# Commodity house prices

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## Abstract

This paper studies how commodity price movements have affected the local house prices in commodity-dependent economies, Australia and New Zealand. We build a geographically hierarchical empirical model and find the commodity prices influence local house prices directly and also indirectly through macroeconomic variables. The impacts of commodity price changes are analogous to "income shocks" rather than "cost shocks". Regional heterogeneity is also observed in terms of differential dynamic responses of local house prices to energy versus non-energy commodity price movements. The results are robust to alternative approaches. Directions for future research are also discussed.

JEL classification: F40, G10, R30

Keywords: regional economies, energy versus non-energy commodity price, propagation mechanism, geographically hierarchical model, dynamic analysis

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# Commodity House Prices

## 1. Introduction

This paper attempts to contribute to several strands of the literature. First, we intend to establish that commodity prices, which are arguably determined in the international market, can influence even the price of non-tradable goods like housing in an open economy. Clearly, the approach of this research, which is to take the commodity price fluctuations as an "*exogenous shock*", is inspired by Chen and Rogoff (2003). In their study of the relationship between the commodity prices and exchange rates, Chen and Rogoff (2003, p.133-134) explain that for some commodity-exporting countries, the shock identification which are in general difficult can be solved easily. They write,

"*The elusive connection between economic fundamentals and exchange rates has been one of the most controversial issues in international finance,… it has also been recognized that if one could find a real shock that were sufficiently volatile, one could potentially go a long way towards resolving these empirical challenges… For most OECD economies, however, it is difficult to know what the shock might be, much less measure it…. We find that these bilateral exchange rates do exhibit significant co-movement with world commodity prices… For Australia, Canada, and New Zealand, because primary commodities constitute a significant component of their exports, world commodity price movements… potentially explain a major component of their terms-of-trade fluctuations*."

In this study, we therefore follow Chen and Rogoff (2003) to focus on commodity-exporting countries, Australia and New Zealand. To further simplify the identification problem, this study focuses on the disaggregate house prices in these countries. The rationale is simple. Houses are clearly non-traded (and durable) consumption goods and unlikely to serve as an intermediate input for the production of other goods. The local house prices are also unlikely to have an impact neither on the aggregate economy nor the world market of commodities. All these features suggest that the causality from the commodity prices to local house prices would be one-directional, which in turn simplifies the analysis and the interpretation of results.

As observed by Chen and Rogoff (2003), international trade, and especially commodity trade is a significant part of the export of the two countries.[1] In the appendix, we provide more details and even confirm the Granger causality between international trade and GDP in both countries. Due to the importance of international trade in general, and commodity trade in particular, it seems reasonable to conjecture that fluctuations in commodity prices could significantly affect the economic variables, including the local house prices, of Australia and New Zealand. This leads to another point we attempt to make. In the previous literature on the relationship between commodity prices and the macro-economy, attention is often focused on oil price.[2] In that literature, oil price fluctuations are often interpreted as "cost shocks" and related to recessions. For commodity-exporting countries, however, commodity price changes can become "*income shocks*" and hence the results could be different. In this paper, we follow Chen and Rogoff (2003) to separate the energy commodity price index from the non-energy commodity price index. Our empirical analysis confirms that they have different effects on the macroeconomic variables as well as on the house prices. It may suggest more caution is needed in modeling "terms of trade shocks" in the theoretical literature. In particular, there may be a need to carefully separate energy-related commodity prices from the non-energy-related counterpart.[3] As the Australia and New Zealand currencies can be viewed as the "commodity

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[1] A specific historical example is the banking crisis between 1890 and 1895. Due to the fall in global commodity prices, it led to a drop in the land prices, putting pressures on the Bank of New Zealand, the main mortgage lender. The government finally rescued the bank in 1895, but it encountered a cost of 1.6% of GDP. See Bordo et al (2010) for more details.
For more details of the composition of commodity export in Australia and New Zealand, see the Appendix.

[2] Clearly, it is beyond the scope of this paper to survey that literature. Among others, see Hamilton (2008) for a review.

[3] There is a very large literature on this issue. For instance, Jones (1979) studies the impact of "terms of trade shock" under different assumptions. Marion (1984) discusses the relationship between oil price increase and non-traded

currency" (Chen and Rogoff, 2003), this paper shows that local house prices in at least some cities of Australia and New Zealand can be viewed as "*commodity house prices*".

Our data set consists of a panel of house prices from 8 cities in Australia and 17 cities in New Zealand. It helps to mitigate the potential aggregation bias, which could arise in national level studies.[4] Since the sampling period and the data frequency are different, we will examine the two countries separately. We also collect national level and regional level data, as much as we can. They include variables that are typically believed to be influential to the house prices (such as the GDP, unemployment, interest rate, etc.) as well as variables that are important for open economies (such as the real exchange rate, capital flow to GDP ratio, debt to GDP ratio, etc.), subject to data availability at the corresponding house price frequency. Stock price (in real terms) is also included as it may capture the general market liquidity and sentiment. Table 1a provides a summary.[5]

**[Table 1a about here]**

In addition, this paper builds and tests a simple empirical model of Australia and New Zealand economy on how shocks could transmit from the national to the regional level. It highlights a *geographically hierarchical propagation mechanism* that allows for regional heterogeneity in response to the same "exogenous shock". To our knowledge, theoretical work along this approach is relatively rare. Hence, the empirical results here might provide a benchmark for future theoretical work.

This paper is also related to an emerging literature which recognizes the influence of "international market" on "local house prices". For instance, Bardhan et al (2004) show in a cross-sectional sample that, other things being equal, a higher city rent is associated with a more

goods. For a discussion of the literature, see Caves et al (1999), Lubik and Teo (2005), Lim and McNelis (2008), among others.

[4] For a discussion of cross-sectional aggregation bias, see Hanushek et al (1996), among others.

[5] We follow Chen and Rogoff (2003) to define the real exchange rate as the amount of goods in Australia/New Zealand that can be exchange for 1 unit of U.S. goods. Clearly, one merit of it is the facilitation of comparison.

open economy in terms of international trade and capital flow. Bardhan et al (2008) show that the excess return of a real estate firm in the stock market is negatively correlated to the economic openness, after controlling national as well as firm factors. This paper complements these researches by focusing on the local house prices of two commodity-exporting economies, and explores the nonlinear dynamic effects of commodity prices at the city-level.

The organization of this paper is simple. The next section will present our econometric framework. Then we will provide more details about our data set, followed by the empirical results. The last section concludes.

## 2. Estimation strategies and the empirical models

Since our objective is to investigate whether (and how) the commodity prices, which are determined in the world market, would impact the local (city-level) house prices in Australia and New Zealand, our econometric framework needs to be flexible enough to include different possibilities. The commodity price may affect the macroeconomic variables, which in turn affects the local house prices. For instance, higher commodity prices may impact the unemployment rate in general and hence the public finance of the national government. This may in turn imply a change in the probability of tax increase and it could affect the house price even at the local level. Higher commodity prices could also means an improvement of the public finance of the regional government if the region's economy heavily depends on the export of the corresponding commodities. It may imply more generous social welfare which would encourage immigration and be interpreted as positive news to the local housing market. On the other hand, higher commodity prices could also lead to higher inflation rate in general, which in turn encourages the central bank to adopt a tighter monetary policy, which tends to depress the house prices. Since the economic structure and "indebtness" of different regions tend to be unequal, the local house prices may be affected unevenly. Figure 1 provides a graphical illustration for these possibilities. Since we do not know the empirical relevance of different channel(s) *a priori*, we proceed with a three-step procedure which naturally captures these possibilities with different parameter estimates.

**[Figure 1 about here]**

*Stage one: extracting the effect of commodity prices on national economic variables*

For the purpose of the empirical analysis, we conduct our empirical analysis in three stages. As we want to separate the influence of national and local factors on the housing market apart from commodity prices, we first study how the aggregate variables of Australia and New Zealand can be influenced by the international commodity prices. Specially, we run the following Vector Auto-Regressive (VAR) equation for each country separately in the first stage:[6]

$$V_t^n = A_0 + A_1 P_t^c + A_2 P_{t-1}^c + A_3 V_{t-1}^n + \widetilde{V_t^n} \qquad (1)$$

where $V_t^n$ is the vector of national variables at time $t$ that are believed to be important and would affect the house prices. They include variables that represent the "economic fundamentals" (i.e. the growth rate of real GDP, the growth rate of national unemployment, the number of net national migration per 1000 people of existing nationwide population), variables that would affect investment as well as those represent the financial market (i.e. the change of real interest rates, the change of log real exchange rates, the change of the real stock price), and the change of bank loans (in real terms) which is proxy for the credit market condition; $P_t^c$ is the vector of commodity prices at time $t$ including energy and non-energy commodity prices;

[6] Recall that the frequency of Australia and New Zealand data are different and hence we need to estimate the models of the two countries separately.

the residual term will become the "filtered national variable vector" $\widetilde{V_t^n}$ [7]. For most variables, we use the change rather than the level because of the stationarity consideration. In the case of Australia, net migration data is not accessible to us. On the other hand, we have access to the debt-to-GDP ratio as well as the net capital flow-to-GDP ratio. These variables can contribute to control for the international capital flow, as some authors argue that capital flow can also influence the house price.

There are two distinctive features of the above equation (1). First, the change of the real exchange rate is included as a national economic variable. Effectively, we treat the change of the log real exchange rate as an endogenous variable following Chen and Rogoff (2003). This formulation will allow the data to inform us whether (and if so, how) the commodity prices would affect the national economic variables. Second, we add the lagged national variables into the equation, to capture the persistence of the national variables. Without that, the estimates can be biased.

*Stage two: extracting the effect of commodity prices on local economic variables*

At stage two we want to examine if the commodity prices affect the local variables directly, or only through the national variables. We allow the local variables to depend on the present as well as past values of filtered national variables and commodity prices. Specifically, we run the following VAR for city *j* in each country:

$$V_{j,t}^r = B_{0,j} + B_1 P_t^c + B_2 P_{t-1}^c + B_3 \widetilde{V_t^n} + B_4 \widetilde{V_{t-1}^n} + B_5 V_{j,t-1}^r + \widetilde{V_{j,t}^r}\ ,\ j = 1, 2, \ldots^{8} \quad (2)$$

where $B_{0,j}$ captures the fixed effect of the regional rent, $V_{j,t}^r$ is the vector of regional/local economic variables for city *j*. Among the data series accessible to us at the same frequency and

[7] It means that it is a vector where the effect from commodity prices on the national variables has been filtered out. However, the effect from other sources, such as government policies, may still remain. More on this point later.
[8] In the case of Australia, *j*=1,2,…,8 and for the case of New Zealand, *j*=1,2,…,17.

during the same sampling period, there is only one relevant regional/local level variable, i.e. the rent for city *j*; the residual term $U_{j,t}^{r}$ will become the "filtered regional variable vector" $\widetilde{V_{j,t}^{r}}$ for city *j*.[9]

<u>*Stage three: extracting the effect of commodity prices on house price movements*</u>

At this stage we want to examine if the commodity prices affect the local house prices directly, or only through the national or regional variables. We allow the local house prices to depend on its past values, the present as well as past values of filtered national variables, the present as well as past value of filtered city variables, and the present as well as past values of commodity prices. Specially, we run the following regression for each country:

$$HP_{j,t} = C_{0,j} + C_1 HP_{j,t-1} + \sum_{k\neq j} \widehat{C_k}\, HP_{k,t-1} + C_2\widetilde{V_t^{n}} + C_3\widetilde{V_{j,t}^{r}} + C_4 P_t^{c} + C_5 P_{t-1}^{c} + \sum_i C_{6i} S_i + U_{jt},\ j = 1, 2, \ldots \quad (3)$$

where $HP_{j,t}$ is the *j*-th city house price at period t; $HP_{k,t-1}$ is the *k*-th city house price (cities other than *j, and hence* $k \neq j$) at period t-1; $C_{0,j}$ represents the city fixed effect; S present the seasonal dummy variables to deal with the seasonal effect in house prices.

It should be noticed that, in spite of its simplicity, the impact of commodity prices on the national level can be captured by $A_1, A_2$, the total effect of national and regional effects by $B_1, B_2$ at the regional level, and the total effect by $C_4, C_5$ at the regional level in this econometric framework.[10] Hence, this framework would help us to identify and dictate, if any, the effect of commodity price on the local house prices.

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[9] Some seminar participants express the concern that equation (2) may not be able to capture cross-city spill over effect that may exist in the data. In Appendix C, we calculate all pair-wise correlation among city rents, once with spot market commodity price data and again with futures market counterpart. We find that most of the correlations are not statistically significant, and even when they are, their numerical values are around 0.3 or even smaller.

[10] See the appendix for a formal proof. We are grateful to an anonymous referee for this point.

## 3. Data Description

This research utilised several data sets. The Australian Bureau of Statistics (ABS) provides the quarterly median house price data on eight Australian cities as well as the data of other macroeconomic variables. To match the data of New Zealand, we focus on the period between 1988 and 2011.[11] The corresponding city-level quarterly median house rent data is purchased from Real Estate Institute of Australia (REIA). Previous studies on Australia house price employ data from the same sources and a comparison of results would be convenient.[12]

For New Zealand, there is a rich monthly data set of freehold (fee simple) open market transactions of detached or semi-detached houses for seventeen selected cities between 1994 and 2009. House price movements for the seventeen selected cities were estimated directly from the transaction data by using Case-Shiller (1987) weighted repeated sale (WRS) method at monthly intervals, which are unique and not publicly available. The transaction data was supplied by Quotable Value (QV), the official database for all property transactions in New Zealand. QV also produces a house price index, but it is on a quarterly basis. Comparing with the quarterly reported index, our estimated monthly price index will unsmooth the price movement and increase the number of observations in a time series analysis. Estimating house price movement on a monthly basis also helps us to match the frequency of the New Zealand commodity price indices. Forcing the monthly commodity prices into quarterly counterparts may introduce time aggregation bias. We choose these seventeen cities because they account well for New Zealand housing stock, as shown in the Appendix A. The geographic locations of these cities are presented in Figure 2.

**< Figures 2a, 2b about here>**

[11] The ABS website (http://www.abs.gov.au) provides very detailed explanation on the construction of their house price data and other data series.
[12] For instance, see Otto (2007) and the reference therein.

Since we have access to *transaction-level data* in New Zealand, extra efforts have been invested in the construction of the house price series.[13] The local house price indices estimated as such are then deflated by the consumer price index (CPI) to derive the real house price indices.

We obtain monthly rental data for detached or semi-detached houses from the Tenancy Services Division of Department of Building and Housing (DBH) in New Zealand. Under the Residential Tenancies Act, all tenancy bonds must be lodged with the DBH within 23 working days from the tenancy start. The bonds normally amount to two or three weeks of rents payable under the new tenancy. The DBH rental data is transaction based and very comprehensive in terms of recording the market rent settings for all new residential tenancies in New Zealand. We first calculate the monthly median rent, and then construct rental indices for each local housing market. The estimated rental indices are then deflated by CPI and should represent the local market supply and demand factors for housing.

National economic variables such as real GDP, CPI, population, unemployment rate, and net migration, are available from Statistics New Zealand.[14] For the quarterly reported aggregate data such as real GDP, CPI and unemployment data, we have interpolated them on a monthly basis. Monthly net migration is calculated on per 1000 people of the existing population. Monthly interest rate, exchange rate and bank loan data are obtained from the Reserve Bank of New Zealand. Stock market price movements are obtained from Datastream. We use the 10-year government bond rate to represent the interest rate for housing, simply because of the long-term nature of owning. For the exchange rate, it is expressed as the New Zealand dollar against

[13] For instance, as the repeat sales method is vulnerable to outliers (Meese and Wallace, 1997), we use prior knowledge to eliminate all multiple sales where the second sale price is less than 0.7 or more than 2.5 times the first sale price. Moreover, since the QV data includes building consent information for all the studied cities except Auckland City, we further eliminate the quality changed repeat sales, thus minimizing the constant quality problem faced by the standard repeat sales method. In New Zealand, building consent data is collected for revaluation purposes only where QV is the valuation service provider for the Council. For Auckland City, QV is not the valuation service provider for the council and for that reason there is no building consent data for Auckland City.

[14] Notice that for Australia, we are unable to identify accessible dis-aggregate migration data.

the US dollar. The interest rate, exchange rate, bank loan and stock prices data are then deflated by CPI to derive their real terms. In the regression, we follow the literature and use log real exchange rate.[15]

Finally, we obtain the commodity prices through various sources. As shown in the appendix, the composition of commodities being exported from Australia and New Zealand are very different. To facilitate a comparison of results, we use the relative weights of Chen and Rogoff (2003) for Australia, whose details are reproduced in the Appendix. For New Zealand, we use the ANZ export commodity price index, which is expressed in US dollars for spot market non-energy commodity prices. The ANZ index starts in January 1986 and is reported on a monthly basis thereafter. The index weights are based on the contributions of each commodity to merchandise exports in New Zealand and adjusted annually. For spot market energy commodity prices, we obtain them from Datastream. For robustness check, we have also built our own futures market energy and non-energy commodity prices following Chen and Rogoff (2003). Futures market commodity prices are obtained from Datastream and Global Financial Database. Due to the data availability our own futures market non-energy commodity price index starts from January 1998. All commodity prices are then converted into their real terms by the CPI adjustment.

# 4. <u>Empirical Results</u>

## 4.1. <u>Testing for unit roots</u>

It is well known that regressions with non-stationary variables can be spurious.[16] Therefore, we first carry out the unit root tests to all economic variables in order to determine their orders

[15] The rationale is well known. If we define $X$ to be the real exchange rate of the New Zealand goods against the US goods, and run two regressions, $Y = a + bX + (control) + U$, and $Y = a' + b'(1/X) + (control) + U'$. We will find that in general, $b \neq 1/b'$. On the other hand, if we replace $X$ by $\ln X$, it is easy to show that $b = -b'$ and that justifies our log formulation. The same logic applies to Australia.

of integration and hence properly de-trend the variables when necessary. Table 1b provides the full names of the cities and the corresponding short-hand that we are going to use throughout this paper. Appendix A shows that the 17 cities in our sample represent the majority of both the population and the number of housing units in New Zealand. It also shows the detailed results from standard augmented Dickey-Fuller (ADF) test for the time series employed by this study. It suffices to say that most series are difference-stationary.[17] Thus, we will use the first-differenced version of those series in our regression.

**<Table 1b about here>**

4.2. Commodity prices and national economic variables

Our first stage regression estimates the relationship between commodity prices and national variables (properly de-trended when needed). In general, the national economic variables of Australia are not as persistent as New Zealand. The details are reserved in the appendix and we only *highlight the effect of commodity prices on national economic variables* in Table 2.

**<Tables 2a, 2b about here>**

Table 2a presents the results of Australia and Table 2b presents the counterpart of New Zealand. To have a compact presentation, we will put "S" *("F")* in the cell if spot (*futures*) market commodity price is found to be statistically significant in influencing the corresponding variable. Thus, it is possible to have both "S" and "F" in the same cell, or have neither of them as well. We use + or – to denote whether the relationship is positive or negative.[18]

Several observations are in order. First, there are some degrees of consistency in the case of Australia, both energy and non-energy commodity prices would have a positive effect on the

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[16] Among others, see Hamilton (1994) for a detailed analysis.

[17] It means that the original series are non-stationary, but become stationary after first-differencing. See the appendix A for more discussion on this.

[18] It is well known that under certain mathematical conditions, point estimates from a linear VAR would coincide with the point estimates that are obtained from each regression running separately. Among others, see Watson (1994) for more details.

GDP growth rate and the real interest rate, and a negative effect on the debt-to-GDP ratio. The real exchange rate is somehow troublesome. When we use spot market commodity prices, we find that lag energy commodity price is positively correlated to the real exchange rate change while current period non-energy commodity price is negatively correlated to the real exchange rate change. In the robustness section, we will examine alternative specifications and study the overall effect of commodity prices on the local house prices.

Second, using spot market commodity prices may give different results than using futures market commodity prices. And commodity prices seem to affect different national economic variables in different countries. For Australia, spot market commodity prices would affect the change of unemployment, change of real interest rate, change of real exchange rate and change of real stock price. However, when futures market commodity prices are used instead, the effect on the change of unemployment rate and change of real stock price will disappear. Instead, futures market commodity prices are found to influence real GDP growth rate, change of debt-to-GDP ratio, and net capital flow-to-GDP ratio, in addition to the effect on change of real interest rate and change of real exchange rate.

For New Zealand, spot market commodity prices are found to influence real GDP growth rate, change of unemployment rate and change of real interest rate. When futures market commodity prices are used instead, then only change of unemployment rate and change of real exchange rate are affected.

There are many potential reasons for the difference in results. First, futures market commodity prices are not perfect predictors of the subsequent period spot market counterparts. In addition, the contents of commodity exports vary across countries. Hence, "energy commodity price index" in different countries has different statistical properties and may therefore interact with the macroeconomic variables differently. Perhaps more importantly, the participation in spot versus futures market is different. Limited by space, we reserve the details in the appendix.

In sum, the results from Tables 2a and 2b have supported our hypothesis that commodity prices have an effect on national economic variables. We now proceed to the next stage of the regression, which examines whether commodity prices would impact the regional economic variables, controlling for the national variables.

### 4.3. Commodity prices and local economic variables

Our second stage regression estimates the impact of commodity prices on local economic variables such as the local housing market rent, controlling for the effect of the national economic variables. To achieve this, we used the "commodity price-filtered" national variable from the first stage regression in our second stage regression. Again, the details are reserved in the appendix and we only highlight the impact of commodity prices on local rent in Table 3. And to facilitate the comparison, our notations in Table 3 are consistent with that in Table 2.

**<Tables 3a, 3b about here>**

Table 3a presents the results in Australia. It is clear that when spot market commodity prices are used, none of the city rent series is affected by the commodity prices. When futures market commodity prices are used instead, the effect on rent in Adelaide, Brisbane, Darwin and Perth are all *in*-significant. Decisive results come from Canberra and Sydney, where lagged non-energy commodity price is found to exert a positive and statistically significant effect on the rent. While lagged energy commodity prices impact the rent in Hobart negatively, the lagged non-energy commodity prices impact the rent in Hobart positively. The case of Melbourne is a bit confusing. While current period non-energy commodity price has a negative effect on the rent in Melbourne, the lagged non-energy commodity price carries a positive effect. This could be due to the fact that there may be relatively more financial market participation in Melbourne and the landlords and renters may not hedge on the same side. Unfortunately, we do not have access to personal financial portfolio to verify this conjecture and can only leave these for the future research to pursue.

The case of New Zealand is very clear. For most cities, their rents are affected by neither spot market nor futures market commodity prices. For the spot market, only the non-energy commodity price can affect (positively) the rent in North Shore and Manukau. For futures market, the energy commodity price affects (negatively) the rent in Hamilton and Palmerston North.

In sum, our second stage regression does not perform as good as the first stage. One possibility is that there are strong correlations among the rents in different cities and our formulation does not capture that. In the appendix, however, we show that the rents among different cities in Australia, as well as among those in New Zealand are not significantly correlated in general.[19] An alternative explanation is that the rental market adjusts slowly and hence it would react to further past (rather than immediately past) of the aggregate economy. However, our sample is relatively short and does not allow for including more lags in the regression with all these filtered variables. It is also possible that the rent is determined by some other variables such as the bargaining power between the landlords and tenants.[20] Unfortunately, among the dataset accessible to us, we do not have the appropriate variable to capture that.

[19] And for those pairwise correlations that are statistically correlated, the numerical values typically do not exceed 0.3, which suggests that the correlations are really not that strong. And since they are not very strongly correlated, even if we replace the filtered macroeconomic variables by some "common factors" or principal components, it may not improve the results significantly.

[20] For a related study, see Harding et al (2003).

## 4.4. Commodity prices and local house prices

Our third stage regression attempts to quantify the effect of commodity prices on local house prices. For the interest of the space, we would first present the results from pooled regression. And we will then highlight some findings when the city-level house prices are regressed individually. Tables 4a and 4b present the results when local house prices are pooled and regressed against commodity prices, the filtered national variable from the first stage regression, and filtered and pooled local economic variables (rents) from the second stage regression. Since seasonality is an important feature for the house prices in both countries, we have added the quarterly seasonal dummies for the regression of Australia and monthly seasonal dummy variables for the case of New Zealand.

**<Tables 4a, 4b about here>**

In Table 4a, the dependent variable is the city-level house price in Australia. The first column presents the results when spot market commodity prices are employed and the second column presents the results when futures market commodity prices are used instead. The results in the two columns are consistent with each other. The signs of the coefficients are typically the same, and even the numerical values are close in many cases. First, it is clear that the lag real house price change has a positive effect on the current period house price change, which is often termed as “momentum effect” in the literature. The magnitude is about 0.3 and hence it is not that large. The signs of the estimated coefficients are mostly expected. Unemployment has a negative effect on house price because a higher unemployment would mean fewer buyers and more sellers in the market, which would depress the house price. External debt and net capital flows have positive effects on the house price as buyers are borrowing from abroad, probably through financial intermediations and compete for houses, and the house price rises as a result. City level rent has a positive effect on the house price because rent is an indicator of the cash flow that house-investors would receive and it seems reasonable to expect that the two are positively correlated. A seasonal dummy is statistically significant as well.

In the appendix, we illustrate that the coefficients for the commodity prices would be the total effect of the commodity prices on the local house prices, when (filtered) national variables as well as (filtered) city level rent are used as control. Table 4a suggests that energy commodity price has no impact on the local house price. On the other hand, non-energy commodity price in the spot market has a positive effect on house price. In the appendix, we conduct the regression on each city's house price on the same set of explanatory variables separately, and find that the result is mainly driven by three cities: Adelaide, Canberra and Perth. This result may not be surprising given the economic structure of these cities. For instance, in the state of Western Australia, where Perth is located, the gross state value added is about 236 billion Australian dollars in the year 2011-12, where Mining alone contributes 83 billion (Australian Bureau of Statistics, 2012). It seems reasonable to expect that commodity price fluctuations can have significant impact on the local house prices.

Table 4b shows the results of New Zealand, which are similar. The results of using spot market and futures market commodity prices are similar qualitatively, and the results are quantitatively more significant with spot market prices. National variables such as migration, real interest rate, real exchange rate, real bank loans, as well as local variables such as local house rents all have statistically significant impacts on local house prices. The effect of non-energy commodity price on local house price is also positive and statistically significant. In the appendix, we report the results that each city's house price is estimated separately. We find that the non-energy commodity prices are influential to the house prices in four cities, Auckland, Hamilton, Manukau and Wellington. The appendix also shows that Auckland and Manukau alone constitute almost 20% of the whole country's population. Thus, it seems reasonable to conclude that the commodity price movements are indeed important for house price movement in New Zealand, at least to a significant part of the population.

Comparing Tables 4a and 4b, we find two obvious differences. First, the sign of previous house price change is positive in Table 4a, but becomes negative in Table 4b. The results suggest that house price movements in New Zealand display some kind of mean reversion. Notice that our estimation results of Australian are based on quarterly data while that of New Zealand are from monthly data. The variations in the institutional settings (such as the real estate agency regulations, the bank loan application and approval procedures, etc.), the conduct of monetary policy (for instance, how strict the central bank follows the "inflation-targeting policy") as well as economic structure may also contribute to the difference in estimation results.

Interestingly, real interest rates are positively correlated to real house price changes both in Australia and New Zealand. This may be related to the inflation-targeting monetary policy adopted by the two countries. For instance, let us consider a positive productivity shock. It will lead to a higher economic growth rate in the short run and possibly a higher inflation rate. In response to that, the central bank would increase the nominal interest rate aggressively so that the real interest rate also increases.[21] At the same time, a positive productivity shock would also stimulate the housing demand. Since the housing supply is almost inelastic in the short run, the house price would also increase. This could lead to a positive correlation between the interest rate and the house price. However, there may be more than one reason why the real interest rate and the house price are positively correlated, and we leave this to future research for further investigation.

