RBA ECONOMICS COMPETITION 2010

Australia's Real Exchange Rate Appreciation:
Determinants and Implications for the Economy

First Prize

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1. Introduction

Australia's real exchange rate (RER) has undergone a sustained appreciation of roughly 60%[1] in trade-weighted terms over the last decade. This essay will examine the various fundamentals driving the appreciation, such as the favourable rise in the terms of trade, the booming mining sector, real interest rate differentials and the relationship to the current account deficit. An ordinary least squares regression will be conducted to find how well the fundamentals explain the RER appreciation. The implications of the appreciation for Australia's long-term economic performance will be discussed, such as the shift to a more commodity based economy and corresponding "Dutch Disease" effects.

2. Definition of Real Exchange Rate

The real exchange rate, q, stated in equation (1), is the nominal exchange rate[2] S adjusted by the relative price differential between home and abroad, $\frac{P}{P*}$.

$$q = \frac{P}{SP*} \tag{1}$$

The RER can be interpreted as the relative price of domestic to foreign goods, with an appreciation ($q\uparrow$) implying the purchasing power of domestic goods in terms of foreign goods increasing.

The measure of Australia's real exchange rate to be used throughout the essay is the Real Trade Weighted Index (RTWI), which is a weighted average of the real exchange rates between Australia and its trading partners[3].

[1] From December 2000 to June 2010

[2] S is the domestic currency cost of a unit of foreign currency

[3] $RTWI = \prod_{i=1}^{n} q_i^{w_i}$, $\sum_{i=1}^{n} w_i = 1$, where q_i is the real exchange rate of the ith trading partner, and the sum of the weights equal 1. The weights are dependent on trade shares.

3. **Decomposing the Real Exchange Rate**

The below analysis *(Stein, 1995)* attempts to decompose the real exchange rate into the terms of trade (TOT) and the relative price of traded to non-traded goods.

(2) $$P = {P_N}^{a} {P_T}^{1-a}$$

(3) $$P^* = {P_{N^*}}^{b} {P_{T^*}}^{1-b}$$

(4) $$\alpha = \frac{P_T}{P_N}$$

(5) $$TOT = \frac{P_E}{SP_{M^*}} = \frac{P_T}{SP_{T^*}}$$

The domestic and world absolute price levels are a function of the non-traded and traded goods prices, as shown in equations (2) and (3). Equation (4) states the relative price of traded to non-traded goods as α, and the TOT in (5) is the ratio of export to import prices. The assumption in (5) is that tradable prices domestically and in the world are equal to their export prices.

(6) $$q = \frac{P}{SP^*} = \frac{{P_N}^{a} {P_T}^{1-a}}{{SP_{N^*}}^{b} {P_{T^*}}^{1-b}} = \frac{P_T}{SP_{T^*}} \left(\frac{P_T}{P_N}\right)^{-a} \left(\frac{P_{T^*}}{P_{N^*}}\right)^{b} = TOT\,\alpha^{-a} \left(\frac{P_{T^*}}{P_{N^*}}\right)^{b}$$

Equation (6) states the RER is positively related to the TOT and negatively to the relative price of traded goods α.

4. **RER and the Terms of Trade**

The positive relationship between the RER and the TOT is well supported by data. One can find a substantial correlation[4] of 0.84 between the TOT and the RTWI from 1995 to 2010 (Figure 1), with both series on a persistent upward trend.

The increase in the TOT is predominantly due to exceptional price growth of non-rural commodity exports such as Iron-Ore and Coal (Figure 2), which rose by 150%

[4] Correlation between two series x, y is measured as $r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 (y_i - \bar{y})^2}}$, where the bar denotes an arithmetic average of the variable.

and 87% respectively from 2004 to 2008 reflecting increased demand from China and other emerging market economies (*Treasury, 2008*).

Assuming the quantities of exports and imports do not change, a rise in the TOT will increase export earnings relative to import payments and shift the trade balance into surplus. The increase in net exports represents a rise in demand for Australian currency, implying a RER appreciation.

An increase in export prices relative to import prices means a larger volume of imports can be purchased with a given volume of exports, increasing the purchasing power of domestic production *(RBA, 2005)*. This means the rise in the TOT enables growth in domestic income to outpace GDP growth, as shown in figure 3. The increase in real income leads to greater spending on non-tradable goods, upward pressure on inflation, and an increase in the relative price of non-traded to traded goods, both effects contributing to a RER appreciation.

5. RER and the Relative Price of Tradable to Non-Tradable Goods

It was shown in section 3 that the RER is negatively related to the relative price of traded to non-traded goods, α . This result can be shown in figure 4 *(Clements, 1981)*. On the right quadrant, the initial equilibrium E_0 of (P_{T0} , P_{N0}) lies along the absolute price schedule A-A[5]. A decline in the relative price of traded goods from α_0 to α_1 will lead to a fall in the traded goods price from P_{T0} to P_{T1} in the new equilibrium E_1.

By Purchasing Power Parity, the nominal exchange rate (NER) is equal to the relative price of traded goods in domestic and foreign prices. As shown in the left quadrant, the decline in the traded goods price leads to a NER[6] appreciation from S_0 to S_1, implying a RER appreciation, as shown in equations (7) and (8).

[5] Along the absolute price schedule A-A, the total price level is kept constant. It is downward sloping as a decline in the traded goods price must be met by an increase in the non-traded goods price to keep the absolute price level fixed.

[6] S is the units of domestic currency per unit of foreign currency. Therefore a fall in S implies an appreciation of the nominal exchange rate.

(7) $$S\downarrow = \frac{P_T\downarrow}{P_T^*}$$

(8) $$q\uparrow = \frac{P}{(S\downarrow)P^*}$$

Examining data from 1998 (Figure 5), one can see a strong positive relationship between the RTWI and the relative price of non-tradable to tradable goods ($\frac{P_N}{P_T} = \frac{1}{\alpha}$), with a correlation of 0.86.

6. **Effect of a Booming Export Sector on the RER**

Given the upward trend of the TOT has been largely driven by substantial price growth in non-rural commodities; Australia has experienced a boom in mining exports. The below analysis follows *Clements et al (2008)* to illustrate how a booming export sector leads to an appreciation of the RER.

Figure 6 illustrates the effects of a booming export sector. Suppose the economy is divided into a non-tradable and tradable sector composed of importables and exportables. The NN schedule represents equilibrium in the non-tradable goods sector and a zero trade balance[7].

E_0 represents equilibrium in the non-traded sector at a specific TOT of $\theta = \frac{P_E}{P_M}$, which is assumed constant. The effect of a booming mining sector is an exogenous increase in net exports, such that points on the original NN schedule now represent points of surplus in the trade account. This means at the original equilibrium E_0 the relative price of importables and exportables in terms of non-traded goods is too high, and requires the NN curve to shift inward in order to attain a zero trade balance. The new equilibrium E_1 is at a lower relative price of importables and exportables. The lower relative price of traded goods as stated in equation (9) causes a RER appreciation.

[7] Points to the right of the NN schedule represent an excess supply of exportables and a positive trade balance (TB>0), and points to the left represent a negative trade balance.

(9) $$\frac{P_T}{P_N} = \beta \frac{P_M}{P_N} + (1-\beta)\frac{P_E}{P_N}, \qquad \frac{P_M}{P_N}\downarrow, \ \frac{P_E}{P_N}\downarrow \Rightarrow \frac{P_T}{P_N}\downarrow$$

7. **RER and the Current Account Deficit**

The adjustment of the RER is fundamental to equilibrating the balance of payments (BOP). Examining recent trends, one can identify a gradual increase in the CAD as a percentage of GDP, from roughly 3% on average in the 1995-2004 period to 5% of GDP from 2004 onwards (Figure 8). This trend is attributed to increasing mining investment, which has risen from 1% to 4.5% of GDP in the last decade (*Budget 2010*).

