1. Introduction

This paper assesses the predictive ability of the monthly survey based business performance indices produced by the Australian Industry Group (Ai Group) with respect to 'official' Australian economic data produced by the Australian Bureau of Statistics (ABS). These monthly indices are known as the Australian Performance of Manufacturing Index® (PMI), the Australian Performance of Services Index® (PSI) and the Australian Performance of Construction Index® (PCI), respectively. Given the timeliness in the publication of indices of this type, both in Australia and internationally, they have been used by economists, financial market analysts and commentators as potential 'leading' indicators of both aggregate and sectoral economic activity and turning points, as measured by the official ABS economic data. That is, given the monthly publication of these indices, they potentially provide more timely information than quarterly official ABS national accounts data and secondly, the indices may provide additional information regarding the future state of the economy and/or turning points than can be provided by past lags of the official data series (Keeton and Verba, 2004). Specifically, in this paper Granger causality testing is used to assess the predictive ability of each of Ai Group's headline indices with respect to sectoral performance, measured by quarterly and annual growth rates of industry gross value added (GVA) for the manufacturing, services and construction sectors, respectively. In addition this paper investigates the predictive ability of the quarterly average of the employment sub-index for each of the manufacturing, services and construction sectors with respect to official quarterly ABS data on employment for each of these sectors.

This paper extends the previous research related to the Australian performance indices in a number of ways. First, the paper provides tests of whether the performance indices have predictive power in

two respects: in terms of providing early information on current period economic conditions or providing information regarding future period economic conditions. Second, it extends the sample of data for the Granger causality testing of the predictive ability of the Australian PMI to include the period encompassing the global financial crisis (GFC) and subsequent economic downturn. Third, the paper applies Granger causality tests to the Australian PSI and Australian PCI, which has not been done in previous literature which have focussed solely on the Australian PMI.

This paper finds that the PMI is a useful predictor of official economic data for the manufacturing sector – both in terms of providing early information on current period economic conditions and providing information regarding future period economic conditions. There is clear evidence of Granger causality from the PMI to the official economic data. The results for the PSI and PCI are mixed, with limited evidence of Granger causality from the PSI to the corresponding official economic data for the services sector. The PCI Granger causality tests suggest some value in the PCI as both a leading indicator as well as a timelier contemporary indicator of construction sector economic activity.

The next section provides an overview of the methodology in constructing the indices and the literature regarding their usefulness in predicting official economic data and turning points in the economy. Section 3 provides an overview of the trends in the indices over time and their correlation with official economic data. Section 4 reviews the Granger causality testing approach to testing the predictive ability of the indices. Section 5 applies this methodology to the Australian indices with a discussion of the results and section 6 provides concluding comments.

2. Review of the indices methodology and related literature

The PMI, PSI and PCI indices are compiled through monthly surveys of up to 500 firms, conducted on a representative sample basis for the respective manufacturing, services and construction industries. Each month senior representatives from firms across Australia (usually chief executive officers or chief financial officers) are asked a series of questions regarding the actual performance of their business over the previous month with respect to a number of components that include production, new orders, employment, sales, supplier deliveries and inventories. Respondents are asked to report changes against the previous month in terms of qualitative responses (e.g. whether sales increased, decreased or did not change at all).

From this information an aggregate 'diffusion index' is calculated. A diffusion index indicates the degree to which an indicated change, such as through survey responses, is dispersed throughout the sample population (Institute for Supply Management 2010). The PMI, PSI and PCI are in fact composites of diffusion indices for their respective components. To calculate a composite diffusion index, for each component, each survey response that indicates a rise against the previous monthly reading for that component is given a value of 1, responses that indicate unchanged activity are given a value of 0.5, and responses that indicate a fall are given a value of 0. These values are summed and multiplied by 100 and then given a weighting. For example, the PMI is a composite index of five components (with weights in parentheses): production (25 per cent), new orders (30 per cent), employment (20 per cent), stocks (10 per cent) and deliveries (15 per cent). The PSI is a composite index of five components (with weights in parentheses): sales (25 per cent), new orders (25 per cent), employment (25 per cent), stocks (10 per cent) and deliveries (15 per cent). The PCI is a composite

index of four components (with weights in parentheses): production (30 per cent), new orders (30 per cent), employment (25 per cent) and deliveries (15 per cent). The diffusion indices for the respective components in each of the PMI and PSI are also weighted according to the gross value added shares of sub-sectors while for the PCI equal weighting is given to the housing, apartments, commercial and engineering sub-sectors. For example, the PSI is based on the following services sub-sectors (gross value added weights in parentheses): wholesale trade (10 per cent), retail trade (12 per cent), accommodation, cafes & restaurants (4 per cent), transport & storage (10 per cent), communication services (5 per cent), finance & insurance (15 per cent), property & business services (25 per cent), health & community services (12 per cent) and personal & recreational services (7 per cent).

As a result of the diffusion index methodology, an aggregate index reading above 50 points indicates activity is generally expanding; while below 50 indicates it is declining. The distance from 50 is indicative of the strength of the expansion or contraction. That is, according to the Institute for Supply Management (2010), at the 100 points level for an index, all respondents are reporting increased activity, and at the 0 points level all respondents are reporting decreased activity. Hence 50 is the mid-point denoting a zero expansion level. For an overview of diffusion index methodology, see Getz and Ulmer (1990) and for an analysis of the informational advantages and disadvantages of qualitative surveys, see Keeton and Verba (2004). In Australia, the indices results for the previous month are published on the 1st, 3rd and 5th working days of each month for the PMI, PSI and PCI,

respectively. Similar indices have been produced and published internationally in a number of countries (see Williamson (2002)) including in the United States by various Federal Reserve banks.[1]

Given the Australian indices are produced monthly and given the quarterly nature of official data on economic output, such as the ABS quarterly national accounts data, the performance indices potentially provide insightful and timely indications of the likely state of expansion/contraction of the economy ahead of the official data releases. For example, the Australian PMI results for the quarter ending June are known by the 1st working day of July whereas the June quarter ABS national accounts figures for the manufacturing industry are usually not known until September. Hence the performance indices can potentially provide more timely information.

There is a substantial international literature examining how well diffusion based performance indices similar to those produced by the Ai Group for Australia predict (or lead) official economic data. Examples of studies examining the usefulness of the manufacturing industry related index produced in the United States include Harris (1991) who finds that the US purchasing managers' index produces at best mixed results as a leading indicator of economic activity but it adds some explanatory power in some econometric models. Kauffman (1999) surveys a broader literature and in contrast points to the usefulness of the US manufacturing industry related index as an indicator. Koenig (2002) examines the same US index in assessing the economy's strength and direction of monetary policy, finding that the index conveys useful information regarding real GDP growth and is useful in an econometric model explaining changes to the federal funds rate. For Europe, Ellis (2010) uses simple correlation analysis and Chow structural break tests to examine how well the European

[1] Internationally the performance indices of this nature are often titled Purchasing Managers' Index.

indices similar to the Australian PMI predicted the recent European economic recession. The author finds the relevant European indices understated the recessions in Germany, France, Italy and the euro area as a whole by up to 5% of GDP and that the time series relationships between the indices and official data have broken down since the recession.

