# LONG-TERM PATTERNS IN AUSTRALIA'S TERMS OF TRADE

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## Abstract

We examine two important aspects of Australia's terms of trade using 135 years of annual data up to 2003/04. Since Australia predominantly exports commodities and imports manufactures, the Prebisch-Singer hypothesis suggests that there should be a negative trend in the terms of trade. But the trend is no more than $-0.1$ per cent per annum, less than the trend decline in world commodity prices relative to manufactured goods prices. The weaker trend appears to be the result of Australia exporting, and importantly diversifying toward, commodities with faster price growth. Extending the sample using projections for the terms of trade for the two years to 2005/06 based on commodity price movements to date, the apparent downward trend disappears. Indeed, based on these projections, the terms of trade will have increased by around 50 per cent over the period 1987–2006, unwinding the decline over the preceding 30 years.

We also investigate the volatility of the terms of trade and demonstrate that it was significantly higher between 1923 and 1952. This is attributable to substantially higher volatility in the export prices of a few key commodity exports. Volatility declined after 1952 due to smaller shocks to the prices of these goods. The diversification in Australia's export base since then means that the terms of trade are less susceptible to shocks to prices of individual commodity exports.



JEL Classification Numbers: E01, E30, F10

Keywords: terms of trade, commodity prices, Prebisch-Singer

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## 1. Introduction

The terms of trade are an important determinant of economic welfare since they govern the quantity of foreign goods that can be purchased with a given amount of domestic output.[1] Changes in this key relative price can have large dynamic consequences for macro variables – notably consumption, savings and investment.[2] Shocks to the terms of trade will also have substantial distributional implications within a country as relative incomes and prices change.

This paper considers two important properties of the Australian terms of trade using 135 years of data: its level and its volatility. Australia largely exports commodities and imports manufactured goods. Over the past century commodities have averaged over four-fifths of Australia's goods exports, while manufactures have constituted a similar proportion of Australia's imports. The Prebisch-Singer hypothesis, that commodity prices decline relative to manufactures prices, suggests that Australia will experience a long-run decline in its terms of trade. Indeed, over the past 135 years, the terms of trade for goods has declined 12 per cent, as seen in Figure 1. From the mid 1950s there was seemingly a stronger negative trend, at least until the mid 1980s. However, since then the terms of trade have improved quite substantially. Indeed, based on projections for the terms of trade using known commodity contract prices, the terms of trade

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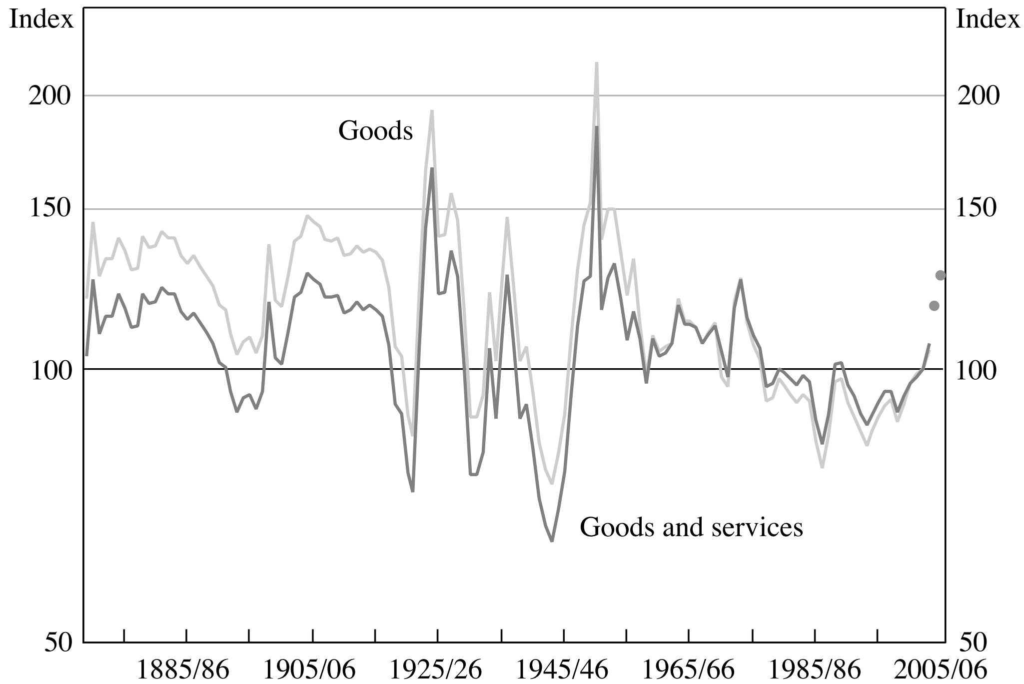
1 Though beyond the scope of this paper, trends in productivity are another important consideration for any welfare analysis. For example, a trend decline in the terms of trade may also be associated with stronger productivity growth in the export sector, which would have an offsetting welfare impact.

2 For example, the traditional Harberger-Laursen-Metzler effect states that domestic saving declines in response to a temporary negative terms of trade shock due to intertemporal consumption smoothing. But a more sustained shock may reduce investment and potentially increase saving in anticipation of lower future output, as Kent and Cashin (2003) demonstrate empirically.

are likely to have increased by around 50 per cent over the period 1987–2006, unwinding the decline over the preceding 30 years.

**Figure 1: Australia's Terms of Trade**
2002/03 = 100, log scale




Notes: The dots indicate projections for the goods and services terms of trade for 2004/05 and 2005/06. The construction of these is outlined in Appendix A.

The other notable aspect of the terms of trade is their changing volatility, as seen in Figure 1. From the end of World War I until the mid 1950s the terms of trade experienced many large shocks, frequently doubling or halving within a matter of years. Such abrupt relative price changes have the potential to cause severe economic dislocation. It is important to know why volatility was so much higher in this period and why it has declined. Understanding this can help us to consider whether a return to such volatility is likely.

The remainder of the paper is structured in two parts, considering first the level of the terms of trade, then changes in the volatility of the terms of trade. In the first part, Section 2, we test whether there is a trend in Australia's terms of trade and assess its magnitude. We then consider export and import developments separately, in particular their changing composition, and how these have influenced the terms of trade. In the second part, Section 3, we address the volatility of the terms of trade by testing whether it has changed in a significant way. To understand the changes we also separately consider the volatility of export and import prices. Because it has experienced greater change, we focus on the export price series and examine whether the main contributor to the return to low volatility in recent decades has been diversification or a decline in price shocks to individual commodities. Finally, Section 4 concludes.

## 2. Trends in the Terms of Trade

Prebisch (1950) and Singer (1950) suggested that countries that primarily export commodities, and import manufactures, had experienced declining terms of trade. Further, they could expect ongoing falls. Prebisch and Singer, and subsequent work, have proposed a range of theories to account for this phenomenon.

The most common theory is that the demand for raw commodities declines, at least proportionately, with ongoing economic development. This lower income elasticity of demand for commodities compared to other goods results in relative price falls as income rises. Another explanation notes that manufactured goods are differentiable, unlike homogenous commodities. As a result, producers of manufactured goods may have greater market power. Productivity increases will then lead to smaller relative price falls for manufactures than for commodities.[3] A less likely justification is that increases in the supply of commodities are met with larger price falls because the demand for commodities is less price elastic. Such an effect would have to be large enough to overcome presumably higher productivity growth in manufactures that is likely to lead to faster growth in production of manufactures than for commodities.

Prebisch and Singer's hypothesis reversed the view previously held by 19th century economists. The conventional wisdom had been that decreasing returns to scale in primary commodity production and constant or increasing returns to scale in the manufacturing sector, combined with population growth, would see relative commodity prices, that is the ratio of commodity prices to manufactures prices, increase over time.

Prebisch and Singer's early empirical work precipitated many studies questioning the validity and robustness of their findings. A frequently cited study is Grilli and Yang (1988). Using a commodity price index they constructed from 24 primary

3 The increasing commodification of some manufactured goods may act to counter this effect.

commodities they found a statistically significant fall of 0.6 per cent annually in non-oil commodity prices relative to manufactured goods prices over the period 1900–1986 (hereafter this series is referred to as relative commodity prices). The vast literature testing the Prebisch-Singer hypothesis has produced many conflicting results due to differences in methodology, even though much of it relies on the Grilli-Yang data. For example, Cuddington, Ludema and Jayasuriya (2002) suggest that relative commodity prices experienced a one-time downward jump in 1921, rather than having an ongoing negative trend.

Despite the methodological differences, work to date broadly supports the Prebisch-Singer hypothesis. For example, Lutz (1999) argues that the univariate trend model estimated by Grilli and Yang (1988) is inappropriate because commodity and manufactures prices are cointegrated. Nonetheless, Lutz finds a statistically significant long-run decline in real commodity prices of 0.9 per cent per annum. More recently, Cashin and McDermott (2002) found a larger 1.3 per cent annual decline in the relative price of commodities using a different data source, the *Economist* commodity price index. In this longer sample, 1862−1999, they found no evidence of a break in the trend.

There is some evidence that declining relative commodity prices have resulted in a negative trend in Australia's terms of trade. A common, and reasonable, assumption is that a small economy such as Australia takes world prices, and so its terms of trade, as given. Sapsford (1990) finds that there was a significant downward trend from 1951 to 1987, even though there was no trend in the first half of the century. Gruen and Kortian (1996) also find a negative trend in the Australian terms of trade.