[21] This is related to the Taylor Principle in the literature on monetary policy. The literature is too large to be reviewed here. See the textbook by Walsh (2010), among others.

Perhaps more importantly, we find that, once we control for the effect of the macroeconomic and local economic variables, energy commodity prices are *not* important in determining the local house prices, both in Australia and New Zealand. This result holds whether we use spot market or futures market commodity prices. On the other hand, *non-energy* commodity prices have statistically significant and positive effect on the local housing prices. Again, the result holds whether we use spot market or futures market commodity prices. These results seem to be intuitive. For Australia, the export of energy commodities used to be less than 20% of total export until recent years. For New Zealand, most exports are non-energy commodities. Hence, an increase in the non-energy commodity prices would have a similar effect as a positive productivity shock, which would encourage the local house prices to increase. It confirms our earlier conjecture that commodity price shock can impact local house prices as a positive "income shock", rather than a negative "cost shock" as emphasized by some previous literatures. Since the energy and non-energy commodity price fluctuations generate very different results, this paper also confirms the findings of Chen and Rogoff (2003) that it is important to consider the two commodity prices separately. In particular, our empirical results seem to suggest that energy commodity prices seem to have a larger effect on the macroeconomic variables, and yet at the end have an almost neglectable overall effect on the local house prices, while non-energy commodity prices seem to affect the local house price directly. Thus, our results seem to justify our conjecture that the local house prices of some of the cities in Australia and New Zealand are "*commodity house prices*" as their currencies are "*commodity currencies*".

### 4.5. Dynamic Analysis

In this section, we would investigate how a change in the commodity prices would affect the local house prices. An obvious candidate is the traditional impulse response analysis (IRA).

However, since commodity prices are exogenous variables in our econometric model, strictly speaking, we cannot apply the traditional IRA. Nonetheless, the simple structure we adopted here allows us to study the dynamic effect of (global) commodity price change on the city-level house prices.[22] The following proposition formalizes the idea.

***Proposition 1***

*Based on the regression equation (1), (2) and (3), we can derive the following formula,*

$$\overrightarrow{HP_t} = C_0(L) + C_1(L)V_t^n + C_2(L)\overrightarrow{V_t^r} + C_3(L)P_t^c + C_4(L)\vec{S} + \overrightarrow{U_t} \qquad (4)$$

*where L is the lag operator, and hence we can describe how an once-and-for-all change in the commodity prices, $\Delta\left(P_t^c\right)$, would affect the local house prices.*

(The proof and the details formulas for the matric polynomials, $C_i\left(L\right)$, $i=1,2,...$ can all be found in the Appendix ).

Equipped with these formulas, we can analyse how a change in the commodity prices would affect the local house prices. For instance, to investigate how a change in the energy commodity price would affect the local house price, we simply set $\Delta(P_t^c) = \binom{\sigma_{energy}}{0}$, where $\sigma_{energy}$ is the standard deviation of the de-trended energy commodity price $P_t^{energy}$. Clearly, this is in parallel to the traditional IRA, where the innovation term would be taken as a standard deviation of the shock. Similarly, we obtain the effect of non-energy commodity prices on house price changes by setting $\Delta(P_t^c) = \binom{0}{\sigma_{non-energy}}$. As an illustration, we will only present the case of one standard deviation increase in the spot market commodity prices, and the case for futures market counterpart can be studied similarly. To make our dynamic response analysis more compatible with the traditional IRA as well as to facilitate comparison across cities, we "normalize" the

[22] A merit of this approach is that since commodity prices are exogenous variables in the system, we may not worry so much about whether the innovation in the commodity prices are structural shocks or not. In fact, without a structural model, impulse responses from a reduced form VAR are difficult to be interpreted. Among others, see Christiano et al (2007), Cooley and Dwyer (1998), Fernandez-Villaverde et al (2007), Kapetanios et al (2007), for more discussion.

house price changes, which is to divide the estimated house price change by the mean of the same city house price. We will present the dynamic responses of the city level house prices of all 8 cities of Australia. For the case of New Zealand, since it is too burdensome to study the impacts of 17 cities, we will focus the three major cities of New Zealand, Auckland (AK), Wellington (WT) and Christchurch (CH).[23] The results are presented in Figure 3.

**<Figures 3a, 3b about here>**

In Figures 3a and 3b, y-axis plots the percentage change of house price, $\Delta(HP_{j,t})/\overline{(HP_j)}$ in Australia and New Zealand respectively, where $\overline{(HP_j)}$ is simply the time-average of $(HP_{j,t})$. The x-axis is the time periods (months). To facilitate the comparison, we plot the responses of city-level house prices to change in energy commodity price as well as non-energy commodity price in one graph. Several observations are immediate from Figure 3a. First, in terms of percentage change, in most of the Australian cities, the responses to non-energy commodity price are much bigger than the energy counterpart, consistent with our results in Table 4a. Second, in most of the Australian cities, an increase in the energy commodity price typically generates a hump-shape response in house price, i.e. the house price will first increase and then decrease. This is somehow similar to what the business cycle literature found with "productivity shock". Perth is an exception. Its house price will drop first and then bound back. It may be related to the fact that Perth may be economically and geographically different from other cities.

Notice that the local house prices typically "overshoot" in response to an increase in the non-energy commodity price, i.e. the initial positive effect on house price generated by the "shock" will die off over time, even becomes a negative response in house price, and then

[23] Previous studies have shown that the house prices in these three cities have a significant effect in affecting the counterparts in smaller cities of New Zealand. Among others, see Shi, Young and Hargreaves (2009). In the appendix, we also apply our dynamic analysis on all 8 cities of Australia and find that the same results hold quantitatively as well.

restore to “normal”.[24] Such “over-shooting” behaviour is different from that in the exchange rate market. In the international finance literature, it is well-known that when the nominal prices are sticky in the short run, the exchange rate may over-shoot, meaning that the short run adjustment is more than the long run adjustment. Here the key is instead the sluggish housing supply. Since the supply of housing cannot adjust quickly to a positive commodity price shock (as an income shock), the local house price increases. Over time, new housing supply arrives at the market and drives down the house price.[25]

Figure 3b shows the case of the 3 selected cities in New Zealand. It is clear that they behave very differently. For instance, an increase in non-energy prices will generate a hump-shape response in the local house price all three cities, Auckland, Wellington, and Christchurch. On the other hand, when there is a positive shock in the energy commodity price, the local house prices of the three cities behave very differently. In Auckland, a momentum of positive responses will build up and then die off, which is qualitatively like a mirror image of the response to non-energy commodity price shock. For Wellington, the response to energy commodity price is qualitatively similar to the response to non-energy commodity price shock, except that the magnitude will be much smaller. For Christchurch, the house price responses to both energy and non-energy commodity prices are very similar, both qualitatively and quantitatively. These differences in house price responses may be due to the differences of the city economies. Auckland is the largest city of New Zealand and a large share of local economy is related to commercial activities, including the trading of energy-related commodities. Wellington is closely linked to government agency and surrounding industrial production. On the other hand, Christchurch is largely agricultural orientated.

[24] We are aware that Hobart is an exception. We lack more detailed city level data to investigate the reason, and can only leave this to future research.
[25] Among others, see Malpezzi and Wachter (2005), Leung (2007) for more discussion on this.

In sum, we can conclude that the house price dynamics driven by a change in energy commodity price can be very different from that generated by the non-energy counterpart, depending on the local economic structure. And we find that similar patterns emerge from both Australian and New Zealand cities, which are somehow commodity-export dependent. This may be worth further attention for theoretical modelling. Obviously, this research benefits a lot from using 8 Australian and 17 New Zealand cities in the analysis. In other words, our hierarchical and dis-aggregate approach may help us to uncover the mechanism through which the global commodity market affecting local house prices.

These observations are clearly at odds with traditional RBC (Real Business Cycles) type models where there is only one shock which drives the economy. At the same time, they seem to give support to the approach of DSGE model, which emphasizes the differential responses of the economy under different shocks.[26] In addition, this paper adds weight to the position that we should analyse the effect of energy-related commodity price shocks separately from the non-energy-related commodity price shocks.

## 5. Robustness checks

### 5.1 What does "filtering" do to the data?

This section attempts to accomplish a few tasks. First, we will show that our approach of a 3-stage regression is indeed important. As a starting point, we first compare the raw data series with the "filtered" counterparts. When we "filter" or "remove" the effect of commodity prices on the national or regional economic variables, do we change the behaviour of those variables significantly? To put it in another way, if the raw data and the filtered data are very similar, then whether regressing the raw data or filtered data in the second and third stage would not make

[26] Again, the literature is too large to be reviewed here. Among others, see Lim and McNelis (2008) for more discussion.

much difference and hence the 3-stage regression approach proposed here may have limited value-added. Table 5 shows the correlation between the raw data and the filtered data. Notice that while we have only one raw data series, our models generated two filtered data series, one is the residual term when the national economic variables are regressed against spot market commodity prices, and another is when the national economic variables are regressed against futures market commodity prices (see Table 2). Therefore we can calculate the correlations between the raw data and the data series filtered by spot market commodity prices, as well as that between the raw data and the data series filtered by futures market commodity prices. The two correlations are reported in two different columns in Table 5.

**<Tables 5a, 5b about here>**

First, whether we filter the data with spot market data or futures market data does not make very significant difference for both Australia and New Zealand. Second, it seems that different national variables show very different results. For instance, in the case of Australia, Table 5a shows that the correlations between the raw and filtered data of GDP growth rate, unemployment, and debt-to-GDP ratio are below 0.7, suggesting that they may be exposed more to changes in the commodity prices. For real interest rate change and real exchange rate change, the correlations are between 0.7 to 0.8, suggesting that they may be less influenced by the commodity price movements. For the stock price, bank loans and capital flow-to-GDP ratio, the correlations are 0.9 or above, suggesting that they are almost immune to the fluctuations of the commodity prices. The correlations among the raw data and the commodity price-filtered-data of most regional rental change are between 0.7 to 0.9 (except Sydney), suggesting the commodity prices on these variables are mild. The difference in these correlations also provide further hints on the channels through which the commodity prices fluctuations in the international market are translated into local house price movements.

A comparison of Tables 5a and 5b might suggest that these channels may be country-specific. Table 5b shows that the correlations among the raw and filtered data for different national level variables of New Zealand. It is clear that while the correlations are still below 0.7 for unemployment, the correlations are above 0.8 for GDP growth, which is very different from the case of Australia. At the same time, the correlations for net migration are below 0.7 and that for bank loans are around 0.7, suggesting that commodity price fluctuations may affect the local house price through changing these variables. On the other hand, real interest rate change, real exchange rate change and real stock price change do not seem to be affected by the filtering of commodity prices, as the corresponding correlations among the raw and filtered data are close to or above 0.9. And for most regional rental changes, the correlations among the raw data and the commodity price-filtered-data are in the range of 0.8 to 0.9. It suggests a minor impact of the commodity prices to these regional variables.

To shed further light on the exact effects of the filtering procedure on the data series are, we calculate the serial correlations of all three series: the raw data, the data series filtered by spot market commodity prices, and the one filtered by futures market commodity prices, and report the results in Tables 6a and 6b.

Several "stylized facts" are obvious. The raw data are significantly correlated and that justifies the inclusion of lagged terms in the regressions.[27] On the other hand, the filtered data of Australia are not serially correlated in general, whether the data is filtered by spot commodity prices or futures commodity prices. For New Zealand, some of the national level data are still serially correlated after filtering. Yet although the correlations may be statistically significant,

[27] For Australia, the real GDP growth, unemployment rate change, real net debt change are all positively correlated intertemporally, while the real exchange rate change is positively correlated with its own lag. For New Zealand, the list is even longer. Real GDP growth, unemployment rate change, net migration, real interest rate change, real exchange rate and real bank loan change are all positively correlated with their own lags. It should be noticed that the Australian data in our sample are in quarterly frequency and that in New Zealand are in monthly frequency and hence a direct comparison may need extra cautions.

their numerical values are around 0.2 or less. Thus, the filtering process significantly reduces, or even removes, the autocorrelation in the national level variables in Australia and New Zealand.

**<Tables 6a, 6b about here>**

### 5.2 Raw data versus filtered data

The previous section studies the effect of filtering onto the national and regional economic variables. It seems natural for this section to re-examine the effect of commodity prices on the local house prices if the raw data, instead of the filtered version, have been used in the analysis. Thus, our robustness check continue to use the (city-level) local house prices as dependent variable and we compare the results of using the raw data, adding the lagged filtered variable in equation (3) and (later) by treating the exchange rate as an exogenous variable with the 3-stage regression approach proposed by this paper. To facilitate the comparison, we reproduce the results in Table 4 as the first two columns of Table 7. In the third and the fourth columns of Table 7, *we use the raw data instead of the filtered ones.* The results of Australia are reported in Table 7a and those of New Zealand in Table 7b. With this side-by-side comparison, several observations are in order. First, in general, the effects of macroeconomic variables on the local house prices are similar. Second, the statistical significance of the local house rent is much weakened (for the case of Australia) or even disappear (for the case of New Zealand) when the raw data rather than the filtered data is used. Thus, using our 3-stage regression approach does *alter the economic conclusion*. Third, the energy commodity prices do not seem to matter for local house prices, whether in Australia or in New Zealand. Fourth, the effect of non-energy commodity prices seems to be the same for Australia. For New Zealand, as evident in Table 7b, the point estimate for the effect of non-energy commodity prices are significantly reduced. For the case of spot market non-energy commodity prices, the estimated coefficient drops from

0.0855 (3-stage regression) to 0.0582 (raw data). For the futures market counterpart, the estimated coefficient drops from 0.0465 (3-stage regression) to 0.0295 (raw data). These observations again confirm the general finding that it is indeed important to use a multi-step procedure to estimate the effect of international commodity price on the local house price.

**<Table 7a, 7b about here>**

The fifth and sixth columns of Table 7 present the results after including the lagged variable of filtered data in equation (3) (see the columns under Eq. (3) – lag). Again, Table 7a presents the results for Australia and Table 7b for New Zealand. Interestingly, the city rent becomes statistically significant again, and most estimated coefficients are similar. Overall, all these suggest that our filtering procedure is indeed important to uncover the relationship between commodity prices and city-level local housing prices in New Zealand.

### 5.3. Exogenous versus endogenous exchange rate

We also modify the original formulation and re-run all the regressions as a robustness check. Specifically, the modified formulation treats the exchange rate as an exogenous variable instead of an endogenous variable, which is the case considered earlier. This change in formulation is motivated by the results in Chen, Rogoff and Rossi (2010) that "commodity currency exchange rates have surprisingly robust power in predicting global commodity prices," yet the "reverse" relationship (commodity prices forecasting exchange rates) is less robust. Formally, our modified model is written as follows:

$$V_t^n = A_0 + A_1 P_t^c + A_2 P_{t-1}^c + A_3 E_t + A_4 V_{t-1}^n + U_t^n \quad (7)$$

where the change of log real exchange rate, $E_t$ , is no longer included in the vector of national variables $V_t^n$, but instead is included on the right hand side as an exogenous variable.

Similarly, we will have the second stage regression as follows:

$$V_{j,t}^{r} = B_0 + B_1 P_t^c + B_2 P_{t-1}^c + B_3 \widetilde{V_t^n} + B_4 \widetilde{V_{t-1}^n} + B_5 E_t + B_6 V_{j,t-1}^r + \widetilde{V_{j,t}^r},\ j = 1, 2, \ldots \quad (8)$$

And then in the third stage, we have

$$HP_{j,t} = C_{0,j} + C_1 HP_{j,t-1} + \sum_{k \neq j} \widehat{C_k}\, HP_{k,t-1} + C_2 \widetilde{V_t^n} + C_3 \widetilde{V_{j,t}^r} + C_4 P_t^c + C_5 P_{t-1}^c + \sum_i C_{6i} S_i + U_{jt},$$

$$j = 1, 2, \ldots \quad (9)$$

Now we have $C_1$ to control for the persistence of house price, $C_2$, $C_3$ for the filtered national variables, $C_4$, $C_5$ for the commodity prices, $C_6$ for the change of the log real exchange rate, which should cover all different possibilities.

The last two columns of Tables 7a and 7b present the results when the changes of log real exchange rates are treated as an exogenous variable (see the column under Eq. (3) – exch. exogenous). Again, except for the point estimate of the effect of non-energy commodity price in the futures market on the local house price, the results are similar to the original estimation (the first and second columns). For the case of Australia, the coefficient of the spot market non-energy commodity price changes from 0.0183 (when exchange rate is treated as an endogenous variable) to 0.0215 (when the exchange rate is treated as an exogenous variable). For the case of New Zealand, the change is more significant. The coefficient of the spot market non-energy commodity price changes from 0.0855 (when exchange rate is treated as an endogenous variable) to 0.0629 (when the exchange rate is treated as an exogenous variable), while maintaining 1% significant level.

Putting all these together, we can safely conclude that the influence of the commodity prices on at least some cities in Australia and New Zealand local house prices are significant and robust. In addition, our 3-stage estimation procedure contributes in uncovering such a relationship.

## 6. Concluding Remarks

Commodity price movements have gained attention in international media such as Wall Street Journal, Financial Times, Economist magazine, etc. in the rent years. They are often perceived as problems to be solved. Recent researches such as Chen and Rogoff (2003), Chen, Rogoff and Rossi (2010), amongst others, take advantage of those movements and use them to enhance our understanding of the business cycles in some “commodity dependent economies”. This paper follows this approach and uses the commodity price movements to identify the mechanism for “external shocks” to affect the local house prices. We develop a simple, geographically hierarchical empirical model for Australia and New Zealand economies as well as their cities. We find that an increase in commodity price functions like a positive “income shock” to these commodity dependent economies which would increase the economic growth rate and suppress the unemployment rate, rather than a “cost shock” which tends to have the opposite effect. We also derive analytical results to capture the dynamic responses for commodity prices to influence the local house prices. We find that commodity prices are important to local house prices. In particular, energy commodity price shocks tend to affect the movement of macroeconomic variables, while non-energy commodity price shocks tend to affect the local house prices more directly. Significant regional heterogeneity is also recognized. It is also important to separate the price shocks from energy commodities from non-energy commodities.

As we discussed in the introduction, it is possible that different levels of government impose policies to “counteract” the effect of commodity price changes. It seems plausible that would be the case for energy price changes, as it typically triggers inflation and inflating-targeting central banks would respond. In fact, our hierarchical model can also be interpreted as the reduced form of a more elaborated model in which economic policy; whether in the form of monetary or fiscal (both at the national and regional level) would respond to the changes of commodity prices and economic variables. We formalize such an idea in the appendix. Thus, our estimated coefficients may be a combination of the coefficients in the "policy reaction functions" and the "genuine economic fundamentals". Thus, future works may further explore how we would separate the possible (endogenous) policy effect from the pure economic response of the market.[28]

Clearly, future research can be extended in other directions as well. First, we can follow Chen and Rogoff (2012) to cover more countries and examine how commodity prices may affect the exchange rates in different countries. We also notice that the local house price responses to commodity price shock seem to depend on the local economic structure. Thus, future research may investigate a more formal way to categorize and quantify such differences and may thus build a deeper linkage between real estate researches to regional economic studies.

In addition, our empirical results can be taken as "stylized facts" which would inform further theoretical modelling, for instance, along the line of open economy DSGE models. The geographically hierarchical empirical model developed here can be modified for other "exogenous shocks" and applied to other economies. In fact, our modelling strategy may also suggest a deeper linkage between house price movements which is traditionally studied in the field of "urban economics" and international asset pricing, which is traditionally studied in the field of "international finance". The globalization may have changed the trade barriers among countries, as well as the research barriers among fields.

[28] Among others, see Bernanke and Blinder (1992), Bernanke and Mihov (1998) for more discussion on this point.

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Figure 1: The mechanism for the commodity price shock to affect the local house prices

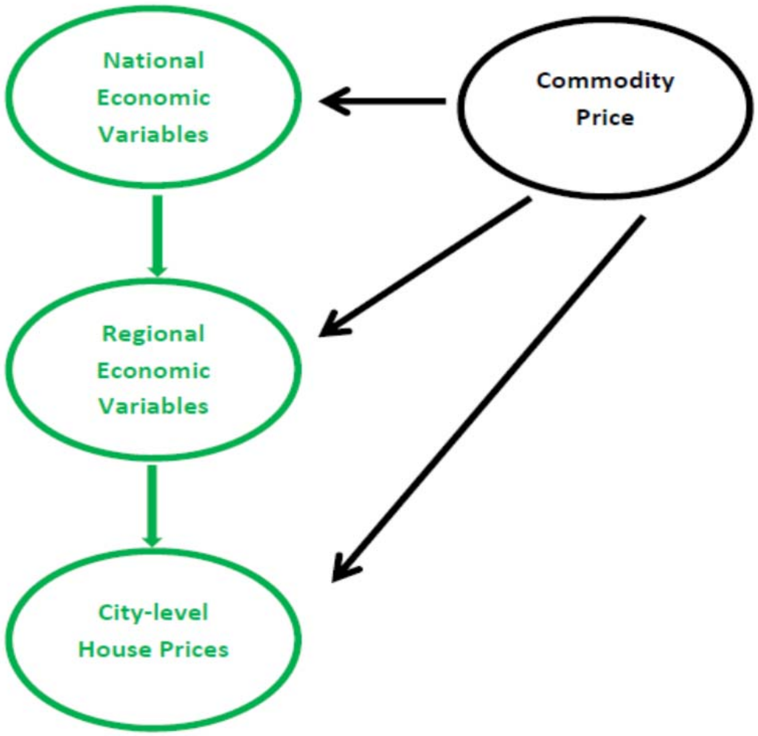


Figure 2a: Geographic locations of 8 selected cities of Australia


Figure 2b: Geographic locations of 17 selected cities of New Zealand

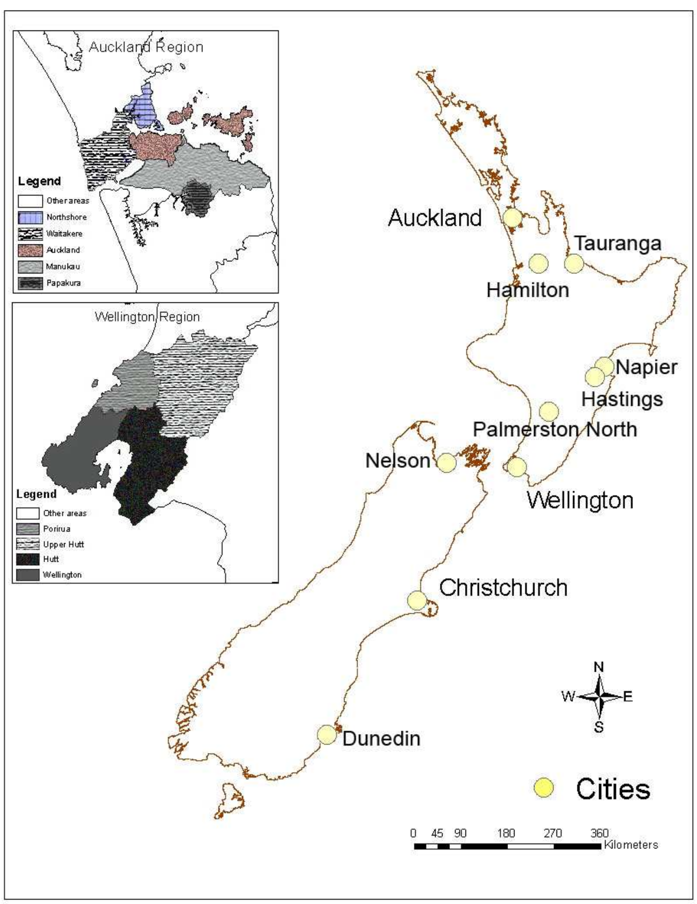
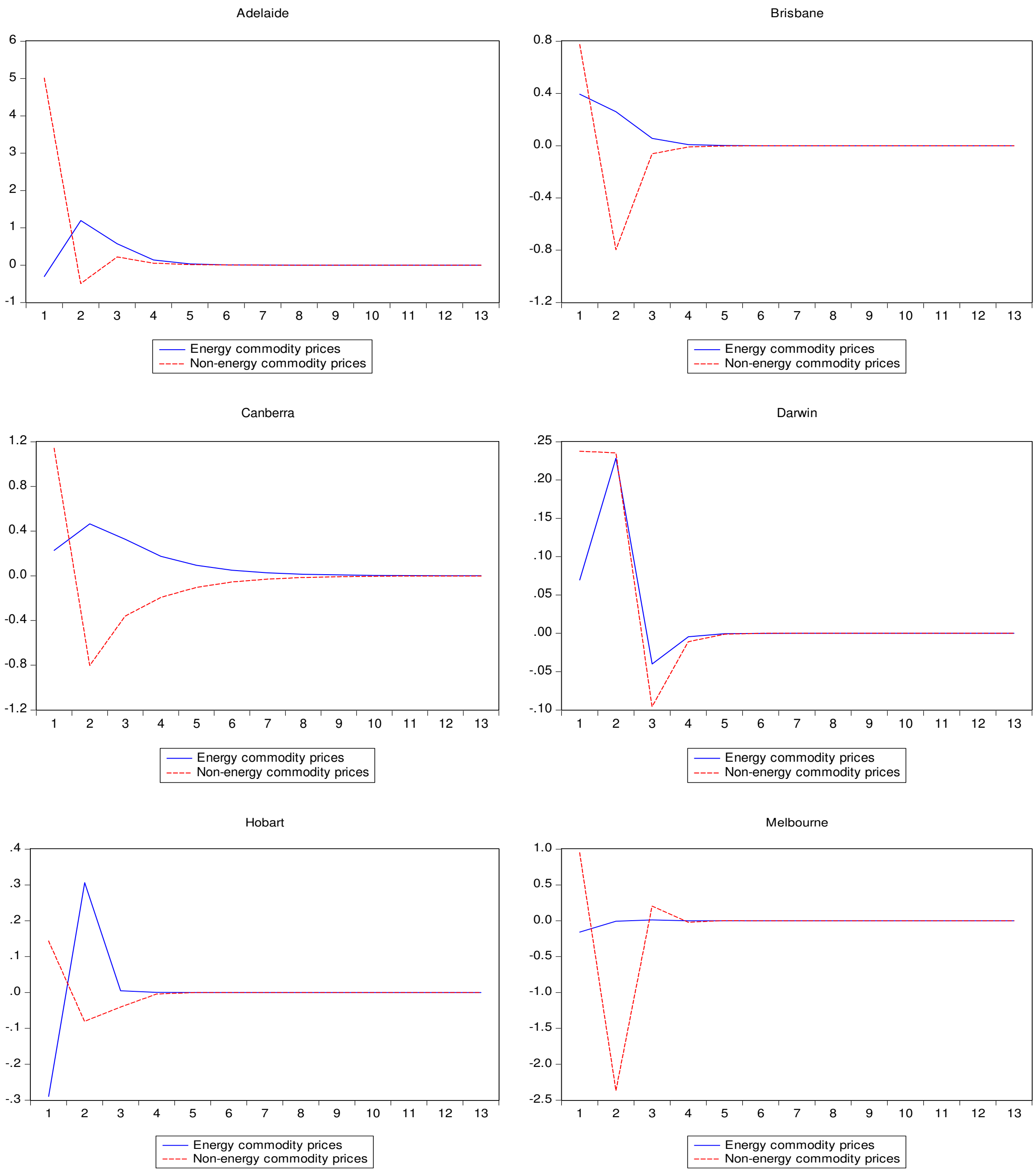
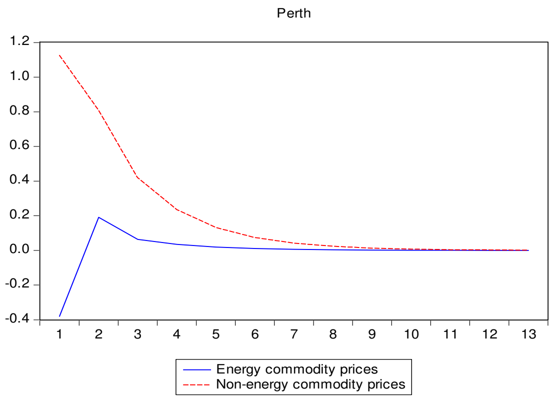