The evidence on the ability for the aggregate Australian performance indices to track official economic data is mixed. Harding, Song and Tran (2001) review the Australian PMI as a tool for acting as an early signal of a turning point in the business cycle. Using vector autoregressive modelling and rules of thumb from the US indices, the authors conclude that the Australian PMI is potentially a reliable tool for signalling business cycle turning points. Nonetheless they suggest a 'dynamic factor approach' may prove to be superior to the Australian PMI.

In comparison, Aylmer and Gill (2003) conducted a review of the predictive ability of various business information surveys in Australia, including the Australian PMI. Their methodology includes using simple pair-wise correlation coefficients, autoregressive models and Granger causality tests to test the ability of various business survey indicators in predicting official economic data. They find no Granger causality (in either direction) between the Australian PMI and GDP; however, the Australian PMI has a relatively high and significant correlation with actual business investment by the manufacturing industry and some Granger causality evidence between the Australian PMI and the ABS measure of manufacturing input prices.

Finally, Blythe (2005) reviews the Australian PSI after its first two years, finding that the services component of GDP growth correlates with the PSI relatively well. He also suggests the employment component of the Australian PSI (i.e. the employment sub-index) is useful in picking upcoming trends

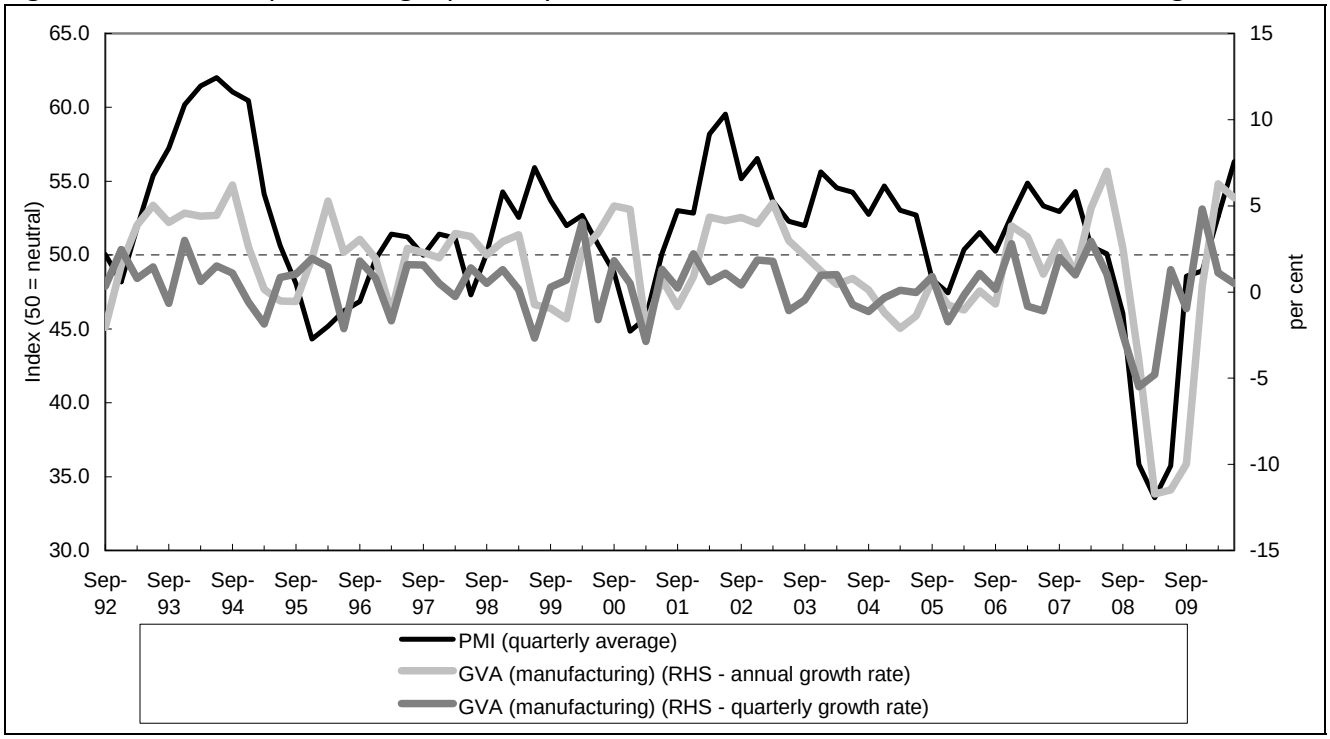
in services employment composition. Finally, changes in the PSI sales component tend to indicate the direction of changes in company profits.

The next section presents an overview of the trends in the three Australian performance indices.

3. An overview of the indices

Figure 1 compares the quarterly average value of the Australian PMI to the annual (year on year) and quarterly growth rate of GVA for the Australian manufacturing industry. We can see that in the early and middle part of the sample the Australian PMI level overstated growth rate in the official GVA data for manufacturing in Australia. This is particularly evident for June 1994 when the average PMI level was at an all time high of 62. In contrast, since the mid 2000s period, the PMI level has been more closely tracking the annual and quarterly growth rates in the official data, including some indication of leading the downturn in the official data during the global financial crisis period. The depth of the recent economic downturn is also picked up by the level of the PMI where, for example, the negative annual growth rate in manufacturing industry GVA data of -11.7 per cent to March 2009 is reflected in the average quarterly PMI reading for March 2009 of 33.6, also suggesting a strong contraction.

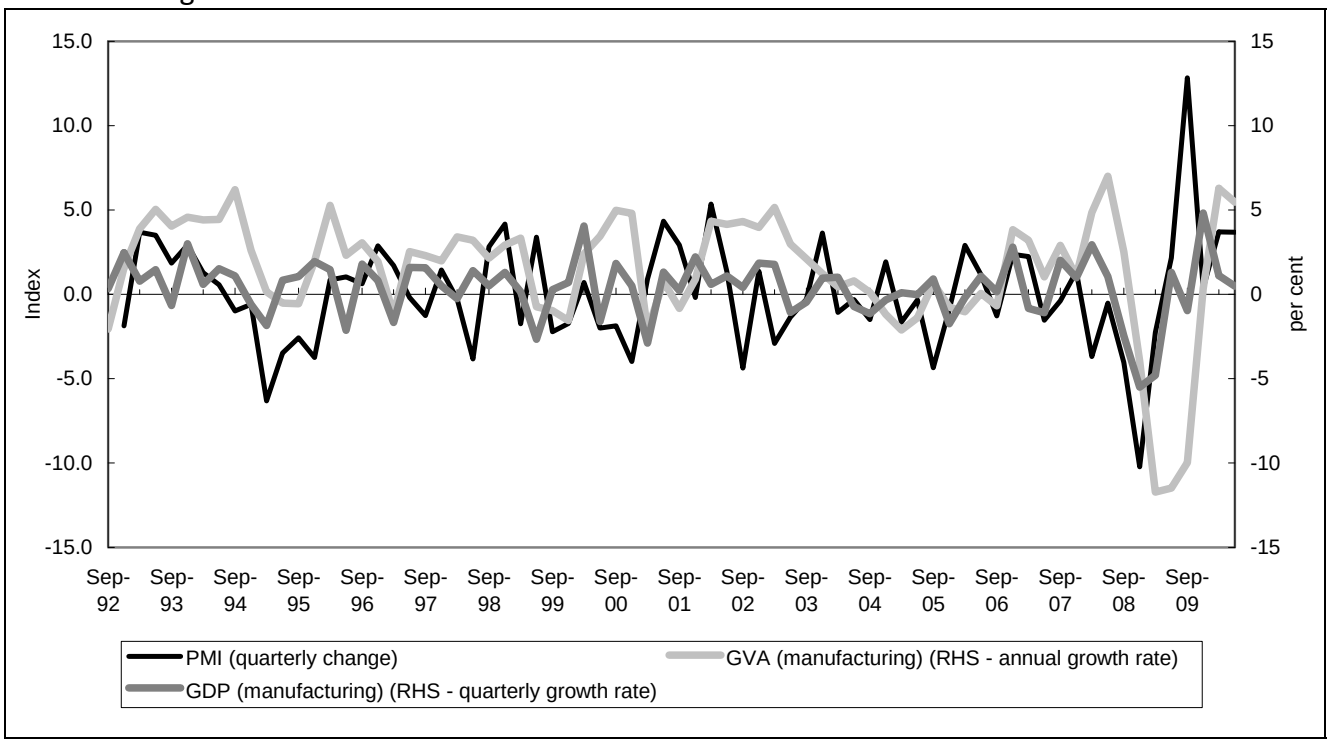
Figure 1: Relationship of average quarterly PMI level to official GDP data for manufacturing[(a)]



