An Economic Analysis of Construction Industries Producer Prices in Australia

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Abstract

Research on construction prices is significant for contractors and traders. A comprehensive understanding of construction prices may influence crucial decisions in business operation and arbitrage activities. This study focuses on the cointegration relationships of regional construction prices in Australia by using a range of econometric techniques including the stationarity test, the Engle-Granger cointegration approach and error correction model. The cointegration relationships amongst the regional construction prices are detected in this study. The application of the Engle-Granger cointegration approach examines the long run equilibrium relationships within the regional markets, and the error correction models explore the short run disequilibrium relationships. Results of this study suggest that the economic system in which construction industry participants operate is characterised by a highly competitive integrated marketplace. Furthermore, the causalities and diffusion patterns among the construction price indices in six states and two territories of Australia are drawn by the cointegration analysis. These outcomes reveal a pattern of diffusion paths and network linkages among the six states and two territories, and then expose the regional price linkages.

Keywords: Cointegration, Error correction model, Construction prices, Diffusion pattern, Causality, Australian

1. Introduction

Construction prices are surveyed and measured in many ways. The producer price index of the construction industry is one of them and is commonly applied as a measure of construction price. The producer price index is a measure of the change in price of goods and services when they depart their prices of production, or when the goods and services enter the production process. It is also a measure of the change in the prices obtained by the domestic producer for their outputs of goods and services, or, alternatively, the change in the prices defrayed by the domestic producers for their intermediate inputs or productions, which were stated by International Monetary Fund (2004). The producer price index is not the actual level of prices and it does not measure the actual output price or input cost of production, it focuses on the measurement of the average change in the prices over time. Therefore, the producer price index is able to measure the average change in the output prices, or the change in the prices defrayed by the producers for their inputs of goods and services production, in order to produce the output production.

The producer price index includes two categories: the input producer price index and the output producer price index. The input producer price index is defined as the measure of the change in the price of goods and services purchased by domestic producers for their intermediate inputs. The input producer price index includes the intermediate inputs of both domestic and imported overseas productions. The valuation of the index is based on the purchase prices. Thus an input PPI is a measurement of the change in the costs of a group of purchases because of the demand of the inputs into the intermediate production process, however, the input PPI excludes the primary inputs such as capital input, land input and labour input. The output producer price index is defined as a measure of the change in the prices of products sold by the domestic producers as their outputs, and the output PPI includes the output products sold both in the domestic market and overseas as exports. Thus the producer price index measures the rate of change in the prices of goods and services bought both by the producers as the inputs of production and sold by the producers as the outputs of production. The PPI is constructed by the input PPI and the output PPI. The input PPI measures the rate of change in the prices of input goods and services purchased by the producers. The output PPI measures the rate of change in the prices of output products sold as the products depart the place of production. A value-added PPI is a weighted average of the input PPI and the output PPI.

The price index for the output of the construction industry belongs to the category of producer price index. The construction price index is a significant element helping to reflect price movement for the construction industry. There is little discussion of construction price or cost indices within the literature. Scholars including Williams (1994), Mills (1995), Wang and Mei (1998), Somerville (1999), Hassanein and Khalil (2006), Nam et al. (2007), Yu and Ive (2008) have contributed some innovative views to promote research around construction price indices. However, in the literature review for the research reported here, it was concluded that the academic research published in this area has primarily focused on models for prediction or on the compilation of construction price indices. This seems to narrow the scope to be discussed in the conventional literature. There are still some other more practical, wider and more profound applications of construction price indices. For example, spatial linkages among construction price markets are helpful to discover and explore spatial arbitrage opportunities. In addition, the development and spread of econometric techniques in recent years makes it possible to research construction price indices from another perspective, and thereby enrich the literature in the area of construction prices.

Based on this assessment of the literature, this study focuses on the cointegration analysis of construction price indices, which is uncommon in the conventional literature, and in this way the research on construction price indices will be extended and enriched. Furthermore, the causalities and the diffusion patterns among the construction price indices in the six states and two territories in Australia are drawn by the use of cointegration analysis. These outcomes reveal a pattern of diffusion paths and network linkages among the six states and two territories, and then expose the regional price linkages.

2. Construction price indices in Australia

The data contained in this study is adopted from the Australian Bureau of Statistics. The Australian Bureau of Statistics is an official statistical organization for the Commonwealth, State and Territory governments. The main functions of the Australian Bureau of Statistics are collecting information and data from a wide range of Australian economic and social activities, compiling statistics and disseminating them to the community, the private sector and the Government. The coverage of collections and datasets processed by the Australian Bureau of Statistics is widely spread over Australian social and economic activities, such as research and development, manufacturing, energy, mining, retail and wholesale trade establishments, interstate trade, tourist accommodation, the census of population and housing, education, health, welfare, justice and other social issues, national accounts, labor forces, household income and expenses and agriculture. The producer price indices and house price indices are also generated from the Australian Bureau of Statistics, and they are significant economic indicators to measure the degree of economic development balance and health.