In this study we use two measures of Australia's terms of trade on an annual basis. The *goods and services* terms of trade incorporates the prices of all exports and imports. We also consider the *goods* terms of trade, for which the Prebisch-Singer hypothesis will be more relevant and is not subject to the difficulties in the measurement of service prices. This series is more consistent over time since terms of trade data before 1949 do not include the, admittedly small, trade in services. Throughout we use the terms of trade in logs, as the change in the logged series between two periods measures the proportionate change in the terms of trade. Descriptions of all data and their sources are given in Appendix A.

Before assessing whether there is a trend in Australia's terms of trade we briefly examine the stationarity of these series. Knowing the degree of integration is important for choosing appropriate econometric techniques to test for a trend. But a finding of a unit root in the terms of trade would be of interest in itself, indicating that shocks to the terms of trade are permanent, and so that export and import prices are not cointegrated.

Table 1 reports results from two common unit root tests. The sample is split in 1955 because the substantial diversification of Australia's exports from this date, as documented in Section 2.1.1, may have changed the behaviour of export prices and so the terms of trade.

**Table 1: Unit Root Tests**

| | **Intercept** | | **Intercept and trend** | |
|---|---|---|---|---|
| | ERS | KPSS | ERS | KPSS |
| **Log goods terms of trade** | | | | |
| 1870–2004 | *** | *** | *** | – |
| 1870–1954 | *** | – | ** | – |
| 1955–2004 | – | *** | – | * |
| **Log goods and services terms of trade** | | | | |
| 1870–2004 | *** | * | *** | – |
| 1870–1954 | *** | – | ** | – |
| 1955–2004 | – | *** | – | – |

Notes: ERS denotes the Elliot, Rottenberg and Stock (1996) unit root test, for which the null hypothesis is that the series contains a unit root. KPSS denotes the Kwiatkowski *et al* (1992) test for which the null hypothesis is stationarity. The Newey-West lag selection criteria was used for the KPSS test and the Bayes information criteria was used to select the number of lags for the ERS test. ***,** and * denote rejection of the null hypothesis at the 1, 5 and 10 per cent levels of significance respectively.

These results suggest that both the goods, and goods and services, terms of trade are stationary series, at least around a trend. The tests cannot reject that the terms of trade contain a unit root after 1955, but this is possibly due to the small sample size.

As a first test it is illustrative to fit a simple linear time trend, $t$, to the natural logarithm of the terms of trade, $tot_t$, as in Equation (1):

$$tot_t = \alpha + \beta t + \varepsilon_t \qquad (1)$$

These results, reported in Table 2, indicate that there has been a statistically significant negative trend in Australia's terms of trade. Over the full sample there has been a −0.3 per cent trend in the goods terms of trade, and a smaller −0.1 per cent trend in the goods and services terms of trade.

**Table 2: Trend in the Terms of Trade**

$$tot_t = \alpha + \beta t + \varepsilon_t$$

| | **Goods** | | |
|---|---|---|---|
| | 1870–2004 | 1870–1954 | 1955–2004 |
| $\alpha$ | 4.936*** | 4.886*** | 4.761*** |
| | (0.035) | (0.046) | (0.035) |
| $\beta$ | −0.003*** | −0.002 | −0.006*** |
| | (0.000) | (0.002) | (0.001) |
| Q(1) | 78.71*** | 49.04*** | 17.79*** |
| Q(5) | 130.51*** | 79.87*** | 20.45*** |
| Arch-LM | 21.73*** | 13.01*** | 6.47** |
| | **Goods and services** | | |
| | 1870–2004 | 1870–1954 | 1955–2004 |
| $\alpha$ | 4.734*** | 4.744*** | 4.725*** |
| | (0.033) | (0.045) | (0.025) |
| $\beta$ | −0.001*** | −0.002 | −0.004*** |
| | (0.000) | (0.002) | (0.001) |
| Q(1) | 76.38*** | 47.46*** | 15.99*** |
| Q(5) | 125.47*** | 77.36*** | 17.98*** |
| Arch-LM | 28.56*** | 11.33*** | 6.07*** |

Notes: ***,** and * denote rejection of the null hypothesis at the 1, 5 and 10 per cent levels of significance respectively. Figures in parentheses are Newey-West robust standard errors. Q(1) and Q(5) are Ljung-Box statistics for autocorrelation at 1 and 5 lags respectively. The null hypothesis is that the series contain no autocorrelation. Arch-LM is the Lagrange multiplier test for autoregressive conditional heteroskedasticity at 1-lag, with the null hypothesis of no heteroskedasticity.

However, the full sample results mask a story of two parts. We split the sample in 1955 based on graphical observation, previous work and evidence that the structure of trade changed after this date, as detailed in Section 2.1.1. After 1955 the trend is larger than over the full sample, −0.6 per cent for the goods terms of trade and −0.4 per cent for the goods and services terms of trade. Before 1955 the trend is statistically insignificant for both series. While these results indicate the negative trend has been lessened by the inclusion of services trade, the difference in the size of the trend is heavily influenced by data in just two years, 1958 and

1959. The significant negative coefficient lends support to the theory that declining relative commodity prices impart a negative trend in Australia's terms of trade, though the magnitude is less than that found for relative commodity prices.

However, the Ljung-Box statistics reported for the regressions in Table 2 indicate significant autocorrelation in the residuals of Equation (1), resulting from some persistence of the terms of trade. We can account for the residual autocorrelation by adding a lagged dependent variable to our trend regressions, as shown in Equation (2).

$$tot_t = \alpha + \beta t + \rho(tot_{t-1}) + \varepsilon_t \qquad (2)$$

Lutz (1999) argued that Equation (2) does not properly account for cointegration between import and export prices because it assumes that they are cointegrated with a long-run elasticity of unity. However, our finding of stationarity for the terms of trade suggests it is an appropriate specification. Table 3 reports the results of this regression.

The lagged dependent variable is highly significant in all samples. In each regression, its inclusion reduces the coefficient on the trend by around two-thirds. Over the full sample, there is still stronger evidence of a trend in the goods terms of trade, though even in this series it is just $-0.1$ per cent per annum. This coefficient roughly accords with the observed 12 per cent decline over the past 135 years. If we extend our sample to include two years of the projections for the goods and services terms of trade the trend is insignificantly different from zero. The trend is economically and statistically insignificant over the first part of the sample for both series. After 1955 it appears slightly stronger. However, we cannot reject that the trend has the same coefficient in the two sub-periods.

As noted earlier, we have some priors that the behaviour of the terms of trade may have changed after 1955, but this may not be the appropriate timing. To account for this we use a test that endogenises the selection of the breakpoint by searching over all possible breakpoints. The *Sup(t)* test, described in Cashin and McDermott (2002), uses standard *t* statistics for the null hypothesis that there has been no change in the growth rates. But the critical values for this test are increased to account for the greater chance of erroneously finding a break when searching over multiple possible breakpoints. While there are episodes when the trend in the terms of trade appears to have changed, over the full sample the

**Table 3: Trend in the Terms of Trade: Allowing for Persistence**

$$tot_t = \alpha + \beta t + \rho(tot_{t-1}) + \varepsilon_t$$

| | **Goods** | | |
|---|---|---|---|
| | 1870−2004 | 1870−1954 | 1955−2004 |
| $\alpha$ | 1.197*** | 1.152*** | 1.629*** |
| | (0.288) | (0.381) | (0.495) |
| $\beta$ | −0.001*** | −0.000 | −0.001 |
| | (0.000) | (0.001) | (0.001) |
| $\rho$ | 0.758*** | 0.764*** | 0.653*** |
| | (0.058) | (0.078) | (0.102) |
| Q(1) | 2.43 | 1.44 | 1.19 |
| Q(5) | 7.55 | 3.07 | 5.47 |
| Arch-LM | 26.90*** | 16.77*** | 1.39 |
| $\rho$-MU | 0.796 | 0.828 | 0.752 |
| | [0.908] | [1.000] | [1.000] |
| Half-life | 3.03 | 3.68 | 2.43 |
| | [1.88, 7.21] | [1.88, $\infty$] | [1.14, $\infty$] |
| | **Goods and services** | | |
| | 1870−2004 | 1870−1954 | 1955−2004 |
| $\alpha$ | 1.202*** | 1.168*** | 1.837*** |
| | (0.358) | (0.379) | (0.497) |
| $\beta$ | −0.000* | −0.000 | −0.001 |
| | (0.000) | (0.001) | (0.001) |
| $\rho$ | 0.746*** | 0.754*** | 0.608*** |
| | (0.074) | (0.080) | (0.104) |
| Q(1) | 1.71 | 1.04 | 1.45 |
| Q(5) | 6.25 | 2.59 | 4.78 |
| Arch-LM | 28.24*** | 15.31*** | 3.41* |
| $\rho$-MU | 0.784 | 0.817 | 0.700 |
| | [0.897] | [1.000] | [1.000] |
| Half-life | 2.84 | 3.43 | 1.95 |
| | [1.78, 6.40] | [1.79, $\infty$] | [0.96, $\infty$] |

Notes: ***,** and * denote rejection of the null hypothesis at the 1, 5 and 10 per cent levels of significance respectively. Figures in parentheses are Newey-West robust standard errors. Q(1) and Q(5) are Ljung-Box statistics for autocorrelation at 1 and 5 lags respectively. Arch-LM is the Lagrange multiplier test for autoregressive conditional heteroskedasticity at 1-lag. $\rho$-MU is the Andrews (1993) median unbiased estimate of $\rho$, figures in brackets below represent a 95 per cent significance upper bound on $\rho$. The numbers in brackets beneath the half-life represent a 90 per cent confidence interval for the half-life of a shock to the terms of trade.