(a) Data are seasonally adjusted.

Figure 2 compares the quarterly change in the average value of the Australian PMI to the annual (year on year) and quarterly growth rate of GVA for the Australian manufacturing industry. The change in the level of the PMI appears to track the official data reasonably well until the later part of the sample where there is a marked divergence.

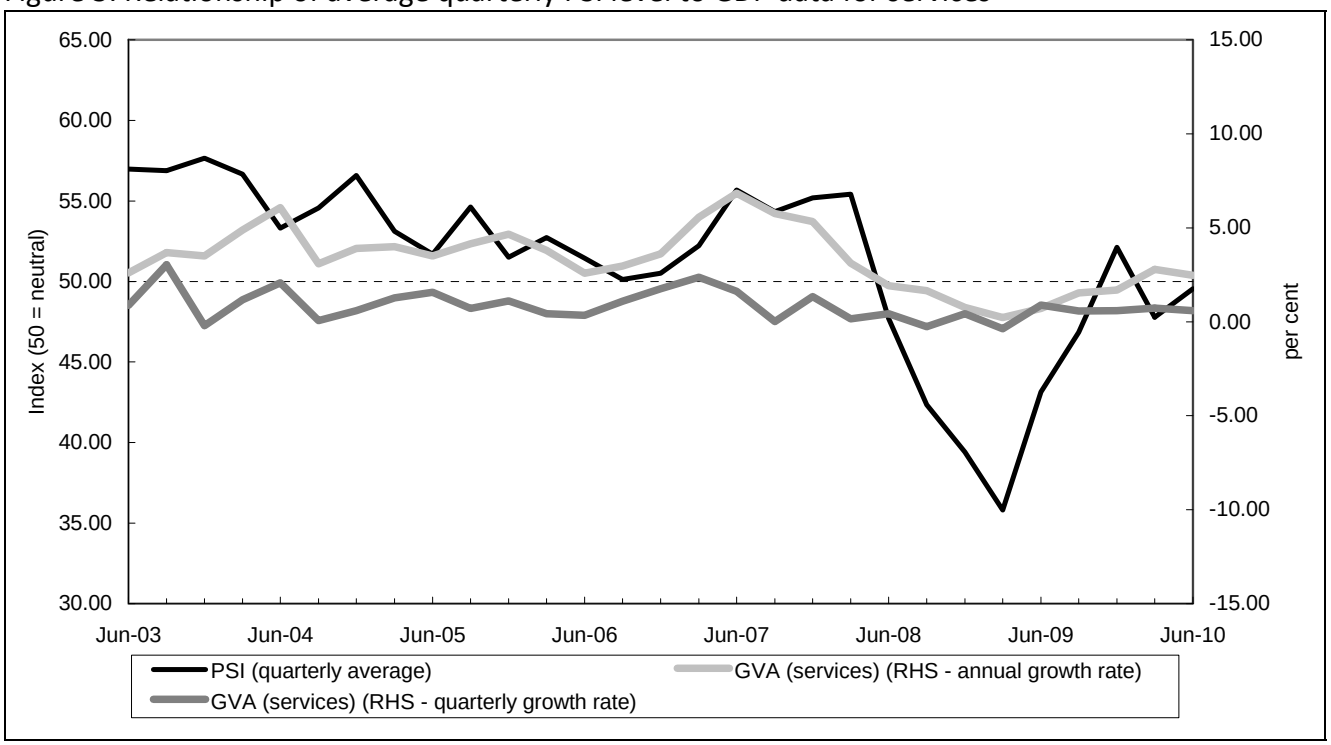
Figure 2: Relationship of the quarterly change in the PMI level to official GDP data for manufacturing[(a)]



(a) Data are seasonally adjusted.

Figure 3 examines the quarterly average value of the Australian PSI to the annual (year on year) and quarterly growth rate of GVA for the Australian services sector. There appears to be a stable relationship between the average quarterly level of the PSI and the growth rates in the official data for the services sector for most of the sample. However, a divergence occurs during the period of the GFC, where the average quarterly level of the PSI dipped significantly below the 50 mark separating contraction from expansion whereas the slowdown in the growth rates in the official data for the services sector were less severe.

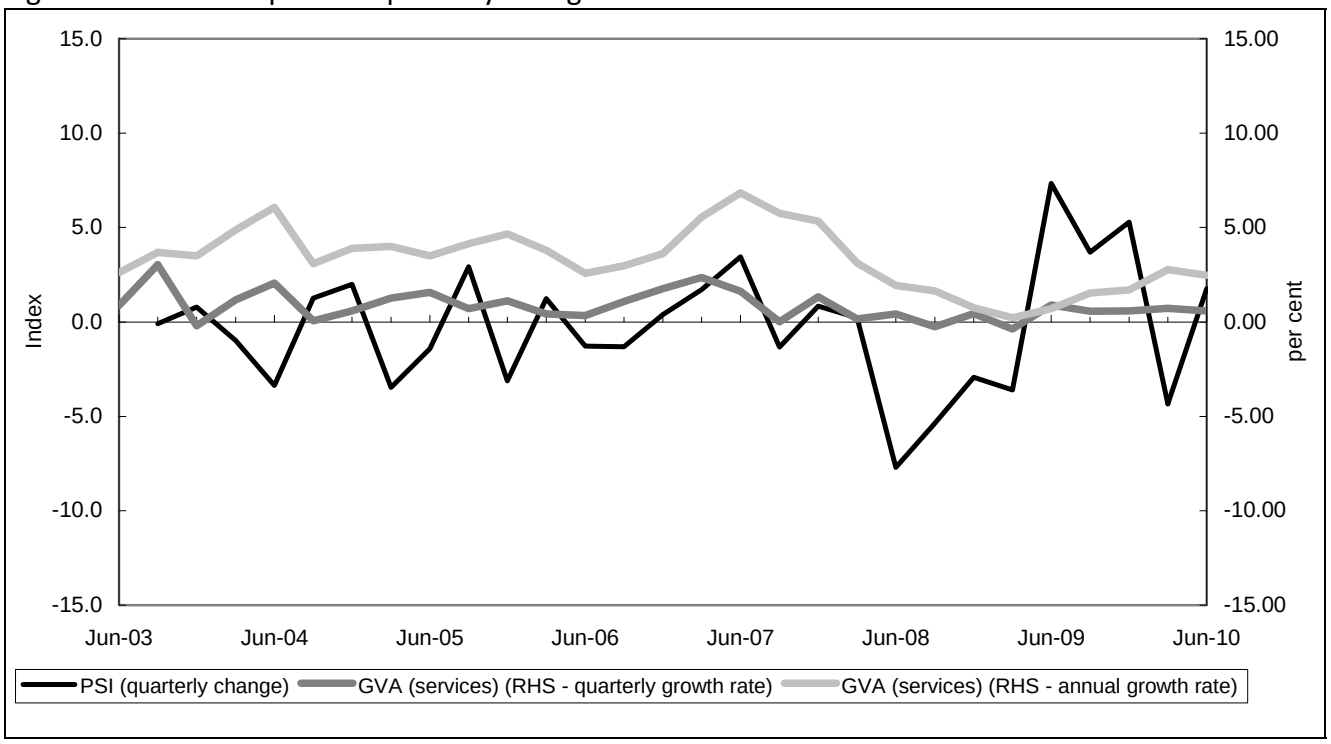
Figure 3: Relationship of average quarterly PSI level to GDP data for services[(a)]