The increase in mining investment and the favourable TOT's effect on the CAD and the RER is illustrated in figure 7, where the former is represented as a rightward shift of the Net Financial Inflows (NFI) curve, and the latter is represented as a leftward shift of the Net Imports curve (NM). The net result is a widening of the CAD, with both shifts reinforcing the appreciation of the RER from q_0 to q_1 to attain BOP equilibrium. A correlation of 0.78 between the RTWI and the CAD to GDP ratio from 1995 to 2010 (Figure 8) indicates a strong positive relationship.

8. **RER and the Real Interest Rate differential**

RER changes can be explained by the real interest rate differential[8] (RIRD). The equations below follow *Gruen (1994)*, making use of Real Interest Rate parity (RIRP). Equation (10) states RIRP; the expected appreciation of the RER, q, is equal to the difference between foreign and domestic real rates (R* and R) on bonds of maturity k.

(10) $$\frac{E_t(q_{t+k}) - q_t}{q_t} = kR_t^* - kR_t$$

Equation (11) states that the expected appreciation is proportional to the difference between the current exchange rate and its long run average $\overline{q}$.

[8] The RIRD is defined as the difference between the domestic and world real rate, r –r*

(11) $$\frac{E_t(q_{t+k}) - q_t}{q_t} = \rho(\bar{q} - q_t) \quad , \quad \rho > 0$$

Equation (12) is found by substituting (11) into (10) to find q_t in terms of current variables. It is clear that there is a positive relationship between q_t and $kR_t - kR_t^*$, which implies that an increase in Australia's RIRD leads to an appreciation of the RER.

(12) $$q_t = \bar{q} + \frac{1}{\rho}(kR_t - kR_t^*)$$

A more intuitive explanation is to consider the effect of the RIRD on the capital account. This is shown in figure 10, where a reduction in the world rate[9] r* leads to a net capital inflow to acquire higher returns on Australian assets, a rise in the capital account (KA) and a RER appreciation from q_0 to q_1 to attain BOP equilibrium. Examining the data from 2002 to 2010 (Figure 9), one can find the RIRD[10] is consistently positive for this period, with a moderate positive correlation of 0.64 with the RTWI.

9. **Regression of the RER against fundamentals**

An OLS regression[11] of the RTWI against 4 explanatory variables, the TOT, relative price of non-traded to traded goods, the RIRD and the CAD to GDP ratio has been conducted. The structure of the regression is shown in equation (13), and the estimated form is shown in equation (14), where the coefficient estimates and their respective p-values are shown. More detailed regression results and the table of data used are in figures (11) and (12).

(13) $$RTWI_t = \alpha + \beta_1 TOT_t + \beta_2\left(\frac{P_N}{P_T}\right)_t + \beta_3(r - r^*)_t + \beta_4\left(\frac{CAD}{GDP}\right)_t + u_t$$

[9] An increase in the RIRD can be represented by a fall in r*, which raises (r-r*)

[10] The world real rate is an arithmetic average of US, UK, Euro and Japan real rates. It is the ex post real rate as it subtracts actual inflation from the nominal interest rate. The nominal interest rates used are central bank policy rates.

[11] The regression assumes classical Gauss-Markov assumptions apply to the error term u_t. More elaborate analysis using cointegration and VAR models are ignored for simplicity. The software program Eviews has been used to run the regression.

$$(14)\quad \hat{RTWI}_t = -19.9 + \underset{(0.49)}{} \quad \underset{(0.0295)}{0.21TOT_t} + \underset{(0.0314)}{83.02\left(\frac{P_N}{P_T}\right)_t} + \underset{(0.0256)}{2.97(r - r^*)_t} + \underset{(0.0000)}{5.26\left(\frac{CAD}{GDP}\right)_t}$$

P - value

The coefficient estimates are all positive; implying an increase in each explanatory variable is expected to appreciate the RER. This conforms to the analytics of previous sections, and the p-values of all coefficient estimates are below 0.05, indicating the coefficients are statistically significant from zero at a 5% level of significance. An R^2 of 0.913 indicates that 91.3% of the variation in the RER is explained by variation in the explanatory variables. Tests in figures (13) and (14) show there are no heteroscedasticity or serial correlation problems in the data, implying the regression results are accurate[12].

10. **Long-term implications for the Australian Economy**

From Section 6, it was shown that a booming mining sector leads to a fall in the relative price of exports and imports in terms of non-tradable goods. Given the consequent RER appreciation, it is clear the profitability and competitiveness of the lagging tradable sector will deteriorate.

This "Dutch Disease" effect[13] has implications for Australia's lagging Manufacturing sector. The RER appreciation increases the costs of non-traded inputs, mobile factors and makes manufacturing exports relatively more expensive overseas, reducing foreign demand. These negative effects are likely to overwhelm the positive effect of lower imported input costs, leading to a net deterioration of the lagging sector *(Freebairn, 1990)*.

Manufacturing export volume growth has shrunk in the 2000s and was even negative in 2003-04 (Figure 15), with stagnant investment as a share of GDP (Figure 16).

[12] The fact that there is no heteroscedasticity and serial correlation in the data implies the error term conforms to the Gauss-Markov assumptions, and consequently the OLS estimators are the most efficient unbiased linear estimators.

[13] "Dutch Disease" effect refers to the adverse impact a commodity boom can have on the lagging tradable sector via a RER appreciation. The term was coined to describe how the North Sea Natural gas boom of the Netherlands caused a decline in their manufacturing sector.

Manufacturing is also hurt by a resource movement effect, where an increase in demand for labour and capital by the booming mining sector will lead to a flow of resources from the lagging to booming sector *(Treasury, 2008)*, which can be seen in figure 17.

The non-tradable sector achieves a net gain in profitability from a RER appreciation, as not only does the relative price of non-traded goods increase (Figure 5), but the cost of imported inputs fall, outweighing the rise in labour costs and export commodity inputs. The RER appreciation partially offsets the benefits to the booming sector, as Australian dollar prices rise by less than the increase in commodity prices, and non-traded inputs and labour costs rise *(Freebairn, 1990)*.

There is an expectation that Australia's TOT boom will sustain for some time into the future, as the increase in demand for commodities is partly structural due to the emergence of industrial China. Mining investment could reach up to 6% of GDP in the future, implying the rise in the RER is to continue and its associated "Dutch Disease" effects, with Australia becoming a more commodity based economy *(Thirwell, 2007)*.

The long-term effects of a RER appreciation on the Australian economy are highly dependent on the state of economic policy. A floating nominal exchange rate has taken the burden of RER adjustment (Figure 18), enabling inflation to be stable and consistent with Australia's inflation targeting regime. Flexible labour markets have enabled structural adjustment to occur by transferring labour from less to more productive sectors. Australian policy should encourage and not impede the resource reallocation required to adjust to structural change.