*Sup(t)* test is not able to find evidence of a statistically significant break.[4] However, the *Sup(t)* test only allows one break. To allow for the possibility that a single break was not found because multiple breaks exist, the Bai and Perron (1998, 2003) test was also applied. The Bai and Perron test gave inconsistent results, but overall was not supportive of a break in the trend, especially so after allowing for persistence. The results of these tests are available from the authors.

While a casual observation suggests the trend decline in the terms of trade may have accelerated in the second half of the century, at least before projected rises are included, statistical tests do not support this conclusion. Overall, these results indicate that there is at most a weak negative deterministic trend.

The statistically significant coefficients on the lagged terms of trade indicate that the terms of trade is relatively persistent. But these coefficients are downward biased because they are on the lagged dependent variable. To get a more accurate estimate of the persistence we also report the median unbiased estimates of the lag term, $\rho$-MU, based on Andrews (1993), which corrects for this bias. These results are shown in Table 3. Note that the downward bias in $\rho$ is greater in the smaller samples. The half-lives of a shock to the terms of trade as determined by $\rho$-MU are shown in the last row of Table 3, together with 90 per cent confidence intervals. Shocks to the terms of trade are found to be transitory, consistent with the finding of stationarity. Over the full sample, half of a shock is found to dissipate within around three years, though in the second half of the century point estimates suggest that shocks were less persistent with half-lives of around two years. Interestingly, these results indicate less persistence than typically found for individual commodities (see for example Cashin, Liang and McDermott 2000).

## 2.1 Decomposing the Level of the Terms of Trade

After accounting for the persistence of shocks, the negative trend in the terms of trade is found to be very small. This is perhaps surprising given the composition of Australia's trade and the stylised fact of falling relative commodity prices. In this section we investigate why the trend in the terms of trade has not been greater. We focus on goods imports and exports since these prices relate more directly to

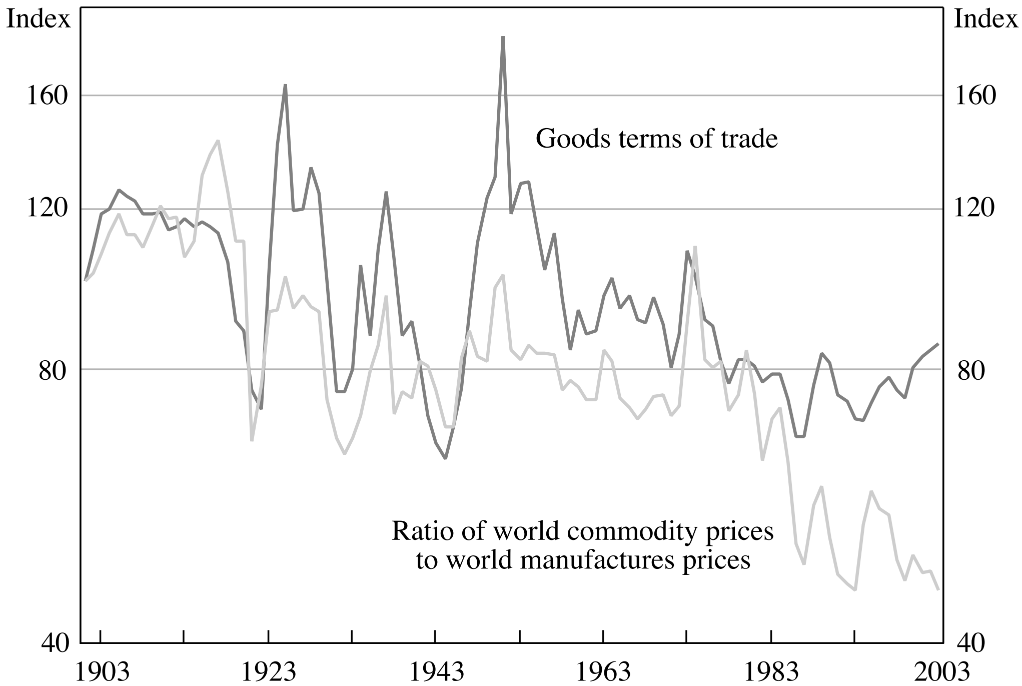
4 The test is sensitive at endpoints, which were excluded. The period examined for breaks was 1891–1984.

the Prebisch-Singer hypothesis and the trend including services is only marginally different.

Figure 2 plots Australia's goods terms of trade together with relative commodity prices, the ratio of world commodity prices to world manufactures prices. This series is an extension of the Grilli-Yang data that are available from 1900 and have been used to highlight the Prebisch-Singer effect.

**Figure 2: Relative Commodity Prices and Australia's Terms of Trade**

1901 = 100, log scale

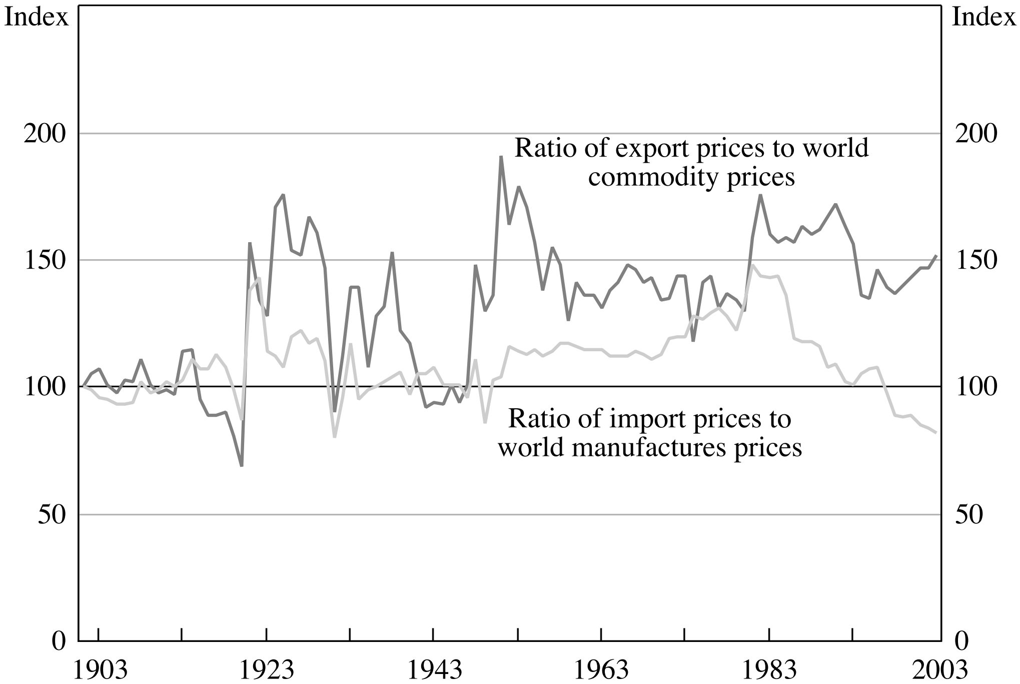



The Australian terms of trade clearly experienced larger swings in the middle part of the 20$^{th}$ century than did the relative commodity prices. This relates to large price movements for specific commodities that represented a large portion of Australia's exports, such as the spikes in wool and metals prices in 1951 due to the Korean war. Despite these differing cycles, over the first three-quarters of the century the total change in the two series were remarkably similar. However, since the mid 1970s real commodity prices have fallen at a much faster rate than Australia's terms of trade.

To better understand the factors influencing the level of the terms of trade we consider import and export prices individually. Figure 3 shows the ratio of export prices to the Grilli-Yang commodity price index and the ratio of import prices to the world manufactures series (the ratios of the two numerators and of the two denominators from the series in Figure 2). These comparisons are meaningful because the majority of Australia's exports are commodities, while imports are mostly manufactures.

**Figure 3: Relative Import and Export Prices**

1901 = 100




The ratio of Australian import prices to world manufactures prices has been remarkably constant for most of the past century. This is not so surprising given the high proportion of manufactures in Australia's import basket. But after a pick-up in this ratio in the 1970s, in part due to higher oil prices, Australia's import prices have been falling relative to world manufactures prices.

The large swings in the ratio of Australian export prices to world commodity prices clouds an interpretation of trends. Nevertheless, it appears to have increased over the course of the century. This has supported the level of the terms of trade and accounts for the smaller trend in Australia's terms of trade than in the Grilli-Yang relative commodity price series.

