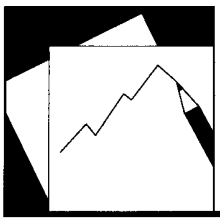
WP/10/291



IMF Working Paper

What Drives House Prices in Australia? A Cross-Country Approach

Patrizia Tumbarello and Shengzu Wang

INTERNATIONAL MONETARY FUND

 WP/10/291

IMF Working Paper

Asia and Pacific Department

What Drives House Prices in Australia? A Cross-Country Approach

Prepared by Patrizia Tumbarello and Shengzu Wang[1]

Authorized for distribution by Ray Brooks

December 2010

Abstract

This paper analyzes the factors driving house prices in Australia from a cross-country perspective using several approaches. It uses a cointegration technique to estimate the long-run equilibrium house prices in Australia, New Zealand, and Canada and assesses the extent of a possible disequilibrium. It also presents an event analysis to shed some light on the link between house prices, capital inflows and the terms of trade. The econometric analysis suggests an overvaluation of 5–10 percent depending on the model specification. Event analysis indicates that terms of trade shocks were associated with larger increases in house prices in Australia, than in the case of strong capital inflow episodes.

JEL Classification Numbers: C32, E20, F21, R31

Keywords: House prices, cointegration, VECM, event analysis, capital inflows, terms of trade

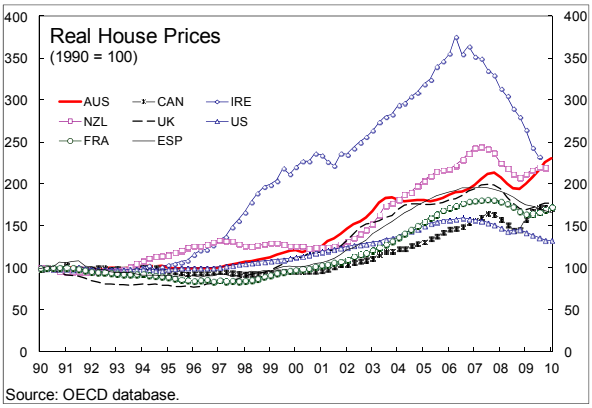
Author's E-Mail Address: ptumbarello@imf.org; swang2@imf.org

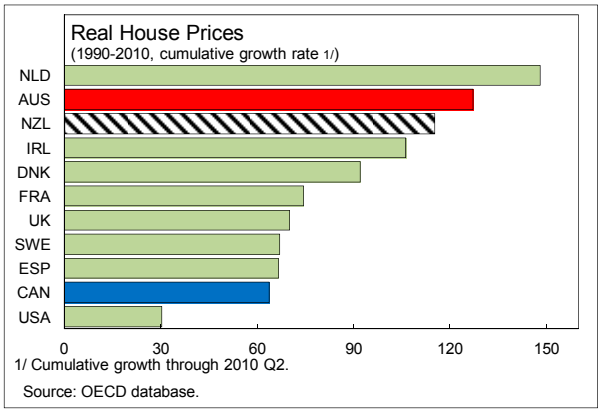
[1] We wish to thank the Australian Treasury officials for their valuable suggestions. This paper has greatly benefited from comments by participants in the seminar held at the Australian Treasury in Canberra in July 2010. We also wish to thank Nicoletta Batini and Ben Hunt for their comments. We are particularly thankful to Prof. Vance Martin for his suggestions on the econometric model. We are very grateful to Ray Brooks for his guidance on this project. Kessia De Leo, Ranee Sirihorachai, and Moshe Shamouilian provided excellent editorial and research assistance.

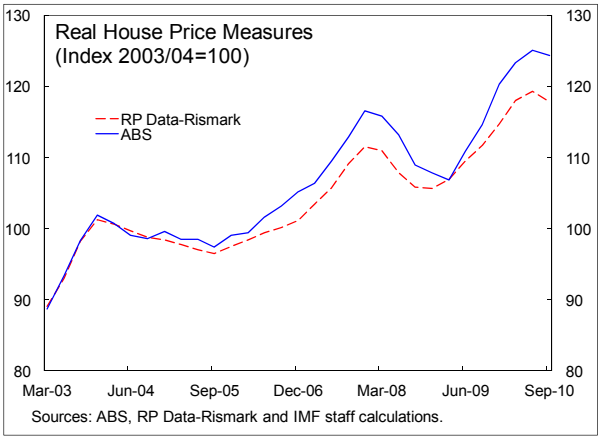
Contents Page

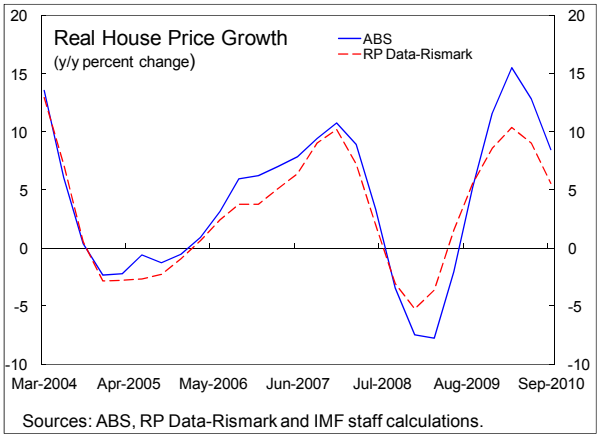
I. Introduction and Main Message

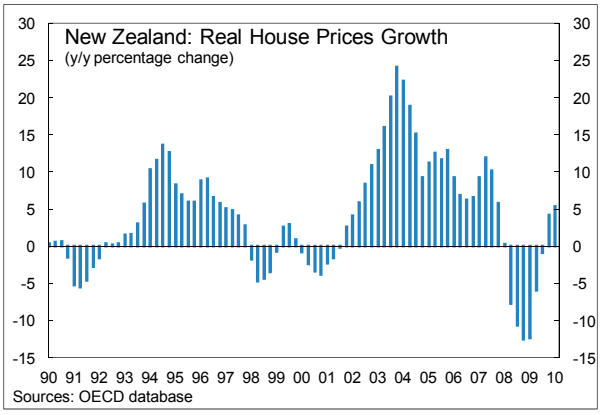
As in other advanced economies, house prices in Australia have increased significantly in the last two decades. House prices rose by almost 120 percent in real terms in the last twenty years—faster than in most comparators. Following the 2008 downturn, the housing market rebounded between the second half of 2009 and mid-2010, with real house prices still growing in the double digits and regaining pre-crisis levels. Since then, house prices have been broadly flat, with real house prices declining slightly.

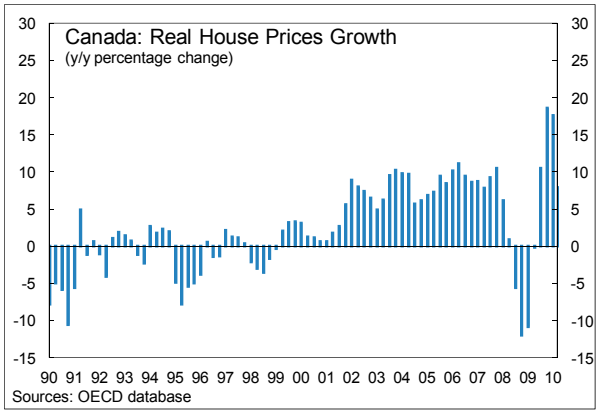












This paper analyzes the factors driving house prices in Australia from a cross-country perspective using several approaches. First, it presents some stylized facts. Second, it uses a cointegration technique to estimate the long-run equilibrium house prices in Australia, New Zealand, and Canada—three advanced country commodity exporters—and assesses the extent of a possible disequilibrium. Finally, the paper presents an event analysis to shed some light on the link between house prices, capital inflows, and terms of trade.

