ARE TERMS OF TRADE RISES INFLATIONARY?

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ABSTRACT

This paper explores the relationship between the terms of trade and inflation. It shows, both analytically and empirically, that the exchange rate response to a change in the terms of trade is crucial to the inflation outcome. It suggests the existence of a 'threshold' exchange rate response. Our best estimate is that (other things being equal) a rise in the terms of trade is inflationary if the associated rise in the real exchange rate *is less than* about $^1/_3$-$^1/_2$ of the rise in the terms of trade. However, if appreciation of the real exchange rate is larger than this, the consequent fall in the domestic price of importables is large enough that the terms of trade rise reduces inflation, at least in the short run.

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1. INTRODUCTION

As a small commodity-exporting economy, Australia is vulnerable to terms of trade shocks. These shocks have an impact on the general price level and, in the short run, affect domestic inflation.[1] Stevens (1992), reviewing the history of Australian inflation, showed that throughout the post-war period of fixed exchange rates, a rise in the terms of trade was inflationary, while a fall reduced inflation. Since the adoption of a floating exchange rate, however, such a clear positive correlation between the terms of trade and inflation has diminished and, on at least one occasion, been reversed. Consequently, there have emerged conflicting views about the impact on inflation of a terms of trade shock. This conflict generates uncertainty about the way in which a recovery in Australia's terms of trade will affect the present environment of low inflation.

One view, put by Gruen and Shuetrim (1994) (henceforth, GS) is that, since the float of the Australian dollar, *rises* in the terms of trade *reduce* domestic inflation in the short run. After presenting a theoretical model, GS calibrate their model using empirical estimates for a large number of key parameters. GS do not, however, present any sensitivity analysis for their results.

This paper revisits the relationship between the terms of trade and domestic inflation. It addresses the question: how robust is the result that a rise in the terms of trade reduces domestic inflation in the short-run? To answer this question, we deal with a range of tricky empirical details to see if plausible changes to parameter values overturn this conclusion. We show, both analytically and empirically, that the exchange rate response to a change in the terms of trade is crucial to the inflation outcome. There is a ‘threshold’ exchange rate response, with a *rise* in the terms of trade being inflationary (other things being equal) if the associated rise in the real exchange rate *is less than* this threshold. By contrast, if

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[1] It is generally assumed that, over the longer run, inflation is determined by the stance of domestic monetary policy.

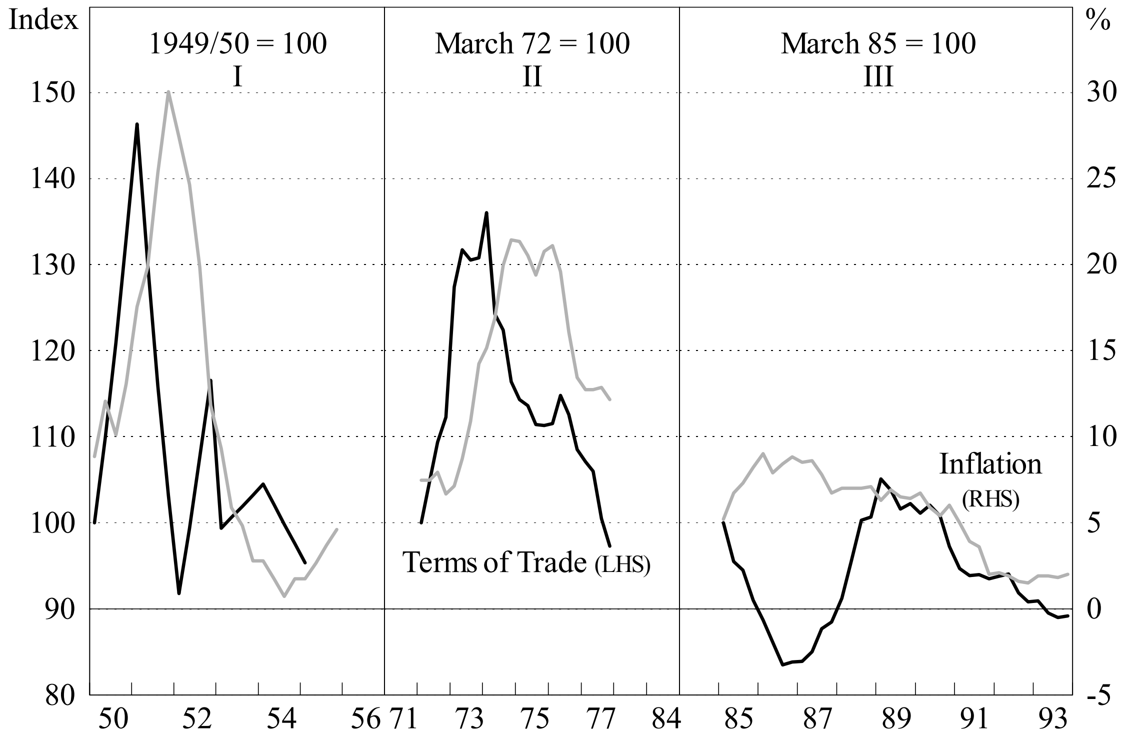
currency appreciation exceeds this threshold, a rise in the terms of trade puts downward pressure on inflation.[2]

The paper is organised as follows. Section 2 presents stylised facts about the link between terms of trade shocks and inflation. In Section 3, an analytical framework is developed which forms the basis of an empirical investigation of the impact of terms of trade shocks on inflation. Estimation and results are presented in Section 4. In Section 5, implications of the results are discussed and conclusions drawn.

2. STYLISED FACTS

Figure 1 shows the relationship between inflation and the terms of trade in Australia during three episodes in which the terms of trade exhibited substantial change.[3]

Figure 1: Inflation and the Terms of Trade



2 All of the conclusions assume 'no policy response', in the sense that the only variables influencing inflation are the terms of trade shock itself and market-induced exchange rate movements.

