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Abstract

This paper proposes a framework to construct indexes of activity which links two strands of the index literature – the traditional business cycle analysis and the latent variable approach. To illustrate the method, we apply the framework to Australian regional data, namely to two resource-rich and two service-based states. The results reveal differences in the evolution and drivers of economic activity across the four states. We also demonstrate the value of the Index in a broader context by using a structural vector autoregression (SVAR) approach to analyse the effects of shocks from the US and from China. This Index-SVAR approach facilitates a richer analysis because the unique feature of the index method proposed here allows impulse responses to be traced back to the components.

JEL classification: C43, E32

Keywords: Regional economic activity, coincident indicators, dynamic latent factor model

1 Introduction

Policy makers and business analysts are often required to compare regions at different stages of economic development and with diverse economic structures and sizes. To facilitate the comparison, information is often cumulated into one overall measure and various approaches have been suggested to summarise diverse information.

The oldest and most enduring index method is that proposed in the 1960s by G.H. Moore and J. Shiskin at the National Bureau of Economic Research (NBER); see MOORE and SHISKIN (1967).[1] This classical method, henceforth NBER index, remains popular today. It is, put simply, the weighted average of a relatively small number of variables. The main advantage of the NBER method is its simplicity and transparency. NBER indexes are easy to build, easy to explain and easy to interpret. The main disadvantage is that the weights and component variables are often selected and determined in an *ad hoc* manner and often independently of each other. To illustrate, let I_t denote the Index, which is made up of N component variables X_{it} with weights w_i :

$$I_t = \sum_{i=1}^{N} w_i X_{it}. \tag{1}$$

In the NBER index, the components are pre-selected on the basis of a range of criteria, and similarly the weights are pre-determined in an *ad hoc* manner. To add to the complication, the index is often not benchmarked to an observable series, rather it is presented as an indicator of economic activity.

To address the somewhat arbitrary weight and component series selection, various alternative methods have been proposed. Among the most prominent alternatives are methods that apply dynamic principal component analysis to large datasets, see STOCK and WATSON (2002) and FORNI et al. (2005) at the European Central Bank (ECB) and for a detailed discussion of various dynamic latent factor models, see STOCK and WATSON (2011). Other prominent

[1] The method aggregates three types of indicators - leading, lagging and coincident - into formal composite indicators of leading, lagging and coincident indicators.

methods are ISSLER and VAHID (2006) who use canonical correlations and ARUOBA et al. (2009) who apply a Kalman filter to a mixed frequencies dataset.[2]

The innovation proposed in this paper is to create an Index which links two strands of the indicator literature - the weighting approach that underpins traditional business cycle analysis and the latent variable approach that underpins recent time series analysis. The application is on Australian regional (State) data; specifically the application has been chosen to obtain insights about the relative performance of 2 resource-rich regions Western Australia (WA) and Queensland (QLD) and 2 service-based regions New South Wales (NSW) and Victoria (VIC). The aims of the paper are (1) to extract underlying regional Indexes, (2) to compare the performance of the regions by analysing the changes in the Index and (3) to use the Indexes more broadly in a structural vector autoregression (SVAR) framework to understand the effects of foreign shocks (namely the US and China) as well as from State specific shocks.

The paper is organised as follows. Section 2 outlines the empirical framework and gives a short discussion of the data. The section shows how the Kalman filter methodology is used to generate estimates which can be directly mapped into weights for the component series. These weights represent the contributions of the drivers of regional business activity. Section 3 gives the estimation results and discusses the evolution of the regional cycles in light of domestic and global shocks. In Section 4, the Indexes are used in a structural vector autoregression framework to assess the effects of foreign (namely US and China) as well as State specific shocks. We show how the use of Indexes in a VAR framework results in a richer analysis as impulse responses can be traced back to the component series of the Indexes. The unique feature of the Index proposed here expands the analysis normally associated with the use of a VAR model. The final Section 5 offers some concluding remarks.

[2] For a study which show that the performance of Indexes that are based on a large dataset or that utilise sophisticated econometric techniques do not necessarily outperform a relatively simple NBER index; see, for example CLAUS (2011).

2 Empirical Framework

The change in the Index is computed as a weighted sum of a set of N standardized components:

$$\begin{aligned} \Delta I_t &= \sum w_i x_{it} \\ x_{it} &= \frac{X_{it} - \mu_i^x}{\sigma_i^x} \, . \end{aligned} \tag{2}$$

The components are standardized so that they are unit-free and the weights can then be conveniently interpreted as the proportional contribution of the component such that $0 < w_i < 1$, and $\sum w_i = 1$. The components are specified as stationary series to ensure that the means (μ_i^x) and standard deviations (σ_i^x) remain stable over time. Thus, changes in the Index can be attributable to deviations of the components from their respective means. By construction, the level of the Index is computed as the accumulation of the changes and thus temporal changes in the Index show the evolution of the Index across time as a result of deviations of the components from their long run average values. A series of positive deviations would cause the Index to evolve in an upward direction; conversely a series of negative deviations would cause the Index to evolve in a downward direction. If the Index is not benchmarked to any particular economic measure, it creates a problem as the weights cannot be determined, for example to optimize the tracking performance of the Index with respect to a reference cycle. One way around this problem would be to let the weights be pre-determined, or to let each weight be equal to $1/N$ where N is the number of component variables. In this latter case, the proposed Index may be viewed as a summary measure of a range of variables deemed of equal relevance to economic activity.

