# TREASURY WORKING PAPER

# 98/3


# Regional Price Convergence in Australia and New Zealand, 1984-1996


## Andrew Coleman & Toby Daglish



**ABSTRACT**

This paper uses disaggregated price data to analyse the extent and the speed of retail price convergence between New Zealand and Australia since 1984. The paper addresses several issues concerning the integration of markets in the two countries. It compares the behaviour of the prices of a set of goods in different cities in Australia with the behaviour of the prices of the same goods in New Zealand. The data is used to answer two sets of questions: first, whether there are systematic differences in the extent to which the retail goods markets between New Zealand and Australia are integrated when compared to the integration of markets between different cities within Australia; and second, whether the theory of purchasing power parity can usefully describe the effect of changes in the bilateral exchange rate on New Zealand prices.



*The authors would like to thank seminar participants at Victoria University of Wellington, The Reserve Bank of New Zealand, and the New Zealand Treasury for useful comments and discussion.*

## SECTION 1: INTRODUCTION

It should be reasonable to assume that the New Zealand economy is well integrated with the Australian economy. The countries have a similar legal heritage, speak the same language, and have largely free trade in capital, labour, and product markets. Moreover, Auckland is substantially closer to Sydney than either Darwin or Perth. From these perspectives, there is little reason why New Zealand should not be considered to be a state of Australia, albeit with a different currency and tax system. This contention is superficially supported by a stroll through any city in New Zealand, for many firms operate in both countries and malls all over Australasia have the same shops, banks, fashions, and goods.

Despite these similarities, a shopping expedition quickly reveals that the prices of everyday items are quite different in New Zealand than they are in Australia. In turn, several shopping expeditions reveal that there is substantially more price variation between Australia and New Zealand than there is between different states within Australia. In order to systematically document the differences, in this paper we examine how price adjustment across the Tasman differs from price adjustment within Australia using both aggregate CPI data and a set of 34 “supermarket” prices. The statistical analysis shows that the volatility of the real exchange rate between the two countries is much greater than the volatility of the relative price indices of the different state capitals, by a factor of ten. The supermarket price data confirm this story, but also show that much of the 30 percent real appreciation that occurred between 1985 and 1987 resulted in a narrowing of price differentials as low New Zealand prices “converged” to higher Australian prices. This narrowing of price differentials notwithstanding, New Zealand retail prices for supermarket goods are still much less influenced by average Australian retail prices than are Australian state prices.

The behaviour of consumer prices in New Zealand relative to those in Australia is consistent with the behaviour of prices in Canada relative to those in the United States. Recent papers by Engel (1993), Rogers and Jenkins (1995), and Engel and Rogers (1996) found that relative price movements between different cities in Canada and the United States are exacerbated by the border and that while there is considerable price variation within each country, the price variation within each country is substantially less than the price variation between the countries. The behaviour of the New Zealand-Australian bilateral real exchange rate is also in keeping with international evidence that shows that real exchange rate movements between countries are frequently large and persistent.

The results of the paper raise questions about the extent to which economic integration between different regions is limited by political borders. There has been a recent increase in interest in this question as the result of an upsurge of regional successionist movements in various countries[1]. Although it is regularly assumed that economic integration is hindered by political borders, the economics profession has yet to provide much insight as to why borders matter. Nonetheless, a recent attempt to document the importance of borders has shown the effects can be large. McCallum (1995) shows that inter-provincial trade between any two Canadian provinces is approximately twenty times greater than trade between Canadian provinces and U.S. states, once distance and economic size are taken into account. These large differences are consistent with the evidence that price movements between different cities in Canada and the United States are exacerbated by the border.

The extent to which the integration of the New Zealand economy into the wider Australasian economy is affected by the political border - or possibly just the different currency zones - is unknown. It is unfortunate that data is not available to allow a comparison of trade flows between Australia and New Zealand and trade flows within Australia. Nonetheless, the results suggest that in terms of price behaviour New Zealand is considerably less integrated into the Australian economy than are states such as Tasmania, Western Australia or Queensland.

The results of the paper also highlight a perennial issue concerning monetary policy in New Zealand: the extent to which changes in the exchange rate result in changes in local prices and consequently the inflation rate. While the results of this paper apply to only a tiny number of the goods that are in the Consumer Price Index, they suggest that exchange rate pass through can be very slow. The narrow coverage of the study means that the results should not be extrapolated further; nonetheless, they are of passing interest, as the level of disaggregation means it is possible to control for changes in prices occurring in overseas (Australian) markets, thus improving the estimation procedure.

The plan of the paper is as follows. In Section 2 there is a brief description of the main ways in which the theory of price equalisation has been examined, followed by a brief review of some of the relevant literature. In Section 3 the real exchange rate between Australia and New Zealand since 1966 is described and contrasted with relative CPI movements within Australia. In Section 4 the behaviour of the retail prices in Australia and New Zealand between 1984 and 1996 is analysed. Conclusions are offered in Section 5.

---

[1] For a recent review of some of this literature see Bolton, Roland and Spolaore (1995).

## SECTION 2: PREVIOUS LITERATURE

### The Law of One Price and Real Exchange Rate Indices

The usual theoretical basis for the examination of real exchange rates begins with arbitrage and the law of one price. Let $P^i_{kt}$ be the retail price of good k in city i at time t, and $E^{ij}_t$ the exchange rate between two cities i and j at time t. The strong form of the law of one price is that the common currency price is the same in both cities:

$$P^i_{kt} = E^{ij}_t P^j_{kt} \quad or \quad p^i_{kt} = e^{ij}_t + p^j_{kt} \tag{1}$$

where the lower case letters refer to logarithms of the variables. In the case that the two cities are within one country, $E^{ij}_t = 1$.

There is little reason to expect equation 1 to hold exactly. It ignores differences in prices that result from different taxes or from the costs of physical arbitrage. Even excluding these factors, equation 1 would hold exactly only if the good were fully tradeable. Typically this is not so. Rather, the retail price of a good reflects the wholesale price of the good plus a retailing charge, with the former but not the latter usually considered tradeable. Consequently, even if the law of one price holds at the wholesale level, there is no guarantee that it holds at the retail level as the physical arbitrage of goods will not ensure that the prices of non-traded retailing services are the same in different cities. Rather, the mark-ups will depend on local wages, the efficiency of the non-traded (retailing) service, and the extent of competition in the city.

Not withstanding the non-tradability of retailing services, there has been considerable interest in establishing the extent to which equation 1 holds in practice for different classes of goods and services. Three sets of questions have typically been asked:

(i) do the prices of a good sold in different cities tend to change simultaneously?

(ii) do absolute deviations from the law of one price tend to disappear over time, or are differences permanent; and

(iii) when the cities are in different currency zones, to what extent do local currency prices change in response to changes in the exchange rate?

In general, these questions have not been answered directly because it has been difficult to find long and reliable time series of prices of the same good in different cities. Rather, most studies have examined the behaviour of real exchange rate indices between cities or countries, by comparing normalised price indices adjusted for currency movements. If $P^{i*}_t$ is a price index of a basket of goods in country i, then the real exchange rate $R^{i*}_t$ is defined as

$$R_t^{ij*} = \frac{P_t^{i*}}{E_t^{ij} P_t^{j*}} \qquad or \quad r_t^{ij*} = p_t^{i*} - e_t^{ij} - p_t^{j*}$$

**(2)**

Moreover, rather than ask the above questions, the following variations are asked:

(i) do price indices in different cities change at the same time;

(ii) do real exchange rate changes disappear over time, or are changes permanent; and

(iii) when the cities are in different currency zones, to what extent do local inflation rates change in response to changes in the exchange rate?

There is one important difference between studies which examine the law of one price and those which examine the behaviour of the real exchange rate. Because real exchange rates are based on price indices, it is not possible to use them to ascertain if price levels are similar or different in different cities. Rather only prices movements can be analysed. The difference is important in this study as the prices of many goods in New Zealand were much lower than the prices of the same goods in Australia in 1984. The large price increases in New Zealand between 1984 and 1986 (in Australian dollar terms) can therefore be interpreted loosely as price convergence, a result only apparent if the initial price levels are known.

**Recent Evidence on Real Exchange Rates and the Law of One Price**

There is a vast empirical literature examining the behaviour of real exchange rates between countries. Most of these studies have shown that real exchange rate movements tend to be large and persistent. A recent consensus suggests that while real exchange rate movements between OECD countries are not permanent they are long lasting; on average the half life of deviations from relative purchasing price parity is 4 - 5 years (see the reviews by Froot and Rogoff (1995) and Rogoff (1996)).

The results of four recent papers analysing disaggregated price data in the United States and Canada are of particular relevance to this study, as they show that the law of one price holds only weakly between contiguous regions separated by a political border. Engel (1993) analysed 34 finely disaggregated price indices between Canada and the United States and showed that the volatility of prices of different goods within one country tended to be less than the volatility of the same good in different countries — or, as he put it “the price of a wool shirt relative to a bottle of wine in the United States is less volatile than the price of a wool shirt in the United States relative to a wool shirt in Canada." (Engel, 1993, p35). The exceptions were typically simple or homogenous goods which have volatile prices such as ground beef, poultry, coffee, apples or gasoline.

Rogers and Jenkins (1995) examined how traded and non-traded goods affected real exchange rate movements between Canada and the United States. They calculated relative price indices for 54 goods and services, and examined whether changes in the indices tended to be permanent or transitory. For only eight goods could they reject the hypothesis that the changes in the relative price index were permanent; these goods were all food items, although for other food items the hypothesis could not be rejected. They concluded that the persistence of changes in the real exchange rate could be attributed both to the effect of different price movements of non-traded goods and the failure of the law of one price to hold for individual tradeable goods.

Engel and Rogers (1996) calculated "disaggregated real exchange rate indices" using price index data disaggregated into seven sub-indices for fourteen US and eight Canadian cities. They found that the quarterly volatility of these relative price indices was higher on average for a pairing of one Canadian and one US city than for city pairs which were either both Canadian or both from the United States. They also found that the quarterly volatility of the relative price indices increased with the distance between the cities. The distance between Canadian and United States cities could not explain this additional volatility, however; rather, the additional volatility caused by the border was equivalent to a distance of at least 1800 miles.[2]

These papers suggest that regional prices are significantly influenced by political borders. Trade across borders does not appear to be a perfect substitute for trade within borders: the extent of economic integration depends in part on whether contiguous regions are in the same country, or at least have the same currency. The results of these price studies are supported by the work of McCallum (1995). He used a unique data set of trade flows between Canadian provinces and between Canadian provinces and U.S. states to estimate a gravity model of trade, whereby trade volumes depend on the economic size of each region and the distance between them. The model showed that once the size of a US state economy and the distance between it and a Canadian province were taken into account, trade between it and a province was only about 5 percent of the trade that would have occurred if the state had been part of Canada. He concluded that if even the "relatively innocuous Canada-U.S. border continues to have a decisive effect on

[2] This figure represents the minimum distance equivalent, using 95 percent confidence intervals. If the mean estimate is used, the distance equivalent of the border is 75000 miles; in other words, crossing a border seems to introduce a qualitatively different amount of volatility into inter city price volatility.

continental trade patterns...national borders in general continue to matter" (p622)

The last paper to mention is a study of price convergence within the United States by Parsley and Wei (1996). This study is unusual because the authors use actual price data rather than price indices so that they can test the law of one price directly. The data consists of the prices of 10 services, 15 perishable goods and 26 non-perishable goods in 48 cities across the United States from 1975 to 1992. Three empirical results are relevant. First, the average price difference for the same good (or service) in different cities was approximately 15 percent; this average is similar for the three classifications of goods and services. Secondly, price variation increased with distance; moreover, price convergence was faster when cities were close together. Finally, the paper found that the prices of most goods and some services were mean reverting - that price differences were transient - and that the rate of convergence was quite rapid. The half life of a price difference between cities was between four and seven quarters, a speed much greater than the half life of four and a half years typically estimated for real exchange rate movements. In cases where the prices of services converged, the speed of adjustment was considerably slower than for goods, however.

This paper conducts an investigation of the behaviour of prices in New Zealand and Australia similar in flavour to that of Parsley and Wei, to ascertain whether the speed of price convergence between Australia and New Zealand is similar to the speed of convergence within Australia. The study is substantially less comprehensive than theirs, however, due to the limited number of goods for which prices are available in both countries. Because of the less comprehensive coverage, both in terms of the number of goods and the time period for which data is available, we have chosen to begin the empirical analysis by examining the bilateral real exchange rate and the internal Australian relative price indices.

**SECTION 3: REAL EXCHANGE RATES INDICES, 1966 - 1996.**

The set of real exchange rates used in this section are calculated using the consumer price indices of each Australian state capital city and New Zealand as the price deflators. (Recall that within Australia the real exchange rate between two cities is defined as the ratio of the consumer price indices.) Let $P^{A^*}_t$ be the average Australian Consumer Price Index, calculated from the individual city indices as follows:

$$p_t^{A*} = \sum_j a^j p_t^{j*}$$

**(3)**

where $\alpha^j$ is a weight based on average city population.[3] The real exchange rate between New Zealand and Australia is calculated as

$$r_t^{ZA*} = p_t^{Z*} - e_t^{ZA} - p_t^{A*}$$

**(4a)**

while the real exchange rate for an Australian city j is calculated as

$$r_t^{jA*} = \frac{p_t^{j*} - p_t^{A*}}{1 - a^j}$$

(**4b**)

The normalisation in the latter equation means that the real exchange rate for each Australian city is compared to the average of all other cities.

---

[3] The weights are Sydney = 0.335;Melbourne = 0.286; Brisbane = 0.127; Adelaide = 0.096; Perth = 0.11; Hobart = 0.017; Canberra = 0.029. Darwin was excluded as data was not available for the full period.

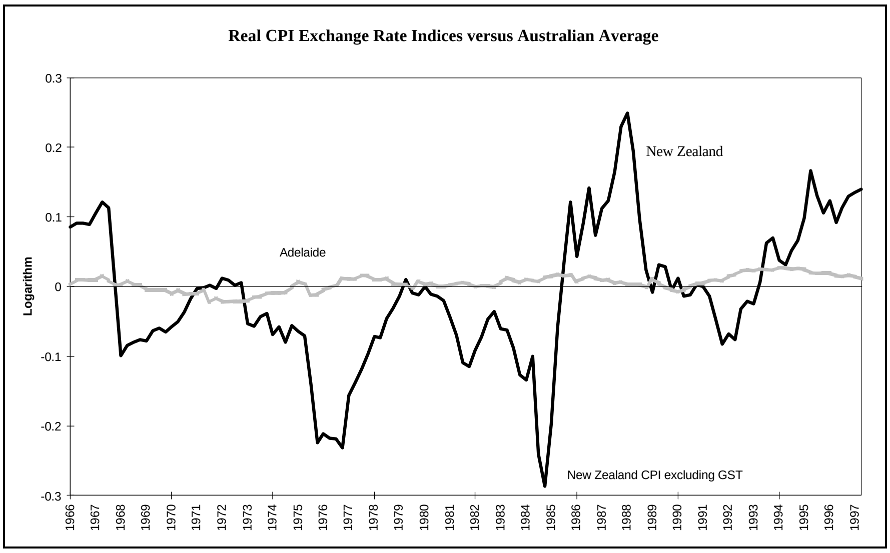



**Figure 1: Real exchange rates - comparing New Zealand with Adelaide**

The real exchange rates for New Zealand and Adelaide are presented in Figure 1[4]. The two most striking features are the difference in the average magnitudes of the real exchange rate movements, with New Zealand being substantially more volatile than Adelaide, and the enormous real appreciation of the New Zealand dollar beginning in 1985. The latter episode is worthy of comment. Prior to 1984, New Zealand fixed the nominal exchange rate against a basket of currencies, maintaining a crawling peg so that the exchange rate was periodically adjusted to keep the real exchange rate constant. In 1984, there was a run on the dollar before the July election; immediately after the election the dollar was devalued by twenty percent. In March 1985 the currency was floated, and it appreciated against most currencies. Between March 1985 and December 1986, the New Zealand dollar appreciated 29 percent against the Australian dollar in nominal terms; since retail price inflation was nearly identical in both countries during the period, the nominal appreciation represented a real appreciation of 30 percent[5].

## Statistical Analysis

The question of whether real exchange rate changes disappear over time or whether they are permanent can be formally examined by testing statistically whether the series revert to their mean value. One test used to examine

4 The graph for Adelaide is qualitatively similar to the graphs for all the other state capitals.

5 The Australian Consumer Price Index increased by 17 percent during the period and the New Zealand Consumer Price Index increased by 18 percent (an amount which excludes the effect of the introduction of a comprehensive 10 percent valued added tax). The real exchange rate subsequently depreciated by 15 percent in the five years to December 1991 and the appreciated by 24 percent in the five years to December 1996. During this time inflation in both countries was similar.

whether or not the real exchange rate indices are mean reverting is the augmented Dickey-Fuller test: whether or not the coefficient ρ is statistically different from zero in the following regression:[6]

$$\Delta r_t^{iA*} = a + r r_{t-1}^{iA*} + \sum_{l=1}^{4} b_l \Delta r_{t-l}^{iA*} + e_t^i \quad (5)$$

If ρ=0, the series $r^{iA*}_t$ contains a unit root, and innovations to the real exchange rate are permanent. If ρ < 0, the series $r^{iA*}_t$ is mean reverting, and an innovation to the real exchange rate will dissipate over time.