Figure 3a: Dynamic Response analysis for one standard deviation of spot market commodity prices on city level housing prices – Australia




Perth
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
1 2 3 4 5 6 7 8 9 10 11 12 13
Energy commodity prices
Non-energy commodity prices

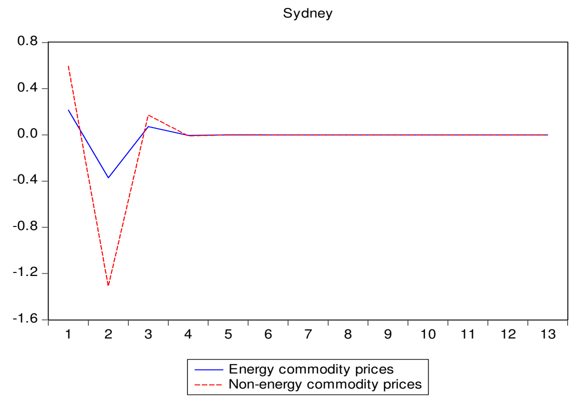

Sydney
0.8
0.4
0.0
-0.4
-0.8
-1.2
-1.6
1 2 3 4 5 6 7 8 9 10 11 12 13
Energy commodity prices
Non-energy commodity prices

Figure 3b: Dynamic Response analysis of spot market commodity prices on selected city level house prices of New Zealand

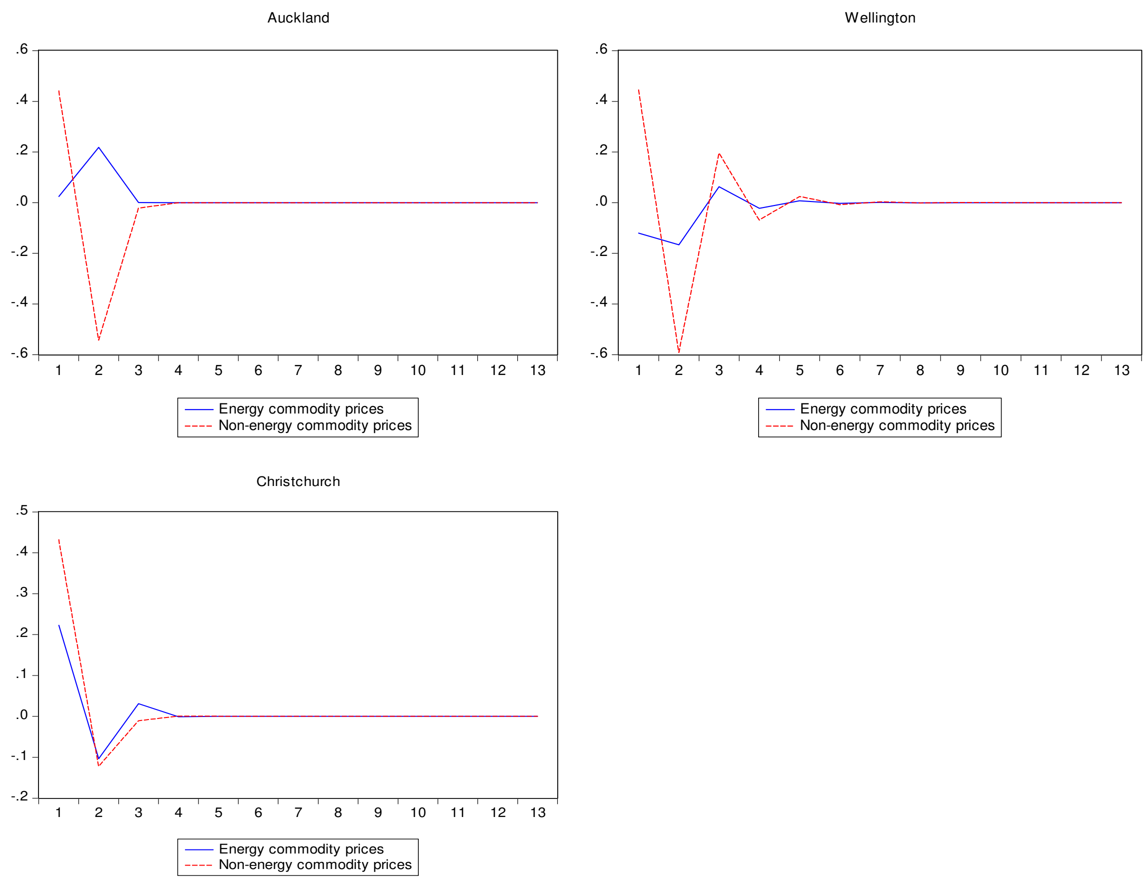


Table 1a Summary table of the Australian and New Zealand data comparison

| | Australia | New Zealand |
|---|---|---|
| Sampling period | 1988 Q3 – 2011 Q4 | 1994 M1 – 2009 M12 |
| Data Frequency | Quarterly | Monthly |
| Available National level Data | Real GDP, Unemployment rate, Real interest rate, Real exchange rate, debt-to-GDP ratio, Real stock price, Net capital flow-to-GDP ratio and Real bank loans | Real GDP, Unemployment rate, Net migration, Real interest rate, Real exchange rate, Real stock price and Real bank loans |
| Available Regional level Data | Real house price and rent * | Real house price and rent |
| Available Regional House price data | 8 cities: Sydney, Melbourne, Brisbane, Adelaide, Perth, Hobart, Canberra, Darwin | 17 cities: North Shore City, Waitakere City, Auckland City, Manukau City, Papakura District, Hamilton City, Tauranga City, Hastings City, Napier City, Palmerston North City, Porirua City, Upper Hutt City, Wellington City, Nelson City, Christchurch City, Dunedin City |

* Rent data for Darwin starts only from 1994Q1.

Table 1b: Short-hand and the original names of the cities

(for Australia)

| Short hand | Original names of the cities |
|---|---|
| SYD | Sydney |
| MEL | Melbourne |
| BRI | Brisbane |
| ADE | Adelaide |
| PER | Perth |
| HOB | Hobart |
| DAR | Darwin |
| CAN | Canberra |

(for New Zealand)

| Short hand | Original names of the cities |
|---|---|
| NS | North Shore |
| WK | Waitakere |
| AK | Auckland |
| MK | Manukau |
| PK | Papakura District |
| HT | Hamilton |
| TR | Tauranga |
| HS | Hastings |
| NP | Napier |
| PN | Palmerston North |
| PR | Porirua |
| UH | Upper Hutt |
| HT | Hutt |
| WT | Wellington |
| NL | Nelson |
| CH | Christchurch |
| DN | Dunedin |

Table 2a: Summary of 1st Stage Regression for Australia, 1988Q3-2011Q4 (Aggregate Variables and Commodity Prices)

| Commodity Price Variables | Real GDP Growth Rate Equation | Change of Unemployment Equation | Change of Debt/GDP Ratio Equation | Change of Real Interest Rate Equation | Change of Real Exchange Rate Equation | Change of Real Stock Price Equation | Changes of Real Bank Loan Equation | Net Capital Flow/GDP Ratio Equation |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Energy | | | | F+ | F- | | | |
| Energy (-1) | F+ | | F- | | S+ | | | F- |
| Non-Energy | F+ | | F- | S+ | S-, F- | S+ | | |
| Non-Energy (-1) | F+ | S- | F- | F+ | | | | |

The number of observations in each case is 92.

Table 2b: Summary of 1st Stage Regression for New Zealand, 1994m1-2009m12 (Aggregate Variables and Commodity Prices)

| Commodity Price Variables | Real GDP Growth Rate Equation | Change of Unemployment Equation | Net Migration | Change of Real Interest Rate Equation | Change of Real Exchange Rate Equation | Change of Real Stock Price Equation | Changes of Real Bank Loan Equation |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| Energy | S- | F+ | | | F- | | |
| Energy (-1) | | S+, F+ | | | | | |
| Non-Energy | | | | S+ | | | |
| Non-Energy (-1) | | | | | | | |

The number of observations in each case is 142

Key: "Energy" denotes "Change of Real Energy Commodity Price", "-1" denotes the lagged values, "Non-Energy" denotes "Changes of Real Non-Energy Commodity Price", "S+" denotes the coefficient being positive and at 5% or 1% statistical significant level when Spot Market Commodity Price is used, "S-" denotes the coefficient being negative and at 5% or 1% statistical significant level when Spot Market Commodity Price is used, "F+" denotes the coefficient being positive and at 5% or 1% statistical significant level when Futures Market Commodity Price is used, "F-" denotes the coefficient being negative and at 5% or 1% statistical significant level when Futures Market Commodity Price is used..

Table 3a: Summary of the Local City Rent Regression for Australia, 1988Q3-2011Q4 (2nd stage regression)

| Commodity Price Variables | Australian Cities | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Adelaide | Brisbane | Canberra | Darwin | Hobart | Melbourne | Perth | Sydney |
| Energy | | | | | | | | |
| Energy (-1) | | | | | F- | F- | | |
| Non-Energy | | | | | | F- | | |
| Non-Energy (-1) | | | F+ | | F+ | F+ | | F+ |

The number of observations in each case is 91.

Table 3b: Summary of the Local City Rent Regression for New Zealand, 1994m1-2009m12 (2nd stage regression)

| Commodity Price Variables | New Zealand Cities | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NS | WK | AK | MK | PK | HT | TR | HS | NP | PN | PR | UH | HT | WT | NL | CH | DN |
| Energy | | | | | | | | | | | | | | | | | |
| Energy (-1) | | | | | | F- | | | | | | | | | | | |
| Non-Energy | | | | S+ | | | | | | | | | | | | | |
| Non-Energy (-1) | S+ | | | | | | | | | F- | | | | | | | |

The number of observations in each case is 141.

Key: "Energy" denotes "Change of Real Energy Commodity Price", "-1" denotes the lagged values, "Non-Energy" denotes "Changes of Real Non-Energy Commodity Price", "S+" denotes the coefficient being positive and at 5% or 1% statistical significant level when Spot Market Commodity Price is used, "S-" denotes the coefficient being negative and at 5% or 1% statistical significant level when Spot Market Commodity Price is used, "F+" denotes the coefficient being positive and at 5% or 1% statistical significant level when Futures Market Commodity Price is used, "F-" denotes the coefficient being negative and at 5% or 1% statistical significant level when Futures Market Commodity Price is used.

Table 4a: City level house price in Australia, 1988 Q3-2011Q4 (3rd stage regression)

| | Spot market commodity prices | | Futures market commodity prices | |
|---|---|---|---|---|
| *Dependant variable is the real city level house price change* | | | | |
| Intercept | 0.0020 | | -0.0002 | |
| Δreal house price(-1) | 0.2909 | *** | 0.2911 | *** |
| Filtered GDP | 0.0456 | | 0.0930 | *** |
| Filtered unemployment | -0.0346 | *** | -0.0237 | ** |
| Filtered external debt | 0.0796 | *** | 0.0927 | *** |
| Filtered interest rate | 0.0148 | * | 0.0246 | *** |
| Filtered exchange rate | 0.0019 | | -0.0258 | ** |
| Filtered stock prices | 0.0114 | | 0.0139 | * |
| Filtered bankloan | 0.0192 | | 0.0362 | |
| Filtered net capital flow | 0.0323 | *** | 0.0355 | *** |
| Filtered city level rents | 0.0450 | *** | 0.0465 | *** |
| ΔReal energy comm. price(t) | 0.0048 | | 0.0000 | |
| ΔReal energy comm. price(t-1) | 0.0006 | | -0.0012 | |
| ΔReal non-energy comm. price(t) | 0.0183 | *** | -0.0095 | |
| ΔReal non energy comm. price(t-1) | -0.0064 | | 0.0125 | |
| Seasonal dummy (1) | -0.0042 | | -0.0002 | |
| Seasonal dummy (2) | -0.0012 | | 0.0011 | |
| Seasonal dummy (3) | 0.0037 | ** | 0.0062 | ** |
| Fixed city effects | | | | |
| ADE | -0.0008 | | -0.0008 | |
| BRI | -0.0004 | | -0.0004 | |
| CAN | 0.0005 | | 0.0005 | |
| DAR | 0.0026 | | 0.0026 | |
| HOB | 0.0010 | | 0.0010 | |
| MEL | -0.0010 | | -0.0010 | |
| PER | 0.0000 | | 0.0000 | |
| SYD | -0.0012 | | -0.0012 | |
| Observations | 707 | | 707 | |
| Adj. R-squared | 0.181 | | 0.170 | |

Notes: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

Table 4b: City level house price in New Zealand, 1994m1 – 2009m12 (3rd Stage regression)

| | Spot market commodity | | Futures market commodity | |
|---|---|---|---|---|
| *Dependant variable is the real city level house price change* | | | | |
| Intercept | 0.0009 | | 0.0091 | *** |
| Δreal house price(-1) | -0.2874 | *** | -0.2844 | *** |
| Filtered GDP | 0.1328 | | -0.3886 | *** |
| Filtered unemployment | -0.0002 | | -0.0083 | |
| Filtered migration | 0.0110 | *** | 0.0149 | *** |
| Filtered interest rate | 0.0352 | *** | 0.0333 | *** |
| Filtered exchange rate | -0.0482 | *** | -0.0286 | * |
| Filtered stock prices | 0.0158 | | 0.0205 | * |
| Filtered bankloan | 0.5728 | *** | 1.1180 | *** |
| Filtered city level rents | 0.0407 | *** | 0.0278 | * |
| ΔReal energy comm. price(t) | -0.0022 | | 0.0087 | * |
| ΔReal energy comm. price(t-1) | -0.0052 | | -0.0023 | |
| ΔReal non-energy comm. price(t) | 0.0855 | *** | 0.0465 | *** |
| ΔReal non energy comm. price(t-1) | 0.0191 | | 0.0134 | |
| Seasonal dummy (1) | 0.0134 | *** | -0.0077 | * |
| Seasonal dummy (2) | 0.0058 | * | -0.0092 | *** |
| Seasonal dummy (3) | 0.0104 | *** | -0.0046 | |
| Seasonal dummy (4) | -0.0019 | | -0.0057 | *** |
| Seasonal dummy (5) | 0.0014 | | -0.0068 | *** |
| Seasonal dummy (6) | -0.0016 | | -0.0106 | *** |
| Seasonal dummy (7) | 0.0005 | | -0.0135 | *** |
| Seasonal dummy (8) | 0.0049 | * | -0.0063 | ** |
| Seasonal dummy (9) | 0.0027 | | -0.0118 | *** |
| Seasonal dummy (10) | -0.0011 | | 0.0129 | *** |
| Seasonal dummy (11) | 0.0023 | | -0.0002 | |
| Fixed city effects | | | | |
| NS | 0.0004 | | -0.0003 | |
| WK | 0.0006 | | -0.0011 | |
| AK | 0.0013 | | 0.0004 | |
| MK | 0.0002 | | -0.0009 | |
| PK | -0.0001 | | -0.0020 | |
| HT | -0.0004 | | -0.0010 | |
| TR | -0.0003 | | -0.0014 | |
| HS | -0.0009 | | 0.0004 | |
| NP | -0.0008 | | 0.0001 | |
| PN | -0.0013 | | 0.0002 | |
| PR | 0.0010 | | 0.0015 | |
| UH | 0.0000 | | 0.0012 | |
| HT | 0.0006 | | 0.0009 | |
| WT | 0.0013 | | 0.0007 | |
| NL | -0.0010 | | 0.0002 | |
| CH | -0.0002 | | -0.0002 | |
| DN | -0.0007 | | 0.0013 | |
| Observations | 3196 | | 2397 | |
| Adj. R-squared | 0.111 | | 0.130 | |

Notes: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

Table 5a: Correlations between the raw and filtered data – Australia, 1988Q3 – 2011Q4

| Variables | Filtered by Spot commodity prices | Filtered by Futures commodity prices |
|---|---|---|
| Real GDP growth | 0.694 | 0.615 |
| Unemployment rate change | 0.615 | 0.630 |
| External debt/GDP ratio change | 0.689 | 0.636 |
| Real interest rate change | 0.784 | 0.784 |
| Real exchange rate change | 0.735 | 0.803 |
| Real stock prices change | 0.896 | 0.955 |
| Real bank loan change | 0.950 | 0.963 |
| Net capital flow/GDP ratio | 0.954 | 0.918 |
| Real rental change | | |
| ADE | 0.787 | 0.797 |
| BRI | 0.844 | 0.841 |
| CAN | 0.777 | 0.773 |
| DAR | 0.833 | 0.885 |
| HOB | 0.752 | 0.737 |
| MEL | 0.853 | 0.751 |
| PER | 0.849 | 0.840 |
| SYD | 0.657 | 0.665 |

Table 5b: Correlations between the raw and filtered data – New Zealand, 1994m1 – 2009m12

| Variables | Filtered by Spot commodity prices | Filtered by Futures commodity prices |
|---|---|---|
| Real GDP growth | 0.843 | 0.819 |
| Unemployment rate change | 0.665 | 0.664 |
| Net migration | 0.622 | 0.630 |
| Real interest rate change | 0.922 | 0.937 |
| Real exchange rate change | 0.887 | 0.869 |
| Real stock prices change | 0.931 | 0.920 |
| Real bank loan change | 0.725 | 0.698 |
| Real rental change | | |
| NS | 0.845 | 0.839 |
| WK | 0.831 | 0.784 |
| AK | 0.809 | 0.794 |
| MK | 0.825 | 0.806 |
| PK | 0.850 | 0.808 |
| HT | 0.868 | 0.818 |
| TR | 0.902 | 0.900 |
| HS | 0.762 | 0.727 |
| NP | 0.852 | 0.828 |
| PN | 0.875 | 0.781 |
| PR | 0.865 | 0.855 |
| UH | 0.825 | 0.844 |
| HT | 0.880 | 0.871 |
| WT | 0.912 | 0.851 |
| NL | 0.841 | 0.809 |
| CH | 0.911 | 0.878 |
| DN | 0.866 | 0.843 |

Table 6a: Autocorrelations in the raw and filtered data – Australia, 1988Q3 – 2011Q4

| Variables | | Raw variables | | Filtered variables: Spot | | Filtered variables: Futures |
|---|---|---|---|---|---|---|
| Real GDP growth | | -0.674 | *** | -0.129 | | -0.074 |
| Unemployment rate change | | -0.262 | *** | 0.051 | | 0.066 |
| Real net debt change | | -0.647 | *** | -0.025 | | 0.019 |
| Real interest rate change | | 0.111 | | -0.020 | | -0.020 |
| Real exchange rate change | | 0.216 | ** | 0.025 | | 0.014 |
| Real stock prices change | | 0.158 | | -0.040 | | -0.009 |
| Real bank loan change | | 0.088 | | -0.048 | | 0.002 |
| Net capital flow/GDP ratio | | -0.146 | | -0.026 | | 0.057 |
| Real rental change | | | | | | |
| | ADE | -0.473 | *** | -0.061 | | -0.050 |
| | BRI | -0.268 | *** | -0.012 | | -0.007 |
| | CAN | -0.150 | | -0.162 | | -0.123 |
| | DAR | -0.115 | | -0.080 | | -0.057 |
| | HOB | -0.237 | ** | -0.210 | ** | -0.158 |
| | MEL | -0.339 | *** | -0.066 | | 0.038 |
| | PER | -0.316 | *** | 0.008 | | 0.013 |
| | SYD | -0.360 | *** | 0.147 | | 0.149 |

Notes: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

Table 6b: Autocorrelations in the raw and filtered data – New Zealand, 1994m1 – 2009m12

| Variables | | Raw variables | | Filtered variables | | | |
|---|---|---|---|---|---|---|---|
| | | | | Spot | | Futures | |
| Real GDP growth | | 0.465 | *** | 0.162 | ** | 0.168 | ** |
| Unemployment rate change | | 0.696 | *** | 0.006 | | 0.015 | |
| Net migration | | 0.757 | *** | -0.059 | | -0.115 | |
| Real interest rate change | | 0.191 | *** | 0.017 | | -0.001 | |
| Real exchange rate change | | 0.362 | *** | 0.025 | | 0.042 | |
| Real stock prices change | | -0.018 | | -0.027 | | -0.045 | |
| Real bank loan change | | 0.645 | *** | -0.149 | ** | -0.207 | ** |
| Real rental change | | | | | | | |
| | NS | -0.474 | *** | -0.138 | * | -0.142 | * |
| | WK | -0.495 | *** | 0.014 | | -0.024 | |
| | AK | -0.480 | *** | -0.039 | | -0.007 | |
| | MK | -0.449 | *** | -0.131 | * | -0.104 | |
| | PK | -0.447 | *** | -0.086 | | -0.129 | |
| | HT | -0.420 | *** | 0.019 | | 0.016 | |
| | TR | -0.302 | *** | -0.092 | | -0.112 | |
| | HS | -0.542 | *** | -0.168 | *** | -0.169 | ** |
| | NP | -0.476 | *** | -0.174 | ** | -0.215 | *** |
| | PN | -0.297 | *** | -0.080 | | -0.083 | |
| | PR | -0.450 | *** | -0.116 | | -0.085 | |
| | UH | -0.451 | *** | -0.143 | ** | -0.117 | |
| | HT | -0.393 | *** | -0.135 | * | -0.115 | |
| | WT | -0.266 | *** | -0.066 | | -0.060 | |
| | NL | -0.482 | *** | -0.159 | ** | -0.141 | * |
| | CH | -0.087 | | -0.070 | | -0.043 | |
| | DN | -0.360 | *** | -0.134 | * | -0.150 | * |

Notes: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

Table 7a: Robustness check – Australia, 1988Q3 – 2011Q4

| | Eq. (3) -original | | Eq. (3) - raw data | | Eq. (3) - lag | | Eq. (3) - exch. exogenous | |
|---|---|---|---|---|---|---|---|---|
| | Spot | Futures | Spot | Futures | Spot | Futures | Spot | Futures |
| *Dependant variable is the real city level house price change* | | | | | | | | |
| Intercept | 0.0020 | -0.0002 | 0.0020 | 0.0010 | -0.0003 | -0.0005 | 0.0022 | 0.0009 |
| ΔReal house price(t-1) | 0.2909 *** | 0.2911 *** | 0.3193 *** | 0.3132 *** | 0.2676 *** | 0.2598 *** | 0.2873 *** | 0.2899 *** |
| ΔReal GDP(t) | 0.0456 | 0.0930 *** | 0.0198 | 0.0428 | 0.0962 ** | 0.1141 *** | 0.0355 | 0.0675 ** |
| ΔReal GDP(t-1) | | | | | 0.0936 ** | 0.0646 * | | |
| ΔUnemployment rate(t) | -0.0346 *** | -0.0237 ** | -0.0339 *** | -0.0270 *** | -0.0282 ** | -0.0205 * | -0.0335 *** | -0.0271 *** |
| ΔUnemployment rate(t-1) | | | | | -0.0124 | -0.0204 * | | |
| ΔExternal debt/GDP(t) | 0.0796 *** | 0.0927 *** | 0.0791 *** | 0.0909 *** | 0.0973 *** | 0.1079 *** | 0.0696 *** | 0.0843 *** |
| ΔExternal debt/GDP(t-1) | | | | | 0.0657 *** | 0.0500 ** | | |
| ΔReal interest rate(t) | 0.0148 * | 0.0246 *** | 0.0143 * | 0.0214 *** | 0.0132 * | 0.0248 *** | 0.0140 * | 0.0268 *** |
| ΔReal interest rate(t-1) | | | | | -0.0009 | 0.0004 | | |
| ΔReal exchange rate(t) | 0.0019 | -0.0258 ** | 0.0042 | -0.0181 | -0.0010 | -0.0322 ** | 0.0104 | -0.0189 |
| Δreal exchange rate(t-1) | | | | | -0.0264 * | -0.0083 | | |
| ΔReal stock prices(t) | 0.0114 | 0.0139 * | 0.0107 | 0.0136 * | 0.0138 * | 0.0127 * | 0.0109 | 0.0076 |
| ΔReal stock prices(t-1) | | | | | 0.0154 ** | 0.0189 ** | | |
| ΔReal bank loan(t) | 0.0192 | 0.0362 | 0.0332 | 0.0393 | 0.0223 | 0.0376 | 0.0239 | 0.0234 |
| ΔReal bank loan(t-1) | | | | | 0.007 | -0.0058 | | |
| Net capital flow/GDP(t) | 0.0323 *** | 0.0355 *** | 0.0296 *** | 0.0325 *** | 0.0364 *** | 0.0359 *** | 0.0304 *** | 0.0307 *** |
| Net capital flow/GDP(t-1) | | | | | 0.0139 | 0.0227 ** | | |
| ΔReal city level rents(t) | 0.0450 *** | 0.0465 *** | 0.0203 * | 0.0231 * | 0.0437 *** | 0.0463 *** | 0.0487 *** | 0.0505 *** |
| ΔReal city level rents(t-1) | | | | | 0.0222 | 0.0191 | | |
| ΔReal energy price(t) | 0.0048 | 0.0000 | -0.0047 | -0.0035 | -0.0043 | -0.0012 | 0.0061 | -0.0011 |
| ΔReal energy price(t-1) | 0.0006 | -0.0012 | 0.0021 | -0.0019 | 0.0016 | -0.0020 | -0.0008 | -0.0002 |
| ΔReal non-energy price(t) | 0.0183 *** | -0.0095 | 0.0171 ** | -0.0152 * | 0.0199 *** | -0.0099 | 0.0215 *** | -0.0148 * |
| ΔReal non energy price(t-1) | -0.0064 | 0.0125 | -0.0136 ** | -0.0015 | -0.0076 | 0.0160 * | -0.0062 | 0.0056 |
| Observations | 707 | 707 | 715 | 715 | 699 | 699 | 707 | 707 |
| Adj. R-squared | 0.181 | 0.170 | 0.190 | 0.184 | 0.187 | 0.160 | 0.182 | 0.164 |

Notes: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

Table 7b: Robustness check – New Zealand, 1994m1 – 2009m12

| | Eq. (3) -original | | Eq. (3) - raw data | | Eq. (3) - lag | | Eq. (3) - exch. exogenous | |
|---|---|---|---|---|---|---|---|---|
| | Spot | Futures | Spot | Futures | Spot | Futures | Spot | Futures |
| *Dependant variable is the real city level house price change* | | | | | | | | |
| Intercept | 0.0009 | 0.0091 *** | -0.0203 *** | -0.0253 *** | 0.0006 | 0.0109 *** | -0.0015 | 0.0077 *** |
| ΔReal house price(-1) | -0.2874 *** | -0.2844 *** | -0.3376 *** | -0.3715 *** | -0.3063 *** | -0.3192 *** | -0.2999 *** | -0.3021 *** |
| ΔReal GDP | 0.1328 | -0.3886 *** | 0.3348 *** | 0.3089 *** | 0.0411 | -0.3338 ** | 0.2274 *** | -0.3378 *** |
| ΔReal GDP(-1) | | | | | 0.0931 | -0.3130 *** | | |
| ΔUnemployment rate | -0.0002 | -0.0083 | -0.0215 *** | -0.0096 * | -0.0011 | -0.0046 | -0.0022 | -0.0062 |
| ΔUnemployment rate(-1) | | | | | -0.0145 * | -0.0133 | | |
| Net migration | 0.0110 *** | 0.0149 *** | 0.0067 *** | 0.0098 *** | 0.0124 *** | 0.0160 *** | 0.0126 *** | 0.0177 *** |
| Net migration (-1) | | | | | 0.0056 *** | 0.0052 * | | |
| ΔReal interest rate | 0.0352 *** | 0.0333 *** | 0.0247 *** | 0.0232 ** | 0.0333 *** | 0.0349 *** | 0.0382 *** | 0.0357 *** |
| ΔReal interest rate (-1) | | | | | 0.0128 | 0.0207 | | |
| ΔReal exchange rate | -0.0482 *** | -0.0286 * | -0.0536 *** | -0.0468 *** | -0.0457 *** | -0.0139 | -0.1167 *** | -0.0878 *** |
| ΔReal exchange rate (-1) | | | | | -0.0677 *** | -0.0622 *** | | |
| ΔReal stock prices | 0.0158 | 0.0205 * | 0.0164 | 0.0224 ** | 0.0197 * | 0.0351 *** | 0.0152 | 0.0191 * |
| ΔReal stock prices (-1) | | | | | 0.0296 *** | 0.0317 *** | | |
| ΔReal bank loan | 0.5728 *** | 1.1180 *** | 0.8036 *** | 1.4485 *** | 0.6099 *** | 1.3022 *** | 0.5626 *** | 1.0679 *** |
| ΔReal bank loan(-1) | | | | | 0.5337 *** | 1.0037 *** | | |
| ΔReal city level rents | 0.0407 *** | 0.0278 * | 0.0116 | 0.0026 | 0.0445 *** | 0.0332 ** | 0.0389 *** | 0.0273 * |
| ΔReal city level rents (-1) | | | | | 0.0519 *** | 0.0534 *** | | |
| ΔReal energy price(t) | -0.0022 | 0.0087 * | 0.0012 | -0.0062 | 0.0005 | 0.0001 | -0.0102 ** | 0.0017 |
| ΔReal energy price(t-1) | -0.0052 | -0.0023 | -0.0040 | -0.0031 | -0.0086 * | 0.0025 | -0.0090 ** | -0.0050 |
| ΔReal non-energy price(t) | 0.0855 *** | 0.0465 *** | 0.0582 *** | 0.0295 *** | 0.0622 *** | 0.0342 *** | 0.0629 *** | 0.0361 *** |
| ΔReal non energy price(t-1) | 0.0191 | 0.0134 | 0.0098 | 0.0120 | 0.0259 | 0.0317 *** | 0.0280 | 0.0139 |
| Observations | 3196 | 2397 | 3230 | 2414 | 3179 | 2380 | 3196 | 2397 |
| Adj. R-squared | 0.111 | 0.130 | 0.173 | 0.231 | 0.134 | 0.166 | 0.129 | 0.153 |

Notes: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

## Appendix

This appendix consists of several sections.