This study focuses on the producer price indices of house construction at the subnational level in Australia. The six states and two territories house construction cost indices are used in this study specifically. The house construction producer price indices are extracted from the producer price indices data of the general construction industry. The data structure chart of PPI of the general construction industry in Australia is presented in Figure 1. The index coverage for the construction industry, which is the division E of the Australian and New Zealand Standard Industrial Classification (ANZSIC), is currently limited to the output of the following ANZSIC classes: House construction (4111), Residential building construction n.e.c. (4112), Non-residential building construction (4113), and Road and bridge construction (4121).

The price indices of the output of the general construction industry are the measurements of the changes in the prices of the principal output of ANZSIC subdivision 41 which is general construction industry. As Australian Bureau of Statistics indicated (2008), the calculations of the output indices are processed on the foundation of the reference base 1998-99=100.00. The constituent groups and classes of the ANZSIC subdivision 41 embrace the building construction group (411), which contains three classes which are house construction (4111), residential building construction n.e.c. and non-residential building construction (4113). Another group is the non-building construction group (412) which is solely contributed to by the class of road and bridge construction (4121) until the coverage of 4121 can be extended to include the class of non-building construction n.e.c. (4122), which includes railways, telecommunications, electricity infrastructure, etc. The core date indices employed in this study is the data series of the output prices of house construction (4111).

The ANZSIC class output indices at the national level are aggregated based on the relevant subdivisions and groups, through the application of the weights obtained primarily from the value magnitudes of new general construction productions in Australia, which are measured in the Input-Output statistics in the Australian Bureau of Statistics. The ANZSIC class output indices at the State and Territory level are aggregated based on the data of national level by applying the proportions, which are based on the foundation of the value amounts of work done by the respective States and Territories, as well as the foundation of the type of construction which is measured in the Australian Bureau of Statistics building and construction activity statistics. The measurement of the indices generally involves applying the prices for work undertaken in the individual capital city, as the construction activities in the capital city is taken to represent the whole State and Territory.

3. Cointegration analysis principles

In the case of the time series dissatisfying the condition of stationarity, then the valid information and the characteristics of the data series are quite difficult to generalize, and a nonstationary data series could cause a spurious regression. Nevertheless, if the combination of nonstationary variables becomes stationary, then the issue of spurious regression can be averted. The concept of cointegration was first suggested by Granger (1981). If several nonstationary variables have a cointegration relationship, it indicates that these nonstationary variables own a common trend and there is an equilibrium relationship among them in the long term. There are two popular econometric cointegration test theories employed in this study. They are Engle-Granger cointegration test and Johansen cointegration test.

The Engle-Granger cointegration test theory was proposed by Engle and Granger (1987). The Engle-Granger cointegration test is good at detecting the pairwise cointegration relationship between variables. When several variables are not satisfying the condition of stationarity while they have the same differencing level to make them stationary, in other words, they have the same integration order, and then the Engle-Granger cointegration test is able to detect the pairwise cointegration relationships between each couple of the variables. Once the pairwise cointegration relationships are discovered, then the certain cointegration equations can be built up on this ground, and the causal links between variables will be explored according to the cointegration models.

There are two steps of the Engle-Granger cointegration test. Firstly, the regression equations of the variables are formulated as:

$$Y_t = \beta_0 + \beta_1 X_t + \varepsilon_t \tag{1}$$

$$Y_t = \beta_0 + \chi t + \beta_1 X_t + \varepsilon_t \tag{2}$$

the corresponding residual series is calculated as:

$$e_t = Y_t - \left(\hat{\beta}_0 + \hat{\beta}_1 X_t\right) \tag{3}$$

where X_t and Y_t are two time series, β_0 is a non-zero drift, β_1 is the coefficient of data series X_t, ε_t is the residual series of regression. The arithmetic product of χ and t denotes a deterministic time trend, $\hat{\beta}_0$ and $\hat{\beta}_1$ are the estimated magnitudes of β_0 and β_1 respectively, $t = 1, 2, 3, \ldots, n$ and n is the dimension of the vector variable. There are two sorts of Engle-Granger cointegration test including in this study. They are the one without deterministic time trend which is stated as *Eq.* (1), and another one with deterministic time trend which is expressed in *Eq.* (2).