3 Inflation is measured by the four quarter ended change in the consumption deflator.

The largest terms of trade shock occurred during the early 1950s (see panel I). At this time, the Korean War induced a wool price boom and, in consequence, there was a record increase in Australia's export prices. With a fixed exchange rate in operation, the attendant surge in income and money balances quickly translated into record inflation. Subsequently, when wool prices collapsed and the terms of trade fell, there was a corresponding fall in the inflation rate.

A similar relationship between the terms of trade and inflation was evident during the 1970s, although the magnitude of the change was significantly less than in the 1950s (see panel II). This time, the terms of trade rise was driven by a broadly-based commodity price boom, including a quadrupling of the US dollar oil price. Again, with a fixed nominal exchange rate, the resultant increase in income and money balances fed into domestic inflation. Similarly, as the terms of trade fell, so too did domestic inflation.[4]

The two experiences provided powerful evidence for the view that the terms of trade and inflation have a strong positive correlation.[5] The income effects of changes in the terms of trade were clearly manifested and, with a lag, were seen to operate on domestic prices. However, with the floating of the exchange rate in December 1983, this conventional relationship appeared to break down.

In the mid 1980s, the terms of trade fell sharply but, for the first time, such a fall did not reduce inflation. It was instead accompanied, at least initially, by an acceleration of domestic inflation (as shown in panel III). The currency depreciated by more than required to cushion the negative income effect of the fall in the terms of trade. In fact, the currency may have depreciated by more than can be explained by economic fundamentals.[6] Consequently, it increased the domestic price of traded goods (in particular imports) and a negative correlation between

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4 It should be acknowledged that while the exchange rate was not freely floating during the 1970s, it was variable. It was revalued several times as the terms of trade rose, and devalued as they fell. However, these currency realignments were not sufficient to insulate the economy from significant changes in the world price of traded goods (Blundell-Wignall, Fahrer and Heath 1993, pp. 35-36).

5 Blundell-Wignall and Gregory (1990) provide a detailed discussion of this view.

6 Blundell-Wignall *et al.* (1993) provide estimates of the extent to which the actual value of the currency departed from its equilibrium value, where the equilibrium value is a function of the terms of trade, real interest rate differentials and net foreign liabilities. See also O'Mara, Wallace and Meshios (1987) for an analysis of the Australian dollar during the mid 1980s.

the terms of trade and inflation emerged. This outcome clearly distinguished the experience of the mid 1980s from that in earlier episodes.

During the rest of the 1980s and the early 1990s, the terms of trade and inflation again moved in line with each other (panel III), suggesting perhaps that the experience of the mid 1980s was an aberration; a consequence of exchange rate 'overshooting'.[7] However, despite an apparent return to the historical relationship between the terms of trade and inflation, it is premature to conclude that, as a general case, a fall in the terms of trade reduces inflation while a rise is inflationary. As ever, it is difficult to disentangle the influence of the terms of trade on this outcome from the effect of the business cycle and domestic policy settings. This task is especially difficult when there has not been a discrete shock of the magnitude witnessed in earlier episodes. Thus the question remains: with a floating exchange rate, are rises or falls in the terms of trade inflationary?

The following section discusses the mechanisms by which changes in the terms of trade have an impact on inflation. A simple model is developed with which to demonstrate the different inflation outcomes under fixed and floating rate regimes.

3. A MODEL

Our model is an extension of the model presented by Gruen and Shuetrim (1994). The aim is to discover the 'impact effect' of a terms of trade shock on the domestic inflation rate and no allowance is made for policy reaction to the shock (that is, we assume that short-term real interest rates are kept constant). We assume a small open economy in which there are three types of goods: exportables, importables and non-traded goods.[8] The domestic prices of these goods, expressed as logs, are p_x, p_m and p_n respectively. The domestic log price level, p, is a linear combination of

[7] Where overshooting is defined here as the exchange rate moving by more than is justified by fundamentals, rather than as defined by Dornbusch (1976).

[8] Exportables refer to actual exports plus the output of export-oriented industries. It is assumed that a single price exists for these goods. Importables refer to actual imports plus import replacements and, again, a single price is assumed to exist. Exportables and importables may comprise final or intermediate goods.

these three prices and hence domestic inflation, Δp, is given by:

$$\Delta p = \alpha \Delta p_x + \beta \Delta p_m + \gamma \Delta p_n \tag{1}$$

where $\alpha + \beta + \gamma = 1$. The prices of importables and exportables are determined in world markets, and the law of one price is assumed to hold. Hence, their first differences are:

$$\begin{aligned} \Delta p_x &= \Delta p_x^* - \Delta e \\ \Delta p_m &= \Delta p_m^* - \Delta e \end{aligned} \tag{2}$$

where world prices are distinguished by an asterisk and Δe is the change in the nominal exchange rate index (expressed in units of foreign currency per unit of domestic currency).

The world price of domestic importables is assumed to rise at the world inflation rate, π^*.[9] However, in general, the world price of domestic exportables is assumed to rise at a different rate:

$$\begin{aligned} \Delta p_m^* &= \pi^* \\ \Delta p_x^* &= \pi^* + \Delta TOT \end{aligned} \tag{3}$$

This difference results from the fact that the change in the log of the domestic terms of trade, ΔTOT, is $\Delta TOT = \Delta p_x^* - \Delta p_m^*$, given the law of one price.[10] The implication is that the terms of trade shock arises from a change in the world price of exportables.

Non-traded goods price inflation, Δp_n, is assumed to be a function of 'core' domestic inflation, π, and a Phillips curve relation of the deviation of log output, y, from its natural rate, y_N. In the absence of the terms of trade shock, output is

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[9] The analysis implicitly assumes a small commodity exporting country (like Australia) which imports mainly manufactures, the prices of which are assumed to rise at the same rate as world consumer prices.