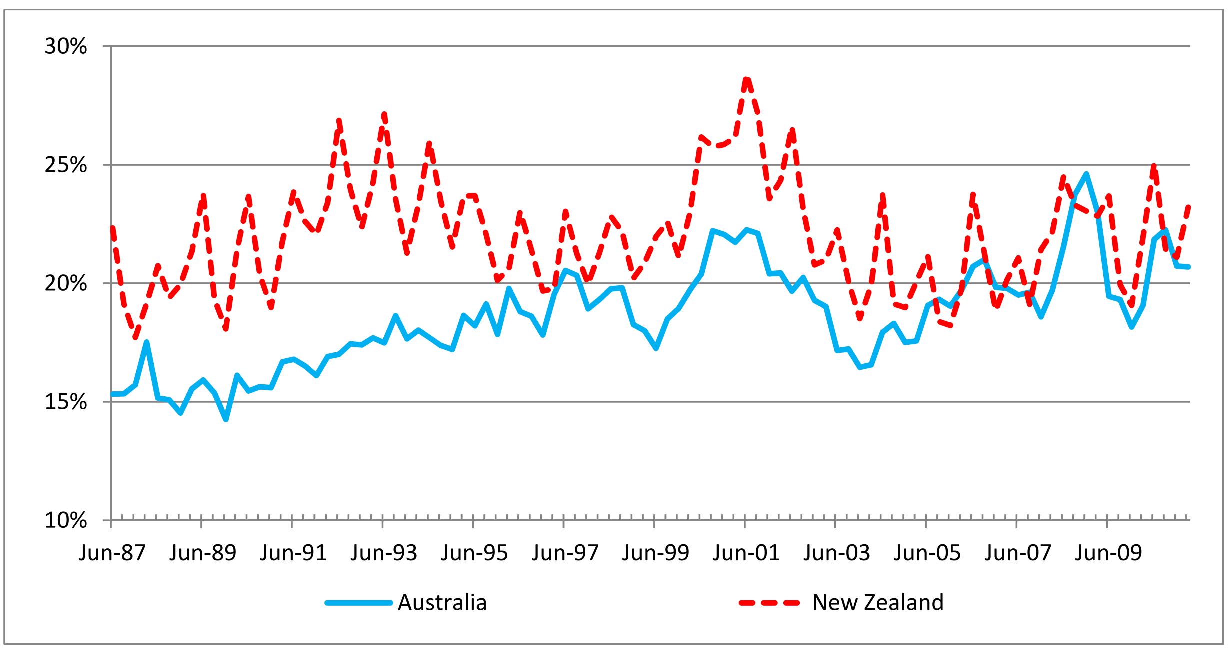
- Appendix A provides detailed and supplementary results.
- Appendix B provides the proof of Proposition 1.
- Appendix C provides evidence that the filtered local house rents are weakly correlated.
- Appendix D provides the detailed results for local house price for each city separately.
- Appendix E shows the dynamic response of local house price in the face of futures market commodity price changes.
- Appendix F provides more details about the construction of the energy versus non-energy, spot market versus futures market commodity price indices.
- Appendix G provides an illustration that Table 4a, 4b are indeed measuring the total effect.
- Appendix H provides the proof that the empirical model employed in the text is observationally equivalent to a richer model where government policies at different levels would respond to the contemporary period economic variables.
- Appendix I considers the dynamics response analysis for an extended model when the persistent effects of commodity prices are taken into consideration

## *A. Further Details and Results on the Australian and New Zealand macro-economies and housing markets*

Appendix A will provide more details about the Australia and New Zealand macroeconomic variables. Figure A1 shows the value of export relative to GDP in both Australia and New Zealand are very significant. Figures A2 and A3 further display the composition of export in the two countries and show that commodity exports constitute very significant proportion in both countries. Table A1 will provide more background information of the series we use, and Table A2 will provide some test results on the relationship between international trade and macro-economy in the two countries. Table A3 re-produces the weights on different commodities used in Chen and Rogoff (2003), Chen, Rogoff and Rossi (2010). Table A4 shows that the 17 cities included in our sample constitute the major share of New Zealand housing market as well as population. Table A5 provides the unit root test results for the time series used in the paper. Table A6 provides the detailed results of the first stage (i.e. national variables) regression. Table A7 provides the detailed results of the second stage (i.e. regional variables) regression.

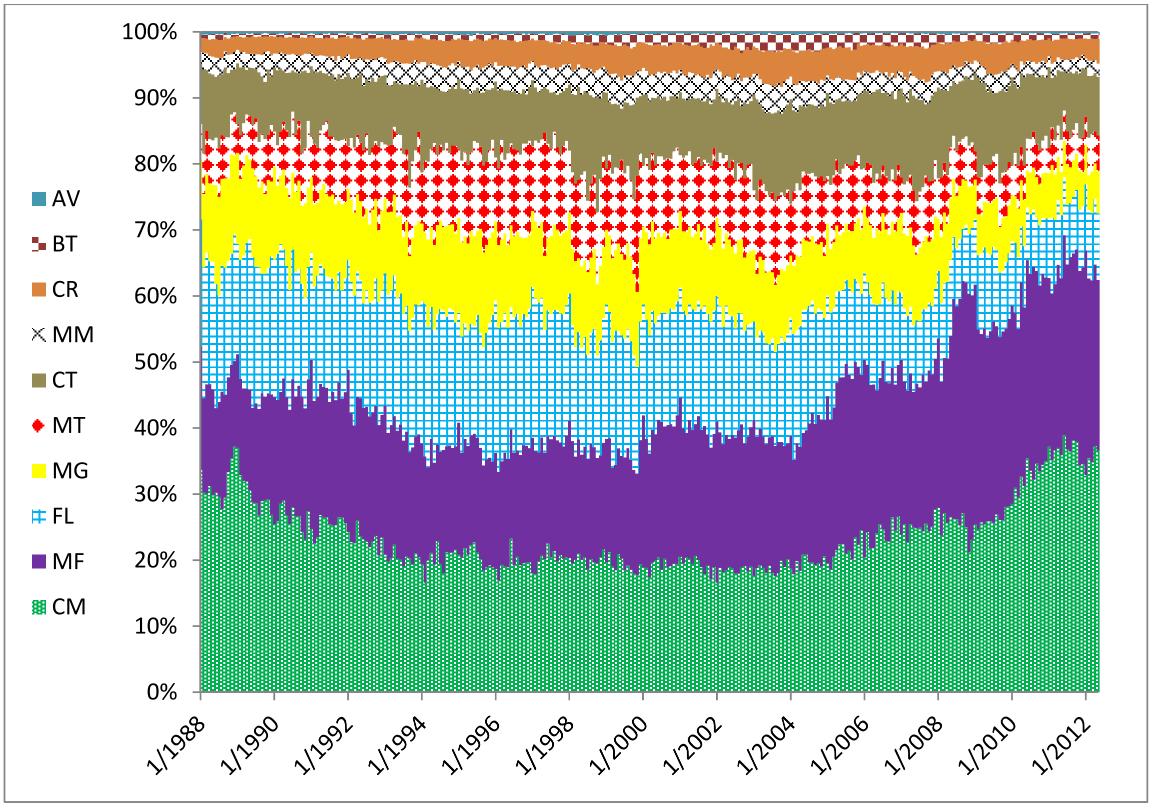
Figure A1 shows that export as a share of GDP is very important in both Australia and New Zealand. Figure A2 displays a decomposition of the exports of Australia, which shows that FL (Food and Live Animals), MF (Mineral Fuels, Lubricants and Related Materials) and CM (Crude Materials, Inedible, except Fuels) are the major export items and account for around two-thirds of the export value of Australia. Moreover, the share of FL has a downward trend and the other two items increase their shares. The other items are relatively stable. For New Zealand, Figure A3 shows that dairy products is the single largest export item accounting for 20~30% of total exports. Wood and paper products, meat products, agricultural and fishery primary products each account for roughly 10%. The category of Metal products, Machinery and Equipment, which combines both commodity and manufactured metallic products, accounts for 20%. Other export items include energy-related products, forestry primary products, textiles and leather products, chemicals, etc.

Figure A1: Value of exports relative to GDP in Australia and New Zealand




Sources: Australian Bureau of Statistics (www.abs.gov.au), Statistics New Zealand (http://www.stats.govt.nz)

Figure A2: Composition of Exports in Australia

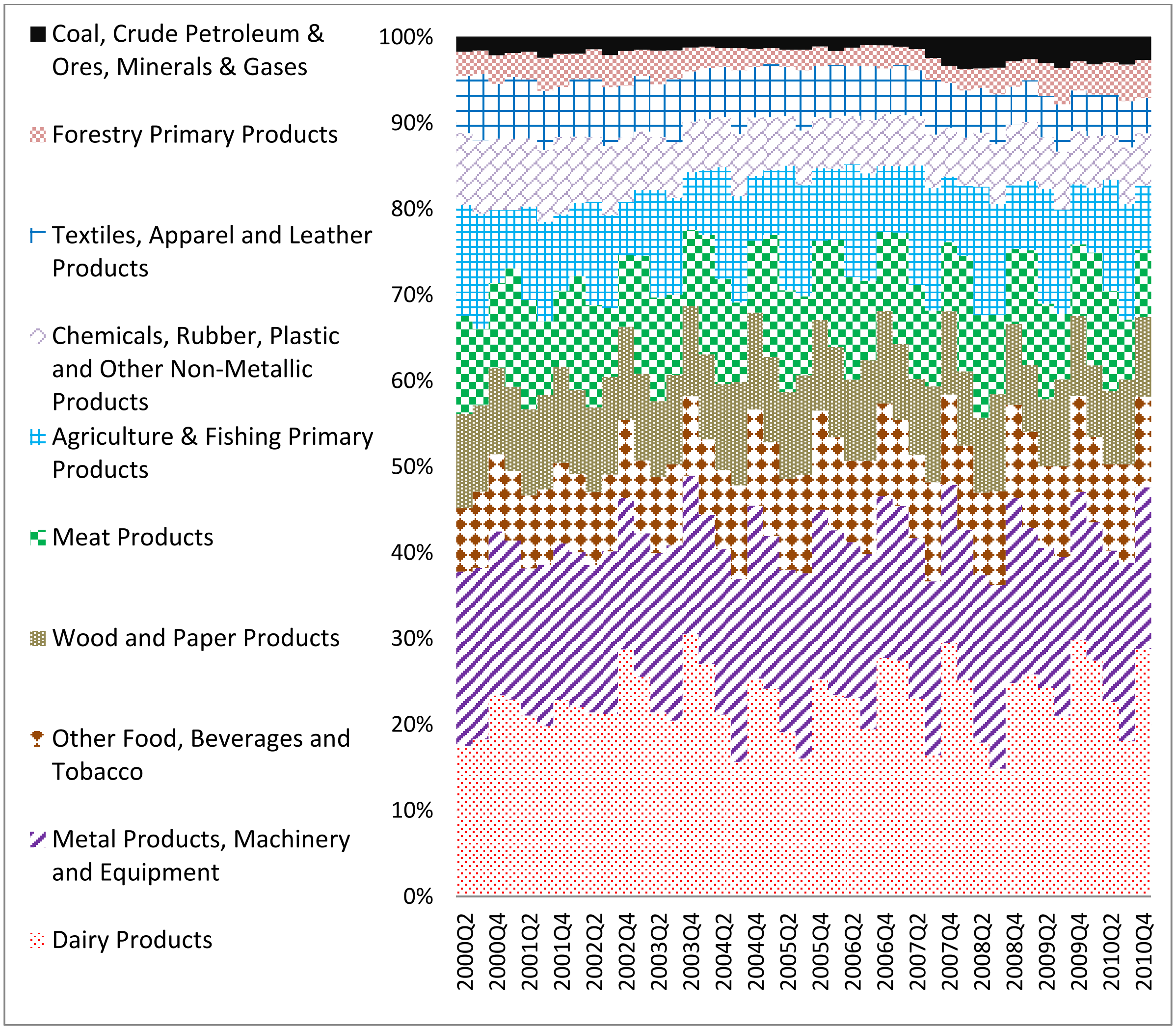



Keys:

AV = Animal and Vegetable Oils, Fats and Waxes; BT = Beverages & Tobacco; CR = Chemicals and Related Products; MM = Miscellaneous Manufactured Articles; CT = Commodities and Transactions; MT = Machinery and Transport Equipment; MG = Manufactured Goods Classified Chiefly by Material; FL = Food & Live Animals; MF = Mineral Fuels, Lubricants and Related Materials; CM = Crude Materials, Inedible, Except Fuels.

Source: Australian Bureau of Statistics (www.abs.gov.au)

Figure A3: Composition of Exports in New Zealand




Source: Statistics New Zealand (http://www.stats.govt.nz)

Table A1-1: Summary statistics of the National Variables

| | Australia | | New Zealand | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| National variables | | | | |
| Real GDP growth | 0.0085 | 0.0658 | 0.0025 | 0.0215 |
| Unemployment rate change | -0.0005 | 0.0770 | 0.0037 | 0.0709 |
| Net migration number | N/A | N/A | 0.2698 | 0.4581 |
| Real interest rate change | -0.0196 | 0.0851 | 0.0002 | 0.0422 |
| Real exchange rate change | -0.0032 | 0.0546 | -0.0011 | 0.0289 |
| Real stock price change | 0.0029 | 0.0709 | -0.0023 | 0.0413 |
| Real bank loan growth | 0.0275 | 0.0185 | 0.0071 | 0.0047 |
| Change of Debt-to-GDP ratio | 0.0053 | 0.0720 | N/A | N/A |
| Net capital flow-to-GDP ratio | 0.0031 | 0.0570 | N/A | N/A |
| Commodity prices | | | | |
| Spot market real energy com. price change | 0.0077 | 0.0899 | 0.0075 | 0.1132 |
| Spot market real non-energy com. price change | -0.0012 | 0.1001 | 0.0011 | 0.0216 |
| Futures market real energy com. price change | 0.0142 | 0.1928 | 0.0069 | 0.0976 |
| Futures market real non-energy com. price change | 0.0042 | 0.0664 | -0.0003 | 0.0503 |

Notes: Australian data is measured quarterly from 1988Q3 to 2011Q4; New Zealand data is measured monthly from 1994m1 to 2009m12. The futures market real non-energy commodity price for New Zealand is only available from 1998m2.

Table A1-2: Summary statistics of real housing price growth rates

| City | Min | Max | Average | Standard Deviation |
|---|---|---|---|---|
| *Panel A: Australia, 1988Q3-2011Q4* | | | | |
| ADE | -0.040 | 0.051 | 0.001 | 0.013 |
| BRI | -0.019 | 0.051 | 0.003 | 0.013 |
| CAN | -0.030 | 0.071 | 0.003 | 0.014 |
| DAR | -0.028 | 0.088 | 0.007 | 0.016 |
| HOB | -0.016 | 0.055 | 0.003 | 0.011 |
| MEL | -0.025 | 0.046 | 0.001 | 0.012 |
| PER | -0.069 | 0.067 | 0.004 | 0.019 |
| SYD | -0.029 | 0.057 | 0.001 | 0.011 |
| *Panel B: New Zealand, 1994M1-2009M12* | | | | |
| NS | -0.048 | 0.040 | 0.004 | 0.015 |
| WK | -0.045 | 0.039 | 0.004 | 0.016 |
| AK | -0.038 | 0.042 | 0.004 | 0.016 |
| MK | -0.055 | 0.040 | 0.003 | 0.017 |
| PK | -0.085 | 0.071 | 0.003 | 0.030 |
| HT | -0.049 | 0.040 | 0.003 | 0.017 |
| TR | -0.054 | 0.052 | 0.003 | 0.018 |
| HS | -0.090 | 0.076 | 0.002 | 0.027 |
| NP | -0.072 | 0.080 | 0.003 | 0.023 |
| PN | -0.056 | 0.045 | 0.002 | 0.017 |
| PR | -0.082 | 0.062 | 0.004 | 0.031 |
| UH | -0.082 | 0.080 | 0.004 | 0.030 |
| HT | -0.055 | 0.059 | 0.004 | 0.021 |
| WT | -0.051 | 0.053 | 0.004 | 0.016 |
| NL | -0.055 | 0.057 | 0.002 | 0.021 |
| CH | -0.035 | 0.046 | 0.003 | 0.012 |
| DN | -0.075 | 0.054 | 0.003 | 0.023 |

A few comments on Table A1-1, Table A1-2 are in order. Notice that the Australian data are in quarterly frequency and the New Zealand data are in monthly frequency, hence they are not directly comparable. Also, the relative weights of different commodity prices within the two countries' commodity price indices are also difference and hence we notice that the mean and standard deviation of the commodity price indices are not exactly the same across countries. Nonetheless, it is clear that there are several variables, including the real interest rate change, real exchange rate change, real stock price change; the energy as well as non-energy commodity price indices are often as volatile as the corresponding national real GDP growth. The city-level house prices in both Australia and New Zealand are also volatile. In most cases, the standard deviations are often larger than the corresponding means.

Table A2-1: Granger Causality Test for the Australian case

| Null Hypothesis: | Obs. | F-Statistic | Prob. |
|---|---|---|---|
| EXPORTS does not Granger Cause GDP (Lag = 4) | 205 | 6.24190 | 0.0001 |
| GDP does not Granger Cause EXPORTS (Lag = 4) | 205 | 18.7784 | 4.E-13 |
| IMPORTS does not Granger Cause GDP (Lag = 4) | 205 | 2.37253 | 0.0537 |
| GDP does not Granger Cause IMPORTS (Lag = 4) | 205 | 7.13570 | 2.E-05 |

Note: First differencing is used for EXPORTS, IMPORTS and GDP.

Again, Table A2-1 shows that GDP and Export *Granger cause each other*, and so are GDP and Import in Australia. As in the previous case, we choose the number of lags optimally based on Akaine Information Criterion (AIC).

Table A2-2: Granger Causality Test for the New Zealand case

| Null Hypothesis: | Obs | F-Statistic | Prob. |
|---|---|---|---|
| G_GDP does not Granger Cause G_EXPORTS (Lag =3) | 92 | 16.0292 | 2.E-08 |
| G_EXPORTS does not Granger Cause G_GDP (Lag =4) | 91 | 3.95921 | 0.0055 |
| G_GDP does not Granger Cause G_IMPORTS (Lag = 4) | 91 | 8.45183 | 9.E-06 |
| G_IMPORTS does not Granger Cause G_GDP (Lag = 1) | 94 | 36.8955 | 3.E-08 |

Key: G_GDP = Growth in real GDP; G_EXPORTS = Growth in real exports; G_IMPORTS = Growth in real imports

Table A2-2 shows that GDP and Export *Granger cause each other*, and so are GDP and Import in New Zealand. In our analysis, we choose the number of lags optimally based on Akaine Information Criterion (AIC).

Table A3: Commodities weight used by Chen, Rogoff (2003) / Chen, Rogoff and Rossi (2010)

(for Australia)

| | Weight |
|---|---|
| Non-energy commodity index | |
| Aluminium | 9.1% |
| Beef | 9.2% |
| Copper | 3.2% |
| Cotton | 3.4% |
| Gold | 19.9% |
| Iron ore | 10.9% |
| Lead | 1.3% |
| Nickel | 2.6% |
| Rice | 0.8% |
| Sugar | 5.9% |
| Wheat | 13.5% |
| Wool | 18.3% |
| Zinc | 1.8% |
| | |
| Energy commodity index | |
| Crude oil | 15.7% |
| Natural gas | 11.1% |
| Coal | 73.2% |

[@] The spot data of copper, gold, sugar, wheat is obtained from Datastream. Others are obtained from IFS.

[^] All commodity futures data is obtained from Datastream. Empty boxes means the data for corresponding sampling period is not available.

(for New Zealand)

| | |
|---|---|
| Dairy products (35.8%) | Wholemeal milk powder (10.6%) |
| | Cheese (8.3%) |
| | Casein (6.7%) |
| | Butter (6.5%) |
| | Skim milk powder (3.7%) |
| Metal products (8.3%) | Aluminium (8.3%) |
| Wood products (11.2%) | Sawn timber (4.6%) |
| | Logs (3.5%) |
| | Pulp (3.1%) |
| Other Agricultural products (44.7%) | Lamb (12.5%) |
| | Beef (9.4%) |
| | Wool (7.7%) |
| | Fish (6.7%) |
| | Kiwi (3.7%) |
| | Apples (3.1%) |
| | Skins (1.6%) |

[@] The spot data is obtained from the ANZ commodity price index and Datastream. All commodity futures data is obtained from Datastream and Global Finance Database.

Table A4: Population and dwellings for 17 New Zealand cities

| City | Population | Population share | No. of Dwellings | Dwellings share |
|---|---|---|---|---|
| NS | 205,605 | 5.1% | 72,114 | 5.0% |
| WK | 186,447 | 4.6% | 61,836 | 4.3% |
| AK | 404,658 | 10.0% | 143,004 | 9.8% |
| MK | 328,968 | 8.2% | 94,284 | 6.5% |
| PK | 45,183 | 1.1% | 14,823 | 1.0% |
| HT | 129,249 | 3.2% | 45,726 | 3.1% |
| TR | 103,632 | 2.6% | 39,954 | 2.7% |
| HS | 70,842 | 1.8% | 25,155 | 1.7% |
| NP | 55,359 | 1.4% | 21,450 | 1.5% |
| PN | 75,540 | 1.9% | 27,513 | 1.9% |
| PR | 48,546 | 1.2% | 15,396 | 1.1% |
| UH | 38,415 | 1.0% | 14,124 | 1.0% |
| HT | 97,701 | 2.4% | 35,364 | 2.4% |
| WT | 179,463 | 4.5% | 67,713 | 4.7% |
| NL | 42,888 | 1.1% | 16,920 | 1.2% |
| CH | 348,435 | 8.7% | 133,746 | 9.2% |
| DN | 118,683 | 2.9% | 44,394 | 3.1% |
| Total | 2,479,614 | 61.6% | 873,516 | 60.1% |

Notes: Population and dwellings are sourced from the 2006 census data published by Statistics New Zealand

<u>Table A5: ADF unit root test results</u>

Australia, 1988 Q3 –2011 Q4, quarterly

| Variables | | Level (constant) | | Level (constant & trend) | | 1st Difference (constant) | |
|---|---|---|---|---|---|---|---|
| *Log real house prices* | | | | | | | |
| | ADE | -0.876 | | -2.131 | | -5.052 | *** |
| | BRI | -0.817 | | -1.698 | | -6.660 | *** |
| | CAN | -1.485 | | -2.661 | | -4.193 | *** |
| | DAR | -0.637 | | -1.946 | | -8.200 | *** |
| | HOB | -0.710 | | -1.830 | | -2.895 | ** |
| | MEL | -0.640 | | -1.376 | | -8.769 | *** |
| | PER | -0.285 | | -4.285 | *** | -3.980 | *** |
| | SYD | -0.841 | | -1.539 | | -4.889 | *** |
| *Log real rents* | | | | | | | |
| | ADE | 0.098 | | -1.408 | | -15.904 | *** |
| | BRI | -0.289 | | -2.092 | | -12.518 | *** |
| | CAN | -0.147 | | -1.447 | | -2.852 | * |
| | DAR | -0.419 | | -1.422 | | -3.653 | *** |
| | HOB | 0.396 | | -1.041 | | -2.717 | * |
| | MEL | -0.791 | | -2.381 | | -4.000 | *** |
| | PER | 0.899 | | -1.494 | | -4.463 | *** |
| | SYD | -0.447 | | -2.378 | | -4.464 | *** |
| Log real GDP | | 0.936 | | -3.988 | ** | -3.852 | *** |
| Unemployment rate | | -2.129 | | -5.084 | *** | -2.993 | ** |
| Log real interest rate | | -1.393 | | -3.286 | * | -5.740 | *** |
| Log real exchange rate | | -1.456 | | -1.796 | | -7.729 | *** |
| Log real stock price | | -1.654 | | -2.223 | | -8.132 | *** |
| Log real bank loan | | -2.630 | * | -1.770 | | -8.676 | *** |
| Log debt-to-GDP ratio | | -1.624 | | -3.605 | ** | -5.019 | *** |
| Net capital flow-to-GDP ratio | | -13.878 | *** | -13.773 | *** | -10.941 | *** |
| Log real spot-market | | | | | | | |
| | non-energy comm. index | -2.453 | | -3.127 | | -7.262 | *** |
| | energy comm. Index | -1.331 | | -2.245 | | -6.078 | *** |
| Log real futures-market | | | | | | | |
| | non-energy comm. index | -0.024 | | -0.806 | | -8.452 | *** |
| | energy comm. Index | -0.875 | | -2.278 | | -9.302 | *** |

The optimum lag is determined by AIC criteria at a maximum lag of 4 quarters.
*** significant at 1% level; ** significant at 5% level; * significant at 10% level.