A better way is to view the Index as an unobservable latent variable. A latent factor can be thought of as an underlying unobservable series that influences significantly other observable series. For example, the economic environment can be thought of as a latent variable because it cannot be directly measured but the economic environment itself would have significant influence on, for example, economic confidence, and other drivers of economic activity. Following STOCK and WATSON (1989) the econometric model which specifies the Index of economic activity as a dynamic latent factor is:

$$\begin{aligned} x_{it} &= \beta_i L_t + u_{it}, \quad i = 1, ...N \\ L_t &= c + \sum_{i=1}^{J} \rho_i L_{t-i} + e_t \\ u_t &\sim N(0, \Sigma), \quad e_t \sim N(0, \sigma_e^2) \end{aligned} \tag{3}$$

where $\Sigma = diag \begin{bmatrix} \sigma_1^2 & \sigma_2^2 & \cdots & \sigma_K^2 \end{bmatrix}$, and $\sigma_i, \beta_i, c, \rho_j$, and σ_e for $i = 1, ..., K$ and $j = 1, ..., J$ are unknown parameters. L_t is the latent (unobservable) variable which is postulated to be an autoregressive data-generating process. Solving for L_t gives:

$$L_t = \frac{1}{\beta_i} x_{it} - \frac{1}{\beta_i} u_{it}, \quad i = 1, ...N \ . \tag{4}$$

Then, under the assumption that $\sum \frac{1}{N} L_t = \Delta I_t$ and since $E(u_{it}) = 0$, plausible estimates of the weights can be derived as:

$$w_i = \frac{1}{\beta_i} \ . \tag{5}$$

The key ingredient to our technique is to restrict the factor loadings β_j in equation (3) so that the weights sum to 1 ($0 < w_i < 1$, and $\sum w_i = 1$). It is this restriction that links the traditional index approach to the latent factor approach and *vice versa*. As the model expressed in (3) is a state space model, the Kalman filter (see KIM and NELSON (1999)) and the maximum likelihood estimation are used to estimate the model (For identification purposes, σ_e^2 is restricted to unity.) The advantage of this approach is that it is internally consistent; the proposed Index is interpretable as a weighted average of a number of components; and the weights and components capture the behaviour of a latent reference economic factor. Thus the weights are not subjective, nor necessarily equal. Also, note that, the significance of the parameters, may be used as a guide to the importance of the selected component.[3]

[3]HAKKIO and KEETON (2009) also propose an index where the weights of the component series are based

3 Regional Indexes of Activity

3.1 Data

The aim is to construct a single Index of activity for each of the four regions to facilitate regional comparisons. We re-iterate an important point about the methodology - the weights are derived from the contribution to the latent variable. Also the weights are scaled to sum to one, hence the list of variables can be large and broad-ranging meaning that the Index is designed as an encompassing concept; or the set of variables can be small and the Index is designed to capture a specific concept. Practical considerations also affect the choice of components. The series must be available at the regional level and the historical data must cover a sufficiently long time span so that an analysis of relative economic conditions over the medium to longer term is feasible. The series must be statistically adequate; they should measure the same economic process over time. The series should exhibit cyclical movements and have a certain degree of smoothness; it is difficult to extract signals from series that exhibit large quarterly swings.

For this application, we are broadly interested in the changes in economic activity in each of the four States as a result of 5 component drivers; namely: (i) state final demand per capita; (ii) employment; (iii) retail trade per capita; (iv) investment per capita; and (v) merchandise exports per capita. The selection of the 5 variables are influenced by the set of economic variables usually identified as indicators of economic activity. The 2 variables - state final demand per capita and employment cover activity and employment. The next 3 variables - retail, investment and exports are to account for the fact that the regions have different industrial structures. NSW and VIC are more sensitive to services and hence are more likely to be affected by changes in retail trade. WA and QLD are more sensitive to the demand for resources and hence total private new capital expenditure and exports have been included.[4] All variables are sourced from the Australian Bureau of Statistics (ABS).

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on latent factor analysis. The draw-back of that index is that it is based on *static* principal component analysis

[4] We have used quarterly merchandise exports because quarterly total exports, goods and services exports, are not available at the State level.

3.2 Econometric Results

The model in equation (4) was applied to the four regions. Note that all the State Indexes have the same set of components. All variables except employment are expressed as first difference; employment is expressed as growth rates (the change in the natural logarithms). The component series are transformed into unit free z-scores ($\overline{x}$), or $\overline{x}_i = (x_i - \mu_i)\,\sigma_i^{-1}$ where μ_i and σ_i are the i^{th} component series' mean and standard deviation.

3.3 Weights

Table 1 gives the estimated weights that are consistent with the parameter estimates presented in Table 3 in Appendix A. Note that $\sum \frac{1}{\beta_i} = \sum w_i = 1$. The weights show the contribution of a 1 standard deviation positive change in the components. The table shows that the drivers of each of the regional Indexes in descending order are: merchandise exports per capita, employment, retail turnover per capita, investment per capita and state final demand per capita for all States. All weights are statistically significant suggesting that all five components are essential drivers of State economic activity and are correctly included in the Index. The weights vary between around 0.14 and 0.24 suggesting that no one driver dominates. This relatively tight spread in weights is of particular importance here. If one weight was considerably larger than all the others then constructing an Index would not be useful as the single component series could serve as the indicator of economic activity.

The large contribution of exports in the Indexes is not surprising given that Australia is a small open economy; about 22 per cent of goods and services produced in Australia are exported (for the four States, these numbers are: 16 per cent for NSW, 12 per cent for VIC, 28 per cent for QLD and 54 per cent for WA) and Australian producers are, mostly price takers. Employment is typically an important driver in Indexes of economic activity and this is also the case here. The low weight on state final demand per capita is evidence for each Index's usefulness. It suggests that relying solely on state final demand as an indicator of economic activity may be misleading.