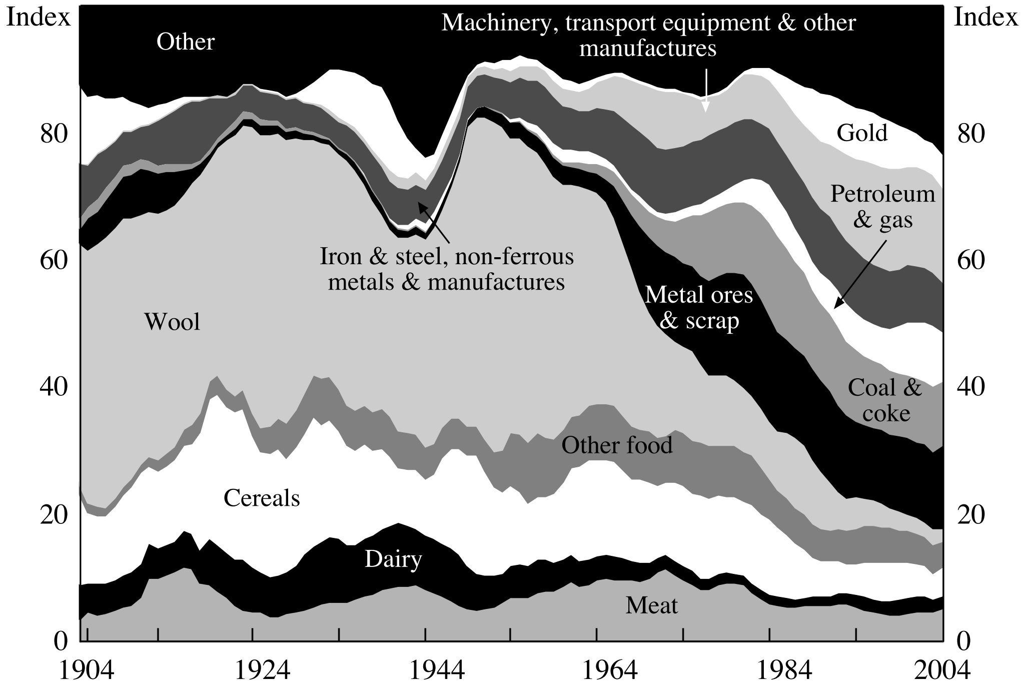
### *2.1.1 Export price developments*

In this section we explore reasons why Australia's export price series appears to have risen relative to world commodity prices.

Protopapadakis and Stoll (1986, p 350) suggest that the law of one price 'is a usable approximation of the behavior of commodity prices for macroeconomic purposes' in the long run. Given that the majority of Australian exports have been commodities, this implies that differences between the Australian export prices and world commodity prices must be due to compositional differences rather than different prices for identical commodities.[5] Related to this, Australia's exports have become significantly more diversified, both within commodity classes and into manufactures, over the past four decades. Figure 4 shows the value shares of Australia's goods exports over the past century for some major export classes.

**Figure 4: Australia's Goods Export Composition**

Share of total




Note: Data are 5-year moving averages

5 Our own examination of comparable Australian and international commodity prices suggested there were important deviations in price growth over periods of up to 10 years, but that over the long run, price growth was equivalent.

Clearly there have been some striking changes in Australia’s export composition. Since the 1950s, wool’s share of exports has been in sharp decline. Around its peak, wool averaged 39 per cent of goods exports in the period 1941–1951 but by 1994–2004 it was only 3 per cent of goods exports. The falling share of wool exports is largely explained by the slow growth in the volume of wool exports relative to other exports. Over this 50 year period, total goods export volumes increased over 15-fold, but wool export volumes less than doubled. The decline is also explained by the collapse in the price of wool following its peak in 1951 during the Korean War. Only during the late 1980s boom did wool regain its 1951 nominal price. In contrast over this period the nominal world commodity price index rose almost three-fold.

The sharp decline in the share of wool in exports through the 1960s marked the beginning of a dramatic change in the composition of Australian exports. Other primary rural commodities that had been the mainstay of Australian exports – meat, dairy, cereals and other food – also declined in share. Their place was taken by the rapid expansion of mineral commodity exports, notably coal & coke, and metal ores & scrap. In recent decades, manufactures have also become an increasingly important component of Australia’s exports.

Smith (1987) suggests that the rapid increase in Australia’s mineral exports beginning in the 1960s was a result of demand from Japan rather than increases in world mineral prices. Despite the low extraction costs of minerals in Australia, transport costs were sufficiently high to prevent the development of a viable export market for some commodities before the economic development of the Japanese economy. As evidence of this, Smith (1987) notes that Australia’s traditional mineral exports had been high value-to-bulk commodities such as copper, lead and zinc. Japan’s prominence in Australia’s commodity exports at the time is illustrated by the fact that by 1969/70 Japan imported 65 per cent of Australia’s metal ores, coal, gas and petroleum exports.[6]

The diversification of Australia’s export base may have changed the growth rate of Australia’s export price series and explain export prices outperforming world commodity prices. However, this does not appear to have been the case, at least from 1904–1975. Over this period the *rural* subcomponent of exports

6 There were restrictions on the export of iron ore and magnesium from 1939–1960, however, Smith (1987) suggests their removal was not a dominant factor in the mineral boom.

recorded only slightly slower price growth than the all goods price index, 3.38 per cent per annum versus 3.45 per cent.[7] And even the broader sub-index of commodities, *rural, metals, coal and gold,* experienced faster price growth than world commodity prices: 3.45 per cent versus 2.94 per cent. (These, and all prices hereafter, are in Australian dollars.)

The availability of disaggregated price data allow a more detailed examination of relative price performance for the period after 1975. Diversification into mineral exports began in the 1960s but it was not until the mid 1970s that these commodities materially contributed to faster growth in the prices of Australian exports. The first two columns in the top panel in Table 4 show that this diversification added about 0.4 per cent per annum to the rate of growth of export prices over the period 1975–2004. Diversification beyond this narrow grouping of *rural goods, metals, coal and gold* to other commodities resulted in slightly faster growth, as seen by comparing the second and third columns. While they are only a small share of exports, petroleum products and natural & manufactured gasses have made a material contribution to the faster growth from diversification (columns three versus four).

Diversification into manufactured exports actually reduced aggregate export price growth over this period (column four in the top panel versus column five in the bottom panel). Indeed, over the full 28 years none of the sub-components of manufactures exports have outperformed total goods exports. More recently, over the period 1990–2004, commodity export prices have risen somewhat less rapidly than world commodity prices, but the growth in total export prices has been dragged further down by manufactures exports.

In summary, the diversification of Australia's export base into goods with faster price growth than traditional rural commodities has substantially boosted the growth of export prices. This began with diversification into mineral exports in the 1960s and has continued with diversification into a broader set of commodities. At least since 1975, on average the broadening of exports into manufactures exports has not increased export price growth.

[7] The rural subcomponent includes cereals, dairy, dried & canned fruit, hides & tallow, meat, sugar and wool.

**Table 4: Component Export Price Series**
Average yearly percentage growth

| | Commodities | | | | Memo item: |
|---|---|---|---|---|---|
| | Rural | Rural, metals, coal & gold | All commodities excluding petroleum & gas | All commodities | world commodity prices |
| 1975–2004 | 3.0 | 3.4 | 3.5 | 3.7 | 3.2 |
| 1975–1990 | 6.4 | 7.1 | 7.3 | 7.2 | 5.6 |
| 1990–2004 | –0.6 | –0.5 | –0.4 | 0.2 | 0.8 |
| | **Manufactures** | | | | **All goods** |
| | Chemicals | Machinery & transport equipment | Other manufactures | All manufactures | |
| 1975–2004 | 3.4 | 3.0 | 3.0 | 3.0 | 3.6 |
| 1975–1990 | 7.4 | 7.6 | 6.3 | 6.8 | 7.2 |
| 1990–2004 | –0.7 | –1.7 | –0.3 | –1.0 | –0.2 |

Notes: Rural refers to cereals, dairy, dried & canned fruit, hides & tallow, meat, sugar and wool. The all goods series shown is a reconstructed series rather than the actual series to maintain consistency with the derived series for the subsets of goods. The correlation with the actual series is 99 per cent. Due to a series break, some goods from Statistical International Trade Classification (SITC) category 63 are included in category 24, and some goods from category 51 are included in category 28 from 1974/75 to 1977/78.

### *2.1.2 Import price developments*

In this section we examine the fall in Australia's import prices relative to world manufactures prices since the mid 1980s.[8] The difference in the growth of these series is presumably attributable to compositional differences between the goods Australia imports and the world manufactures price index, again because Australia is likely to be a price taker for these goods on world markets.

Since 1985/86, around the time the downward trend in import prices relative to world manufactures prices became apparent, Australia's import prices of

8 Differences in index construction methodology may account for some of the difference. The Australian goods import price series is a Paasche price index whereas the world manufactures price index is a periodically re-based fixed-weight index. This means that the Australian import price series is downward biased while the world manufactures series is upward biased. It is unlikely that these methodological differences could account for more than a small part of the difference between the series.

elaborately transformed manufactures (ETMs) have grown at a rate close to that of total import prices, −0.7 per cent versus −0.3 per cent. Also, ETMs accounted for 84 per cent of Australia's imports on average over this period. Hence, differential price growth for non-manufactures cannot explain the difference between the growth in prices of goods imported by Australia and world manufactures prices.

Over the period 1985/86 to 2003/04 there has been little change at the 2-digit SITC level of disaggregation in the type of manufactures imported by Australia. In contrast, the source of imports now differs substantially from those used to construct the world manufactures price index, which is based only on industrialised country manufactures. An increasing proportion of Australia's imports come from non-industrialised countries, notably China and the ASEAN countries (Figure 5). The share of imports from non-Japan Asia has increased for all major classes of manufactured goods (Figure 6). This suggests that Australia's import prices have risen at a slower rate than world manufactures prices because of the substitution to cheaper imports sourced from Asia.