Secondly, the stationarity of these residual series is tested and the test equations are as follows:

$$\Delta e_t = \gamma e_{t-1} + \sum_{i=1}^{m} \lambda_i \Delta e_{t-i} + \varepsilon_t \tag{4}$$

$$\Delta e_t = \alpha + \gamma e_{t-1} + \sum_{i=1}^{m} \lambda_i \Delta e_{t-i} + \varepsilon_t \tag{5}$$

$$\Delta e_t = \alpha + \delta t + \gamma e_{t-1} + \sum_{i=1}^{m} \lambda_i \Delta e_{t-i} + \varepsilon_t \tag{6}$$

where the symbol α denotes a drift which is not zero, and the product value of δ and t denotes a deterministic time trend, Δe_t is the first difference of the residual series e_t derived from *Eq.* (3). The symbol *i* is the lagged term of each variable and e_{t-i} represents the *i*th lagged term of the variable match along with e_t. ε_t is the generated residual series of the stationarity test equation, $t = 1, 2, 3, \ldots, n$ and *n* is dimension of the vector variable. The pairwise cointegration relationships exist between the couples of variables if the residual series are tested as stationary by using the unit root test on e_t and the regression equation is considered as the cointegration regression equation. It is concluded that there is no pairwise cointegration relationships existing between the couples of variables if the residual series are tested as nonstationary, and then the regression equation will be regarded as a spurious regression equation. Therefore, the variable of Y_t and X_t are cointegrated if the residual series of e_t is tested as stationary one, otherwise, there is not any cointegration relationship between the variables of Y_t and X_t.

When the pairwise cointegration relationships are detected by the cointegration test, it does not support the notion that the equilibrium relationships are occurring between the pairs of variables all the time, because they are probably in disequilibrium in the short term. However, there are plenty of equilibrium errors maintaining the long term equilibrium relationships within variables. The equilibrium error term was firstly proposed by Sargan (1964), and it is named as ‘error correction mechanism’. The notion of error correction mechanism was promoted by Davidson et al. (1978) and then combines with cointegration theorem by Engle and Granger (1987). The danger of spurious regression can be eliminated by the analysis of the cointegration relationship, and the error correction models can used to present the causality between the pairs of variables.

The error correction model is expressed as:

$$\Delta Y_t = \alpha_0 \Delta X_t + \phi\, ecm_{t-1} + \mu_t \tag{7}$$

$$ecm_{t-1} = Y_{t-1} - \beta_0 - \beta_1 X_{t-1} \tag{8}$$

where ΔY_t represents the data series derived from the first difference of the time series Y_t and ΔX_t denotes the data series X_t at the fires difference level, $t = 1, 2, 3, \ldots, n$ and *n* is dimension of the vector variable. The time series of Y_t and X_t are both hypothesized as I (1), which indicates that they are both integrated at the first difference level. The symbol α_0 denotes the short term elasticity, and the symbol ϕ represents the rapidity of adjustment back to equilibrium status and the item of μ_t denotes the residual value of the ECM. The item of ecm_{t-1} denotes the error correction term, and in the expression of ecm_{t-1}, the symbol β_0 is the constant item and the symbol β_1 represents the long term elasticity. The calculation of the item of ecm_{t-1} is derived as the residual value of the cointegration regression equation.

4. Cointegration analysis applications

4.1 Pairwise cointegration analysis

It has become common to make use of cointegration techniques to the detecting of regional price linkages, both to determine the law of one price and to find out the extent to which various regions are mutually integrated (McNew and Fackler, 1997). The cointegration analysis is an approach to detect the long term equilibrium relationships. The variables are cointegrated if they share a common trend and tie together in a long term equilibrium relationship. The Engle-Granger test method is employed in this research to test the cointegration relationships of the six states and two territories producer price indices of house construction. The casual relationships between the regional indices will be explored as well. The Engle-Granger test method was proposed by Engle and Granger (1987). The Engle-Granger test method firstly makes a least square regression estimation of one regional producer price indices of house construction on another one, and then tests the stationarity of the residuals series obtained from the regression. If the residuals series are stationary, the two states producer price index series of house construction are considered integrated, and so there is no spurious regression in this cointegration analysis.

The raw data of the producer price indices of house construction in eight regional markets are tested nonstationary. There are two circumstances of cointegration regression analysis including in this research: cointegration regression analysis without deterministic trend is shown in Table 1, and cointegration regression analysis with deterministic trend is presented in Table 2. For every pair of any two states, there is one least square regression equation respectively, k_0 denotes the intercept item, k_1 denotes the regression coefficient, R squared is the correlation coefficient, DW is short for Durbin-Watson statistic, ADF on residuals is the Augmented Dickey-Fuller unit root test method results on the residuals obtained from each least square regression equation. The item of ‘na’ denotes the series of residual acquired from individual regression equation is nonstationary according to the ADF unit root test method. If some percentage numbers show up, these are the significance levels when the null hypothesis are rejected respectively, which indicates that the series of residual is stationary, so these two variables in this regression equation are considered cointegrated.

The Eagle-Granger pairwise cointegration test results of six states and two territories producer price indices of house construction are presented in Tables 1 and 2. Table 1 is the cointegration regression results without deterministic trend, and Table 2 is the results with deterministic trend. From the results revealed in Table 1, there are 25 pairs of states producer price indices of house construction which are cointegrated, each pair having a long term equilibrium relationship. There are four pairs of states series are tested to be cointegrated, and they are all observed as cointegrated pairs in Table 1 as well. In the same way, the pairwise cointegration test results also suggest that there is convergence occurring between some pairs of regional markets, such as New South Wales and the Australian Capital Territory, Victoria and New South Wales, Queensland and Western Australia, South Australia and the Australian Capital Territory, etc.