Table 1: Estimated weights

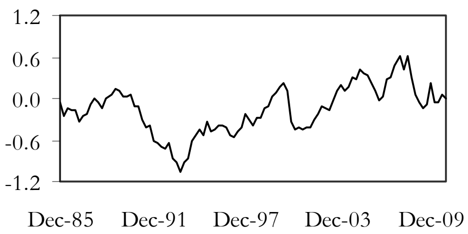
Variable	NSW	VIC	QLD	WA
sfd	0.1546	0.1457	0.1599	0.1417
emp	0.2288	0.2265	0.2192	0.2367
retail	0.2152	0.2104	0.2143	0.2136
inv	0.1653	0.1846	0.1790	0.1664
exp	0.2362	0.2328	0.2277	0.2416

3.4 Regional Indexes

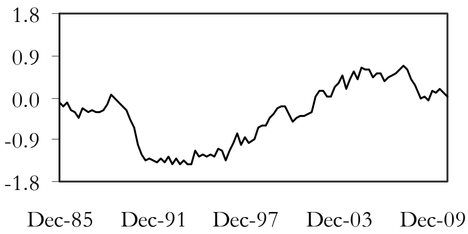
Figures 1 a to d show the level of the Regional Indexes between December 1985 and December 2010. The levels are calculated by summing up all the quarterly changes over the sample period. In general the levels of these Indexes are not comparable, unless there is consensus about the reference points where Indexes with the same value describe the same level of economic activity. Growth rates of the Indexes are however comparable. Thus when the growth rate of Index j, is shown to be greater than the growth rate of Index k, this means that economic conditions in State j has improved by more than economic activity in State k.

Figure 1: Four regional indexes - levels

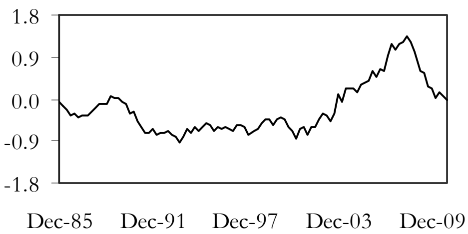
a. NSW



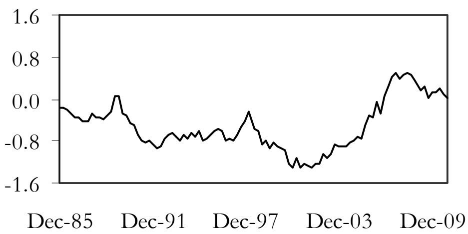
b. VIC



c. QLD



d. WA



Figures 1 a to d show that activity has evolved differently across the four States over the past 25 years. The only two common points in the figures are a peak in economic activity in 1989 followed by a trough in activity in the first half of the 1990s reflecting the last recession in Australia in 1990-91[5] and a slow-down in activity during the global financial crisis (GFC) that culminated with the collapse of Lehman Brothers in September 2008.

In NSW (Figure 1 a) the 1990-91 recession caused a sharp decline in economic activity from which the State recovered relatively fast. The Asian Financial Crisis (AFC) does not seem to have affected activity in NSW but another slow-down in activity seems to have occurred between September 2000 and June 2002 around the time of the dot-com bubble burst in April 2000 and the slow-down in global economic activity that followed. Though activity moderated during the GFC, the State did not experience large declines in economic activity.

Figure 1 b suggests that the decline in activity in VIC associated with the 1990-91 recession was the sharpest among all four States and that the VIC economy recovered more slowly than NSW. An interesting feature of the VIC Index is that although a moderation in economic activity during the GFC is apparent, activity seems to have plateaued before the crisis, in the second half of 2005.

Economic activity in QLD (Figure 1 c) seems to have been the least affected by the 1990-91 recession and unlike the other three States, activity remained moderate for the entire 1990s decade. What seems to have been a turn-around for activity in QLD is a rapid rise in the world demand for commodities and the associated rapid rise in commodity prices to record highs. The figure shows a rapid rise in activity in line with the global commodity boom. This rapid expansion in activity seems to have come to an end with the GFC. The QLD activity Index recorded the largest declines of all States during the GFC.

In WA (Figure 1 d) economic activity moderated with the 1990-91 recession and, similar to QLD, activity remained relatively moderate for most of the 1990s. Interestingly, WA seems

[5] There exists considerable disagreement among economists on the definition of a recession. A simple and popular rule of thumb is to define a recession as at least two consecutive quarterly declines in real GDP and this is the definition used here.

to be the only State economy out of the four that was considerably affected by the AFC that began in July 1997 indicated by marked declines in the WA activity Index in the late 1990s. Similar to QLD, the Index shows a rapid expansion over much of the 2000s in line with the global commodity boom that came to halt with the GFC. However, for WA, the slow-down was less pronounced than in QLD.

To sum up, the two major events affecting Australian economic activity over the past 25 years, that is the 1990-91 recession and the GFC, are clearly visible in the activity Indexes of all four States but their impacts differed considerably. Further, the evolution of economic activity over the past two and a half decades has been markedly different in the four States. Though there are some similarities among the two resource rich regions of QLD and WA and the two service based regions of NSW and VIC, there are considerable differences. NSW and WA seem to have experienced more ebbs and flows in activity. VIC's Index suggests robust expansion in the State that seems to have plateaued before the GFC. The QLD Index suggests relatively subdued activity over most of the 1990s followed by a relatively rapid expansion in line with the global commodity boom that also seems to have accelerated activity in WA. Last but not least, various world events have impacted some but not other States. The dot com bubble burst seems to have mostly affected NSW, the AFC mostly WA and the global commodity boom seems to have mostly affected QLD and WA.