The results of the regressions for each state capital and for New Zealand are presented in Table 1. In no case could the hypothesis that the real exchange rates contain a unit root be rejected using the appropriate Dickey-Fuller test statistics. These tests have notoriously low power against the null hypothesis that the coefficient ρ is negative but near zero, so that while the null of a unit root cannot be rejected, these tests should not be considered proof that the series actually have a unit root. Nonetheless, they do attest to the fact that shocks to a real exchange rate are very persistent.

The persistence of shocks to the real exchange rate series can also be analysed by examining the variances of changes to real exchange rates. Table 2 presents the standard deviation of exchange rate movements measured over a different number of quarters, $s(r_t - r_{t-k})$, and Table 3 presents the associated variance ratio statistics

$$V(k)[r] = \frac{Var(r_t - r_{t-k})}{k.Var(r_t - r_{t-1})} \quad (6)$$

If the series r is mean reverting, a change in r will gradually die out over time, and as the lag k gets large *V(k)[r]* will approach zero. Alternatively, if shocks to r are permanent, so that r has a unit root, the variance of ($r_t - r_{t-k}$) will grow with k and the ratio *V(k)[r]* will approach a non zero number *v* that is the fraction of a shock that is expected to persist permanently.

Like other tests of unit roots, the variance ratio test has low power, but has been presented here as it shows the extent to which real exchange rate shocks prove to be persistent. The asymptotic standard deviations of the variance ratio test are calculated using the same procedure as Cochrane (1988).[7] After ten

---

6 This regression was run after a similar regression including a time trend was estimated. In no case was it possible to reject either the hypothesis that the coefficient on the time trend was zero, or the joint hypothesis that the coefficient on the time trend was zero and ρ was zero. Consequently, we estimated equation 4.

7 The asymptotic variance is calculated by noting that the estimated k-lag variance of a series is proportional to the Bartlett estimate of the spectral density of the series at

quarters, there is no evidence that a movement in the real exchange rate of New Zealand, Perth, Adelaide, or Sydney will have reversed itself; however, it is not possible to reject the hypothesis that a real exchange rate change in Brisbane would have reversed itself in ten quarters. The evidence in Melbourne, Canberra, and Hobart is mixed, with somewhat over half of any change in the real exchange rate proving to be persistent after ten quarters.

Given the persistence of shocks evident in Table 3, the importance of the difference in the average size of real exchange rate shocks between Australian states and New Zealand becomes apparent. The average real exchange rate movement between two Australian states within a quarter is 0.4 - 0.5 percent; between Australia and New Zealand it is nearly 4 percent. Over a two-year period, the average size of a real exchange rate movement within Australia is 1 percent; between Australia and New Zealand it is 12 percent. Clearly, relative price movements between New Zealand and Australia, expressed in Australian dollars, are much more volatile than relative price movements between Australian states; the border, or perhaps the different currency zones, makes a difference. While it is not clear whether it is the border or the currency zone that matter the most, it is perhaps worth noting that the nominal exchange rate volatility between Australia and New Zealand is almost the same as the real exchange rate volatility.

---

frequency zero; the estimate is thus 4/3*k/T*V(k)[r], where the variance estimate has a degrees of freedom correction. See Anderson (1971). The exact small sample estimate derived by Lo and MacKinlay (1989) was not followed because of the serial correlation in the differenced series.

## SECTION 4: RETAIL PRICE CONVERGENCE IN AUSTRALIA AND NEW ZEALAND.

### Data

This part of the paper is based on the analysis of the prices of 34 goods typically sold in supermarkets in Australia and New Zealand. The goods are listed in the appendix. The goods chosen are a subset of the items whose prices are published in the Australian Bureau of Statistics quarterly publication "Average Retail Prices of Select Items: Eight Capital Cities."[8] Price data for the same items was collected from microfiche records for six cities in New Zealand from Statistics New Zealand.[9] Unfortunately, a wider set of data is not available in Australia. The data represent the price of a particular good averaged over a set of outlets in each city.

The data have been classified into three groups, A, B, and C, according to the authors' view on the comparability of the packaging of the goods in the two countries. The 15 goods in Group A are the same in both countries in all periods. The 12 goods in Group B are the same good but are quoted in similar but different sized packets for at least part of the time. The New Zealand price is multiplied by the appropriate ratio to convert it to the Australian price. The 7 goods in Group C are most problematic. Three of these goods had substantial size reclassifications during the period in New Zealand; two of the goods are canned food sold in different sized cans; and the other two goods are "petrol" and "whisky sold in a public bar" both of which are subject to extensive taxes.

Statistics New Zealand revises the consumer price index every five years at which time different outlets are chosen and variations on the size of goods may be incorporated. During the change-over quarters, December 1988 and December 1993, average prices for the goods under both the old and the new weightings were published. In each case the price data used in this analysis are chain linked to ensure as much continuity as possible. Occasionally the Australian Bureau of Statistics records a different package size in a particular city; these observations are omitted. Considerable care has been taken checking data for obvious data entry mistakes, both by the author and by the Statistics Departments. In the rare cases where the data suggests unusually large price movements have taken place in a single city for a single quarter, the observation has been omitted.

Both New Zealand and Australian prices were adjusted for sales taxes. In the New Zealand case, prices were deflated by the appropriate amount for GST

8 The data can be purchased from the Australian Bureau of Statistics.

9 The data, along with 40 prices on a much wider range of goods and services, is available from the author. The cities, with 1991 census population figures in parenthesis, are Whangarei (44183), Auckland (885571), Rotorua (53702), Wellington (325682), Christchurch (307179) and Invercargill (51984).

during those years in which the regime was in place. The Australian case was handled slightly differently, by increasing the NZ prices by a similar fraction to the Australian prices[10].

## Basic Statistics

### *Mean Price Differences*

Table 4 shows the average price differences for the various goods between New Zealand and Australia, where the prices are converted into Australian dollars at the average exchange rate prevailing during the quarter. In 1984, New Zealand prices were on average 26 per cent lower than their Australian counterparts, but by 1988 this difference had narrowed to only 2 per cent. However, the average price difference *increased* in the second half of the period, and in 1996 New Zealand prices were on average 7 percent below Australian prices. These average swings are consistent with the swings in the real exchange rate presented in Figure 1. What is apparent from Table 4, however, is that in 1984 prices in New Zealand were much lower than prices in Australia, so that the increase in the real exchange rate in some sense caused average prices in New Zealand to converge to those in Australia.

There is considerable variety in the difference between Australian and New Zealand prices for different goods. In contrast, Australian prices varied relatively little from city to city. The average price differences in 1996 within Australia and between Australia and New Zealand are shown in Table 5. Restricting the analysis to the 27 goods in schedules A and B, there were 7 goods in New Zealand which had prices less than 75 percent of the Australian average in 1996; in contrast, there were only two examples in the rest of Australia where a price was less than 75 percent of the Australian average. Within Australia, most state prices were within 10 percent of the national average. In Sydney there were 22, in Brisbane 24, in Perth 20, in Adelaide 14 and in Hobart 12. In New Zealand, however, only 9 goods were priced within plus or minus 10 percent of the Australian average. This data clearly suggests that on average price differences between Australia and New Zealand exceed price differences within Australia.[11] Moreover, prices are much more likely to be cheaper in New Zealand than they are in other “distant” parts of Australia such as Hobart, Darwin, or Perth.

---

[10] This does not in fact bias calculation of mean or variances of differences in Australia, since prices have been logged before calculation of means or variances.

[11] Moreover, the snapshot of 1996 price differences overstates the diversity of prices across Australia over a longer timeframe. The mean price difference between states calculated over a longer period of time is typically closer to zero than the mean price difference calculated in a single year, as Australian state prices have a tendency to revert towards their national mean. In Hobart, for instance, when the average is calculated over the whole period, the mean price of 18 of the goods was within 10 percent of the Australian average, whereas in 1996 the figure was only 12. In New Zealand, the figures are 10 and 9 respectively.

Adelaide and Brisbane have the lowest wages in Australia, at 6.5 percent below the national average in 1996 and 7.2 percent below respectively. New Zealand shows this behaviour to an even greater extent, with wages (measured in Australian dollars) being 21.1 percent below the Australian average in 1996.

***Three Examples***

There is also considerable diversity in the extent to which New Zealand prices of different goods appear to converge to Australian prices over the period, although the general trend has been for New Zealand prices to rise towards Australian prices. Three examples are given below. The prices of some goods, such as pork loin chops, exhibit a fairly close relationship, as shown in Figure 2. Except for a short period in 1984 immediately following the depreciation of the New Zealand dollar, the New Zealand price has tended to remain within 10 percent of the Australian price over the period.

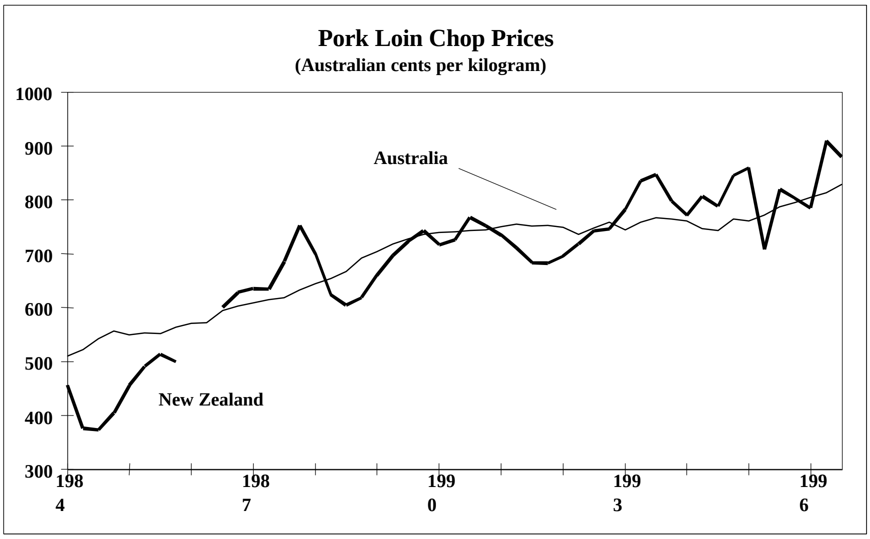



**Figure 2: Pork Loin chop prices**

In contrast, the price of butter shows little obvious relationship in the two countries (see Figure 3). The price of butter in New Zealand was less than half the price in Australia in 1984, but the two moved closer together as the result of an increase in the price in New Zealand between 1984 and 1988. Since then “convergence” has been neither rapid nor continuous, and for long periods the prices remained apart at almost constant levels. At the end of 1996 butter was still 20 percent cheaper in New Zealand than in Australia.

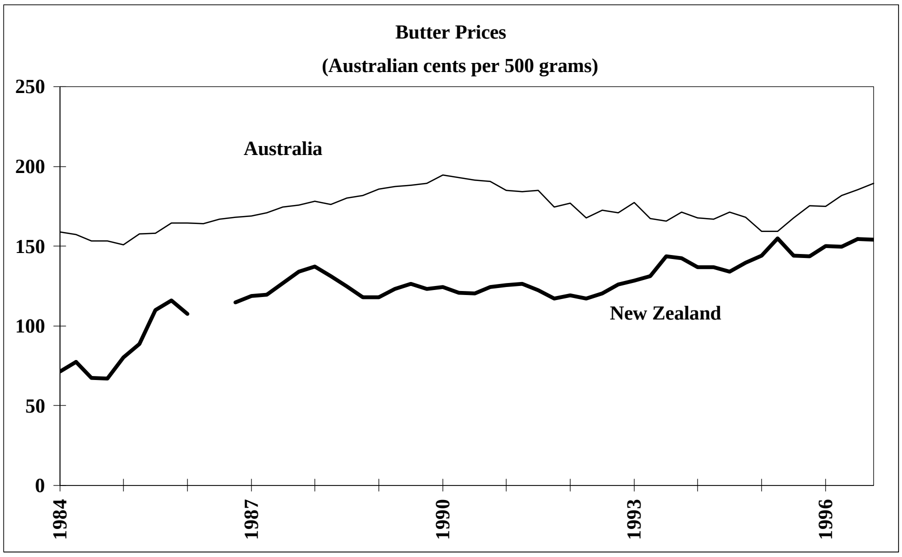



**Figure 3: Butter prices**

The third example is toothpaste (Figure 4). While the prices in each country increased over the period, they showed few signs of moving together. Note that the greater volatility of the New Zealand price series in this graph reflects the fact that the New Zealand price has been converted to Australian currency rather than vice versa.

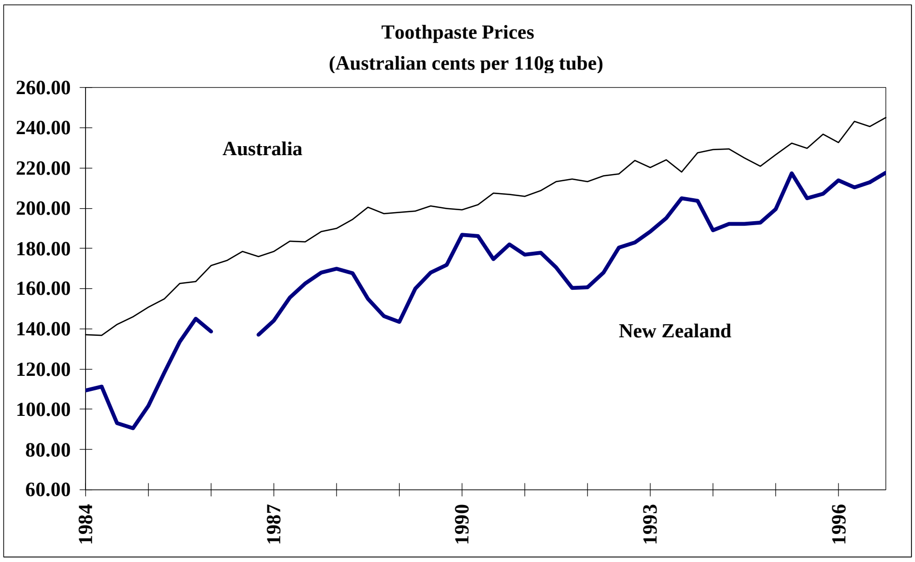



**Figure 4: Prices of Toothpaste**

The considerable diversity in these price patterns means it is unlikely that there is an easy way to summarise the process of price convergence between the countries. Nonetheless, some price adjustment appears to be taking place for most of the goods examined, although in some cases this has been very slow, and by the end of the period the prices of many goods were still substantially different.

## Empirical Framework

### *(1) A Question of Cointegration.*

Tests of the law of one price are usually conducted within the statistical framework of cointegration. This framework is a natural choice as it means that the idea "prices should not vary by too much" can be formalised statistically as the requirement that the difference between two prices is a stationary series. If the difference in prices is stationary - or, to take into account taxes, some linear combination of prices is stationary - then the prices move together in the long term, so that even if the prices individually vary widely over time, the difference between them is mean reverting.

The focus of this paper is not whether or not the individual price series in different states and in New Zealand are cointegrated with each other, due to the low statistical power of tests for cointegration when there are only 50 quarterly observations available. Rather, the focus is on a series of price adjustment equations of the type:

$$\Delta p_{kt}^{i} = a_{k}^{i} + r_{k}^{i}\Delta p_{k,t}^{au} + g_{k}^{i}\left(p_{k,t-1}^{au} - e_{t-1} - p_{k,t-1}^{i}\right) + e_{kt}^{i}$$

**(7)**

This equation links the change in a price in a particular state to the contemporaneous change in the price in the rest of Australia, and the lagged difference between prices in the state and the rest of Australia. If the prices are cointegrated, the coefficient $\gamma_k^i$ will be positive; if there is no long-term relationship between the series, $\gamma_k^i$ will be zero. Moreover, the greater is $\gamma_k^i$, the faster will be the speed at which state prices change in response to their difference with average Australian prices.

## Individual Centre Cointegration Equations

While the focus of the paper is not whether the prices in different centres are cointegrated, tests for cointegration have been estimated. These tests have two parts. In the first part, each individual *price* was tested for a unit root using the augmented Dickey Fuller equation:

$$\Delta p_{kt}^{i} = a_{k}^{i} + r_{k}^{i} p_{k,t-1}^{i} + b_{k}^{i}\Delta p_{k,t-1}^{i} + d_{k}^{i} t + e_{kt}^{i}$$

**(8)**

Typically the time trend for this equation was insignificantly different from zero, and the equation was re-estimated without the time trend[12]. In general, it was very difficult to reject the hypothesis that the series contained a unit root (ie that ρ = 0); there were only 13 rejections at the five percent level for the 8x34 = 272 Australian city-good combinations, of which eight were for dish-washing detergent, and there was only one rejection for New Zealand.[13] The median estimate of the coefficient ρ within Australia was -0.067, and the ninetieth percentile estimate was -0.229; for New Zealand the estimates were -0.07 and -0.21 respectively. These results are consistent with most international evidence that level prices contain a unit root and thus are not mean-reverting.