New Zealand, 1994m1 – 2009m12, monthly

| Variables | | Level (constant) | | Level (constant & trend) | | 1st Difference (constant) | |
|---|---|---|---|---|---|---|---|
| *Log real house prices* | | | | | | | |
| | NS | -1.140 | | -2.315 | | -3.496 | *** |
| | WK | -1.478 | | -2.116 | | -4.517 | *** |
| | AK | -1.369 | | -2.321 | | -4.304 | *** |
| | MK | -0.991 | | -2.055 | | -4.423 | *** |
| | PK | -1.931 | | -1.648 | | -19.860 | *** |
| | HT | -1.023 | | -1.765 | | -3.130 | ** |
| | TR | -1.218 | | -1.688 | | -3.450 | ** |
| | HS | -0.828 | | -1.932 | | -3.182 | ** |
| | NP | -0.808 | | -2.084 | | -3.210 | ** |
| | PN | -0.488 | | -1.928 | | -3.775 | *** |
| | PR | -0.283 | | -1.788 | | -14.633 | *** |
| | UH | -0.219 | | -2.520 | | -5.218 | *** |
| | HT | -0.659 | | -2.123 | | -5.275 | *** |
| | WT | -0.990 | | -2.257 | | -4.239 | *** |
| | NL | -0.853 | | -2.139 | | -3.813 | *** |
| | CH | -0.952 | | -2.290 | | -3.638 | *** |
| | DN | -0.419 | | -1.976 | | -4.398 | *** |
| *Log real rents* | | | | | | | |
| | NS | -1.379 | | -1.962 | | -5.375 | *** |
| | WK | -2.834 | * | -3.437 | ** | -23.590 | *** |
| | AK | -2.999 | ** | -3.193 | * | -3.210 | ** |
| | MK | -1.869 | | -1.908 | | -12.949 | *** |
| | PK | -2.548 | | -2.540 | | -10.886 | *** |
| | HT | -1.204 | | -2.009 | | -10.316 | *** |
| | TR | -0.857 | | -1.452 | | -11.494 | *** |
| | HS | 0.269 | | -2.057 | | -9.953 | *** |
| | NP | -0.786 | | -1.317 | | -9.415 | *** |
| | PN | 0.092 | | -1.437 | | -5.278 | *** |
| | PR | -1.088 | | -2.647 | | -7.411 | *** |
| | UH | 0.194 | | -1.329 | | -9.779 | *** |
| | HT | -0.390 | | -1.305 | | -7.566 | *** |
| | WT | -0.922 | | -1.501 | | -5.163 | *** |
| | NL | -0.071 | | -2.402 | | -9.905 | *** |
| | CH | -0.794 | | -1.481 | | -2.658 | * |
| | DN | -0.086 | | -1.561 | | -3.605 | *** |
| Log real GDP | | -1.290 | | -1.595 | | -3.098 | ** |
| Unemployment rate | | -1.778 | | -2.429 | | -4.528 | *** |
| Net migration | | -2.450 | | -2.392 | | -2.748 | * |
| Log real interest rate | | -2.217 | | -4.905 | *** | -7.540 | *** |
| Log real exchange rate | | -1.675 | | -1.744 | | -5.834 | *** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Log real stock prices | -1.921 | | -1.960 | | -14.008 | *** |
| Log real bank loans | -1.780 | | -1.056 | | -3.818 | *** |
| Log real spot-market | | | | | | |
| non-energy comm. index | -3.093 | ** | -3.634 | ** | -4.841 | *** |
| energy comm. Index | -1.425 | | -3.314 | * | -13.177 | *** |
| Log real futures-market | | | | | | |
| non-energy comm. index | -3.485 | *** | -3.520 | ** | -6.437 | *** |
| energy comm. Index | -1.314 | | -3.454 | ** | -4.612 | *** |

The optimum lag is determined by AIC criteria at a maximum lag of 12 months.
*** significant at 1% level; ** significant at 5% level; * significant at 10% level.

For New Zealand, the stationarity of net migration, real interest rates and non-energy commodity prices are not as clear. For instance, the net migration process will become stationary in levels if we relax the maximum lag in the ADF test from 12 to 14. The net migration is estimated at per 1000 people of exiting population and there is no good reason to believe the number of net migration is a unit root process. Using the quarterly data for the period 1962 to 2006, Coleman and Landon-Lane (2007) show that net migration series is indeed an I(0) process. As a result, we include the net migration as an I(0) process in our study. For the case of real interest rates, the ADF result show that the series itself could become stationary in levels if we add both a constant and a time trend in the unit root regression. To be compatible with other variables, we use the first difference for the real interest rate, which is stationary, in the regression. Finally, it is surprising that the non-energy commodity prices, both for the spot and futures markets, are I(0) processes. This is in sharp contrast to the energy commodity prices, which are I (1) processes. In fact, the non-energy commodity prices are simply aggregated export commodity prices. It is possible to become I(0) process at the aggregated level even though the individual commodity prices are still I(1) processes. In this study we use the first differences to non-energy commodity prices for our main reporting, but use the non-energy commodity price in levels for robustness check[29].

[29] The results for using the non-energy commodity price in levels are very similar to the results using the first differences. Further statistical results are available at request.

Table A6-1 Detailed Results of the 1st Stage Regression, Aggregate variables and commodity prices in Australia, 1988Q3 -2011Q4

| Variables | Real GDP growth rate | Change of unemployment | Change of debt/GDP ratio | Change of real interest rate | Change of real exchange rate | Change of real stock prices | Change of real bank loan | Net capital flow/GDP ratio |
|---|---|---|---|---|---|---|---|---|
| | | | | Panel A: Spot market commodity prices | | | | |
| Constant | 0.009 | -0.007 | 0.013 | -0.041 ** | -0.004 | 0.010 | 0.022 *** | 0.002 |
| ΔReal energy comm. price(t) | -0.113 | 0.014 | 0.130 | 0.160 | -0.096 | 0.037 | -0.021 | 0.012 |
| ΔReal energy comm. price(t-1) | 0.064 | -0.017 | -0.045 | -0.132 | 0.133 ** | -0.179 * | -0.008 | 0.084 |
| ΔReal non-energy comm. price(t) | -0.009 | 0.031 | -0.109 | 0.383 *** | -0.301 *** | 0.209 ** | 0.014 | 0.041 |
| ΔReal non energy comm. price(t-1) | 0.015 | -0.243 *** | -0.003 | 0.041 | 0.014 | 0.091 | -0.046 | 0.027 |
| Real GDP growth rate(t-1) | -0.652 ** | 0.427 | 0.618 ** | -0.293 | 0.095 | -0.166 | 0.074 | 0.078 |
| Change of unemployment(t-1) | -0.135 | 0.078 | 0.025 | 0.157 | -0.046 | -0.059 | -0.005 | 0.066 |
| Change of debt/GDP ratio(t-1) | 0.120 | -0.324 | -0.192 | -0.262 | 0.026 | 0.053 | 0.051 | 0.131 |
| Change of real interest rate(t-1) | -0.038 | -0.106 | 0.048 | -0.119 | -0.060 | -0.012 | -0.001 | -0.029 |
| Change of real exchange rate(t-1) | -0.014 | -0.044 | 0.052 | -0.096 | 0.082 | 0.209 | -0.095 | 0.104 |
| Change of real stock prices(t-1) | 0.052 | -0.202 ** | -0.026 | 0.042 | 0.090 | 0.092 | -0.001 | 0.063 |
| Change of real bank loan(t-1) | 0.120 | 0.113 | -0.386 | 0.821 * | -0.047 | -0.115 | 0.137 | 0.062 |
| Net capital flow/GDP ratio(t-1) | -0.107 | -0.007 | 0.098 | 0.012 | 0.004 | -0.084 | 0.060 | -0.099 |
| Adj. $R^2$ | 0.445 | 0.565 | 0.452 | 0.292 | 0.378 | 0.075 | -0.040 | -0.047 |
| No. obs. | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| | | | | Panel B: Futures market commodity prices | | | | |
| Constant | 0.005 | -0.002 | 0.018 * | -0.053 *** | 0.010 | 0.000 | 0.024 *** | 0.007 |
| ΔReal energy comm. price(t) | -0.023 | 0.022 | -0.014 | 0.195 *** | -0.099 *** | 0.056 | -0.005 | 0.003 |
| ΔReal energy comm. price(t-1) | 0.098 *** | -0.059 | -0.078 ** | -0.010 | -0.004 | -0.010 | -0.003 | -0.076 ** |
| ΔReal non-energy comm. price(t) | 0.222 *** | -0.059 | -0.241 *** | -0.047 | -0.280 *** | 0.121 | -0.034 | -0.092 |
| ΔReal non energy comm. price(t-1) | 0.156 * | -0.099 | -0.194 ** | 0.320 ** | -0.137 | 0.056 | 0.018 | 0.115 |
| Real GDP growth rate(t-1) | -0.944 *** | 0.467 | 0.899 *** | -0.321 | 0.060 | -0.145 | 0.007 | 0.182 |
| Change of unemployment(t-1) | -0.114 | 0.072 | -0.034 | 0.259 ** | -0.205 ** | 0.073 | -0.009 | 0.029 |
| Change of debt/GDP ratio(t-1) | -0.174 | -0.351 | 0.145 | -0.423 | 0.152 | -0.042 | -0.032 | 0.283 |
| Change of real interest rate(t-1) | -0.133 * | -0.145 | 0.120 | -0.066 | -0.056 | 0.012 | -0.019 | 0.100 |
| Change of real exchange rate(t-1) | 0.250 * | 0.077 | -0.249 * | 0.042 | -0.040 | 0.203 | -0.025 | -0.016 |
| Change of real stock prices(t-1) | 0.009 | -0.229 ** | -0.007 | 0.179 | 0.016 | 0.175 | -0.002 | 0.080 |
| Change of real bank loan(t-1) | 0.266 | -0.005 | -0.586 * | 1.178 *** | -0.424 | 0.152 | 0.107 | -0.058 |
| Net capital flow/GDP ratio(t-1) | -0.128 | -0.041 | 0.116 | 0.051 | -0.061 | -0.037 | 0.052 | -0.063 |
| Adj. $R^2$ | 0.564 | 0.543 | 0.535 | 0.291 | 0.257 | -0.050 | -0.069 | 0.029 |
| No. obs. | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |

Notes: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

Table A6-2 Detailed Results of the 1st Stage Regression, Aggregate variables and commodity prices in New Zealand, 1994m1 -2009m12

| Variables | Real GDP growth rate | Change of unemployment | Net migration | Change of real interest rate | Change of real exchange rate | Change of real stock | Change of real bank loan |
|---|---|---|---|---|---|---|---|
| | Panel A: Spot market commodity prices | | | | | | |
| Constant | 0.000 | 0.000 | 0.097 ** | -0.006 | 0.002 | -0.010 * | 0.002 *** |
| ΔReal energy comm. price(t) | -0.039 *** | 0.063 * | -0.039 | -0.006 | -0.033 * | 0.039 | 0.002 |
| ΔReal energy comm. price(t-1) | -0.007 | 0.091 ** | 0.260 | -0.037 | -0.023 | -0.031 | -0.003 |
| ΔReal non-energy comm. price(t) | -0.001 | 0.350 | 0.609 | 0.488 *** | -0.134 | 0.043 | -0.028 * |
| ΔReal non energy comm. price(t-1) | 0.098 | 0.167 | -2.255 * | -0.009 | 0.084 | 0.236 | 0.021 |
| Real GDP growth rate(t-1) | 0.438 *** | 0.219 | 1.741 * | -0.243 | -0.156 | 0.072 | 0.005 |
| Change of unemployment(t-1) | 0.008 | 0.642 *** | -0.356 | 0.101 ** | 0.034 | -0.152 *** | 0.000 |
| Net migration(t-1) | 0.006 * | 0.004 | 0.743 *** | 0.004 | -0.012 *** | 0.000 | 0.002 *** |
| Change of real interest rate(t-1) | 0.005 | -0.126 | 0.488 | 0.136 * | -0.055 | 0.021 | 0.008 |
| Change of real exchange rate(t-1) | 0.026 | 0.460 *** | -1.759 ** | -0.155 | 0.236 *** | -0.012 | -0.007 |
| Change of real stock prices(t-1) | -0.029 | 0.015 | -0.598 | -0.023 | -0.045 | -0.112 | 0.004 |
| Change of real bank loan(t-1) | 0.107 | -0.172 | -4.905 | 0.657 | 0.200 | 1.200 * | 0.597 *** |
| Adj. $R^2$ | 0.245 | 0.531 | 0.589 | 0.096 | 0.164 | 0.080 | 0.441 |
| No. obs. | 189 | 189 | 189 | 189 | 189 | 189 | 189 |
| | Panel B: Futures market commodity prices | | | | | | |
| Constant | -0.002 | -0.005 | 0.108 ** | -0.005 | 0.002 | -0.015 ** | 0.002 *** |
| ΔReal energy comm. price(t) | -0.018 | 0.106 ** | -0.057 | -0.012 | -0.070 *** | 0.009 | -0.003 |
| ΔReal energy comm. price(t-1) | 0.009 | 0.123 ** | 0.089 | 0.027 | -0.029 | 0.016 | -0.003 |
| ΔReal non-energy comm. price(t) | -0.051 | 0.118 | -0.528 | 0.041 | -0.023 | 0.066 | -0.007 |
| ΔReal non energy comm. price(t-1) | 0.003 | 0.005 | -0.342 | 0.114 | -0.001 | -0.054 | 0.003 |
| Real GDP growth rate(t-1) | 0.456 *** | 0.266 | 1.020 | -0.212 | -0.277 ** | 0.188 | -0.010 |
| Change of unemployment(t-1) | 0.011 | 0.634 *** | -0.543 | 0.090 * | 0.067 * | -0.137 *** | 0.002 |
| Net migration(t-1) | 0.008 ** | 0.005 | 0.717 *** | 0.008 | -0.013 ** | 0.002 | 0.002 *** |
| Change of real interest rate(t-1) | 0.043 | -0.147 | 0.241 | 0.099 | -0.010 | 0.075 | 0.010 |
| Change of real exchange rate(t-1) | 0.060 | 0.526 *** | -2.058 ** | -0.158 | 0.174 ** | 0.022 | -0.009 |
| Change of real stock prices(t-1) | -0.019 | 0.068 | -0.581 | 0.064 | -0.056 | -0.124 | 0.004 |
| Change of real bank loan(t-1) | 0.362 | 0.673 | -8.847 | 0.436 | 0.083 | 2.033 ** | 0.659 *** |
| Adj. $R^2$ | 0.273 | 0.522 | 0.569 | 0.048 | 0.181 | 0.081 | 0.472 |
| No. obs. | 142 | 142 | 142 | 142 | 142 | 142 | 142 |

Notes: *** significance at 1% level, ** significance at 5% level, * significance at 10% level.

Table A7-1: Local City Rent Regression for cities in Australian, 1988 Q3- 2011Q4 (2nd stage regression)

| | Panel A: Spot market commodity prices | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | Adelaide | Brisbane | Canberra | Darwin | Hobart | Melbourne | Perth | Sydney |
| Constant | 0.003 | 0.003 | 0.006 * | 0.010 | 0.005 * | 0.003 | 0.006 | -0.001 |
| ΔReal energy comm. price(t) | 0.032 | 0.025 | -0.054 | 0.042 | 0.024 | 0.018 | 0.045 | 0.005 |
| ΔReal energy comm. price(t-1) | 0.008 | -0.047 | 0.008 | -0.055 | -0.012 | -0.026 | 0.005 | 0.048 |
| ΔReal non-energy comm. price(t) | 0.011 | -0.007 | 0.031 | -0.105 | 0.039 | -0.014 | 0.040 | 0.048 |
| ΔReal non energy comm. price(t-1) | -0.075 * | 0.035 | 0.015 | 0.046 | -0.051 | -0.006 | -0.087 | -0.038 |
| Filtered GDP(t) | 0.364 * | -0.237 | 0.230 | 0.239 | 0.757 *** | 0.093 | -0.056 | 0.098 |
| Filtered GDP(t-1) | -0.102 | 0.091 | 0.507 *** | 0.203 | 0.273 | 0.362 | 0.222 | 0.272 |
| Filtered unemployment(t) | -0.027 | 0.096 | 0.124 * | -0.247 | 0.000 | -0.007 | -0.056 | 0.012 |
| Filtered unemployment(t-1) | -0.060 | -0.018 | 0.001 | 0.356 ** | -0.101 | -0.142 | 0.167 | 0.002 |
| Filtered net external debt(t) | 0.389 * | -0.247 | 0.110 | 0.412 | 0.686 *** | 0.230 | -0.120 | -0.160 |
| Filtered net external debt(t-1) | -0.204 | -0.068 | 0.157 | 0.283 | 0.036 | 0.253 | 0.139 | 0.069 |
| Filtered interest rate(t) | 0.004 | -0.074 | 0.037 | 0.231 * | 0.095 * | 0.049 | 0.001 | -0.033 |
| Filtered interest rate(t-1) | -0.028 | 0.074 | -0.006 | 0.110 | -0.046 | 0.153 * | 0.140 | 0.023 |
| Filtered exchange rate(t) | 0.002 | -0.059 | -0.096 | -0.232 | -0.262 ** | -0.108 | 0.078 | 0.165 * |
| Filtered exchange rate(t-1) | 0.070 | 0.019 | -0.002 | -0.181 | 0.107 | -0.160 | -0.042 | -0.190 * |
| Filtered stock prices(t) | 0.115 * | -0.005 | -0.092 * | -0.033 | 0.007 | 0.021 | 0.067 | 0.005 |
| Filtered stock prices(t-1) | -0.023 | -0.055 | 0.015 | 0.052 | 0.023 | -0.005 | -0.037 | -0.133 *** |
| Filtered bank loan(t) | -0.056 | 0.002 | -0.209 | -0.447 | -0.086 | -0.024 | -0.051 | 0.283 |
| Filtered bank loan(t-1) | -0.335 | -0.365 * | -0.255 | 1.321 * | -0.104 | -0.482 * | -0.451 | -0.843 *** |
| Filtered net capital flow(t) | 0.044 | -0.109 | 0.038 | 0.106 | 0.005 | 0.006 | 0.036 | -0.004 |
| Filtered net capital flow(t-1) | 0.029 | -0.133 | -0.007 | -0.278 * | -0.029 | -0.011 | -0.267 ** | -0.011 |
| City level rent(t-1) | -0.376 *** | -0.260 ** | -0.169 | -0.186 | -0.250 ** | -0.373 *** | -0.290 ** | -0.298 *** |
| Adj. $R^2$ | 0.193 | 0.071 | 0.213 | 0.003 | 0.263 | 0.051 | 0.060 | 0.437 |
| No. obs. | 91 | 91 | 91 | 70 | 91 | 91 | 91 | 91 |
| | Panel B: Futures market commodity prices | | | | | | | |
| Constant | 0.004 | 0.002 | 0.005 * | 0.006 | 0.005 * | 0.004 | 0.006 | -0.001 |
| ΔReal energy comm. price(t) | -0.006 | -0.002 | -0.002 | 0.023 | 0.010 | -0.024 | 0.000 | 0.015 |
| ΔReal energy comm. price(t-1) | -0.014 | -0.017 | -0.020 | -0.028 | -0.032 ** | -0.065 *** | -0.040 | -0.004 |
| ΔReal non-energy comm. price(t) | -0.042 | 0.062 | 0.009 | 0.044 | 0.028 | -0.148 ** | 0.105 | 0.029 |
| ΔReal non energy comm. price(t-1) | 0.057 | 0.016 | 0.120 ** | -0.024 | 0.149 *** | 0.144 ** | 0.063 | 0.119 ** |
| Filtered GDP(t) | 0.377 * | -0.220 | 0.175 | 0.221 | 0.676 *** | 0.209 | 0.050 | 0.191 |
| Filtered GDP(t-1) | 0.036 | 0.169 | 0.575 *** | 0.191 | 0.294 * | 0.333 | 0.176 | 0.289 |
| Filtered unemployment(t) | 0.016 | 0.038 | 0.104 | -0.265 | 0.000 | -0.027 | -0.004 | 0.014 |
| Filtered unemployment(t-1) | -0.077 | 0.043 | 0.047 | 0.237 | -0.035 | -0.123 | 0.138 | -0.008 |
| Filtered migration(t) | 0.411 ** | -0.203 | 0.095 | 0.299 | 0.617 *** | 0.302 | -0.039 | -0.052 |
| Filtered migration(t-1) | -0.100 | -0.002 | 0.169 | 0.259 | 0.070 | 0.303 | 0.087 | 0.056 |
| Filtered interest rate(t) | -0.005 | -0.057 | 0.047 | 0.115 | 0.060 | 0.030 | 0.025 | -0.021 |
| Filtered interest rate(t-1) | 0.006 | 0.108 * | 0.046 | 0.078 | -0.025 | 0.237 *** | 0.107 | 0.032 |
| Filtered exchange rate(t) | -0.052 | -0.044 | -0.119 | 0.065 | -0.230 ** | -0.193 * | 0.067 | 0.070 |
| Filtered exchange rate(t-1) | 0.034 | -0.080 | -0.034 | -0.123 | 0.109 | -0.173 | 0.100 | -0.139 |
| Filtered stock prices(t) | 0.108 * | -0.006 | -0.078 | -0.059 | 0.001 | -0.056 | 0.060 | 0.003 |
| Filtered stock prices(t-1) | -0.023 | -0.054 | -0.005 | 0.019 | 0.024 | 0.010 | -0.039 | -0.129 ** |
| Filtered bank loan(t) | 0.008 | -0.096 | -0.281 | -0.103 | -0.115 | -0.045 | 0.041 | 0.331 * |
| Filtered bank loan(t-1) | -0.353 | -0.329 | -0.222 | 0.288 | 0.017 | -0.624 *** | -0.557 * | -0.877 *** |
| Filtered net capital flow(t) | 0.050 | -0.119 | 0.075 | 0.031 | 0.001 | -0.161 | -0.019 | -0.012 |
| Filtered net capital flow(t-1) | 0.011 | -0.130 | -0.011 | -0.184 | -0.055 | 0.028 | -0.246 ** | 0.016 |
| City level rent(t-1) | -0.364 *** | -0.280 ** | -0.233 ** | -0.071 | -0.269 ** | -0.406 *** | -0.341 *** | -0.270 ** |
| Adj. $R^2$ | 0.172 | 0.077 | 0.221 | -0.125 | 0.291 | 0.264 | 0.080 | 0.423 |
| No. obs. | 91 | 91 | 91 | 70 | 91 | 91 | 91 | 91 |