3.5 Contributions of the Components

To re-iterate from section 2, changes in the Index over time are the result of deviations of the components from their long run values. A sector may be large in absolute terms and hence be important for the level of activity; but if it varies little, it may not be important in driving the ebbs and flows of activity. Similarly, a sector may be small but if it experiences large swings, it may be an important driver of changes in activity.

Figures 2a to d show the contributions of each component to each State Index between December 1985 and December 2010. The contribution is calculated by applying $L_t = \frac{1}{\beta_i} x_{it}$ of equation (4) to the data. The contributions do not add to 1 as shocks, i.e. $\frac{1}{\beta_i} u_{it}$ of equation (4) or are not included here. The shocks are discussed in detail in Section 3.6 below. A positive reading for a series means that the component adds to growth in the Index while a negative reading means that the component detracts from growth.

Figures 2a to d illustrate that not only has the evolution of economic activity differed across States over the past 25 years their drivers have also differed. Overall, reflecting their relative weight, exports and employment have been important drivers of activity. Employment was the main force behind the 1989 peak and this occasion appears to be the only time over the sample period that the drivers of activity aligned across all States.

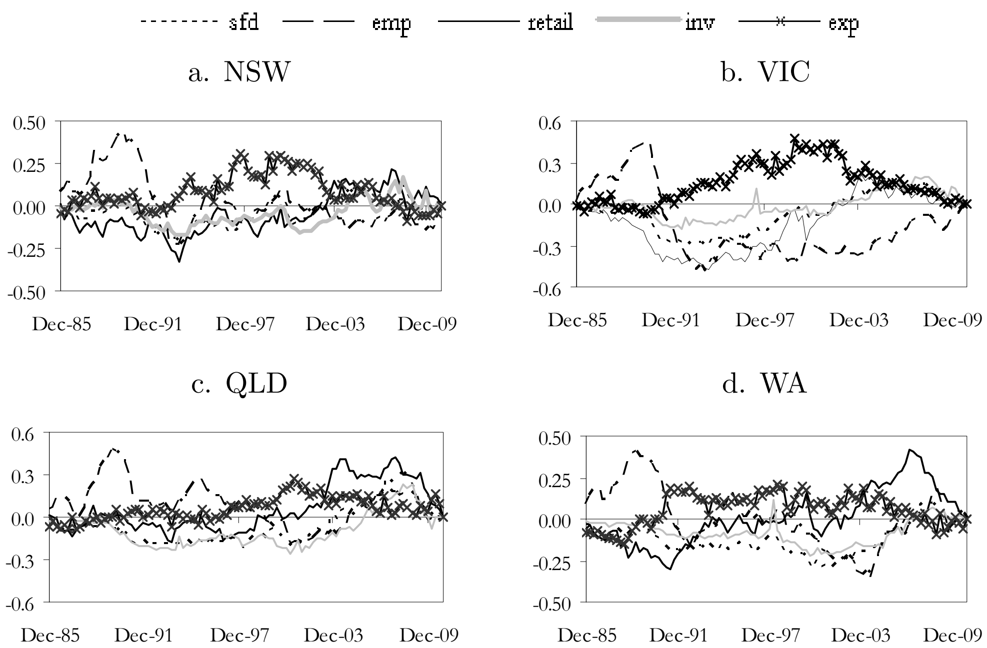
In NSW (Figure 2a), the 1990s recession was mainly driven by a downturn in employment and, to a lesser extend, downturns in retail sales and state final demand. Exports were the engine of growth over the 1990s. Pre-GFC growth was broad based with only employment subtracting from growth. Apart from the 2000s, retail trade has not been adding to activity in NSW.

In VIC (Figure 2b) the 1990-91 was driven by all components except exports. In fact, exports were the only driver of activity in the 1990s with the exception of investment in the June quarter 1997. Since the early 2000s, the importance of exports has been declining and the other components, except employment, have also been contributing to activity.

In QLD (Figure 2c), employment and exports made positive contributions to activity over most of the 1990s while clearly the biggest driver of activity over the 2000s has been retail sales. Interestingly, the positive contribution of exports does not seem to have been affected by the GFC.

In WA (Figure 2d), exports have been making a positive contribution to activity over most of the sample but unlike QLD, exports seem to have been affected by the GFC. The overall average contribution shows a relatively smaller but steady contribution from exports for WA suggesting more stable export growth in WA compared to the other three States. Investment started to make positive contribution to growth in the second half of the 2000s as the commodity boom gathered momentum. Resource extraction is very (physical) capital intensive suggesting that the growth in investment was largely driven by mining investment. Interestingly, investment has continued to make positive albeit small contributions to growth in the wake of the GFC. This perhaps suggests that Western Australians expect continued strength in the commodities market in the near to medium future. As in QLD, retail sales have been the most important driver of activity over the 2000s.