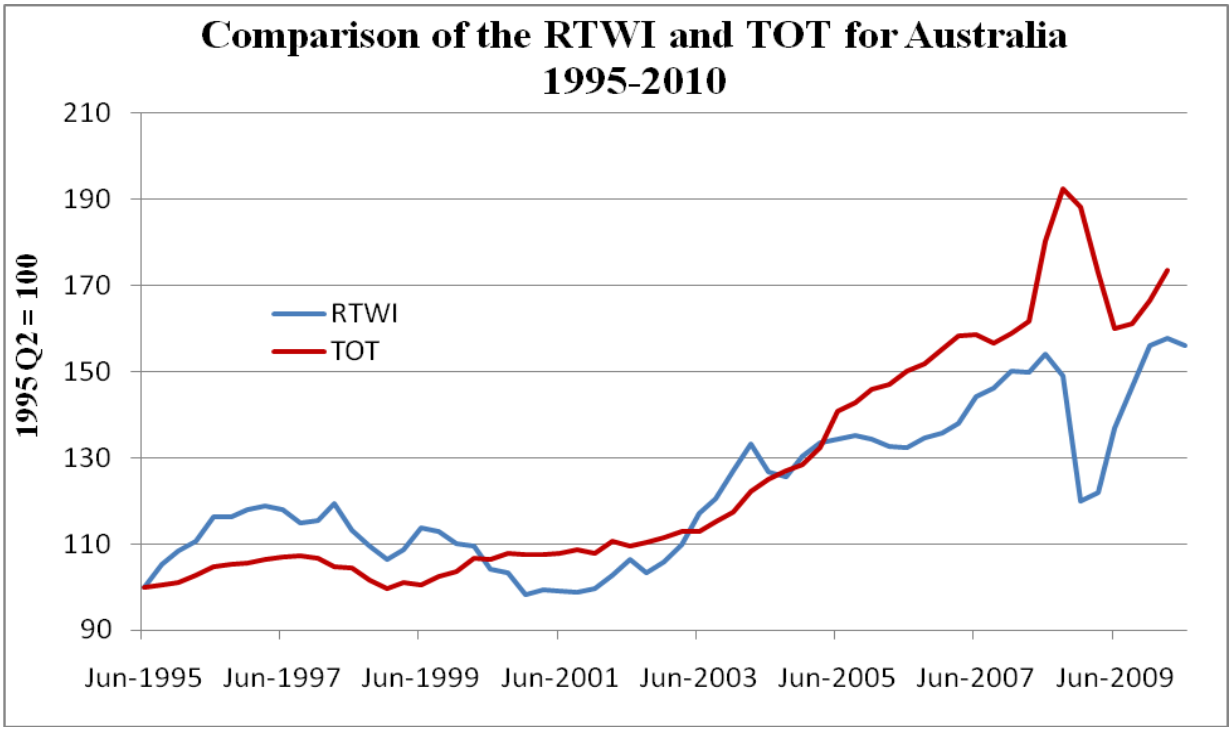
11. **Conclusion**

The essay has examined both the determinants and implications of the recent RER appreciation on the Australian economy. A substantial improvement in the TOT and the associated commodity boom has been the main impetus for a RER appreciation. The consequent rise in real income stimulates demand on non-tradable goods, increasing their relative price. A substantial rise in mining investment has increased

the CAD, and Australia's RIRD has been consistently positive over this period. These observations explain much of the real appreciation, and a regression analysis finds the TOT, relative price of non-traded goods, RIRD and the CAD to GDP ratio explaining 91% of the RER movement over the last decade. The predominant economic effect of the appreciation is to induce "Dutch Disease" effects, where the lagging manufacturing sector suffers a relative decline and the commodities and non-tradable sectors rise in importance. The RER appreciation facilitates a transfer of real resources from less to more productive sectors of the economy, promoting structural change thereby making the tradable sector more efficient and competitive.

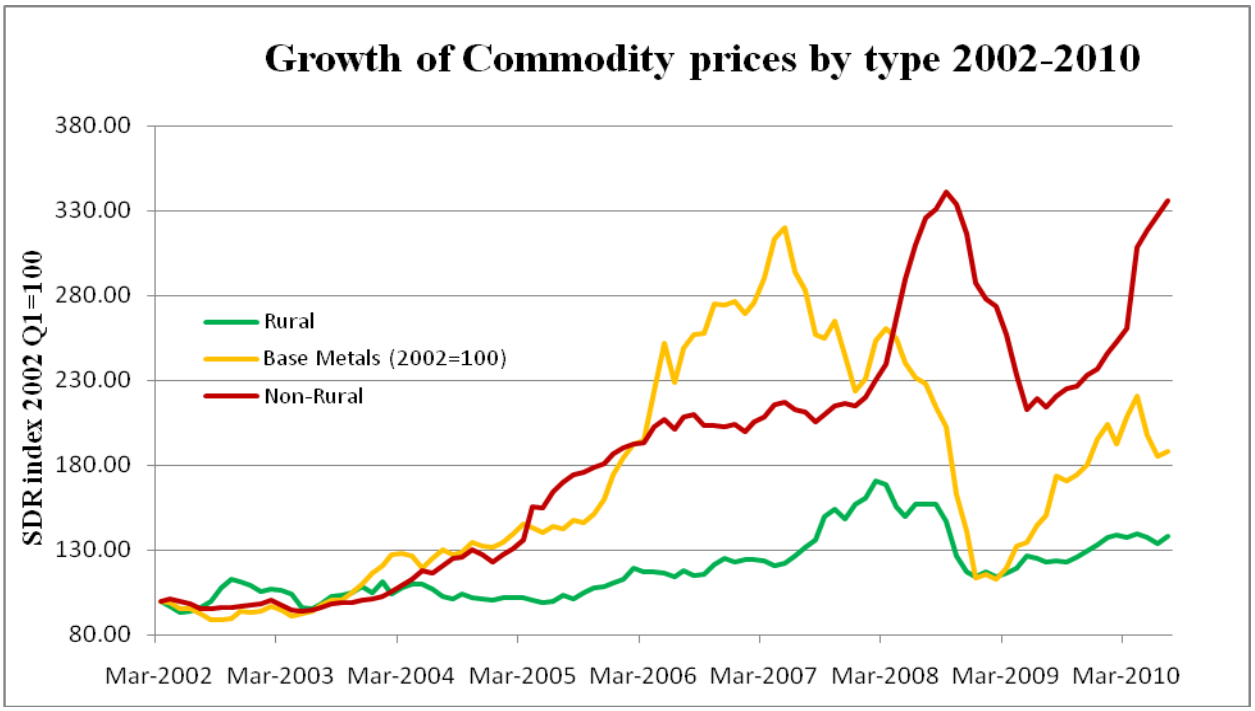
Appendix

Figure 1



Source: RBA Statistics (2010), Series F15 and G4

Figure 2



Source: RBA Statistics (2010), Series G5

Figure 3

Contributions to Gross National Income (GNI) Growth, TOT effect makes GNI greater than GDP in 2000s *(Source: Budget paper 2010)*

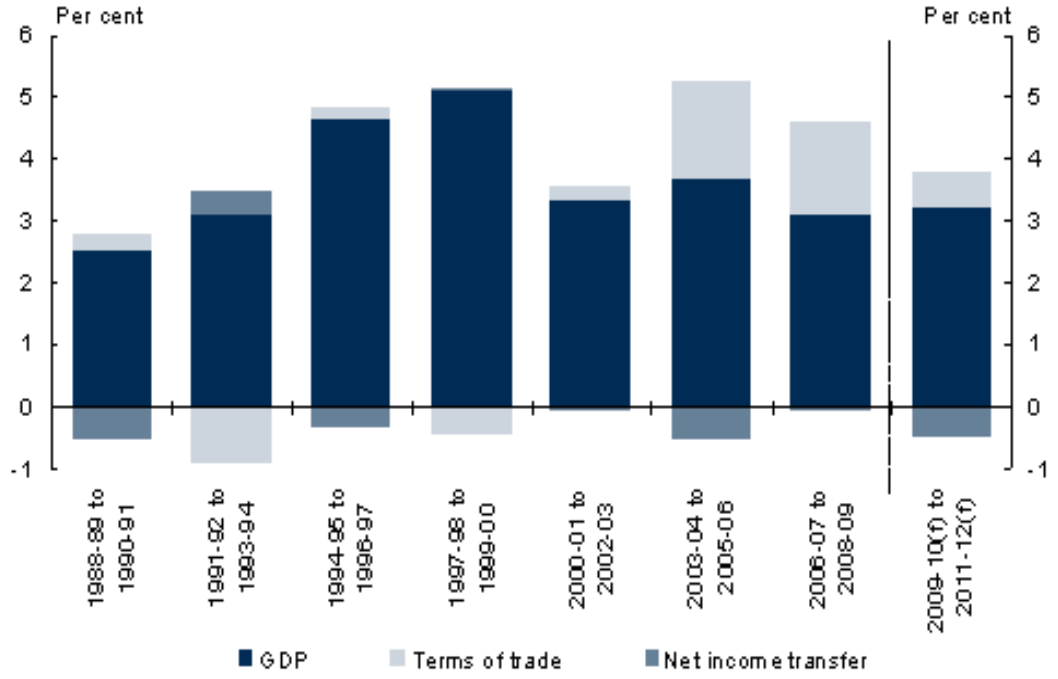


Figure 4

A decline in the relative price of traded goods appreciates the RER

Source: Clements et al (2007)