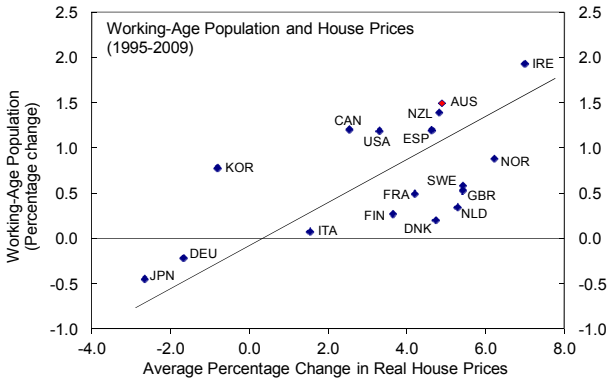
The econometric analysis suggests an overvaluation of 5–10 percent depending on the model specification, while simple analysis of price-to-rent ratios and price-to-income ratios point to a higher overvaluation (Table 1). Some model specifications suggest the terms of trade matter in determining equilibrium house prices in Australia over the last twenty years. The event analysis indicates that positive terms of trade shocks were associated with larger increases in house prices in Australia, New Zealand, and Canada than in the case of strong capital flow episodes, making the property markets in these economies more vulnerable to commodity price volatility. Moreover, looking at a larger sample of advanced economies, including Australia, countercyclical fiscal policy through expenditure restraint during episodes of large capital inflows has been associated with a smaller post-inflow decline in GDP growth and smaller corrections in house prices once the inflows abated.

An additional policy implication can be drawn from these findings. Because the terms of trade are correlated with house prices, they could affect domestic demand through wealth effects on households, in addition to the normal channels, such as income. Thus, it would be prudent for monetary and fiscal policy to take account of such wealth effects caused by swings in commodity prices.

Looking ahead, some country-specific mitigating factors suggest that any house price correction in Australia is likely to be orderly. From a financial stability perspective, stress tests suggest that a correction in house prices is not expected to take a toll on banks because of the low level of high-risk mortgages (see Rozhkov, 2008; Takats and Tumbarello, 2009; and APRA, 2010). However, a fall in house prices and deleveraging by highly indebted households could negatively impact household spending (IMF, 2010). This said, the current historically high terms of trade are expected to be long lasting. Strong population growth and high real income growth in the wake of record-high commodity prices this year will continue to support house prices.

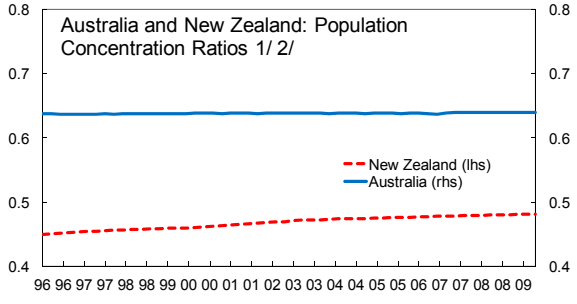
II. Recent Developments in House Prices and Long-Run Stylized Facts

Graphic analysis suggests that most of the increase in house prices in recent years in Australia is explained by fundamentals (Figure 1). Population growth in Australia and New Zealand has been higher than in other advanced economies, mainly because of strong immigration.[2] The wealth effect from the sharp increase in the terms of trade may have also pushed up house prices, as did high household disposable income growth. Policy driven measures during the crisis, such as the first home buyer subsidy in Australia and Canada and a deposit subsidy on mortgages introduced in New Zealand were also factors supporting demand. In addition, the fall in mortgage interest rates in 2008/09 increased housing affordability.

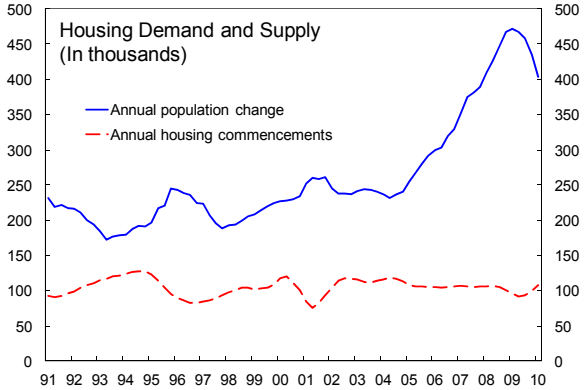


Sources: UN database, OECD database, and IMF staff calculations.

Supply-side factors also played a role. The increasing scarcity of land in main urban centers in Australia is an important factor, including the existence of various constraints on land development, such as growth corridors and boundaries (RBA, 2008). The fact that such a high proportion of Australia's population live in two major centers tends to drive up average house prices (Ellis and Andrews, 2001), although concentration ratios have remained very stable over the last 15 years. Moreover, the gap between housing starts and population growth in recent years has contributed to put pressure on house prices. As reported in the Australia's Future Tax System (Box 6.1. Part 1, Overview), evidence suggests that the current supply of housing is insufficient, placing ongoing pressure on house prices. The recommended reforms to stamp duties and land taxes should reduce the current impediment to housing supply generated by the tax system.



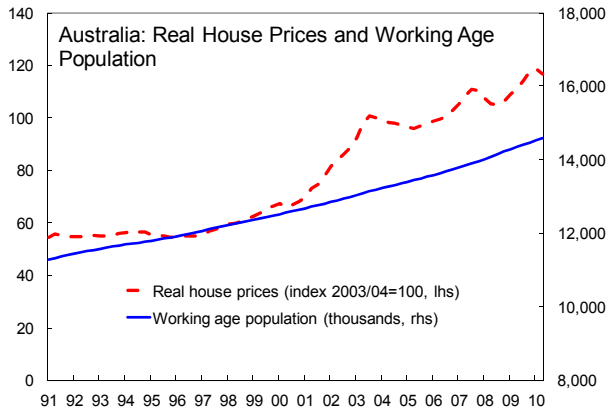
1/ Australia: population of eight capital cities to total population in percent (the cities are: Sydney, Melbourne, Brisbane, Adelaide, Perth, Hobart, Darwin and Canberra).
2/ New Zealand: population of eight largest cities (Auckland, Christchurch, Manukau, North Shore, Waitakere, Wellington, Hamilton and Dunedin) to total population in percent.
Sources: ABS, Statistics New Zealand, CEIC Asia, and Fund staff calculations.



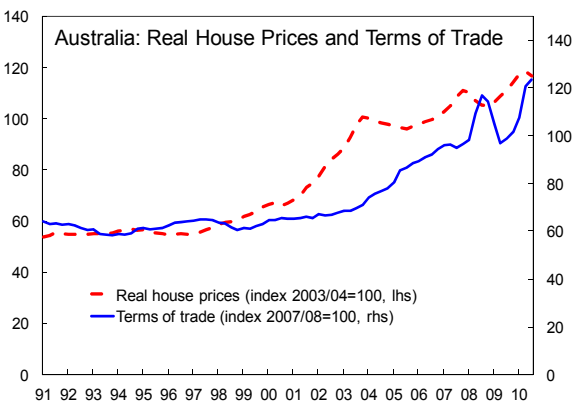
Source: Australian Bureau of Statistics.