The second part of the cointegration test is to estimate the augmented Dickey-Fuller equation for the difference in prices:

$$\Delta r_{kt}^{i} = a_{k}^{i} + r_{k}^{i} r_{k,t-1}^{i} + b_{k}^{i} \Delta r_{k,t-1}^{i} + d_{k}^{i} t + e_{kt}^{i} \qquad \textbf{(9)}$$

where $r_{kt}^{i} = p_{kt}^{i} - e_{t}^{iau} - p_{kt}^{au}$

If $\rho < 0$, $r^{i}_{kt}$ was a mean reverting series around the trend $-(\alpha^{i}_{k}+\delta^{i}_{k}t)/\rho$ over the sample period 1984 - 1996. The more negative is ρ, the faster the price difference between city i and the Australian average disappeared. Conversely, if $\rho = 0$, $r^{i}_{kt}$ was non-stationary and there was no long term statistical relationship between the price of good k in city i and the rest of Australia.

A sample equation in which there is price convergence in the period 1984 - 1996 is presented in detail below. The price of canned pineapple in Brisbane started the period on average 10 percent lower than the price elsewhere in Australia; by the end of the period it was only 2 - 3 percent lower. The appropriate equations, with t-statistics in parenthesis, are:

$$\Delta r_{kt}^{i} = -0.061 + 0.017 r_{k,t-1}^{i} - 0.30 \Delta r_{k,t-1}^{i} + e_{kt}^{i} \qquad R^2 = 0.08 \quad Durbin-h = -1.4$$
$$(0.5) \quad (0.7) \quad (2.0) \qquad n = 50 \quad F(2,46) = 3.1$$

$$\Delta r_{kt}^{i} = -0.094 - 0.59 r_{k,t-1}^{i} - 0.15 \Delta r_{k,t-1}^{i} + 0.0015t + e_{kt}^{i} \qquad R^2 = 0.43 \quad Durbin-h = 0.3$$
$$(4.2) \quad (4.1) \quad (1.2) \quad (4.0) \qquad n = 50 \quad F(2,46) = 9.3$$

The F-statistic is the F-test that the coefficient on the lagged dependent variable and the time trend are both zero. The 95 percent critical value for the test is 7.8. The interpretation of the second equation is that the difference between the price of canned pineapple in Brisbane and the price in the rest of

12 Results are available from the authors on request.

13 The New Zealand prices are quoted in Australian dollars unless otherwise stated. The unit root tests were also estimated for New Zealand prices in New Zealand dollars; again, it proved difficult to reject the unit root hypothesis.

Australia followed a first order autoregressive process around a time trend from 1984 to 1996. On average, prices in Brisbane increased by 4x0.0015 = 0.6 percent per year to the Australian average, having started the period 9.4 percent lower than average. When the Brisbane price was not equal to its trend level, 59 percent of the price deviation was removed within one quarter.

This particular equation is relatively straightforward. Interpretation of the equations was generally inconclusive, however, because it was not normally possible to formally reject the hypothesis that the coefficient $\rho = 0$ despite coefficients that were estimated to be substantially lower than zero. Of the 272 state capital coefficients, it was only possible to formally reject the unit root hypothesis in 72 or 26 percent of the cases despite 80 percent of the coefficient estimates being less than -0.3. It was possible to reject the unit root hypothesis in only 4 out of 34 cases for New Zealand[14]. The essential difficulty is the low power of the tests. The critical value of the augmented Dickey Fuller ($Z_t$ ) test statistic that the coefficient ρ equals zero is approximately -3.8; since the mean standard error of the estimates of ρ was 0.135, to reject the hypothesis that $\rho = 0$, it is necessary for the true value of ρ to be approximately -0.5. This degree of mean reversion is very rapid; the typical estimates of Parsley and Wei (1996) were nearer -0.15 [15].

---

14 The estimated equations are in Table 7.

15 The discussion of Stock (1991) is relevant to this problem. He calculates the confidence intervals of coefficient estimates and their associated t-statistics when ρ is near zero. For instance, with 50 observations, if the true value of $\rho = 0.3$, the 95 percent confidence interval for the estimated t-statistic of the estimate of ρ is (-4.5, -2.2), and the median estimate is -3.2. At the median estimate of -3.2, however, the 95 percent confidence interval for the coefficient estimate is (-0.58, +0.06). In fact if the true value of ρ were 0.3, the 95 percent confidence interval for the estimates of ρ would exclude 0 only 30 percent of the time.

The asymptotic confidence intervals of the estimates of the t-statistics of the estimates of ρ conditional on the true value of ρ are given in Table 6, along with the sample distribution of the estimates of the t-statistics from the 272 within-Australia and the 34 New Zealand city-good pairs. As can be seen, if the true value of $\rho = 0$ for all the city good pairs, it would be expected that 50 percent of the sample t-statistics would be greater than -2.2; in fact only ten percent of the within Australia sample t-statistics were. Similarly, if the true value of $\rho = 0$ for all the city good pairs, it would be expected that 95 percent of the sample t-statistics would be greater than -3.5; in fact only slightly less than 50 percent of the within Australia sample t-statistics were. These comparisons raise serious doubt as to whether the null hypothesis that $\rho = 0$ is true despite the fact that it is only possible to reject the hypothesis at the 5 percent level in 26 percent of the cases.

The main difficulty with these tests for cointegration is that it is not possible to suggest a simple alternative null hypothesis that is appropriate to all city-good pairs as it is not being assumed that the value of ρ is constant across cities, goods, or both. From Table 6 it is quite apparent that the sample distribution does not exactly resemble the distribution of the sample t-statistics corresponding to values of ρ ranging from 0.1 to 0.4, for while the upper tail resembles that corresponding to $\rho=0.2$, the lower tail is nearer that corresponding to $\rho=0.4$.

Ignoring the very large confidence intervals associated with the estimates for the moment, the median estimate of 272 Australian equations was -0.50, while the inter-quartile range was -0.31 to -0.66. While only 26 percent of the estimates were statistically different from zero at the 5 percent level these estimates are consistent with very rapid price adjustment between the city price level to the Australian average price level, adjusted for a time varying margin.[16] The half-life corresponding to the median estimate of -0.5 is only 1.4 quarters, much more rapid than that estimated by Parsley and Wei. There are some apparent differences between cities. The median coefficient estimates were smaller in Melbourne, Sydney, and Brisbane than they were in the other cities, suggesting greater price convergence on the eastern seaboard than in the rest of the country. The median coefficient estimate in each of the three cities was less than -0.56; in the other cities the median was greater than -0.44. Since the three eastern seaboard cities are also the three largest cities, it is not clear whether or not this greater integration is a result of size or the relative closeness of the three cities[17].

**Pooled Centre Cointegration Equations**

In light of the inconclusiveness of the individual equation cointegration tests, the data was pooled by good across cities and pooled cointegration tests were estimated:

$$\Delta r^i_{kt} = a^i_k + r_k r^i_{k,t-1} + b^i_k \Delta r^i_{k,t-1} + d^i_k t + e^i_{kt} \qquad i = SY, ME, ..DA$$

$$Cov(e^i_{kt} e^i_{kt}) = (s^i_k)^2 \qquad Cov(e^i_{kt} e^j_{kt}) = 0$$

**(10)**

Equation 10 differs from equation 9 by imposing the restriction that $\rho^i_k$ is identical in each state. Note that the variances are not assumed to be identical

---

At the heart of the issue is the appropriateness of the prior that the null hypothesis should be that ρ = 0, that prices of the same good in different centres are not stationary. The empirical evidence presented here is that the hypothesis is not a good prior, for the level of rejections across city-good pairs at any significance level appears *collectively* to be inconsistent with the hypothesis that all coefficients are equal to zero. For this evidence to be useful, it is necessary to convert the collective evidence into a prior for an individual city-good pairing, and then test the hypothesis that an individual coefficient ρ = 0 on the basis of this prior. This procedure is outside the scope of this paper, however.

16 Parsley and Wei (1996) suggest that these estimates may be biased because of measurement errors which induce a moving average component into the series. Diagnostic statistics did not indicate the presence of such moving average components; nor did changing the number of lags in the augmented Dickey Fuller equation substantially change the results. Attempts to estimate an ARMA(1,1) model on the series directly using the Kalman filter maximum likelihood technique proved to be unsatisfactory, possibly because of the short samples.

17 However, it should be noted that the distribution of coefficients in Canberra was different to the other south-east cities.

for each city. The equations were estimated first for the eight Australian cities and secondly for the eight Australian cities and New Zealand. Each set of estimates were made in two stages. In the first stage, the unrestricted equation 9 was estimated for each state, and the residuals were used to construct an estimate of $\sigma_k^i$. In the second stage, these estimates of $\sigma_k^i$ were used to estimate equation 10 using feasible generalised least squares. These results are presented in Table 8[18]. For the within-Australia equations, an F-test testing the restriction that all coefficients are the same was calculated. For the Australia- New Zealand equations, an F-test testing the restriction that the coefficient for New Zealand equalled the restricted coefficient for Australia was tested.

It is possible to reject the null hypothesis that the coefficents $\rho_k^i$ were the same within Australia at the one percent significance level for 8 of the 34 goods, and at the five percent level for an additional 5 of the goods. In each of the remaining cases it was possible to reject the hypothesis that the restricted coefficient was equal to zero. For these 21 goods, the estimates are similar to those of the individual equations, and suggest that price convergence within Australia occurs very rapidly.

Of these 21 equations, it was possible to reject the hypothesis that the coefficient $\rho_k^{NZ} = \rho_k^{AU}$ at ninety-five per cent confidence in a further nine cases. Consequently, for twelve goods, it is not possible to reject the hypothesis that NZ prices converge to Australian prices; moreover, the estimated rate of convergence for these goods is very high, averaging –0.39 for the non fruit and vegetable items. The standard errors of the unrestricted coefficients $\rho_k^{NZ}$ were large, however, and in only four of the twelve cases did the ninety-five per cent confidence intervals exclude zero. Consequently, these regressions do not really improve the evidence as to whether or not New Zealand prices are cointegrated with Australian prices. As with the individual New Zealand price equations, it appears that in some case the prices are cointegrated, but in most it is not possible to reject the hypothesis of no cointegration.

### *(2) A model for price correction*

In light of the inconclusiveness of the cointegration regressions, a different approach was adopted. Since it is expected that individual Australian state prices would move together over time, the following model was proposed within Australia:

$$\Delta p_{kt}^{i} = a_k^i + r_k^i \Delta p_{k,t}^{au} + g_k^i \left( p_{k,t-1}^{au} - p_{k,t-1}^{i} \right) + b_k^i \Delta p_{k,t-1}^{i} + e_{kt}^{i}$$

---

18 Note that the heteroscedasticity adjusted F-test was calculated using the covariance matrix estimated with the unrestricted equation. This means it is the Lagrange Multiplier form of the test, which compared to the Wald form of the test favours acceptance of the null hypothesis that the coefficients are equal.

**(7)**

The equation links the change in a state price to a contemporaneous change in the average Australian price, the lagged difference between the state price and the average Australian price, and a lagged term to allow for some autocorrelation. The constant is included to allow for the possibility that the attractor in the error correction term is non-zero. This allows for some margin to account for different wages in different cities, or the cost of transporting goods from one city to another. The results for Perth are in Table 9. In general, results were varied[19]. In three quarters of the cases the estimates of ρ, the coefficient measuring instantaneous pass through, were between 0.6 and 1.1, with highly significant t statistics (see Figure 5). This indicates that for most goods in most Australian cities, local prices respond to changes in average Australian prices in the same quarter.

The distribution of the estimates of γ, the coefficient on the lagged difference between the local price and the average Australian price, is given in Figure 6. Three quarters of the estimates are statistically different from zero at a ninety-five percent significance level. The median value is 0.29, indicating that roughly a third of any price discrepancy between a city in Australia and the Australian average price is corrected in any given quarter by a local price change. The median estimate was similar in each of the Australian cities[20].

The estimates of the constants were consistent with the mean differences in prices between cities in Table 5. The median estimated ratio $a/g$ was 4.1% in Perth, while in Hobart it was 9.3% and in Darwin it was 10.5%. The constants were typically near zero for the East Coast cities.

Equation (7) can be estimated for New Zealand by expressing New Zealand prices in Australian dollar terms:

$$\Delta p_{kt}^{nz} + \Delta e_t = a_k^{nz} + r_k^{nz} \Delta p_{k,t}^{au} + g_k^{nz} \left( p_{k,t-1}^{au} - e_{t-1} - p_{k,t-1}^{nz} \right) + b_k^{nz} \Delta p_{k,t-1}^{nz} + e_{kt}^{nz}$$

**(11)**

Here $p_{kt}^{nz}$ refers to the price (in New Zealand dollars) of good k at time t in New Zealand and $e_t$ is the exchange rate (the number of New Zealand dollars required to purchase one Australian dollar). Equation (11) postulates that New Zealand prices in Australian dollar terms behave like the prices in any Australian state. If γ>0, New Zealand prices ultimately converge to Australian prices, except for a constant level; if ρ>0, prices also adjust in part to some of the change in the average Australian price within a quarter.

---

19 Results of the 272 good-city equations are available from the authors.

20 The largest median estimate of γ was for Brisbane, at 0.4.

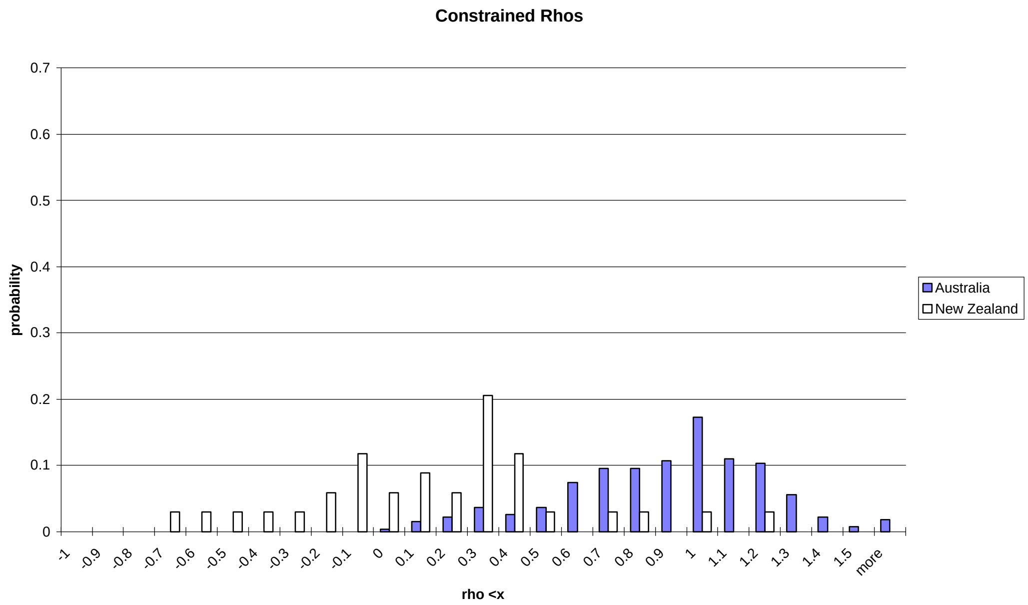



**Figure 5: estimated distribution of ρ for New Zealand and Australia (equation 11)**

The estimated equations for the New Zealand regressions are presented in Table 10, and histograms of the distribution of the estimates of ρ and γ are presented graphically in Figure 5 and 6. The sets of equations are quite different. In New Zealand only four of the thirty-four estimates of ρ were statistically significant and positive, in contrast to 90 percent of the Australian estimates. There is no obvious pattern with 38 percent of the New Zealand estimates negative (but none significantly so).

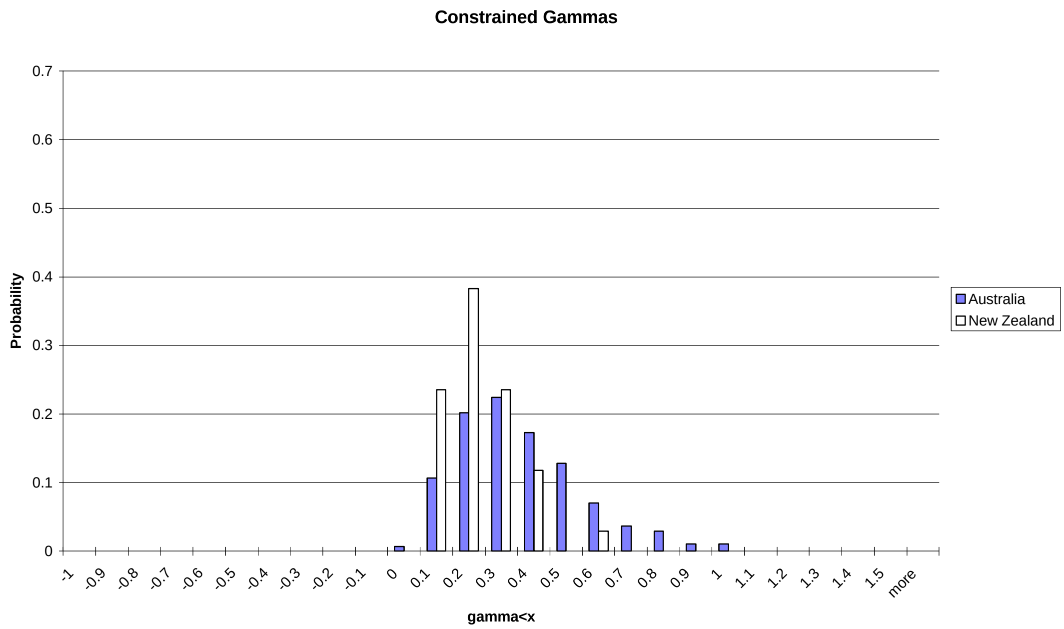



**Figure 6: estimated distribution of γ for New Zealand and Australia (equation 11)**

Estimates of the coefficient γ for New Zealand also indicate much weaker price convergence than the Australian estimates. In general, the estimates of γ were nearer zero in New Zealand than in Australian cities. In all the regressions γ was estimated to be positive. Of the 34 goods examined, 25 had statistically significant positive t-statistics, similar to Australia where 75 percent were significant and positive. In Figure 6, a histogram of these statistics is presented. The differences here are less extreme than in Figure 5. However, given the lack of instantaneous price correction in New Zealand, the price adjustment represented by the coefficient γ is the main component of total price correction in New Zealand, whereas it is only responsible for the last few per cent of any change in Australia. Consequently, the lower estimates of γ combined with the largely insignificant estimates of ρ mean that in total New Zealand prices change much less rapidly to changes in average Australian prices than do Australian state prices.