[10] In practice, passthrough to domestic traded prices is not instantaneous, and its rate differs between importables and exportables. This effect has been ignored here as it appears to be small in magnitude (Dwyer, Kent and Pease 1993).

assumed to be at y_N. Note, however, that a change in the relative price of exportables (importables) has a substitution effect that also induces a change in the price of non-traded goods.[11] Thus the change in the price of non-traded goods is given by:

$$\Delta p_n = \pi + \phi(y - y_N) + \sigma(\Delta p_x - \Delta p_n) + \mu(\Delta p_m - \Delta p_n) \tag{4}$$

The above expressions for changes in p_x, p_m and p_n can now be combined to form expressions for the change in the general price level, assuming both fixed and floating nominal exchange rates regimes.

With a fixed nominal exchange rate ($\Delta e = 0$) that has been operating for long enough that domestic core inflation is equal to world inflation ($\pi = \pi^*$), domestic inflation is given by:

$$\Delta p = \pi + \underbrace{\alpha \Delta TOT}_{direct\ price} + \underbrace{\gamma\phi\chi(y - y_N)}_{income} + \underbrace{\gamma\sigma\chi\Delta TOT}_{substitution} \tag{5}$$

where $\chi = (1 + \sigma + \mu)^{-1}$. From equation (5) the inflationary impact of an increase in the terms of trade can be seen to comprise three effects.

- First, there is a *direct price effect*. Provided $\alpha > 0$ an increase in exportable prices will contribute directly to domestic inflation.
- Second, there is an *income* effect. A terms of trade rise increases domestic income. Some of this extra income is spent in the domestic non-traded sector, driving up the prices of non-traded goods and again adding to domestic inflation by a proportion $\gamma\phi\chi$.
- Third, there is a *substitution* effect. An increase in the relative price of exportables induces substitution in consumption towards non-traded goods and substitution in production away from them, increasing domestic inflation by a proportion $\gamma\sigma\chi$.

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[11] An increase in the domestic price of exportables (or importables) encourages a shift in demand towards the relatively cheaper non-traded goods. At the same time, there is a shift of supply away from the non-traded goods sector. The resulting excess demand places upward pressure on the price of non-traded goods so that σ and μ are unambiguously positive. For further discussion see Dornbusch (1980) and Edwards and van Wijnbergen (1987).

With a fixed exchange rate, all effects are positive and imply that an increase in the terms of trade is unambiguously inflationary.[12] Given the symmetry of the model, a fall in the terms of trade is unambiguously disinflationary.[13]

A floating exchange rate will, however, alter this relationship. To derive the new expression, we introduce the change in the real exchange rate, $\Delta q = \Delta e + \Delta p - \pi^*$, which measures deviations from purchasing power parity. We note the well-established relationship between the real exchange rate and the terms of trade:[14]

$$\Delta q = \delta \Delta TOT, \quad \delta > 0 \tag{6}$$

With a floating nominal exchange rate, domestic core inflation need not equal world inflation ($\pi \neq \pi^*$). As shown in Appendix 2, domestic inflation is now given by:

$$\Delta p = \pi + \underbrace{\Delta TOT\left(\frac{\alpha}{\chi\gamma}(1-\delta) - \frac{\beta}{\chi\gamma}\delta\right)}_{direct\ price} + \underbrace{\phi(y - y_N)}_{income} + \underbrace{\Delta TOT(\sigma - \sigma\delta - \mu\delta)}_{substitution} \tag{7}$$

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12 That is, assuming that the increase in the terms of trade stems from an increase in export prices. Should the increase in the terms of trade result from a fall in import prices, given a fixed exchange rate, a different result would be found. Whilst the income effect would be of the same positive sign, the substitution effect would be negative as the lower price of importables encourages a shift in demand away from non-tradeables towards the relatively cheaper importables. Importantly, when the exchange rate floats, whether the shock arises from changes in the world price of exportables or importables is immaterial. This is the result of our assumption that purchasing power parity holds: following a change in the world price of exportables or importables, the resultant movement of the nominal exchange rate delivers an identical change in domestic prices. Consequently, there are identical income and substitution effects, *whatever the source of change in the terms of trade*.

13 Of course, these are short-run effects. With a fixed nominal exchange rate, domestic inflation, π, must return to the world rate, π^*, in the longer run. In this case, domestic monetary policy is subservient to the monetary policy of the anchor country.

14 This accords with analyses of the equilibrium value of the exchange rate. See Neary (1988), Warr (1986), O'Mara *et al.* (1987), Gruen and Wilkinson (1991) and Blundell-Wignall *et al.* (1993).

A rise in the terms of trade induces a real appreciation of the domestic currency. But with a floating exchange rate, this real appreciation occurs via nominal appreciation. This nominal appreciation has four consequences.

- First, it substantially modifies the direct price effect of exportables on the domestic price index. This direct price effect is now $\Delta TOT(\alpha(1-\delta)/\chi\gamma)$ which, for most plausible values of δ and γ (see later), is now less than when the exchange rate was fixed.[15]

- Second, the rise in the terms of trade leads to a smaller rise in output, $\left(y - y_N\right)$, because with cheaper imports, the proportion of domestic income spent on non-traded goods falls.

- Third, it reduces, and may reverse, the inflationary impact of the substitution effects because, with cheaper imports, demand switches away from non-traded goods while supply switches towards them.

- Fourth, and most importantly, it introduces a direct price effect of importables, $-\Delta TOT(\beta\delta/\chi\gamma)$, which acts to reduce domestic inflation.