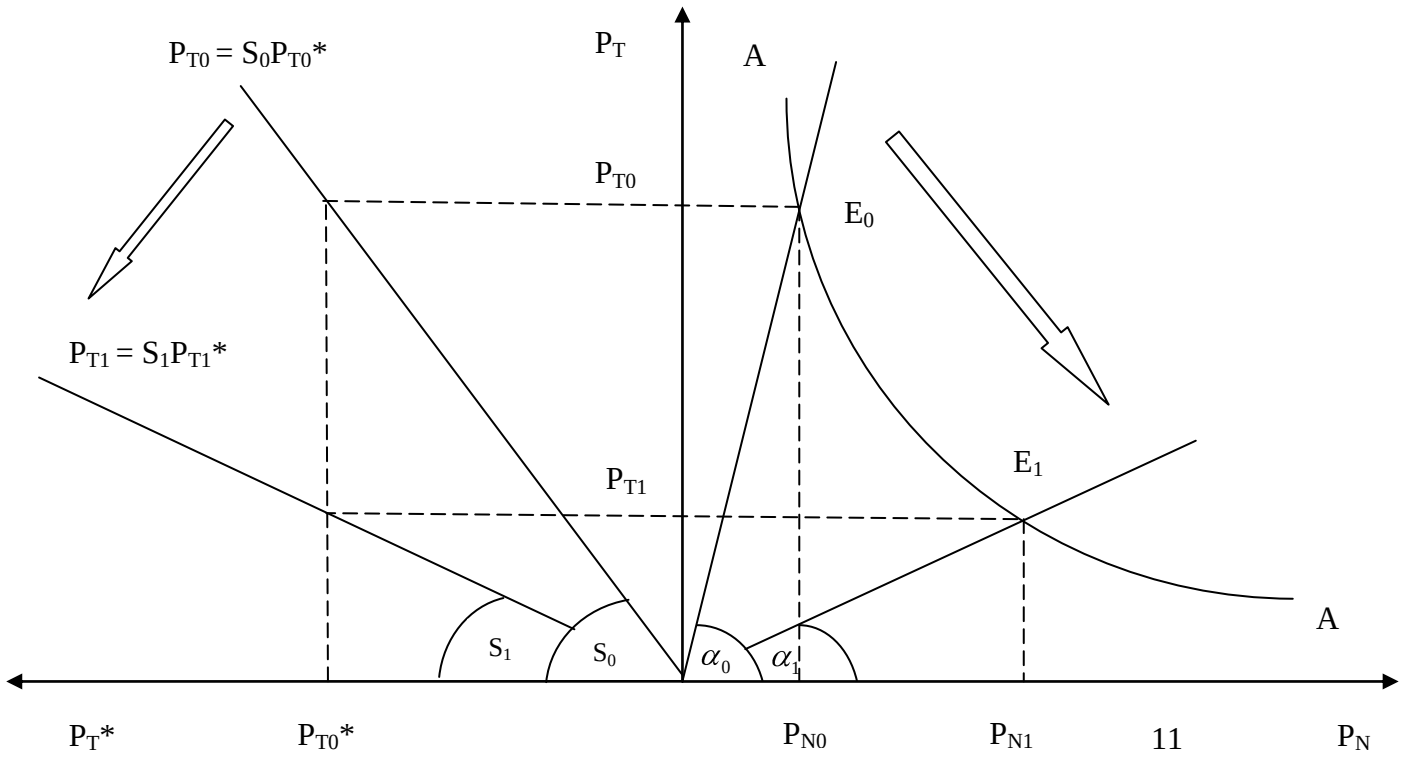
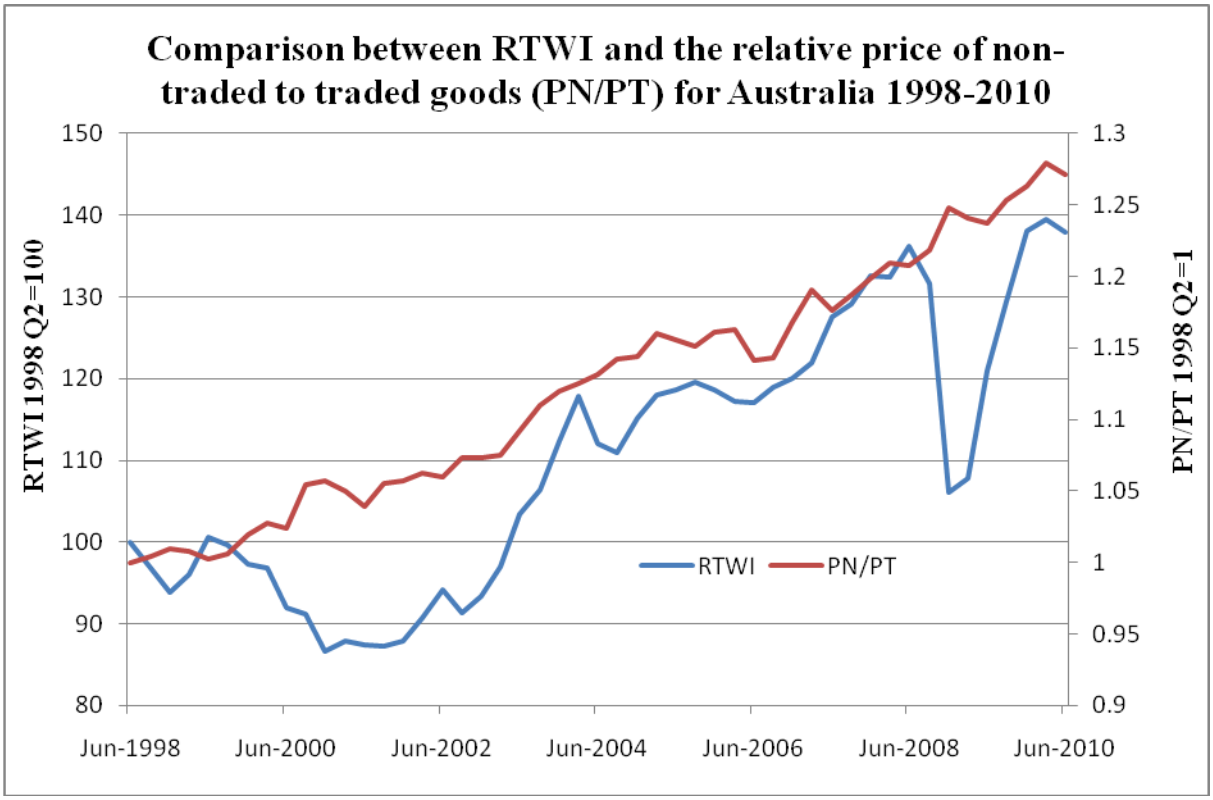


Figure 5



Source: RBA Statistics (2010), Series F15 and G2

Figure 6

The effect of a booming export sector on the relative price of exports and imports *Source: Clements et al (2007)*