As showed in Tables 1 and 2, most of the pairwise relationships between six states and two territories producer price indices of house construction are quite firm, and the correlation coefficients of regression are mainly higher than or equal to 0.911138. There are only a few pairs correlation coefficients of regression lower than 0.911138. For example, the regression of Northern Territory on the Australian Capital Territory with R squared is 0.818563; the regression of Northern Territory on New South Wales with R squared is 0.848959; the regression of South Australia on Northern Territory with R squared is 0.845378; the regression of Victoria on Northern Territory with R squared is 0.798158; the regression of Western Australia on Australia Capital Territory with R squared is 0.843764; the regression of Western Australia on New South Wales with R squared is 0.880431; the regression of Western Australia on South Australia with R squared is 0.865097; the regression of Western Australia on Victoria with R squared is 0.824782. There are several factors affecting cointegration, such as the amount of market information reflected in prices at a particular market (Buccola, 1985), an agent’s cost and risk associated with trading activities between markets (Buccola, 1989). Maybe the factor of market volume (Tomek, 1980), and the degree of the industry concentration (Goodwin and Schroeder, 1991) are also relevant in affecting cointegration. The cointegration regression tests explore the long term equilibrium relationship of the pairs of states producer price index series of house construction, and indicate that the law of one price exists in the market, and the cointegration regional linkages are shown through the test results. All the outcomes support the hypothesis that there are some regional relationships of construction prices.

4.2 Multivariable cointegration analysis

The pairwise cointegration analysis based on Engle-Granger cointegration test method has revealed the detailed interaction between subnational markets. Johanson cointegration test method is adopted in this research to explore the cointegration relationships among the eight regional markets. The Johanson cointegration test theory was developed by Johanson (1988). The results of Johanson cointegration test among the producer price markets of house construction in the six states and two territories in Australia are shown in Table 3.

There are five different types of test, which are based on five diverse kinds of hypothesis on the data trends. Two sorts of lags interval have been chosen in the test, which are 1 to 1 and 1 to 2. The Johanson cointegration test cannot keep processing when the lags interval is greater than 1 to 2, because of the insufficient of research data. The multivariable cointegration relationships are presented in the summary, obviously there are several cointegration relationships existing among the eight regional markets. These results suggest that several long term equilibrium relationships occur within the eight regional markets, and these markets share a common trend and tie together in the long term. Furthermore, the Johanson cointegration test results demonstrate that there is convergence and the law of one price existing among these eight subnational markets as well. The results again support the hypothesis that there are some regional linkages of construction prices hidden behind the time series.

5. Causality linkages of regional construction prices

The cointegration regression tests explore the long term equilibrium relationship of the pairs of states producer price index series of house construction; however, during the process of long term equilibrium, there are still some short term disequilibrium circumstances caused by short term changes. Error correction model is applied to estimate this short term disequilibrium. In practice, the error correcting mechanism can be the arbitrage and trading activities in the economy system. Based on the 25 cointegrated pairs acquired from the cointegration regression tests, error correction models can then be estimated. Table 4 presents the error correction model equations of six states and two territories producer price index series of house construction based on Eagle-Granger cointegration test results. Each error correction model equation is corresponding to a pairwise cointegrated relationship revealed in Tables 1 and 2.

In Table 4, D (.) denotes the data series of the item included in the bracket at the first difference level. The item of *ecm* denotes the error correction term, which is derived from the Eagle-Granger cointegration regression equation, the coefficient of the D (.) on the right of the equation denotes the short term elasticity of changing. It is the short term changing rate. The coefficient of *ecm* denotes the speed of adjustment from short term disequilibrium back to a long term equilibrium relationship. After the discovery of long term equilibrium relationship and short term disequilibrium relationship, the causalities between the six states and two territories producer price index series of house construction can be detected, while the direction of causal links can be identified from the error correction model equations in Table 4. As Johansen (1988) stated, when the cointegration relationship exists, it is considered that the Granger causality must occur in at least one direction. The causal links between six states and two territories have been presented in Figure 2, which shows the diffusion patterns of six states and two territories producer price index series of house construction based on cointegration regression test and error correction model estimation without deterministic trend.

This figure indicates the causal relationships between six states and two territories producer price index series of house construction in Australia. It is found that Queensland affects Western Australia, Northern Territory, South Australia, Victoria and New South Wales directly, and then influences the Australian Capital Territory and Tasmania indirectly. Similarly, New South Wales and Victoria influence four regional markets directly. However, Western Australia only influences Queensland directly, and indirectly impacts other regional markets via Queensland. In a similar way, Northern Territory does not affect other states directly except New South Wales and Queensland, and then the influence diffuses to other subnational markets. As revealed in Figure 2, New South Wales impacts Western Australia in a quite indirect way, There are three paths for New South Wales to affect Western Australia, via Northern Territory to Queensland and then to Western Australia, via Victoria to South Australia and then pass to Western Australia, or via Tasmania to South Australia and then diffuse to Western Australia. The indirect diffusion path is quite frequent in this research, such as Victoria influences Queensland, Western Australia affects Australia Capital Territory and Tasmania, South Australia influences Northern Territory, Tasmania impacts on Queensland and Australia Capital Territory affects Queensland.