An attempt was also made to include the change in average wages in the model. This was intended to function as a proxy for the difference between the traded and non-traded cost of production, since the non-traded component of costs is labour intensive. The statistical significance of the wage component of price changes was very low, so the variable was removed from the model.

**Is pass-through instantaneous?**

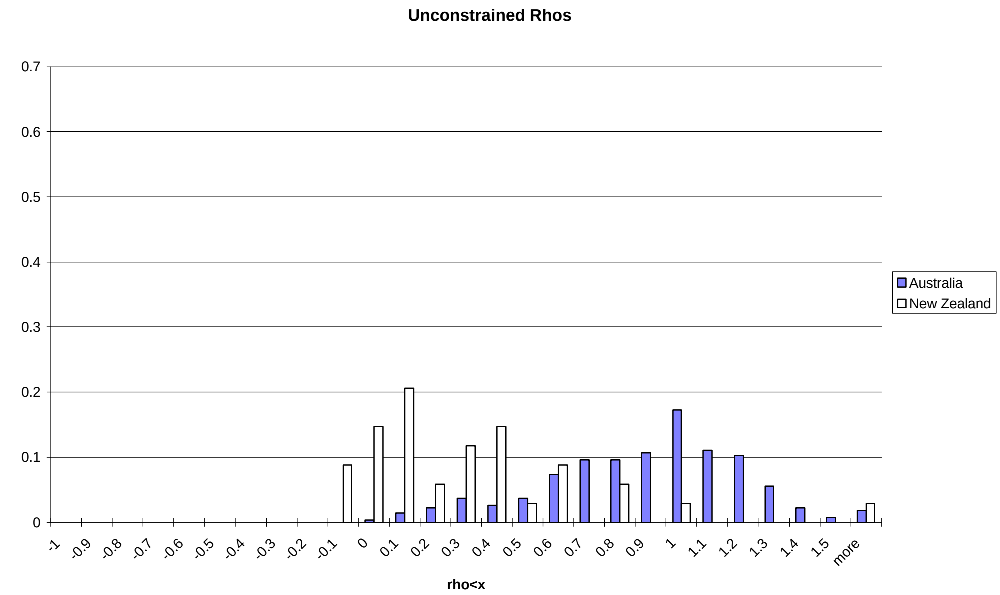
The model was relaxed by allowing for the possibility that there might not be immediate pass through of exchange rate changes to individual goods prices.

$$\Delta p_{kt}^{nz} = a_k^{nz} + r_k^{nz}\Delta p_{k,t}^{au} + h_k^{nz}\Delta e_t + g_k^{nz}\left(p_{k,t-1}^{au} - e_{t-1} - p_{k,t-1}^{nz}\right) + b_k^{nz}\Delta p_{k,t-1}^{nz} + e_{kt}^{nz}$$

**(12)**

The results from this regression are given in Table 11. In general, the estimates of $\eta$ were close to zero and in only one case was the estimate statistically significant. Clearly, changes in the exchange rate do not have a one for one instantaneous effect on changes in the New Zealand dollar price of goods in New Zealand.

Since the restriction that $\eta$=-1 in equation 11 appears false, the estimates of $\beta$, $\gamma$ and $\rho$ will be biased. The unrestricted coefficient estimates differ slightly from the restricted estimates. There is stronger evidence that New Zealand prices change when Australian prices change, with ten of the estimated coefficients statistically different from zero. However, only 20 of the estimated coefficients $\gamma$ are statistically significant, and the median size fell from 0.12 to 0.05. This rate of price convergence is considerably smaller than that estimated for the Australian states. The corresponding histograms of the distribution of the estimates of $\rho$ and $\gamma$ to those given for equation (11) appear below.



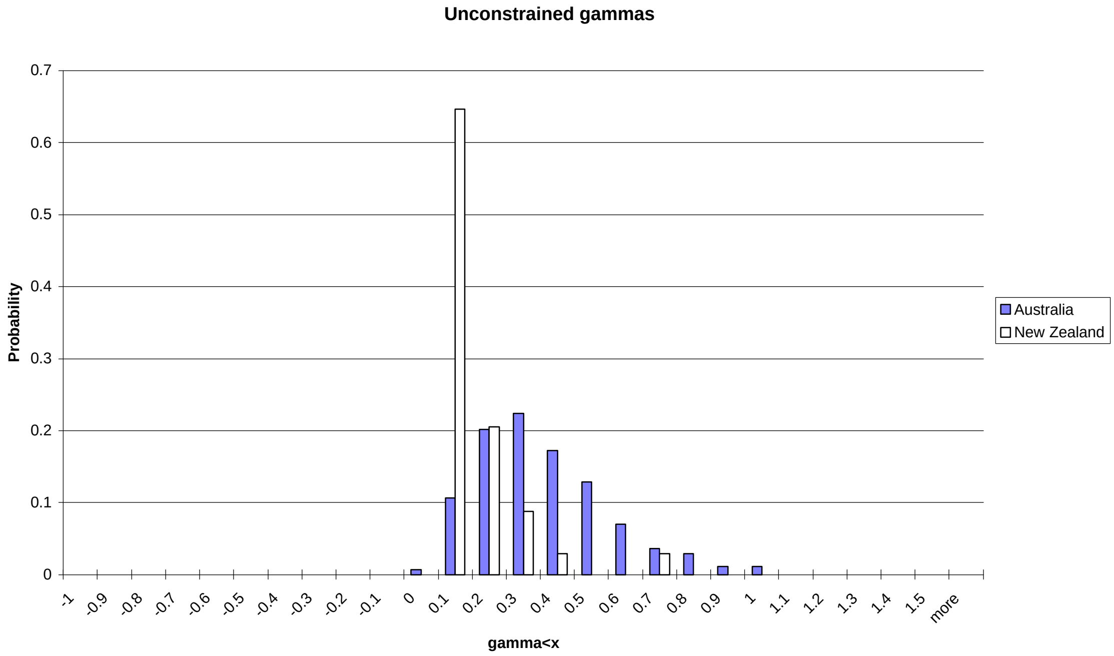




**Figure 7: Estimated distribution of ρ and γ for New Zealand and Australia (equation 12)**

## Summary

The estimates of equation 7 show that Australian prices display strong tendencies to move together. In a majority of cases, price changes occur in all cities within the same quarter, and any residual price differences are adjusted fairly rapidly over the following quarters.

In contrast, New Zealand prices do not tend to move at the same time as their Australian counterparts. They tend to adapt slowly over the quarters following the quarter in which a price change occurs in Australia or in which the exchange rate changes. For one third of the goods, New Zealand prices had no statistically significant link to Australian prices, and so the evidence in favour of overall convergence is weak at best.

Equation 12 provides striking evidence that there is *no immediate pass through* of shocks to the exchange rate to supermarket prices in New Zealand. The evidence here is very strong, since unlike previous studies, the regression allows for the effect of changes in international (Australian) prices, rather than just considering the effect of exchange rate shocks on New Zealand prices. While the model also allows the exchange rate to affect New Zealand prices with a lag, for over half the goods very little responsiveness of New Zealand prices to changes in the exchange rate could be discerned.

### *(3) A Generalised Price Correction Mechanism*

One possible explanation for the poor fit of equation 12 is that the adjustment of New Zealand prices to changes in average Australian prices occurs as a combination of New Zealand dollar price changes and exchange rate changes, not just as a change in the New Zealand dollar price[21]. Two additional sets of equations were estimated to allow for this possibility.

*(a) Chow Tests.*

Chow tests were performed on equation 12, to test whether there were statistically significant differences between the coefficients for pre-1988 and post-1988 data sets. Although in a few cases there was evidence of a change in regime, in general it was not possible to reject the hypothesis that the coefficients of the variables were the same in the two sub-periods.

*(b) A revised model of price adjustment*

The second set of equations allow individual good price adjustment to depend on both the individual good price difference between Australia and New Zealand and the average price difference between Australia and New Zealand. The intuition here is that when all New Zealand prices are relatively high (or low) it is most likely to be because of a high (or low) value of the exchange rate, and the price response is possibly different than when an individual price difference is high when other price differences are not large. To model this, we split the individual price difference into two components

21 It will be recalled that from 1984 to 1986 there was a large real and nominal appreciation of the New Zealand dollar, which resulted in initially low New Zealand prices rising in Australian dollar terms to be closer to Australian prices.

$$p_{kt-1}^{au} - e_{t-1} - p_{kt-1}^{nz} = \left(\left(p_{kt-1}^{au} - e_{t-1} - p_{kt-1}^{nz}\right) - \left(\overline{p}_{t-1}^{au} - e_{t-1} - \overline{p}_{t-1}^{nz}\right)\right) + \left(\overline{p}_{t-1}^{au} - e_{t-1} - \overline{p}_{t-1}^{nz}\right)$$
$$= \left(\left(p_{kt-1}^{au} - p_{kt-1}^{nz}\right) - \left(\overline{p}_{t-1}^{au} - \overline{p}_{t-1}^{nz}\right)\right) + \left(\overline{p}_{t-1}^{au} - e_{t-1} - \overline{p}_{t-1}^{nz}\right)$$

**(13)**

where $p^{au}{}_t$ is an Australian average price, in practice taken to be the Australian CPI.

The following regression is then estimated:

$$\Delta p_{kt}^{nz} - \Delta\overline{p}_{t}^{nz} = a_k + b_k\left(\Delta p_{kt}^{au} - \Delta\overline{p}_{t}^{au}\right) + g_k\left(p_{kt-1}^{au} - p_{kt-1}^{nz} - \overline{p}_{t-1}^{au} + \overline{p}_{t-1}^{nz}\right) + d_k\left(\overline{p}_{t-1}^{au} - e_{t-1} - \overline{p}_{t-1}^{nz}\right)$$

(**14)**

This equation links mean or inflation adjusted changes in New Zealand prices to mean adjusted changes in Australian prices. A constant is needed as the CPI is not directly comparable with the nominal good prices.

The results are presented in Table 12. Twelve of the thirty-four estimates of $\gamma$, the coefficient on the lagged difference of the CPI-level adjusted good prices, are significant, while only six of the estimates of $\delta$, the coefficient on the lagged real exchange rate are significant. In fact, the standard errors of the estimates of $\delta$ are such that it is only possible to reject the hypothesis that $\gamma = \delta$ in seven of the cases. The lack of significance of these results prevents firm conclusions from being reached, although it appears that price adjustments mainly occurred when an individual good's prices were different in Australia and New Zealand, but average prices were not very different. Regressions were subsequently run with $\delta$ restricted to zero, with the results tabulated in Table 13. Eleven of the 34 equations have statistically significant coefficient estimates of $\gamma$, while twenty-two of the remaining twenty-three are positive but insignificant. The results are weaker than those estimated for equation 12, where 20 of the 34 goods had statistically significant error correction terms.

The estimates of $\beta$ were generally small, with New Zealand prices changing little in response to Australian price changes within a single quarter. Only seven of the coefficients were positive and statistically significant at the five percent level; surprisingly, two were negative and statistically significant (tomato sauce and bacon). These estimates are broadly in line with the earlier results.

This evidence again seems far from conclusive. While there seems to be some evidence that (for some goods at least) changes in prices can be explained as being a result of individual goods prices being inconsistent with other goods prices, it seems that for many goods, there is insufficient evidence to accept this as general behaviour.

### Half-lives of shocks

In order to give some meaning to the estimates derived above, the half-lives of the correction processes were calculated. These measure the amount of time required for half the difference in prices for the given good to be corrected. The results for New Zealand are given in Table 14. It can be seen that there is quite a range of halflives present. Unfortunately, the standard errors for these estimates are very large, so that statistical significance cannot be ascribed to these results.

## SECTION 5: CONCLUSIONS

The primary purpose of this paper was to establish whether or not New Zealand prices behave in a similar manner to Australian state prices. The answer is quite conclusive; no. The New Zealand-Australia real exchange rate is substantially more volatile than the relative value of a state's CPI compared to the Australian average, by a factor of ten. Changes to the real exchange rate are highly persistent and in line with other international studies, there is little evidence that the bilateral real exchange rate is mean reverting.

Individual supermarket prices are also quite different in New Zealand than in the various states of Australia. In terms of levels, New Zealand prices are on average much lower than prices in Australia. Moreover, the difference between New Zealand and Australian prices is greater than the difference between prices in either Hobart, Perth or Darwin and the Australian average, and the latter prices tend to be higher, not lower than the rest of Australia.

Unlike Australian state prices, which tend to change at the same time, New Zealand prices tend to only have weak relationships with average Australian prices. In most cases, there was little pass through of either exchange rate shocks or Australian price shocks within a quarter and subsequent adjustment was slow. In a quarter of the goods analysed, it was not possible to reject the hypothesis that the New Zealand prices were unrelated to the Australian prices. The results are in stark contrast with the estimates examining price adjustment within Australia which show that prices tend to move simultaneously in different states. In fact the small amount of price variation across Australia is surprising, being considerably less than the price variation across the United States.

The different behaviour of prices in New Zealand and the various Australian states is consistent with the difference in behaviour of Canadian and United States prices. These differences suggest that the integration of the New Zealand economy into the wider Australasian economy is far from complete. It is not known if the high degree of price variation between Australia and New Zealand is primarily caused by border effects or currency effects – although the high correlation between the real and nominal exchange rate makes it seem likely that much of the variation is caused by currency movements. Either way, the evidence from Canada suggests that so long as the countries maintain currency and political barriers, the path to greater economic integration is likely to be slow.

## REFERENCES


Anderson. T.W. (1971) *The Statistical Analysis of Time series* (New York: John Wiley and Sons, 1971)

Australian Bureau of Statistics, *Average Retail Prices of Select Items: Eight Capital Cities*, Canberra: ABS 1984-1996

Balassa, B. (1964) The Purchasing Power Parity Doctrine: A Reappraisal. *Journal of Political Economy* v72 584 - 596

Bolton, P., Gerard, R., Spolaore, E., (1996) Economic Theories of the Break-Up and and Integration of Nations. *European Economic Review* 40 697-705

Cochrane, J.H (1988) How Big is the Random walk in GNP? *Journal of Political Economy* 96(5) 893-920.

Engel, C. (1993) Real Exchange Rates and Relative Prices: an Empirical Investigation. *Journal of Monetary Economics* 32 35 - 50.

Engel, C. and Rogers, J.H. (1996) How Wide is the Border? *American Economic Review* 86(5) 1112-1225

Froot, Kenneth A. and Rogoff, Kenneth (1995) Perspectives on PPP and Long-Run Real Exchange Rates pp 1647-88 in
Grossman, Gene M. and Rogoff, Kenneth, eds. *Handbook of international economics. Volume 3.* (Amsterdam; New York and Oxford: Elsevier, North-Holland)

Lo, Andrew W. and A. Craig MacKinlay (1989) The Size and Power of the Variance Ratio Test in Finite Samples. *Journal of Econometrics 40* 203 – 238

McCallum, J. (1995) National Borders Matter: Canada-US Regional Trade Patterns. *American Economic Review* 85 615-623

Parsley, D.C and Shang-Jin Wei. (1996) Convergence to the Law of One Price without Trade Barriers or Currency Fluctuations. *Quarterly Journal of Economics* 447 1213-1236.

Rogers, J.H. and Jenkins, M. (1995) Haircuts or Hysteresis? Sources of Movements in Real Exchange Rates. *Journal of International Economics* 38 339 360.

Rogoff, Kenneth (1996) The Purchasing Power Parity Puzzle *Journal of Economic Literature* 34(2) (June 1996) 647-668.