Thus a floating exchange rate has insulating properties that reduce the direct price effect, substitution effect and income effect of the higher price of exportables. Other things being constant, a rise in the terms of trade is less inflationary than when the exchange rate is fixed. However, a floating exchange rate also introduces a role for the price of importables. If this direct price effect of importables exceeds the combination of other effects, an increase in the terms of trade will reduce inflation. Again, given the symmetry in the model, it follows that under such circumstances a terms of trade fall will be inflationary. In other words, with a floating exchange rate, there is no general theoretical result for the relationship between the terms of trade and inflation. The relationship is conditional upon the size of the importables price effect relative to other effects.

[15] For a detailed analysis of the insulation properties of a floating exchange rate see Blundell-Wignall and Gregory (1990) and Pitchford (1993). Note that the direct price effect is now also influenced by the size of the substitution effects.

4. ESTIMATING THE IMPACT OF TERMS OF TRADE SHOCKS ON INFLATION

The above model forms the basis of an empirical exercise in which the component effects of a terms of trade shock are estimated, and summed, to form the total effect on inflation. We estimate the effect on the domestic price level two years after a ten per cent rise in the terms of trade, and to do so, several parameters of the economy must be known. For most of these parameters, estimates for Australia already exist in the empirical literature on various aspects of open economy macroeconomics. We choose various published estimates of the parameters, calculate the corresponding inflation outcomes and then examine the sensitivity of the results to changes in the key parameter values.

Accepting the stylised fact that a rise in the terms of trade was inflationary before the float, we focus our attention on simulating the inflationary effect of a terms of trade shock when the exchange rate is freely floating.

4.1 The Parameters of the Economy

The parameter estimates to be imposed in the simulation exercise are listed below with a comment on their features. These, and other data to be used in the empirical analysis, are described in Appendix 1.

σ, μ	the substitution effects are assumed to be zero.
α	the share of exportables in domestic consumption is 0.05.
β	the share of importables in domestic consumption is 0.20.
γ	the share of non-traded goods in domestic consumption is 0.75, since $\gamma = 1 - \alpha - \beta$.
δ	the change in the real exchange rate attributable to a change in the terms of trade is assumed to be 0.885 and, in another simulation, is 0.51.
ϕ	is 0.4.

In our numerical estimates to follow, we assume the substitution effects, σ and μ, are zero (and hence χ is unity). We have no empirical estimates of these effects, but have theoretical reasons for expecting small elasticities of substitution between exportables and non-traded goods, for a commodity-exporting country.[16] Similarly, we might expect substitution to be limited between importables and non-traded goods. However, to the extent that a substitution effect does exist, it would tend to reduce the inflationary impact of rises in the terms of trade.

The share of exportables in consumption, α, should include both exportable goods that are consumed (e.g., meat) as well as exportables used as intermediate goods in the production of consumer goods (such as energy and base metals). We assume α is 0.05, based on examining both the expenditure classes of the CPI and econometrically-derived estimates of the importance of energy and base metals for domestic consumer prices.[17]

The share of importables in consumption, β, is assumed to be significantly larger, since the prices of both actual imports and import competing goods are represented in the CPI. We estimate these goods to have a collective weight of about 20 per cent in the CPI regimen, hence we assume that β is 0.20.[18] Since

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[16] Those theoretical analyses in which substitution effects are considered important tend to relate to non-commodity exporting economies (see Dornbusch (1980) and Edwards and van Wijnbergen (1987)). However, as discussed by Blundell-Wignall and Gregory (1990), the importance of substitution effects is often overstated for a commodity exporting economy. Put most simply, commodity exports (such as wheat) are not close substitutes for non-traded goods (such as haircuts). Thus we would not expect a change in the price of wheat to induce a change in demand for haircuts and so affect their price. We would, instead, expect the *income* effect of the change in the price of wheat to influence demand for non-traded goods.

[17] Export prices are not represented in any consumer price series. While the domestic prices of export-oriented goods comprise nearly 5 per cent in the regimen of the CPI (where goods are classified as export-oriented as in Dwyer (1992)), these prices are largely explained by domestic factors, suggesting that $\alpha << 0.05$. However, econometric models that estimate the combined effect of the price of exportables, particularly energy and base metals, for consumer prices yield an estimate of α of about 0.05 (Ricky Lam, RBA, personal communication).

[18] Within a given expenditure class in the CPI, a good may be import competing or imported. Specifically, import competing goods are identified as the output of industries where more than 10 per cent of domestic production is of an import substitute, as in Dwyer (1992). These goods account for about 20 per cent of the CPI regimen. However, since these goods are characterised by high import penetration of domestic sales, within their respective expenditure class, there exists a subset of items that are 'wholly or predominantly imported'. (This subset has, on average, accounted for about 10 per cent of the CPI regimen over the past four years.)

$\alpha + \beta + \gamma = 1$, it follows that γ is 0.75. (This share of consumption attributable to non-traded goods is similar to other estimates used in the empirical literature.)[19]

As we shall show, the parameter δ is critical for determining the impact of terms of trade shocks on inflation in the post-float era. The extent to which the real exchange rate moves in response to a change in the terms of trade greatly influences the magnitude of the direct price effects of exportables and importables. In consequence, a range of values for δ are considered. For a permanent terms of trade rise, Blundell-Wignall *et al.* (1993) estimate that δ is 0.885 over the post-float period.[20] Using a slightly different specification, Gruen and Wilkinson (1991) estimate that δ is 0.51 post-float.[21] We focus on these alternative estimates of δ and observe changes in the estimated inflation outcome as δ varies between these values.

Finally, the income effect is estimated by a two-step procedure. First, the change in output attributable to the terms of trade is estimated and used as a proxy for $(y - y_N)$. Second, an estimate is made of the impact of this change in output on inflation, given a nominated value of ϕ.

With respect to the first step, a proxy for $(y - y_N)$ is found by using a simple regression model to estimate the effect of a change in the terms of trade on the level of real GDP, cumulated over two years, for the post-float era (see Appendix 3). We estimate that, over two years, a 10 per cent rise in the terms of trade increases the level of GDP by about 1.1 per cent-years.

