell 2002; Artis, 2003).

The Beveridge-Nelson (BN) (1981) decomposition method in this analysis follows the state-space approach by Morley et al. (2003) and Morley (2002). Basically, the BN decomposition method is based on an autoregressive-moving average (ARMA(p, q)) model. The ARMA(p, q) model engages the unobserved components of the time series, within a theoretical equivalence of the unobserved-components (UC) representation, where output is considered as the sum of the components that constitute a long-term stochastic growth trend. Similarly, a short-term stationary deviation from long-term stochastic trend component is regarded as the cycle. In this context, the basic general form of an ARMA(p, q) model is represented as an UC-ARMA(p, q) model. Thus, within an UC-ARMA(p, q) model process, cyclical innovations are assumed to be perfectly negatively correlated with trend innovations. Hence, this implies that the UC-ARMA(p, q) model cannot be specified (see, e.g., Watson, 1986). Initially, this condition can be satisfied by restricting or assuming the value of the covariance to zero to deal with the problem of correlation between the innovations of the stochastic trend and the cycle. Earlier work by Clark (1987)

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[10] See OECD website: http://www.oecd.org/document/0/0,3343,en_2649_34349_36410880_1_1_1_1,00.html

suggested specifying the autoregressive component (p) of the UC-ARMA(p, q) model where p = 2 given that the cycle may not be periodic. This induces a periodic cyclical process by way of having a peak in its spectral density function. Further, the specifications for the covariance can be relaxed by casting the UC-ARMA(p, q) model into a state-space approach by including the cycle component with the implied trend in the state transition equation. This process enables the trend and cycle innovations to be uncorrelated. However, Morley et al. (2003) argue that due to differences in the trend and the cycle in some data, it was possible to find non-zero autocovariance. Since the UC-ARMA(p, q) is equivalent to a univariate ARIMA representation, this implies that the UC-ARMA(p, q) and its corresponding reduced-form ARIMA(p, d, q) must have MA order $q^* = \max (p, q + 1)$. This suggests that the reduced-form ARIMA(p, d, q) must have a $q + 2$ moving-average (MA) parameter on the condition that $p \geq q + 2$. For instance, when p = 2 and q = 0, the reduced-form model must have $q^* = 2$.

From available evidence (e.g., Low et al. 2006) for Australia and from determining an appropriate representation of an UC-ARMA(p, q) model, the UC-AR(2) representations for the real GDP series for Australia, as well as for New Zealand satisfy p = 2, q = 0, consistent with the specifications for the reduced-form ARIMA(2,1,2).[11, 12] The reduced-form ARIMA(2,1,2) specification was applied by Low et al. (2006) for the Australian real GDP as was the case for the US real GDP, applied by Morley (2002) and Morley et al.(2003). For the PICs, determining an appropriate representation for an UC-ARMA(p, q) based on a standard model selection assessment (see footnote 12) showed that an UC-ARMA(2,1) was the best fit for all the PICs except for the Solomon Islands with an UC-ARMA(2,2).[13] Thus p = 2 for all PICs, and q = 1 for all PICs excluding the Solomon Islands with q = 2, showed that the orders for the MA violated the condition $p \geq q + 2$. This implied that the specifications were under-identified as there was no unique UC-ARMA(p, q) model from the PICs that matched the reduced-form ARIMA(2,1,2) model. Hence, the UC-AR(2) model was considered for all PICs that matched the reduced-form ARIMA(2,1,2) as in the case of Australia and New Zealand. The reduced-form ARIMA(2,1,2) is

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[11] The representation for an UC-ARMA(p, q) fit for real GDP for New Zealand was between AR(1) and AR(2). The equivalent specifications for the reduced-form ARIMA(2,1,2) model rules out the possibility for an unobserved AR(1) model.

[12] The basic ARIMA(p,d,q) model selection criteria (see, e.g., Enders, 2004) generally evaluates the significance of the estimates, autocorrelation structure (using Ljung-Box Q-statistic) and considers the lowest value of the Akaike information criteria (AIC) and Schwarz Bayesian information criteria (SBC) to determine an appropriate choice of the ARIMA(p,d,q) model that best fits the data.

[13] For consistency in discussion, the order of integration term, d, is ignored for models in a non reduced-form UC-ARMA representation.

a general form that ensures a degree of accuracy of the forecasts for the model when cast into state-space form (Morley, 2002; Morley et al., 2003). In practise, the GAUSS program code (Morley et al., 2003) incorporates the necessary specifications within the state-space approach and performs the maximum likelihood estimation of Harvey (1981) to estimate parameters of the model. From the estimated parameters, the embedded Kalman filter algorithm generates the expected trend component which is identical to the BN stochastic trend.[14] The cycle is then extracted from the implied trend and the observed series. A limitation argued by a number of authors (e.g., Nelson and Plosser, 1982; Morley et al., 2003) is that the BN decomposition assigns more observed variance in output to the trend component and that the cycle is noisy and small in amplitude. The details of the BN decomposition procedure are shown in Appendix A.3.