**Figure 5: Source of Australian Imports**

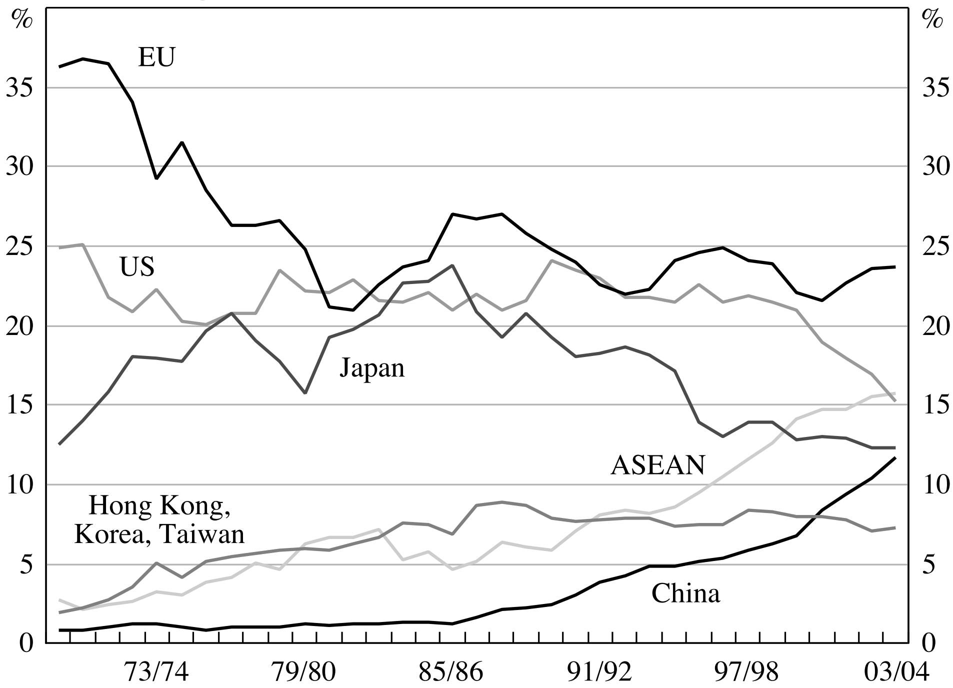
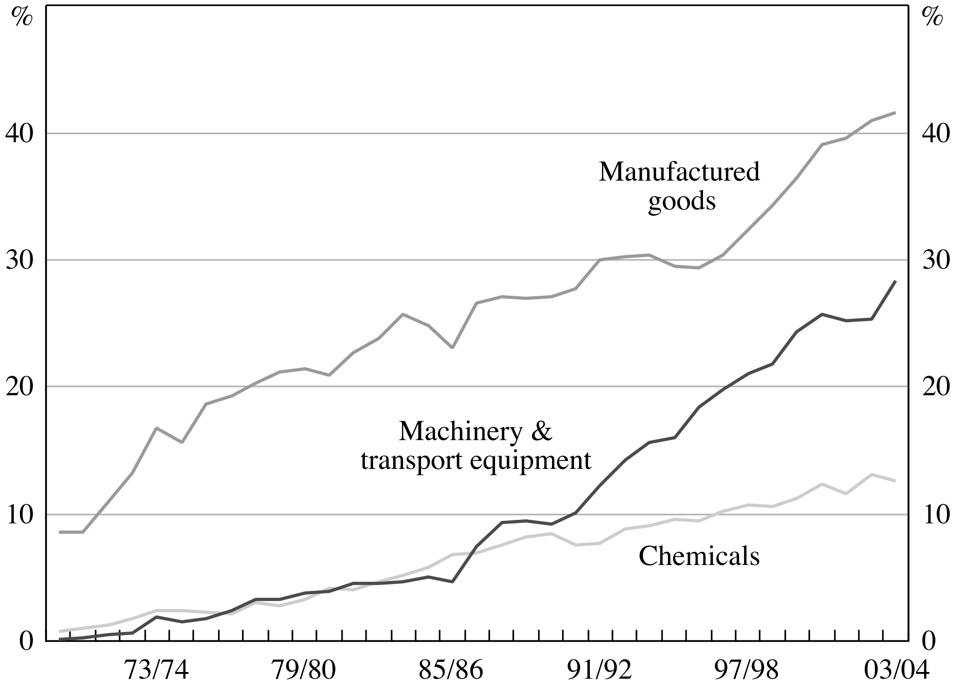


**Figure 6: Manufactures Imports from Non-Japan Asia**

Share of total




Note: Non-Japan Asia refers to the Association of South East Asian Nations (ASEAN), plus China, Hong Hong, Korea and Taiwan.

## 3. Terms of Trade Volatility

The Australian terms of trade have had many episodes of exceptionally high volatility, as seen in Figure 1. Notably, as Table 5 summarises, dividing the sample into thirds, volatility was substantially higher in the middle portion of the sample.[9] The standard deviation and proportion of volatile years in the most recent third of the sample have been remarkably similar to the first third. The middle part of the sample stands out for its higher volatility.

Abstracting from a sustained decline throughout the 1890s and sharp reversal around the turn of the century, the terms of trade were quite stable from 1870 until World War I. Following World War I the terms of trade were subject to many sharp swings, frequently doubling or halving within the space of just a few years. They declined rapidly after the war, only to more than double in three years with the 1920s boom. This was short lived, with the terms of trade halving leading into the

9 The pattern of goods terms of trade volatility in Table 5 is virtually identical for the broader goods and services terms of trade.

Great Depression. Indeed, many authors, including Valentine (1987), have stressed the role of falling commodity prices, and so export earnings, in transmitting the Great Depression to Australia. Another large upward spike preceding World War II was followed by the terms of trade almost tripling over the period 1944–1951. This rapid growth was due to an increase in the price of wool exports resulting from the Korean War. The impact of shocks to individual commodities was all the greater because exports were highly concentrated in just a few goods. During the post-World War II episode, wool made up over 50 per cent of Australia's goods exports by value. While there have been more recent cyclical swings, notably the spike induced by the mineral price boom in the early 1970s and the OPEC oil price shock, the volatility of the goods terms of trade has declined sharply over recent decades, as seen in Table 5.

**Table 5: Volatility of the Goods Terms of Trade**

| | Proportion of volatile years[(a)] (per cent) | Standard deviation[(b)] |
|---|---|---|
| 1870–1914 | 9 | 0.10 |
| 1915–1959 | 56 | 0.24 |
| 1960–2004 | 11 | 0.11 |

Notes: (a) Proportion of years with changes in the log goods terms of trade that are in the top quartile of changes from the full sample period, 1870–2004.
(b) Standard deviation of logged terms of trade.

A likely reason for the reduction in terms of trade volatility in recent decades is the diversification of Australia's export base. If the prices of goods exported are not perfectly correlated, then a broader export base may lead to lower price volatility. Even if the range of goods exported does not change, so long as exports become less concentrated in just a few of those goods, volatility can decline. The volatility of the terms of trade could also have been reduced by diversification into manufactures and services trade, which will have reduced the compositional difference between Australia's import and export baskets. Note that export composition was broadly stable during the first half of the 20$^{th}$ century, so changing composition cannot account for the increase in volatility during the inter-war years.

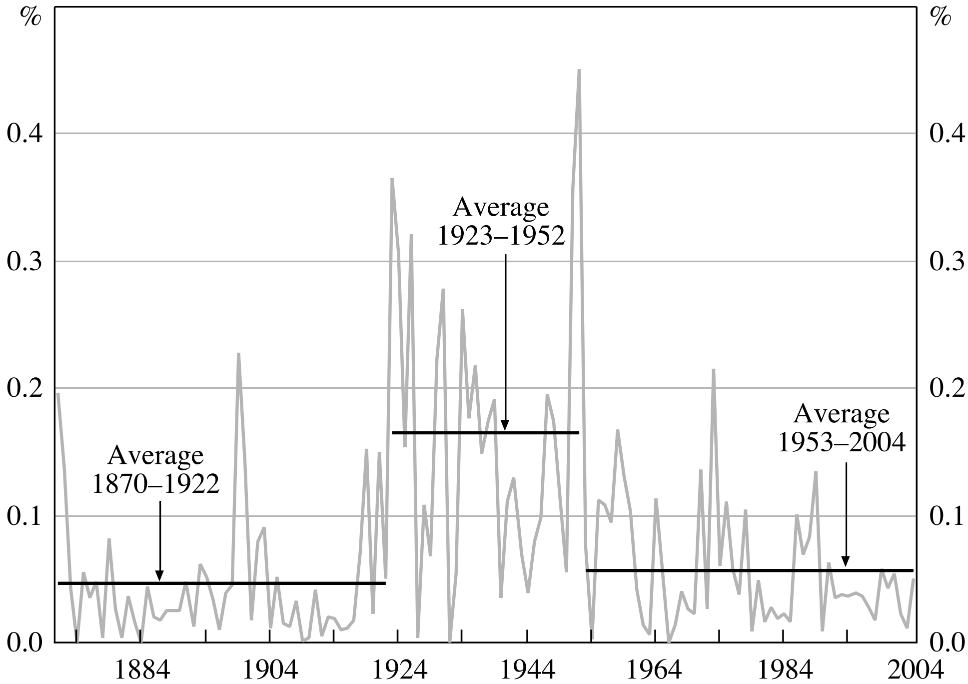
Changes in the volatility of Australia's terms of trade may also have been driven by volatility of global commodity prices. This in turn may have been influenced by changes in global exchange rate regimes. Cashin and McDermott (2002) and Cuddington and Liang (1998) find that real commodity prices have been more volatile during floating exchange rate periods. The fixed exchange rate regimes prior to World War I and post-World War II may have been associated with the less volatile terms of trade during these periods. The flexible exchange rates in the inter-war years may then be associated with a more variable terms of trade. But this observation does not accord with the slightly more stable terms of trade in the era of flexible exchange rates, whether measured from the float of the Australian dollar in 1983 or the end of Bretton Woods in 1972. For example, the standard deviation of the log terms of trade from 1960–1983 was 0.089 but thereafter has been only 0.074. Alternatively, high commodity price volatility in the inter-war years (and the breakdown of fixed exchange rate regimes) may have been due to geopolitical instability.

