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# Estimating impacts of consumer prices on house prices

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**Abstract:** Real estate is widely considered as a reliable hedge of inflation rate and there have been many literatures examining the inflation-hedging characteristics of the real estate. The study described in this paper focuses on testing the significances of impacts of consumer price on house price in eight Australia's capital cities. The Autoregressive Distributed Lag model is introduced to obtain the estimates of the coefficients. The significances of the impacts are defined as the accept probability of  $t$  statistics of the coefficients. Analyses and comparisons of these significances suggested that the impacts of consumer prices on house prices depend on the inherent characteristics of cities.

**Key words:** house price indices, consumer price indices, ADL model, significances of the impacts

## INTRODUCTION

Real estate is traditionally regarded as a good hedge against the inflation. During the past decades, house prices have kept increasing in most countries. A huge amount of investment is put into the real estate market to hedge the risk of the inflation as well as to get the high profits. Previous research indicated that strong risk-adjusted returns

are delivered by both direct industrial property and industrial LPTs (Newell 2007). Moreover, many of historical studies have argued that a better performance of real estate can be found to against the inflation rate. However, only a few literatures discussed the effects of consumer on house prices. The consumer prices seem to have a conflict impact on the house prices. The increase of consumer prices will lead to higher building costs, which will drive the increase of house prices. On the other hand, householders' expenditure increases because of the high consumer prices, therefore their investment in real estate will decrease. The diminution of house-demand makes the house price reduce.

Fama and Schwert (1977) estimated that the extent of real estate was a complete hedge against inflation. Since then many research publications have focused on the inflation hedging characteristics of the real estate market and the Real Estate Investment Trust market. A multivariate estimation procedure of the co-integrating vector was introduced to investigate the inflation hedging characteristics of the commercial property in UK. It is concluded that the commercial property does not hedge the inflation rate in short-term, but a positive correspondence exists between the property and the inflation (Matysiak *et al.* 1996). Newell (1996) compared the hedging characteristics of the Australian commercial property with different types, places and market factors. His study indicated that the hedging characteristics would be different. Liu *et al.* (1997) studied the performance of real estate performance in foreign countries given security design differences, and the results support the comment that real estate securities act as a good hedge in some countries while in others bad. Nevertheless, it is concluded that the relationship between the return of the REITs and the inflation is in fact a manifestation of the effects of changes in monetary

policies (Glascock *et al.* 2002). Barber *et al.* (1997) found that the commercial property can hedge the inflation in some forms, based on the investigation of the statistical similarities among UK commercial property capital and rental values and the price level. However, it is not able to hedge general shocks to the price level.

Although numerous work have analysed the inflation-hedging characteristics of the real estate, the clear conclusion can not be found. Kolari (2002) examined the long-run impact of inflation on homeowner equity by investigating the relationship between house prices and prices of non-housing goods and services in the USA, and concluded that there is a long-run relationship between the house price and the non-housing prices. Their findings support that the house prices are a stable inflation hedge over a period of time. Luo *et al.* (2007b) commented that certain diffusion pattern exists among Australia's capital cities. Furthermore, Victoria was used as an example to detect the influence of the macroeconomic variables on house price. The findings indicated that the relationship between house prices and those variables exist but instable (Luo *et al.* 2007a).

This paper focuses on the significances of the impacts of consumer price indices on house price indices in the Australia's capital cities. The significances are analysed and compared temporally and spatially. This paper is organized as follows. The next section of this paper introduces the econometric theories used in the study. A general description of the data and the method of the impacting significances generation follow. Next, the empirical results of those are displayed and a discussion of the results is presented. The final section summarizes the findings of the study.

## **IMPACT IDENTIFICATION BASED ON ECONOMETRIC THEORIES**

In this study the house price indices (HPI) and consumer price indices (CPI) are used to estimate impacts of consumer price on house price through econometrical methods. Most of the economic data is non-stationary and is influenced by its past values. When the regression is based on the data with those two problems, the regression is biased and  $t$ -statistics for the estimated coefficients are unreliable. Therefore, a unit root test is often used to make sure whether the time series is stationary or not. Once the series is proved to be non-stationary, the regression should be estimated based on the differenced values of the data. In order to deal with the latter problem, Autoregressive Distributed Lag (ADL) model is introduced and determine how many lagged variables should be included in the ADL model. The  $p$ -values of  $t$  statistics for the coefficients of house price indices and consumer price indices are used to quantize the significances of their relationships.