Common Cycles Approach

In contrast to the Baxter-King filter and the BN decomposition method, the testing method for common cycles by Vahid and Engle (1993) embraces the concept of the serial correlation common feature (SCCF) initiated by Engle and Kozicki (1993) and cointegration (Engle and Granger, 1987; Stock and Watson, 1988; Johansen, 1998, 1991). An advantage of the Vahid-Engle methodology is that it incorporates the cointegration framework within a vector autoregressive (VAR) model set-up that allows for the dynamic interactions between variables and the identification of innovation sources to determine the existence of the trend (long-run) and cycle (short-run) components. The Vahid and Engle (1993) test is applied as a measure in assessing the extent of common business cycle synchronisation. It is a relatively new and growing research area. This analysis draws insights from recent empirical studies such as Cheung and Westermann (2003), Hernandez (2004), Harvey and Mills (2005), Sato and Zhang (2007) and Chen and Mills (2009). Hence, the application of this methodology for the PICs contributes new perspectives to this field of research.

Vahid and Engle's (1993) test determines the actual number of co-feature combinations (common cycles) within a group of non-stationary series subject to cointegration in the system. The basic premise is that when a group of non-stationary $I(1)$ series, X_t, are cointegrated, then there exist r cointegrating vectors. This implies that there are r linear combinations of the variables in X_t that yield stationary $I(0)$ series. It is noted that the co-feature combinations (common cycles) are detected from the co-movements of the stationary r linear combinations. On the other hand, the

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[14] Basically, the Kalman filter computes the optimal estimator of the state vector by estimating a minimum mean squared error (MSE) linear projection for the state vector. It is beyond this analysis to discuss the Kalman filter.

co-features (common stochastic trends) are detected from the non-stationary series, X_t. Thus, X_t would have common stochastic trends equal to the number of variables in the system N, minus r.

When common trends restrictions are imposed on the model, similarly, the number of co-feature combinations denoted as s, or common cycles is constrained by the dimension of the VECM and cointegration. Thus, the choice of r is critical as it has implications on the test outcome given that the number of linear combinations of variables in the system equals the number of squared canonical correlations implied from the test. Broadly speaking, the test by Vahid and Engle (1993) determines whether there is synchronisation of cycles among a group of variables over a given period. The null is a test for the existence of co-feature combinations (common cycles). In particular, the test performs a canonical correlation analysis similar to Tiao and Tsay's (1989) test for the scalar components model. However, apart from imposing cointegrating restrictions, the Vahid and Engle (1993) test incorporates the lag of the error-correction term in the instrument set. The past series is defined by the lagged error-correction term and the lagged stationary elements in X_t. The squared canonical correlations from the test are derived by solving an eigenvalue problem of a matrix consisting of the variables of interest.[15] The Vahid-Engle test procedure is presented in Appendix A.4.[16]

Lastly, as discussed earlier, similar (or dissimilar) business cycle behaviour can be experienced by a number of PICs including Australia and New Zealand depending on the degree and nature of shocks affecting these countries and how these countries react to these shocks. Moreover, heterogeneity among countries such as differences (or similarities) in economic structures (e.g., developed vs developing economies), geographical location, policies etc has implications on business cycles. The varying techniques applied can identify such similarities (dissimilarities) in the behaviour of business cycles among countries.

5. EMPIRICAL RESULTS

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[15] A test for co-dependence features has also been proposed by Vahid and Engle (1997). However, it is not considered here.

[16] A limitation of the common cycle approach, described as the strong form of reduced rank structure (Hecq et al. 2000, 2006) is the nature of its decomposition into weak form (WF) and mixed form (MF) structures. Since the MF is not nested within the WF, a test based on canonical correlations is not feasible (Mills and Harvey, 2005; Chen and Mills, 2009). This drawback does not affect this analysis as this paper is not concerned about any further tests for properties of WF nor MF features. It is also noted that the use of seasonally adjusted data may lead to low power and possible size distortions in the common cycle tests. However, studies such as Hernandez (2004) disproved this.

Our findings from the estimated business cycles generated by the Baxter-King filter and the BN decomposition methods are presented in Figure 1. As expected, the BN cycles for the PICs appear generally noisy compared to the Baxter-King cycles. The latter cycles appeared smoother and more persistent. This is evident amongst the PICs and also with Australia and New Zealand.[17] As discussed earlier, this is attributed to the varying properties associated with the respective methods applied.

Figure 1: Business Cycles for the PICs, Australia and New Zealand
- Baxter-King Cycles and BN Cycles, 1980: Qtr 1 to 2006: Qtr 4