To test whether there have been statistically significant breaks in the volatility of Australia's terms of trade we use the Bai and Perron (1998) test, which endogenises the selection of multiple breakpoints. We measure volatility as the absolute value of annual changes in the log terms of trade, and look for breaks in the mean of this series (Figure 7). We use absolute changes, as do Ahmed, Levin and Wilson (2002), rather than squared changes because the latter magnifies the amplitude of large changes and so is presentationally more cumbersome. The test results using squared annual changes in the log terms of trade lead to the same conclusions. Table 6 reports the results of this test over the 1870–2004 sample.

The sequential test fails to find a break for both terms of trade series but this is most likely because the test cannot reject zero breaks against one break. The double maximum tests clearly reject zero breaks against an unspecified number of breaks for both series. After allowing for one break, the SupF tests reject one break in favour of two, but not two in favour of three at the 5 per cent significance level. In addition, the two information criteria tests indicate two breaks. Together these results strongly suggest that there are two breaks in the volatility of the terms of trade. Conditional on there being two breaks, the Bai and Perron test selects 1923 and 1953 as the most likely break dates.

**Figure 7: Goods Terms of Trade Volatility**

Absolute difference of log terms of trade




The volatility of the terms of trade was significantly higher over the period 1923−1952 than before or after these years, as shown in Figure 7. This episode of increased terms of trade volatility is coincident with the inter-war period of flexible exchange regimes. The end of World War II and subsequent establishment of the Bretton Woods fixed exchange regime in 1946 may have been important factors in locating the subsequent fall in terms of trade volatility. The sharp increase in wool prices between 1946 and 1951, when it was 44 per cent of goods exports, may account for not finding a break in Australia's terms of trade at the time Bretton Woods commenced. As mentioned, diversification of Australia's export base may have contributed to the post-World War II fall in terms of trade volatility. While the broadening of the export base was relatively rapid, it did take a number of years and so this explanation may be less able to tie down a particular breakpoint.

**Table 6: Volatility Break in the Terms of Trade**
Test for breaks in mean of absolute log difference

| Double maximum tests | Information criteria | SupF tests | Sequential test | Break dates |
|---|---|---|---|---|
| | | **Goods terms of trade** | | |
| UDMax | BIC | SupF(2\|1) | 0 breaks | 1923 |
| 20.77*** | 2 breaks | 23.04*** | | 1953 |
| WDMax | LWZ | SupF(3\|2) | | |
| 27.27*** | 2 breaks | 5.07 | | |
| | | **Goods and services terms of trade** | | |
| UDMax | BIC | SupF(2\|1) | 0 breaks | 1923 |
| 21.44*** | 2 breaks | 26.14*** | | 1953 |
| WDMax | LWZ | SupF(3\|2) | | |
| 28.15*** | 2 breaks | 4.39 | | |

Notes: The double maximum tests are tests for an unspecified number of breaks against the null of zero breaks. Both the WDMax and UDMax test statistics evaluate an F-statistic for 1–5 breaks, with the breakpoints selected by global minimisation of the sum of squared residuals. The UDMax statistic weights the five F-statistics equally, while the WDMax statistic weights the F-statistics such that the marginal p-values are equal across the number of breaks. The WDMax test statistic reported is for a 1 per cent significance level test. The LWZ statistic is a modified Schwarz criterion. The SupF(i+1|i) test is a test for *i*+1 breaks against the null of *i* breaks. The sequential test selects the number of breaks stepwise from zero breaks using the SupF test. The break dates are those identified by minimising the sum of squared errors conditional on the number of breaks found. ***, ** and * represent significance at the 1, 5 and 10 per cent levels of significance respectively.

## 3.1 Decomposing Volatility

To better understand the changes in its volatility, we decompose the variance of the terms of trade into the variance and covariance of its components. The log of the terms of trade, $tot$, is rearranged to express it as the difference between detrended log export and import prices, as shown in Equation (3),

$$\begin{aligned} tot &= p_t^X - p_t^M \\ &= (p_t^X - d_t) - (p_t^M - d_t) \end{aligned} \tag{3}$$

where $p_t^X$ and $p_t^M$, are the logged export and import price series at time $t$ and $d_t$ is a common HP filter used to detrend the prices. Detrending avoids overstating the variability due to a common trend in the two series, notably inflation.[10]

The volatility of the terms of trade is decomposed as in Equation (4).

$$\begin{aligned} var(tot) = var(p_t^X - d_t) + var(p_t^M - d_t) \\ - 2cov(p_t^X - d_t, p_t^M - d_t) \end{aligned} \tag{4}$$

The sample is split in 1923 and 1953, the break dates selected by the Bai and Perron test. Table 7 reports these results in two parts, to highlight the increase and subsequent decrease in terms of trade volatility. For brevity, we only report results for the goods terms of trade as the results are similar to those for the goods and services series.

**Table 7: Decomposition of Terms of Trade Variance**

Goods terms of trade variance

| | Export component | Import component | −2× covariance component | Terms of trade variance |
|---|---|---|---|---|
| | | **Increase in volatility** | | |
| 1870−1922 | 0.008 | 0.010 | −0.003 | 0.015 |
| 1923−1952 | 0.050 | 0.007 | 0.016 | 0.072 |
| Per cent increase | 538 | −36 | −594 | 378 |
| Contribution to increase | 73 | −7 | 33 | – |
| | | **Decrease in volatility** | | |
| 1923−1952 | 0.050 | 0.007 | 0.016 | 0.072 |
| 1953−2004 | 0.008 | 0.007 | 0.005 | 0.021 |
| Per cent decrease | 84 | −5 | 66 | 71 |
| Contribution to decrease | 80 | −1 | 20 | – |

Note: All series are in logs.

The volatility of the goods terms of trade was almost five times higher over the period 1923−1952 than 1870−1922, and more than three times higher than from 1953−2004. The rise and subsequent fall in export price volatility is almost entirely responsible for this development. In fact, import price variance

[10] $\lambda = 100$ was used as the smoothing parameter as is standard for annual data, though results are generally robust to the use of a range of lambda values greater than 100. Using the Australian GDP deflator instead of an HP filter trend gives qualitatively similar results.

was 36 per cent lower in the middle period and almost unchanged in the post 1953 sample. The covariance of detrended export and import prices was lower from 1923–1952 than 1870–1922, contributing to an increase in terms of trade volatility. From 1923–1952 and 1953–2004 the results indicate a negative correlation between import and export prices, but these correlations are sensitive to the detrending series used.

### 3.2 Changes in Export Price Volatility

Since export prices made the largest contribution to the rise and subsequent fall in terms of trade volatility, we consider their role in greater detail. As documented in Section 2.1.1, there was little change in Australia's export composition until the mid 1950s but there was substantial diversification thereafter. So while an increase in price shocks caused the increase in export price volatility in the inter-war years, both diversification of the export base and a decline in price shocks may have contributed to lower export price volatility from the mid 1950s. To determine the relative importance of these effects in reducing export price volatility we compare the volatility of the detrended export price series for different subsets of goods exports. Table 8 reports these results for various episodes, starting in 1904 because of the availability of component price data.[11]

**Table 8: The Effect of Diversification on Goods Export Price Variance**

Standard deviation

| | Rural goods | Rural goods, metals, coal and gold | All goods |
|---|---|---|---|
| 1904–1922 | 0.101 | 0.101 | 0.088 |
| 1923–1952 | 0.202 | 0.195 | 0.182 |
| 1953–2004 | 0.096 | 0.075 | 0.074 |

Notes: The all goods series is a reconstructed all goods series which has been used to remain consistent with the methodology and data used to construct the sub-aggregate series. The all goods series is the same as the rural goods, metals, coal and gold series from 1937–1975. Index weights within the sub-aggregate categories reported are allowed to vary to reflect the changing weights in the all goods series. All logged series were detrended using an HP filter trend with $\lambda = 100$.

The effect of diversification on export price volatility can be seen by looking across the columns for each sample. Australia's exports remained primarily rural goods

[11] Because the move to a floating exchange rate in 1983 may mechanically impart volatility in the Australian export price series, we repeated the calculations in Table 8 using the Australian import price series to detrend. The results using this series are qualitatively similar to those shown in Table 8.

from 1904–1952, and as expected the rural goods series had similar volatility to the broader export price series. After 1953, diversification from rural goods into metals, coal and gold reduced the volatility of export prices, as seen in the last row of Table 8. However, diversification to include a broader range of commodities and manufactures did not significantly reduce export price volatility. This may be because rural goods, metals, coal and gold still constituted on average two-thirds of goods exports over the period 1953–2004.

Comparing the rows for each subset of goods exports, it can be seen that their price volatility was substantially higher over the period 1923–1952 than before or after this period. This suggests that an increase in price shocks was primarily responsible for the increase in export price volatility from 1923–1952. However, the results in Table 8 are not conclusive because within each grouping of goods considered, the weights vary over time. So changes in the composition of exports at a more disaggregated level may be causing an overestimation of the impact of price shocks.