Samuelson, P.A. (1964) Theoretical Notes on Trade Problems. *The Review of Economics and Statistics*, V46, 145 - 154

Stock, J.H. (1991) Confidence intervals for the largest autoregressive root in U.S. macroeconomic time series. *Journal of Monetary Economics* 28 435-459.

| **Unit Root Tests for Australasian Real Exchange Rate Series 1966 - 1996** | | | | |
|---|---|---|---|---|
| | *r* | *s* ( *r* ) | "t" test | "F" test |
| Sydney | -0.087 | 0.031 | -2.77 | 4.03 |
| Melbourne | -0.085 | 0.039 | -2.18 | 2.43 |
| Brisbane | -0.060 | 0.038 | -1.59 | 1.82 |
| Adelaide | -0.062 | 0.037 | -1.66 | 1.39 |
| Perth | -0.092 | 0.039 | -2.34 | 2.83 |
| Hobart | -0.093 | 0.041 | -2.24 | 2.64 |
| Canberra | -0.140 | 0.046 | -3.04 | 4.95 |
| New Zealand | -0.102 | 0.039 | -2.61 | 3.38 |

See Section 3. The real exchange rate for an Australian city is $\ln(CPI^{city}) - \ln(CPI^{Au})$
The real exchange rate for New Zealand is $\ln(CPI^{NZ}) - \ln(e) - \ln(CPI^{Au})$
Column 1 is the coefficient on the lagged real exchange rate.
Columns 2 and 3 are the associated standard errors and “t-statistics”.
Column 4 is the “F-test” of the hypothesis that $\rho=0$ and $\alpha=0$.
The 95 % critical values for columns 3 and 4 are -3.17 and 5.57 respectively.

## Table 1: Unit Root Tests for Australasian Real Exchange Rates

The table gives the estimates of equation (5), the augmented Dickey Fuller tests for the Australasian real exchange rates. The real exchange rate for a state is the ratio of the state CPI to the rest of Australia CPI.

| Standard Deviation of k-quarter changes in Real Exchange Rates 1966 - 1996 | | | | | | |
|---|---|---|---|---|---|---|
| | Quarters:1 | 2 | 3 | 4 | 8 | 10 |
| Sydney | 0.47 | 0.66 | 0.78 | 0.95 | 1.51 | 1.76 |
| Melbourne | 0.40 | 0.52 | 0.57 | 0.68 | 0.99 | 1.12 |
| Brisbane | 0.46 | 0.57 | 0.64 | 0.67 | 0.74 | 0.78 |
| Adelaide | 0.45 | 0.60 | 0.69 | 0.79 | 1.13 | 1.29 |
| Perth | 0.53 | 0.77 | 0.93 | 1.07 | 1.55 | 1.79 |
| Hobart | 0.46 | 0.62 | 0.70 | 0.77 | 1.06 | 1.24 |
| Canberra | 0.47 | 0.58 | 0.70 | 0.78 | 0.94 | 1.04 |
| New Zealand | 3.88 | 6.43 | 8.05 | 9.16 | 12.76 | 13.71 |
| $Au-NZ | 3.88 | 6.31 | 8.04 | 9.34 | 12.46 | 13.32 |

See Section 3. Estimated standard deviations of logarithms of real exchange rates, expressed as a percentage.
The real exchange rate for an Australian city is $\ln(CPI^{city}) - \ln(CPI^{Au})$
The real exchange rate for New Zealand is $\ln(CPI^{NZ}) - \ln(e) - \ln(CPI^{Au})$
The last row is the nominal exchange rate.

### Table 2: Standard deviation of k-quarter changes in real exchange rates

The table gives the estimates of the standard deviations of ($r_t$-$r_{t-k}$) the k-quarter difference in the real exchange rate. The real exchange rate for a state is the ratio of the state CPI to the rest of Australia CPI.

| Variance Ratios of k-quarter changes in Real Exchange Rates | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1966 - 1996 | | | | | |
| | 2 | | 4 | | 8 | | 10 | |
| Sydney | 0.99 | (0.15) | 1.02 | (0.21) | 1.29 | (0.33) | 1.39 | (0.39) |
| Melbourne | 0.84 | (0.13) | 0.70 | (0.17) | 0.76 | (0.26) | 0.77 | (0.29) |
| Brisbane | 0.75 | (0.13) | 0.53 | (0.15) | 0.32 | (0.17) | 0.28 | (0.17) |
| Adelaide | 0.88 | (0.14) | 0.77 | (0.18) | 0.77 | (0.26) | 0.81 | (0.29) |
| Perth | 1.04 | (0.15) | 1.01 | (0.21) | 1.07 | (0.30) | 1.13 | (0.35) |
| Hobart | 0.89 | (0.14) | 0.69 | (0.17) | 0.66 | (0.24) | 0.72 | (0.28) |
| Canberra | 0.76 | (0.13) | 0.69 | (0.17) | 0.50 | (0.21) | 0.49 | (0.23) |
| New Zealand | 1.37 | (0.17) | 1.39 | (0.24) | 1.35 | (0.34) | 1.25 | (0.37) |
| $Au-NZ | 1.33 | (0.17) | 1.45 | (0.25) | 1.29 | (0.33) | 1.18 | (0.36) |

See Section 3. Variance Ratios of logarithms of real exchange rates, followed by estimated standard errors.
The real exchange rate for an Australian city is $\ln(CPI^{city}) - \ln(CPI^{Au})$
The real exchange rate for New Zealand is $\ln(CPI^{NZ}) - \ln(e) - \ln(CPI^{Au})$
The last row is the nominal exchange rate.

### Table 3: Variance ratios of k-quarter changes in real exchange rates

The table gives the estimates of the variance ratio statistics of ($r_t$-$r_{t-k}$) the k-quarter difference in the real exchange rate. See equation (6). The real exchange rate for a state is the ratio of the state CPI to the rest of Australia CPI.

| Group A | 1984 | 1988 | change | | 1988 | 1996 | change |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| Rump Steak | -36.6% | -30.2% | 6.4% | | -30.2% | -33.6% | -3.4% |
| Corned Beef | -24.8% | -12.6% | 12.2% | | -12.6% | -17.4% | -4.8% |
| Lamb chops | -23.0% | -22.9% | 0.1% | | -22.9% | 6.0% | 28.9% |
| Pork chops | -21.1% | 2.9% | 24.0% | | 2.9% | 4.0% | 1.1% |
| Salmon, canned | -15.4% | -14.6% | 0.8% | | -14.6% | -35.5% | -20.9% |
| Oranges | 8.4% | 48.0% | 39.6% | | 48.0% | 19.1% | -28.9% |
| Bananas | -14.2% | 30.8% | 45.0% | | 30.8% | -28.7% | -59.5% |
| Potatoes | -25.7% | -17.8% | 7.9% | | -17.8% | -17.3% | 0.5% |
| Carrots | -28.5% | -31.9% | -3.4% | | -31.9% | -8.5% | 23.4% |
| Pineapple, canned | 6.3% | 14.4% | 8.1% | | 14.4% | 0.7% | -13.7% |
| Eggs | -33.0% | -3.5% | 29.5% | | -3.5% | -17.2% | -13.7% |
| Tomato sauce | -32.9% | 13.0% | 45.9% | | 13.0% | -2.0% | -15.0% |
| Margarine | -30.8% | 9.5% | 40.3% | | 9.5% | -8.8% | -18.3% |
| Butter | -54.6% | -28.7% | 25.9% | | -28.7% | -16.8% | 11.9% |
| Toilet Paper | -45.8% | -25.6% | 20.2% | | -25.6% | -21.8% | 3.8% |
| mean | -24.8% | -4.6% | 20.2% | | -4.6% | -11.9% | -7.2% |
| median | -25.7% | -12.6% | 20.2% | | -12.6% | -16.8% | -4.8% |
| | | | | | | | |
| Group B | **1984** | **1988** | **change** | | **1988** | **1996** | **change** |
| Bread | -50.2% | -21.7% | 28.5% | | -21.7% | -26.8% | -5.1% |
| Flour | -38.7% | -27.7% | 11.0% | | -27.7% | -32.8% | -5.1% |
| Rice | -5.4% | -5.0% | 0.4% | | -5.0% | -15.2% | -10.2% |
| Chicken, frozen | -14.8% | 26.1% | 40.9% | | 26.1% | 13.0% | -13.1% |
| Bacon | -23.6% | 19.6% | 43.2% | | 19.6% | 8.7% | -10.9% |
| Peas, frozen | -43.4% | -20.4% | 23.0% | | -20.4% | -39.7% | -19.3% |
| Chocolate Bar | -32.4% | 4.5% | 36.9% | | 4.5% | -2.1% | -6.6% |
| Sugar | -20.9% | 8.3% | 29.2% | | 8.3% | -10.1% | -18.4% |
| Coffee, instant | -40.7% | -21.1% | 19.6% | | -21.1% | -3.7% | 17.4% |
| Laundry Detergent | -54.7% | -29.4% | 25.3% | | -29.4% | -25.8% | 3.6% |
| Dish Detergent | -42.7% | -41.3% | 1.4% | | -41.3% | -22.6% | 18.7% |
| Toothpaste | -28.4% | -18.4% | 10.0% | | -18.4% | -11.1% | 7.3% |
| mean | -33.0% | -10.5% | 22.5% | | -10.5% | -14.0% | -3.5% |
| median | -35.6% | -19.4% | 24.2% | | -19.4% | -13.2% | -5.9% |
| | | | | | | | |
| Group C | **1984** | **1988** | **change** | | **1988** | **1996** | **change** |
| Paper tissues | -33.7% | -0.3% | 33.4% | | -0.3% | 34.5% | 34.8% |
| Petrol | 18.5% | 41.7% | 23.2% | | 41.7% | 16.2% | -25.5% |
| Whisky, in pub | -51.7% | -36.1% | 15.6% | | -36.1% | -43.6% | -7.5% |
| Petfood, canned | -17.9% | 10.6% | 28.5% | | 10.6% | -3.0% | -13.6% |
| Peaches, canned | -2.2% | 51.0% | 53.2% | | 51.0% | 44.8% | -6.2% |
| Soap, bar | 0.3% | 45.5% | 45.2% | | 45.5% | 40.5% | -5.0% |
| cheese, processed | -27.6% | 23.7% | 51.3% | | 23.7% | 12.2% | -11.5% |
| mean | -16.3% | 19.4% | 35.8% | | 19.4% | 14.5% | -4.9% |
| median | -17.9% | 23.7% | 33.4% | | 23.7% | 16.2% | -7.5% |
| | | | | | | | |
| All groups mean | -25.9% | -1.8% | 24.2% | | -1.8% | -7.2% | -5.4% |
| All groups median | -28.0% | -4.3% | 24.7% | | -4.3% | -9.5% | -6.4% |

The first two columns are the average price difference between New Zealand and Australia in two different years. A negative number means the New Zealand price (in Australian dollars) is lower. The third column is the change in relative price in the intervening period.

**Table 4: Average price differences between New Zealand and Australia**

| Group A | NZ | Sydney | Brisbane | Adelaide | Perth | Hobart | Darwin |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| Rump Steak | -33.6% | 13.5% | -7.5% | -2.8% | -6.7% | -2.4% | 9.2% |
| Corned Beef | -17.4% | 3.7% | -9.8% | -1.3% | 6.1% | -2.0% | -11.5% |
| Lamb chops | 6.0% | -5.6% | -3.6% | 7.2% | 21.8% | 3.4% | 13.7% |
| Pork chops | 4.0% | 8.5% | 5.8% | -4.8% | -0.1% | -1.1% | 5.6% |
| Salmon, canned | -35.5% | -1.7% | 3.2% | -5.7% | 0.8% | 19.5% | 13.0% |
| Oranges | 19.1% | 62.3% | -23.1% | -40.5% | 22.9% | -23.0% | 8.0% |
| Bananas | -28.7% | 4.6% | -9.8% | 2.1% | 14.8% | 2.2% | -10.7% |
| Potatoes | -17.3% | -5.4% | -5.1% | -27.0% | 30.1% | -12.3% | 20.0% |
| Carrots | -8.5% | 36.3% | -14.5% | -16.4% | -16.3% | 0.5% | 43.9% |
| Pineapple, canned | 0.7% | 10.9% | -4.3% | -14.6% | 7.8% | 21.3% | 20.7% |
| Eggs | -17.2% | 4.4% | 8.3% | -7.9% | -7.4% | 8.6% | 12.8% |
| Tomato sauce | -2.0% | -6.6% | 9.5% | -13.2% | 9.3% | 11.3% | 15.6% |
| Margarine | -8.8% | 8.7% | -2.0% | -10.5% | 9.2% | 7.9% | 27.6% |
| Butter | -16.8% | -4.9% | -8.7% | -10.2% | 9.3% | 16.2% | 9.7% |
| Toilet Paper | -21.8% | -1.0% | 6.8% | -7.3% | -0.9% | 15.2% | 3.6% |
| mean | -11.9% | 8.5% | -3.7% | -10.2% | 6.7% | 4.4% | 12.1% |
| median | -16.8% | 4.4% | -4.3% | -7.9% | 7.8% | 3.4% | 12.8% |
| | | | | | | | |
| Group B | **NZ** | **Sydney** | **Brisbane** | **Adelaide** | **Perth** | **Hobart** | **Darwin** |
| Bread | -26.8% | 9.7% | 2.7% | -19.0% | -3.5% | -12.5% | 5.2% |
| Flour | -32.8% | 11.3% | -15.6% | -24.6% | -16.0% | -6.8% | 1.5% |
| Rice | -15.2% | -1.5% | 0.7% | -15.4% | 9.1% | 12.4% | 21.1% |
| Chicken, frozen | 13.0% | -7.8% | -7.1% | 9.4% | 1.6% | 13.1% | 13.0% |
| Bacon | 8.7% | -3.2% | -1.0% | -1.5% | 13.3% | 9.1% | 19.1% |
| Peas, frozen | -39.7% | -4.3% | 4.8% | -11.7% | 4.6% | 16.6% | 36.2% |
| Chocolate Bar | -2.1% | 1.9% | 2.5% | -7.5% | 0.4% | 6.8% | 1.1% |
| Sugar | -10.1% | 7.2% | -4.5% | -14.0% | 6.9% | 13.2% | 22.4% |
| Coffee, instant | -3.7% | 1.4% | 2.1% | -8.2% | -0.5% | 11.2% | 2.3% |
| Laundry Detergent | -25.8% | 4.9% | 6.7% | -11.0% | 2.1% | 12.2% | 4.7% |
| Dish Detergent | -22.6% | 2.0% | -7.6% | 0.6% | -0.6% | 10.9% | 4.7% |
| Toothpaste | -11.1% | -2.3% | 7.9% | 0.4% | 5.3% | 7.7% | 5.2% |
| mean | -14.0% | 1.6% | -0.7% | -8.5% | 1.9% | 7.8% | 11.4% |
| median | -13.2% | 1.7% | 1.4% | -9.6% | 1.9% | 11.1% | 5.2% |
| | | | | | | | |
| Group C | **NZ** | **Sydney** | **Brisbane** | **Adelaide** | **Perth** | **Hobart** | **Darwin** |
| Paper tissues | 34.5% | 0.9% | -0.4% | -3.6% | 3.2% | 16.9% | 7.5% |
| Petrol | 16.2% | 1.9% | -12.3% | 2.6% | 4.0% | 5.2% | 8.1% |
| Whisky, in pub | -43.6% | 10.0% | -17.4% | 11.7% | 16.2% | -21.2% | 4.2% |
| Petfood, canned | -3.0% | 1.3% | 0.6% | -3.0% | 6.3% | 14.8% | 7.0% |
| Peaches, canned | 44.8% | -0.2% | -1.0% | -4.6% | 11.0% | 13.4% | 30.6% |
| Soap, bar | 40.5% | 0.7% | 5.5% | -2.7% | -1.0% | 14.9% | 9.3% |
| cheese, processed | 12.2% | 3.7% | -1.7% | -8.6% | -3.7% | 5.4% | 9.3% |
| mean | 14.5% | 2.6% | -3.8% | -1.2% | 5.1% | 7.1% | 10.9% |
| median | 16.2% | 1.3% | -1.0% | -3.0% | 4.0% | 13.4% | 8.1% |
| | | | | | | | |
| All groups mean | -7.2% | 4.9% | -2.6% | -7.8% | 4.7% | 6.1% | 11.6% |
| All groups median | -9.5% | 1.9% | -1.4% | -7.4% | 4.3% | 8.9% | 9.3% |

Each column is the average price difference between a state and Australia in 1996
A negative number means the state price is lower.
New Zealand prices are converted into Australian dollars

**Table 5: Price differences between states and Australian average, 1996**

| Percentile values of estimated coeffocients and t-statistics | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Australia | | | | | |
| | **97.5** | **95** | **90** | **85** | **50** | **15** | **10** | **5** | **2.5** |
| **Coefficient** | -1.05 | -0.92 | -0.82 | -0.76 | -0.47 | -0.25 | -0.20 | -0.16 | -0.12 |
| **t-statistic** | -5.3 | -4.8 | -4.5 | -4.2 | -3.1 | -2.2 | -2.0 | -1.7 | -1.5 |
| | | | | New Zealand | | | | | |
| **Coefficient** | -0.88 | -0.55 | -0.55 | -0.47 | -0.28 | -0.19 | -0.18 | -0.14 | -0.10 |
| **t-statistic** | -4.5 | -4.1 | -3.9 | -3.5 | -2.8 | -2.4 | -2.4 | -2.2 | -2.1 |
| | | | | Stock Distribution of t-statistics for given rho | | | | | |
| **rho** | **97.5** | **95** | **90** | **85** | **50** | **15** | **10** | **5** | **2.5** |
| **0.0** | -3.8 | -3.5 | -3.2 | -2.9 | -2.2 | -1.5 | -1.2 | -0.9 | -0.6 |
| **0.1** | -3.9 | -3.6 | -3.4 | -3.2 | -2.5 | -1.8 | -1.7 | -1.5 | -1.3 |
| **0.2** | -4.2 | -3.9 | -3.6 | -3.5 | -2.8 | -2.3 | -2.2 | -1.9 | -1.7 |
| **0.3** | -4.5 | -4.3 | -4.0 | -3.9 | -3.2 | -2.6 | -2.5 | -2.4 | -2.2 |
| **0.4** | -4.8 | -4.6 | -4.4 | -4.3 | -3.6 | -3.0 | -2.9 | -2.7 | -2.6 |