Moreover, both New South Wales and Victoria widely receive influences from several directions. New South Wales is affected by five states: Queensland, Victoria, Northern Territory, Tasmania and the Australian Capital Territory. Victoria is also impacted by five regional markets: Queensland, New South Wales, Northern Territory, South Australia and Tasmania. Queensland, Western Austral, Northern Territory and Tasmania all receive influences from only two directions. In the diffusion patterns, there are 20 pairs of regional markets are bidirectional, and only five passing lines are unilateral. Each regional market has at least one regurgitant path with other regional markets directly or indirectly. This suggests that every subnational market can play a role of epicenter, and there is a possibility that all the subnational markets would be the epicenters of the diffusion patterns.

It seems like the causal links between states are not exactly through adjoining states in a geographical sense in this diffusion patterns. There are some causal relationships between several pairs of contiguous states as we expected, such as South Australia and Victoria, New South Wales and the Australian Capital Territory, New South Wales and Victoria, and Victoria and the Australian Capital Territory, etc. However, there are also many causal links between noncontiguous states arising, which is unexpected in this research. For example, the causality of Western Australia to Queensland or Queensland to Western Australia, New South Wales to Tasmania or Tasmania to New South Wales, South Australia to the Australian Capital Territory or the Australian Capital Territory to South Australia, Queensland to Victoria or Victoria to Queensland, and Northern Territory to New South Wales or New South Wales to Northern Territory, etc. Furthermore, some adjoining states exhibit no straight causal links in this diffusion patterns, such as Western Australia and Northern Territory, South Australia and Northern Territory, News South Wales and South Australia, etc. As expected normally, some noncontiguous regions do not present straight causal relationships, such as Northern Territory and the Australian Capital Territory, Queensland and the Australian Capital Territory, and Western Australia and New South Wales, etc. Therefore, the analyzing results in this research indicate that the diffusion of producer price of house construction in Australian regional markets is not always through the contiguous state. The outcomes have some potential usefulness for the discovering of the arbitrage and trade opportunities amongst the eight regional markets.

6. Conclusions

This study focused on exploring the cointegration relationships of regional construction prices by employing several econometric techniques and some primary data from the Australian Bureau of Statistics. The techniques included the cointegration test, an error correction model, the Engle-Granger cointegration approach, and the data on producer price indices of the construction industry. This research suggests that the economic system in which the construction industry participants operate is characterized by a highly competitive, integrated marketplace. Moreover, the diffusion patterns indicate that the causal links between states are not exactly between adjoining states in a geographical sense, and many causal relationships show up between states which are not contiguous. There is at least one returning diffusion path for every regional market, and the influences go back to the state at the starting point of the path through the others.

The findings complement the previous research on construction prices, spatial linkages and the cointegration relationships, and enrich the literature by quantifying the regional relationships of construction price indices. However, there are still several future research paths need to be continuously explored. One of the future research paths could be on the national levels, adding the variables of national macroeconomic data into the analysis. Future work could also focus on the actual construction prices rather than the indices, as the application of index form may cause some difficulties in applying the research findings.

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Table 1. Pairwise cointegration test results (without deterministic trend)