Figure 2: Contribution of components

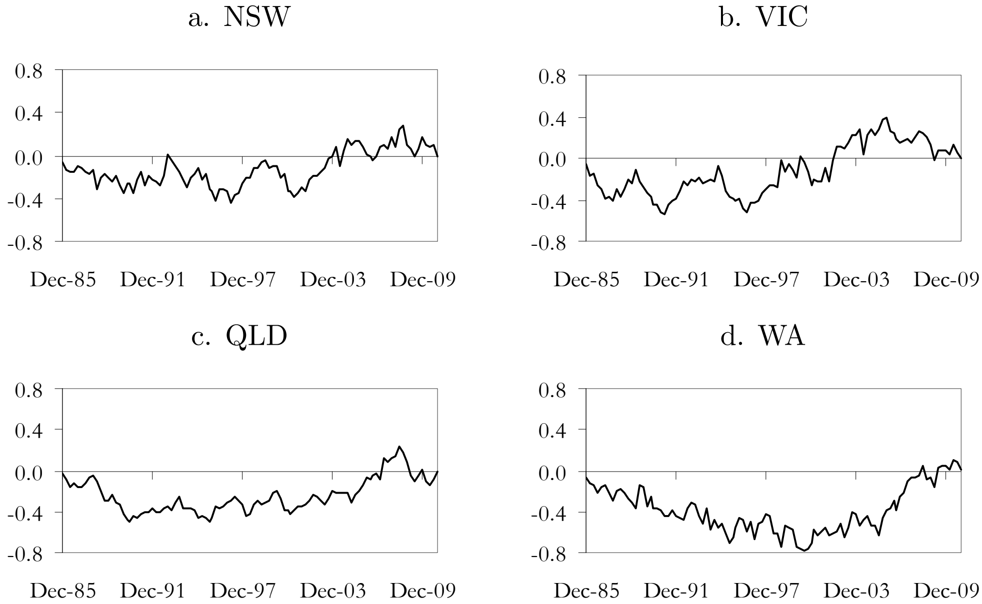


Overall, employment was the main driver of the 1989 peak and subsequent drop in activity. Exports were an important driver of growth over the 1990s and retail trade has been more important for activity in QLD and WA than in NSW and VIC, suggesting that QLD and WA consumers have been benefitting from the commodities boom. Perhaps the most surprising result is the low contribution of exports to the QLD Index and the high contribution of exports to the NSW and the VIC Index. This illustrates the point that the volatility can play an important role in driving ebbs and flows in economic activity.

3.6 Shocks

Figures 3 a to plot the cumulated shocks for each of the four activity Indexes, i.e. $\frac{1}{\beta_i} u_{it}$ the second part of equation (4). The cumulated shocks plus the contributions discussed above give the latent factor extracted L_t given in Figure 1. The cumulation makes the shocks persistent and the series will only return to zero if large negative shocks are offset by large positive shocks and vice versa. Figures 3 a to d show that negative shock earlier in the sample are offset by a series of positive shocks later in the sample.

Figure 3: Cumulated shocks



In NSW (Figure 3 a), a series of negative shocks in the 1980s and most of the 1990s were offset by a series of positive shocks over the remainder of the sample. This suggests that exogenous shocks put mostly downward pressure on activity in NSW in the 1980s and 1990s but upward pressure on activity over the 2000s. The figure also suggests a series of positive shocks prior to the 1997 AFC. Exogenous shocks in VIC mostly put downward pressure on activity in Victoria during the 1980s, the mid 1990s and the second half of the 2000s. Unlike any of the other three States, shock mainly put downward pressure on activity since the mid 2000s. In Queensland, shocks leading up to the early 1990s recessions were mostly negative. Shocks were small during the remaining part of the 1990s followed by relatively small positive shocks mainly during the first half of the 2000s. In WA shocks mainly put downward pressure on activity until the onset of the commodities boom.

4 Estimating an Index-SVAR

We apply the SVAR methodology to the four Indexes and build an Index SVAR (ISVAR) to demonstrate the additional information that can be extracted from using the Indexes. The ISVAR methodology is part of the class of factor augmented VARs (FAVAR); see, for example, BERNANKE et al. (2005) and VASISHTHA et al. for an overview of the literature. FAVARs are becoming increasingly popular as they are a convenient way to decrease the dimensions of the VAR.

To demonstrate the appeal of the INDEX-SVAR approach, we construct a model which contains the 4 State Indexes, Australian GDP (to allow for national effects) and the GDP of the US and China. The US has been one of Australia's major trading partner, but China has risen recently to become the most important market for Australian exports. The structural form of the ISVAR can be represented as:

$$B_0 Z_t = B_1 Z_{t-1} + \varepsilon_t. \tag{6}$$

Z_t is the vector of variables $Z_t = [\text{US GDP, CH GDP, NSW, VIC, QLD, WA, AU GDP}]_t'$. US GDP is US real GDP, CH GDP is real Chinese GDP and AU GDP is real Australian GDP; all three are expressed in per cent changes. NSW, VIC, QLD and WA are the first difference of each State Index. The Schwartz information criterion indicates a lag length of one for the system. B_i, $i = 0, 1$ are (7×7) matrices containing the parameter estimates and the structural error term is given by ε_t and $\varepsilon_t \sim N(0, D)$. The foreign variables are treated as an exogenous foreign block in the ISVAR because US and Chinese economic activity affects Australia but changes in economic activity in Australia do not affect the US or China.[6] The four Indexes plus Australian GDP form the endogenous block of the model.

Identification is achieved by the usual lower triangular composition and normalization on the diagonal of the B_0 matrix. We impose further restrictions as follows: the US GDP and CH GDP equations are pure autoregressive processes; there is no contemporaneous relationship between the States but US GDP and CH GDP affect all states and AU GDP contemporaneously. Lastly, all States affect AU GDP contemporaneously. All these restrictions translate into zero elements in the two coefficients matrices, B_0 and B_1. The parameter estimates are presented in Table 4 in Appendix B.

Any VAR specification is open to criticism. The one chosen here is relatively general: all restrictions are on the contemporaneous inter-state relationships; no restrictions are imposed on the lagged relationships (even though a number of parameter estimates are not statistically significant, see Table 4 in Appendix B). The restrictions on the B_0 matrix conform with the small-open economy assumption and moreover, any Australia wide shocks, such as monetary policy shocks, that affect the States contemporaneously, are absorbed in the AU GDP equation. An alternative is to not impose any restrictions on the endogenous block and to compute generalized impulse responses as proposed by PESERAN AND SHIN (1998). Using this alternative gives very similar results to those presented here (results are available from the authors).