Notes: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

## Table A7-2: Local City Rent Regression for cities in New Zealand, 1994m1 – 2009m12 (2nd stage regression)

| Variables | NS | WK | AK | MK | PK | HT | TR | HS | NP | PN | PR | UH | HT | WT | NL | CH | DN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Panel A: Spot market commodity prices | | | | | | | | | | | | | | | | |
| Constant | 0.002 | 0.001 | 0.002 | 0.002 | 0.002 | 0.001 | 0.002 | 0.001 | 0.002 | 0.000 | 0.002 | 0.002 | 0.001 | 0.002 | 0.002 | 0.001 | 0.002 |
| ΔReal energy comm. price(t) | 0.008 | -0.002 | 0.029 * | -0.020 | -0.014 | 0.013 | 0.010 | 0.003 | 0.010 | -0.042 * | 0.024 | -0.008 | -0.016 | -0.013 | -0.023 | -0.001 | -0.042 |
| ΔReal energy comm. price(t-1) | -0.012 | 0.005 | -0.012 | -0.031 * | -0.021 | -0.010 | -0.011 | 0.023 | 0.007 | -0.028 | -0.011 | -0.016 | 0.001 | -0.029 | -0.020 | -0.020 | -0.016 |
| ΔReal non-energy comm. price(t) | -0.097 | 0.064 | 0.104 | 0.236 ** | 0.090 | 0.057 | 0.037 | -0.091 | 0.038 | 0.195 | 0.059 | 0.170 | -0.084 | 0.128 | -0.042 | 0.051 | 0.307 * |
| ΔReal non energy comm. price(t-1) | 0.184 ** | -0.017 | -0.054 | -0.192 * | 0.018 | -0.042 | 0.061 | 0.167 | 0.045 | 0.078 | -0.112 | -0.010 | 0.167 | -0.037 | 0.078 | 0.008 | -0.283 * |
| Filtered GDP(t) | 0.050 | -0.014 | 0.117 | -0.115 | 0.036 | -0.194 ** | -0.163 * | 0.003 | -0.077 | 0.365 *** | 0.268 | 0.054 | 0.223 | -0.194 | -0.021 | -0.104 | -0.294 * |
| Filtered GDP(t-1) | -0.026 | -0.042 | -0.280 *** | 0.201 * | 0.039 | 0.118 | 0.171 * | -0.099 | 0.011 | -0.085 | 0.149 | 0.170 | -0.098 | -0.039 | 0.148 | -0.111 | 0.001 |
| Filtered unempolyment(t) | 0.010 | -0.012 | -0.065 | 0.012 | -0.058 | -0.015 | -0.084 ** | -0.001 | 0.005 | -0.006 | -0.017 | 0.079 | -0.013 | 0.029 | -0.025 | -0.059 * | 0.002 |
| Filtered unempolyment(t-1) | -0.015 | -0.006 | -0.121 *** | 0.034 | 0.011 | -0.023 | 0.004 | 0.024 | -0.009 | 0.051 | -0.099 | -0.147 *** | 0.022 | 0.001 | -0.021 | 0.095 *** | 0.072 |
| Filtered migration(t) | 0.010 | 0.001 | -0.005 | 0.001 | 0.006 | -0.007 | -0.002 | -0.007 | 0.001 | -0.008 | -0.001 | 0.010 | 0.010 | -0.004 | -0.005 | 0.002 | 0.015 |
| Filtered migration(t-1) | 0.007 | 0.013 *** | 0.006 | 0.002 | -0.006 | 0.006 | 0.006 | -0.008 | 0.005 | 0.015 * | -0.004 | -0.012 | -0.014 | 0.022 ** | 0.003 | 0.018 *** | 0.026 ** |
| Filtered interest rate(t) | 0.067 | 0.006 | -0.015 | 0.022 | 0.024 | -0.048 | -0.012 | 0.061 | 0.044 | 0.166 ** | -0.160 | 0.054 | -0.048 | -0.047 | 0.056 | -0.007 | 0.017 |
| Filtered interest rate(t-1) | -0.061 | 0.030 | -0.077 | -0.136 *** | -0.088 | -0.037 | 0.015 | 0.130 ** | -0.054 | -0.028 | 0.016 | -0.032 | 0.004 | 0.040 | 0.005 | 0.015 | -0.082 |
| Filtered exchange rate(t) | -0.017 | 0.021 | 0.100 | -0.020 | -0.118 | 0.027 | 0.014 | 0.299 *** | -0.049 | 0.022 | 0.125 | -0.052 | -0.121 | 0.028 | -0.045 | 0.012 | 0.114 |
| Filtered exchange rate(t-1) | -0.008 | -0.072 | -0.055 | -0.017 | 0.037 | -0.078 | 0.080 | -0.044 | 0.088 | 0.001 | -0.008 | 0.028 | -0.013 | 0.038 | 0.023 | -0.097 | -0.161 |
| Filtered stock prices(t) | 0.014 | 0.045 | -0.034 | 0.053 | -0.093 * | 0.008 | 0.027 | -0.045 | -0.014 | 0.028 | -0.089 | -0.070 | 0.026 | -0.138 * | -0.063 | -0.007 | 0.061 |
| Filtered stock prices(t-1) | 0.015 | -0.056 | -0.072 | -0.142 *** | -0.024 | -0.089 * | -0.001 | 0.146 ** | 0.042 | -0.126 * | -0.101 | -0.043 | -0.073 | -0.113 | 0.045 | -0.047 | -0.128 |
| Filtered bankloan(t) | 0.146 | -0.040 | -0.061 | 0.226 | 0.791 | 0.721 | -1.109 ** | 0.014 | 0.395 | -0.211 | -0.572 | 0.369 | 0.236 | 0.919 | -0.645 | 0.466 | 0.876 |
| Filtered bankloan(t-1) | 0.447 | 0.107 | -0.567 | 0.111 | 0.426 | 0.094 | -0.280 | 0.977 | 0.674 | -0.898 | 0.594 | 0.202 | 0.943 | 0.852 | 0.432 | -0.069 | 0.246 |
| City level rent(t-1) | -0.502 *** | -0.482 *** | -0.479 *** | -0.473 *** | -0.486 *** | -0.420 *** | -0.269 *** | -0.585 *** | -0.474 *** | -0.335 *** | -0.463 *** | -0.478 *** | -0.398 *** | -0.303 *** | -0.500 *** | -0.086 | -0.392 *** |
| Adj. $R^2$ | 0.204 | 0.232 | 0.271 | 0.242 | 0.197 | 0.162 | 0.094 | 0.353 | 0.193 | 0.147 | 0.167 | 0.243 | 0.137 | 0.075 | 0.213 | 0.076 | 0.166 |
| No. obs. | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 |
| | Panel B: Futures market commodity prices | | | | | | | | | | | | | | | | |
| Constant | 0.002 | 0.000 | 0.001 | 0.000 | 0.000 | 0.001 | 0.001 | 0.003 | 0.002 | 0.000 | 0.002 | 0.002 | 0.002 | 0.002 | 0.003 | 0.001 | 0.002 |
| ΔReal energy comm. price(t) | -0.023 | -0.003 | 0.022 | -0.018 | -0.009 | 0.019 | 0.013 | -0.020 | 0.010 | 0.014 | 0.012 | 0.002 | -0.029 | -0.054 * | -0.011 | -0.031 | 0.013 |
| ΔReal energy comm. price(t-1) | -0.021 | 0.008 | -0.034 | 0.004 | -0.012 | -0.041 ** | -0.006 | -0.002 | -0.005 | -0.011 | -0.006 | 0.024 | 0.027 | -0.032 | -0.025 | -0.019 | -0.001 |
| ΔReal non-energy comm. price(t) | 0.016 | -0.001 | 0.025 | 0.002 | -0.083 | -0.039 | 0.036 | -0.001 | -0.008 | 0.003 | -0.130 | 0.037 | 0.056 | 0.008 | -0.041 | 0.015 | -0.105 |
| ΔReal non energy comm. price(t-1) | -0.015 | 0.025 | -0.012 | 0.003 | 0.007 | 0.013 | -0.044 | 0.046 | 0.028 | -0.143 *** | 0.073 | -0.080 | -0.079 | 0.013 | 0.014 | -0.030 | 0.087 |
| Filtered GDP(t) | 0.092 | -0.073 | 0.104 | -0.115 | -0.007 | -0.465 *** | -0.179 | -0.087 | -0.101 | 0.551 *** | 0.240 | 0.202 | 0.026 | -0.523 *** | -0.054 | -0.144 | -0.422 * |
| Filtered GDP(t-1) | -0.160 | 0.057 | -0.410 *** | 0.327 ** | 0.183 | 0.185 | 0.202 * | -0.281 * | -0.086 | 0.097 | 0.141 | -0.045 | -0.179 | -0.188 | 0.290 * | -0.177 | 0.130 |
| Filtered unempolyment(t) | 0.022 | -0.004 | -0.037 | -0.013 | -0.044 | 0.004 | -0.067 * | 0.023 | -0.017 | 0.027 | 0.056 | 0.042 | 0.015 | 0.084 | -0.029 | 0.000 | -0.015 |
| Filtered unempolyment(t-1) | 0.014 | -0.015 | -0.097 ** | 0.032 | 0.032 | -0.009 | 0.017 | 0.091 * | 0.031 | 0.050 | -0.114 | -0.093 * | 0.045 | 0.071 | -0.052 | 0.107 *** | 0.033 |
| Filtered migration(t) | 0.010 | 0.001 | -0.008 | 0.011 | 0.009 | -0.003 | -0.001 | -0.002 | 0.001 | 0.001 | 0.005 | 0.015 | 0.011 | 0.000 | -0.001 | 0.006 | 0.015 |
| Filtered migration(t-1) | 0.007 | 0.011 ** | 0.001 | -0.002 | -0.006 | 0.011 * | 0.008 | -0.009 | 0.014 * | 0.013 | 0.002 | -0.008 | -0.011 | 0.031 *** | 0.012 | 0.019 *** | 0.032 ** |
| Filtered interest rate(t) | 0.090 | 0.008 | 0.030 | 0.041 | 0.075 | -0.010 | 0.010 | 0.076 | 0.037 | 0.153 ** | -0.105 | 0.023 | 0.094 | 0.032 | 0.009 | 0.065 | 0.036 |
| Filtered interest rate(t-1) | -0.026 | 0.009 | 0.015 | -0.115 * | -0.116 * | -0.057 | -0.024 | 0.237 *** | -0.009 | 0.084 | 0.028 | 0.026 | 0.057 | 0.100 | -0.017 | 0.055 | -0.159 |
| Filtered exchange rate(t) | -0.018 | 0.036 | 0.112 | 0.003 | -0.153 * | 0.011 | 0.047 | 0.260 *** | -0.080 | 0.052 | 0.112 | -0.058 | -0.129 | -0.075 | -0.010 | 0.044 | 0.170 |
| Filtered exchange rate(t-1) | -0.013 | -0.056 | -0.008 | 0.048 | 0.019 | -0.087 | 0.040 | -0.060 | 0.127 | -0.009 | 0.079 | -0.029 | -0.042 | -0.042 | 0.048 | -0.112 * | -0.219 |
| Filtered stock prices(t) | 0.011 | 0.027 | 0.017 | 0.074 | -0.121 * | 0.010 | 0.024 | -0.033 | -0.038 | 0.082 | -0.062 | 0.035 | 0.028 | -0.138 * | -0.126 * | 0.023 | 0.088 |
| Filtered stock prices(t-1) | 0.041 | -0.084 ** | -0.040 | -0.081 | -0.042 | -0.065 | -0.049 | 0.191 *** | 0.086 | -0.111 * | -0.077 | 0.018 | -0.139 | -0.174 ** | 0.067 | -0.041 | -0.169 * |
| Filtered bankloan(t) | 0.657 | 0.245 | 0.273 | 0.274 | 0.820 | 0.655 | -0.598 | -0.063 | -0.291 | 0.507 | 1.144 | -0.145 | 0.881 | 2.171 ** | -0.276 | 1.124 * | 1.010 |
| Filtered bankloan(t-1) | 0.223 | 0.250 | -0.427 | -0.109 | 0.335 | 1.061 | -0.179 | 1.574 * | 0.902 | -0.924 | -0.562 | 0.008 | 1.466 | 1.545 | 1.233 | 0.021 | 0.973 |
| City level rent(t-1) | -0.506 *** | -0.558 *** | -0.531 *** | -0.524 *** | -0.521 *** | -0.380 *** | -0.243 *** | -0.597 *** | -0.448 *** | -0.441 *** | -0.457 *** | -0.437 *** | -0.371 *** | -0.360 *** | -0.531 *** | -0.078 | -0.358 *** |
| Adj. $R^2$ | 0.186 | 0.289 | 0.269 | 0.245 | 0.245 | 0.225 | 0.061 | 0.388 | 0.207 | 0.293 | 0.154 | 0.176 | 0.126 | 0.162 | 0.242 | 0.108 | 0.177 |
| No. obs. | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 |

Notes: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

B. Proof of the Proposition 1

This appendix attempts to prove the formulae used in the section of dynamic analysis. Recall the national equation, the regional equation and the city-level housing equation are respectively,

(1) $V_t^n = A_0 + A_1 P_t^c + A_2 P_{t-1}^c + A_3 V_{t-1}^n + \widetilde{V_t^n}$

(2) $V_{j,t}^r = B_{0,j} + B_1 P_t^c + B_2 P_{t-1}^c + B_3 \widetilde{V_t^n} + B_4 \widetilde{V_{t-1}^n} + B_5 V_{j,t-1}^r + \widetilde{V_{j,t}^r}$ , $j$ = 1, 2, …[30]

To facilitate the algebraic manipulation, we can re-write (2) in the matrix form,

(2') $\overrightarrow{V_t^r} = \overrightarrow{B_0} + B_1^M P_t^c + B_2^M P_{t-1}^c + B_3^M \widetilde{V_t^n} + B_4^M \widetilde{V_{t-1}^n} + B_5^M \overrightarrow{V_{t-1}^r} + \overrightarrow{V_t^{rr}}$

where, with some abuse of the notations, $\overrightarrow{V_t^r}$ is the row vector of all city-level regional variables, $\overrightarrow{V_t^r} = \begin{pmatrix} V_{1,t}^r \\ V_{2,t}^r \\ \vdots \end{pmatrix}$, $\overrightarrow{B_0}$ is the row vector of intercept, $B_i^M$ is a matrix, where each row is identically $B_i$, $i$ =1,2,,…, and has the same number of rows as the vector $\overrightarrow{V_t^r}$,[31] $\overrightarrow{V_t^{rr}}$ is the vector of the residual term in this regional vector equation.

Similarly, we can re-write (3) in the matrix form, (3')

(3') $\overrightarrow{HP_t} = \overrightarrow{C_0} + C_1^M \overrightarrow{HP_{t-1}} + C_2^M \widetilde{V_t^n} + C_3^M \overrightarrow{V_t^{rr}} + C_4^M P_t^c + C_5^M P_{t-1}^c + C_6^M \vec{S} + \overrightarrow{U_t}$

where, with some abuse of the notations, $\overrightarrow{HP_t}$ is the row vector of all city-level house price,

---

[30] In the case of Australia, $j$=1,2,…,8 and for the case of New Zealand, $j$=1,2,…,17.

[31] For instance, if $\overrightarrow{V_t^r}$ is a row vector, $n_1 \times 1$, and say $P_t^c$ is another row vector, $n_2 \times 1$. Then $B_1^M$ is a matrix with dimension $n_1 \times n_2$.

$\overrightarrow{HP_t} = \begin{pmatrix} HP_{1,t} \\ HP_{2,t} \\ \vdots \end{pmatrix}$, $\overrightarrow{C_0}$ is the row vector of fixed effect for different cities, $C_1^M$ is a matrix of coefficients, whose diagonal elements describe the impact of own lag effect, and the off-diagonal elements measure the lagged effect of other cities house price, i.e. $\{\widehat{C_{j,k}}\}_{j,k,k\neq j}$, $C_i^M$ is a matrix, where each row is identically $C_i$, $i$ = 2,3,4,…, and has the same number of rows as the vector $\overrightarrow{HP_t}$, $\vec{S}$ is the row vector of seasonal dummies, $\overrightarrow{U_t}$ is the vector of the error term.

Notice also that in (1), $V_t^n$ is a column vector and the dimension of $V_t^n$, $V_{t-1}^n$ must be the same. It follows that $A_3$ must be a square matrix. Thus, we can re-write (1) as

(1') $\widetilde{V_t^n} = (I - A_3 L)V_t^n - A_0 - (A_1 + A_2 L)P_t^c$

where $I$ is simply the identity matrix, $L$ is the lag operator, such that $Lc = c$ for any constant $c$, and for any $x_t$, $Lx_t = x_{t-1}$.[32] Similarly, we can re-write (2') as

(2'') $(I - B_5^M L)\overrightarrow{V_t^r} = \overrightarrow{B_0} + (B_1^M + B_2^M L)P_t^c + (B_3^M + B_4^M L)\widetilde{V_t^n} + \overrightarrow{V_t^{rr}}$

And re-write (3') as

(3'') $(I - C_1^M L)\overrightarrow{HP_t} = \overrightarrow{C_0} + C_2^M \widetilde{V_t^n} + C_3^M \overrightarrow{V_t^{rr}} + (C_4^M + C_5^M L)P_t^c + C_6^M \vec{S} + \overrightarrow{U_t}$,

Combining (1') and (2''), we have (2$^{(3)}$)

$$\overrightarrow{V_t^{rr}} = (I - B_5^M L)\overrightarrow{V_t^r} - \left[\overrightarrow{B_0} - (B_3^M + B_4^M L)A_0\right] - [(B_1^M + B_2^M L) - (B_3^M + B_4^M L)(A_1 + A_2 L)]P_t^c - (B_3^M + B_4^M L)(I - A_3 L)V_t^n$$

[32] Lag operator has been widely used in economics. Sargent (1979), among others, provides an early textbook treatment for the related issues.

We can now combine (1'), ($2^{(3)}$) with (3'') and get

$$
\begin{aligned}
(I - C_1^M L)\overrightarrow{HP_t} = \overrightarrow{C_0} + C_2^M[(I - A_3L)V_t^n - A_0 - (A_1 + A_2L)P_t^c] \\
+C_3^M\{(I - B_5^M L)\overrightarrow{V_t^r} - \left[\overrightarrow{B_0} - (B_3^M + B_4^M L)A_0\right] - [(B_1^M + B_2^M L) - \\
(B_3^M + B_4^M L)(A_1 + A_2L)]P_t^c \; -(B_3^M + B_4^M L)(I - A_3L)V_t^n\} \\
+(C_4^M + C_5^M L)P_t^c + C_6^M\vec{S} + \overrightarrow{U_t},
\end{aligned}
$$

which can be simplified as ($3^{(3)}$),

$$
\begin{aligned}
(I - C_1^M L)\overrightarrow{HP_t} = [\overrightarrow{C_0} - C_2^M A_0 - C_3^M\left[\overrightarrow{B_0} - (B_3^M + B_4^M L)A_0\right]] \\
+[C_2^M(I - A_3L) - C_3^M(B_3^M + B_4^M L)(I - A_3L)]V_t^n + C_3^M(I - B_5^M L)\overrightarrow{V_t^r} \\
+[-C_2^M(A_1 + A_2L) - C_3^M[(B_1^M + B_2^M L) - (B_3^M + B_4^M L)(A_1 + A_2L)] + \left(C_4^M + C_5^M L\right)]P_t^c \\
+C_6^M\vec{S} + \overrightarrow{U_t}
\end{aligned}
$$

Now we assume that $(I - C_1^M L)^{-1}$ exists. We can then multiply both sides of ($3^{(3)}$) by $(I - C_1^M L)^{-1}$ and obtain the equation we need.

$$
\overrightarrow{HP_t} = C_0(L) + C_1(L)V_t^n + C_2(L)\overrightarrow{V_t^r} + C_3(L)P_t^c + C_4(L)\vec{S} + \overrightarrow{U_t}
$$

where

$$
\begin{aligned}
C_0(L) &= (I - C_1^M L)^{-1}\,\{\overrightarrow{C_0} - C_2^M A_0 - C_3^M\left[\overrightarrow{B_0} - (B_3^M + B_4^M L)A_0\right]\} \\
C_1(L) &= (I - C_1^M L)^{-1}\,\{C_2^M(I - A_3L) - C_3^M(B_3^M + B_4^M L)(I - A_3L)\} \\
C_2(L) &= (I - C_1^M L)^{-1}\,C_3^M(I - B_5^M L) \\
C_3(L) &= (I - C_1^M L)^{-1}\,\{-C_2^M(A_1 + A_2L) - C_3^M[(B_1^M + B_2^M L) - (B_3^M + B_4^M L)(A_1 + A_2L)] + (C_4^M + C_5^M L)\} \\
C_4(L) &= (I - C_1^M L)^{-1}\,C_6^M
\end{aligned}
$$

Notice that $(I - C_1^M L)^{-1}$ is actually a polynomial,

$$(I - C_1^M L)^{-1} = I + (C_1^M L) + (C_1^M L)^2 + \cdots$$

Thus, we have,

$$\Delta\left(\overrightarrow{HP_t}\right) = C_3(L)\Delta(P_t^c).$$

Notice that

$$C_3(L) = (I - C_1^M L)^{-1}\{[-C_2^M A_1 - C_3^M(B_1^M - B_3^M A_1) + C_4] + [-C_2^M A_2 - C_3^M(B_2^M - B_3^M A_2 - B_4^M A_1) + C_5]L + C_3^M B_4^M A_2 \mathrm{L}^2\},$$

*where*

$$C_0^R = [-C_2^M A_1 - C_3^M(B_1^M - B_3^M A_1) + C_4]$$
$$C_1^R = [-C_2^M A_2 - C_3^M(B_2^M - B_3^M A_2 - B_4^M A_1) + C_5]$$
$$C_2^R = C_3^M B_4^M A_2$$

Hence,

$$C_3(L) = (I - C_1^M L)^{-1}\{C_0^R + C_1^R L + C_2^R L^2\}$$
$$= C_0^R + (C_1^R + C_1^M C_0^R)L + \textstyle\sum_{j=2}[(C_1^M)^{j-2} C_2^R + (C_1^M)^{j-1} C_1^R + \left(C_1^M\right)^j C_0^R\big]L^j.$$

Substituting this expression into the formula, $\Delta\left(\overrightarrow{HP_t}\right) = C_3(L)\Delta(P_t^c)$, we can therefore trace how the house prices change with an once-and-for-all change in commodity prices.

C. Correlations of filtered local house rents

In this appendix, we present some further results. Table C1 and C2 show that the correlations among the rent in different cities in Australia and New Zealand are relatively weak.

Table C1: Correlations among filtered rent – 8 Australian cities

| | ADE | BRI | CAN | DAR | HOB | MEL | PER | SYD |
|---|---|---|---|---|---|---|---|---|
| ADE | 1.000 | 0.302** | -0.072 | 0.153 | 0.018 | 0.095 | 0.261 | 0.078 |
| BRI | 0.336*** | 1.000 | 0.264** | 0.033 | 0.173 | 0.015 | 0.101 | 0.075 |
| CAN | -0.009 | 0.251** | 1.000 | 0.069 | 0.114 | 0.094 | 0.044 | 0.042 |
| DAR | 0.157 | 0.112 | 0.062 | 1.000 | 0.076 | 0.167 | 0.142 | -0.051 |
| HOB | 0.050 | 0.159 | 0.091 | 0.097 | 1.000 | 0.296*** | 0.131 | 0.008 |
| MEL | 0.161 | 0.008 | 0.080 | 0.047 | 0.326*** | 1.000 | 0.342*** | 0.241** |
| PER | 0.283** | 0.119 | 0.005 | 0.179 | 0.197 | 0.287** | 1.000 | 0.138 |
| SYD | 0.078 | 0.087 | 0.008 | -0.012 | 0.020 | 0.237** | 0.138 | 1.000 |

Notes: the lower triangle indicates for the results filtered by spot market commodity prices; the upper triangle indicates the results filtered by future commodity prices.
*** significance at 1% level, ** significance at 5% level

Table C2: Correlation among filtered rent – 17 New Zealand cities

| | NS | WK | AK | MK | PK | HT | TR | HS | NP | PN | PR | UH | HT | WT | NL | CH | DN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NS | 1.000 | 0.055 | 0.143 | 0.168 ** | 0.033 | 0.256 *** | 0.009 | 0.072 | 0.087 | 0.002 | 0.116 | -0.093 | 0.091 | 0.049 | 0.258 *** | 0.085 | -0.011 |
| WK | 0.047 | 1.000 | 0.040 | -0.070 | -0.001 | -0.095 | -0.013 | 0.069 | 0.020 | 0.075 | -0.219 *** | 0.002 | 0.152 | 0.078 | 0.189 ** | 0.150 | 0.006 |
| AK | 0.158 ** | -0.030 | 1.000 | 0.096 | 0.031 | 0.252 *** | 0.080 | 0.016 | 0.097 | 0.214 *** | 0.021 | 0.032 | 0.032 | 0.064 | -0.005 | 0.137 | 0.118 |
| MK | 0.175 ** | -0.047 | 0.081 | 1.000 | -0.027 | -0.006 | 0.075 | 0.095 | -0.024 | 0.113 | 0.163 | 0.110 | 0.024 | -0.075 | 0.142 | 0.185 ** | 0.164 |
| PK | 0.011 | 0.007 | 0.018 | 0.011 | 1.000 | 0.078 | 0.227 *** | 0.008 | -0.013 | -0.105 | 0.138 | 0.143 | 0.068 | 0.213 *** | 0.071 | 0.037 | 0.049 |
| HT | 0.224 *** | -0.019 | 0.145 ** | 0.011 | 0.070 | 1.000 | 0.004 | 0.040 | 0.046 | 0.038 | 0.143 | 0.144 | 0.121 | 0.072 | 0.017 | 0.072 | 0.144 |
| TR | -0.026 | 0.095 | 0.050 | 0.003 | 0.114 | 0.041 | 1.000 | 0.064 | 0.091 | 0.074 | 0.142 | 0.057 | 0.039 | 0.083 | 0.091 | 0.114 | 0.101 |
| HS | 0.029 | -0.036 | 0.013 | 0.200 *** | -0.016 | 0.046 | -0.047 | 1.000 | 0.014 | 0.081 | 0.115 | -0.039 | 0.185 ** | -0.060 | 0.097 | 0.123 | 0.009 |
| NP | 0.079 | -0.011 | 0.112 | 0.019 | 0.000 | 0.063 | -0.037 | 0.065 | 1.000 | -0.006 | 0.061 | 0.045 | -0.071 | 0.146 | -0.008 | 0.100 | 0.027 |
| PN | -0.021 | -0.019 | 0.184 ** | 0.021 | -0.130 | -0.056 | -0.004 | 0.129 | 0.023 | 1.000 | -0.152 | -0.150 | 0.121 | -0.002 | -0.014 | 0.304 *** | 0.127 |
| PR | 0.119 | -0.111 | 0.032 | 0.182 ** | 0.061 | 0.082 | 0.201 *** | 0.101 | 0.091 | -0.118 | 1.000 | 0.068 | 0.091 | 0.104 | 0.103 | -0.025 | 0.052 |
| UH | -0.065 | -0.083 | -0.012 | 0.056 | 0.069 | 0.029 | 0.015 | -0.058 | 0.007 | -0.066 | -0.096 | 1.000 | -0.139 | -0.220 *** | -0.214 ** | -0.059 | -0.016 |
| HT | 0.079 | 0.129 | 0.006 | -0.017 | 0.066 | 0.055 | 0.041 | 0.120 | -0.067 | -0.016 | 0.114 | -0.164 ** | 1.000 | 0.238 | 0.174 ** | 0.212 ** | 0.129 |
| WT | 0.080 | 0.058 | 0.033 | -0.160 ** | 0.203 *** | 0.082 | 0.081 | -0.107 | 0.083 | -0.006 | 0.030 | -0.131 | 0.115 | 1.000 | 0.159 | 0.257 *** | 0.080 |
| NL | 0.219 *** | 0.179 ** | -0.022 | 0.122 | 0.047 | 0.053 | 0.143 ** | 0.083 | 0.066 | -0.011 | 0.144 ** | -0.179 ** | 0.109 | 0.104 | 1.000 | 0.166 ** | -0.049 |
| CH | 0.093 | 0.042 | 0.147 ** | 0.180 ** | 0.043 | 0.141 | 0.110 | 0.135 | 0.090 | 0.342 *** | 0.003 | -0.079 | 0.134 | 0.200 *** | 0.116 | 1.000 | 0.011 |
| DN | -0.037 | 0.017 | 0.102 | 0.043 | 0.044 | 0.083 | 0.091 | -0.011 | 0.046 | 0.089 | 0.019 | -0.013 | 0.104 | 0.068 | -0.040 | 0.028 | 1.000 |

Notes: the lower triangle indicates for the results filtered by spot market commodity prices; the upper triangle indicates the results filtered by future commodity prices.
*** significance at 1% level, ** significance at 5% level

D. Results on City-level House Price Changes

In this appendix, we will run the regression on the house price of each city separately; taking consideration that there may be "spatial correlations" among different cities within the same country. To avoid the possible endogeneity bias, we use the lagged values of other city house price on the right hand side. Thus, we modify the original regression model in (3)

$$HP_{j,t} = C_{0,j} + C_1 HP_{j,t-1} + C_2 \widetilde{V_t^n} + C_3 \widetilde{V_t^r} + C_4 P_t^c + C_5 P_{t-1}^c + C_{6,i} S_i + U_{j,t}, j = 1, 2, \dots, 17 \qquad (3)$$

as the follows:

$$HP_{j,t} = C_{0,j} + C_1 HP_{j,t-1} + \sum_{k \neq j} \widehat{C_k}\, HP_{k,t-1} + C_2 \widetilde{V_t^n} + C_3 \widetilde{V_t^r} + C_4 P_t^c + C_5 P_{t-1}^c + \sum_i C_{6i} S_i + U_{jt}, j = 1, 2, \dots$$

In our implementation, we use all 8 city data series for Australia. For New Zealand, however, our sample is too small to identify all possible spatial and temporal dependence among all 17 city level house price series. In addition, as previous research has confirmed, "ripple effect" exists among New Zealand city level house prices (among others, see Shi et al, 2009). It means that the house prices in small cities follow the counterpart in the "large cities". In light of these considerations, we allow for the city-level house price to depend on only 3 major cities, which are Auckland (AK), Wellington (WH) and Christchurch (CH).