		ACT	NSW	NT	QLD	SA	TAS	VIC	WA
ACT	k_0		41.87886	-29.99757	-12.57133	18.69882	-27.4917	64.97855	-66.6355
	k_1		0.59242	1.188309	1.065752	0.821277	1.195573	0.370112	1.557457
	R squared	-	0.971963	0.818563	0.949005	0.986307	0.940583	0.976742	0.843764
	DW		0.302518	0.051950	0.119791	0.533619	0.141679	0.544756	0.048514
	ADF on residuals		-3.00986	-1.742987	-1.724776	-3.692827	-2.237404	-3.398879	-2.238571
			5%	na	na	1%	na	10%	na
NSW	k_0	-65.08877		-114.955	-85.53271	-37.28053	-110.4933	-3.777423	-178.936
	k_1	1.640667		2.013918	1.778894	1.368758	2.005321	1.053213	2.647576
	R squared	0.971963	-	0.848959	0.954697	0.989227	0.955481	0.98485	0.880431
	DW	0.300466		0.071969	0.178984	0.423159	0.157644	0.597809	0.071051
	ADF on residuals	-2.836856		-2.88743	-2.121617	-2.202594	-2.827274	-2.99388	-2.511895
		10%		10%	na	na	10%	5%	na
NT	k_0	44.0934	66.3391		26.87541	53.28599	16.10427	67.3498	-23.45379
	k_1	0.688848	0.421546		0.795264	0.578903	0.897448	0.433787	1.27934
	R squared	0.818563	0.848959	-	0.911559	0.845378	0.914261	0.788158	0.982125
	DW	0.052279	0.07435		0.116015	0.07473	0.093458	0.08675	0.242737
	ADF on residuals	-2.04718	-3.28194		-2.754927	-2.445921	-1.343074	-2.306592	-1.978495
		na	10%		5%	na	na	na	na
QLD	k_0	17.77941	51.26669	-19.88719		32.03876	-12.34282	50.61533	-50.51473
	k_1	0.890456	0.53668	1.146235		0.741401	1.113445	0.562056	1.479366
	R squared	0.949005	0.954697	0.911559	-	0.962019	0.976397	0.929675	0.911138
	DW	0.118397	0.179642	0.114292		0.196586	0.323729	0.191248	0.106355
	ADF on residuals	-1.982238	-4.00841	-2.72525		-2.908034	-2.053175	-3.06691	-3.85061
		na	1%	10%		10%	na	5%	1%
SA	k_0	-20.68807	28.21869	-58.727547	-36.82286		-54.2463	25.38548	-103.422
	k_1	1.200944	0.722719	1.460311	1.297569		1.452012	0.765645	1.907017
	R squared	0.986307	0.989227	0.845378	0.962019	-	0.948751	0.985711	0.865097
	DW	0.531094	0.422686	0.071876	0.195455		0.167667	0.808001	0.06618
	ADF on residuals	-3.603449	-2.28561	-2.313903	-2.462371		-2.560856	-3.883619	-2.676667
		5%	na	na	na		na	1%	10%
TAS	k_0	29.30111	57.91724	-5.821162	13.77522	41.83828		58.00793	-34.39718
	k_1	0.786721	0.476473	1.018734	0.876915	0.653404		0.495632	1.330857
	R squared	0.940583	0.955481	0.914261	0.976397	0.948751	-	0.917915	0.936283
	DW	0.143192	0.161209	0.094643	0.326636	0.171705		0.18066	0.106453
	ADF on residuals	-2.299797	-3.20114	-1.024621	-1.981313	-2.722097		-3.37284	-1.763935
		na	5%	na	na	10%		5%	na
VIC	k_0	-58.23124	5.325649	-99.00371	-74.9265	-30.89931	-97.01487		-157.4418
	k_1	1.549724	0.935091	1.839974	1.654062	1.287426	1.852009		2.414568
	R squared	0.976742	0.98485	0.798158	0.929675	0.985711	0.917915	-	0.824782
	DW	0.570895	0.592147	0.078708	0.184928	0.802813	0.171433		0.083076
	ADF on residuals	-3.273565	-2.83839	-1.478044	-2.293809	-3.296239	-2.735975		-1.601808
		5%	10%	na	na	5%	10%		na
WA	k_0	56.27568	73.65843	20.21175	42.22446	63.7459	32.28463	74.96416	
	k_1	0.541758	0.332542	0.767681	0.615898	0.453639	0.703518	0.341586	
	R squared	0.843764	0.880431	0.982125	0.911138	0.865097	0.936283	0.824782	-
	DW	0.05037	0.074959	0.244264	0.109604	0.070561	0.106796	0.092646	
	ADF on residuals	-1.998246	-2.47483	-1.094161	-3.671854	-2.383054	-1.825311	-2.1565	
		na	na	na	10%	na	na	na	

Note: the percentage number in the ADF on residuals row denotes the significance level when the null hypothesis is rejected respectively.

Table 2. Pairwise cointegration test results (with deterministic trend)