(a) Data are seasonally adjusted.

Figure 4 compares the quarterly change in the average value of the Australian PSI to the annual (year on year) and quarterly growth rate of GVA for the Australian services sector. As expected, the divergence between the series is evident in the second half of the sample.

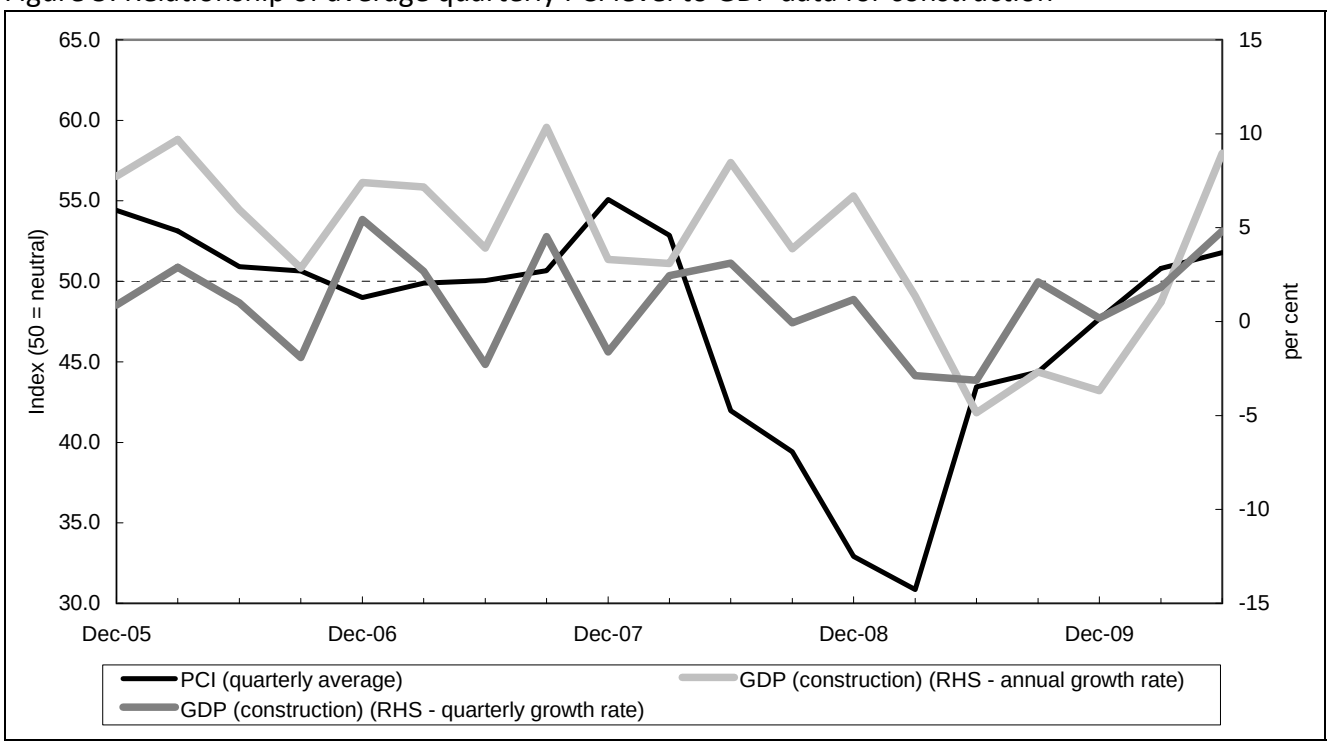
Figure 4: Relationship of the quarterly change in the PSI level to official GDP data for services[(a)]



(a) Data are seasonally adjusted.

Figure 5 examines the quarterly average value of the Australian PCI to the annual (year on year) and quarterly growth rate of GVA for the Australian construction industry. Similar to the PSI, the PCI has shown some divergence from the official data during the recent period from early 2008. For example, the PCI overstated the degree of the downturn in GVA for the construction sector during 2007-08.

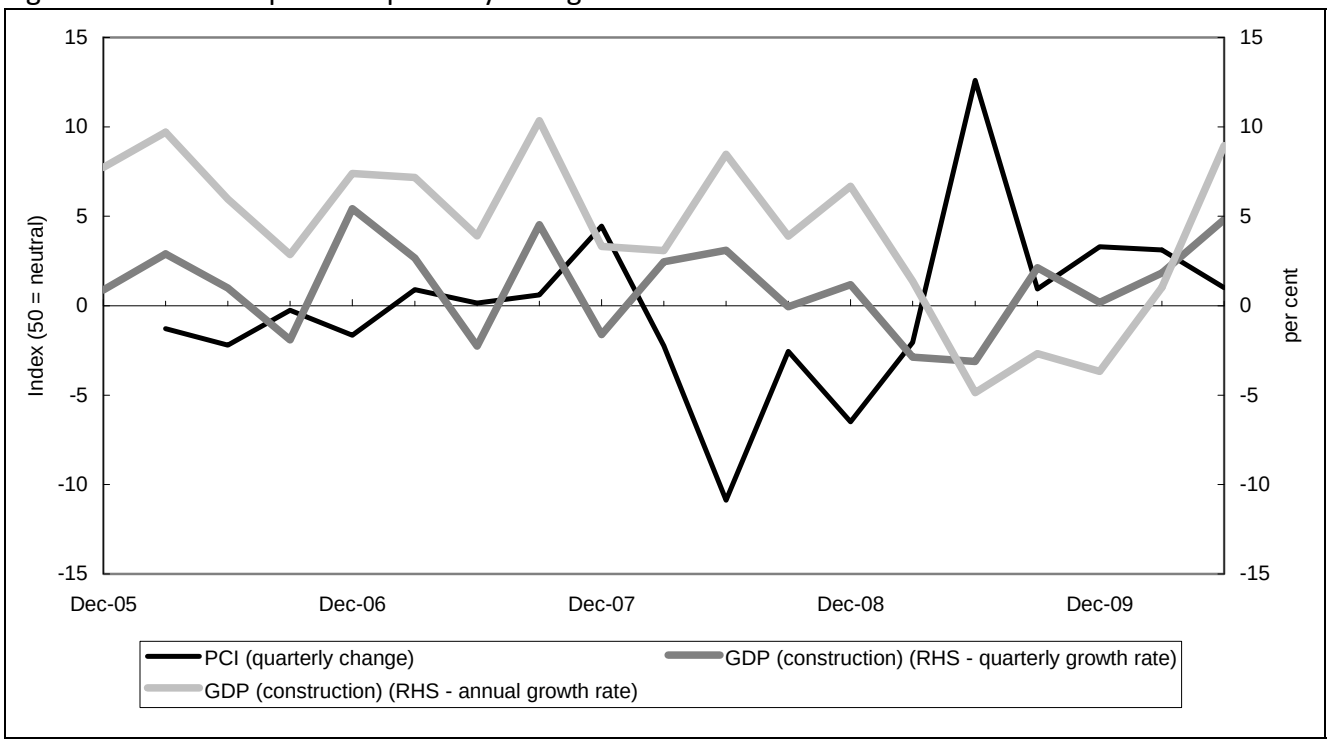
Figure 5: Relationship of average quarterly PCI level to GDP data for construction[(a)]