[2] In 2009, Australia's population grew by over 2 percent, of which more than half was driven by net migration. In New Zealand, between 2001 and 2006, adult population increased by 8 percent (cumulative), with 93 percent of this increase driven by net migration (Maré and Stillman, 2008). Canada's population grew only by 1 percent starting in 2001, with net immigration accounting for ⅔ of this increase.

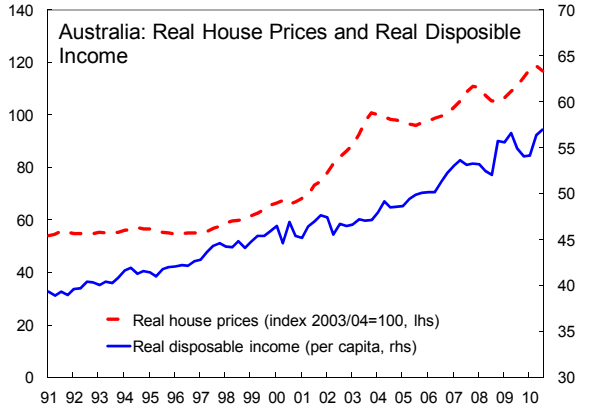
Figure 1. Australia: Determinants of House Prices—Graphic Analysis



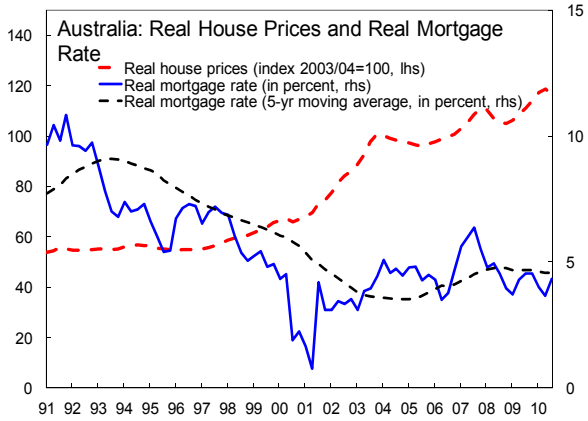
Sources: Australian Bureau of Statistics; and Fund staff calculations.



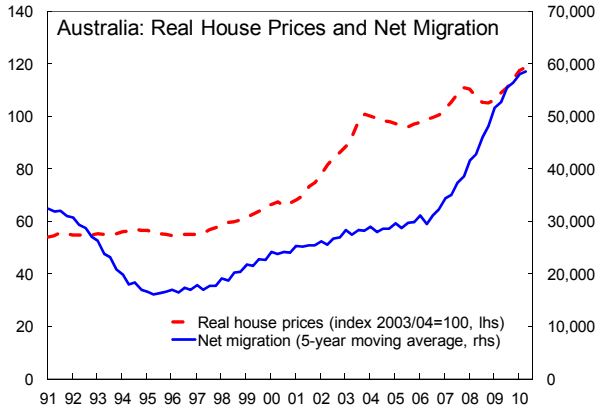
Sources: Australian Bureau of Statistics; and Fund staff calculations.



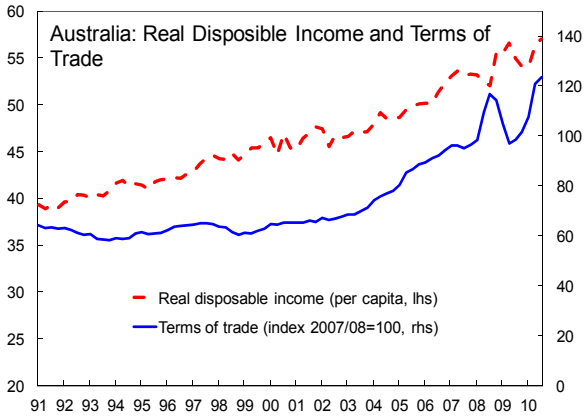
Sources: Australian Bureau of Statistics; and Fund staff calculations.



Sources: Australian Bureau of Statistics; RBA; and Fund staff calculations.

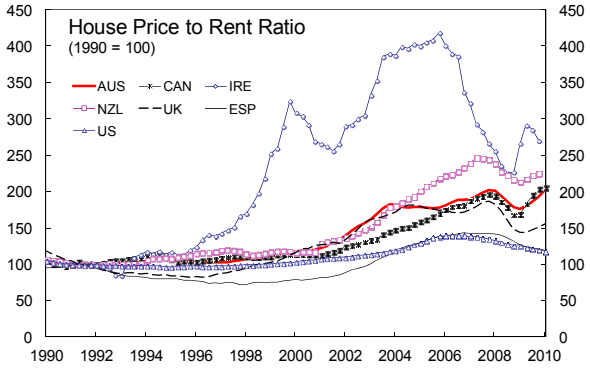


Sources: Australian Bureau of Statistics; and Fund staff calculations.

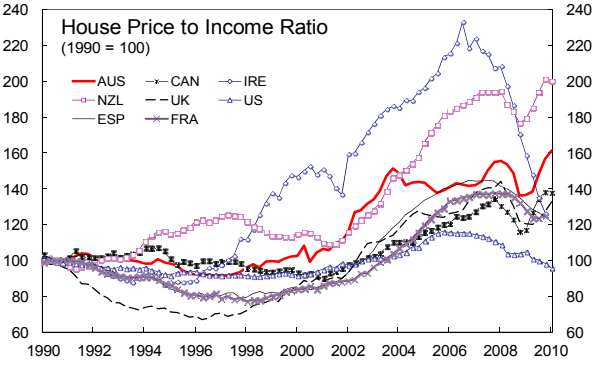


Sources: Australian Bureau of Statistics; and Fund staff calculations.

Metrics of house price-to-rent ratio and house price-to-income ratio—a proxy for affordability—point to house price overvaluation for Australia, New Zealand, and Canada. After declining in all three countries during the global turndown, these ratios started to rebound in mid-2009.



Source: OECD database.



Source: OECD database.

However, using these ratios as the only proxy of misalignment of house prices presents some shortcomings. Structural changes such as permanently lower nominal interest rates that have occurred since 2000 as well as increasing scarcity of land close to urban centers can contribute to a sustainable increase in these ratios. One way to allow for these factors is to evaluate the current price levels relative to medium-run moving averages that proxy for the sustainable level. Price-to-income ratios appear to be above 10-year averages at end-June 2010 by about 20 percent in Australia, 15 percent in Canada, and by 26 percent in New Zealand at end-March 2010. These ratios appear considerably lower when the 7-year moving average is computed, suggesting that they are very sensitive to the period considered.[3] While these metrics indicate that some house price correction may be required, bivariate correlations do not take into account the role of fundamentals, such as demographics and the impact of interest rates, which are better captured by a multivariate econometric approach.

Despite these shortcomings, in retrospective, these ratios were good indicators of overvaluation in house prices in countries that subsequently experienced a correction. In Ireland for example, at the peak of the housing boom in mid-2006, the house price-to-income ratio and house price-to-rent ratio were respectively about 40 percent and 30 percent above their 10-year average. Since then real prices in Ireland have declined by 35 percent in real terms, and ratios of house prices to rents and income have fallen from historically high levels.[4]

[3] Moreover, for Australia the house price series only covers the eight largest cities, while denominator (income) includes the entire country (Battellino, 2010). Therefore these statistics may not be an accurate measure of affordability, resulting in an upward bias of the house price-to-income ratios.

[4] Ireland was among the countries experiencing the most pronounced housing boom-and-bust cycle and is still in the process of downward corrections.