The distribution of the estimated coefficients and corresponding t-statistics in the augmented Dickey Fuller equation
There are 272 Australian coefficients and 34 New Zealand coefficients.
The bottom half of the table gives the confidence intervals for the estimated augmented Dickey Fuller t-statistics for true values of rho (Stock, 1991, p442)

**Table 6: Distribution of coefficient and t-statistic estimates, Equation (9).**

| Group A | constant | t-stat | lag y | t-stat | lag difference | t-stat | time | t-stat | F(2,42) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Rump Steak | -0.1403 | **(-2.82)** | -0.4123 | (-3.39) | 0.2696 | (1.76) | 0.0001 | (0.16) | 5.6897 |
| Corned Beef | -0.0789 | (-2.60) | -0.5510 | **(-3.89)** | 0.3382 | **(2.14)** | 0.0006 | **(0.75)** | 7.4121 |
| Lamb chops | -0.1086 | (-2.17) | -0.2813 | (-2.95) | 0.1222 | (0.75) | 0.0036 | (2.29) | 4.3190 |
| Pork chops | -0.0577 | (-2.18) | -0.3635 | (-3.15) | 0.1595 | **(1.06)** | 0.0018 | (2.14) | 4.9659 |
| Salmon, canned | -0.0027 | (-0.10) | -0.3995 | **(-2.94)** | 0.1668 | (1.05) | -0.0025 | **(-2.31)** | 4.4796 |
| Oranges | 0.3395 | **(3.21)** | -0.8944 | **(-4.06)** | 0.0340 | **(0.22)** | -0.0025 | **(-1.46)** | 8.2591 |
| Bananas | -0.0307 | (-0.36) | -0.2984 | (-2.10) | -0.0834 | (-0.52) | -0.0025 | (-1.07) | 2.2199 |
| Potatoes | -0.1148 | (-1.32) | -0.4698 | **(-3.17)** | -0.0410 | **(-0.25)** | 0.0002 | (0.09) | 4.9146 |
| Carrots | -0.2307 | **(-2.12)** | -0.4830 | (-3.42) | 0.1437 | **(0.94)** | 0.0021 | (0.95) | 5.7906 |
| Pineapple, canned | 0.0433 | (1.64) | -0.2932 | (-2.94) | 0.2961 | **(1.92)** | -0.0010 | **(-1.30)** | 4.2620 |
| Eggs | -0.0289 | (-1.17) | -0.2040 | (-2.41) | 0.3719 | **(2.60)** | 0.0004 | (0.56) | 2.9279 |
| Tomato sauce | -0.0242 | (-1.16) | -0.1484 | (-2.19) | 0.2931 | **(2.00)** | 0.0004 | (0.65) | 2.3929 |
| Margarine | -0.0062 | (-0.29) | -0.2653 | (-2.53) | 0.1960 | **(1.30)** | -0.0004 | **(-0.53)** | 3.2484 |
| Butter | -0.1280 | (-2.16) | -0.3026 | (-2.65) | 0.2106 | (1.40) | 0.0019 | (1.73) | 3.7044 |
| Toilet Paper | -0.0846 | (-2.10) | -0.2345 | (-2.45) | 0.2278 | **(1.58)** | 0.0010 | (1.33) | 2.9639 |
| Mean | -0.0436 | (-1.05) | -0.3734 | (-2.95) | 0.1803 | **(1.20)** | 0.0002 | (0.27) | 4.5033 |
| | | | | | | | | | |
| Group B | | | | | | | | | |
| Bread | -0.0751 | (-1.90) | -0.2418 | (-2.57) | 0.2424 | (1.61) | 0.0003 | (0.44) | 3.5738 |
| Flour | -0.1271 | (-2.85) | -0.4321 | (-2.97) | 0.1188 | (0.76) | -0.0003 | (-0.53) | 4.3914 |
| Rice | 0.0291 | (1.48) | -0.8781 | (-4.85) | 0.4717 | **(2.96)** | -0.0030 | **(-3.50)** | 11.6570 |
| Chicken, frozen | 0.0074 | **(0.38)** | -0.2555 | (-2.49) | 0.2272 | **(1.51)** | 0.0006 | (0.84) | 3.1045 |
| Bacon | -0.0114 | (-0.59) | -0.2125 | (-2.49) | 0.2778 | (1.93) | 0.0007 | (1.03) | 3.0599 |
| Peas, frozen | -0.0715 | (-2.25) | -0.1910 | (-2.45) | 0.3122 | (2.13) | -0.0005 | (-0.67) | 3.0785 |
| Chocolate Bar | -0.0146 | (-0.63) | -0.2795 | (-2.55) | 0.2849 | (1.94) | 0.0001 | (0.17) | 3.4247 |
| Sugar | -0.0372 | (-1.56) | -0.3220 | (-2.81) | 0.2097 | (1.28) | 0.0005 | (0.74) | 3.9416 |
| Coffee, instant | -0.1400 | (-2.74) | -0.2969 | **(-3.10)** | 0.2638 | (1.79) | 0.0025 | (2.27) | 4.7955 |
| Laundry Detergent | -0.1691 | (-2.48) | -0.3736 | (-2.84) | 0.1998 | (1.32) | 0.0019 | (1.86) | 4.1036 |
| Dish Detergent | -0.1956 | (-3.79) | -0.1006 | (-3.46) | 0.3043 | (2.23) | 0.0027 | (3.68) | 7.7278 |
| Toothpaste | -0.1471 | (-4.02) | -0.5458 | (-4.47) | 0.4642 | (3.27) | 0.0019 | (2.78) | 9.8842 |
| Mean | -0.0793 | (-1.74) | -0.3441 | (-3.09) | 0.2814 | (1.89) | 0.0006 | (0.76) | 5.2285 |
| | | | | | | | | | |
| Group C | | | | | | | | | |
| Paper tissues | -0.0411 | (-1.49) | -0.1423 | (-2.29) | 0.4030 | (2.86) | 0.0017 | (1.80) | 2.6439 |
| Petrol | 0.0619 | (2.31) | -0.2248 | **(-2.67)** | 0.3729 | (2.51) | -0.0009 | (-1.55) | 3.5348 |
| Whisky, in pub | -0.1085 | (-2.60) | -0.2139 | (-2.73) | 0.4169 | (2.96) | -0.0003 | (-0.49) | 3.6607 |
| Petfood, canned | -0.0084 | (-0.49) | -0.2422 | (-3.46) | 0.4185 | (3.37) | 0.0002 | (0.32) | 5.8556 |
| Peaches, canned | 0.0344 | (1.66) | -0.1770 | (-2.73) | 0.3408 | (2.46) | 0.0006 | (1.03) | 3.6553 |
| Soap, bar | 0.0836 | **(2.43)** | -0.3475 | (-2.93) | 0.2295 | (1.54) | 0.0001 | (0.12) | 4.3116 |
| cheese, processed | 0.0045 | (0.22) | -0.2434 | **(-2.49)** | 0.3088 | (2.12) | 0.0004 | (0.61) | 3.1656 |
| Mean | 0.0038 | (0.29) | -0.2273 | (-2.76) | 0.3558 | (2.55) | 0.0003 | (0.26) | 3.8325 |
| | | | | | | | | | |
| Mean | -0.0464 | (-1.02) | -0.3330 | (-2.96) | 0.2521 | (1.72) | 0.0004 | (0.44) | 4.6212 |
| Median, all groups | -0.0052 | (-0.36) | 0.0686 | (0.32) | 0.1096 | (1.74) | 0.0234 | (0.49) | |

The table gives the estimates of the coefficients of the augmented Dickey Fuller equation for New Zealand price differences with Australia. The 5 percent critcal value for the "t-statistic" on rho is -3.95. The "F-test" is the test that both rho and delta are zero; the 5 percent critical value is 7.8. There are 44 degrees of freedom.

## Table 7 : Augmented Dickey-Fuller equations for New Zealand

| Group A | rho(AU) | (se) | F-stat | rho(NZ) | (se) | F-stat | rho (NZ+AU) | (se) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Rump Steak | **-0.2318** | **0.0363** | 1.2105 | -0.4395 | 0.1227 | 2.6441 | **-0.2482** | **0.0349** |
| Corned Beef | **-0.2795** | **0.0395** | 1.4476 | **-0.5025** | **0.1261** | 2.8744 | **-0.2985** | **0.0378** |
| Lamb chops | **-0.3223** | **0.0384** | 3.6173 | | | | | |
| Pork chops | **-0.2675** | **0.0346** | 1.1726 | -0.3579 | 0.1111 | 0.6008 | **-0.2757** | **0.0332** |
| Salmon, canned | **-0.5802** | **0.0493** | 1.3319 | **-0.3866** | **0.0992** | 3.1406 | **-0.5439** | **0.0444** |
| Oranges | **-0.8589** | **0.0570** | 1.3893 | **-1.0584** | **0.1754** | 1.1956 | **-0.8761** | **0.0543** |
| Bananas | **-0.5589** | **0.0483** | 1.3449 | -0.3633 | 0.1217 | 2.2451 | **-0.5327** | **0.0450** |
| Potatoes | **-0.5028** | **0.0466** | 1.8236 | -0.5671 | 0.1596 | 0.1716 | **-0.5037** | **0.0446** |
| Carrots | **-0.8652** | **0.0549** | 4.5110 | | | | | |
| Pineapple, canned | **-0.3192** | **0.0406** | 1.7890 | -0.3124 | 0.0935 | 0.0011 | **-0.3152** | **0.0371** |
| Eggs | **-0.1976** | **0.0314** | 1.2026 | -0.1516 | 0.0722 | 0.3467 | **-0.1905** | **0.0287** |
| Tomato sauce | **-0.4081** | **0.0459** | 2.1922 | | | | | |
| Margarine | **-0.5729** | **0.0540** | 2.5648 | | | | | |
| Butter | **-0.4060** | **0.0437** | 1.6335 | -0.2648 | 0.0907 | 1.9197 | **-0.3781** | **0.0394** |
| Toilet Paper | **-0.6178** | **0.0537** | 2.0779 | | | | | |
| | | | | | | | | |
| Group B | | | | | | | | |
| Bread | **-0.2145** | **0.0337** | 2.9483 | | | | | |
| Flour | **-0.4199** | **0.0472** | 0.9917 | -0.4007 | 0.1117 | 0.0201 | **-0.4152** | **0.0434** |
| Rice | **-0.5751** | **0.0532** | 2.6017 | | | | | |
| Chicken, frozen | **-0.7954** | **0.0587** | 1.7353 | -0.2231 | 0.0780 | 33.8629 | | |
| Bacon | **-0.3889** | **0.0457** | 1.7564 | -0.1891 | 0.0720 | 5.4014 | | |
| Peas, frozen | **-0.6596** | **0.0571** | 1.4829 | -0.1880 | 0.0706 | 26.5388 | | |
| Chocolate Bar | **-0.6003** | **0.0515** | 2.4069 | | | | | |
| Sugar | **-0.3230** | **0.0398** | 2.8382 | | | | | |
| Coffee, instant | **-0.7598** | **0.0540** | 2.8403 | | | | | |
| Laundry Detergent | **-0.5564** | **0.0522** | 1.8019 | -0.3284 | 0.1018 | 3.9325 | | |
| Dish Detergent | **-0.7368** | **0.0555** | 1.9412 | **-0.9910** | **0.1538** | 2.4795 | **-0.7633** | **0.0523** |
| Toothpaste | **-0.4776** | **0.0494** | 1.7134 | **-0.5312** | **0.1075** | 0.2347 | **-0.4838** | **0.0448** |
| | | | | | | | | |
| Group C | | | | | | | | |
| Paper tissues | **-0.4360** | **0.0451** | 2.8644 | | | | | |
| Petrol | **-0.3495** | **0.0391** | 1.7353 | -0.1549 | 0.0674 | 6.1629 | | |
| Whisky, in pub | **-0.1249** | **0.0263** | 3.0825 | | | | | |
| Petfood, canned | **-0.5340** | **0.0489** | 1.4245 | -0.2301 | 0.0799 | 10.2728 | | |
| Peaches, canned | **-0.6177** | **0.0528** | 1.5844 | -0.1676 | 0.0661 | 28.2074 | | |
| Soap, bar | **-0.4172** | **0.0492** | 5.2668 | | | | | |
| cheese, processed | **-0.4401** | **0.0480** | 1.4507 | -0.1996 | 0.0678 | 8.5809 | | |

## Table 8: Pooled cointegration regression statistics.

The table summarises the pooled Augmented Dickey Fuller tests (Equation 10). The first three columns summarise the regression with 8 Australian cities. The first two columns are the restricted coefficient ρ and its standard error. The third column is the F(7,368) statistic of the restriction that all 8 coefficients are equal (the critical value is 2.01). The second three columns summarise the regression with 8 Australian cities and New Zealand. The first two columns are the estimated coefficient when the New Zealand coefficient is restricted to be the same as all eight Australian coefficients; the third column is the F(1, 424) test of the restriction (whose critical value is 3.84). The last two columns are the estimates when the coefficients ρ of all eight states and New Zealand are restricted to be equal. Bold figures denote significance at the ninety-five percent level.

| Group A | **constant** | **(t-stat)** | $\Delta p_t^{perth} - \Delta p_t^{au}$ | **(t-stat)** | $p_{kt-1}^{au} - p_{kt-1}^{Perth}$ | **(t-stat)** | $\Delta p_{kt-1}^{perth}$ | **(t-stat)** |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Rump Steak | 0.0046 | (0.38) | 0.4247 | (1.28) | 0.1367 | (1.72) | -0.1475 | (-0.98) |
| Corned Beef | -0.0096 | (-1.33) | 0.7720 | **(2.98)** | 0.2068 | **(2.25)** | -0.2798 | **(-2.25)** |
| Lamb chops | 0.0706 | **(2.72)** | 0.5525 | **(4.10)** | 0.2133 | **(2.18)** | -0.2456 | (-1.97) |
| Pork chops | 0.0126 | (1.44) | 0.6443 | **(2.16)** | 0.2743 | **(2.67)** | -0.1219 | (-0.88) |
| Salmon, canned | 0.0110 | (1.26) | 1.0537 | **(17.11)** | 0.4228 | **(3.52)** | 0.0041 | (0.07) |
| Oranges | 0.1193 | **(3.72)** | 1.2121 | **(8.42)** | 0.2997 | **(2.59)** | -0.0768 | (-0.78) |
| Bananas | -0.0146 | (-0.44) | 0.6188 | **(8.84)** | 0.1934 | **(2.27)** | -0.0154 | (-0.17) |
| Potatoes | 0.0026 | (0.13) | 0.1713 | **(2.78)** | 0.0692 | (1.44) | 0.1771 | (1.29) |
| Carrots | -0.1915 | **(-4.40)** | 0.6640 | **(6.53)** | 0.5274 | **(4.61)** | -0.1314 | (-1.34) |
| Pineapple, canned | 0.0283 | **(2.48)** | 0.9359 | **(6.15)** | 0.3408 | **(3.22)** | -0.1612 | (-1.54) |
| Eggs | -0.0063 | (-1.09) | 0.2494 | **(2.30)** | 0.2454 | **(4.69)** | -0.2627 | **(-2.10)** |
| Tomato sauce | 0.0121 | (1.02) | 0.8098 | **(3.34)** | 0.3715 | **(2.83)** | -0.2116 | (-1.73) |
| Margarine | 0.0250 | (1.45) | 0.8303 | **(3.82)** | 0.4048 | **(2.75)** | -0.3013 | **(-2.16)** |
| Butter | 0.0056 | (0.46) | 0.8599 | **(3.61)** | 0.1814 | **(2.15)** | 0.2277 | (1.60) |
| Toilet Paper | 0.0062 | (0.60) | 0.7110 | **(5.05)** | 0.5494 | **(4.35)** | 0.0432 | (0.38) |
| Median | 0.0062 | (0.60) | 0.7110 | **(3.82)** | 0.2743 | **(2.67)** | -0.1314 | (-0.98) |
| | | | | | | | | |
| Group B | | | | | | | | |
| Bread | -0.0132 | (-0.83) | 1.1955 | **(2.50)** | 0.2824 | **(2.57)** | 0.0458 | (0.29) |
| Flour | -0.0306 | (-1.11) | 1.1412 | **(3.27)** | 0.2161 | **(2.27)** | -0.0936 | (-0.68) |
| Rice | 0.0152 | (1.50) | 1.0267 | **(6.45)** | 0.3379 | **(2.65)** | -0.1061 | (-0.81) |
| Chicken, frozen | 0.0237 | (1.50) | 0.8743 | **(4.12)** | 0.3376 | **(2.69)** | -0.3075 | **(-2.60)** |
| Bacon | 0.0316 | **(2.25)** | 0.9121 | **(2.58)** | 0.1306 | **(2.30)** | -0.1850 | (-1.37) |
| Peas, frozen | 0.0288 | **(2.25)** | 0.7409 | **(3.73)** | 0.4109 | **(3.74)** | -0.1813 | (-1.54) |
| Chocolate Bar | 0.0259 | **(3.55)** | 0.7059 | **(5.59)** | 0.2311 | **(2.56)** | -0.2248 | **(-2.02)** |
| Sugar | 0.0082 | (1.19) | 1.1177 | **(14.78)** | 0.1548 | **(2.59)** | -0.0765 | (-1.21) |
| Coffee, instant | -0.0029 | (-0.35) | 0.9067 | **(13.53)** | 0.6181 | **(5.04)** | -0.0208 | (-0.35) |
| Laundry Detergent | 0.0376 | **(4.23)** | 0.7894 | **(4.68)** | 0.3473 | **(3.08)** | -0.2337 | **(-2.04)** |
| Dish Detergent | 0.0261 | **(2.11)** | 0.9004 | **(5.68)** | 0.5625 | **(3.58)** | -0.0216 | (-0.27) |
| Toothpaste | 0.0232 | **(2.38)** | 0.6786 | **(2.67)** | 0.2938 | **(2.98)** | -0.3451 | **(-3.12)** |
| Median | 0.0234 | (1.81) | 0.9036 | **(4.40)** | 0.3157 | **(2.67)** | -0.1437 | (-1.29) |
| | | | | | | | | |
| Group C | | | | | | | | |
| Paper tissues | 0.0034 | (0.47) | 0.9064 | **(9.00)** | 0.3269 | **(2.99)** | -0.0076 | (-0.08) |
| Petrol | 0.0078 | (1.48) | 0.9310 | **(19.22)** | 0.2134 | **(2.80)** | -0.0381 | (-0.77) |
| Whisky, in pub | -0.0002 | (-0.01) | 2.0264 | **(4.61)** | 0.0539 | (0.74) | -0.0067 | (-0.06) |
| Petfood, canned | 0.0368 | **(2.62)** | 0.6708 | **(3.39)** | 0.3467 | **(3.46)** | 0.0344 | (0.35) |
| Peaches, canned | 0.0344 | **(2.70)** | 0.7801 | **(3.74)** | 0.3273 | **(3.70)** | -0.2125 | (-1.83) |
| Soap, bar | 0.0080 | (1.11) | 0.6649 | **(4.45)** | 0.1158 | (1.57) | 0.0438 | (0.33) |
| cheese, processed | -0.0001 | (-0.01) | 1.2107 | **(6.62)** | 0.2167 | **(2.37)** | 0.0026 | (0.02) |
| Median | 0.0078 | (1.11) | 0.9064 | **(4.61)** | 0.2167 | **(2.80)** | -0.0067 | (-0.06) |