(a) Data are seasonally adjusted.

Figure 6 compares the quarterly change in the average value of the Australian PCI to the annual (year on year) and quarterly growth rate of GVA for the Australian construction industry. Figure 6 indicates that in the second half of the sample the movement in the PCI has been more volatile than corresponding official economic data for the construction industry. For example, during 2008 the PCI was indicating a contraction in construction industry activity when this was not evident in the official economic data. Likewise, following this period, the PCI overshot the mark in terms of the pick-up in activity in the construction industry.

Figure 6: Relationship of the quarterly change in the PCI level to official GDP data for construction[(a)]



(a) Data are seasonally adjusted.

4. Testing the predictive ability of the indices

Bivariate Granger causality tests involve using regression analysis to provide an indication of whether lagged values of one variable x can help predict current values of another variable y. The approach involves seeing how much of the current value of y can be explained by past values of y and then to see whether adding lagged values of x can improve the explanation of y. Hence variable y is said to be Granger-caused by x if lagged values of x help in the prediction of y, or equivalently if the coefficients on the lagged x's are statistically significant (Granger 1969).

According to Asteriou and Hall (2007) there are four different potential results from a bivariate Granger causality test:

- Lagged x terms (in a regression of y on lagged values of y and x) may be statistically different from zero as a group and the lagged y terms are not statistically different from zero. Hence here we have x Granger causing y.

- Lagged y terms (in a regression of x on lagged values of y and x) may be statistically different from zero as a group and the lagged x terms are not statistically different from zero. Hence here we have y Granger causing x.

- Both sets of x and y terms are statistically different from zero (in the two regressions outlined above) and so we have bi-directional causality.

- Both sets of x and y terms are not statistically different from zero (in the two regressions outlined above) and so x and y are independent of each other.

The Granger causality tests in the situation of a vector autoregressive model with two stationary variables y and x involves estimating the following time series regressions:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_l y_{t-l} + \beta_1 x_{t-1} + \ldots + \beta_l x_{t-l} + \epsilon_t \quad (1)$$

$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \ldots + \alpha_l x_{t-l} + \beta_1 y_{t-1} + \ldots + \beta_l y_{t-l} + u_t \quad (2)$$

where ϵ_t and u_t are uncorrelated error terms and involves testing the joint null hypothesis: $\beta_1 = \beta_2 = \ldots = \beta_l = 0$ in each regression equation (i.e. testing the null hypothesis that x does not Granger cause y in the first regression and that y does not Granger cause x in the second regression).

In the case of assessing the predictive capabilities of the Ai Group performance indices, we can consider either of the PMI, the PSI or the PCI as the x variable and the official data series (whether GDP, employment or some other official economic data) as the y variable. In assessing whether the

Ai Group performance indices contain information which helps predict the official data, we are assessing the usefulness of the indices as leading indicators of economic activity in two respects. First, if the performance indices are truly leading indicators of future economic activity then, for example, if y_t represents June quarter GDP growth for manufacturing in regression (1) above, then x_{t-1} represents the average PMI reading (whether in growth rate or change terms) for the March quarter. For brevity the Granger causality tests based on this specification are referred to as the 'leading indicator' tests in the section that follows. Second, through the timing of the performance indices release ahead of official economic data, we should consider whether the reading for one of the performance indices for a given quarter is a leading indicator of the corresponding official economic data for the same quarter. For example, if y_t represents June quarter GDP growth for manufacturing in regression (1) above, then x_{t-1} in this case represents the average PMI reading (whether in growth rate or change terms) for the same June quarter. For brevity the Granger causality tests based on this specification are referred to as the 'contemporaneous information' tests in the section that follows.

5. Test results

5.1 Test results for the PMI

Tables 1 and 2 provide both the leading indicator and contemporaneous information Granger causality test results for the PMI. The variables are seasonally adjusted and include: the quarterly average aggregate Australian PMI level or quarterly change in the aggregate PMI, the year on year or quarterly growth rates of GVA for the manufacturing industry, the quarterly average PMI employment sub-index, in terms of levels and monthly change form, and the growth rate in the

quarterly official employment data for the manufacturing industry. The sample is from 1992Q(3) to 2010Q(2).

Table 1 [(a)] Leading indicator Granger causality tests for the PMI

	PMI lags	y variable lags	Chi-sq stat	p-value	Granger causality? [(b)]
Tests of PMI index level and GVA for manufacturing sector					
Null hypothesis:					
GVA - man (agr) does not Granger Cause PMI index level	2	2	5.01	0.08	No**
PMI index level does not Granger Cause GVA - man (agr)	2	2	17.06	0.00	Yes*
GVA - man (qgr) does not Granger Cause PMI index level	4	4	8.49	0.07	No**
PMI index level does not Granger Cause GVA - man (qgr)	4	4	13.31	0.00	Yes*
Tests of quarterly change in PMI index and GVA for manufacturing sector					
Null hypothesis:					
GVA - man (agr) does not Granger Cause PMI index change	2	2	9.88	0.00	Yes*
PMI index change does not Granger Cause GVA - man (agr)	2	2	12.44	0.00	Yes*
GVA - man (qgr) does not Granger Cause PMI index change	3	3	13.49	0.00	Yes*
PMI index change does not Granger Cause GVA - man (qgr)	3	3	10.97	0.01	Yes*
Tests of PMI employment sub-index level and manufacturing sector employment					
Null hypothesis:					
Man. emp (agr) does not Granger Cause PMI emp sub-index level	3	3	8.17	0.04	Yes*
PMI emp sub-index level does not Granger Cause Man. emp (agr)	3	3	3.97	0.26	No
Man. emp (qgr) does not Granger Cause PMI emp sub-index level	1	1	1.81	0.17	No
PMI emp sub-index level does not Granger Cause Man. emp (qgr)	1	1	2.71	0.09	No**
Tests of quarterly change in PMI employment sub-index and manufacturing sector employment					
Null hypothesis:					
Man. emp (agr) does not Granger Cause PMI emp sub-index change	3	3	12.58	0.00	Yes*
PMI emp sub-index change does not Granger Cause Man. emp (agr)	3	3	1.38	0.70	No
Man. emp (qgr) does not Granger Cause PMI emp sub-index change	3	3	10.06	0.01	Yes*
PMI emp sub-index change does not Granger Cause Man. emp (qgr)	3	3	3.75	0.28	No

* Statistically significant at 5% level of significance.