Table 1: Australia, Canada, and New Zealand: Percent Deviation from Medium-Term Average Levels

	Australia		Canada		New Zealand	
	Relative to 10-year moving average as of September 2010	Relative to 7-year moving average as of September 2010	Relative to 10-year moving average as of September 2010	Relative to 7-year moving average as of September 2010	Relative to 10-year moving average as of June 2010	Relative to 7-year moving average as of June 2010
Price-to-income ratio	17.8	10.9	15.3	8.0	27.7	14.7
Price-to-rent ratio	16.5	7.8	22.5	13.1	18.0	4.7

Sources: OECD database and IMF staff calculations.

III. THE ECONOMETRIC ANALYSIS

The model

This paper focuses on the fundamental factors determining house prices in Australia and assesses the extent of a possible house price gap (i.e., disequilibrium). The paper builds on previous IMF work (Hunt, Nguyen, Tumbarello, 2009; and Terrones, 2004), but introduces some important modifications:

- First, it uses a cointegration technique to uncover the long-run relationship between house prices and its fundamentals, using variables expressed in levels.[5] Cointegration models are preferable to single equation models with variables expressed in percentage changes because, contrary to those models, cointegrating techniques can be used to estimate long-run equilibrium house prices.

- Second, some specifications use the terms of trade, instead of real per capital income, as one of the variables to estimate equilibrium house prices, in addition to more traditional variables, such as demographics and the real mortgage rate.

- And finally, it provides some cross-country comparisons. A cointegrating model is estimated separately for three commodity exporters: Australia, New Zealand, and Canada.

In order to investigate the robustness of the results, we use, within the cointegration framework, alternative techniques: a Vector Error Correction Model (VECM) and a single equation model estimated with OLS. All variables are all in levels.[6] A detailed description of the data and sources are reported in Appendix I.

[5] If two or more non-stationary variables are cointegrated, then they do not deviate continually from the long-run equilibrium relationship.

[6] Technically, both sets of estimates are super consistent i.e., they converge to the true values at a faster rate than the case where the variables are stationary. Ideally the result from the cointegrating vector should line up with the OLS single equation results. In practice, for databases particularly noisy such as house prices the single

(continued)

Empirical Results

We found cointegration among the variables considered in the different models (see Appendix II). Using the same VECM for Australia, New Zealand, and Canada, the empirical results show that the terms of trade and working-age population (as a share of total population), as well as the real mortgage rate are important determinants of equilibrium house prices in for Australia, New Zealand, and Canada (Table 2). Moreover, the coefficients appear remarkably similar across these three countries.

The main findings are as follows:

- In the long run, a 1 percent increase in the working-age population as a share of total population will raise the equilibrium house price by about 4 percent in Australia and New Zealand and by about 3 percent in Canada, in line with other studies on OECD countries.[7] However, the coefficient on working-age population appears strongly significant only for Australia, suggesting that perhaps supply constraints play a larger role in Australia compared to the rest of the other two commodity exporters.[8]

- The terms of trade have a significant positive effect on house prices with an elasticity ranging from 0.5 to 0.8 .The terms of trade variable can be interpreted as a proxy for wealth and for permanent income.[9]

- The real mortgage rate has a very high and significant impact on house prices across the three countries. The five-year moving average of the real mortgage rate is used to help identify the long-term trend in interest rates rather than the short-run market fluctuations. In the long run, a 1 percentage point increase in the interest rate will lead on average to a fall in house prices between 5 and 9 percent in Australia. However, this coefficient expresses the long-run relationship between real house prices and interest rate and should not be used to gauge the short-term impact of interest rate changes on house prices.

---

equation model estimated through the OLS with variables expressed in level provides a consistency check for the sign and the significance of the coefficients.

[7] See Williams 2009, and Egert and Mihaljeck, 2007. Egert and Mihaljeck show that the average long-run elasticity of house prices to the working-age population ratio is close to 4 for 19 OECD countries.

[8] The variance decomposition also shows that the interest rate in Australia plays a larger role in explaining house prices changes than in New Zealand and Canada.

[9] By using the terms of trade as a proxy for income, the model implicitly assumes that over the medium term, the structure of these economies will not change. Commodities are still expected to have a large impact on the economy, both through direct (production and exports) and indirect (nominal income) channels. For Canada, Tsounta (2009) indeed finds a similar degree of misalignment in house prices by using disposable income.

- The negative sign of the coefficient of the error correction term for all three countries suggests that indeed the system is correcting back to its long-run equilibrium, but at a relatively slow pace of about one-tenth of the disequilibrium per quarter.

For Australia, the results of the econometric analysis based on a broader range of model specifications point to an overvaluation between 5 and 10 percent (Table 3), with the single equation OLS estimates being at the lower end of this range.[10] The estimates are robust to changes in the estimation period, as similar coefficients are obtained if the estimation period starts in 1985, 1990, or 1995.

Cyclical factors are likely to have contributed to the increase in house prices in recent years—in particular the lower market mortgage interest rate compared to the medium-term average. However, by September 2010, market rates have returned to their long-run average.

Table 2. Determinants of Equilibrium House Prices: Australia, Canada, and New Zealand 1/, 2/

	Australia	Canada	New Zealand
Sample period 3/	1992-2010	1990-2010	1995-2010
	Dependent variable: real housing prices		
Ratio of working age population	4.38	2.75	3.69
to total population	[4.91]	[1.23]	[0.69]
Terms of trade	0.46	0.66	0.80
	[3.71]	[2.06]	[2.08]
Real mortgage rate 4/	-0.09	-0.10	-0.09
	[-7.52]	[-12.14]	[-3.59]
Error Correction:	-0.07	-0.11	-0.10
	[-3.01]	[-2.43]	[-2.58]

Source: IMF staff estimates.

1/ Quarterly data. All variables in the VECM are in log levels with the exception of the real mortgage interest rate.

2/ T statistics in parenthesis [ ].

3/ For Australia through 2010Q3, for Canada and New Zealand through 2010Q2.

4/ Five-year moving average.

[10] Contrary to the terms of trade, the coefficient of real per capita income appears with the wrong sign (negative) most of the time (we report only one specification here), allowing the coefficient of working-age population to be larger.

Table 3. Australia: Determinants of Equilibrium House Prices Under Different Models

	VECM 1, 2/	VECM 1, 2/	OLS 2/	OLS 2/	OLS 2/
Sample period 3/	1992-2010	1992-2010	1992-2010	1992-2010	1989-2010
	Dependent variable: real housing prices				
Net migration	…	0.06	…	…	…
	…	[0.94]	…	…	…
Working age population	…	…	1.35	…	1.83
	…	…	[2.43]	…	[3.98]
Ratio of working age population	4.38	…	…	2.78	…
to total population	[4.91]	…	…	[8.16]	…
Real per capita income	…	1.20	…	…	0.33
	…	[15.92]	…	…	[0.91]
Terms of trade	0.46	…	0.41	0.68	…
	[3.71]	…	[5.31]	[14.12]	…
Real mortgage rate 4/	-0.09	-0.07	-0.06	-0.08	-0.05
	[-7.52]	[-4.92]	[-3.06]	[-15.33]	[-7.03]
Error Correction:	-0.07	-0.07	…	…	…
	[-3.01]	[-3.25]	…	…	…
Overvaluation (in percent)	8.7	7.5	5.2	6.4	4.8

Source: IMF staff estimates.