**Table 9: Price adjustment equations for Perth, 1984 - 1996.**

The table summarises the estimates for the price adjustment equation (7) for Perth.

| Group A | constant | (t-stat) | $\Delta p_t^{au}$ | (t-stat) | $p_{kt-1}^{au} - p_{kt-1}^{nz} - e_{t-1}$ | (t-stat) | $\Delta p_{t-1}^{nz}$ | (t-stat) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Rump Steak | -0.1129 | **(-2.63)** | -0.4624 | (-0.69) | 0.3528 | **(3.05)** | 0.3210 | **(2.05)** |
| Corned Beef | -0.0526 | **(-2.21)** | 0.3185 | (0.46) | 0.3880 | **(3.33)** | 0.2875 | (1.94) |
| Lamb chops | 0.0022 | (0.09) | -0.2442 | (-0.92) | 0.0931 | (1.57) | 0.2543 | (1.67) |
| Pork chops | 0.0232 | (0.96) | -0.7766 | (-0.92) | 0.2178 | **(2.35)** | 0.0446 | (0.29) |
| Salmon, canned | -0.0261 | (-0.92) | 0.6740 | **(3.73)** | 0.2279 | **(2.56)** | 0.4235 | **(3.11)** |
| Oranges | 0.4046 | **(6.86)** | 0.9322 | **(3.09)** | 0.5616 | **(3.22)** | -0.0941 | (-0.61) |
| Bananas | 0.0347 | (0.92) | 0.0153 | (0.14) | 0.0557 | (0.95) | -0.2675 | (-1.73) |
| Potatoes | -0.1791 | **(-2.76)** | 0.4577 | **(2.40)** | 0.3895 | **(2.38)** | 0.0939 | (0.55) |
| Carrots | -0.2332 | **(-3.45)** | 0.2842 | (1.54) | 0.2494 | **(2.08)** | 0.0128 | (0.08) |
| Pineapple, canned | 0.0458 | **(2.27)** | -0.1374 | (-0.28) | 0.1974 | **(2.54)** | 0.3875 | **(2.58)** |
| Eggs | -0.0025 | (-0.14) | -0.1059 | (-0.32) | 0.1375 | **(2.22)** | 0.3219 | **(2.23)** |
| Tomato sauce | 0.0077 | (0.43) | 0.0516 | (0.12) | 0.0894 | (1.65) | 0.3220 | **(2.15)** |
| Margarine | -0.0008 | (-0.04) | 0.2071 | (0.95) | 0.1500 | **(2.52)** | 0.3476 | **(2.50)** |
| Butter | -0.0114 | (-0.44) | 0.1724 | (0.49) | 0.0889 | (1.66) | 0.2218 | (1.46) |
| Toilet Paper | -0.0236 | (-0.97) | 0.2675 | (1.22) | 0.0906 | (1.69) | 0.2498 | (1.66) |
| Median | -0.0025 | (-0.14) | 0.1724 | (0.46) | 0.1974 | **(2.35)** | 0.2543 | (1.67) |
| | | | | | | | | |
| Group B | | | | | | | | |
| Bread | -0.0461 | (-1.49) | 0.2749 | (0.50) | 0.1640 | **(2.43)** | 0.2424 | (1.63) |
| Flour | -0.1013 | **(-2.30)** | -0.0516 | (-0.11) | 0.2705 | **(2.68)** | 0.3439 | **(2.18)** |
| Rice | -0.0025 | (-0.14) | -0.3032 | (-1.09) | 0.2080 | **(2.23)** | 0.2919 | (1.89) |
| Chicken, frozen | 0.0243 | (1.60) | 0.0899 | (0.40) | 0.1661 | **(2.77)** | 0.3808 | **(2.75)** |
| Bacon | 0.0232 | (1.51) | -0.5092 | (-1.23) | 0.1223 | **(2.13)** | 0.3576 | **(2.47)** |
| Peas, frozen | -0.0086 | (-0.25) | -0.1070 | (-0.35) | 0.0548 | (0.92) | 0.3367 | **(2.16)** |
| Chocolate Bar | 0.0090 | (0.55) | 0.2113 | (0.76) | 0.1670 | **(2.68)** | 0.4366 | **(3.14)** |
| Sugar | -0.0073 | (-0.36) | 0.2699 | (1.06) | 0.2338 | **(2.29)** | 0.2770 | (1.70) |
| Coffee, instant | -0.0431 | (-1.45) | 0.1806 | (0.60) | 0.2023 | **(2.59)** | 0.4993 | **(3.18)** |
| Laundry Detergent | -0.0417 | (-1.19) | 0.3337 | (0.76) | 0.1547 | **(2.30)** | 0.2898 | (1.82) |
| Dish Detergent | -0.0295 | (-0.90) | 0.3531 | (1.69) | 0.0753 | (1.38) | 0.2534 | (1.67) |
| Toothpaste | -0.0496 | **(-2.36)** | -0.6746 | (-1.82) | 0.3492 | **(4.37)** | 0.5569 | **(4.35)** |
| Median | -0.0190 | (-0.63) | 0.1352 | (0.45) | 0.1665 | **(2.36)** | 0.3403 | **(2.17)** |
| | | | | | | | | |
| Group C | | | | | | | | |
| Paper tissues | 0.0165 | (1.05) | -0.1186 | (-0.53) | 0.0538 | (1.54) | 0.4097 | **(2.89)** |
| Petrol | 0.0259 | (1.53) | 0.7801 | **(5.75)** | 0.1078 | (1.83) | 0.3597 | **(3.18)** |
| Whisky, in pub | -0.1028 | (-1.87) | 1.1783 | (1.68) | 0.1824 | **(2.35)** | 0.3818 | **(2.56)** |
| Petfood, canned | 0.0097 | (0.62) | -0.0425 | (-0.13) | 0.1750 | **(2.40)** | 0.2757 | (1.88) |
| Peaches, canned | 0.0601 | **(2.58)** | 0.3232 | (0.80) | 0.1208 | **(2.04)** | 0.2941 | (1.99) |
| Soap, bar | 0.1079 | **(3.29)** | -0.2105 | (-0.36) | 0.2678 | **(2.86)** | 0.3279 | **(2.10)** |
| cheese, processed | 0.0238 | (1.39) | 0.2302 | (0.75) | 0.1244 | **(2.05)** | 0.3740 | **(2.57)** |
| Median | 0.0238 | (1.39) | 0.2302 | (0.75) | 0.1244 | **(2.05)** | 0.3597 | **(2.56)** |

## Table 10: New Zealand price adjustment regressions with instant pass through of exchange rates

These are the coefficients for equation (11) - New Zealand's price convergence equation for New Zealand prices denominated in Australian dollars.

| Group A | constant | (t-stat) | $\Delta p^{au}_{t}$ | (t-stat) | $\Delta e_t$ | (t-stat) | $p^{au}_{kt-1} - p^{nz}_{kt-1} - e_{t-1}$ | (t-stat) | $\Delta p^{nz}_{t-1}$ | (t-stat) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| Rump Steak | -0.0861 | **(-2.99)** | 0.3602 | (0.70) | 0.0239 | (0.16) | 0.2254 | **(2.91)** | 0.0285 | (0.17) |
| Corned Beef | -0.0343 | **(-2.53)** | 1.5494 | **(3.51)** | 0.1157 | (0.96) | 0.2832 | **(4.42)** | -0.2438 | (-1.85) |
| Lamb chops | -0.0215 | (-1.40) | -0.0239 | (-0.15) | 0.0725 | (0.59) | 0.0800 | **(2.32)** | 0.3184 | **(2.29)** |
| Pork chops | 0.0024 | (0.15) | 0.7866 | (1.36) | 0.0555 | (0.39) | 0.0734 | (1.20) | -0.2880 | (-1.91) |
| Salmon, canned | -0.0228 | (-1.09) | 0.5049 | **(3.63)** | -0.1725 | (-0.96) | 0.1798 | **(2.86)** | 0.5136 | **(4.17)** |
| Oranges | 0.4129 | **(7.05)** | 0.9488 | **(3.18)** | -0.3707 | (-0.75) | 0.6309 | **(3.69)** | -0.0779 | (-0.55) |
| Bananas | 0.0133 | (0.38) | 0.0886 | (0.87) | -0.1812 | (-0.60) | 0.0339 | (0.64) | -0.4289 | **(-2.89)** |
| Potatoes | -0.1800 | **(-2.94)** | 0.4288 | **(2.33)** | -0.1178 | (-0.28) | 0.3727 | **(2.42)** | 0.0628 | (0.38) |
| Carrots | -0.2253 | **(-3.46)** | 0.2513 | (1.43) | 0.1089 | (0.22) | 0.2139 | (1.88) | -0.0277 | (-0.17) |
| Pineapple, canned | 0.0226 | **(2.33)** | 0.3489 | (1.45) | -0.0368 | (-0.42) | 0.1308 | **(3.54)** | 0.4046 | **(3.04)** |
| Eggs | -0.0047 | (-0.58) | -0.1191 | (-0.81) | 0.0662 | (0.84) | 0.0560 | (1.99) | 0.2873 | **(2.03)** |
| Tomato sauce | 0.0065 | (0.89) | -0.1303 | (-0.70) | 0.0340 | (0.49) | 0.0197 | (0.88) | 0.1502 | (0.90) |
| Margarine | -0.0049 | (-0.63) | 0.2650 | **(2.66)** | -0.0773 | (-1.06) | 0.0719 | **(2.49)** | 0.4228 | **(3.30)** |
| Butter | -0.0184 | (-1.56) | -0.0009 | (-0.01) | 0.0316 | (0.42) | 0.0852 | **(3.30)** | -0.0867 | (-0.57) |
| Toilet Paper | -0.0236 | (-1.94) | 0.1215 | (1.12) | -0.1052 | (-1.38) | 0.0684 | **(2.54)** | 0.0450 | (0.29) |
| Median | -0.0184 | (-1.09) | 0.2650 | (1.36) | 0.0239 | (0.16) | 0.0852 | **(2.49)** | 0.0450 | (0.29) |
| | | | | | | | | | | |
| Group B | | | | | | | | | | |
| Bread | -0.0290 | (-1.85) | 0.2073 | (0.76) | -0.0490 | (-0.58) | 0.1085 | **(3.08)** | -0.0275 | (-0.18) |
| Flour | -0.0434 | (-1.83) | 0.0452 | (0.18) | -0.0513 | (-0.57) | 0.0911 | (1.69) | 0.1671 | (1.04) |
| Rice | -0.0105 | (-1.17) | 0.0431 | (0.30) | -0.2042 | **(-2.48)** | 0.1391 | **(3.05)** | 0.5021 | **(4.22)** |
| Chicken, frozen | 0.0066 | (0.75) | 0.0528 | (0.43) | -0.1378 | (-1.69) | 0.0502 | (1.44) | -0.1226 | (-0.80) |
| Bacon | 0.0081 | (1.50) | -0.0879 | (-0.60) | -0.0321 | (-0.58) | 0.0349 | (1.71) | 0.2790 | (1.90) |
| Peas, frozen | 0.0042 | (0.25) | 0.3127 | (1.97) | 0.1124 | (1.17) | 0.0003 | (0.01) | 0.0349 | (0.22) |
| Chocolate Bar | 0.0122 | (1.29) | 0.0583 | (0.35) | -0.0854 | (-0.95) | 0.0753 | **(2.09)** | 0.2133 | (1.38) |
| Sugar | -0.0031 | (-0.24) | 0.3202 | **(2.00)** | 0.0386 | (0.32) | 0.0130 | (0.20) | 0.0845 | (0.48) |
| Coffee, instant | -0.0351 | (-1.91) | 0.7106 | **(3.25)** | 0.2468 | (1.53) | 0.1224 | **(2.57)** | 0.1217 | (0.73) |
| Laundry Detergent | -0.0165 | (-0.79) | 0.0259 | (0.09) | 0.0281 | (0.25) | 0.0882 | **(2.19)** | 0.0542 | (0.32) |
| Dish Detergent | 0.0075 | (0.40) | 0.2450 | **(2.15)** | -0.0590 | (-0.60) | 0.0032 | (0.10) | 0.0185 | (0.12) |
| Toothpaste | -0.0135 | (-1.27) | -0.0386 | (-0.20) | -0.0368 | (-0.50) | 0.1019 | **(2.51)** | 0.3496 | **(2.51)** |
| Median | -0.0068 | (-0.52) | 0.0556 | (0.39) | -0.0429 | (-0.57) | 0.0818 | (1.90) | 0.1031 | (0.60) |
| | | | | | | | | | | |
| Group C | | | | | | | | | | |
| Paper tissues | 0.0075 | (1.16) | 0.0479 | (0.53) | -0.0270 | (-0.41) | 0.0325 | **(2.24)** | 0.2366 | (1.48) |
| Petrol | 0.0051 | (0.49) | 0.5913 | **(6.61)** | -0.3505 | **(-4.18)** | 0.0472 | (1.32) | 0.4376 | **(3.83)** |
| Whisky, in pub | 0.0056 | (0.26) | 0.1153 | (0.40) | -0.0110 | (-0.17) | 0.0187 | (0.62) | 0.2391 | (1.48) |
| Petfood, canned | 0.0036 | (0.54) | -0.1221 | (-0.90) | -0.0597 | (-0.90) | 0.0794 | **(2.52)** | 0.0036 | (0.02) |
| Peaches, canned | 0.0291 | (2.82) | 0.5087 | **(2.89)** | -0.0246 | (-0.34) | 0.0495 | (1.88) | -0.0408 | (-0.29) |
| Soap, bar | 0.0722 | (3.45) | -0.0116 | (-0.03) | 0.1532 | (1.05) | 0.1665 | **(2.83)** | -0.0535 | (-0.34) |
| cheese, processed | 0.0114 | (1.22) | 0.3829 | **(2.34)** | 0.0103 | (0.11) | 0.0510 | (1.58) | 0.0672 | (0.45) |
| Median | 0.0075 | (1.16) | 0.1153 | (0.53) | -0.0246 | (-0.34) | 0.0495 | (1.88) | 0.0672 | (0.45) |