** Statistically significant at 10% level of significance but not the 5% level.

(a) Unit root tests were performed on each series to confirm stationarity before Granger causality tests were applied. Lag length selection based on LR tests subject to stability tests (AR Root). Where stability tests indicated VAR did not satisfy stability condition, lag length was adjusted downwards to ensure stability. LM autocorrelation tests for the residuals were also conducted up to lag length 12 and no statistically significant autocorrelation was detected. The estimated VAR is passes stability tests. (b) Decision rule: Do not reject null hypothesis if probability (p-value) is above level of significance (such as 0.05 at the 5% level of significance). agr = annual growth rate; qgr = quarterly growth rate.

The leading indicator Granger causality test results outlined in Table 1 for the PMI provide some evidence that this index provides some useful leading information to help predict future values of official economic data. For example, the null hypothesis that the PMI index level does not Granger cause the annual growth rate in GVA for manufacturing is rejected at the 5% level of significance

(Chi-square test statistic of 17.06 and p-value of 0.00). The results indicate the current quarter PMI level can provide some leading information on the annual or quarterly change for next quarter's GVA for manufacturing. The change in the PMI level for this quarter also provides some leading information for next quarter's measure of annual or quarterly change in manufacturing GVA although in this case there is evidence of Granger causation running both ways. This is suggestive that the previous quarter's annual or quarterly growth rate in actual manufacturing GVA has some influence in respondents determination of this quarter's PMI quarterly change.

With respect to employment, there is very little evidence that the employment sub-index for the PMI provides any leading information with respect to official employment data for the manufacturing industry. In fact, Table 1 indicates that predominantly the direction of Granger causality is from the official data to the PMI related employment sub-index. For example, the null hypothesis that annual manufacturing employment growth (measured on a quarterly basis) does not Granger cause the PMI employment sub-index level is rejected at the 5% level of significance (Chi-square test statistic of 8.17 and p-value of 0.04).

The contemporaneous information Granger causality test results outlined in Table 2 for the PMI provide similar conclusions to the leading indicator results. That is, there is evidence that the PMI reading for the current quarter provides some useful information (with regard to its early timing) with respect to GVA measures for manufacturing for the same quarters which are not published until usually a month later by the ABS. However, again there is clear evidence of two-way Granger causality between the quarterly change in the PMI and the official GVA measures for the

manufacturing sector. For example, all of the test results for the quarterly change in the PMI index and GVA for the manufacturing sector suggest two-way Granger causality.

Table 2 [(a)] Contemporaneous information Granger causality tests for the PMI

	PMI lags	y variable lags	Chi-sq stat	p-value	Granger causality? [(b)]
Tests of PMI index level and GVA for manufacturing sector					
Null hypothesis:					
GVA - man (agr) does not Granger Cause PMI index level	4	4	6.43	0.16	No
PMI index level does not Granger Cause GVA - man (agr)	4	4	18.86	0.00	Yes*
GVA - man (qgr) does not Granger Cause PMI index level	4	4	5.40	0.24	No
PMI index level does not Granger Cause GVA - man (qgr)	4	4	12.53	0.01	Yes*
Tests of quarterly change in PMI index and GVA for manufacturing sector					
Null hypothesis:					
GVA - man (agr) does not Granger Cause PMI index change	6	6	16.63	0.01	Yes*
PMI index change does not Granger Cause GVA - man (agr)	6	6	18.59	0.00	Yes*
GVA - man (qgr) does not Granger Cause PMI index change	6	6	15.63	0.01	Yes*
PMI index change does not Granger Cause GVA - man (qgr)	6	6	12.78	0.04	Yes*
Tests of PMI employment sub-index level and manufacturing sector employment					
Null hypothesis:					
Man. emp (agr) does not Granger Cause PMI emp sub-index level	2	2	10.14	0.00	Yes*
PMI emp sub-index level does not Granger Cause Man. emp (agr)	2	2	6.29	0.04	Yes*
Man. emp (qgr) does not Granger Cause PMI emp sub-index level	1	1	1.37	0.24	No
PMI emp sub-index level does not Granger Cause Man. emp (qgr)	1	1	2.69	0.10	No
Tests of quarterly change in PMI employment sub-index and manufacturing sector employment					
Null hypothesis:					
Man. emp (agr) does not Granger Cause PMI emp sub-index change	6	6	15.73	0.01	Yes*
PMI emp sub-index change does not Granger Cause Man. emp (agr)	6	6	12.05	0.06	No**
Man. emp (qgr) does not Granger Cause PMI emp sub-index change	6	6	8.68	0.19	No
PMI emp sub-index change does not Granger Cause Man. emp (qgr)	6	6	11.12	0.08	No**

* Statistically significant at 5% level of significance.

** Statistically significant at 10% level of significance but not the 5% level.

(a) Unit root tests were performed on each series to confirm stationarity before Granger causality tests were applied. Lag length selection based on LR tests subject to stability tests (AR Root). Where stability tests indicated VAR did not satisfy stability condition, lag length was adjusted downwards to ensure stability. LM autocorrelation tests for the residuals were also conducted up to lag length 12 and no statistically significant autocorrelation was detected. The estimated VAR is passes stability tests. (b) Decision rule: Do not reject null hypothesis if probability (p-value) is above level of significance (such as 0.05 at the 5% level of significance). agr = annual growth rate; qgr = quarterly growth rate.

5.2 Test results for the PSI

Tables 3 and 4 provide both the leading indicator and contemporaneous information Granger causality test results for the PSI. The variables are seasonally adjusted and include: the quarterly

average aggregate Australian PSI level or quarterly change in the aggregate PSI, the year on year or quarterly growth rates of official aggregate GDP and GVA for the services sector, the monthly PSI employment sub-index, in terms of levels and monthly change form and the growth rate in the monthly official employment data for the services sector. The sample is from 2003Q(4) to 2009Q(4).