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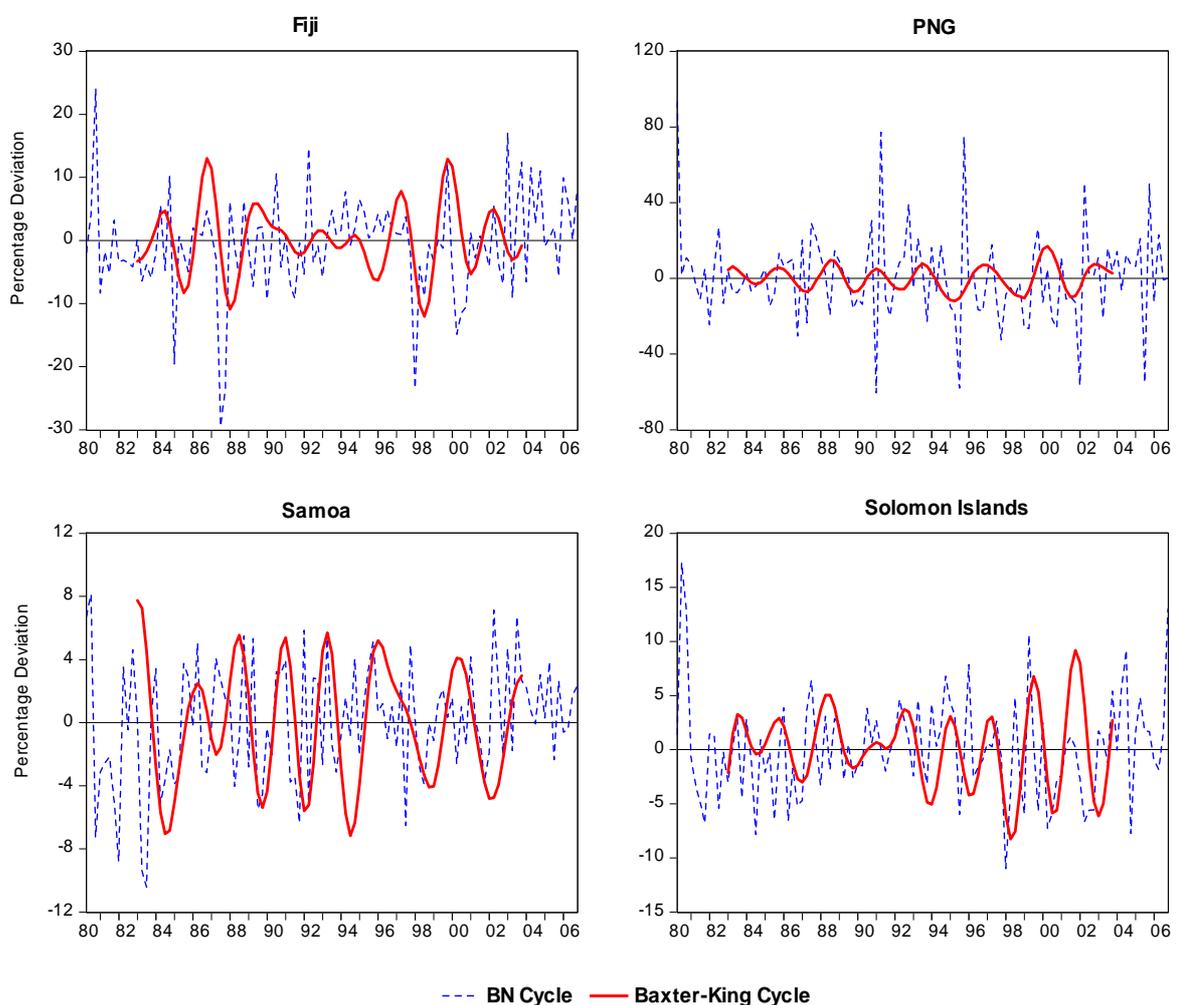
[17] The BN cycles show some periods of extremely narrow and steeper cycles such as in PNG's case especially during 1991, 1995, 2002, and 2005. Although, this is generally an expected feature of the model specifications, it also reflects major events in the time series data. The years 1991, 1995 are periods during the Bougainville ethnic crisis and the temporary closer of the Panguna copper mine, In 1991, the currency was affected by the devaluation of the Kina by some 10%; 2002 was the period when the new government took office after the elections also at the time of the mining boom; 2005 was when Australia withdrew its police force from PNG.