To investigate whether this is the case we have made use of century-long price data for 19 commodities and produced two fixed-weight commodity price indices. By definition these series do not permit any diversification across commodities. Appendix A contains a list of the commodities included in the index. In 1905 these commodities comprised 82 per cent of total goods exports. While their share of total exports declined steadily they still represented 44 per cent of goods exports in the year 2000. The standard deviations of the constructed commodity price series are reported in Table 9.

**Table 9: Standard Deviation of Fixed-weight Commodity Price Series**
Export value index weights

| | Average 1905–1955 | Average 1955–2000 |
|---|---|---|
| 1904–1922 | 0.112 | 0.118 |
| 1923–1952 | 0.173 | 0.119 |
| 1953–2004 | 0.102 | 0.083 |

Notes: Both commodity price indices are in logs, are in Australian dollars, and were detrended by an HP filter trend with $\lambda = 100$. Export shares for metals include ores, concentrates and simply transformed manufactures of metals.

Sources: See Table A3 for a list of data sources.

Using 1905–1955 average value weights, over which time exports were primarily rural, the commodity price index volatility increased substantially over the period

1923−1952. This confirms our finding from Table 8 that increased price shocks caused the increase in export price volatility in the inter-war years. From the 1950s, the share of rural goods fell steadily, as mineral exports became more prominent. If Australia's exports from 1904−1952 had instead been as it was on average in the latter half of the 20th century, the period 1923−1952 would not have been one of relatively high export price volatility. This suggests that higher price shocks during the period 1923−1952 were particularly pronounced for Australia's traditional major commodity exports. But the fall in volatility over the period 1953−2004 for the index using average 1905−1955 export value weights indicates that even if Australia's export base had not diversified beyond traditional commodity exports, volatility would still have fallen.

These results can also be seen in individual commodity price series. Table 10 reports the standard deviations of detrended logged prices for 14 important commodities for which a long time series of data are available. It can be seen that commodities prominent in Australia's exports in inter-war years, notably wool and wheat, experienced much larger price shocks over these years.

**Table 10: Standard Deviation of Some Important Commodity Prices**

| | Wool | Wheat | Gold | Beef | Coal | Butter[(a)] | Sugar |
|---|---|---|---|---|---|---|---|
| 1904−1922 | 0.127 | 0.141 | 0.085 | 0.272 | 0.100 | 0.184 | 0.309 |
| 1923−1952 | 0.292 | 0.215 | 0.153 | 0.244 | 0.097 | 0.118 | 0.207 |
| 1953−2004 | 0.185 | 0.149 | 0.144 | 0.205 | 0.122 | 0.117 | 0.357 |
| *Average percentage share of total goods exports* | | | | | | | |
| 1905−1955 | *39.2* | *10.0* | *5.0* | *2.8* | *0.6* | *5.6* | *1.5* |
| 1955−2000 | *18.1* | *7.6* | *2.5* | *5.3* | *6.9* | *1.1* | *3.2* |
| | **Lead** | **Crude oil** | **Aluminium** | **Copper** | **Lamb** | **Zinc** | **Hides** |
| 1904−1922 | 0.176 | 0.258 | 0.287 | 0.203 | 0.278 | 0.224 | 0.211 |
| 1923−1952 | 0.166 | 0.163 | 0.145 | 0.142 | 0.213 | 0.181 | 0.231 |
| 1953−2004 | 0.173 | 0.213 | 0.133 | 0.129 | 0.198 | 0.127 | 0.187 |
| *Average percentage share of total goods exports* | | | | | | | |
| 1905−1955 | *2.8* | *0.1* | *0.0* | *1.4* | *1.8* | *1.1* | *1.1* |
| 1955−2000 | *1.7* | *3.1* | *2.9* | *1.4* | *0.5* | *1.1* | *0.6* |

Notes: (a) Price data for butter were unavailable before 1913.
Each commodity price series is in logs in Australian dollars and was detrended by an HP filter trend with $\lambda = 100$. The commodities shown have either had a 3 per cent or greater share of exports by value at some point over the past 100 years or have represented greater than 1 per cent of goods exports on average over that period. Average export shares were calculated using export data at 5-year intervals from 1905. Export shares for metals include ores, concentrates and simply transformed manufactures of metals.

Sources: See Table A3 for a list of data sources.

# 4. Conclusion

Commodities have long constituted the majority of Australia's exports, averaging 73 per cent by value over the past century. While there has been a diversification away from commodity exports, they still account for over half of goods exports. Given that the majority of imports have been manufactures, the Prebisch-Singer hypothesis of falling relative commodity prices suggests that there should be a negative trend in Australia's terms of trade. But the trend is no more than −0.1 per cent per annum over the full sample. The trend appears to have changed at several times during the century, notably there was seemingly a stronger negative trend in the period 1955–1987, which has since largely been reversed. But statistical tests are not able to identify changes in the trend. The fact that Australia's terms of trade declined by less than the decline in the ratio of world commodity prices to world manufactures prices is due to two factors. First, the commodities that Australia has traditionally exported experienced faster price growth than a broader basket of commodities. Second, the export base diversified toward commodities that experienced relatively faster price growth. Perhaps surprisingly, the growth in manufactures exports had little role in ameliorating the negative trend. Manufactures export prices have risen more slowly than those of commodities, at least over the past 30 years. Overall, the negative trend is so slight that it is economically insignificant. Of more significance is the fact that shocks to the terms of trade have become shorter-lived.

Arguably, the more notable feature of Australia's terms of trade is their significant volatility, which is considered in the second part of the paper. We document that there have been two significant breaks in the volatility of the terms of trade, in 1923 and 1953. The volatility was over three times as high in the intervening years and remarkably similar in the adjoining periods. The episode of higher volatility is attributable to more volatile export prices for Australia's traditional commodity exports. The timing of the rapid diversification of exports coinciding with the second break would suggest this might have been a factor in the fall in volatility. We find that had Australia's exports been as diversified over the period 1923−1952 as they were in the latter half of the century, then volatility would not have increased as much over this period. However, even if Australia's export base had not become more diversified, volatility would also have fallen. In some ways this is not so surprising given volatility increased around 1923 even when the export base did not change. Undoubtedly diversification has made a return to the highly volatile terms of trade of the inter-war years less likely.

# Appendix A: Data Sources

Table A1 contains a list of data sources for the aggregate level data series. All data are in Australian dollars.

**Table A1: Data Sources – Aggregate Level Data**

| Series | Data source | Sample |
|---|---|---|
| Export and import prices | Vamplew (1987), Table ITFC81–83 | 1870–1901 |
| | Butlin (1977), R7701.2H, R7701.2I | 1901–1959 |
| | CBCS, Balance of payments (for goods) | 1949–1959 |
| | ABS Cat No 5302.0 | 1959–2004 |
| World commodity prices | GYCPI | 1900–1987 |
| | GYCPI updated by the IMF | 1988–1998 |
| | Updated by authors using IMF IFS data | 1999–2004[(a)] |
| World manufactures prices | Grilli-Yang modified UN MUV series | 1900–1987 |
| | Modified UN MUV updated by the IMF | 1988–1998 |
| | IMF MUV series | 1999–2003 |
| Import shares by country | ABS Cat No 5302.0 | 1969–2004 |
| ETMs prices | ABS Cat No 5302.0 | 1986–2004 |
| A$/US$ exchange rate | Butlin (1977) R7701.19B | 1901–1969 |
| | RBA *Bulletin* Table F.11 | 1970–2004 |
| Export values | CBCS Overseas Trade and earlier titles | 1908–1975 |
| | ABS Cat No 5302.0 | 1975–2004 |

Notes: (a) Data for 2004 are an average of the months to November.
Australian Bureau of Statistics (ABS), Commonwealth Bureau of Census and Statistics (CBCS), elaborately transformed manufactures (ETM), Grilli-Yang commodity price index (GYCPI), International Monetary Fund (IMF), *International Financial Statistics* (IFS), manufactures unit value (MUV). World commodity and manufactures price data and data from Vamplew (1987) are for calendar years. All other data are for financial years, except for export values data which are for calendar years until 1913. World commodity and manufactures price data were converted to Australian dollars using year-ended exchange rates until 1969 and calendar year average exchange rates thereafter.

The forecast goods and services terms of trade data in Figure 1 for 2004/05 and 2005/06 were constructed using known contract prices for some major commodity exports, holding all other factors, including import prices, constant. The 2004/05 value is an average of actual data for the September and December quarters 2004, the December quarter 2005 in place of the March quarter 2005 and a forecast for the June quarter 2005. Because contract prices for major commodity exports are set on an annual basis, the June quarter 2005 value was held constant as the forecast for the terms of trade in 2006.

Table A2 lists the data sources used to re-construct Australia's export price series for subsets of goods exports. The weighting method and re-basing pattern shown in Table A2 was used to aggregate the components for each sub-aggregate export price series constructed. After 1975, the index type and re-basing pattern recreates the ABS's export price implicit price deflator. Before 1975, sub-component export price data were only available from the 'Export Price Index' release. These data and the weighting scheme were used as a proxy for the data and weighting used by the ABS and CBCS export price implicit price deflator. Before 1975, the re-constructed series is a fixed base price index.