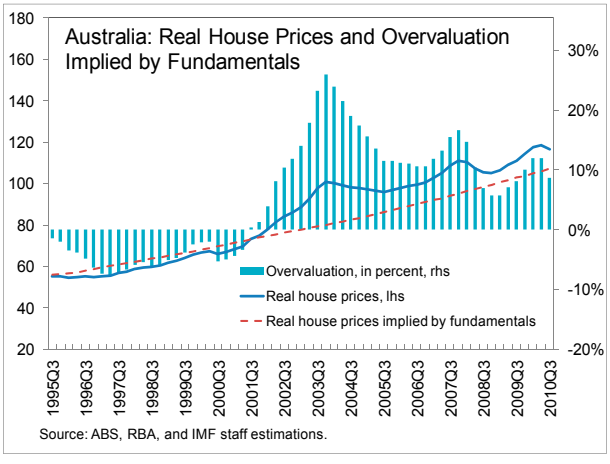
1/ Quarterly data. All variables are in log levels with the exception of the real mortgage interest rate.

2/ T values are in parenthesis [ ].

3/ All models through 2010Q3.

4/ Five-year moving average.

These estimates are subject to considerable uncertainty, but they can still be interpreted as another piece of evidence that points to disequilibrium in house prices. The degree of overvaluation appears milder than in the past, however. The text chart shows that according to the model presented in Table 2, the overvaluation as of end-2003 was about was about 25 percent. The overvaluation in March 2010 was about 5–15 percent, as noted in the 2010 IMF staff report (IMF, 2010). Since then, real house prices have been flat and the overvaluation has been lower (5–10 percent). The model presented in Table 2 suggests an increase in the equilibrium house prices driven by strong fundamentals, mainly an increase in the terms of trade and population.



Looking ahead, while the house price gaps under different metrics (econometrics, price-to-rent, and price-to-income ratios) suggest that some adjustment in house prices would be required, it is useful to remember that sustainable levels can be achieved if incomes and rents

grow faster than house prices or other fundamentals, such as migration and terms of trade change. Thus, a decline in house prices is only one way for the adjustment to occur, and the correction required in prices can occur gradually. Support from fundamentals, such as real income growth in the wake of record-high commodity prices this year would also help to close the gap. Limited new housing supply, despite rapid population growth, should result in strong demand for housing in the years ahead. Banks show resilience to a fall in house prices based on stress tests by Australian Prudential Regulation Authority (APRA), because of a low level of high-risk mortgages. But the authorities should remain vigilant to emerging risks, given that household debt is relatively high at over 150 percent of household disposable income.

IV. Event Analysis: Linking Capital Flows and Terms of Trade to House Prices

In contrast to the econometric models presented above, event analysis focuses on the relationship between economic variables only during periods characterized by particularly large shocks. While it does not attempt to determine the direction of causality, event analysis represents a useful complement to econometric models because it allows us to uncover the non-linear dynamics of economic relationships that are likely to be missed by standard econometric specifications. We focus on the link between capital inflows, terms of trade, and house prices.

The question is whether lessons can be drawn from past episodes of capital inflows and terms of trade shocks as regards the likely evolution of house prices. To this end, we look at previous episodes of terms of trade shocks and large capital inflows and analyze the behavior of house prices and some key macroeconomic indicators.

Episodes of large net capital inflows and positive terms of trade shocks were identified based on the following methodology:

- Large capital inflows episodes were defined as periods when the ratio of capital inflows to GDP is at least one standard deviation above trend.

- Terms-of-trade-shock episodes were defined as periods when the terms of trade for a particular country is higher than the trend terms of trade of that country by ½ standard deviation (see Appendix 1 for a detailed definition of the episodes).

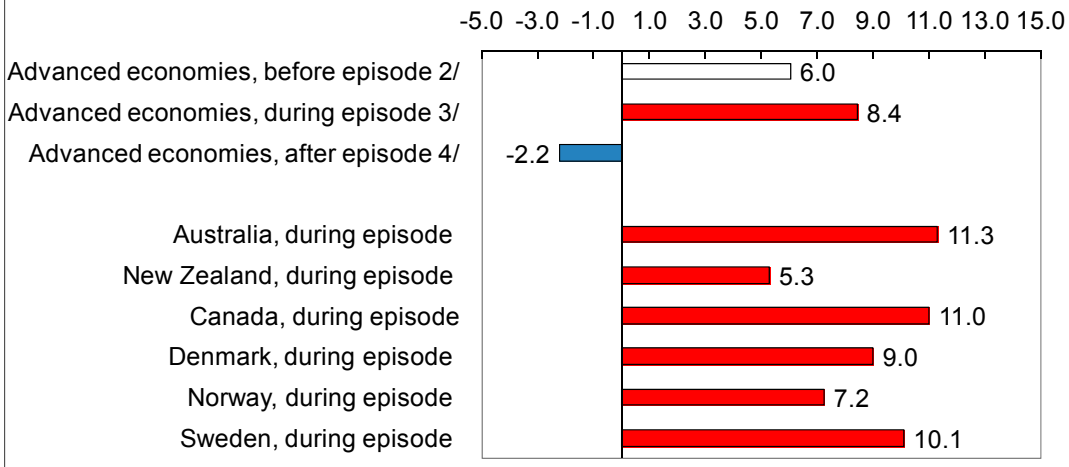
The main findings are as follows:

- Episodes of positive terms of trade shocks were associated with in an increase in house prices for all six countries in the sample, with Australia and Canada experiencing the largest increase—above the average of the advanced countries in the sample, including the other commodity exporters.

- Episodes of large capital inflows were also associated with an increase in house prices, for all countries except Canada, where house prices remained flat. However, in the case of Australia, the surge in capital inflows was associated with much smaller increase in house prices than in the case of terms of trade.

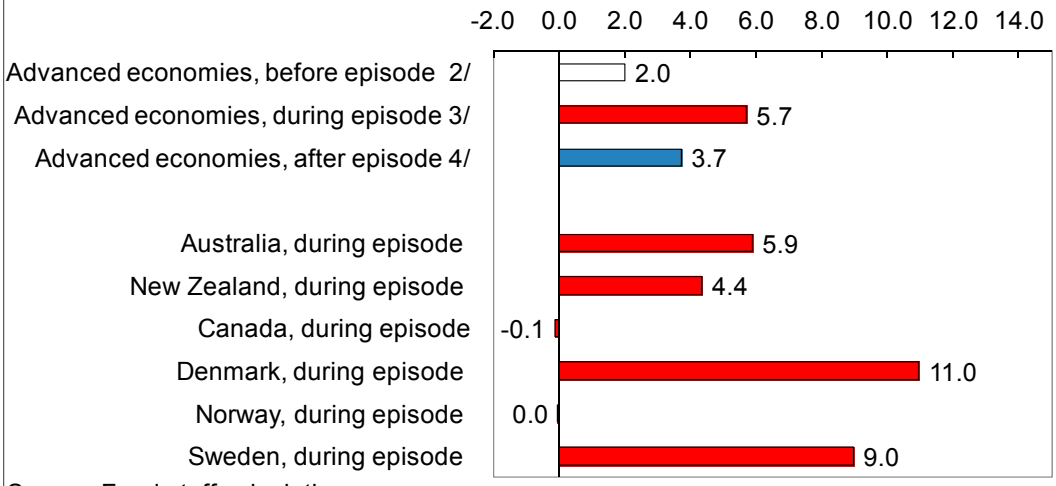
- Looking at a broader macro picture, countries characterized by a sharp decline in GDP growth once the capital inflows stopped were the ones with strong increases in the cyclical component of government spending during the inflow period and the strongest increase in house prices. On the other hand, expenditure restraint during the capital inflow episode was associated with a more moderate decline in GDP growth once the inflows abated. Fiscal prudence may have helped reduce upward pressure on the exchange rate and aggregate demand, facilitating an orderly adjustment of house prices in the post-inflows period. Thus, a countercyclical fiscal policy through expenditure restraint during the episodes of large capital inflows is associated with a smaller post-inflow decline in GDP growth and smaller corrections in house prices.