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Cont…Figure 1: Business Cycles for the PICs, Australia and New Zealand
- Baxter-King Cycles and BN Cycles, 1980: Qtr 1 to 2006: Qtr 4
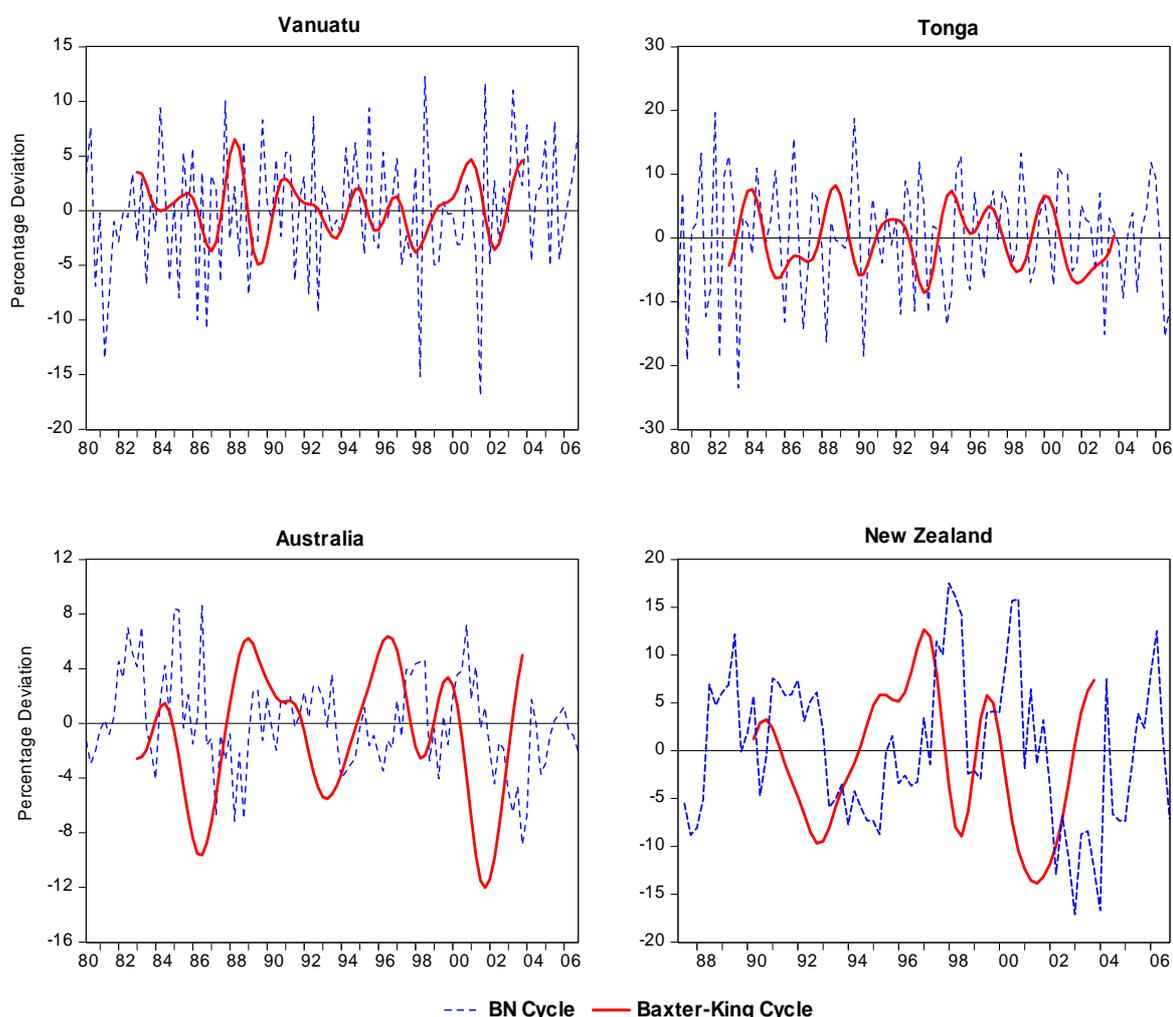
In addition, Table 1 below presents the contemporaneous cross-correlations that show evidence of the extent of synchronisation (or non-synchronisation). Positive correlations indicate synchronisation and negative correlations suggest non-synchronisation among the cycles. For Group 1 countries, intra-country comparisons for the Baxter-King cycle shows a degree of non-synchronised cycles from the negative cross-correlations for countries such as Fiji and Samoa, PNG and the Solomon Islands, and Samoa and the Solomon Islands.

In terms of behaviour of the BN cycles, a similar degree of non-synchronisation is found although with differences in intra-country cross-correlations for countries such as Fiji and Tonga, Fiji and Vanuatu, PNG and Vanuatu, and Solomon Islands and Tonga. This indicates the varying effects of asymmetric shocks that affect individual PICs in different ways, and implies a general lack of strong evidence of coherence in macroeconomic policies for the PICs as a whole. In addition,

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Table 1: Contemporaneous Cross-Correlations of the Baxter-King Cycles and BN Cycles

Country	Pacific[a]	Fiji	PNG	Samoa	S.I.	Tonga	Vatu	Aust	NZ
Baxter-King Cycle									
Fiji	0.054	1							
PNG	0.152	0.134	1						
Samoa	0.613	-0.108	0.614	1					
S.I.	-0.005	0.201	-0.074	-0.036	1				
Tonga	0.357	0.196	0.170	0.081	0.217	1			
Vatu.	0.192	-0.334	0.368	0.410	0.335	0.365	1		
Aust	0.386	-0.010	0.184	0.190	-0.063	0.648	0.167	1	
NZ[b]	0.445	0.270	0.190	0.315	0.137	0.571	0.137	0.892	1
BN Cycle									
Fiji	0.030	1							
PNG	0.058	0.009	1						
Samoa	0.294	0.101	0.280	1					
S.I.	0.134	0.242	0.076	0.064	1				
Tonga	-0.102	-0.120	0.008	0.233	-0.262	1			
Vatu.	-0.002	-0.032	-0.089	0.076	0.032	-0.013	1		
Aust	-0.135	-0.320	-0.131	-0.247	-0.193	0.215	-0.241	1	
NZ[b]	-0.215	-0.276	-0.179	-0.321	-0.223	0.060	-0.179	0.746	1

[a] Correlations for total Pacific are calculated less country of correlation to avoid multicolinearity.
[b] Based on sample 1987:2 to 2006:4; Vatu = Vanuatu, Aust = Australia, S.I. = Solomon Islands, NZ = New Zealand.