Table D1: City level results for the 3rd stage regression with spatial correlations – Australia (Spot Market)

| | Ade | Bri | Can | Dar | Hob | Mel | Per | Syd |
|---|---|---|---|---|---|---|---|---|
| *Dependant variable is the real city level house price change* | | | | | | | | |
| Intercept | 0.0073 | 0.0037 | -0.0064 | 0.0167 *** | 0.0036 | 0.0007 | 0.0019 | 0.0015 |
| Δreal house price Ade(-1) | 0.2382 | -0.1475 | -0.0543 | 0.0375 | 0.0741 | -0.0032 | 0.0510 | 0.0989 |
| Δreal house price Bri(-1) | -0.0806 | 0.1625 | -0.1158 | -0.2598 | 0.0316 | -0.1919 | -0.2171 | -0.0669 |
| Δreal house price Can(-1) | 0.0767 | 0.2040 * | 0.5351 *** | 0.3074 * | 0.1365 | -0.0567 | -0.0114 | 0.0665 |
| Δreal house price Dar(-1) | -0.2624 ** | 0.0407 | -0.0816 | 0.1151 | 0.0023 | -0.0056 | -0.2194 * | 0.0058 |
| Δreal house price Hob(-1) | -0.1416 | 0.0346 | -0.0708 | -0.0032 | 0.1033 | 0.0579 | 0.0802 | -0.0327 |
| Δreal house price Mel(-1) | -0.1401 | -0.1113 | -0.3569 ** | -0.5184 *** | -0.2248 | -0.1028 | -0.2164 | 0.0339 |
| Δreal house price Per(-1) | -0.0812 | -0.0587 | -0.2323 ** | 0.2936 ** | -0.0225 | -0.0888 | 0.5611 *** | 0.0275 |
| Δreal house price Syd(-1) | 0.4946 ** | 0.2128 | 0.4703 ** | -0.1545 | 0.0949 | 0.5281 *** | 0.1795 | -0.0545 |
| Filtered GDP | -0.0364 | 0.0413 | 0.2248 ** | -0.0707 | 0.0007 | 0.1337 | 0.0527 | 0.0221 |
| Filtered unemployment | -0.0733 ** | -0.0660 ** | -0.0164 | -0.0001 | -0.0462 | -0.0556 * | -0.0297 | -0.0259 |
| Filtered external debt | 0.0586 | 0.0974 | 0.1420 ** | 0.1302 * | 0.0826 | 0.1208 * | 0.0526 | 0.0505 |
| Filtered interest rate | 0.0150 | 0.0222 | 0.0227 | 0.0326 | -0.0158 | 0.0239 | 0.0218 | 0.0193 |
| Filtered exchange rate | 0.0229 | -0.0103 | 0.0250 | -0.0292 | -0.0546 | -0.0281 | 0.0346 | 0.0037 |
| Filtered stock prices | 0.0102 | -0.0070 | 0.0455 ** | -0.0094 | 0.0298 | 0.0356 * | -0.0022 | 0.0084 |
| Filtered bankloan | 0.1245 | 0.0917 | 0.0734 | 0.2031 | -0.0223 | -0.0115 | 0.0134 | 0.0151 |
| Filtered net capital flow | -0.0233 | 0.0533 * | 0.0337 | 0.0080 | 0.0221 | 0.0832 *** | 0.0029 | 0.0511 * |
| Filtered city level rents | 0.0882 * | 0.1058 ** | 0.1137 ** | 0.0590 | -0.0317 | -0.0072 | 0.0599 | 0.0487 |
| ΔReal energy comm. price(t) | 0.0074 | 0.0258 | -0.0040 | 0.0309 | 0.0044 | 0.0070 | -0.0123 | 0.0134 |
| ΔReal energy comm. price(t-1) | 0.0062 | 0.0029 | 0.0181 | -0.0029 | -0.0006 | -0.0021 | 0.0194 | -0.0053 |
| ΔReal non-energy comm. price(t) | 0.0325 * | 0.0191 | 0.0337 ** | 0.0138 | 0.0115 | 0.0241 | 0.0357 * | 0.0162 |
| ΔReal non energy comm. price(t-1) | -0.0067 | -0.0047 | -0.0281 * | -0.0039 | 0.0110 | -0.0053 | 0.0070 | -0.0106 |
| Seasonal dummy (1) | -0.0081 | -0.0086 | 0.0104 | -0.0200 * | -0.0035 | -0.0015 | -0.0005 | -0.0056 |
| Seasonal dummy (2) | -0.0092 | -0.0037 | 0.0144 * | -0.0200 ** | -0.0007 | -0.0007 | -0.0017 | -0.0007 |
| Seasonal dummy (3) | -0.0005 | -0.0007 | 0.0124 ** | -0.0043 | 0.0007 | 0.0042 | 0.0043 | 0.0024 |
| Observations | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |
| Adj. R-squared | 0.0145 | 0.2424 | 0.3351 | 0.2392 | -0.0453 | 0.1285 | 0.3544 | -0.0928 |

Note: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

Table D2: City level results for the 3rd stage regression with spatial correlations – Australia (Futures Market)

| | Ade | Bri | Can | Dar | Hob | Mel | Per | Syd |
|---|---|---|---|---|---|---|---|---|
| *Dependant variable is the real city level house price change* | | | | | | | | |
| Intercept | 0.0027 | -0.0035 | -0.0078 | 0.0066 | -0.0014 | 0.0011 | -0.0042 | 0.0015 |
| Δreal house price Ade(-1) | 0.2103 | -0.2227 * | -0.0802 | -0.0300 | 0.0539 | 0.0275 | 0.0169 | 0.0990 |
| Δreal house price Bri(-1) | -0.1296 | 0.1667 | -0.1213 | -0.2760 | 0.0221 | -0.2217 | -0.2615 | -0.0740 |
| Δreal house price Can(-1) | 0.0605 | 0.1842 * | 0.5272 *** | 0.3442 * | 0.1259 | -0.0590 | 0.0137 | 0.0571 |
| Δreal house price Dar(-1) | -0.1951 * | 0.0307 | -0.0833 | 0.0962 | -0.0117 | -0.0221 | -0.2024 * | -0.0038 |
| Δreal house price Hob(-1) | -0.0875 | 0.1259 | -0.0558 | 0.1073 | 0.1562 | 0.0735 | 0.0923 | -0.0179 |
| Δreal house price Mel(-1) | -0.1357 | 0.0042 | -0.3436 ** | -0.4350 ** | -0.2251 | -0.1127 | -0.1628 | 0.0712 |
| Δreal house price Per(-1) | -0.1229 | -0.0386 | -0.2031 * | 0.4061 ** | -0.0253 | -0.0386 | 0.6234 *** | 0.0639 |
| Δreal house price Syd(-1) | 0.5389 ** | 0.1702 | 0.3746 * | -0.2959 | 0.1077 | 0.4431 ** | 0.1000 | -0.1121 |
| Filtered GDP | 0.0411 | 0.1534 * | 0.2813 *** | 0.0773 | 0.0773 | 0.1607 * | 0.1546 | 0.0429 |
| Filtered unemployment | -0.0629 * | -0.0449 * | 0.0090 | -0.0027 | -0.0293 | -0.0314 | -0.0185 | -0.0143 |
| Filtered external debt | 0.0724 | 0.1249 ** | 0.1526 ** | 0.1446 * | 0.0768 | 0.1287 ** | 0.0660 | 0.0639 |
| Filtered interest rate | 0.0418 | 0.0321 | 0.0407 | 0.0329 | -0.0103 | 0.0328 | 0.0329 | 0.0255 |
| Filtered exchange rate | 0.0098 | -0.0461 | -0.0126 | -0.0591 | -0.0680 * | -0.0671 * | -0.0085 | -0.0274 |
| Filtered stock prices | 0.0188 | -0.0084 | 0.0455 ** | -0.0164 | 0.0331 | 0.0343 * | 0.0019 | 0.0076 |
| Filtered bankloan | 0.1196 | 0.1060 | 0.1199 | 0.1769 | 0.0059 | 0.0295 | 0.0257 | 0.0292 |
| Filtered net capital flow | -0.0041 | 0.0496 | 0.0413 | 0.0211 | 0.0342 | 0.0944 *** | 0.0100 | 0.0571 * |
| Filtered city level rents | 0.0883 * | 0.0811 ** | 0.1246 ** | 0.0649 * | -0.0089 | 0.0150 | 0.0562 | 0.0569 |
| ΔReal energy comm. price(t) | -0.0054 | -0.0035 | -0.0016 | 0.0071 | -0.0029 | 0.0070 | 0.0025 | 0.0064 |
| ΔReal energy comm. price(t-1) | 0.0008 | -0.0016 | 0.0005 | -0.0020 | 0.0098 | 0.0069 | 0.0034 | -0.0032 |
| ΔReal non-energy comm. price(t) | 0.0251 | -0.0120 | 0.0126 | -0.0509 * | 0.0098 | -0.0075 | -0.0004 | -0.0274 |
| ΔReal non energy comm. price(t-1) | 0.0039 | 0.0493 ** | 0.0122 | 0.0198 | 0.0009 | -0.0086 | 0.0342 | 0.0000 |
| Seasonal dummy (1) | 0.0010 | 0.0025 | 0.0139 | -0.0031 | 0.0059 | -0.0011 | 0.0089 | -0.0053 |
| Seasonal dummy (2) | -0.0039 | 0.0062 | 0.0148 | -0.0085 | 0.0060 | -0.0030 | 0.0057 | -0.0015 |
| Seasonal dummy (3) | 0.0021 | 0.0067 | 0.0140 | 0.0050 | 0.0042 | 0.0038 | 0.0097 * | 0.0032 |
| Observations | 91 | 91 | 91 | 70 | 91 | 91 | 91 | 91 |
| Adj. R-squared | 0.0144 | 0.2056 | 0.2937 | 0.2279 | -0.0356 | 0.1628 | 0.3544 | -0.0744 |

Note: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

## Table D3: City Level Results for the 3rd Stage Regression with Spatial Correlations – New Zealand (Spot Market)

| | NS | WK | AK | MK | PK | HT | TR | HS | NP | PN | PR | UH | HT | WT | NL | CH | DN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Dependant variable is the real city level house price change* | | | | | | | | | | | | | | | | | |
| Intercept | -0.0053 | 0.0003 | 0.0031 | -0.0035 | 0.0006 | 0.0000 | 0.0058 | -0.0105 | 0.0037 | 0.0009 | -0.0050 | -0.0144 | 0.0026 | -0.0134 ** | -0.0038 | 0.0007 | -0.0156 * |
| Δreal house price(-1) | -0.1218 | -0.1621 ** | 0.0001 | -0.2643 *** | -0.3896 *** | -0.2483 *** | -0.2854 *** | -0.3752 *** | -0.3422 *** | -0.3931 *** | -0.4314 *** | -0.4399 *** | -0.4017 *** | -0.3509 *** | -0.2536 *** | -0.0435 | -0.2806 *** |
| Δreal house price AK(-1) | 0.4131 *** | 0.2053 ** | | 0.3621 *** | 0.2184 | 0.1927 ** | 0.2279 *** | 0.0663 | 0.4252 *** | 0.1564 * | 0.2453 * | 0.0361 | 0.0909 | 0.2795 *** | 0.3382 *** | 0.2774 *** | 0.1582 |
| Δreal house price WT(-1) | 0.1909 *** | 0.1109 | 0.1747 ** | -0.0217 | 0.2830 * | 0.1046 | 0.2023 ** | 0.1905 | 0.0267 | 0.0810 | -0.2006 | -0.0775 | 0.2400 ** | | 0.1152 | 0.1024 * | 0.0224 |
| Δreal house price CH(-1) | 0.1772 * | 0.3220 *** | 0.1918 * | 0.3658 *** | 0.3483 * | 0.2573 ** | 0.3332 *** | 0.6755 *** | 0.2881 * | 0.3858 *** | 0.5407 *** | 0.4616 ** | 0.2918 ** | 0.2597 ** | 0.3314 ** | | 0.4355 *** |
| Filtered GDP | 0.0833 | 0.2068 | -0.1571 | 0.1744 | 0.0593 | -0.0379 | -0.0374 | 0.4552 | 0.2601 | -0.0047 | 0.9910 ** | 0.7179 | 0.1571 | 0.6565 *** | 0.3986 | 0.0118 | 0.3661 |
| Filtered unemployment | -0.0050 | 0.0170 | -0.0319 | -0.0198 | 0.0282 | 0.0290 | -0.0146 | 0.0702 * | 0.0309 | -0.0187 | -0.0301 | 0.0152 | -0.0549 * | -0.0254 | 0.0178 ** | -0.0170 | 0.0375 |
| Filtered immigration | 0.0058 | 0.0116 * | 0.0041 | 0.0021 | 0.0069 | 0.0054 | 0.0100 | 0.0074 | 0.0088 | -0.0061 | 0.0014 | 0.0067 | 0.0047 | 0.0006 | 0.0179 | 0.0064 | 0.0095 |
| Filtered interest rate | -0.0275 | 0.0261 | 0.0618 ** | -0.0299 | -0.0345 | 0.0049 | 0.0483 | 0.0436 | -0.0944 ** | 0.0108 | 0.0851 | 0.0153 | 0.0177 | -0.0167 | 0.0021 | 0.0137 | 0.0106 |
| Filtered exchange rate | -0.0490 | -0.0056 | -0.0280 | -0.0244 | 0.0081 | -0.1323 *** | -0.0484 | -0.0301 | -0.0907 | 0.0328 | 0.0474 | -0.0927 | -0.0262 | -0.0398 | -0.0022 | -0.0272 | -0.0057 |
| Filtered stock prices | -0.0018 | 0.0088 | 0.0594 * | 0.0599 ** | -0.0354 | -0.0268 | 0.0057 | -0.0236 | -0.0287 | 0.0326 | 0.0874 | 0.0285 | 0.0450 | 0.0467 | 0.0199 | 0.0293 | 0.0314 |
| Filtered bankloan | -0.1565 | 0.4528 | 0.0256 | 0.2939 | -0.1096 | 0.0676 | -0.0796 | 0.5276 | 1.2806 ** | -0.5506 | 1.6653 *** | 0.2410 | 0.0267 | 0.5138 | -0.5921 | 0.0635 | 0.0523 |
| Filtered city level rents | 0.1101 ** | 0.1600 ** | 0.0487 | 0.0493 | -0.0200 | 0.0823 | 0.0532 | -0.0377 | 0.0474 | 0.0783 * | 0.0262 | 0.0032 | 0.0447 | 0.0372 | 0.0403 | 0.0400 | 0.0452 |
| ΔReal energy comm. price(t) | -0.0093 | -0.0112 | 0.0099 | 0.0020 | 0.0268 | 0.0141 | 0.0107 | -0.0272 | -0.0104 | 0.0060 | -0.0411 | -0.0040 | 0.0045 | -0.0275 ** | -0.0330 * | 0.0062 | -0.0325 |
| ΔReal energy comm. price(t-1) | -0.0022 | -0.0084 | 0.0041 | -0.0005 | 0.0037 | -0.0111 | -0.0054 | -0.0215 | 0.0111 | -0.0097 | -0.0348 * | -0.0227 | -0.0059 | -0.0167 | -0.0040 | -0.0044 | -0.0105 |
| ΔReal non-energy comm. price(t) | 0.0754 | 0.0608 | 0.1263 * | 0.1393 ** | -0.1075 | 0.1032 | -0.0421 | -0.0642 | 0.0880 | -0.0339 | -0.1191 | 0.0879 | -0.0149 | 0.0663 | -0.0597 | 0.0712 | 0.0191 |
| ΔReal non energy comm. price(t-1) | -0.0736 | 0.0110 | -0.1316 * | -0.1030 | 0.1393 | -0.1577 ** | 0.0373 | 0.1308 | -0.1666 * | 0.0381 | 0.2534 ** | 0.0687 | 0.0714 | -0.0062 | 0.0444 | -0.0264 | 0.1606 * |
| Seasonal dummy (1) | 0.0229 * | 0.0146 | 0.0017 | 0.0193 | 0.0037 | 0.0094 | 0.0063 | 0.0382 * | 0.0149 | 0.0113 | 0.0554 ** | 0.0443 | 0.0105 | 0.0445 *** | 0.0297 | 0.0086 | 0.0433 |
| Seasonal dummy (2) | 0.0003 | 0.0070 | -0.0037 | 0.0011 | -0.0044 | -0.0030 | -0.0132 | 0.0236 | -0.0037 | -0.0027 | 0.0151 | 0.0248 | 0.0001 | 0.0273 *** | -0.0021 | -0.0004 | 0.0191 |
| Seasonal dummy (3) | 0.0097 | 0.0030 | -0.0015 | 0.0025 | 0.0116 | 0.0043 | -0.0023 | 0.0123 | 0.0080 | -0.0124 | 0.0267 | 0.0308 * | 0.0024 | 0.0263 *** | 0.0138 | 0.0049 | 0.0289 |
| Seasonal dummy (4) | 0.0009 | -0.0029 | -0.0019 | -0.0019 | -0.0138 | 0.0021 | -0.0086 | 0.0142 | -0.0134 | -0.0030 | -0.0029 | 0.0024 | 0.0005 | 0.0101 * | -0.0001 | -0.0033 | 0.0039 |
| Seasonal dummy (5) | 0.0083 | -0.0009 | -0.0073 | 0.0091 | -0.0028 | -0.0040 | -0.0040 | 0.0075 | -0.0003 | 0.0042 | 0.0120 | 0.0192 | -0.0088 | 0.0132 ** | 0.0015 | 0.0024 | 0.0188 |
| Seasonal dummy (6) | 0.0063 | -0.0012 | 0.0021 | 0.0085 | 0.0071 | 0.0042 | -0.0051 | 0.0085 | -0.0010 | -0.0015 | -0.0006 | 0.0110 | -0.0034 | 0.0114 * | 0.0016 | -0.0008 | 0.0087 |
| Seasonal dummy (7) | 0.0069 | 0.0022 | -0.0008 | 0.0004 | -0.0025 | -0.0003 | -0.0063 | 0.0210 | -0.0046 | -0.0015 | 0.0140 | 0.0146 | 0.0158 | 0.0299 *** | 0.0078 | -0.0050 | 0.0193 |
| Seasonal dummy (8) | 0.0099 | 0.0069 | -0.0011 | 0.0135 | -0.0075 | 0.0034 | -0.0077 | 0.0217 | -0.0058 | 0.0023 | 0.0088 | 0.0319 | -0.0026 | 0.0236 *** | 0.0074 | 0.0044 | 0.0250 |
| Seasonal dummy (9) | 0.0114 | 0.0027 | 0.0056 | 0.0017 | -0.0003 | 0.0039 | -0.0128 | 0.0041 | -0.0064 | 0.0023 | 0.0171 | 0.0233 | -0.0034 | 0.0254 *** | 0.0094 | 0.0055 | 0.0148 |
| Seasonal dummy (10) | -0.0042 | -0.0120 | 0.0025 | -0.0048 | 0.0059 | 0.0009 | 0.0002 | -0.0157 | -0.0272 ** | 0.0005 | -0.0229 | -0.0071 | -0.0046 | -0.0059 | -0.0149 | -0.0041 | -0.0002 |
| Seasonal dummy (11) | 0.0025 | 0.0014 | -0.0003 | 0.0111 | 0.0045 | -0.0023 | -0.0053 | 0.0017 | 0.0032 | -0.0017 | -0.0084 | 0.0201 ** | -0.0040 | 0.0044 | -0.0022 | -0.0025 | 0.0239 |
| Observations | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 |
| Adj. R-squared | 0.2743 | 0.1701 | 0.1232 | 0.2630 | 0.1477 | 0.1779 | 0.1993 | 0.1972 | 0.2364 | 0.1291 | 0.2915 | 0.1740 | 0.1834 | 0.2543 | 0.1284 | 0.1644 | 0.1617 |

Note: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

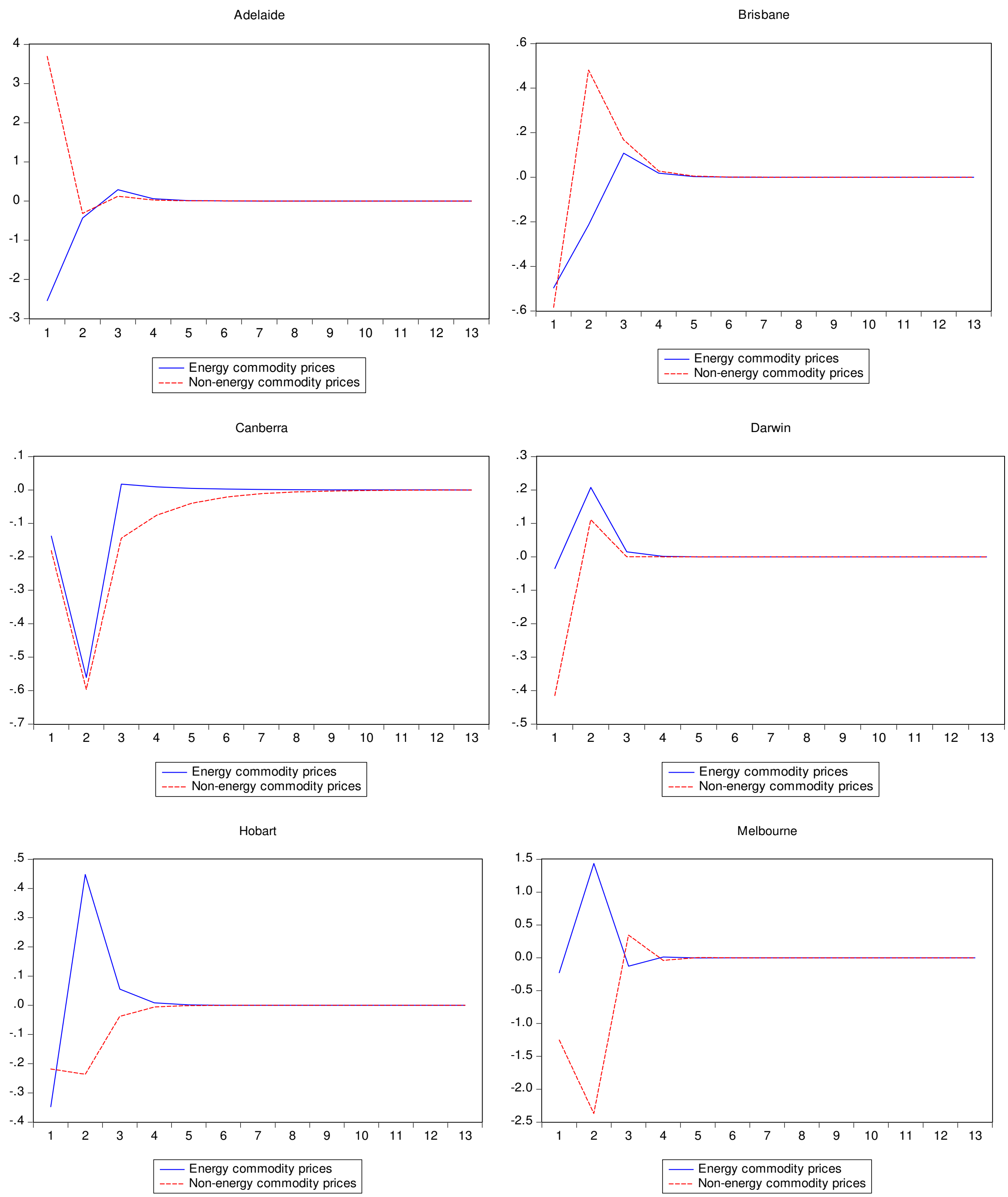
## Results for the 3rd Table D4: City Level Results for the 3rd Stage Regression with Spatial Correlations – New Zealand (Futures Market)

| | NS | WK | AK | MK | PK | HT | TR | HS | NP | PN | PR | UH | HT | WT | NL | CH | DN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Dependant variable is the real city level house price change* | | | | | | | | | | | | | | | | | |
| Intercept | -0.0081 | 0.0009 | 0.0039 | 0.0018 | 0.0001 | 0.0014 | 0.0115 * | 0.0084 | 0.0168 | 0.0098 | 0.0031 | 0.0051 | 0.0074 | -0.0051 | 0.0033 | 0.0069 | -0.0103 |
| Δreal house price(-1) | -0.2106 ** | -0.2304 ** | -0.0397 | -0.2845 *** | -0.3894 *** | -0.2191 ** | -0.2908 *** | -0.3176 *** | -0.3920 *** | -0.4205 *** | -0.4445 *** | -0.4481 *** | -0.4627 *** | -0.3715 *** | -0.2473 *** | 0.0154 | -0.1696 * |
| Δreal house price AK(-1) | 0.4023 *** | 0.1707 * | | 0.2961 *** | 0.1527 | 0.1697 | 0.2659 ** | 0.0402 | 0.6173 *** | 0.1983 * | 0.2546 | 0.0698 | 0.2305 * | 0.3080 *** | 0.4640 *** | 0.3395 *** | 0.1779 |
| Δreal house price WT(-1) | 0.2042 ** | 0.0643 | 0.1824 ** | -0.0309 | 0.1190 | 0.1587 | 0.2308 ** | 0.2278 | 0.1155 | 0.1352 | 0.0560 | -0.1087 | 0.2752 ** | | 0.1968 | 0.0804 | -0.0538 |
| Δreal house price CH(-1) | 0.2436 ** | 0.4500 *** | 0.2314 * | 0.4463 *** | 0.3812 | 0.2269 | 0.2224 | 0.6701 *** | 0.1541 | 0.3045 ** | 0.4193 * | 0.3661 | 0.3153 * | 0.2786 ** | 0.2695 | | 0.5013 *** |
| Filtered GDP | -0.0847 | 0.0738 | -0.2163 | -0.0756 | 0.6023 | -0.2678 | -0.4771 | -0.4779 | -0.2132 | -0.5009 | 0.5665 | -0.4247 | -0.1263 | 0.0546 | -0.0392 | -0.2185 | 0.2472 |
| Filtered unemployment | -0.0208 | 0.0038 | -0.0287 | -0.0155 | 0.0524 | 0.0359 | -0.0029 | 0.0248 | 0.0210 | -0.0013 | -0.0355 | 0.0139 | -0.0337 | -0.0119 | 0.0145 | -0.0182 | -0.0052 |
| Filtered immigration | 0.0040 | 0.0097 | 0.0040 | 0.0080 | 0.0186 | 0.0112 | 0.0173 ** | 0.0093 | 0.0210 * | 0.0011 | 0.0011 | 0.0056 | 0.0061 | 0.0000 | 0.0199 * | 0.0127 ** | 0.0206 * |
| Filtered interest rate | -0.0460 | 0.0077 | 0.0581 | -0.0112 | -0.0566 | 0.0032 | 0.0412 | 0.0531 | -0.0734 | 0.0022 | 0.0796 | 0.0437 | 0.0630 | 0.0126 | -0.0213 | 0.0065 | -0.0170 |
| Filtered exchange rate | -0.0580 | 0.0031 | -0.0307 | -0.0135 | -0.0082 | -0.1269 ** | -0.0360 | 0.0225 | -0.0581 | 0.0547 | 0.0425 | -0.0758 | 0.0310 | -0.0287 | 0.0552 | -0.0087 | 0.0308 |
| Filtered stock prices | 0.0105 | 0.0221 | 0.0655 ** | 0.0738 ** | 0.0144 | 0.0007 | -0.0046 | -0.0641 | -0.0458 | 0.0309 | 0.0551 | 0.0533 | 0.0747 * | 0.0724 ** | 0.0117 | 0.0305 | 0.0383 |
| Filtered bankloan | -0.7579 * | 0.2259 | -0.1470 | 0.1309 | -0.2727 | 0.1087 | 0.8193 | 1.4203 * | 1.2009 * | 0.5563 | 2.3791 *** | 1.3262 | 1.1442 * | 0.5985 | -0.3308 | 0.2963 | 0.5355 |
| Filtered city level rents | 0.1024 ** | 0.0538 | 0.0233 | -0.0211 | 0.0108 | -0.0044 | 0.0626 | -0.0705 | 0.0192 | 0.0627 | 0.0332 | 0.0382 | 0.0063 | 0.0036 | 0.0454 | 0.0020 | 0.0539 |
| ΔReal energy comm. price(t) | -0.0054 | -0.0170 | 0.0087 | 0.0227 * | 0.0072 | 0.0150 | 0.0135 | -0.0183 | 0.0347 * | 0.0021 | -0.0357 | 0.0165 | -0.0015 | 0.0077 | -0.0020 | 0.0099 | -0.0184 |
| ΔReal energy comm. price(t-1) | -0.0153 | 0.0063 | -0.0157 | -0.0190 | -0.0262 | -0.0240 * | -0.0313 ** | 0.0485 ** | -0.0162 | -0.0186 | 0.0129 | -0.0203 | 0.0149 | -0.0073 | -0.0078 | -0.0021 | 0.0462 *** |
| ΔReal non-energy comm. price(t) | -0.0142 | 0.0328 | 0.0445 | 0.0318 | -0.0032 | -0.0052 | 0.0435 | 0.0794 | -0.0228 | 0.0262 | -0.0087 | 0.1365 ** | 0.0405 | -0.0041 | 0.0216 | 0.0489 * | -0.0385 |
| ΔReal non energy comm. price(t-1) | 0.0308 | 0.0037 | -0.0207 | 0.0003 | -0.0220 | -0.0023 | -0.0107 | -0.0953 ** | 0.0353 | -0.0229 | -0.0256 | 0.0143 | -0.0038 | -0.0171 | -0.0322 | -0.0056 | 0.0613 |
| Seasonal dummy (1) | 0.0190 | 0.0108 | -0.0001 | 0.0102 | 0.0136 | 0.0060 | -0.0104 | -0.0033 | -0.0116 | -0.0101 | 0.0392 | -0.0124 | 0.0004 | 0.0202 | 0.0109 | -0.0021 | 0.0419 ** |
| Seasonal dummy (2) | 0.0011 | 0.0046 | -0.0068 | -0.0102 | -0.0006 | -0.0110 | -0.0266 ** | -0.0084 | -0.0283 ** | -0.0176 | -0.0022 | -0.0057 | -0.0087 | 0.0143 | -0.0190 | -0.0131 * | 0.0024 |
| Seasonal dummy (3) | 0.0119 | -0.0034 | -0.0004 | -0.0049 | 0.0288 | 0.0047 | -0.0106 | -0.0197 | -0.0064 | -0.0236 * | 0.0149 | -0.0053 | -0.0080 | 0.0056 | 0.0050 | -0.0006 | 0.0318 * |
| Seasonal dummy (4) | 0.0022 | -0.0060 | -0.0037 | -0.0055 | -0.0215 * | 0.0026 | -0.0113 | 0.0054 | -0.0223 ** | -0.0037 | -0.0045 | -0.0058 | -0.0002 | 0.0035 | -0.0075 | -0.0099 * | -0.0064 |
| Seasonal dummy (5) | 0.0154 ** | -0.0005 | -0.0054 | 0.0025 | 0.0019 | -0.0061 | -0.0103 | -0.0125 | -0.0118 | -0.0012 | -0.0043 | -0.0014 | -0.0116 | 0.0041 | -0.0047 | -0.0029 | 0.0210 * |
| Seasonal dummy (6) | 0.0051 | -0.0067 | -0.0005 | -0.0020 | 0.0070 | -0.0016 | -0.0109 | -0.0150 | -0.0140 | -0.0044 | -0.0074 | -0.0009 | -0.0085 | -0.0010 | -0.0040 | -0.0088 | 0.0021 |
| Seasonal dummy (7) | 0.0100 | -0.0024 | -0.0028 | -0.0096 | -0.0055 | -0.0030 | -0.0171 | -0.0028 | -0.0208 | -0.0128 | 0.0026 | -0.0156 | 0.0040 | 0.0126 | 0.0000 | -0.0170 ** | 0.0113 |
| Seasonal dummy (8) | 0.0110 | 0.0076 | -0.0032 | 0.0084 | 0.0008 | 0.0003 | -0.0146 | -0.0010 | -0.0264 ** | -0.0068 | -0.0049 | 0.0081 | -0.0055 | 0.0134 | -0.0049 | -0.0023 | 0.0219 * |
| Seasonal dummy (9) | 0.0146 * | 0.0004 | 0.0059 | -0.0068 | -0.0012 | -0.0028 | -0.0270 *** | -0.0225 | -0.0232 * | -0.0169 | 0.0048 | -0.0029 | -0.0105 | 0.0129 | 0.0011 | -0.0045 | 0.0039 |
| Seasonal dummy (10) | 0.0057 | -0.0093 | 0.0010 | -0.0018 | -0.0148 | 0.0081 | 0.0146 | 0.0054 | -0.0233 | 0.0118 | -0.0104 | 0.0231 | 0.0023 | 0.0053 | 0.0021 | -0.0003 | 0.0027 |
| Seasonal dummy (11) | 0.0116 * | 0.0039 | -0.0041 | 0.0083 | -0.0053 | -0.0010 | -0.0113 | -0.0104 | 0.0005 | -0.0013 | -0.0123 | 0.0163 | -0.0100 | 0.0087 | -0.0063 | -0.0057 | 0.0255 *** |
| Observations | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 | 141 |
| Adj. R-squared | 0.3132 | 0.2371 | 0.1180 | 0.2691 | 0.0958 | 0.1646 | 0.2575 | 0.2736 | 0.2988 | 0.1139 | 0.3014 | 0.1741 | 0.2555 | 0.2658 | 0.1656 | 0.2635 | 0.2770 |