### **Stationary test**

A time series is said to be stationary if its mean and variance are constant and, the variances depend on the distance of two time periods. Before estimating the model with time series, it is important to test the stationarity of these data, for the useful information or the characteristics may not be caught in a non-stationary time series. Thus, the estimating regression would be spurious if a non-stationary series is included. However, most of the economic time series are not stationary in practice,

which can be solved by differencing without changing the useful information or characteristics contained in the time series.

The stationarity can be detected if a time series contains a unit root. A unit root test is used to test the variables' stationary and the order of integration. Three methods are widely used, namely Dicky-Fuller unit root test, Augment Dicky-Fuller (ADF) unit root test and Phillips-Perron unit root test (Dicky and Fuller 1979). In this study the ADF test is mainly used to examine the stationarity of the time series and the test formula are presented as follows:

$$\Delta y_t = \delta y_{t-1} + \sum_{i=2}^p \beta_i \Delta y_{t-i+1} + e_t \quad (1)$$

$$\Delta y_t = \delta y_{t-1} + \sum_{i=2}^p \beta_i \Delta y_{t-i+1} + e_t + \beta_0 \quad (2)$$

$$\Delta y_t = \delta y_{t-1} + \sum_{i=2}^p \beta_i \Delta y_{t-i+1} + e_t + \beta_0 + \beta_1 t \quad (3)$$

where, *Eq.(1)* is used to test whether the time series are non-stationary, because of a simple random walk. Where  $\delta$  is the estimate,  $\sum_{i=2}^p \beta_i \Delta y_{t-i+1}$  is lagged values of  $\Delta y_t$  to eliminate autocorrelation from the equation, and  $e_t$  is the error term. If  $\delta$  is equal to 0, which means that the data is generated by a random walk, it is proved that the data is non-stationary. While  $\beta_0$  in *Eq.(2)* represents a drift and *Eq.(3)* is used when testing for the presence of both the drift and trend, where the trend is expressed by  $\beta_1 t$ .

### **ADL model and the optimal lags**

The ADL model is often introduced to estimate the regression, because most of the time series are non-stationary and auto-correlated. It is expressed as:

$$Y_t = a + b_i \sum_{i=1}^m Y_{t-i} + c_i \sum_{i=1}^m X_{t-i} + \varepsilon_t, \quad (4)$$

where,  $m$  is the optimal lag,  $a$ ,  $b$ , and  $c$  are the estimates, and  $\varepsilon_t$  is the residual term.

In this study, ADL model is estimated via the first differenced time series, and thus Eq.(4) is rewritten as

$$\Delta HPI_t = c + \alpha_i \sum_{i=1}^n \Delta HPI_{t-i} + \beta_i \sum_{i=1}^n \Delta CPI_{t-i} + \mu_t \quad (5)$$

where,  $\Delta HPI_t$  is the differencing HPI at period  $t$ , and  $c$ ,  $\alpha_i$ ,  $\beta_i$  are estimates, while  $\mu_t$  is the error term. The problem when we estimate the ADL model is how to choose the number of lags in the model. If too few lags are included the estimates will be biased and the statistics will be unreliable. If too many lags are included in the model, multicollinearity may exit, which can make the  $t$  statistics unreliable (Gujarati 2003).

The Akaike information Criterion (AIC) (Akaike 1974) and Schwartz Bayesian Criteria (SBC) (Schwarz 1978) are used to choose the optimal lags of the ADL model.

The formulae for the AIC and SBC are:

$$AIC = (-2)\ln(ML) + 2(p/n) \quad (6)$$

$$SBC = (-2)\ln(ML) + 2\ln n(p/n) \quad (7)$$

where,  $ML$  represents the maximised likelihood estimates of the model, while  $n$  is the number of the observations and  $p$  is the number of the estimates including the constant. In most case  $ML$  could be calculated as the sum of squared errors, known as the residual variation ( $RSS$ ).  $RSS$  represents what the model cannot explain or how



closely the model fits the data. If a model fits the data well these criteria, should take small values. So they can be used to compare models with different length of lags. Including an extra lag increases  $p$  and reduces the  $RSS$ . The value of such criteria will fall when an extra lag is included only if the reduction in the  $RSS$  has a greater impact than the increase in  $p$ .