Table 2: Contemporaneous Cross-Correlations – Group 2 (Melanesia)

Country	Melanesian Cycle[a]	
	Baxter-King Cycle	BN Cycle
Fiji	0.059	0.032
PNG	0.098	0.025
S.I.	-0.034	0.130
Vatu.	0.182	0.004
Aust	0.386	-0.127
NZ[b]	0.217	-0.210

[a] Correlations for total Melanesia are calculated less country of correlation to avoid multicolinearity.
[b] Based on sample 1987:2-2006:4; Vatu = Vanuatu; Aust = Australia, S.I. = Solomon Islands;
NZ = New Zealand.

further prospects for the PICs are considered through the Melanesian (Group 2) sub-group. Table 2 results from both the Baxter-King and BN cycles shows evidence of synchronisation in terms of the positive cross-correlations between the cycles of an individual Melanesian country and

Melanesia as a whole. However, for the Baxter-King cycle, a negative correlation is observed for the Solomon Islands and Melanesia. Moreover, given the low (closer to zero) correlations, more integration efforts in terms of structural reforms and harmonisation of macroeconomic policy is required among the Melanesian countries to ensure increased co-movement among individual country cycles. In hindsight, it can be argued that given the positive but insignificant correlations among the cycles, this provides an argument against a Melanesian union.

Table 3: Common Feature Test (Vahid and Engle, 1993)

Pacific (Group 1)											
$s \geq 1$		$s \geq 2$		$s \geq 3$		$s \geq 4$		$s \geq 5$		$s \geq 6$	
Test Stat	Crit. Value	Test Stat	Crit. Value	Test Stat	Crit. Value	Test Stat	Crit. Value	Test Stat	Crit. Value	Test Stat	Crit. Value
12.2*	26.3(5%) 23.5(10%)	37.9*	48.6(5%) 44.9(10%)	91.5	72.2(5%) 67.7(10%)	151.1	97.4(5%) 92.2(10%)	227.7	124.3(5%) 118.5(10%)	326.3	153.2(5%) 146.7(10%)

Melanesia (Group 2)							
$s \geq 1$		$s \geq 2$		$s \geq 3$		$s \geq 4$	
Test Stat	Crit. Value	Test Stat	Crit. Value	Test Stat	Crit. Value	Test Stat	Crit. Value
10.9*	19.68(5%) 17.28(10%)	28.9*	36.42(5%) 33.20(10%)	78.4	54.57(5%) 50.66(10%)	141.1	74.5(5%) 69.9(10%)

* denotes significance at the 5% level.

The above findings suggest two scenarios. The first indicates evidence in favour of Melanesia (Group 2) forming a union conditional upon further efforts to realign polices to maintain a degree of similarity in business cycles among the respective countries. A possible argument in favour of this is that over more than two decades, efforts have been made among the Melanesian countries in fostering cultural, economic co-operation, regional integration and trade since an initial agreement in 1988. Until the establishment of the Melanesian Spearhead Group (MSG) in 1993, and the recent setup of the MSG Secretariat in 2008, these efforts have contributed to improved inter-regional trade among the member countries and are likely to further contribute to regional growth and cooperation once the new MSG Secretariat begins to implement policies for the MSG countries. On the other hand, the second scene alludes to the possible evidence against a

Melanesian union. One may argue that it may be too early to consider prospects for a union given the lack of strong substantive evidence in support of Melanesian countries to fully meet the conditions for a union in the strictest sense, that is, where synchronisation of cycles is present in all cases. Furthermore, assuming that Melanesian countries meet all the conditions for a union, then any further prospects for a union among Melanesia with either Australia or New Zealand may not be feasible as observed from the mixed results.

Regarding the common cycle approach, our empirical model is based on the VAR with lag, *p=4*, where *p* is based on the likelihood ratio (LR) test criteria with a maximum of 12 lags.[18] The results are provided in Appendix A.5. In addition, given that the number of common features is constrained by the presence of cointegration, the test for cointegration based on the trace rank test was undertaken. These results are presented in Appendix A.6. Again, our analysis begins with Pacific (Group 1). Cointegration (trace rank test) results shows that there are three cointegrating vectors among Group 1 countries that implies three ($N - r$) common stochastic trends. More importantly, our tests result in Table 3 earlier shows that the common feature test does not reject the null of *s = 1* and *s = 2* at the 5% significance levels. This indicates the presence of at least two co-feature vectors corresponding to two synchronised common cycles. The presence of the synchronised common cycles is an important precondition for a currency or monetary union. However, from a theoretical perspective, for a single union-wide common policy to be effective, a single synchronised common cycle among the PICs would be the most ideal condition.

On the other hand, the achievement of a single common cycle may not be practically feasible in the short-to-medium term or even in the long-run given the varying extent of heterogeneity and the likely effects of unforeseen asymmetric shocks among countries over time. For example, to work towards a single synchronised common cycle over time may cause more divergence than convergence in individual country policies when faced with asymmetric shocks. Hence, the timing to form a union, ex-*post*, once there is a single common cycle may not necessarily be an issue subject to the condition that a system (e.g., structural adjustment policy) is in place to ensure that the goal of a single synchronised common cycle is achieved in the long-run, even after forming a union (see, e.g., Kydland and Prescott, 1977; Tavlas, 1993). Further investigation for the Melanesian countries (Group 2) shows a similar test result to that of Group 1. Thus, with two synchronised common cycles, the argument for a union, *ex-ante*, is feasible, again, subject to further harmonisation of policies.