		ACT	NSW	NT	QLD	SA	TAS	VIC	WA
ACT	k_0	-	86.83644	no trend	51.83048	55.0564	92.66842	39.51325	no trend
	k_1		0.133128		0.407815	0.449843	-0.031998	0.630269	
	Time trend		0.717636		1.028015	0.580358	1.918057	0.40649	
	R squared		0.980908		0.954543	0.989396	0.955765	0.976742	
	DW		0.283801		0.113439	0.52082	0.112923	0.578608	
	ADF on residuals		-6.114737		-2.666011	-3.622851	-2.330067	-3.520734	
			1%		na	5%	na	5%	
NSW	k_0	no trend	-	143.6518	-7.849203	15.73713	-9.742606	20.03596	78.7906
	k_1			-0.583656	0.998603	0.836222	0.993331	0.81402	0.058842
	Time trend			2.444769	0.73439	0.501209	0.952459	0.225123	2.436449
	R squared			0.877535	0.958414	0.992256	0.960405	0.985878	0.897462
	DW			0.044689	0.14325	0.479328	0.118579	0.600036	0.041925
	ADF on residuals			-0.731223	-3.141328	-2.067239	-3.028186	-3.117919	-2.092148
				na	na	na	na	na	na
NT	k_0	no trend	no trend	-	no trend	no trend	no trend	no trend	-8.070353
	k_1								1.086892
	Time trend								0.418744
	R squared								0.985268
	DW								0.249274
	ADF on residuals								-1.942861
									na
QLD	k_0	88.42089	no trend	-10.46729	-	no trend	15.38468	no trend	-5.207172
	k_1	0.108056		1.041903			0.806345		0.977556
	Time trend	1.360021		0.181356			0.533822		0.872281
	R squared	0.985584		0.911936			0.980106		0.916372
	DW	0.269404		0.104632			0.287934		0.077325
	ADF on residuals	-2.755338		-2.589808			-1.577889		-2.364799
		na		na			na		na
SA	k_0	32.97368	42.21577	184.6834	-15.05914	-	52.15039	33.92172	220.7668
	k_1	0.658423	0.581208	-1.00056	1.077538		0.376339	0.679343	-1.37054
	Time trend	0.700991	0.182846	3.179684	0.284302		1.389875	0.11151	4.234923
	R squared	0.989386	0.989807	0.8821	0.962442		0.956715	0.985902	0.904185
	DW	0.427802	0.377441	0.058745	0.171337		0.112881	0.772089	0.073416
	ADF on residuals	-3.164454	-2.210084	-0.324608	-2.71705		-2.439792	-3.789808	-1.593953
		na	na	na	na		na	5%	na
TAS	k_0	no trend	no trend	-3.267675	30.84025	no trend	-	no trend	-30.73874
	k_1			0.989648	0.682533				1.289185
	Time trend			0.056873	0.380082				0.081483
	R squared			0.914295	0.978618				0.936325
	DW			0.092268	0.304252				0.103075
	ADF on residuals			-0.327904	-1.696583				-1.717661
				na	na				na
VIC	k_0	no trend	43.58503	no ttrend	85.67667	no trend	no trend	-	no trend
	k_1		0.555777		0.061794				
	Time trend		0.380036		1.595294				
	R squared		0.98914		0.952481				
	DW		0.462461		0.12683				
	ADF on residuals		-2.134112		-2.573619				
			na		na				
WA	k_0	no trend	no trend	18.61695	no trend	no trend	no trend	no trend	-
	k_1			0.787874					
	Time trend			-0.056042					
	R squared			0.982203					
	DW			0.250405					
	ADF on residuals			-0.963792					
				na					

Note: the percentage number in the ADF on residuals row denotes the significance level when the null hypothesis is rejected respectively.

Table 3. Multivariable cointegration summary

a) lags interval: 1 to 1					
Data trend	None	None	Linear	Linear	Quadratic
Test type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	7	8	5	7	8
Max-Eig	2	3	3	4	2
b) lags interval: 1 to 2					
Data trend	None	None	Linear	Linear	Quadratic
Test type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	7	8	6	8	8
Max-Eig	7	8	7	8	8

*Critical values based on MacKinnon-Haug-Michelis(1999)

Table 4. Error correction models of producer price indices of house construction

State	Error correction model equation
ACT	$D(ACT) = 1.31327 + 0.246033 * D(NSW) - 0.082549 * ecm_{t-1}$
	$D(ACT) = 1.082924 + 0.347193 * D(SA) - 0.206881 * ecm_{t-1}$
	$D(ACT) = 1.306542 + 0.222919 * D(VIC) - 0.224507 * ecm_{t-1}$
NSW	$D(NSW) = 0.815876 + 0.113758 * D(ACT) - 0.106933 * ecm_{t-1}$
	$D(NSW) = 1.015512 - 0.010895 * D(NT) - 0.036369 * ecm_{t-1}$
	$D(NSW) = 0.77682 + 0.136486 * D(QLD) - 0.17778 * ecm_{t-1}$
	$D(NSW) = 0.626314 + 0.224307 * D(TAS) - 0.132953 * ecm_{t-1}$
	$D(NSW) = 0.59971 + 0.356235 * D(VIC) - 0.228528 * ecm_{t-1}$
NT	$D(NT) = 1.972242 - 0.142322 * D(NSW) - 0.020493 * ecm_{t-1}$
	$D(NT) = 1.664967 + 0.101443 * D(QLD) - 0.039052 * ecm_{t-1}$
QLD	$D(QLD) = 1.518459 + 0.071598 * D(NT) - 0.004504 * ecm_{t-1}$
	$D(QLD) = 1.682922 - 0.011835 * D(WA) + 0.039003 * ecm_{t-1}$
SA	$D(SA) = 0.855903 + 0.339253 * D(ACT) - 0.182118 * ecm_{t-1}$
	$D(SA) = 0.88089 + 0.312935 * D(QLD) - 0.146546 * ecm_{t-1}$
	$D(SA) = 1.054098 + 0.205644 * D(TAS) - 0.068406 * ecm_{t-1}$
	$D(SA) = 0.946587 + 0.396464 * D(VIC) - 0.20616 * ecm_{t-1}$
TAS	$D(TAS) = 0.821409 + 0.802137 * D(NSW) - 0.110688 * ecm_{t-1}$
	$D(TAS) = 1.397037 + 0.196958 * D(VIC) - 0.081848 * ecm_{t-1}$
VIC	$D(VIC) = 1.353973 + 0.17032 * D(ACT) - 0.066751 * ecm_{t-1}$
	$D(VIC) = 0.276123 + 0.825498 * D(NSW) - 0.303686 * ecm_{t-1}$
	$D(VIC) = 0.749603 + 0.212340 * D(QLD) - 0.158099 * ecm_{t-1}$
	$D(VIC) = 0.558027 + 0.394586 * D(SA) - 0.398236 * ecm_{t-1}$
	$D(VIC) = 0.834413 + 0.155317 * D(TAS) - 0.140794 * ecm_{t-1}$
WA	$D(WA) = 2.210292 + 0.041615 * D(QLD) - 0.061156 * ecm_{t-1}$
	$D(WA) = 2.118667 + 0.109861 * D(SA) - 0.038877 * ecm_{t-1}$