An attractive feature of VAR models is the generation of impulse responses of the system. The impulse response function of a variable within the system shows the dynamic response of that variable to a shock in the error term to a particular equation.[7] The impulse response function gives the response of each variable to a one time impulse with all other variables at time t or earlier held constant, or

$$r_{it} = \sum_{j=0}^{\infty} \sum_{k=1}^{7} c_{j,k} e_{k,t-j} \tag{7}$$

[6] This is the small open economy assumption. Global developments affect activity in Australia but developments in Australia do not affect economic activity in the US or China.

[7] For a detailed description of the impulse response function see Hamilton (1994), chapter 11.

where $c_0 = I$, $c_1 = B_0^{-1}B_1$ and $c_i = c_{i-1}B_0^{-1}B_1\ for\ i \geq 1$ and where r_{it} is one of the 7 dependent variables and c_{jk} is the j^{th} impulse response associated with the k^{th} shock. There are 7 shocks in the system, 2 from the exogenous block and 5 from the endogenous block. Describing a shock to a particular error term as a shock to a particular variable is a frequently used short hand notation - and that convention is also followed here.

4.1 Decomposing the impulse responses

The Indexes give an additional layer of information - the cumulative impulse responses of the Index can be disaggregated into impulses from each of the five components. Combining equation (7) with (4) and solving for x_i as well as re-introducing the variables' unit by multiplying each series with its standard deviation gives

$$\widehat{x}_{it} = (r_{it}/w_i) \cdot \sigma_i \tag{8}$$

where $\widehat{x}_{it}$ is the approximate response of an Index component variable i. For example, equation (8) gives the response of employment in each of the States to, say a shock to US GDP growth. This is a richer analysis than what is obtained from a traditional SVAR analysis K variables. In effect, the approach allows and analysis of KN interactions (where N is the number of components).

This decomposition of impulse responses is unique to the Index technique proposed here and cannot be applied to other FVARs proposed in the literature.[8] An alternative to this Index impulse response decomposition would be a large scale structural model that explicitly models the relationships between the five Index component series for each of the four States, the two exogenous variables US GDP and CH GDP and Australian GDP. Using the same restriction as above, this necessitates the estimation of 465 parameters. The technique proposed here offers a substantial improvement on this large loss of degrees of freedom. The number of parameter

[8] To our knowdlege, no FVAR study has propsed a restriction on the weights in a Kalman filter or principal component analysis that makes this decomposition possible.

Table 2: Disaggregated responses

Variable	NSW	VIC	QLD	WA	NSW	VIC	QLD	WA
	— shock to US GDP —				— shock to CH GDP —			
sfd	183	221	223	164	12	6	47	112
emp	5	6	5	2	0	0	1	2
retail	31	38	31	16	2	1	7	11
inv	77	111	110	168	5	3	23	115
exp	48	55	116	146	3	2	24	100

estimates is greatly reduced to 97, 50 from the Index construction plus 47 from the ISVAR.

4.2 Impulse responses

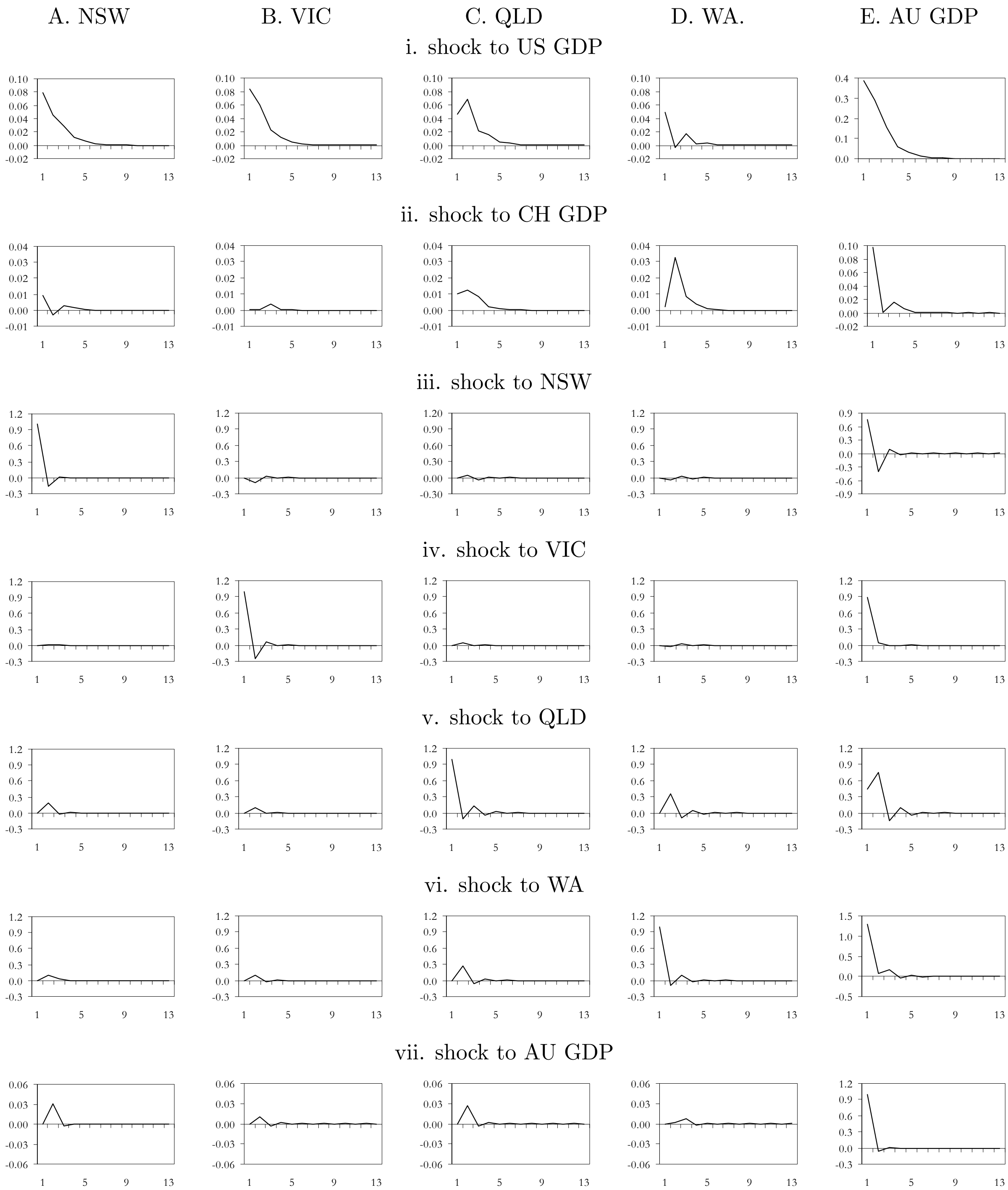
Figure 4 shows the impulse responses of the endogenous block (columns A to E in the Figure) to all 7 possible shocks (rows i to vii in the Figure). To conserve space the impulse responses of the exogenous block are not shown here but are available from the authors.