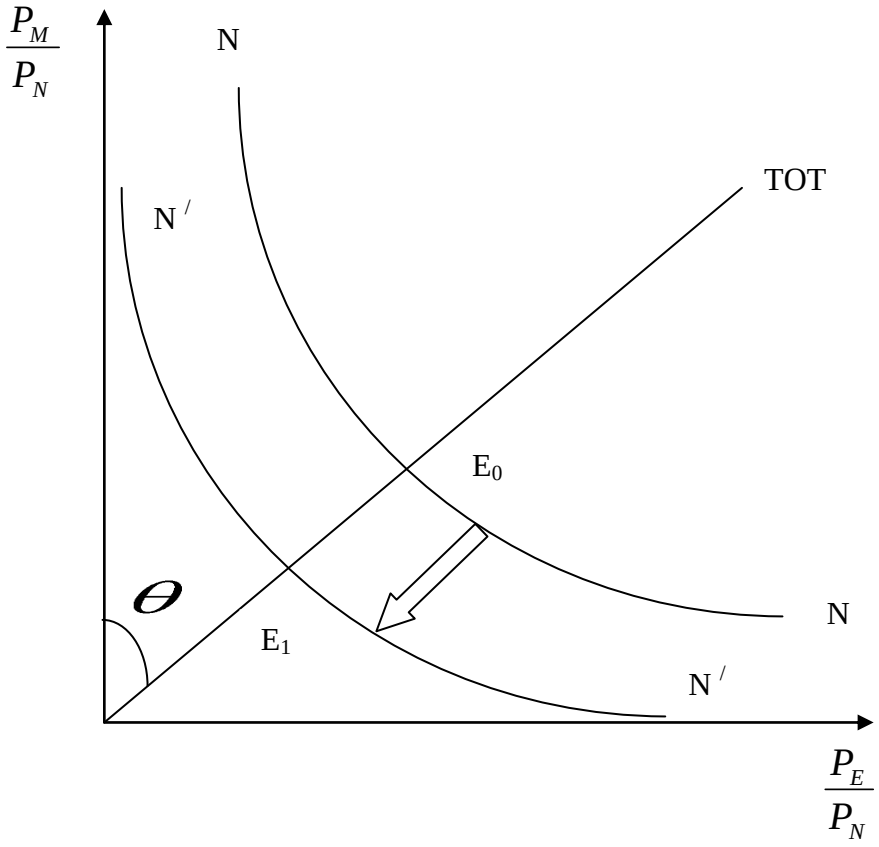
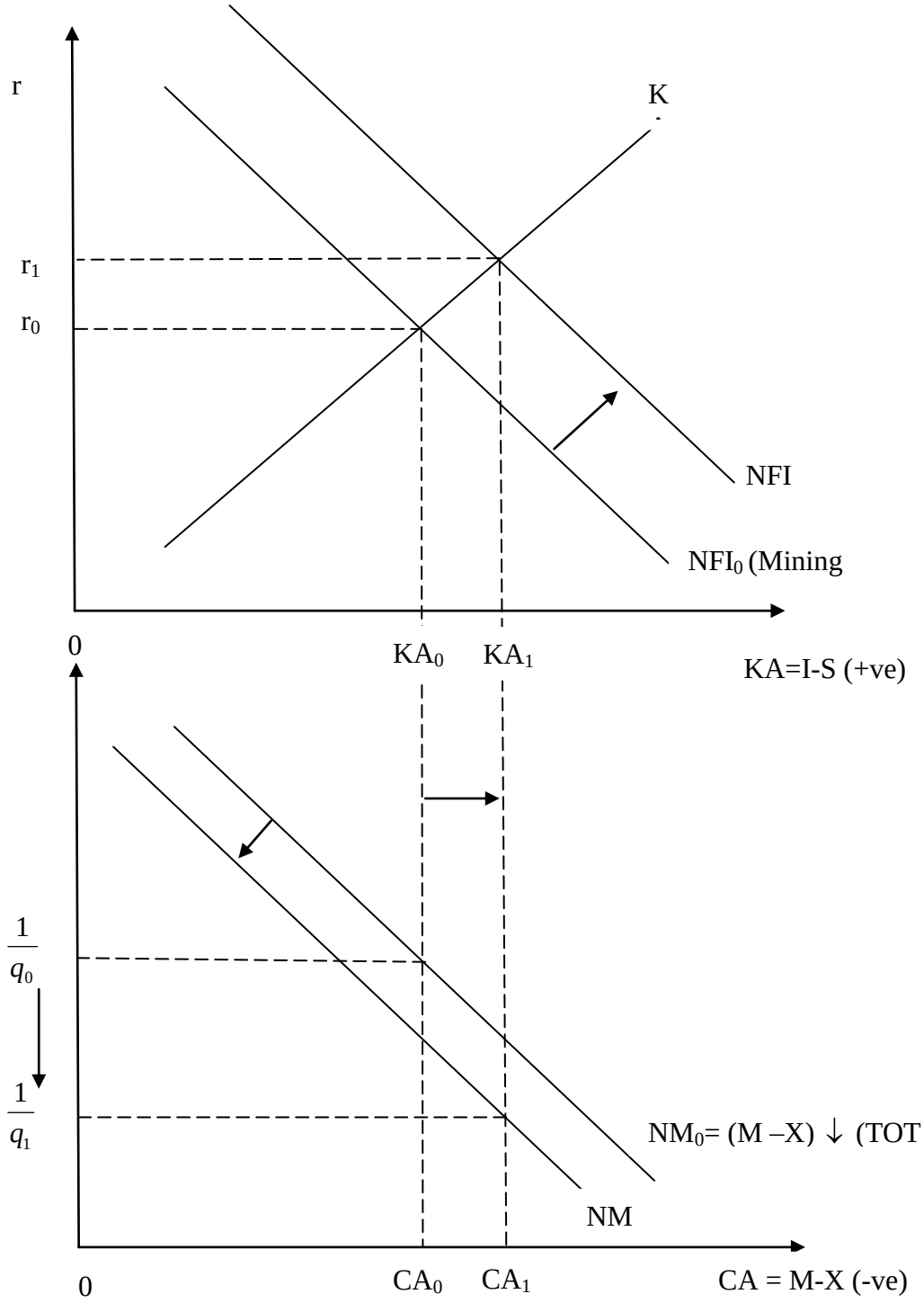