**Table A2: Data Sources – Export Price Series by Component**

| Sample | Data source | Index type | Export value weights |
|---|---|---|---|
| 1904–1928/29 | CBCS Monthly index of export prices 1928–1937 | Fixed base | Average 1904–1915/16 |
| 1929/30–1935/36 | CBCS Monthly index of export prices 1928–1937 | Fixed base | 1928 |
| 1936/37–1959/60 | CBCS Export price index (various) | Fixed base | Average 1933/34–1935/36 |
| 1960/61–1968/69 | CBCS Export price index (various) | Fixed base | Average 1956/57–1960/61 |
| 1969/70–1974/75 | ABS/CBCS Export price index (various) | Fixed base | 1969/70 |
| 1975/76–1985/86 | ABS Cat No 5302.0 | Paasche | 1984/85 quantity weights |
| 1986/87–2003/04 | ABS Cat No 5302.0 | Paasche | Annually re-weighted |

From 1901–1935/36, the export price index consists of five component price series: agricultural, pastoral, dairy, mineral and miscellaneous. From 1936/37 to 1959/60, the export price index includes: meat, butter, wheat, dried fruits, sugar, hides, tallow, wool, metals and gold. From 1959/60 to 1974/75, it comprises: meat, dairy, cereals, dried & canned fruit, sugar, hides & tallow, wool, metals & coal and gold. After 1974/75, export data at the 2-digit Statistical International Trade Classification (SITC) level were used.

Table A3 contains a list of the commodities included in the construction of the fixed-weight commodity price index, the data sources for their prices and each commodity's average share of goods exports over the period 1905–2000.

Note also, that in constructing Figure 5, data available for 1985/86 for Hong Kong were found to be incorrect. The 1984/85 data were used instead.

**Table A3: Commodities Included in the Fixed-weight Commodity Price Index**

**Commodity prices constructed from Australian sources**

| Commodity | Average export share 1905–2000 (per cent) | Data source | Sample |
|---|---|---|---|
| Butter | 3.36 | CBCS *Australian year book* (various) | 1913–1936 |
| | | CBCS Export price index | 1937–1947 |
| | | IMF IFS | 1948–2004 |
| Coal | 3.77 | CBCS and ABS *Australian year book* (various) | 1901–1961 |
| | | *The Australian mineral industry review* 1965 | 1962–1966 |
| | | IMF IFS | 1967–2004 |
| Crude oil | 1.63 | www.eere.energy.gov | 1901–1960 |
| | | IMF IFS | 1961–2004 |
| Gold | 5.78 | www.mcalvany.com/historicalgoldprices.asp | 1901–2003 |
| | | IMF IFS | 2004 |
| Wheat | 8.76 | CBCS *Australian year book* (various) | 1901–1949 |
| | | Bureau of Agricultural Economics *The wheat situation* | 1950–1968 |
| | | Bureau of Agricultural Economics *Wheat: situation and outlook* | 1969–1982 |
| | | RBA Commodity price index | 1983–2004 |
| Wool | 27.57 | CBCS *Australian year book* (various) | 1901–1959 |
| | | Bureau of Agricultural Economics *The wool outlook* | 1960–1975 |
| | | National council of wool selling brokers *Wool review* | 1976–1982 |
| | | RBA Commodity price index | 1983–2004 |

**World commodity price data**

Data source: Grilli-Yang updated by IMF (1901–1998) and IMF IFS (1999–2004)

| Commodity | Average export share 1905–2000 (per cent) | Commodity | Average export share 1905–2000 (per cent) |
|---|---|---|---|
| Aluminium | 1.45 | Rice | 0.21 |
| Beef | 3.92 | Silver | 0.66 |
| Copper | 1.44 | Sugar | 2.24 |
| Cotton | 0.26 | Timber | 0.51 |
| Hide | 0.92 | Tin | 0.38 |
| Lamb | 1.17 | Zinc | 1.11 |
| Lead | 2.21 | | |

Notes: All price data are for calendar years except for: butter price data from 1936/37–1946/47, wheat price data 1914/15–1934/35 and 1949/50–2003/04, and wool price data from 1914/15 onward.

# Appendix B: Index Construction

The fixed base indices were constructed as follows:

$$\hat{P}_t = \frac{\sum_{i=1}^{n} \hat{P}_{i,t} w_i}{\sum_{i=1}^{n} \hat{P}_{i,r} w_i} \tag{B1}$$

where $\hat{P}_t$ is the level of the price index at time $t$, $n$ is the number of components contained in the index, $\hat{P}_{i,t}$ is the price of component $i$ at time $t$ where $\hat{P}_{i,r}$ is normalised to 1 and $w_i$ is the weight of component $i$ in the price index.

In the case where the export price series takes the form of a fixed base Paasche price index, its construction is as follows:

$$P_t = P_r \frac{\sum_{i=1}^{n} P_{i,t} Q_{i,t}}{\sum_{i=1}^{n} P_{i,r} Q_{i,t}} \tag{B2}$$

where $P_t$ is the level of the Paasche price index at time $t$, $P_r$ is the arbitrary level of the index at time $r$, $P_{i,t}$ is the implicit price deflator for category $i$ at time $t$ and $Q_{i,t}$ is the volume of component $i$ exported at time $t$. This same method was used to construct the fixed base commodity price series.

In 1986, the ABS began constructing chain price measures of export volumes. This means that after 1986 the export price implicit price deflator is an annually re-weighted Paasche price index. Its construction is in Equation (B3):

$$P_t = P_r \prod_{i=1}^{n} \frac{\sum_{i=1}^{n} P_{i,t} Q_{i,t}}{\sum_{i=1}^{n} P_{i,t-1} Q_{i,t}} \tag{B3}$$

where $P_t$ is the level of the Paasche price index at time $t$, for $t$ greater than $r$.

The indices for each sample were spliced together to form century-long series.

## References

**Ahmed S, A Levin and BA Wilson (2002),** 'Recent US macroeconomic stability: good policies, good practices or good luck?', Board of Governors of the Federal Reserve System International Finance Division Discussion Paper No 730.

**Andrews DWK (1993),** 'Exactly median-unbiased estimation of first order autoregressive/unit root models', *Econometrica*, 61(1), pp 139–165.

**Bai J and P Perron (1998),** 'Estimating and testing linear models with multiple structural changes', *Econometrica*, 66(1), pp 47–78.

**Bai J and P Perron (2003),** 'Computation and analysis of multiple structural change models', *Journal of Applied Econometrics*, 18(1), pp 1–22.

**Butlin M (1977),** 'A preliminary annual database 1900/01 to 1973/74', Reserve Bank of Australia Research Discussion Paper No 7701.

**Cashin P, H Liang and CJ McDermott (2000),** 'How persistent are shocks to world commodity prices?', *IMF Staff Papers*, 47(2), pp 177–217.

**Cashin P and CJ McDermott (2002),** 'The long-run behavior of commodity prices: small trends and big variability', *IMF Staff Papers*, 49(2), pp 175–199.

**Cuddington JT and H Liang (1998),** 'Commodity price volatility across exchange rate regimes', Georgetown University Working Paper No 97-01.

**Cuddington JT, R Ludema and SA Jayasuriya (2002),** 'Prebisch-Singer redux', Banco Central de Chile Documento de Trabajo No 140.

**Elliot G, T Rottenberg and J Stock (1996),** 'Efficient tests for an autoregressive unit root', *Econometrica*, 64(4), pp 813–836.

**Grilli ER and MC Yang (1988),** 'Primary commodity prices, manufactured goods prices, and the terms of trade of developing countries: what the long run shows', *The World Bank Economic Review*, 2(1), pp 1–47.

**Gruen D and T Kortian (1996),** 'Why does the Australian dollar move so closely with the terms of trade?', Reserve Bank of Australia Research Discussion Paper No 9601.

**Kent C and P Cashin (2003),** ‘The response of the current account to terms of trade shocks: persistence matters’, IMF Working Paper No WP/03/143.

**Kwiatkowski D, P Phillips, P Schmidt and Y Shin (1992),** ‘Testing the null hypothesis of stationarity against the alternative of a unit root: how sure are we that economic time series have a unit root?’, *Journal of Econometrics*, 54, pp 44–57.

**Lutz MG (1999),** ‘A general test of the Prebisch-Singer hypothesis’, *Review of Development Economics*, 3(1), pp 44–57.

**Prebisch R (1950),** ‘*The economic development of Latin America and its principal problems*’, sponsored by the Economic Commission for Latin America, United Nations, New York. Reprinted in *Economic Bulletin for Latin America*, 7(1), pp 1–22.

**Protopapadakis AA and HR Stoll (1986),** ‘The law of one price in international commodity markets: a reformulation and some formal tests’, *Journal of International Money and Finance*, 5(3), pp 335–360.

**Sapsford D (1990),** ‘Primary commodity prices and the terms of trade’, *Economic Record*, 66, pp 342–356.

**Singer HW (1950),** ‘U.S. foreign investment in underdeveloped areas: the distribution of gains between investing and borrowing countries’, *American Economic Review, Papers and Proceedings*, 40, pp 473–485.

**Smith B (1987),** ‘The role of resource development in Australia’s economic growth’, Australian National University, Centre for Economic Policy Research Discussion Paper No 167.

**Valentine T (1987),** ‘The depression of the 1930s’, in R Maddock and I McLean (eds), *The Australian economy in the long run*, Cambridge University Press, Cambridge, pp 61–78.

**Vamplew W (ed) (1987),** *Australians: historical statistics*, Australians: a historical library, Fairfax, Syme and Weldon Associates, Sydney.