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[18] The optimal lag length was consistent with analysis of the common cycles in recent studies (e.g., Chen and Mills, 2009) where the LR test criterion was applied.

6. CONCLUSION

This paper analyses the prospects for a currency union among Pacific Island countries (PICs), and where feasible with either Australia or New Zealand by evaluating the synchronisation of business cycles. The analysis is based on the optimal currency area (OCA) theory regarding symmetry of shocks. Analysis of the PICs (Group 1), and the Pacific sub-group, Melanesia (Group 2) are undertaken using three different methodologies namely the Baxter-King band pass filter, the BN decomposition, and the common features econometric test by Vahid and Engle (1993). The overall findings provide the following conclusions: first, the combined results shows that it was not feasible for the Pacific Islands (Group 1), as a group, to form a currency union. Secondly, further analysis for Group 2 (Melanesia) reveals generally mixed results that allude to two main arguments. The first argues against a Melanesian union based on the mixed results. The opposing argument contends that a Melanesian currency union is feasible, ex-ante, and subject to further harmonisation of policies. This is based on the similar (positive) directions in business cycles even though their corresponding correlations appear weak or closer to zero.

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Appendix A.1

Table 1: Summary Statistics of Real GDP growth (year-ended), 1980 - 2006

Country	Mean	Median	Maximum %	Minimum	Std. Dev.	Skewness	Obs
Fiji	2.77	2.91	22.27	-17.03	6.51	-0.13	104
PNG	3.10	3.18	25.27	-18.08	8.49	0.28	104
Samoa	5.57	3.44	78.75	-26.29	17.75	1.60	104
S.I	2.12	2.36	16.06	-15.92	6.22	-0.44	104
Tonga	4.94	2.69	66.03	-11.01	10.28	3.58	104
Vanuatu	2.77	2.74	15.46	-9.01	4.70	-0.03	104
Australia	3.23	3.81	7.56	-3.43	2.06	-1.01	104
NZ[a]	2.71	2.83	7.67	-2.37	2.18	-0.33	75

Notes: [a] Sample for NZ series is based on data from 1987:2 to 2006:4.

Appendix A.2

Baxter and King (1999) Filter

Baxter and King (1999) approximates the form of a 2-sided infinite moving-average, X_t, and derives a new series, X_t^{BK} in the following form,

$$X_t^{BK} = \sum_{k=-K}^{K} a_k X_{t-k} = a(L) X_t \tag{A2.1}$$

where L is the lag operator and symmetry is imposed on moving averages where $a_k = a_{-K}$ for $k = 1,..., K$ to isolate trends in the series. The filtered stationary series, X_t^{BK}, in equation (A2.1) is derived within the premise of the frequency-domain theory, in the form of the Cramer representation,

$$X_t = \int_{-\pi}^{\pi} \xi(\omega) d\omega \tag{A2.2}$$

where $\xi(\omega)$ represents the random periodic components that are mutually orthogonal $(E\xi(\omega_1)\xi(w_2)' = 0 \ for \ \omega_1 \neq \omega_2)$. Thus the filtered time series, X_t^{BK} in equation (A2.1) can be represented as,

$$X_t^{BK} = \int_{-\pi}^{\pi} \alpha(\omega)\xi(\omega) d\omega \tag{A2.3}$$

where $\alpha(\omega) = \sum_{h=-K}^{K} a_h e^{-i\omega h}$ represents the frequency-response function of the liner filter. It is the weight attached to the periodic component $\xi(\omega)$. Thus from a frequency-domain logic, a band-pass filter, constructed from two low-pass filters, passes only frequencies $-\omega_1 \leq \omega \leq \omega_1$. It will have a frequency response function given by $\beta(\omega) = 1$ for $|\omega| \leq \omega_1$ and $\beta(\omega) = 0$ for $|\omega| > \omega_1$ within a time domain representation given by the two-sided infinite-order moving-average, $b(L) = \sum_{h=-\infty}^{\infty} b_h L^h$ with weights given by $b_h = \int_{-\pi}^{\pi} \beta(\omega)e^{i\omega h} d\omega$. The weights are simply $b_0 = \omega_1/\pi$ and $b_h = sin(h\omega_1/h\omega)$. To approximate the ideal filter with a finite K-th order moving average $a(L) = \sum_{h=-K}^{K} a_h L^h$ with frequency response function, $\alpha_K(\omega)$, the aim is to choose the weights of the approximating filter to minimize a quadratic loss function

$Q = \int_{-\pi}^{\pi} |\beta(\omega) - \alpha_K(\omega)|^2 d\omega$ so as to minimise the discrepancies between the finite-sample filter and the ideal band-pass filter. An approximation to the ideal band-pass filter that passes frequencies between $-\omega_1 \leq \omega \leq \omega_2$ is then constructed with cut-off frequencies ω_1 and ω_2. In the case where stationary time series are required to be filtered from non-stationary series, Baxter and King show that the optimal approximate low-pass filter weights, $a_h = b_h + \theta$, can be adjusted by the adjustment coefficient θ where $\theta = (1 - \sum_{h-K}^{K} b_h)/(2K + 1)$. The weights for the optimal approximate band-pass filter are $a_h = (\bar{b}_h + \underline{b}_h) + (\bar{\theta} - \underline{\theta})$, where $\bar{\theta}$ and $\underline{\theta}$ are the adjustment coefficients for the upper and lower cut-off filters respectively. In order to implement the BK filter, the researcher must first choose the range of durations (periodicities) to pass through, that is, the cut-off frequencies, ω_1 and ω_2, and the order of the moving average, K.