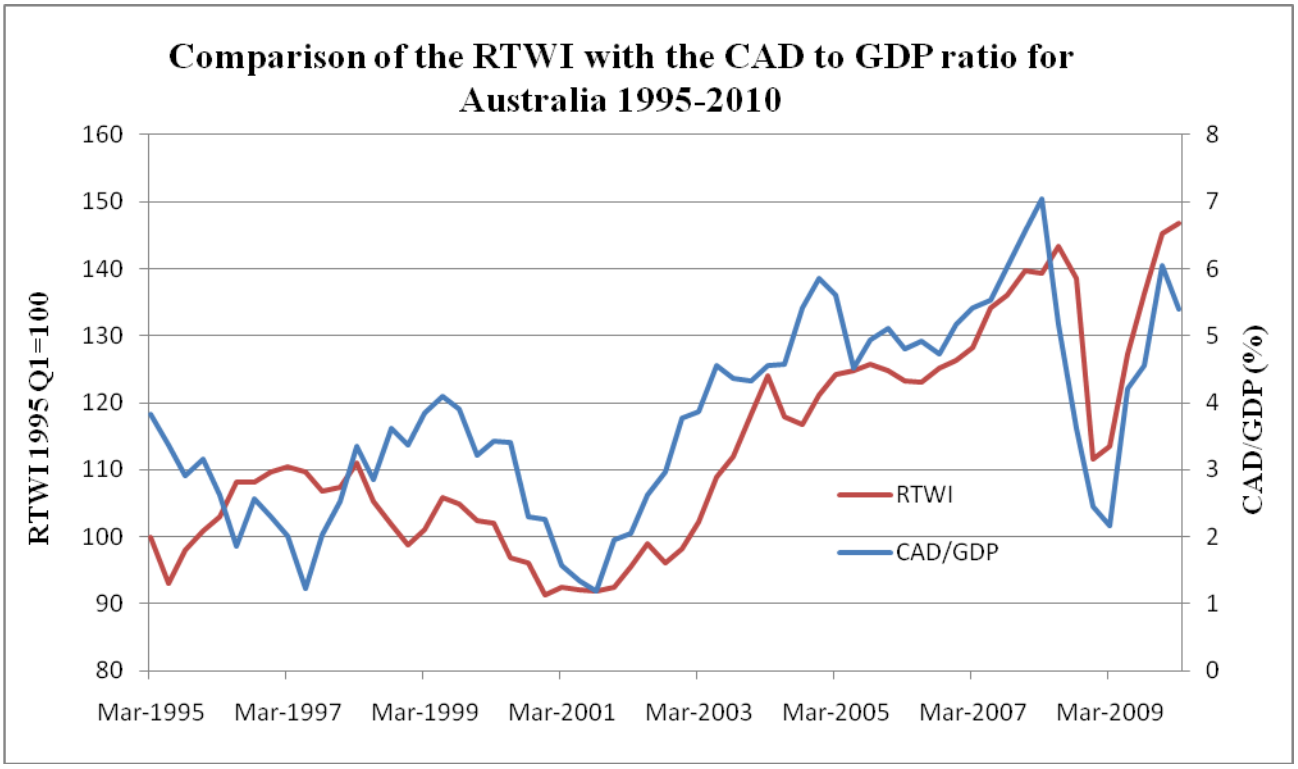
Figure 7

The effect of an increase in mining investment and a TOT boom on the CAD and the RER



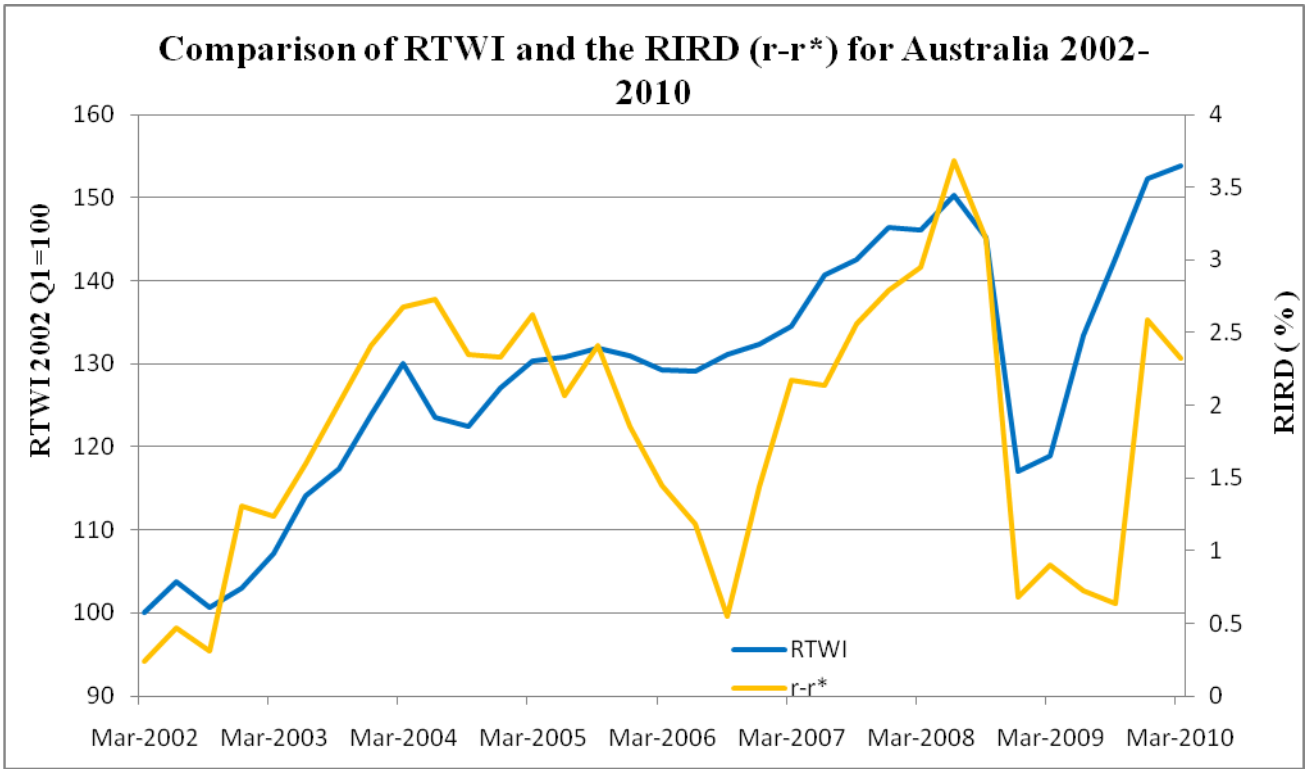
Symbols: CA = Current Account, KA= Capital Account, NFI= Net Financial Inflows, NM= Net imports