### **$t$ statistics test and significances generation**

$t$  statistics is often used to test whether the estimates of a regression are significantly different from 0. The null hypothesis of  $t$  statistics is assuming the estimated coefficient is 0, while the opposite hypothesis is that the estimated coefficient is different from 0. The value of  $t$  statistics is calculated as follows:

$$t_{n-m} = \frac{\beta}{SE(\beta)} \quad (8)$$

where,  $t_{n-m}$  is the statistic value,  $\beta$  is the value of the estimate,  $n$  is the number of the observations,  $m$  is the number of the estimates, and  $SE(\beta)$  is the standard deviation of the estimate. The null hypothesis is rejected when the observed value exceeds the critical value. In empirical study the  $p$ -value, which stands for the probability of  $\beta = 0$ , is often used to compare with the critical level. Therefore the  $p$ -values of the coefficients of HPI and CPI are defined as the significances of the impacts CPI.

### **DATA DESCRIPTION**

As mentioned in section 1, this study focuses the impacts of consumer prices on house prices in eight capital cities. The house price indices (ABS 2007b) and consumer price indices (ABS 2007a) of eight capital cities are collected from the publications of Australian Bureau of Statistics (ABS). The catalogue numbers of those two indices are 6416.0 and 6401.0 respectively. The observation period is from the December quarter 1989 to the June quarter 2007. Both of these two indices were established quarterly and were calculated on the reference base 1989-90 =100. Table 1 shows the means and the standard deviations of house price indices and consumer price indices for each capital city. Over the observation period, Brisbane has the highest average house price indices (about 204.05), while Sydney has the lowest one (about 146.43). The standard deviation of HPI in Hobart is the biggest among the eight cities, and the smallest one is in Perth. The statistic values for the CPI show more modified from city to city, comparing with the results of HPI. The highest average consumer price index is in Sydney at 127.99, and the lowest one 123.88 in Hobart. The standard deviations for each city's CPI did not appear as different from each other as the average consumer price index. Sydney has the highest one, which is 17.05, while Brisbane has the lowest one 14.48.

**Table 1: Statistics for HPI and CPI**

		SYD	MEL	ADE	BRI	PER	DAR	HOB	CAN
HPI	Mean	<b>146.43</b>	<b>175.79</b>	<b>163.23</b>	<b>204.05</b>	<b>145.96</b>	<b>152.03</b>	<b>150.42</b>	<b>160.47</b>
	Std. Dev.	<b>53.74</b>	<b>66.97</b>	<b>54.78</b>	<b>73.80</b>	<b>41.09</b>	<b>63.08</b>	<b>74.93</b>	<b>59.08</b>
CPI	Mean	<b>127.99</b>	<b>126.47</b>	<b>126.03</b>	<b>124.78</b>	<b>125.94</b>	<b>125.42</b>	<b>123.88</b>	<b>125.97</b>
	Std. Dev.	<b>17.05</b>	<b>17.03</b>	<b>16.22</b>	<b>14.48</b>	<b>16.16</b>	<b>15.83</b>	<b>16.15</b>	<b>16.94</b>

Additionally, it is necessary to generate the significances of the impacts. A group of significances of  $\beta$  can be collected, by changing the data time period of the

regressing model. Take Sydney as an example. First, *Eq.(2)* is estimated based on the data region from the December Quarter 1989 to the March Quarter 2001. The first significance of  $\beta$  for Sydney can be gained. Next re-estimate the equation under a longer period, namely one quarter longer, from the December Quarter 1989 to the June Quarter 2001, and second significances of  $\beta$  for Sydney could be obtained from the new estimation. Repeat those steps above until the June Quarter 2007, and a series of significances of the impacts of CPI on Sydney's HPI is generated.

## **EMPIRICAL RESULTS**

### **Stationarity test**

The methodology employed in this study involves several procedures. The first procedure is to check whether the data series is stationary. A stationary time series process has a stable probability distribution over a period of time. Stationary process plays an important role in time series analysis. It is difficult to generalise valuable information from its behaviour because the non-stationary time series behaviour is unpredictable over time. Unit root test will be used to test the stationarity and the order of integration to avoid the problems described above.

The ADF unit root test was introduced by (Dickey and Fuller 1979). Its null hypothesis of non-stationary is performed at the 1%, 5% and 10% critical levels respectively. As mentioned above, in this study the test with an intercept and trend is carried out. Table 2 summarises the results of the ADF unit root test for HPI and CPI. According to the

ADF test, none of house price indices are stationary. But after the differencing, most of them become integrated, except Brisbane and Darwin. Table 2 also indicates that consumer price indices of the eight capital cities are integrated at the first difference.