Figure 2. Event Analysis: House Price Changes During Episodes of Terms of Trade Shock 1/



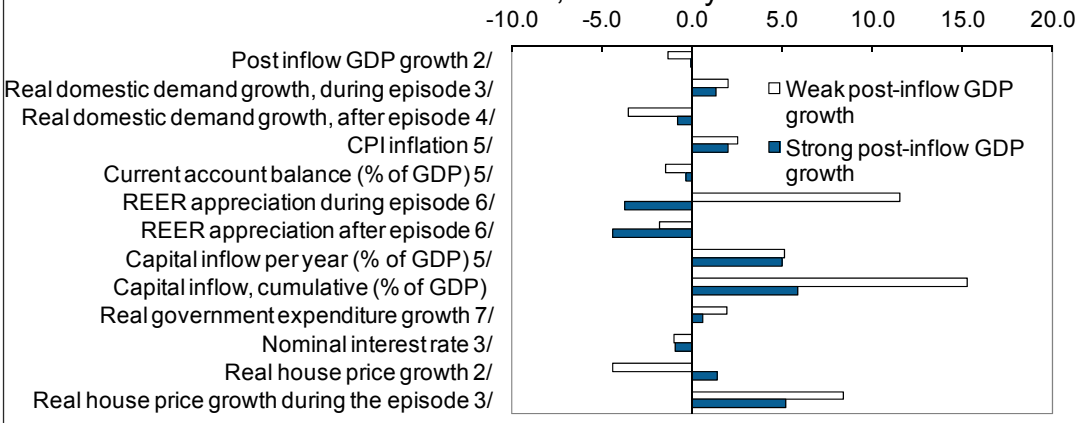
Source: Fund staff calculations.
1/ Real house prices, annual percentage change.
2/ For all countries, average growth rate two years before episode.
3/ For all countries, average growth rate during episode.
4/ For all countries, average growth rate two years after episode for episodes before 2008, one year growth rate used if 2008 is identified as an episode.

Figure 3. Event Analysis: House Price Changes During Episodes of Large Capital Inflows 1/



Source: Fund staff calculations.
1/ Real house prices, annual percentage change.
2/ For all countries, average growth rate two years before episode.
3/ For all countries, average growth rate during episode.
4/ For all countries, average growth rate two years after episode .

Figure 4. Advanced Economies: Post-Capital-Inflow GDP, Selected Macroeconomic Variables, and Policy Indicators 1/



Source: Fund staff calculations.
1/ Values reported are medians for the two groups of episodes.
2/ Average growth in the two years after the episode minus average during episode.
3/ Average during episode minus average in two years before episode.
4/ Average in two years after episode minus average during episode.
5/ Average during espisode.
6/ Cumulative change.
7/ Average deviations from trend of real government expenditures (excluding interest) during the episode, minus average in the two years before the episode. The trend component is obtained from a Hodrick-Pestcott filter.

However, one important caveat is that event analysis does not determine causality. This is because it does not control for the endogeneity of the variables and should therefore not be interpreted as indicating a causality relationship among them. The only purpose is to analyze the correlation between the dependent and policy variables within a macro framework context. For example, in the case of capital inflows, the study does not determine that a slowing in capital inflows causes a fall in GDP growth and a narrowing of the current account deficit. Capital inflows may be driven by an upswing in the domestic economic cycle that increases the current account deficit which in turn requires funding by capital inflows. This implies that domestic demand, the current account deficit, and capital inflows would fall as the domestic cycle cools (Debelle and Galati, 2005). In the case of house prices, the causality relationship could also work the other way: an increase in house prices that would bring the central bank to increase interest rates could trigger an increase in capital flows. Nonetheless, this narrative approach could still be useful, if appropriately integrated with other analysis (including econometrics) in identifying macroeconomic indicators that have signaled in the past the onset of an externally driven boom-bust cycle in the property market.

Table 4. Australia: House Price Changes During Large Capital Inflow and Positive Terms of Trade Shock Episodes

		Advanced Countries[2]	New Zealand 1995-97	New Zealand 2000	New Zealand 2004-06	Australia 1988-90	Australia 1995-99	Australia 2003-06	Canada 1997-98	
Private capital inflows[1]	Before	2.0	5.9	-0.2	7.7	-1.5	1.4	11.2	-4.6	
Real House Prices*	During	5.7	7.0	-1.0	13.6	9.0	2.4	6.2	-0.1	
	After	3.7	-0.2	0.6	4.1	-0.5	6.2	4.3	1.5	
		Advanced Countries[3]	New Zealand 1987-90	New Zealand 2000	New Zealand 2004	New Zealand 2008	Australia 1989	Australia 2003-2008	Canada 1989	Canada 2004-2008
Terms of trade[4]	Before	6.0	1.6	-0.2	7.7	8.7	6.3	11.2	14.3	5.8
Real House Prices*	During	8.4	1.3	-1.0	21.4	-0.5	17.0	5.6	14.0	8.0
	After	-2.2	-3.7	0.6	9.6	-11.7	-2.7	0.2	-7.3	-10.5

Sources: WEO October 2007, Chapter 3, Managing Large Capital Inflows; and Fund staff calculations.
* Percentage change, annual growth.
1/ Values reported are medians for the country groupings. "Before" denotes values in the two years before the episodes. "After" denotes values in the two years after the
2/ The episodes for advanced countries include Australia (1988-90, 1995-99, 2003-06), Canada (1997-98), Denmark (1994, 1997, 1999), New Zealand (1992, 1995-97, 2000, 2004-06), Norway (1993, 1996-97), and Sweden (1988-90, 1996-2000).
3/ Terms of trade episodes include Australia (1989, 2003-08), Canada (1989, 2004-08), Denmark (2003-06), New Zealand (1987-90, 2000, 2004, 2008), Norway (2000-01) and Sweden (1986-89).
4/ Terms of trade episodes are defined as the deviation of terms of trade of a country from its trend exceeding half of the historical standard deviation in year *t*. If 2008 is identifed as an episode, "After" denotes values in 2009.

Table 5. Australia: Large Capital Inflow Episodes in Advanced Countries, Selected Macro Economic and Policy Indicators[1]

		Advanced Countries[2]	Australia 1988–1990	Australia 1995–1999	Australia 2003–2006
GDP growth	Before	3.1	3.3	4.5	3.1
(In percent)	During	3.8	3.4	4.3	3.0
	After	2.3	0.4	2.8	3.6
Real domestic demand growth	Before	3.1	1.8	4.3	3.6
(In percent)	During	4.0	3.8	4.7	4.8
	After	3.2	-0.3	1.7	5.5
Current account balance	Before	0.7	-4.6	-4.0	-2.9
(As percent of GDP)	During	1.1	-5.1	-4.4	-5.7
	After	1.4	-3.5	-2.9	-5.2
Real effective exchange rate[3]	Before	-1.9	-12.8	-2.6	0.6
(In percent)	During	-0.1	13.9	-2.7	24.0
	After	-1.6	7.7	-8.7	31.8
Terms of trade	Before	…	-7.4	-4.2	2.3
(In percent)	During	…	17.3	4.0	36.7
	After	…	8.8	10.1	53.3
CPI inflation	Before	1.9	8.8	1.9	3.7
(In percent)	During	2.2	7.4	2.0	2.8
	After	2.3	2.1	4.4	3.3
Net private capital inflows	Before	-1.5	3.5	2.8	3.0
(As percent of GDP)	During	5.0	5.6	5.0	6.1
	After	-0.2	2.5	3.3	5.3
Nominal interest rates	Before	5.6	14.4	5.1	4.8
(In percent)	During	4.8	14.5	6.0	5.3
	After	5.3	8.5	5.5	6.5
Real house prices	Before	2.0	-1.5	1.4	11.2
(In percent)	During	5.7	9.0	2.4	6.2
	After	3.7	-0.5	6.2	4.3

Sources: *WEO* October 2007, Chapter 3, Managing Large Capital Inflows; and Fund staff calculations.