All impulse responses converge back to zero quickly so that responses cumulated over 12 quarters following a shock can be taken as the long run responses. For convenience of exposition, Table 2 gives the **cumulative** responses of each component series of each State Index to the US and Chinese GDP shocks in the ISVAR system. The decomposition of the remaining five shocks are presented in Table 5 in Appendix B. All data are A$ per person with the exception of employment which is in number of jobs.

Juxtaposing the effects of a temporary one percentage point increase in US quarterly growth (Figures 4Ai-Ei) with those of a one percentage point increase in Chinese quarterly growth (Figures 4Ai-Bi) reveals that a US shock raises activity in all States but a Chinese shock mainly affects QLD and WA.[9] The cumulated effect of a one percentage point rise in US quarterly GDP growth twelve quarters on is between about A$160 and A$220 for state final demand per

[9] Unlike Australian data, US and Chinese GDP are generally expressed at annual rather than quarterly growth rates. A one percentage point rise in the quarterly growth rates translates into a four percentage point rise in annual rates.

Figure 4: Impulse response analysis



capita for all four States. (Table 2).

A temporary rise in Chinese growth raises state final demand per capita about A$50 in QLD and A$110 in WA but only about A$10 in NSW and VIC. Exports per capita remain virtually unchanged in NSW and VIC but rise by a similar amount as state final demand per capita in WA. Though investment per capita rises in both QLD and WA, the rise is almost four times larger in WA than QLD (Table 2). This may again be a reflection of the capital intensity of raw material extraction. These results suggest that a re-orientation away from the US toward China has the potential to increase divergence in economic activity across Australian States. In popular terms, this is sometimes referred to as the 'two track economy' where QLD and WA are on the growth fast track and the rest of the country is on a slower track.

Interestingly, positive state specific shocks in economic activity do not necessarily translate into activity elsewhere in the country. For example, a temporary rise in economic activity in NSW dampens activity in both VIC and WA (Figures Biii and Diii and Table 5). Positive shocks to either QLD and WA has a relatively large and positive impact on each other. Lastly, a rise in Australian GDP per capita has a positive impact across all States with the biggest impact on NSW and QLD.

To sum up, the impulse response analysis gives three important results. First, all States benefit from a rise in economic activity in the US but QLD and WA benefit relatively more from a rise in activity in China. Second, the indirect effects of increased activity in QLD and WA, such as from a commodity boom, on the non-commodity States of VIC and NSW are relatively small. Third, a rise in activity in one state does not necessarily translate positively into activity in the other States. For example, a rise in activity in NSW has negative efects on VIC and WA. In the absence of data on interstate trade, these results shed some light into the nature of interstate economic interactions.

5 Concluding Remarks

The literature covering the construction of Indexes of economic activity is huge. The methods reflect varying degrees of technical sophistication, ranging from simple scoring of changes to relying on frequency domain methods to extract dynamic latent factors from a large dataset. This paper proposes a framework that links two popular strands of the literature, the traditional NBER approach and the dynamic latent factor approach. Though the NBER method involves a degree of subjectivity and perhaps arbitrariness, it has endured partly because of its simplicity in extracting underlying drivers of activity. The proposed framework incorporates these features while applying a less arbitrary empirical methodology.

To illustrate the method, we apply the framework to Australian regional (State) data, namely the two resource rich states of QLD and WA and the two service based economies of NSW and VIC. The results show that although the two major events affecting Australian economic activity over the past 25 years, that is the 1990-91 recession and the GFC, have clearly affected activity across all four States, the magnitude of their impacts differed considerably. Various world events have impacted some but not other States. The dot com bubble burst seems to have mostly affected NSW, the AFC mostly WA and the global commodity boom seems to have mostly affected QLD and WA. Dissecting the drivers of growth in each State gives perhaps surprising results. The contribution of changes in merchandise exports to changes in activity in NSW and VIC is high while its contribution to changes in activity in QLD is low. Retail trade has been important for growth in QLD and WA but not in NSW and VIC.