With respect to the second step, an inference is made about the impact of this terms of trade induced change in output on inflation. We take advantage of a

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[19] See, for example, Pitchford (1986), Treasury Dept. (1988), Martin and Nguyen (1989) and Teal (1989).

[20] This estimate is over the period from 1984:Q1 to 1992:Q3. The real trade-weighted value of the currency is a function of the terms of trade, real long interest differentials and net foreign liabilities. The estimated elasticity of the real exchange rate to changes in the terms of trade, 0.885, is a long-run estimate, though dynamic simulation of the Blundell-Wignall *et al.* equation suggests that full adjustment is very rapid.

[21] Their estimation is from 1984:Q4 to 1990:Q3. Their results differ from Blundell-Wignall *et al.* (1993) mainly due to the different sample period and the exclusion of net foreign liabilities as a determinant of the real exchange rate.

sacrifice ratio – that is, the cumulated loss of output in per cent-years when inflation is reduced by one percentage point.[22] Since, in the present paper, we are interested in the *reverse* case when inflation is affected by a change in output, the reciprocal of a known sacrifice ratio is useful. When output is boosted (say, from an increase in the terms of trade), its effect on inflation can be inferred by the change in output multiplied by the reciprocal of the sacrifice ratio.[23] Stevens (1992) estimates a sacrifice ratio of 2.5 for Australia, the reciprocal of which is 0.4 and is therefore chosen as the value for ϕ.

4.2 The Component Effects of a Terms of Trade Shock

Substitution of the above parameter values into equation (7) permits estimation of the component price and income effects of a terms of trade shock with a floating exchange rate. The effects can be summed to form an estimate of the total impact of a terms of trade shock on inflation. All calculations have been performed for a permanent 10 per cent rise in the terms of trade and are reported in Table 1 for the post-float period. Given the pivotal role played by the real exchange rate response, two values of δ are considered.

As shown in Table 1, with either value of δ, the price effect for importables is sufficiently large to offset the other effects. Consequently, a rise in the terms of trade reduces inflation when the exchange rate floats. This relationship is clearly the *opposite* of that evident before the float.

[22] See Andersen (1992) and Stevens (1992, p. 218) for further discussion.

[23] For this to be valid, the short-run Phillips curve must be linear, which appears to be the case (Stevens 1992, p. 253).

Table 1: Estimated Inflationary Effect Within Two Years of a 10 per cent Rise in the Terms of Trade
(α=0.05, β=0.20)

Adding up direct price and income effects (δ=0.885)	**Percentage points**
Direct price effects	
Exportables effect	+0.1
Importables effect	-2.4
Income effect:	+0.4
Total Effect	**-1.9**
Adding up direct price and income effects (δ=0.51)	
Direct price effects:	
Exportables effect	+0.3
Importables effect	-1.4
Income effect:	+0.4
Total Effect	**-0.7**

Note: The results show the contribution of each effect to the change in the price level two years after a 10 per cent terms of trade rise. Hence, dividing the numbers shown by two gives the average effect on the annual inflation rate over the two years. No allowance is made for policy reaction.

4.3 Sensitivity of the Results

The results presented in Table 1 provide support for the notion that since the float the correlation between terms of trade shocks and inflation has become negative. However, an important issue is the robustness of this result to the choice of parameter estimates and other economic relationships. To what extent is this reported outcome for the post-float era true in general?

The impact of a terms of trade shock on inflation in the post-float era differs from the impact before the float largely because of the introduction of an importables price effect. Consequently, we examine the factors that govern the size of the importables price effect and demonstrate the sensitivity of the estimated inflation outcome to changes in these factors.[24] Principally, the size of the importables price effect is governed by three factors:

- the share of importables in consumption, β;
- the extent to which the real exchange rate responds to changes in the terms of trade, δ; and
- the extent to which these changes in the exchange rate are passed through to the domestic price of imports.

We replicate the calculations performed to derive Table 1 allowing for changes in each of the above factors. First, we generate results for three alternative values for the share of importables in consumption: $\beta = 0.1$, $\beta = 0.2$ and $\beta = 0.3$.[25] The value $\beta = 0.1$ represents the share of imported final goods in the CPI basket, $\beta = 0.2$ represents imported final goods plus import-competing goods (see earlier) while $\beta = 0.3$ is an econometrically-derived estimate of the total contribution of import prices to domestic prices (and so includes the indirect contribution of imports as inputs into non-traded and exportable goods).[26]

Second, given these alternative estimates of β, we replicate the calculations performed to derive Table 1 in an iterative way, varying δ from 0 to 1. The results are illustrated in Figure 2. At $\delta = 0$, movements in the real exchange rate are independent of the terms of trade, while at $\delta = 1$, the real exchange rate moves one-for-one with the terms of trade.

Figure 2 indicates that when β equals 0.1, for values of δ up to about 0.55, an increase in the terms of trade is inflationary, while for greater values of δ, the reverse is true. The figure also indicates that the threshold value of δ, beyond which the inflationary effect of a change in the terms of trade changes sign, is significantly reduced as the share of importables in consumption increases. If δ is close to unity, as estimated by Blundell-Wignall *et al.* (1993), a rise in the terms of trade reduces inflation for any of our values of β. Even if δ is close to 0.5, as