Table 3 [(a)] Leading indicator Granger causality tests for the PSI

	PSI lags	y variable lags	Chi-sq stat	p-value	Granger causality? [(b)]
Tests of PSI index level and GVA for services sector					
Null hypothesis:					
GVA - serv (agr) does not Granger Cause PSI index level	1	1	1.66	0.19	No
PSI index level does not Granger Cause GVA - serv (agr)	1	1	3.49	0.06	No**
GVA - serv (qgr) does not Granger Cause PSI index level	1	1	3.62	0.05	Yes*
PSI index level does not Granger Cause GVA - serv (qgr)	1	1	2.30	0.12	No
Tests of quarterly change in PSI index and GVA for services sector					
Null hypothesis:					
GVA - serv (agr) does not Granger Cause PSI index change	1	1	0.16	0.69	No
PSI index change does not Granger Cause GVA - serv (agr)	1	1	3.47	0.06	No**
GVA - serv (qgr) does not Granger Cause PSI index change	1	1	0.86	0.35	No
PSI index change does not Granger Cause GVA - serv (qgr)	1	1	0.48	0.48	No
Tests of PSI employment sub-index level and services sector employment					
Null hypothesis:					
Serv. emp (agr) does not Granger Cause PSI emp sub-index level	1	1	3.30	0.06	No**
PSI emp sub-index level does not Granger Cause Serv. emp (agr)	1	1	0.15	0.69	No
Serv. emp (qgr) does not Granger Cause PSI emp sub-index level	1	1	0.44	0.50	No
PSI emp sub-index level does not Granger Cause Serv. emp (qgr)	1	1	0.28	0.59	No
Tests of quarterly change in PSI employment sub-index and services sector employment					
Null hypothesis:					
Serv. emp (agr) does not Granger Cause PSI emp sub-index change	1	1	0.31	0.57	No
PSI emp sub-index change does not Granger Cause Serv. emp (agr)	1	1	0.34	0.55	No
Serv. emp (qgr) does not Granger Cause PSI emp sub-index change	1	1	0.31	0.57	No
PSI emp sub-index change does not Granger Cause Serv. emp (qgr)	1	1	0.90	0.34	No

* Statistically significant at 5% level of significance.

** Statistically significant at 10% level of significance but not the 5% level.

(a) Unit root tests were performed on each series to confirm stationarity before Granger causality tests were applied. Lag length selection based on LR tests subject to stability tests (AR Root). Where stability tests indicated VAR did not satisfy stability condition, lag length was adjusted downwards to ensure stability. LM autocorrelation tests for the residuals were also conducted up to lag length 12 and no statistically significant autocorrelation was detected. The estimated VAR is passes stability tests. (b) Decision rule: Do not reject null hypothesis if probability (p-value) is above level of significance (such as 0.05 at the 5% level of significance). agr = annual growth rate; qgr = quarterly growth rate.

The leading indicator Granger causality test results outlined in Table 3 for the PSI provide very limited evidence that current quarter PSI readings (either the aggregate PSI or in relation to the employment

sub-index) can provide leading information regarding next quarter's official economic data for the services sector. For example, the null hypothesis that the PSI index level does not Granger cause the annual growth rate in GVA for the services sector can only be rejected at the 10% level of significance (Chi-square test statistic of 3.49 and p-value of 0.06). Similarly, the null hypothesis that the PSI index change does not Granger cause the annual growth rate in GVA for the services sector also is only rejected at the 10% level of significance.

Table 4 [(a)] Contemporaneous information Granger causality tests for the PSI

	PSI lags	y variable lags	Chi-sq stat	p-value	Granger causality? [(b)]
Tests of PSI index level and GVA for services sector					
Null hypothesis:					
GVA - serv (agr) does not Granger Cause PSI index level	1	1	0.00	0.95	No
PSI index level does not Granger Cause GVA - serv (agr)	1	1	7.41	0.00	Yes*
GVA - serv (qgr) does not Granger Cause PSI index level	1	1	2.59	0.10	No
PSI index level does not Granger Cause GVA - serv (qgr)	1	1	4.54	0.03	Yes
Tests of quarterly change in PSI index and GVA for services sector					
Null hypothesis:					
GVA - serv (agr) does not Granger Cause PSI index change	1	1	1.40	0.23	No
PSI index change does not Granger Cause GVA - serv (agr)	1	1	0.81	0.36	No
GVA - serv (qgr) does not Granger Cause PSI index change	4	4	1.95	0.74	No
PSI index change does not Granger Cause GVA - serv (qgr)	4	4	0.94	0.91	No
Tests of PSI employment sub-index level and services sector employment					
Null hypothesis:					
Serv. emp (agr) does not Granger Cause PSI emp sub-index level	1	1	0.15	0.69	No
PSI emp sub-index level does not Granger Cause Serv. emp (agr)	1	1	0.55	0.45	No
Serv. emp (qgr) does not Granger Cause PSI emp sub-index level	1	1	1.65	0.19	No
PSI emp sub-index level does not Granger Cause Serv. emp (qgr)	1	1	0.00	0.94	No
Tests of quarterly change in PSI employment sub-index and services sector employment					
Null hypothesis:					
Serv. emp (agr) does not Granger Cause PSI emp sub-index change	1	1	0.52	0.46	No
PSI emp sub-index change does not Granger Cause Serv. emp (agr)	1	1	0.14	0.69	No
Serv. emp (qgr) does not Granger Cause PSI emp sub-index change	1	1	0.92	0.33	No
PSI emp sub-index change does not Granger Cause Serv. emp (qgr)	1	1	0.77	0.37	No

* Statistically significant at 5% level of significance.

** Statistically significant at 10% level of significance but not the 5% level.

(a) Unit root tests were performed on each series to confirm stationarity before Granger causality tests were applied. Lag length selection based on LR tests subject to stability tests (AR Root). Where stability tests indicated VAR did not satisfy stability condition, lag length was adjusted downwards to ensure stability. LM autocorrelation tests for the residuals were also conducted up to lag length 12 and no statistically significant autocorrelation was detected. The estimated VAR is passes stability tests. (b) Decision rule: Do not reject null hypothesis if probability (p-value) is above level of significance (such as 0.05 at the 5% level of significance). agr = annual growth rate; qgr = quarterly growth rate.

The contemporaneous information Granger causality test results outlined in Table 4 for the PSI indicate that only the null hypothesis that the PSI index level does not Granger cause the annual growth rate in services sector GVA can be rejected at the 5% level of significance. The conclusion is that the PSI is of limited use as a timely early information source on official economic data for the services sector for the same given period. This suggests there is a need to examine the coverage and construction of the PSI survey (noting the results may also be influenced by the smaller sample size). For example, section 2 outlined the appropriate weighting of PSI survey responses by services sub-sectors, reflecting the contribution of each sub-sector to gross value added. However, a review of whether the monthly samples obtained for the PSI are reflective of these weightings suggests some over and under-representation of sub-sectors. For example, responses form the retail trade sub-sector should ideally represent 12 per cent of responses however, in the last year, the average monthly response rate has averaged around 8 per cent of the sample. Hence there has been a smaller than ideal sub-sample of retail industry respondents, potentially skewing the results. Similar sampling problems have not been found with the PMI and PCI.

5.3 Test results for the PCI

Tables 5 and 6 provide both the leading indicator and contemporaneous information Granger causality test results for the PCI. The variables are seasonally adjusted and include: the quarterly average aggregate Australian PCI level or quarterly change in the aggregate PCI, the year on year or quarterly growth rates of official aggregate GDP and GVA for the construction industry, the monthly PCI employment sub-index, in terms of levels and monthly change form and the growth rate in the monthly official employment data for the construction industry. The sample period covers 2005Q(4) to 2009Q(4).