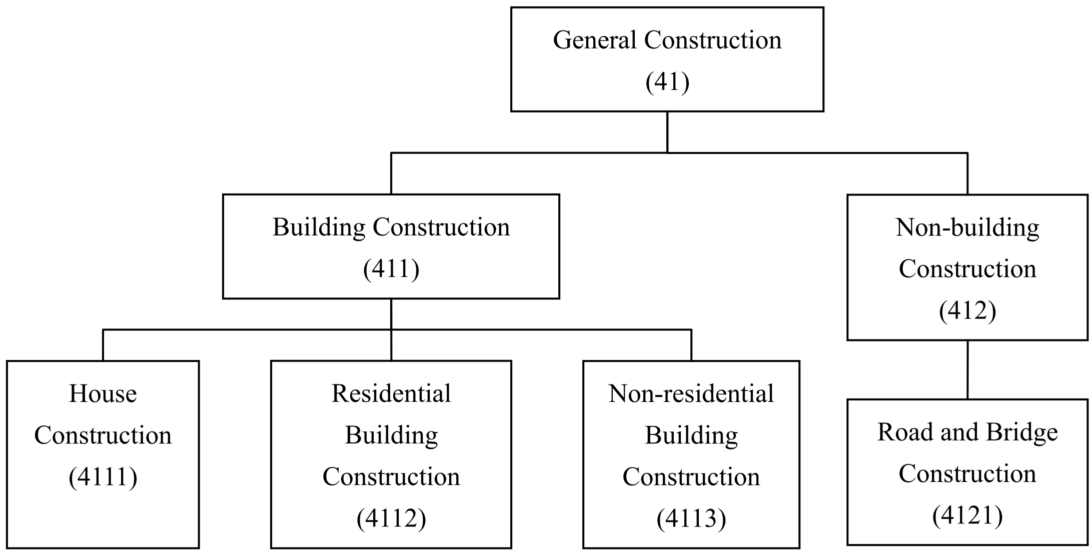

Figure 1. Structure chart of producer price indices of the general construction industry in Australia

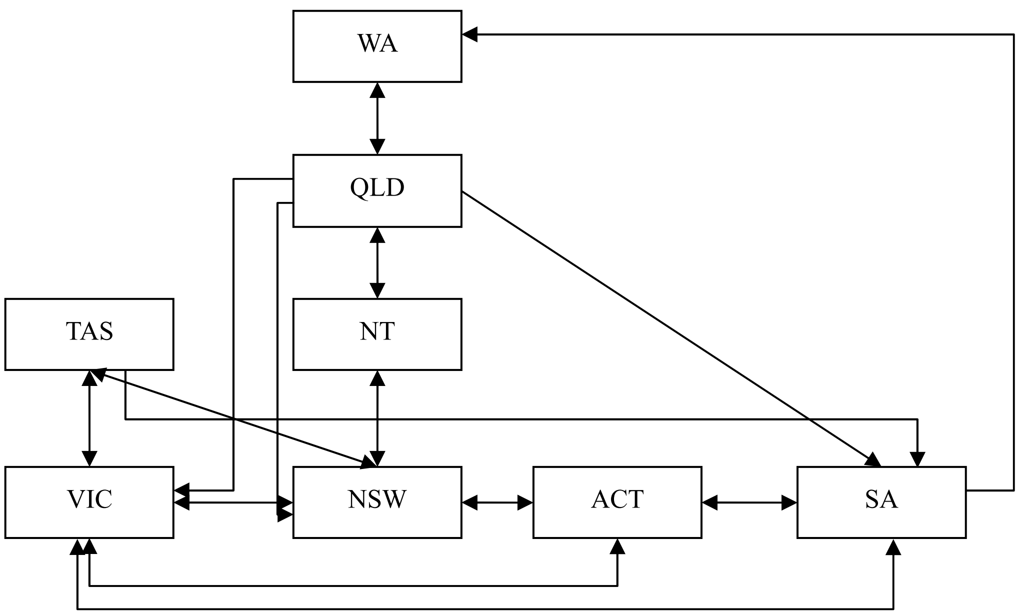

Figure 2. Causal relationships amongst eight regional markets