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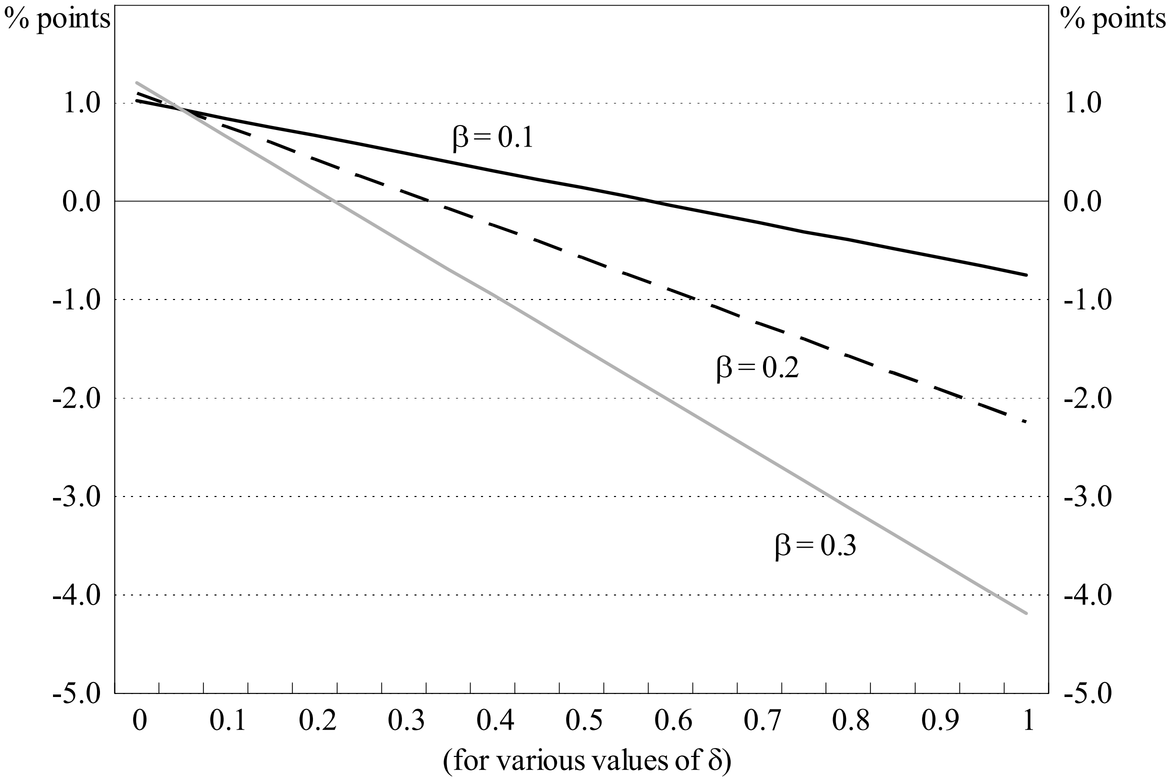
24 Recall from equation (7) that the importables price effect of a terms of trade shock is equal to $-\Delta TOT(\beta\delta / \gamma)$, when substitution effects are absent.

25 We leave α unchanged at 0.05. Since $\gamma = 1 - \alpha - \beta$, we vary γ accordingly.

26 See Cockerell and Russell (1995).

estimated by Gruen and Wilkinson (1991), a rise in the terms of trade reduces inflation for most estimates of β.

Figure 2: Estimated Inflationary Effect Within Two Years of a 10 per cent Rise in the Terms of Trade



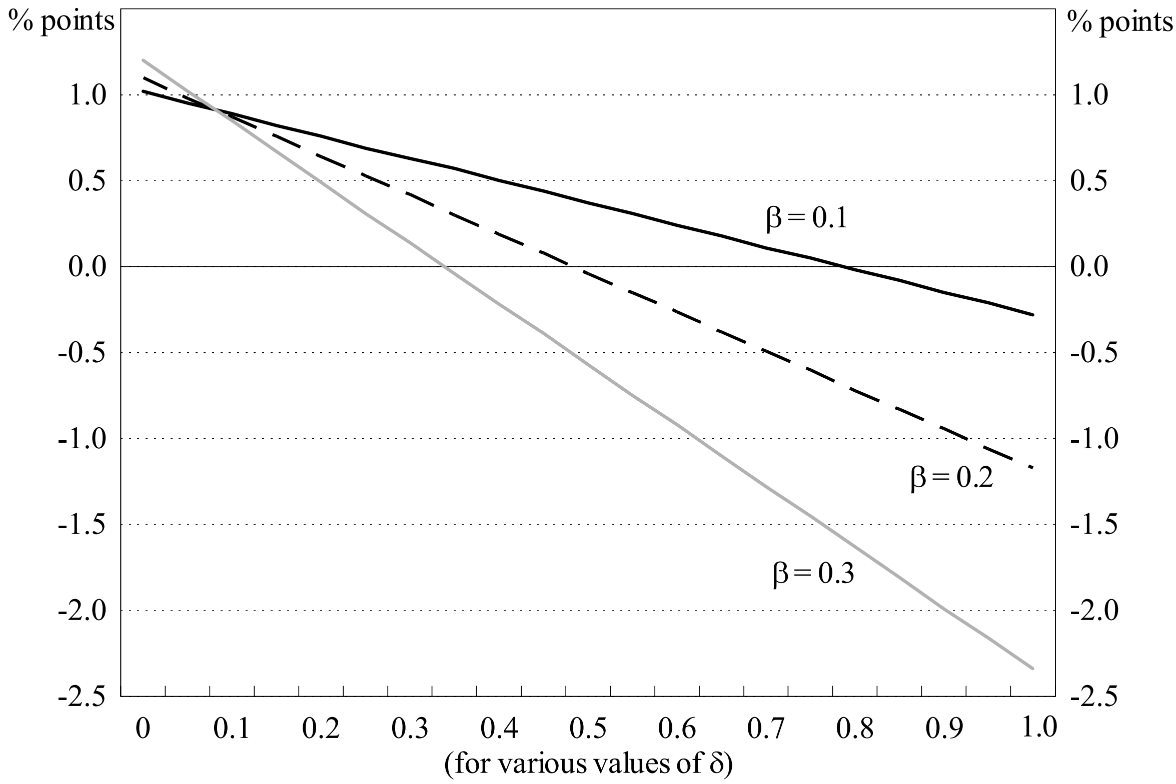
Note: The figure shows the change in the price level two years after the terms of trade rise. Hence, dividing the numbers shown by two gives the average effect on the annual inflation rate over the two years. No allowance is made for policy reaction.