To demonstrate how the Indexes could be used more broadly, we estimated an SVAR model which contains the Indexes, Australian GDP per capita and an exogenous block in the system that consists of US and Chinese real GDP growth. This is to investigate the effects of the rise in China as Australia's most important export market and the related commodities boom. Impulse response analysis shows that, although all States benefit from a rise in economic activity in the US, QLD and WA benefit relatively more from a rise in activity in China. This suggests that a continued re-orientation away from the US toward China has the potential to increase divergence in economic activity among Australian States, the so called 'two track economy'.

The distinctive feature of the Index construction method proposed here also allows another layer of analysis - the dissection of the impulse responses into the underlying components of the Index. Traditional SVAR analysis provides an understanding of the behaviour of key aggregates; the Index-SVAR approach proposed here extends the standard analysis by providing a coherent way to extract the behaviour of the components driving the aggregates.

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A Regional Indexes of Activity Estimation Results

Table 3 presents the estimation results from applying the model in equation (3) to the datasets of each of the four States. The table gives the parameter estimates with standard errors in parenthesis. The ρ and the constant (c) are not statistically significant indicating that the latent factor is a random walk in levels (but not growth rates). This is supported by likelihood ratio reported in the table where the restriction is a zero on ρ and the constant.

Table 3: Parameter estimates, standard errors in paranthesis

	NSW		VIC		QLD		WA	
	β_i	σ_i	β_i	σ_i	β_i	σ_i	β_i	σ_i
sfd	6.468	0.505	6.865	0.164	6.255	0.514	7.058	0.314
	(0.319)	(0.068)	(0.333)	(0.211)	(0.337)	(0.065)	(0.384)	(0.112)
emp	4.370	1.060	4.415	1.029	4.563	0.990	4.225	1.111
	(0.307)	(0.055)	(0.308)	(0.052)	(0.310)	(0.051)	(0.340)	(0.060)
retail	4.648	0.994	4.752	0.945	4.667	0.965	4.681	1.005
	(0.276)	(0.053)	(0.307)	(0.040)	(0.330)	(0.044)	(0.316)	(0.049)
inv	6.051	0.643	5.416	0.777	5.586	0.729	6.009	0.694
	(0.329)	(0.048)	(0.292)	(0.048)	(0.284)	(0.048)	(0.370)	(0.045)
exp	4.234	1.094	4.297	1.068	4.393	1.011	4.139	1.103
	(0.263)	(0.065)	(0.315)	(0.055)	(0.274)	(0.055)	(0.257)	(0.064)
ρ	0.044		-0.028		0.021		-0.042	
	(0.414)		(0.396)		(0.368)		(0.415)	
c	0.00005		0.00005		-0.00002		0.0001	
	(0.073)		(0.072)		(0.074)		(0.071)	
Likelihood Ratio	-0.011		-0.005		-0.003		-0.003	

B ISVAR Estimation Results

Table 4 gives the parameter estimates of the coefficient matrices B_i, $i = 0, 1$ in equation (6). The p-values based on White-adjusted standard errors are in parenthesis.

Table 4: ISVAR parameter estimates

Dependent variables	US GDP	CH GDP	NSW	VIC	QLD	WA	AU GDP
	Explanatory variables						
	Contemporaneous parameter estimates (B_0)						
US GDP	1						
CH GDP		1					
NSW	0.079	0.009	1				
	(0.000)	(0.327)					
VIC	0.084	0.000		1			
	(0.000)	(0.984)					
QLD	0.046	0.010			1		
	(0.023)	(0.282)					
WA	0.049	0.0019				1	
	(0.010)	(0.894)					
AU GDP	0.168	0.083	0.759	0.884	0.443	1.295	1
	(0.131)	(0.132)	(0.115)	(0.047)	(0.291)	(0.002)	
	Lag one parameter estimates (B_1)						
US GDP	0.444						
	(0.000)						
CH GDP		0.247					
		(0.077)					
NSW	0.002	-0.009	-0.176	-0.011	0.182	0.057	0.0310
	(0.890)	(0.339)	(0.101)	(0.914)	(0.066)	(0.629)	(0.121)
VIC	0.040	-0.000	-0.103	-0.249	0.086	0.087	0.010
	(0.112)	(0.968)	(0.366)	(0.024)	(0.488)	(0.419)	(0.692)
QLD	0.028	0.008	0.025	0.021	-0.131	0.241	0.027
	(0.262)	(0.465)	(0.810)	(0.833)	(0.206)	(0.011)	(0.175)
WA	-0.032	0.029	-0.050	-0.018	0.347	-0.096	0.002
	(0.206)	(0.009)	(0.679)	(0.852)	(0.001)	(0.399)	(0.945)
AU GDP	0.109	-0.057	-0.086	0.339	0.175	0.050	-0.100
	(0.316)	(0.294)	(0.847)	(0.487)	(0.660)	(0.907)	(0.394)

Table 5: Disaggregated responses

Variable	NSW	VIC	QLD	WA	NSW	VIC	QLD	WA
	— shock to NSW —				— shock to VIC —			
sfd	901	-80	30	-72	24	948	51	-3
emp	25	-2	1	-1	1	26	1	0
retail	152	-14	4	-7	4	162	7	0
inv	379	-40	15	-74	10	477	25	-3
exp	236	-20	15	-64	6	238	27	-3
	— shock to QLD —				— shock to WA —			
sfd	204	96	1348	712	131	104	344	2326
emp	6	3	31	10	4	3	8	32
retail	34	16	187	69	22	18	48	225
inv	86	48	665	728	55	52	170	2379
exp	53	24	700	633	34	26	179	2069
	— shock to AU GDP —							
sfd	31	9	35	19				
emp	1	0	1	0				
retail	5	2	5	2				
inv	13	5	17	19				
exp	8	2	18	17				