Note: *** significance at 1% level, ** significance at 5% level, * significance at 10% level

E: Dynamic Responses of local house prices with a change in futures market commodity prices

Figure E-1: Dynamic Response analysis for one standard deviation of futures market commodity prices on city level housing prices – Australia



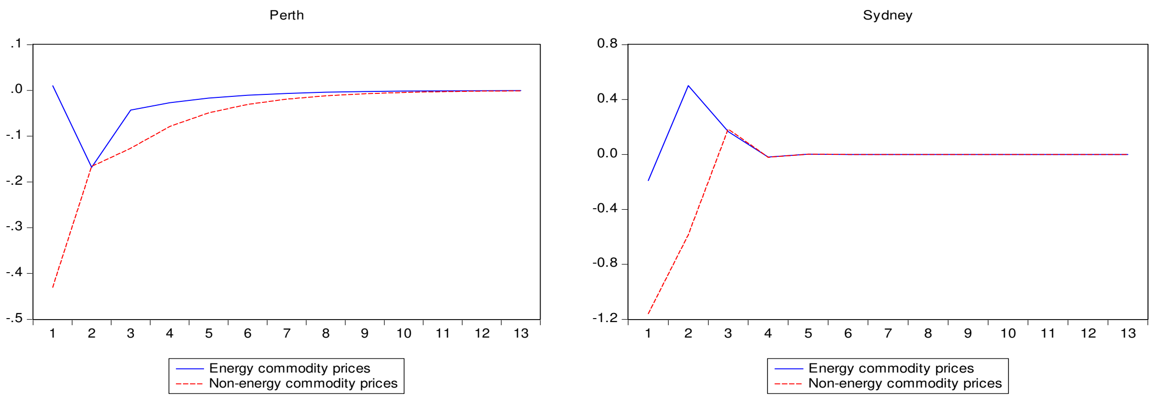
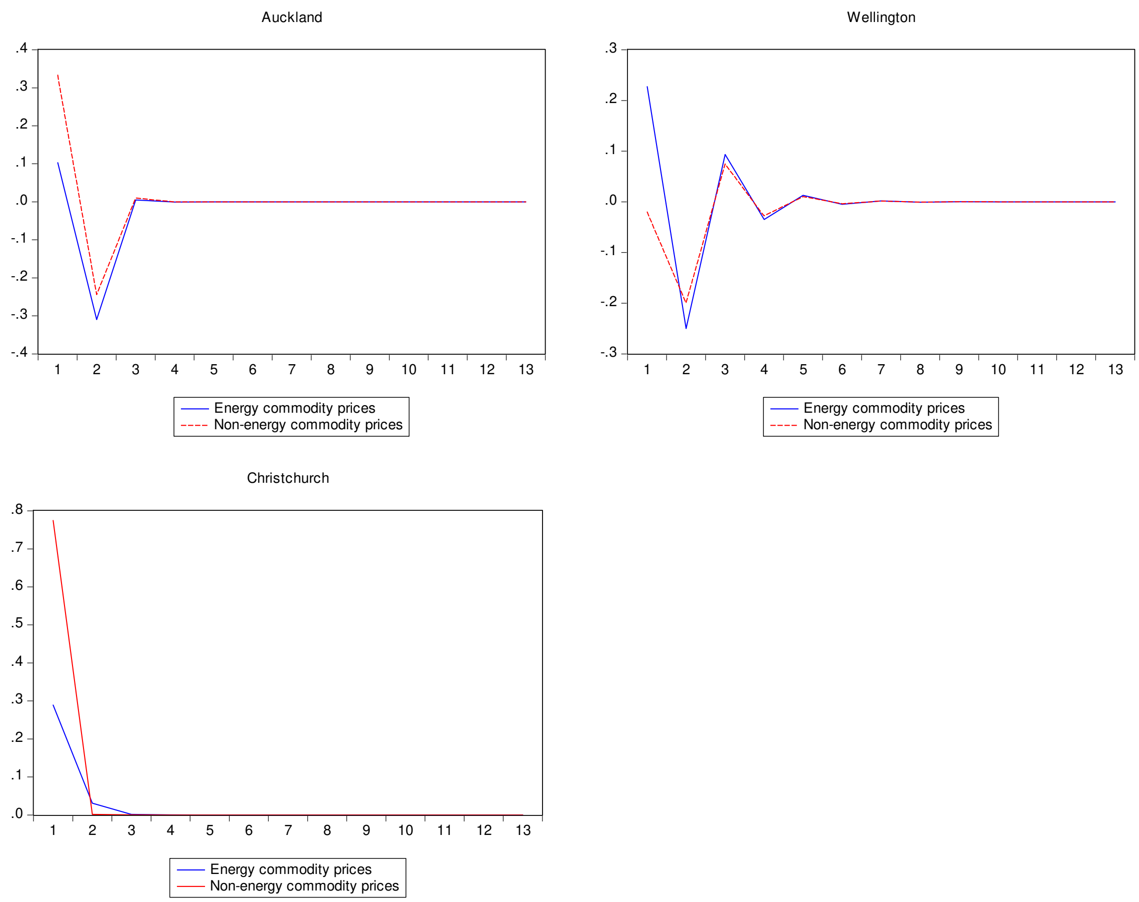

Perth
.1
.0
-.1
-.2
-.3
-.4
-.5
1 2 3 4 5 6 7 8 9 10 11 12 13
Energy commodity prices
Non-energy commodity prices
Sydney
0.8
0.4
0.0
-0.4
-0.8
-1.2
1 2 3 4 5 6 7 8 9 10 11 12 13
Energy commodity prices
Non-energy commodity prices

Figure E-2: Dynamic Response analysis of futures market commodity prices on selected city level house prices of New Zealand




A few observations follow:

1. For Australian cities, the effects on local house prices from futures market commodity price changes vary significantly across cities. For Brisbane, Canberra, Darwin and Sydney, the effect from energy and non-energy commodity price changes are similar.
2. For New Zealand cities, both energy and non-energy futures market commodity price changes tend to have very similar effect. Initially positive effect of non-energy commodity prices on local house price quickly turns into a negative impact. Overall, the effect on house price quickly dies out.

We admit that at this stage we have not been able to develop very good intuitions for these graphs. Certain data necessary for a more in-depth analysis is missing. We do not have data about the economic structure of different cities. Perhaps equally important, we do not have the home purchase pattern of people in those cities. As we present our paper in different conferences, economists from Australia suggest to us that mine workers, who themselves do not live the major cities, may nevertheless buy their "second houses" in the major cities within the same state for rental income, and thus become literally "absentee landlords". Media in Australia has provided anecdotal evidence. We are, however, unable to find any systematic evidence for that.

F. More details of the energy versus non-energy, spot market versus futures market commodity prices

Some readers are curious why there is a difference in results between spot market commodity prices versus the futures market counterpart. First, we want to recall from the literature that futures market commodity prices do not always predict the subsequent movement in spot market counterparts (e.g. Alquist and Kilian, 2010; Pindyck, 2001; Reichsfeld and Roache, 2011; Sockin and Xiong, 2013, among others). In particular, Sockin and Xiong (2013) show that "…as a result of information frictions, unexpected heavy buying by financial traders can lead to a higher futures price, which, under certain conditions, can in turn drive up producers' commodity demand and thus the spot price." Thus, it may be reasonable to expect that the local house price impact of futures market commodity price could be very different from the spot market counterpart.

In fact, for the series of both Australia and New Zealand, we calculate the correlation between the spot market commodity price and the futures market counterpart. The correlations are positive and significant. On the other hand, it is also clear that the correlations are less than unity for our sample.

| | Correlation (spot market index, futures market index) |
|---|---|
| Australia Energy Commodity Price | 0.847*** |
| Australia Non-Energy Commodity Price | 0.678*** |
| New Zealand Energy Commodity Price | 0.986*** |
| New Zealand Non-Energy Commodity Price | 0.811*** |

Key: All series are stationary after first-differencing. *** represents 1% significance level.

In addition, we suspect that one reason why the futures market commodity price may matter more at the national level, while the spot market commodity price matter more at the local level is due to the endogenous government policy. Recently, there are much research efforts on how monetary policy should react to commodity price change (for instance, see Bodenstein et al, 2012; Catao and Chang, 2012; De Gregorio, 2012, among others). And the government (including the central bank and fiscal authority) may have a comparative advantage in responding to changes in the futures market. For instance, the central bank can monitor the futures commodity market prices on a daily basis and may intervene in the money market and/or the foreign exchange market correspondingly. Notice that, unlike small business or households, the central bank in principle has neither a long nor a short position in the commodity market, and hence has no immediate incentive for hedge. Thus, they may be less responsive to the spot commodity prices than the private sector. In addition, we also prove in another section of the appendix that it is not easy to identify the policy effect when the government policies respond to economic variables (including the commodity prices and other macroeconomic variables) endogenously. We can only identify the total effect.

Another related question is why the results in Australia and New Zealand are different. Recall that due to the difference in endowment and possibly other historical factors, the composition of commodity export of the two countries are different. Thus, the commodity price series may not be that correlated. The following table enables us to see the difference.

| | Spot Market | Futures Market |
|---|---|---|
| Corr( $PC_{AU}^{energy}$ , $PC_{NZ}^{energy}$ ) | 0.816*** | 1.000*** |
| Corr( $PC_{AU}^{non-energy}$ , $PC_{NZ}^{non-energy}$ ) | 0.369** | 0.213 |

Key: All series are stationary after first-differencing. *** and ** represents 1% and 5% significance level respectively.

Clearly, the correlations of energy commodity price series for the two countries are highly correlated, especially in the futures market. On the other hand, for the non-energy commodity price series, the correlations are much weaker. In the case of futures market, the correlation between the two series is not even statistically significant.

We speculate that there is at least one more explanation for the discrepancy between the results of spot market commodity prices versus futures market commodity prices. In a standard finance textbook, producers and buyers of commodity would always hedge through the futures market. In practice, we do not know if it is the case. We missed the information of the portfolio of both the commodity producers and buyers. We suspect that there may be a difference between energy commodities versus non-energy commodities. Due to technological or other reasons, energy producers are often large firms, even international firms. On the other hand, non-energy producers may be very large (for instance, in the case of metallic non-energy commodities), and can also be small (for instance, in the case of some farmers who produce food, which are also included as non-energy commodities). Their participation in the spot and futures markets could be different. We regret that we miss the corresponding information and can only leave these speculations to future research.

G. An illustration that Tables 4a and 4b are measuring the total effect

(This derivation is kindly provided by an anonymous referee, who is gratefully acknowledged by the authors).

For expositional purpose, we will assume that there are only two stages of the regression: (and to simplify the exposition, the lags and dynamics are suppressed)

(G1) $hp_t^i = \gamma P_t^c + \theta y_t + u_t$

(G2) $y_t = \beta P_t^c + v_t$

(G1) says that the house price $hp_t^i$ depends on the commodity price $P_t^c$, national economic variables $y_t$ and an innovation term $u_t$. (G2) says that the national economic variables $y_t$ may be affected by the commodity price $P_t^c$ as well. We can interpret $v_t$ as our "commodity price-filtered economic variables", or simply "filtered economic variables". Thus, (G2) is analogous to our first-stage regression.

Simply substitute (G2) into (G1) we have

(G3) $hp_t^i = \left(\gamma + \theta\beta\right) P_t^c + \theta v_t + u_t$

Now (G3) is analogous to our third-stage regression, where the house price is regressed against the commodity price and filtered economic variables. In that case, the corresponding coefficient of the commodity price is the total effect for the commodity price exerting on the house price.

H: Hierarchical Model as a reduced form with policy effect taken into consideration

In this model, we will show the simple fact that our hierarchical model can be interpreted as a reduced form model, with the effect of "policy" being taken into consideration.

For instance, let us assume that (1) is modified as

$(1^P)$ $V_t^n = A_0 + A_1 P_t^c + A_2 P_{t-1}^c + A_3 V_{t-1}^n + A_4 NatPolicy_t + \widetilde{V_t^n}$ .

Now we assume further that the national policy variables, $NatPolicy_t$, react to contemporary national variables and commodity prices,

(P1) $NatPolicy_t = \widehat{A}_0 + \widehat{A}_1 P_t^c + \widehat{A}_2 V_t^n + \overline{U}_t$ .

Hence, when we combine $(1^P)$ and (P1), we have

$$\left(I - A_4 \widehat{A}_2\right) V_t^n = \left(A_0 + A_4 \widehat{A}_0\right) + \left(A_1 + A_4 \widehat{A}_1\right) P_t^c + A_2 P_{t-1}^c + A_3 V_{t-1}^n + \left(A_4 \overline{U}_t + \widetilde{V_t^n}\right), \text{ or}$$

$$V_t^n = \left(I - A_4 \widehat{A}_2\right)^{-1} \left[\left(A_0 + A_4 \widehat{A}_0\right) + \left(A_1 + A_4 \widehat{A}_1\right) P_t^c + A_2 P_{t-1}^c + A_3 V_{t-1}^n + \left(A_4 \overline{U}_t + \widetilde{V_t^n}\right)\right], \text{ or}$$

$$V_t^n = \left(I - A_4 \widehat{A}_2\right)^{-1} \left(A_0 + A_4 \widehat{A}_0\right) + \left(I - A_4 \widehat{A}_2\right)^{-1} \left(A_1 + A_4 \widehat{A}_1\right) P_t^c$$

$$+ \left(I - A_4 \widehat{A}_2\right)^{-1} A_2 P_{t-1}^c + \left(I - A_4 \widehat{A}_2\right)^{-1} A_3 V_{t-1}^n + \left(I - A_4 \widehat{A}_2\right)^{-1} \left(A_4 \overline{U}_t + \widetilde{V_t^n}\right)$$

if $\left(I - A_4 \widehat{A}_2\right)^{-1}$ exists.

Notice that the last expression is in the form of (1), except that $A_0$ is replaced by $\left(I - A_4 \widehat{A}_2\right)^{-1} \left(A_0 + A_4 \widehat{A}_0\right)$, $A_1$ is replaced by $\left(I - A_4 \widehat{A}_2\right)^{-1} \left(A_1 + A_4 \widehat{A}_1\right)$, $\widetilde{V_t^n}$ is replaced by $\left(I - A_4 \widehat{A}_2\right)^{-1} \left(A_4 \overline{U}_t + \widetilde{V_t^n}\right)$.

Similarly, we can imagine that (2) is modified as

$(2^P)$ $V_{j,t}^r = B_0 + B_1 P_t^c + B_2 P_{t-1}^c + B_3 \widetilde{V_t^n} + B_4 \widetilde{V_{t-1}^n} + B_5 V_{j,t-1}^r + B_6 \, RegPolicy_t^j + \widetilde{V_{j,t}^r}, \; j = 1, 2, \ldots$

Now we assume further that the policy variables for the *j*-th region, $RegPolicy_t^j$, $j = 1, 2, \ldots$ react to contemporary national variables and commodity prices,

(P2) $RegPolicy_t^j = \overline{B}_0 + \overline{B}_1 P_t^c + \overline{B}_3 \widetilde{V_t^n} + \overline{U_{j,t}^r}, \; j = 1, 2, \ldots$

Hence, when we combine $(2^P)$ and (P2), we have

$$V_{j,t}^r = B_0 + B_1 P_t^c + B_2 P_{t-1}^c + B_3 \widetilde{V_t^n} + B_4 \widetilde{V_{t-1}^n} + B_5 V_{j,t-1}^r + B_6 \left(\overline{B}_0 + \overline{B}_1 P_t^c + \overline{B}_3 \widetilde{V_t^n} + \overline{U_{j,t}^r}\right) + \widetilde{V_{j,t}^r}, \; j = 1, 2, \ldots \text{ or}$$

$$V_{j,t}^r = \left(B_0 + B_6 \overline{B}_0\right) + \left(B_1 + B_6 \overline{B}_1\right) P_t^c + B_2 P_{t-1}^c + \left(B_3 + B_6 \overline{B}_3\right) \widetilde{V_t^n} + B_4 \widetilde{V_{t-1}^n} + B_5 V_{j,t-1}^r + \left(B_6 \overline{U_{j,t}^r} + \widetilde{V_{j,t}^r}\right), \; j = 1, 2, \ldots$$

Clearly, the last expression is in the form of (2), except that $B_0$ is replaced by $\left(B_0 + B_6 \widehat{B}_0\right)$, $B_1$ is replaced by $\left(B_1 + B_6 \widehat{B}_1\right)$, $\widetilde{V_{j,t}^r}$ is replaced by $\left(B_6 \overline{U_{j,t}^r} + \widetilde{V_{j,t}^r}\right)$.

Hence, the results here are consistent with the previous literature that in a dynamic setting with endogenous policy, the policy effect may not be identified (among others, see Bernanke and Blinder, 1992; Bernanke and Mihov, 1998).

## Appendix I: Dynamics response analysis for an extended model when the persistent effects of commodity prices are taken into consideration

In the text, we only consider an once-and-for-all change in the commodity prices. In practice, the commodity prices themselves may follow a stochastic process with some degree of presistence. To address this, we have done some supplementary analysis. Here are the details.

First, we estimate a supplementary model for the commodity prices,

$$P_t^c = A_0^c + A_1^c P_{t-1}^c + U_t^c, U_t^c \sim N(\vec{0}, \Omega^c) \qquad \text{(equation P)}$$

For simplicity, we assume that $\Omega^c$ is a diagonal matrix, and hence $\Omega^c = \begin{pmatrix} \sigma_{c,energy}^2 & 0 \\ 0 & \sigma_{c,non-energy}^2 \end{pmatrix}$.

We can then re-write (equation P) as $P_t^c = \left(I - A_1^c L\right)^{-1} A_0^c + \left(I - A_1^c L\right)^{-1} U_t^c$, where *L* is the lag operator, assuming that $\left(I - A_1^c L\right)^{-1}$ exists.

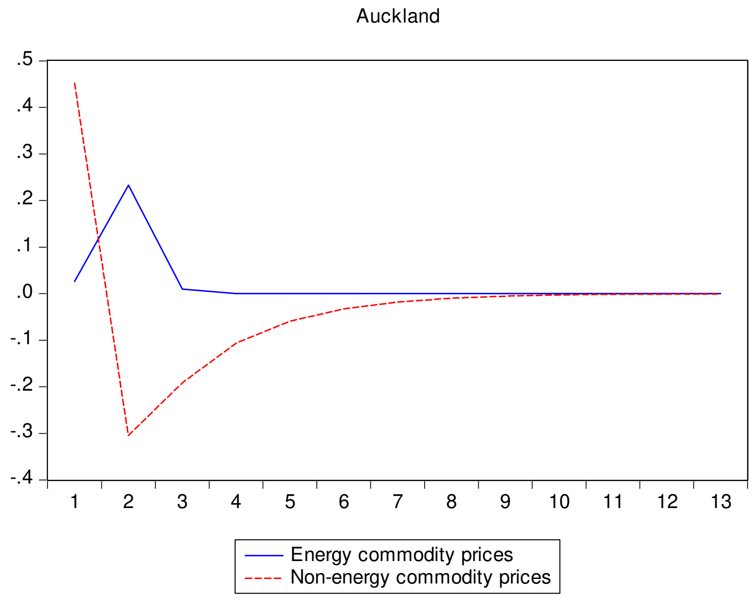
Second, we can then consider the impulse response of all concerned variables to an innovation in $U_t^c$.

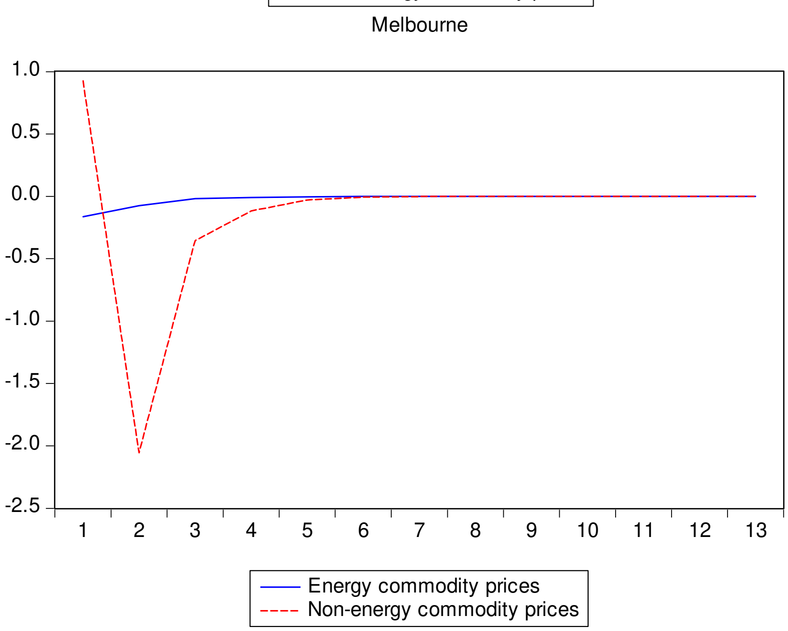
For instance, let us say $U_t^c = \begin{pmatrix} \sigma_{c,energy}^2 \\ 0 \end{pmatrix}, U_{t+k}^c = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, k = 1, 2, \ldots$ By equation P, we can trace the path of $\left\{P_{t+k}^c\right\}_{k=0}$. And then by equation (4), we can trace the whole path of $\left\{\overrightarrow{HP_{t+k}}\right\}_{k=0}$,

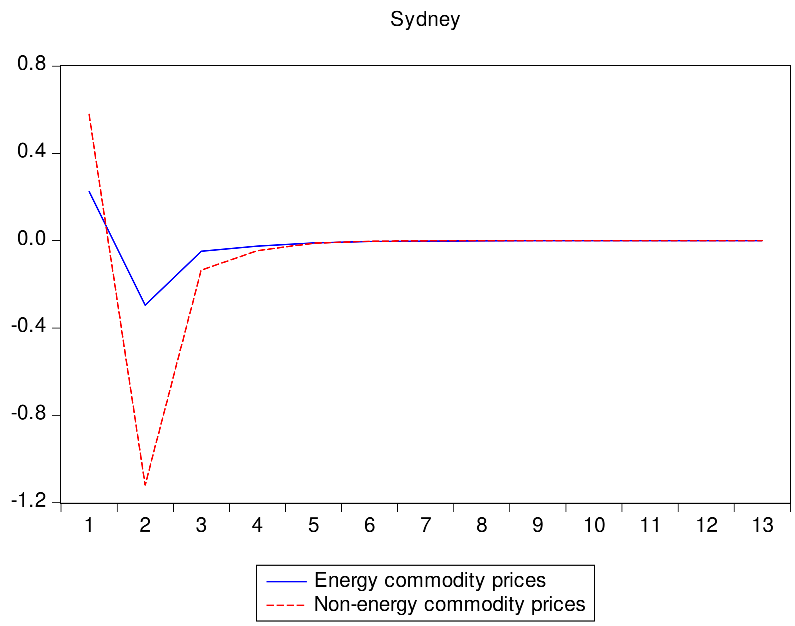
(equation 4 in the paper) $\overrightarrow{HP_t} = C_0(L) + C_1(L)\overrightarrow{V_t^n} + C_2(L)\overrightarrow{V_t^r} + C_3(L)P_t^c + C_4(L)\vec{S} + \overrightarrow{U_t}$.

Clearly, it would be space-occupying to compute the response of all local house prices for all Australian and New Zealand cities. Therefore, we will display only the major cities in Australia and New Zealand, which are Melbourne, Sydney and Auckland.

Figure I-1: Unobservable dynamic Response analysis for one standard deviation of commodity prices on selected city level housing prices






Notes:

These new graphs show some signficantly smoothy effects when compared to those graphs obtained in the previous dynamic analysis. Because the unobservable shocks as generated by equation (p) are quickly dying out over time a short period of time, there won't be much material differences from the previous results after 4 months. The new graphs are based on the accumulated effects of the unobservable shocks over a 13 months time period.