Figure 8



Source: RBA Statistics (2010) Series F15, G10 and H1

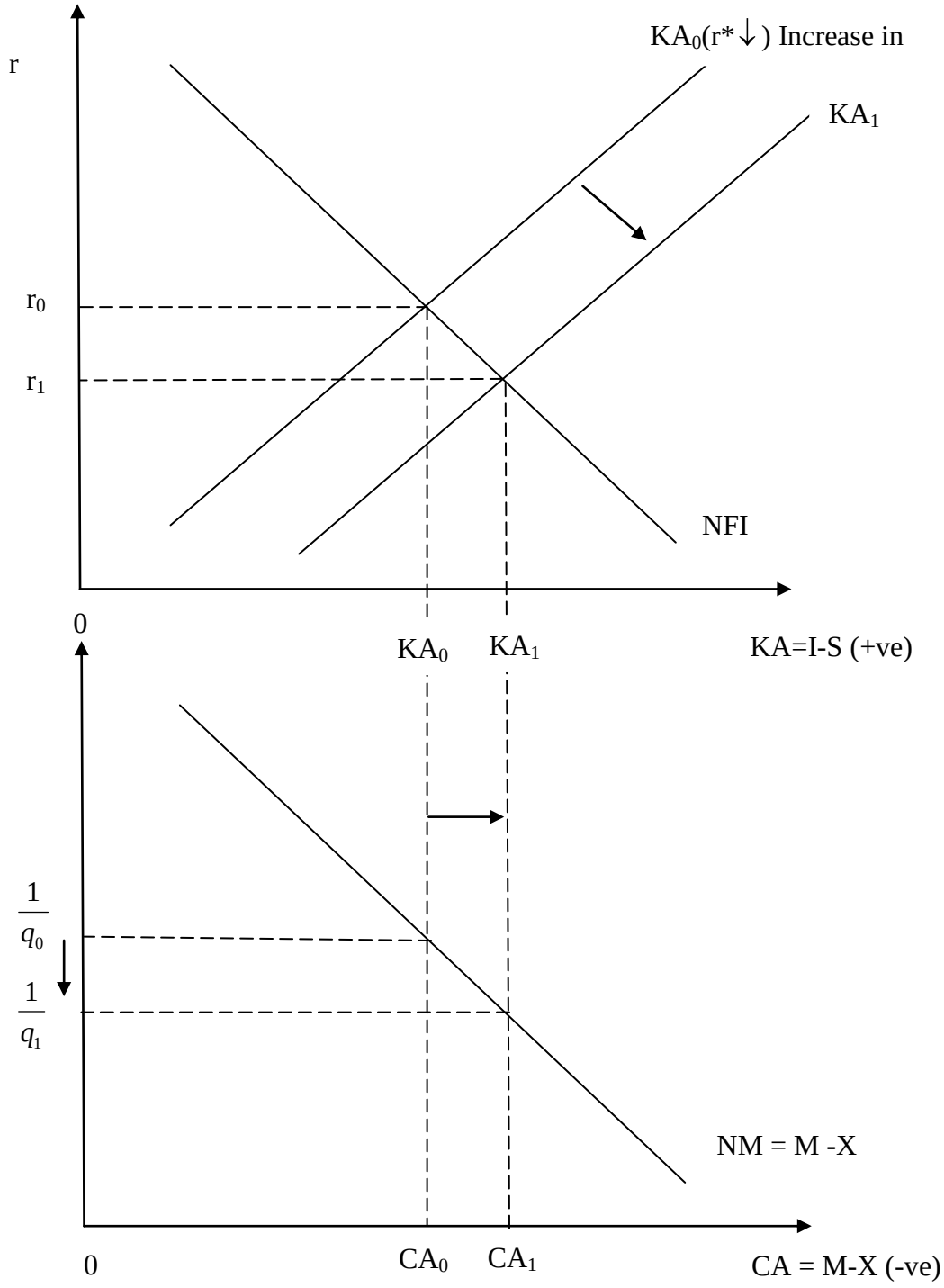
Figure 9



Source: RBA Statistics (2010) Series F13, F15, G1 and I2

Figure 10

The effect of an increase in the RIRD (r*fall) on the RER



Symbols: CA = Current Account, KA= Capital Account, NFI= Net Financial Inflows, NM= Net imports

Figure 11

Data used for regression of RTWI *(Source: Refer to figures 2,6,8,9)*

Note: Below data rounded off for presentation, actual regression used more exact data

Date	RTWI	TOT	PN/PT	RIRD (%)	CAD/GDP (%)
Mar-2002	100.0	100.0	1.000	0.242	2.05
Jun-2002	103.8	99.1	0.998	0.465	2.62
Sep-2002	100.6	99.9	1.011	0.307	2.97
Dec-2002	103.0	100.9	1.010	1.306	3.77
Mar-2003	107.0	102.1	1.012	1.241	3.86
Jun-2003	114.1	102.2	1.029	1.595	4.56
Sep-2003	117.4	104.0	1.045	2.010	4.37
Dec-2003	123.9	106.1	1.054	2.408	4.32
Mar-2004	129.9	110.6	1.059	2.679	4.56
Jun-2004	123.5	113.0	1.065	2.729	4.58
Sep-2004	122.4	114.8	1.075	2.352	5.42
Dec-2004	127.0	116.2	1.077	2.330	5.85
Mar-2005	130.2	119.8	1.092	2.619	5.60
Jun-2005	130.8	127.3	1.088	2.067	4.51
Sep-2005	131.8	129.1	1.084	2.409	4.95
Dec-2005	130.8	132.0	1.093	1.858	5.11
Mar-2006	129.2	133.1	1.094	1.447	4.80
Jun-2006	129.0	135.8	1.075	1.187	4.92
Sep-2006	131.1	137.3	1.076	0.545	4.72
Dec-2006	132.4	140.5	1.100	1.441	5.17
Mar-2007	134.4	143.2	1.121	2.176	5.43
Jun-2007	140.6	143.4	1.107	2.140	5.53
Sep-2007	142.5	141.6	1.117	2.559	6.04
Dec-2007	146.3	143.8	1.129	2.791	6.56
Mar-2008	146.1	146.3	1.139	2.949	7.05
Jun-2008	150.3	163.0	1.137	3.686	5.16
Sep-2008	145.1	174.1	1.147	3.143	3.63
Dec-2008	117.0	170.3	1.175	0.676	2.45
Mar-2009	118.9	156.5	1.168	0.902	2.17
Jun-2009	133.3	144.9	1.165	0.728	4.21
Sep-2009	142.7	145.9	1.180	0.637	4.56
Dec-2009	152.2	150.7	1.189	2.588	6.05
Mar-2010	153.8	156.9	1.205	2.325	5.39

Figure 12

Regression results

Dependent Variable: RTWI
Method: Least Squares
Date: 08/17/10 Time: 09:50
Sample: 2002Q1 2010Q1
Included observations: 33

	Coefficient	Std. Error	t-Statistic	Prob.
C	-19.94265	28.54443	-0.698653	0.4905
TOT	0.212808	0.092740	2.294672	0.0295
PN_PT	83.01869	36.63475	2.266118	0.0314
R_R_	2.974646	1.261801	2.357461	0.0256
CAD_GDP	5.263323	0.990141	5.315728	0.0000

R-squared	0.912845	Mean dependent var	128.5201
Adjusted R-squared	0.900394	S.D. dependent var	14.98763
S.E. of regression	4.730154	Akaike info criterion	6.084520
Sum squared resid	626.4821	Schwarz criterion	6.311264
Log likelihood	-95.39458	Hannan-Quinn criter.	6.160812
F-statistic	73.31661	Durbin-Watson stat	1.452613
Prob(F-statistic)	0.000000		

Source: Eviews Version 6

Figure 13

Heteroscedasticity Test: White (No cross terms)

$$\hat{u}_t^{\,2} = \alpha + \beta_1 TOT_t^{\,2} + \beta_2\left(\frac{P_N}{P_T}_t\right)^2 + \beta_3 (r - r^*)_t^{\,2} + \beta_4\left(\frac{CAD}{GDP}_t\right)^2 + v_t$$

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ (Homoscedasticity)

H_1: At least one β not equal to zero (Heteroscedasticity)

P-value > 0.05 implies do not reject H_0 at 5% level of significance, therefore no evidence of Heteroscedasticity in data.

Results

F-statistic	2.344635	Prob. F(4,28)	**0.0791**
Obs*R-squared	8.279934	Prob. Chi-Square(4)	0.0818
Scaled explained SS	5.801547	Prob. Chi-Square(4)	0.2145

Source: Eviews Version 6

Figure 14

Breusch-Godfrey Serial Correlation LM Test (1 lag):

$$\hat{u}_t = \beta_0 + \beta_1 TOT_t + \beta_2\left(\frac{P_N}{P_T}_t\right) + \beta_3(r - r^*)_t + \beta_4\left(\frac{CAD}{GDP}_t\right) + \beta_5 \hat{u}_{t-1} + v_t$$

H_0: $\beta_5 = 0$ (No serial correlation)

H_1: $\beta_5 \neq 0$ (Serial correlation)

P-value > 0.05 implies do not reject H_0 at 5% level of significance, therefore no evidence of serial correlation in data.