1/ Values reported are medians for the country groupings. "Before" denotes values in the two years before the episodes. "After" denotes values in the two years after the episode.
2/ The episodes for advanced countries include Australia (1988-90, 1995-99, 2003-06), Canada (1997-98), Denmark (1994, 1997, 1999), New Zealand (1992, 1995-97, 2000, 2004-06), Norway (1993, 1996-97), and Sweden (1988-90, 1996-2000).
3/ Cumulative change within periods.

APPENDIX I. DATA DEFINITION AND SOURCES

Australia

- House price: index of aggregate nominal house prices from ABS, and RP Data-Rismark.
- Mortgage interest rate: Housing Loans: Banks: Standard Variable Rate (EOP, % p.a.), RBA.
- CPI: RBA Table G02, all groups.
- Working-age population: population age group of 15–64, ABS.
- Terms of trade: ABS and Haver Analytics.

Canada

- House price: index of aggregate house prices (nominal and real) from the OECD data base.
- Mortgage interest rate: 5-Year Average Residential Mortgage Lending Rate, Bank of Canada and Haver Analytics.
- CPI: Statistics Canada and Haver Analytics.
- Working-age population: population age group of 15–64, Statistics Canada and Haver Analytics.
- Terms of trade: Statistics Canada and Haver Analytics.

New Zealand

- House price: index of aggregate house prices (nominal and real) from the OECD data base and RBNZ.
- Mortgage interest rate: First Mortgage Housing Rate (% per annum), RBNZ.
- CPI: RBNZ.
- Working-age population: population age group of 15–64, SNZ.
- Terms of trade: SNZ and Haver Analytics.

APPENDIX II. ECONOMETRIC MODEL

We model the equilibrium house prices using a vector error correction model (VECM). The VECM is a restricted VAR designed for use with nonstationary series that are known to be cointegrated. The VECM has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. Since the VECM applies only to cointegrated series with the same level of integration, we first perform unit root tests and then the Johansen cointegration test. More specifically:

The cointegation analysis includes the following steps: first, we test the presence of unit roots of each variable using the augmented Dickey-Fuller (ADF) tests. All variables are tested to be I(1) (see Appendix II Table 1); second, we determined the appropriate lag length for each variable from certain criteria, i.e., Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC), and Adjusted Likelihood Ratio (ALR) tests. Once the optimal lag order has been chosen and given the results of unit roots tests, the following step was to test for cointegration by using the Johansen (1988), Johansen and Juselius (1990) maximum likelihood procedure. After finding cointegration, we estimated the cointegrating vector and the coefficients of the VECM.

The VECM takes the form:

$$\Delta Z_t = \lambda + \delta \mu_{t-1} + \sum_{i=1}^{p} \Gamma_i \Delta Z_{t-i} + \gamma_t \qquad (1)$$

Where Z_t is the vector of endogenous variables mentioned above, μ_{t-1} is the lagged error term from the cointegrating equation, also known as the error-correction term, ΔZ_{t-i} is the lagged difference value of Z_t, and γ_t is the error term.

According to the Augmented Dickey-Fuller test, the logs of real home prices, terms of trade, and a five-year moving average of the real mortgage rate are all integrated of order one. Working age population as well as the working age population as a share of total population is integrated of order one for all countries.

When testing for the existence of a cointegrating relationship for all variables considered, we find only one cointegrating relationship.

The theoretical foundations of the cointegration among house prices and fundamentals can be found in (Malpezzi, 1999; Capozza et al., 2002; Meen, 2002). More recent literature, links house prices to terms of trade (Tomura, 2008).

Appendix Table 1. Unit Root Tests

Variables	Australia		Canada		New Zealand	
	T-Statistic 1/	Probability	T-Statistic 1/	Probability	T-Statistic 1/	Probability
Real house price (log)						
Level	0.315	0.978	0.622	0.990	-0.822	0.809
First-order difference	-5.760	0.000	-7.767	0.000	-4.400	0.001
Real mortgage rate (5-year average)						
Level	-1.763	0.397	-0.673	0.848	-1.559	0.500
First-order difference	-2.828	0.058	-4.117	0.002	-4.082	0.002
Working-age population to total population						
Level	0.108	0.964	0.484	0.818	0.255	0.757
First-order difference	-2.246	0.025	-2.368	0.018	-6.483	0.000
Working-age population (log)						
Level	-0.470	0.892	0.018	0.958	-0.296	0.920
First-order difference	-3.341	0.069	-4.532	0.000	-2.560	0.106
Terms of trade (log)						
Level	0.157	0.969	-1.245	0.653	-1.464	0.547
First-order difference	-6.924	0.000	-7.607	0.000	-7.871	0.000

1/ Augmented Dickey-Fuller test statistic. Null Hypothesis: variable has a unit root.

Source: IMF staff estimates.

Appendix Table 2. Cointegration Tests 1/

Australia				
No. of Cointegrating Vector(s)	Eigenvalue	Max-Eigen Statistic	Critical Value 2/	Probability
None * 3/	0.249	40.990	40.175	0.041
At most 1	0.195	19.543	24.276	0.176
At most 2	0.043	3.300	12.321	0.809
At most 3	0.001	0.039	4.130	0.872
Max-eigenvalue test indicates 1 cointegrating equation at the 0.05 level.				

Canada				
No. of Cointegrating Vector(s)	Eigenvalue	Max-Eigen Statistic	Critical Value 2/	Probability
None * 3/	0.474	52.107	32.118	0.000
At most 1	0.260	24.426	25.823	0.076
At most 2	0.174	15.501	19.387	0.168
At most 3	0.130	11.253	12.518	0.081
Max-eigenvalue test indicates 1 cointegrating equation at the 0.05 level.				

New Zealand				
No. of Cointegrating Vector(s)	Eigenvalue	Max-Eigen Statistic	Critical Value 2/	Probability
None * 3/	0.425	57.391	40.175	0.000
At most 1	0.274	23.629	24.276	0.060
At most 2	0.064	4.067	12.321	0.701
At most 3	0.000	0.006	4.130	0.948
Max-eigenvalue test indicates 1 cointegrating equation at the 0.05 level.				

1/ Unrestricted Cointegration Rank Test (Max-eigenvalue). Cointegrating variables tested: real house price, terms of trade, ration of working age population to total population, and real mortgage rate.

2/ MacKinnon-Haug-Michelis (1999) p-values at the 0.05 level.

3/ * denotes rejection of the hypothesis at the 0.05 level.

Source: IMF staff estimates.