**Table 2: Augmented Dicky-Fuller test for HPI and CPI**

		<b>SYD</b>	<b>MEL</b>	<b>ADE</b>	<b>BRI</b>	<b>PER</b>	<b>DAR</b>	<b>HOB</b>	<b>CAN</b>
<b>HPI</b>	<i>t</i> -test for level	-1.9786	-1.6159	0.2224	-0.0477	3.4766	-2.8957	0.4913	-0.6193
	<i>p</i> -value	0.6023	0.7768	0.9978	0.9948	1.0000	0.1706	0.9991	0.9746
	<i>t</i> -test for first difference	-4.1162	-7.3534	-5.2589	-2.5477	-3.9334	-2.2600	-3.4381	-4.3765
	<i>p</i> -value	0.0095	0.0000	0.0003	0.3051	0.0158	0.4493	0.0548	0.0044
<b>CPI</b>	<i>t</i> -test for level	-1.0938	-0.8789	0.6654	-0.4977	0.0946	-0.4519	-0.7729	-0.6743
	<i>p</i> -value	0.9225	0.9522	0.9906	0.9815	0.9967	0.9836	0.4423	0.9708
	<i>t</i> -test for first difference	-6.5926	-7.7107	-7.5857	-7.7110	-7.3539	-6.7283	-7.7478	-7.1026
	<i>p</i> -value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
test critical values: 1% level		-4.0966, 5% level		-3.4762, 10% level		-3.1656			

### **ADL model estimation and the optimal lags selection**

Since both HPI and CPI are stationary at the first difference, the ADL model can be estimated with those differenced variables. Several lags are introduced in the model, in order to find the optimal lag. In this study lags 1, 2, 3, 4, and 5 are involved and the lag, with which the model has the smallest values of the AIC and the SBC, is determined to be the optimal lag.

Table 3 Shows that the most of the cities fit the model well with lag 1. According to the values of AIC, Adelaide, Canberra, Darwin, and Sydney are good with lag 1, while Brisbane and Perth fit the model well when lag 3 and lag 2 were included respectively in the model. Moreover Melbourne and Hobart could not fit the model perfectly unless even a bigger lag could be included.

**Table 3: Values of AIC & SBC**

	AIC				SBC			
	Lag 1	Lag 2	Lag 3	Lag 4	Lag 1	Lag 2	Lag 3	Lag 4
SYD	5.2463*	5.2648	5.2892	5.5756	5.3434*	5.4280	5.5195	6.8774
MEL	5.6600	5.5619	5.5313	5.4646*	5.7571	5.7251*	5.7617	5.7632
ADE	5.3031*	5.3298	5.3613	5.4122	5.4002*	5.4930	5.5916	5.7107
BRI	5.3151	5.3688	5.3087*	5.3742	5.4122*	5.5320	5.5390	5.6728
PER	5.8599	5.8534*	5.9060	5.9738	5.9570*	6.0166	6.1363	6.2724
DAR	8.3699*	8.4315	8.4323	8.3522	8.4670*	8.5947	8.6627	8.6508
HOB	5.2825	4.9912	4.9821	4.9613*	5.3804	5.1557*	5.2144	5.2623
CAN	5.2596*	5.2856	5.2602	5.3263	5.3568*	5.4488	5.4905	5.6249

\* indicates the smallest values of AIC and SBC

On the other hand, SBC shows that data from all cities will fit the model better when lag 1 was introduced into the model, except Melbourne and Hobart. Therefore, in this study, all the models were estimated with the lag 1 and the *Eq.(5)* is simplified as follows

$$\Delta HPI_t = c + \alpha \Delta HPI_{t-1} + \beta \Delta CPI_{t-1} + \mu_t \quad (9)$$

Table 4 shows the results of the estimates of *Eq.(9)* and *t*-tests. According to Table 4, the probability of accepting  $\alpha$  not significantly different from 0 is very low, except Darwin, which is about 82.18%. It means that HPI of the seven cities are influenced by past values, while there is not such an obvious relationship exists in Darwin. Unlike the strong relationships between HPI and its historical values, the significances of the relationship between HPI and CPI are not similar to each other. In some cities the impact of the CPI on the HPI is distinct, like Sydney and Melbourne, with the first and second lowest significances at 0.0850 and 0.1688 respectively. However, CPI in other cities does not affect their HPI as much, such as Hobart with *p*-value at 0.9974.