There is one final issue deserving of our attention: the slow pass-through of import prices to consumer prices. For Australia, import prices over the docks respond rapidly to changes in the exchange rate. The bulk of the adjustment occurs within two quarters and is complete within a year (Dwyer *et al.* 1993). In contrast, it takes considerable time before increases in import prices over the docks are passed on to final consumer prices – with only about sixty per cent of the change passed through within our two-year window.[27] When we take account of this slow pass-through, the importables price effect is muted and therefore has less impact on the inflation outcome of a terms of trade shock, as shown in Figure 3.

[27] See for example, de Brouwer and Ericsson (1995), Wilkinson and Lam (1995) and Dwyer and Lam (1994).

Figure 3: Estimated Inflationary Effect Within Two Years of a 10 per cent Rise in the Terms of Trade

(Assuming 60 per cent of the import price change is passed through to consumer prices)



Note: The figure shows the change in the price level two years after the terms of trade rise. Hence, dividing the numbers shown by two gives the average effect on the annual inflation rate over the two years. No allowance is made for policy reaction.

In this case, when β is 0.1, a rise in the terms of trade is inflationary for most values of δ, and is largely neutral as δ approaches unity. For higher values of β, though, there is still a threshold value of δ, beyond which the inflationary effect of a change in the terms of trade changes sign. As previously, this threshold is significantly lower the higher is the assumed share of importables in consumption.

When β is 0.2, for values of δ up to about 0.5, an increase in the terms of trade is inflationary, while for greater values of δ the reverse holds. If δ is close to unity, a rise in the terms of trade is mildly disinflationary, while a fall is mildly inflationary. If δ is close to 0.5, the outcome is largely neutral. When β is 0.3 (an estimate which includes both direct and indirect effects of import prices on consumer prices), however, a rise in the terms of trade reduces inflation if δ is greater than about 0.35.

5. DISCUSSION AND CONCLUSIONS

At the outset of the paper we posed the question: when the exchange rate floats, are rises or falls in the terms of trade inflationary? The answer is 'it depends'. It depends on the size of the importables price effect relative to the other component effects. How then can the general case be distinguished from the specific cases? This requires estimates of the component effects of a terms of trade shock. These estimates are, however, subject to measurement errors which may be substantial.

The approach adopted in this paper has been to simulate a range of inflation outcomes from a given terms of trade shock, allowing key parameters to vary. In particular, we have focussed on the implications of different degrees of responsiveness of changes in the real exchange rate to changes in the terms of trade – that is, we have focussed on the effect of variations in δ. We have sought to identify the threshold value of δ, movement beyond which causes the inflationary effect of a terms of trade shock to change sign.

Our best guess, given reasonable estimates of the share of importables in consumption, and reasonable estimates of exchange rate pass-through, is that this threshold value of δ is about $^1/_3$ to $^1/_2$. Consequently, if movement of the real exchange rate is about half that of the terms of trade (as estimated by Gruen and Wilkinson (1991)), a rise in the terms of trade will have almost no impact on domestic inflation. Alternatively, if the real exchange rate moves almost one-for-one with the terms of trade (as estimated by Blundell-Wignall *et al.* (1993)), a rise in the terms of trade will put downward pressure on inflation, at least in the short run.

Importantly, though, even if the responsiveness of the real exchange rate to changes in the terms of trade is high, the absolute change in inflation is relatively small. The insulation properties of a floating exchange rate are substantial. This suggests that terms of trade shocks *should not* manifest themselves in disturbances to inflation of the magnitude witnessed in earlier episodes before the float.

APPENDIX 1: DATA

All data are quarterly, seasonally adjusted and expressed as 1989/90 constant prices for the period 1972:Q1 to 1994:Q2, unless otherwise specified.

(a) Prices

The general price level is the private consumption deflator. Source: ABS Cat. No. 5206.0.

The terms of trade is the ratio of the implicit price deflator of exports of goods and services to imports of goods and services. Source: ABS Cat. No. 5206.0.

The price of imports is the implicit price deflator for endogenous imports. Source: ABS Cat. No. 5206.0.

The price of import competing goods is an index of the domestic producer prices of industries identified as import competing. Data are not seasonally adjusted, but do not exhibit a seasonal pattern, and are for the period 1972:Q2 to 1992:Q2. Source: Dwyer (1992).

The world price of imports is an index of the export prices of the 17 largest non-oil exporting countries from which Australia imports. Source: Dwyer *et al.* (1993).

(b) Output

Output is represented by real gross domestic product (GDP(A)). Source: ABS Cat. No. 5206.0.

(c) Interest Rates

Interest rates are 90-day bank bill rates. Source: Reserve Bank of Australia, *Bulletin*.

(d) Exchange Rates

The nominal exchange rate is the trade weighted index, expressed as a quarterly average. Source: Reserve Bank of Australia, *Bulletin*.

The real exchange rate is calculated as a geometrically weighted quarterly average of the bilateral nominal exchange rate indices adjusted for relative consumer prices. Weights are proportional to merchandise trade shares between Australia and its 22 largest trading partners. Source: Reserve Bank of Australia, unpublished.

(e) Shares of Exportables and Importables in Consumption

The share of exportables in consumption is represented by the following expenditure classes of the CPI: dairy products; meat and seafoods; and breakfast cereal products. Source: ABS Cat. No. 6450.0.