APPENDIX III. EVENT ANALYSIS: DEFINITION OF EPISODES

Episodes of Large Capital Inflows

To identify these episodes, two criteria are used to account for both country- and region-specific dimensions. (1) The country-specific dimension of the episodes is captured by the following criterion: the ratio of net capital inflows to GDP (NPCIR) for a particular country must be significantly (one standard deviation) larger than the trend of capital inflows to that country. For each country in the sample, a rolling, backward-looking Hodrick-Prescott (HP) filter was applied to annual NPCIRs to generate the trend. (2) The regional dimension is captured by the following criterion: capital inflows are significantly larger than a regional threshold (the 75th percentile of the distribution of NPCIRs of the countries in that region), even if they are not out of line with country-specific historical trends. An episode is defined as a year or a string of years, in which at least one of these criteria is met (see World Economy Outlook, October 2007 for a detailed discussion of the methodology).

Episodes of Terms of Trade Shocks

Unlike capital flows, terms of trade shocks tend to be more country-specific and more persistent. The country-specific dimension of the episodes is captured by the following criterion: the terms of trade for a particular country must be greater than the trend of terms of trade of that country by ½ standard deviation. The trend is obtained from a 5-year moving average on the terms of trade over the sample period. An episode is defined as a year, or a string of years, when the above criterion is met.

References

Abelson, Peter, Roselyne Joyeux, George Milunovich and Demi Chung, 2005, "House Prices in Australia: 1970 to 2003 Facts and Explanations," *The Economic Record*, Vol. 81, pp. 96–103.

Australian Prudential Regulation Authority (APRA), 2010, "The Australian Banking System Under Stress?," http://www.apra.gov.au/speeches/THE-AUSTRALIAN-BANKING-SYSTEM-UNDER-STRESS.cfm

Battellino, Ric, 2010,"Aspects of Australia's Finances, and Transcript of Q &A Session," Reserve Bank of Australia, Sydney, June 10, 2010, http://www.rba.gov.au/speeches/2010/pdf/sp-dg-150610-qa.pdf

Bodman, Philip M. and Mark Crosby, 2003, "How Far to Fall? Bubbles in Major City House Prices in Australia," *Australian Property Journal,* Vol. 38, No. 3.

Brooks, Ray, 2008, "Assessing the Impact of a Disruption to Capital Inflows on New Zealand," New Zealand: Selected Issues, *IMF Country Report* No. 08/164, (Washington: International Monetary Fund).

Capozza, Dennis R., Hendershott, Partic H., Mack, Charlotte, and Mayer,Christopher, J. (2002). "Determinants of Real House Price Dynamics," NBER Working Paper 9262, Cambridge, Massachusetts.

Cardarelli, Roberto, Selim Elekdag and M. Ayhan Kose, 2007, "Managing Large Capital Inflows," *World Economic Outlook: Globalization and Inequality*, October, (Washington: International Monetary Fund).

Coleman, Andrew, 2007, "Credit Constraints and Housing Markets in New Zealand," *Discussion Paper Series*, DP 2007/11, Reserve Bank of New Zealand.

Coleman, Andrew and John Landon-Lane, 2007, "Housing Markets and Migration in New Zealand, 1962–2006," *Discussion Paper Series,* DP 2007/12, Reserve Bank of New Zealand.

Commonwealth of Australia, 2009, *Australia's Future Tax System*, December 2009.

Debelle, Guy and G. Galati, 2005, "Current Account Adjustment and Capital Flows" BIS Working Paper No. 169 (Basel: Bank for International Settlements).

Dungey, Mardi and Adrian Pagan, 2009, "Extending a SVAR Model of the Australian Economy," *The Economic Record*, 85, Issue 268, pp. 1–20.

Dvornak, Nikola and Marion Kohler, 2007, "Housing Wealth, Stock Market Wealth and Consumption: A Panel Analysis for Australia," *The Economic Record*, 83, Issue 261, pp. 117–130.

Ellis Luci, 2006, "Housing and Housing Finance: the View from Australia and Beyond," Research Discussion paper, RDP 2006–12, Reserve Bank of Australia.

_____2010, "Recent Developments in the Housing Market and its Financing," Speech, Reserve Bank of Australia.

Egert, Balazs and Dubravko Mihaljek, 2007, "Determinants of House Prices in Central and Eastern Europe," *Comparative Economic Studies*, 49, pp. 367–388.

Ellis, Luci, and Dan, Andrews, 2001, "City Sizes, Housing Costs, and Wealth," *Reserve Bank of Australia Research Discussion Paper,* 2001–08.

Fry, Renée, Vance L. Martin and Nicholas Voukelatos, 2009, "Overvaluation in Australian Housing and Equity Markets: Wealth Effects or Monetary Policy?" *CAMA Working Paper,* Australian National University.

Fry, Renée, James Hocking, and Vance L. Martin, 2008, "The Role of Portfolio Shocks in a Structural Vector Autoregressive Model of the Australian Economy," *The Economic Record*, 84, Issue 264, pp. 17–33.

Johansen, S., 1988, "Statistical Analysis of Cointegration Vectors," Journal of Economic Dynamics and Control, 12, pp. 231–54.

Johansen, S., and K., Juselius,1990, "Maximum likelihood estimation and inference on cointegration—with applications to the demand for money," Oxford Bulletin of Economics and Statistics 52, pp.169–210.

Hunt, Ben, Khoi Nguyen, and Patrizia Tumbarello, 2009, "Australian Household Vulnerabilities," Australia: Selected Issues, IMF Country Report No. 09/249, (Washington: International Monetary Fund).

International Monetary Fund, 2010, Australia: 2010 Article IV Consultation - Staff Report, IMF Country Report No. 10/331, (Washington: International Monetary Fund).

Malpezzi, Stephen, 1999, "A Simple Error Correction Model of House, Prices," *Journal of Housing Economics*, 8, pp. 27–62.

Maré, C.and Stillman, S., 2008, "Housing Markets and Migration: Evidence from New Zealand," *Economic Impacts of Immigration Working Paper Series* (Wellington: Department of Labour).

Meen, Geoffrey, 2002, "The Time-Series Behavior of House Prices: A Transatlantic Divide?" *Journal of Housing Economics*, 11, pp. 1–23.

Mikhed, Vyacheslav and Petr Zemčík, 2007, "Do House Prices Reflect Fundamentals? Aggregate and Panel Data Evidence," *Center for Economic Research and Graduate Education – Economic Institute Working Paper Series* No. 337 (Prague: Charles University).

Reserve Bank of Australia, 2008, "Some Observations on the Cost of Housing in Australia," available at www.rba.gov.au/publications/bullettin/2008/apr/pdf/bu-0408-5.pdf

Reserve Bank of New Zealand, 2007, *Monetary Policy Statement*, December 2007 (Reserve Bank of New Zealand).

Rozhkov, D., 2008, "Australian Banks: Weathering the Global Storm," *Australia: Selected Issues*, IMF Country Report No. 08/311 (Washington: International Monetary Fund).

Takats E. and Tumbarello P., 2009, "Australian Bank and Corporate Sector Vulnerabilities—An International Perspective," *IMF Working Paper WP/09/223.*

Terrones, M., 2004, "What Explains the Recent Run-Up in House Prices?" Box 2.1 in Chapter 2, *World Economic Outlook*, September 2004 (Washington: International Monetary Fund).

Tomura, H., 2008, "A Model of Housing Boom and Bust in a Small Open Economy," Working Paper/Document de travail 2008-9, Bank of Canada.

Tsounta, Evridiki, 2009, "Is the Canadian Housing Market Overvalued? A Post-Crisis Assessment," Working Paper No. 09/235, (Washington: International Monetary Fund).

Williams, David M, 2009, "House Prices and Financial Liberalisation in Australia," *Working paper series,* No. 432, University of Oxford, Department of Economics.