**Table 4: The estimates and the  $p$ -values**

	$c$	$p$ -value	$\alpha$	$p$ -value	$\beta$	$p$ -value
SYD	1.6044	0.0087	0.6143	0.0000	-0.8718	0.0850
MEL	1.4023	0.0632	0.3061	0.0140	0.8217	0.1688
ADE	0.9661	0.1206	0.5525	0.0000	0.3603	0.4397
BRI	0.6286	0.3260	0.8399	0.0000	0.1824	0.7218
PER	0.1978	0.7951	0.7913	0.0000	0.7391	0.2669
DAR	0.1649	0.9544	0.0746	0.8218	2.8445	0.2350
HOB	1.8972	0.0017	0.2882	0.0240	-0.3540	0.4945
CAN	1.1121	0.0575	0.6072	0.0000	0.0015	0.9974

$p$ -value is the property to accept the null hypothesis of the t-statistic, whose  $H_0$  is that the estimate equal 0.

### Seasonal significances generation and further discussion

In order to investigate the significances of the impacts of CPI on HPI, the ADL model are estimated reduplicative via changing the data region and the  $p$ -values of the estimates are collected. Moreover, in order to avoid the weakness of insufficient data, the March quarter 1989 to March quarter 2001, which contains 48 observation for both of the HPI and the CPI, is chosen as the beginning data region. The significances from the March Quarter 2001 to the June Quarter 2007 are calculated and Table 5 shows the results of the seasonal significances of the effects of CPI and the statistics of these significances. Over the research period, the significances of the eight cities fluctuate but not very much, and the relationship between HPI and CPI in Perth, which has the biggest standard deviation, is the most fluctuant. According to the  $p$ -values in Sydney and Melbourne, the impacts seem more stable during the observation period. Meanwhile, Sydney and Melbourne have the lowest means of the

significances, which mean that the influences of CPI in Sydney and Melbourne are stronger than other six cities. On the other hand, CPI does not affect HPI as much in Darwin, Hobart and Canberra. The average  $p$ -values of the three cities are 0.6430, 0.7134 and 0.7432 respectively, which indicate a weak impact of CPI on HPI.

**Table 5: The statistics of significances of the impacts**

	SYD	MEL	ADE	BRI	PER	DAR	HOB	CAN
Std. Dev.	0.0369	0.1006	0.1613	0.1150	0.2272	0.1530	0.1352	0.1459
Maximum	0.2050	0.4575	0.5959	0.7218	0.8854	0.9221	0.9396	0.9974
Minimum	0.0490	0.0763	0.1125	0.1433	0.1577	0.2350	0.4945	0.4930
Median	0.1195	0.1399	0.1891	0.3340	0.3540	0.6417	0.7376	0.7162
Mean	0.1213	0.1914	0.2871	0.3368	0.4369	0.6430	0.7134	0.7432

An interesting phenomenon is unveiled when comparing the average  $p$ -values of the coefficients between HPI and CPI with the population in the eight cities. It is that cities, which have similar amount of populations, are likely to have the similar relationships between house price indices and consumer price indices. Nevertheless, the significances of the impacts are different from cities when the cities' population is distinguished from each other. Sydney and Melbourne have the biggest populations, which are over 4.3 and 3.6million respectively. The influences of CPI to HPI in these two cities are the strongest accordingly. On the other hand Darwin, Hobart and Canberra are cities with the smallest populations, and the average significances of the impacts are at the bottom of the eight cities. Moreover, the populations of the other three cities, Adelaide, Brisbane and Perth, are in the middle of the eight cities and the impacts of CPI on HPI are weaker than Sydney and Melbourne's but higher than Darwin, Hobart and Canberra's. In that case, human activities seem to perform as a linkage between CPI and HPI. It is thought that when the CPI goes up, the cost of

building increases. Therefore, the house price will move up only if there are plenty of demands. The big population is a guarantee for huge and stable house-demanders. In this case, it is suggested that the relationship between HPI and CPI should not only be account for themselves, but it also should concern the characteristic of the city.

## **CONCLUSIONS**

This paper examined the impacts of consumer price on house price in Australia's capital cities. The ADL model is introduced to estimate the regression, and *t* statistic test is used to investigate the significances of the impacts. The empirical results are discussed and compared with the capital cities' populations. The following conclusions can be stated:

(1) The eight capital cities have dynamic significances of the impacts of CPI on HPI during the observation period. The degree of impact is unequal. Perth, which has the highest standard deviation of 0.2272, has the most fluctuated significance. Sydney has the most stable significances with the lowest standard deviation.

(2) It appears that the significances of impacts of CPI on HPI in Australian capital cities might relate to the characteristics of cities, such as population. Cities, different population from others, experience distinct degree of impacts while cities, having close population, experience the similar significances of the impacts, such as Sydney and Melbourne, Adelaide and Brisbane and Perth, or Darwin, Hobart and Canberra.



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