Appendix A.3

Beveridge-Nelson (1981) Decomposition

Beveridge-Nelson (BN) (1981)'s univariate decomposition, following from Morley et al.'s (2003) approach, begins with the theoretical equivalence of the following unobserved-components (UC) representation,

$$X_t = T_t + C_t, \tag{A3.1}$$
$$T_t = T_{t-1} + \mu + \xi_t, \qquad \xi_t \sim i.i.d. \, N(0, Q_\xi^2), \tag{A3.2}$$

where X_t is the observed series, T is the unobserved stochastic trend assumed to be a random walk with mean growth rate, μ, and C_t is the unobserved stationary cycle.[19] The trend innovation, ξ_t, is independently and identically distributed with mean zero and variance, Q_ξ^2. This process allows that C_t is a stationary and invertible ARMA(p, q) process whose cyclical innovations, ϵ_t, may be contemporaneously cross-correlated with trend innovations, ξ_t, where,

$$\phi_p(L)C_t = \theta_q(L)\epsilon_t, \qquad \epsilon \sim i.i.d \, N(0, Q_\epsilon^2) \tag{A3.3}$$
$$Cov(\xi_t, \epsilon_{t\pm k}) = \begin{cases} Q\epsilon\xi & \text{for } k = 0, \\ 0 & \text{otherwise} \end{cases}$$

The above covariance can take the value of zero or non-zero. Restricting the value of the covariance to zero may address the problem of correlation between the innovations of the stochastic trend and the cycle. To specify the necessary conditions, Clark (1987) propose that the autoregressive component (p) = 2, as applied by Morley et al. (2003). This engages the cyclical process to be periodic. The UC-ARMA(p, q) model is then cast into state-space form. This process implies that the trend and cycle innovations are uncorrelated and that the model is augmented to include $Q_{\epsilon\xi} = 0$.[20] However, Koopman (1997) and recently Morley et al. (2003) argue that differences in the implied trend and cycle in some data may often imply a non-zero covariance suggesting that the unobserved model may be misspecified. To resolve this, the conditions are specified in the context of the reduced-form ARIMA(p, d, q) since the UC-ARMA(p, q) implies an equivalent univariate ARIMA(p, d, q) representation. Substituting equations (A3.2) and (A3.3) into (A3.1), we get the reduced-form ARIMA (p, d, q) where ΔX_t takes the form,

$$\phi_p(L)(1 - L)X_t = \phi_p(L)\mu + \phi_p(L)\xi_t + \theta_q(L)(1 - L)\epsilon_t \tag{A3.4}$$

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[19] The μ is allowed to behave as a random walk and in some cases with an addition of an irregular term. This change may have little influence on the estimated cycle (Morley et al. 2003).

[20] This set-up continues to be standard framework for the treatment of trend-cycle decomposition in the state-space framework as in Proietti (2002), Morley (2002), Morley et al. (2003) and Harvey (2008).

where the right-hand side of equation (E2.4.) represent the sum of the MA(p) and MA($q* + 1$) processes. This means that the UC-ARMA(p, q) and the reduced-form ARIMA(p, d, q) must have MA order $q* = $ max (p, $q + 1$).[21] It implies that the autoregressive (AR) component of equation (E2.4) and the reduced-from ARIMA(p, d, q) are equivalent. Therefore the reduced-form ARIMA(p, d, q) must have $q + 2$ MA parameters and $p \geq q + 2$. Following from Morley et al. (2003) and earlier discussion by Morley (2002), the state-space approach is applied for computing the exact BN cycle given a reduced-form ARIMA(2,1,2) model. The state-space framework generalises that the reduced-form ARIMA(2,1,2) model when cast in state-space form is able to generate accurate forecasts since $\Delta X_t - \mu = [h_1, h_2 \ldots h_k] X_t$, where $h_1, h_2 \ldots h_k$ are the weight of the i-th element of X_t, in determining $(\Delta X_t - \mu)$. Thus $(\Delta X_t - \mu)$ is a liner combination of the first elements in the state-vector Z_t, given as,

$$Z_t = F Z_{t-1} + v_t, \qquad v_t \sim N(0, \psi) \tag{A3.5}$$

where the eigenvalues of F take the values less than one in modulus. Thus, the BN trend is computed as,

$$T_t^{BN} = X_t + [h_1, h_2 \ldots h_k] F (I - F)^{-1} Z_{t|t} \tag{A3.6}$$

where the $Z_{t|t}$ term assumes the realised value of the state-vector since the elements are all observed at time t. The BN cycle is,