The leading indicator Granger causality test results outlined in Table 5 for the PCI provide some indication that the quarterly PCI index level Granger causes the annual or quarterly growth rate for GVA for the construction sector. For example, the null hypothesis that PCI index level does not Granger cause the annual growth rate for construction sector GVA is rejected at the 5% level of significance (Chi-square test statistic of 37.93 and p-value of 0.00). Similarly, the null hypothesis that the PCI index level does not Granger Cause the quarterly growth rate in GVA for the construction sector is also rejected. There is also some evidence of leading indicator properties of the PCI employment sub-index with the null hypothesis that this sub-index does not Granger cause the annual growth rate in construction sector gross value added rejected at the 5% level of significance.

Table 5 [(a)] Leading indicator Granger causality tests for the PCI

	PCI lags	y variable lags	Chi-sq stat	p-value	Granger causality? [(b)]
Tests of PCI index level and GVA for construction sector					
Null hypothesis:					
GVA - cons (agr) does not Granger Cause PCI index level	4	4	4.47	0.34	No
PCI index level does not Granger Cause GVA - cons (agr)	4	4	37.93	0.00	Yes*
GVA - cons (qgr) does not Granger Cause PCI index level	4	4	6.74	0.15	No
PCI index level does not Granger Cause GVA - cons (qgr)	4	4	19.36	0.00	Yes*
Tests of quarterly change in PCI index and GVA for construction sector					
Null hypothesis:					
GVA - cons (agr) does not Granger Cause PCI index change	3	3	1.23	0.74	No
PCI index change does not Granger Cause GVA - cons (agr)	3	3	0.98	0.80	No
GVA - cons (qgr) does not Granger Cause PCI index change	1	1	0.25	0.61	No
PCI index change does not Granger Cause GVA - cons (qgr)	1	1	1.25	0.26	No
Tests of PCI employment sub-index level and construction sector employment					
Null hypothesis:					
Cons. emp (agr) does not Granger Cause PCI emp sub-index level	4	4	3.03	0.55	No
PCI emp sub-index level does not Granger Cause Cons. emp (agr)	4	4	16.26	0.00	Yes*
Cons. emp (qgr) does not Granger Cause PCI emp sub-index level	2	2	4.13	0.12	No
PCI emp sub-index level does not Granger Cause Cons. emp (qgr)	2	2	3.38	0.18	No
Tests of quarterly change in PCI employment sub-index and construction sector employment					
Null hypothesis:					
Cons. emp (agr) does not Granger Cause PCI emp sub-index change	3	3	5.24	0.15	No
PCI emp sub-index change does not Granger Cause Cons. emp (agr)	3	3	2.65	0.44	No
Cons. emp (qgr) does not Granger Cause PCI emp sub-index change	3	3	5.07	0.16	No
PCI emp sub-index change does not Granger Cause Cons. emp (qgr)	3	3	2.00	0.57	No

* Statistically significant at 5% level of significance.

** Statistically significant at 10% level of significance but not the 5% level.

(a) Unit root tests were performed on each series to confirm stationarity before Granger causality tests were applied. Lag length selection based on LR tests subject to stability tests (AR Root). Where stability tests indicated VAR did not satisfy stability condition, lag length was adjusted downwards to ensure stability. LM autocorrelation tests for the residuals were also conducted up to lag length 12 and no statistically significant autocorrelation was detected. The estimated VAR is passes stability tests. (b) Decision rule: Do not reject null hypothesis if probability (p-value) is above level of significance (such as 0.05 at the 5% level of significance). agr = annual growth rate; qgr = quarterly growth rate.

The contemporaneous information Granger causality test results outlined in Table 6 for the PCI indicate that the PCI is a highly useful in terms of providing early information on current period economic conditions for the construction industry. Of the eight null hypotheses regarding the PCI (or the PCI employment sub-index) not Granger causing official economic data for the construction sector (GVA or employment growth), five are rejected in favour of Granger causality running from the PCI to the official economic data.

Table 6 [(a)] Contemporaneous information Granger causality tests for the PCI

	PCI lags	y variable lags	Chi-sq stat	p-value	Granger causality? [(b)]
Tests of PCI index level and GVA for construction sector					
Null hypothesis:					
GVA - cons (agr) does not Granger Cause PCI index level	2	2	0.99	0.60	No
PCI index level does not Granger Cause GVA - cons (agr)	2	2	12.24	0.00	Yes*
GVA - cons (qgr) does not Granger Cause PCI index level	2	2	1.41	0.49	No
PCI index level does not Granger Cause GVA - cons (qgr)	2	2	14.70	0.00	Yes*
Tests of quarterly change in PCI index and GVA for construction sector					
Null hypothesis:					
GVA - cons (agr) does not Granger Cause PCI index change	3	3	4.23	0.23	No
PCI index change does not Granger Cause GVA - cons (agr)	3	3	5.34	0.14	No
GVA - cons (qgr) does not Granger Cause PCI index change	1	1	0.07	0.78	No
PCI index change does not Granger Cause GVA - cons (qgr)	1	1	4.54	0.03	Yes*
Tests of PCI employment sub-index level and construction sector employment					
Null hypothesis:					
Cons. emp (agr) does not Granger Cause PCI emp sub-index level	3	3	3.85	0.27	No
PCI emp sub-index level does not Granger Cause Cons. emp (agr)	3	3	10.27	0.01	Yes*
Cons. emp (qgr) does not Granger Cause PCI emp sub-index level	1	1	2.90	0.08	No
PCI emp sub-index level does not Granger Cause Cons. emp (qgr)	1	1	5.01	0.02	Yes*
Tests of quarterly change in PCI employment sub-index and construction sector employment					
Null hypothesis:					
Cons. emp (agr) does not Granger Cause PCI emp sub-index change	3	3	5.15	0.16	No
PCI emp sub-index change does not Granger Cause Cons. emp (agr)	3	3	2.76	0.42	No
Cons. emp (qgr) does not Granger Cause PCI emp sub-index change	3	3	4.65	0.19	No
PCI emp sub-index change does not Granger Cause Cons. emp (qgr)	3	3	3.29	0.34	No

* Statistically significant at 5% level of significance.

** Statistically significant at 10% level of significance but not the 5% level.

(a) Unit root tests were performed on each series to confirm stationarity before Granger causality tests were applied. Lag length selection based on LR tests subject to stability tests (AR Root). Where stability tests indicated VAR did not satisfy stability condition, lag length was adjusted downwards to ensure stability. LM autocorrelation tests for the residuals were also conducted up to lag length 12 and no statistically significant autocorrelation was detected. The estimated VAR is passes stability tests. (b) Decision rule: Do not reject null hypothesis if probability (p-value) is above level of significance (such as 0.05 at the 5% level of significance). agr = annual growth rate; qgr = quarterly growth rate.

6. Conclusion

This paper finds on the basis of Granger causality tests that amongst the Ai Group business survey based performance indices, the PMI is the most useful leading and timelier contemporary indicator of economic activity with respect to official economic data for the industry. On all measures of

economic activity tested (GVA for manufacturing, and manufacturing employment) Granger causality from the PMI to the official data is found.

The results for the PSI and PCI are mixed, with limited evidence of Granger causality from the PSI to the corresponding official economic data for the services sector. This result is disappointing given the importance of having a useful predictor for such a large part of the economy. The results for the PSI suggest there is a need to examine the coverage and components of the PSI survey to improve its predictive ability. The PCI Granger causality tests suggest some value in the PCI as both a leading indicator as well as a timelier contemporary indicator of construction sector economic activity.

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