The share of importables in consumption is represented by the following expenditure classes of the CPI: processed fruit and vegetables; confectionery; margarine; cooking oils and fats; clothing (less dry cleaning and shoe repairs); furniture and floor coverings; appliances; household textiles; household utensils and tools; motor vehicles; and recreation goods. Source: ABS Cat. No. 6450.0.

APPENDIX 2: DERIVATION OF EQUATION (7) IN THE TEXT

Equation (4) in the text, together with the definition $\chi = (1+\sigma+\mu)^{-1}$, implies that:

$$\Delta p_n = \chi\left(\pi + \phi(y - y_N) + \sigma \Delta p_x + \mu \Delta p_m\right) \qquad \text{(A2.1)}$$

Substituting equations (2), (3) and (A2.1) into equation (1) in the text, and using the definition of the change in the real exchange rate, $\Delta q = \Delta e + \Delta p - \pi^*$, gives:

$$\Delta p = (\alpha + \gamma\chi\sigma).(\Delta p - \Delta q + \Delta TOT) + (\beta + \gamma\chi\mu).(\Delta p - \Delta q) + \gamma\chi\left(\pi + \phi(y - y_N)\right) \qquad \text{(A2.2)}$$

and therefore, after collecting like terms:

$$\gamma\chi\Delta p = \Delta q\left(-\alpha - \beta - \gamma\chi(\sigma + \mu)\right) + (\alpha + \gamma\chi\sigma)\Delta TOT + \gamma\chi\left(\pi + \phi(y - y_N)\right) \qquad \text{(A2.3)}$$

Dividing both sides by $\gamma\chi$ and recognising that $\Delta q = \delta\Delta TOT$ then leads straightforwardly to equation (7) in the text.

APPENDIX 3: THE INCOME EFFECT

The income effect associated with a rise in the terms of trade is estimated using the following regression model:

$$\Delta GDP_t = a + \sum_{j=1}^{4} b_j \Delta GDP_{t-j} + \sum_{j=0}^{7} c_j \Delta TOT_{t-j} + \sum_{j=0}^{7} d_j \Delta RTWI_{t-j} + \sum_{j=2}^{6} e_j RBR_{t-j} \tag{A3.1}$$

where *GDP* is real gross domestic product, *RTWI* is the real trade-weighted index of the Australian dollar, and *RBR* is the real 90-day bank bill rate and controls for the influence of monetary policy.[28]

All data are quarterly and described in Appendix 1. The lag structure follows Gruen and Shuetrim (1994, p. 356) and allows for the possibility that past changes in GDP influence the current change in output, that changes in the terms of trade and the real exchange rate may take up to two years to influence *GDP* while real interest rates operate with a lag of two to six quarters. We test whether the nominated set of lags is significant collectively, rather than eliminating all insignificant lags. Ordinary Least Squares (OLS) estimation is used with standard errors estimated using a Newey-West correction allowing for fourth order autocorrelation.

Lags of the dependent variable were jointly insignificant and so were eliminated from the regression. In this reduced regression, lags of $\Delta RTWI$ were insignificant and were also eliminated.[29] Results from the preferred specification are presented in Table A3.1. The sum of the coefficients on the lags is reported.

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[28] GS conduct a similar exercise although their estimation period includes some of the pre-float period. For reasons explained by GS (p. 356), the specification chosen allows estimation of the average income effect from a terms of trade rise.

[29] In the original specification (A3.1), lags of the dependent variable and (the change in) the real TWI are *jointly significant*. We therefore checked the robustness of our results using a specification in which only lags of the dependent variable were eliminated from (A3.1). Setting $\Delta RTWI_{t-j} = \delta \Delta TOT_{t-j}$ and using either $\delta = 0.51$ or $\delta = 0.885$ gives estimates of the

Table A3.1: Regression model for GDP growth
(Dependent variable: Quarterly GDP growth)

ΔTOT	-0.04###
{lags}	{0 to 7}
RBR	-0.14***
{lags}	{2 to 6}
R^2	0.80
$\overline{R}^2$	0.38
GDP impact	0.11
Standard error of GDP impact	0.05

Note: The sum of the coefficients on the lags are reported. The sample period is 1984:1 to 1994:2. ***, **, * indicate rejection at 1%, 5%, 10% level of the hypothesis that the sum of the coefficients on the lags is zero. ### indicates rejection of the hypothesis that the coefficients are jointly zero at the 1% level. Hypothesis tests are based on standard errors estimated using a Newey-West correction allowing for fourth order autocorrelation.

The sum of the coefficients on the terms of trade, while negative, is insignificantly different from zero. The coefficients on the first two lags are substantially positive, implying that a rise in the terms of trade provides an initial boost to GDP, after which *the level of GDP* returns to its long-run equilibrium. In other words, a terms of trade rise has only a temporary positive impact on output. The sum of the coefficients on *RBR* is of the expected negative sign and highly significant, indicating that a tightening of monetary policy reduces growth.

The per cent-years of real GDP gained within two years of a once-off change in the terms of trade, ΔTOT, is given by:

$$Extra\ GDP = \Delta TOT \sum_{j=0}^{7} \left\{ \left(\frac{8-j}{4} \right) c_j \right\} \tag{A3.2}$$

This formula cumulates the impact of a change in the terms of trade on GDP over two years (for which coefficient estimates for lags 0 to 7 are required). (Dividing by 4 converts the result from per cent-quarters to per cent-years.) The result of this

income effect of a terms of trade rise that are almost identical to those reported, although the standard errors are larger.

calculation is reported in the table and indicates that for a 10 per cent rise in the terms of trade, the level of real GDP rises by $0.11 \times 10 = 1.1$ per cent-years.

The inflationary effect of the higher income is found by multiplying the real GDP impact by the parameter ϕ (see the text). Thus, for a 10 per cent rise in the terms of trade, the higher income causes an increase in inflation of $1.1 \times \phi = 1.1 \times 0.4 = 0.44$ percentage points.

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