$$C_t^{BN} = -[h_1, h_2 \ldots h_k] F (I - F)^{-1} Z_{t|t} \tag{A3.7}$$

Appendix A.4

Common Cycle Test

The common cycle testing approach (Vahid and Engle, 1993) is a test for the existence of cofeature combinations or common cycles. The test is preformed sequentially beginning with the null that there is at least one co-feature combination, s, against the alternative that there is none. If this does not hold, the null of at least two co-feature combinations are tested until the number of linear combinations is, $s \leq N - r$; N represents the number of variables in the vector autoregressive model; r represents the of number of cointegrating vectors in the system. Thus the test statistic that determines the actual number of co-feature combinations, s, is presented as,

$$C(p, s) = -(T - p - 1) \sum_{j=1}^{s} \ln (1 - \ell_j^2)$$

where the ℓ_j^2, for $j = 1, \ldots, s$, are the s smallest estimated squared canonical correlations between ΔX_t and its related history $H(p) = (\Delta X_{t-1}, \ldots, \Delta X_{t-p}, e_{t-1})$ where e_{t-1} is the lagged error-correction term. T is the total number of observations of the variables of interest. Accordingly, when defining Z_t as the matrix of elements consisting of ΔX_t and H_{-1} as the matrix of elements consisting of $H(p)$, then $\tilde{\ell}^2, \ldots, \tilde{\ell}_s^2$ are derived as the s smallest eigenvalues of

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[21] See discussion also in Oh et al. (2008).

$(Z'Z)^{-1}Z'\,H_{-1}(H'_{-1}H_{-1})^{-1}\,H'_{-1}Z$.[22] This test statistic $C(p,s)$ under the null has an asymptotic χ^2 distribution with $s(Np+r)$ - $s(N-s)$ degrees of freedom, where p is the lag order of the VECM.

Appendix A.5 – VAR Lag Order Selection

VAR Lag order Selection Criteria - Max Lag selection 12

Lag	0	1	2	3	4	5	6	7	8	9	10	11	12
						Pacific (Group 1)							
LR	NA	423.7	49.77	41.44	65.5*	38.70	45.23	31.99	40.59	31.29	24.80	49.02	33.86
AIC	-7.6	-11.6	-11.5	-11.3	-11.4	-11.3	-11.3	-11.2	-11.3	-11.3	-11.2	-12.2	-12.9*
SC	-7.5	-10*	-9.44	-8.27	-7.48	-6.36	-5.42	-4.31	-3.46	-2.51	-1.51	-1.49	-1.25
HQ	-7.6	-11*	-10.6	-10.1	-9.86	-9.32	-8.95	-8.41	-8.14	-7.76	-7.33	-7.88	-8.22
						Melanesia (Group 2)							
LR	NA	346.7	24.37	23.35	27.7*	20.71	22.16	9.35	22.70	6.25	10.73	14.21	14.09
AIC	-3.9	-7.4*	-7.37	-7.32	-7.34	-7.28	-7.26	-7.07	-7.09	-6.86	-6.73	-6.67	-6.64
SC	-3.8	-6.8*	-6.41	-5.93	-5.52	-5.04	-4.59	-3.97	-3.57	-2.91	-2.35	-1.86	-1.40
HQ	-3.9	-7.2*	-6.98	-6.76	-6.60	-6.37	-6.18	-5.81	-5.67	-5.27	-4.96	-4.73	-4.52

* indicates lag order selected by the criterion; LR: sequential modified LR test statistic (each test at 5% level); AIC: Akaike Information Criterion; SBC: Schwarz Bayesian Information Criterion; HQ: Hannan-Quinn Information Criterion

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[22] See further discussion in Harvey and Mills (2005) and Chen and Mills (2009).

Appendix A.6 - Johansen Cointegration Test Results

ln(Real GDP, base year, 2000): Trend assumption: Linear deterministic trend; Lags interval (in first differences): 1-3 lags; N (original) = 1980:1 to 2006:4											
Pacific (Group 1)	Trace Test, λ_{trace}						Max-Eigenvalue Test, λ_{max}					
	r=0*	r≤1*	r≤2*	r≤3	r≤4	r≤5	r=0*	r≤1	r≤2	r≤3	r≤4	r≤5
Eigenvalue.	0.48	0.25	0.21	0.20	0.03	0.00	0.48	0.25	0.21	0.20	0.03	0.00
Test-Statistic	148.17	80.18	50.82	26.20	3.05	0.06	67.99	29.36	24.62	23.15	2.99	0.06
5% Crit.value	95.75	69.82	47.86	29.80	15.49	3.84	40.08	33.88	27.58	21.13	14.26	3.84
*p-value**	0.00	0.01	0.03	0.12	0.96	0.80	0.00	0.16	0.11	0.03	0.95	0.80
Melanesia (Group 1)	Trace Test, λ_{trace}						Max-Eigenvalue Test, λ_{max}					
	r=0*	r≤1*	r≤2	r≤3	r≤4	r≤5	r=0*	r≤1*	r≤2	r≤3	r≤4	r≤5
Eige value.	0.38	0.23	0.08	0.00			0.38	0.23	0.08	0.00		
Test-Statistic	84.75	35.58	8.41	0.03			49.17	27.17	8.38	0.03		
5% Crit.value	47.86	29.80	15.49	3.84			27.58	21.13	14.26	3.84		
*p-value**	0.00	0.01	0.42	0.87			0.00	0.01	0.34	0.87		

** The *p-values* are from MacKinnon-Haug-Michelis (1999); * Represents significance at 0.05 level.