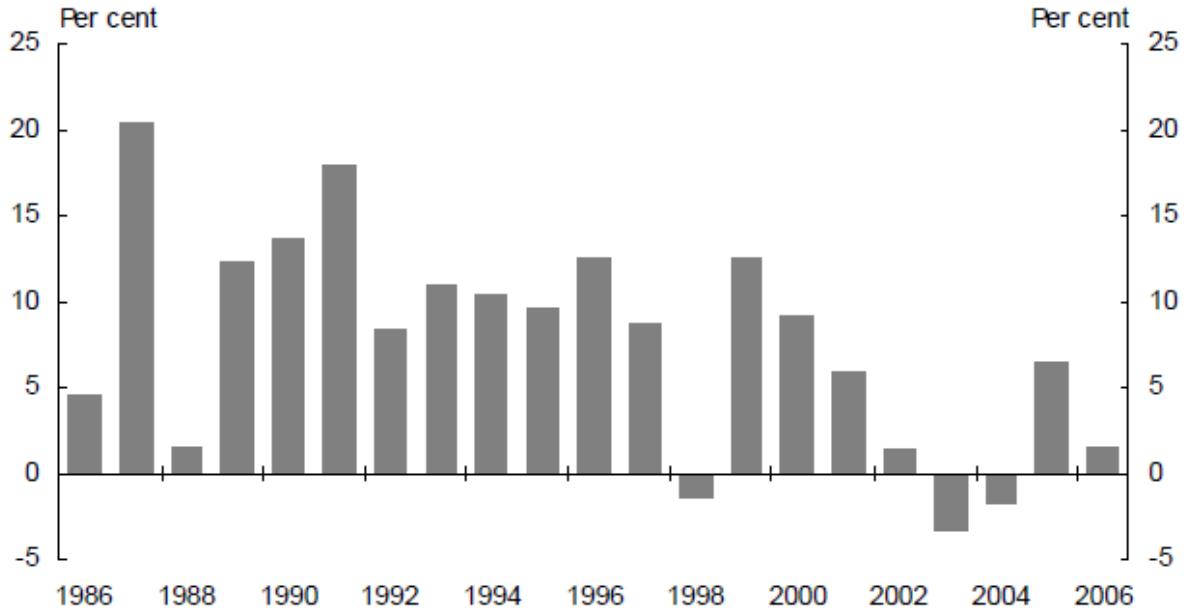
Results

F-statistic	1.736716	Prob. F(1,27)	**0.1986**
Obs*R-squared	1.994370	Prob. Chi-Square(1)	0.1579

Source: Eviews Version 6

Figure 15

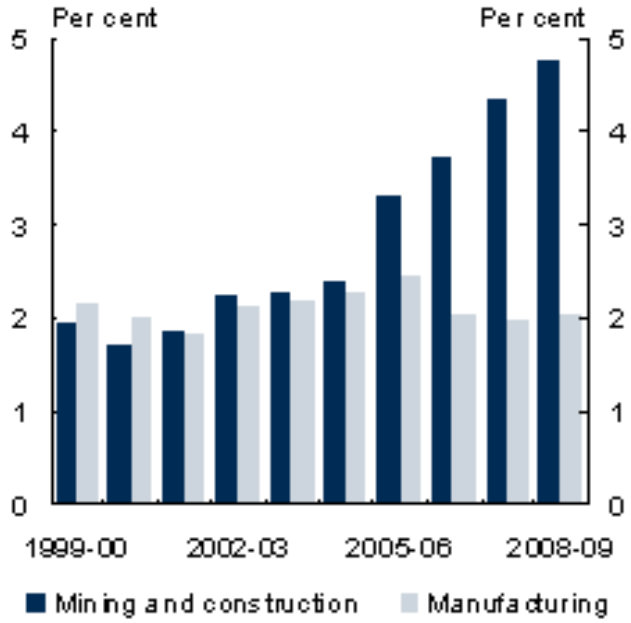
Australian manufacturing export volumes; annual percentage change



Source: Standing Committee on Economics, Finance and Administration (2007)

Figure 16

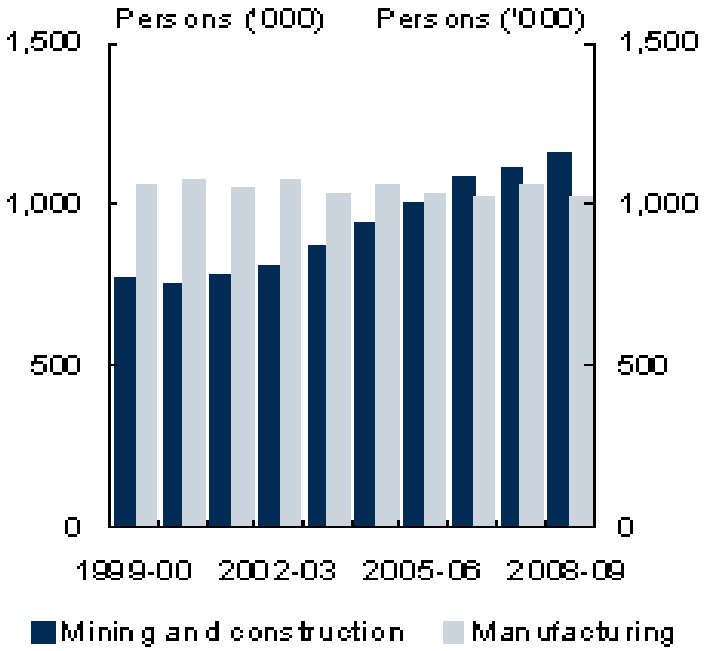
Australian mining and manufacturing investment shares of GDP



Source: Budget (2010)

Figure 17

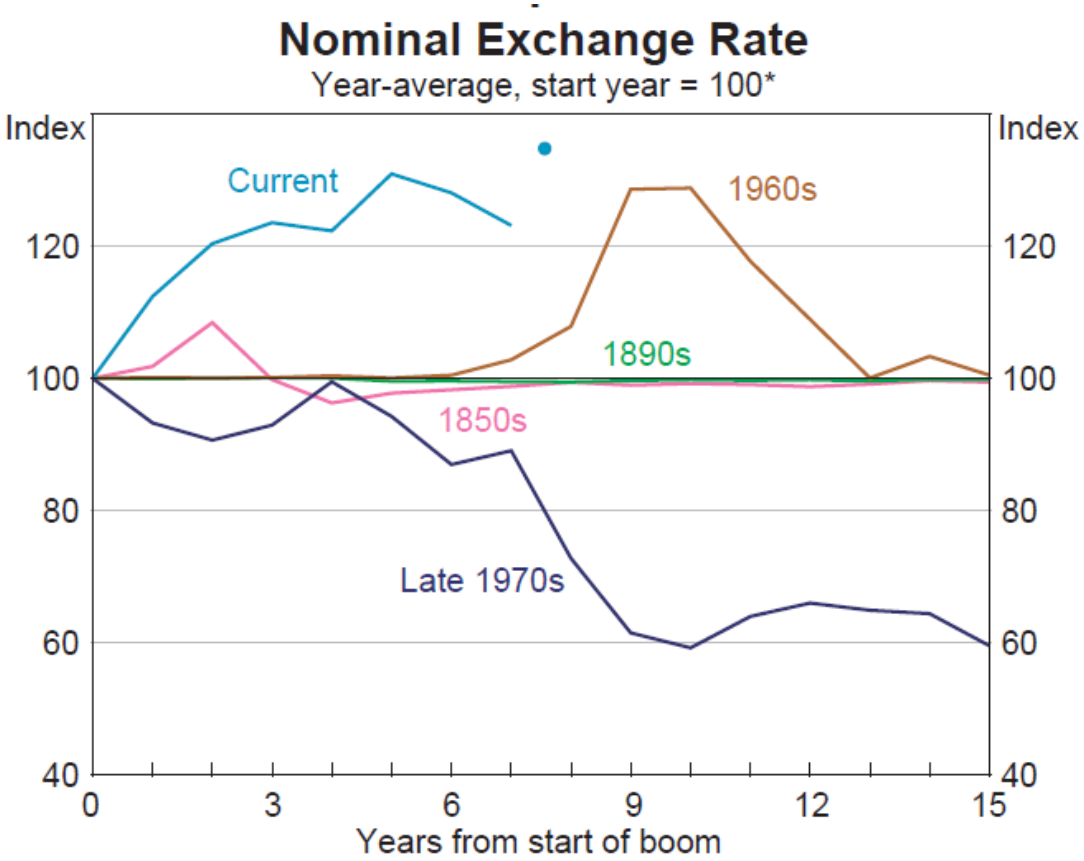
Australian mining and manufacturing labour employment



Source: Budget (2010)

Figure 18

RER adjustment via a nominal appreciation to current mining boom



Source: Battellino (2010)

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