## Table 11: New Zealand price adjustment regressions allowing for lack of pass through of exchange rates

be expected for the change in exchange rate if there were 100% instantaneous pass through.

| Group A | constant | (t-stat) | $\Delta p_t^{au} - \Delta \bar{p}_t^{au}$ | (t-stat) | $p^{au}_{kt-1} - p^{nz}_{kt-1} - \bar{p}^{au}_{t-1} + \bar{p}^{nz}_{t-1}$ | (t-stat) | $\bar{p}^{au}_{t-1} - \bar{p}^{nz}_{t-1} - e_{t-1}$ | (t-stat) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Rump Steak | -0.0725 | **(-2.52)** | -0.0164 | (-0.03) | 0.1497 | (1.74) | 0.1554 | (1.78) |
| Corned Beef | -0.0213 | (-1.10) | 1.1540 | **(2.32)** | 0.2610 | **(2.81)** | 0.1907 | **(2.80)** |
| Lamb chops | -0.0252 | (-1.05) | -0.0350 | (-0.19) | 0.0439 | (1.08) | 0.0446 | (0.65) |
| Pork chops | 0.0590 | (1.97) | 0.4994 | (0.95) | 0.2860 | **(2.62)** | 0.0105 | (0.18) |
| Salmon, canned | -0.0554 | (-1.68) | 0.5561 | **(3.63)** | 0.1139 | (1.64) | 0.2450 | **(2.19)** |
| Oranges | 0.4217 | **(4.91)** | 0.7981 | **(2.80)** | 0.6534 | **(4.44)** | 0.5735 | **(2.39)** |
| Bananas | 0.0365 | (0.72) | 0.0689 | (0.65) | 0.0642 | (1.10) | 0.0095 | (0.07) |
| Potatoes | -0.1261 | (-1.86) | 0.4544 | **(2.55)** | 0.3942 | **(2.68)** | 0.1777 | (0.85) |
| Carrots | -0.1928 | **(-2.47)** | 0.2631 | (1.55) | 0.2594 | **(2.21)** | 0.0604 | (0.27) |
| Pineapple, canned | -0.0114 | (-0.75) | 0.1181 | (0.55) | 0.1232 | **(3.12)** | 0.2005 | **(4.47)** |
| Eggs | 0.0153 | (1.09) | -0.2404 | (-1.53) | 0.1030 | **(2.65)** | -0.0481 | (-1.22) |
| Tomato sauce | 0.0353 | (1.73) | 0.0296 | (0.14) | 0.1425 | **(2.12)** | -0.0711 | (-1.72) |
| Margarine | -0.0173 | (-1.09) | 0.0984 | (0.89) | 0.0624 | **(1.18)** | 0.0797 | **(2.23)** |
| Butter | -0.0132 | (-1.03) | 0.0300 | (0.18) | 0.0716 | (1.84) | 0.0229 | (0.58) |
| Toilet Paper | -0.0203 | (-1.50) | -0.0508 | (-0.41) | 0.1453 | **(2.48)** | -0.0211 | (-0.52) |
| Median | -0.0173 | (-1.05) | 0.0984 | (0.65) | 0.1425 | **(2.21)** | 0.0604 | (0.65) |
| | | | | | | | | |
| Group B | | | | | | | | |
| Bread | -0.0143 | (-1.01) | -0.1217 | (-0.46) | 0.1343 | (1.86) | 0.0035 | (0.09) |
| Flour | -0.0424 | (-1.99) | -0.2504 | (-1.07) | 0.1144 | (1.75) | 0.0440 | (0.86) |
| Rice | -0.0274 | (-1.97) | 0.0159 | (0.11) | 0.1705 | **(3.67)** | 0.1694 | **(2.80)** |
| Chicken, frozen | 0.0538 | **(2.00)** | -0.0521 | (-0.41) | 0.1434 | **(2.14)** | -0.0559 | (-1.58) |
| Bacon | 0.0135 | (0.69) | -0.2604 | (-1.77) | 0.0397 | (0.75) | -0.0327 | (-1.22) |
| Peas, frozen | 0.0015 | (0.09) | 0.1361 | (0.83) | 0.0129 | (0.35) | -0.0361 | (-0.80) |
| Chocolate Bar | 0.0189 | (0.67) | 0.0686 | (0.36) | 0.0782 | (0.72) | 0.0158 | (0.33) |
| Sugar | 0.0274 | (1.45) | 0.2991 | (1.92) | 0.0888 | (1.05) | -0.0890 | (-1.49) |
| Coffee, instant | -0.0370 | (-1.61) | 0.7008 | **(3.82)** | 0.0643 | (0.65) | 0.1243 | (1.83) |
| Laundry Detergent | -0.0021 | (-0.11) | -0.0899 | (-0.35) | 0.1141 | (1.76) | -0.0309 | (-0.64) |
| Dish Detergent | 0.0080 | (0.41) | 0.2166 | (1.53) | 0.0379 | (0.99) | -0.0748 | (-1.45) |
| Toothpaste | -0.0052 | (-0.38) | -0.1796 | (-0.77) | 0.1096 | (1.50) | 0.0234 | (0.49) |
| Median | -0.0003 | (-0.01) | -0.0181 | (-0.12) | 0.0992 | (1.27) | -0.0137 | (-0.27) |
| | | | | | | | | |
| Group C | | | | | | | | |
| Paper tissues | -0.0059 | (-0.36) | 0.0043 | (0.04) | 0.0120 | (0.41) | 0.0302 | (0.79) |
| Petrol | -0.0133 | (-0.72) | 0.2776 | **(2.97)** | 0.0435 | (1.04) | 0.0768 | (1.71) |
| Whisky, in pub | 0.0165 | (0.87) | 0.0922 | (0.32) | -0.0269 | (-0.65) | 0.0048 | (0.17) |
| Petfood, canned | 0.0074 | (0.41) | -0.0125 | (-0.12) | 0.1047 | (1.58) | 0.0322 | (0.94) |
| Peaches, canned | 0.0659 | (1.57) | 0.2917 | (1.44) | 0.0924 | (1.35) | -0.0333 | (-0.84) |
| Soap, bar | 0.1341 | **(2.15)** | -0.4265 | (-1.21) | 0.2682 | (2.41) | 0.0824 | (1.42) |
| cheese, processed | 0.0629 | (1.71) | 0.4368 | **(2.13)** | 0.1448 | (1.70) | -0.0582 | (-1.14) |
| Median | 0.0165 | (0.87) | 0.0922 | (0.32) | 0.0924 | (1.35) | 0.0302 | (0.79) |
| | | | | | | | | |
| Mean, all groups | 0.0071 | (-0.05) | 0.1376 | (0.66) | 0.1351 | (1.73) | 0.0520 | (0.49) |
| Median, all groups | -0.0052 | (-0.36) | 0.0686 | (0.32) | 0.1096 | (1.74) | 0.0234 | (0.49) |

## Table 12: Revised NZ price adjustment equations

Price adjustment equation (14) regressions.

| Group A | **constant** | **(t-stat)** | $\Delta p_t^{au} - \Delta \overline{p}_t^{au}$ | **(t-stat)** | $p_{kt-1}^{au} - p_{kt-1}^{nz} - \overline{p}_{t-1}^{au} + \overline{p}_{t-1}^{nz}$ | **(t-stat)** |
|---|---|---|---|---|---|---|
| | | | | | | |
| Rump Steak | -0.0285 | (-1.89) | -0.2516 | (-0.43) | 0.0513 | (0.76) |
| Corned Beef | 0.0034 | (0.18) | 1.1253 | (2.09) | 0.1036 | (1.30) |
| Lamb chops | -0.0148 | (-0.83) | -0.0669 | (-0.38) | 0.0341 | (0.91) |
| Pork chops | 0.0607 | **(2.18)** | 0.4974 | (0.96) | 0.2818 | **(2.67)** |
| Salmon, canned | 0.0022 | (0.11) | 0.5348 | **(3.35)** | 0.0225 | (0.39) |
| Oranges | 0.4998 | **(5.96)** | 0.6584 | **(2.23)** | 0.5025 | **(3.58)** |
| Bananas | 0.0391 | (1.14) | 0.0688 | (0.65) | 0.0640 | (1.11) |
| Potatoes | -0.0853 | (-1.78) | 0.4101 | **(2.42)** | 0.3470 | **(2.55)** |
| Carrots | -0.1769 | **(-3.46)** | 0.2571 | (1.55) | 0.2561 | **(2.22)** |
| Pineapple, canned | 0.0096 | (0.55) | 0.1409 | (0.55) | 0.0322 | (0.79) |
| Eggs | 0.0038 | (0.36) | -0.1882 | (-1.24) | 0.1056 | **(2.71)** |
| Tomato sauce | 0.0058 | (0.52) | -0.0511 | (-0.25) | 0.0726 | (1.33) |
| Margarine | 0.0052 | (0.40) | 0.1406 | (1.24) | 0.0741 | (1.35) |
| Butter | -0.0080 | (-0.89) | 0.0150 | (0.09) | 0.0771 | **(2.06)** |
| Toilet Paper | -0.0251 | **(-2.57)** | -0.0454 | (-0.37) | 0.1379 | **(2.45)** |
| Median | 0.0034 | (0.18) | 0.1406 | (0.65) | 0.0771 | (1.35) |
| | | | | | | |
| Group B | | | | | | |
| Bread | -0.0135 | (-1.29) | -0.1244 | (-0.48) | 0.1351 | (1.91) |
| Flour | -0.0266 | **(-2.49)** | -0.2669 | (-1.15) | 0.0790 | (1.57) |
| Rice | -0.0018 | (-0.16) | -0.0696 | (-0.45) | 0.0737 | **(2.20)** |
| Chicken, frozen | 0.0414 | (1.58) | -0.0532 | (-0.41) | 0.1496 | **(2.19)** |
| Bacon | -0.0004 | (-0.02) | -0.2787 | (-1.89) | 0.0215 | (0.42) |
| Peas, frozen | -0.0083 | (-0.68) | 0.1651 | (1.04) | 0.0152 | (0.42) |
| Chocolate Bar | 0.0249 | (1.18) | 0.0781 | (0.42) | 0.0888 | (0.86) |
| Sugar | 0.0162 | (0.92) | 0.3454 | **(2.23)** | 0.1542 | **(2.10)** |
| Coffee, instant | -0.0038 | (-0.26) | 0.7808 | **(4.27)** | 0.1189 | (1.23) |
| Laundry Detergent | -0.0096 | (-0.61) | -0.0944 | (-0.37) | 0.1108 | (1.72) |
| Dish Detergent | -0.0109 | (-0.74) | 0.1100 | (0.90) | 0.0404 | (1.04) |
| Toothpaste | -0.0003 | (-0.04) | -0.1825 | (-0.79) | 0.0893 | (1.50) |
| Median | -0.0028 | (-0.21) | -0.0614 | (-0.39) | 0.0891 | (1.53) |
| | | | | | | |
| Group C | | | | | | |
| Paper tissues | 0.0051 | (0.58) | 0.0069 | (0.07) | 0.0251 | (1.06) |
| Petrol | -0.0094 | (-0.50) | 0.3137 | **(3.37)** | 0.0065 | (0.18) |
| Whisky, in pub | 0.0184 | (1.25) | 0.0911 | (0.32) | -0.0289 | (-0.74) |
| Petfood, canned | 0.0117 | (0.68) | -0.0086 | (-0.08) | 0.0882 | (1.38) |
| Peaches, canned | 0.0499 | (1.34) | 0.2519 | (1.29) | 0.0793 | (1.20) |
| Soap, bar | 0.1538 | **(2.50)** | -0.4147 | (-1.17) | 0.2648 | **(2.35)** |
| cheese, processed | 0.0356 | (1.27) | 0.4355 | **(2.12)** | 0.1077 | (1.36) |
| Median | 0.0184 | (1.25) | 0.0911 | (0.32) | 0.0793 | (1.20) |
| | | | | | | |
| Mean, all groups | 0.0157 | (0.12) | 0.1225 | (0.61) | 0.1097 | (1.47) |
| Median, all groups | 0.0022 | (0.11) | 0.0688 | (0.32) | 0.0793 | (1.35) |

**Table 13: Revised New Zealand price adjustment equations ($\delta$=0)**

| | Halflives for various commoditie<br>New Zealand | |
|---|---|---|
| Group A | HALFLIFE | Standard Error |
| | | |
| Rump Steak | 17.4158 | (26.63) |
| Corned Beef | 0.0000 | (0.00) |
| Lamb chops | 21.8478 | (25.64) |
| Pork chops | 0.0158 | (3.12) |
| Salmon, canned | 0.0000 | (0.00) |
| Oranges | 0.0000 | (0.00) |
| Bananas | 9.4060 | (9.39) |
| Potatoes | 0.3878 | (0.78) |
| Carrots | 1.3384 | (1.21) |
| Pineapple, canned | 16.5676 | (22.23) |
| Eggs | 7.7524 | (3.06) |
| Tomato sauce | 9.8599 | (8.69) |
| Margarine | 7.0315 | (5.93) |
| Butter | 8.4497 | (5.20) |
| Toilet Paper | 4.9719 | (2.43) |
| Median | 7.0315 | (3.12) |
| | | |
| Group B | | |
| Bread | 5.5836 | (3.70) |
| Flour | 11.2966 | (7.88) |
| Rice | 9.9337 | (4.78) |
| Chicken, frozen | 4.5969 | (2.51) |
| Bacon | 43.1825 | (105.93) |
| Peas, frozen | 33.4083 | (83.30) |
| Chocolate Bar | 6.5768 | (9.12) |
| Sugar | 1.6087 | (1.75) |
| Coffee, instant | 0.0000 | (0.00) |
| Laundry Detergent | 6.6678 | (4.86) |
| Dish Detergent | 13.9831 | (14.63) |
| Toothpaste | 9.1975 | (7.25) |
| Median | 7.9326 | (6.06) |
| | | |
| Group C | | |
| Paper tissues | 26.9752 | (26.22) |
| Petrol | 48.6794 | (278.92) |
| Whisky, in pub | 0.0000 | (0.00) |
| Petfood, canned | 7.5981 | (6.38) |
| Peaches, canned | 4.8777 | (5.72) |
| Soap, bar | 3.3813 | (2.01) |
| cheese, processed | 1.0645 | (3.62) |
| Median | 4.8777 | (5.72) |
| | | |
| Mean, all groups | 9.9617 | (19.22) |
| Median, all groups | 7.0315 | (5.20) |

**Table 14 : Halflives of various goods price adjustment mechanisms**

## APPENDIX 1: THE GOODS

The goods are classified into three groups according to the comparability between countries. The goods in Group A are the same in each country in all periods. The goods in Group B differ for at least part of the time in the two countries, but are otherwise the same good. The New Zealand price is multiplied by the appropriate ratio to convert it to the Australian price. The goods in Group C are most problematic. The two non-supermarket items, petrol and whisky sold in a pub are included in this list, as are facial tissues, soap and petfood as each of these goods had substantial size reclassifications in the period.

| Group A | Australia | New Zealand |
|---|---|---|
| Rump Steak | 1 kg | same |
| Corned Beef | 1 kg | |
| Lamb Chops, Forequarter | 1 kg | |
| Pork Chops, Loin | 1 kg | |
| Salmon, canned | 210 g can | |
| oranges | 1 kg | |
| bananas | 1 kg | |
| potatoes | 1 kg | |
| carrots | 1 kg | |
| pineapple, canned | 450g can | |
| Eggs | 1 dozen | |
| Tomato Sauce, canned | 600g can | |
| Margarine | 500g packet | |
| Butter | 500g packet | |
| Toilet paper | 4 rolls | |

| Group B | Australia | New Zealand |
|---|---|---|
| Bread | 680 g loaf | 750 g loaf <1994<br>680g loaf >1994,cheapest |
| Flour, white | 2kg | 1.5 kg < 1994<br>1.5 kg >1994, cheapest |
| Rice, white | 1 kg | 500g < 1994<br>1 kg > 1994 |
| Chicken, frozen | 1kg | No 6 - 1.5 kg |
| Bacon | 250 g | 1kg |
| Peaches, canned | 825g | 425 g |
| Peas, frozen | 500g | 1kg |
| Chocolate bar | 250g | 275 g < 1994<br>250 g > 1994 |
| Sugar | 2kg | 1.5kg |
| Coffee, instant | 150g jar | 100g packet |
| Detergent, laundry | 1kg | 1.1kg < 1994 |

| | | |
|---|---|---|
| | | 1kg > 1994 |
| Detergent, dishwashing | 1 litre | 990ml < 1994 |
| | | 900 ml > 1994 |
| Toothpaste | 140g tube | 100 g < 1988 |
| | | 110 g 1989-1993 |
| | | 140 g >1994 |

| **Group C** | **Australia** | **New Zealand** |
|---|---|---|
| Processed Cheese | 500g | 250g, sliced |
| Tissues, facial | pkt 224 | pkt 80 < 1988 |
| | | pkt 200 >1989 |
| Petrol | 1 litre | 10 litres |
| Whisky, in pub | 30 ml nip | 1 nip |
| Petfood | 410g | 410g < 1988 |
| | | 700g > 1989 |
| Soap, toilet | 2x125g bars | 1x150g bar < 1994 |
| | | 2x125g bar > 1994 |