Demographic transition and the real exchange rate in Australia: An empirical investigation

Kamrul Hassan[1]

Ruhul Salim*[2]

and

Harry Bloch[2]

[1]School of Management & Governance
Murdoch University,
90 South Street, Murdoch, Perth, WA 6150

[2]School of Economics & Finance
Curtin Business School

* Corresponding author. School of Economics & Finance, Curtin Business School (CBS), Curtin University, P. O. Box U1987, Perth, WA 6845, Australia. e-mails: Ruhul.Salim@cbs.curtin.edu.au

Acknowledgement: The authors are grateful to the anonymous referees for constructive and useful comments which tremendously improve the quality and presentation of this paper. However, usual disclaimer applies.

Demographic transition and the real exchange rate in Australia: An empirical investigation

Abstract

This article utilizes the empirical findings that age structure of the population affects saving, investment and capital flow and hypothesizes that age structure influences the real exchange rate. Based on this link, an empirical model is specified for Australia and estimated with annual data for the period 1970–2011. An autoregressive distributed lag (ARDL) model of cointegration indicates that Australia's real exchange rate is cointegrated with its productivity differential and the relative share of young dependents (0 – 14 years) in the population. Long-run estimates show that young cohort has an appreciating influence on the real exchange rate. Also, the short-run adjustment is substantial, with more than 65% of the disequilibrium corrected in a year.

Demographic transition and the real exchange rate in Australia: An empirical investigation

Introduction

The world population is ageing. Falling fertility coupled with longer life-expectancy increases the number of people aged 65 years and above. Population ageing creates various social and economic challenges for the countries around the world. In 1950, 130 million people (5.2 percent of total population) were in this age group. In 2010, this figure increased more than four times to 524 million or 6.9 percent of total population. By 2050 it will exceed 1510 million or 16 percent of total population. Like other developed countries, Australia is also heading towards an ageing country. Its older population (65+) occupied only 8.2 percent share in total population in 1950. This share increased to 13.4 percent in 2010 and it is projected to be 23.10 percent in 2050.

Australia's demographic transition ~~into an ageing population~~ has significant economic and policy implications. Population ageing, on the one hand, is anticipated to increase government spending from 22.4 percent of GDP in 2015-16 to 27.1 percent of GDP in 2049-50, which will create a fiscal gap of 2.75 percent of GDP. As a consequence, net debt is projected to emerge in 2040s and grow to nearly 20 percent of GDP by 2049–2050 and the budget deficit is projected to be 3.75 percent of GDP by 2049 – 2050. A small~~er~~ workforce, on the other hand, is projected to reduce the rate of labor force participation rate. Total participation rate will fall from 65.10 percent in 2009–10 to 60.60 percent in 2049–50. Because of this lower participation rate average annual GDP growth rate is projected to slow down to 2.7 percent over the next 40 years (2010–2050), as compared to the average annual realized GDP growth rate of 3.3 percent over the previous 40 years.[1]

Australia's ageing population has been focused on by policymakers for its likely effects on fiscal balance, labor participation rate and real GDP growth. However, another important avenue of influence has hardly been given any attention. Population ageing has substantial influence on saving, investment, capital flows and thereby on the real exchange rate. The nexus between population ~~A~~ageing and the real exchange rate ~~nexus~~ is an emerging issue of research in the international finance literature. An early theoretical attempt to link demography with the real exchange rate is taken by Cantor and Driskill (1999), who show that the effect of demographic change on the real exchange rate comes through a change in

[1] Intergenerational Report 2010.

steady-state net foreign indebtedness when the birth/death rate changes. On the empirical side, Andersson and Österholm (2005) study this issue using Swedish data and find that young adults (15-24), young retirees (65-74) and old retirees (75 and above), who borrow or reduce savings, have an appreciating effect on the real exchange rate. In contrast, the prime aged (25-49) and middle-aged (50-64) group, who are productive and savers generate capital outflow, have a depreciating effect on the real exchange rate. Their follow-up study on a panel of OECD (organization of Economic cooperation and Development) countries (Andersson and Österholm, 2006) yields similar results.

Given the demographic transition in Australia, it is important to examine the effect of its ageing population on the real exchange rate. Productivity differentials (Lowe, 1992; Lee *et al.*, 2002) and real interest rate differentials (Gruen and Wilkinson, 1991) have also been found to be important factors affecting Australia's real exchange rate. Recently, employing a macroeconomic balance approach Dvornak *et al.* (2005) conclude that an increase in Australia's current account deficit is consistent with an appreciation of its real exchange rate.

Although some studies (e.g., Olekalns and Wilkins, 1998; Tawadros, 2002) argue that Australia's real exchange rate is mean reverting and hence economic fundamentals do not have any permanent impact on the real exchange rate, the majority of studies point to the contrary, for example Corbae and Ouliaris (1991); Lee *et al.* (2002); Henry and Olekalns (2002); Darné and Hoarau (2008); Hassan and Salim (2011). These papers suggest that economic fundamentals have permanent impact on Australia's real exchange rate.

The rest of the paper is structured as follows. Section 2 presents a theoretical framework to analyze the relationship between population age structure and the real exchange rate. Section 3 identifies some other factors that affect the real exchange rate. Section 4 contains data sources, estimation and the analysis of results. Conclusions follow in Section 5.

2. Population age structure and the real exchange rate

The theoretical linkage between the real exchange rate and demography comes from the relation between age structure of population and the resultant consumption and saving pattern in an economy as postulated in the Life Cycle Hypothesis (LCH). According to the LCH, people smooth their consumption by saving during their working life and dis-saving in the rest of the life until death (Modigliani and Brumberg, 1954). So in an economy, where the proportion of working population relative to the rest of the world is greater than the proportion of the young or old dependents, home country saving will be relatively greater. If aggregate saving exceeds domestic investments, there will be an international capital outflow, which will appreciate the real exchange rate.

There is another channel through which working age population can affect the real exchange rate. A larger working age population or higher labor force raises the marginal product of capital and hence attracts investment. In this case there may be a capital inflow and real appreciation. It also lowers marginal product of labor and hence wage and saving, further increasing capital inflow and appreciating the real exchange rate.

The magnitude of relative changes in investment and saving determine the net effect of the working age proportion of the population on the real exchange rate. If saving increases relative to investment, capital is exported and the real exchange rate will be depreciated. If investment dominates, capital is imported and the exchange rate depreciates. The direction of the net effect remains an empirical issue.

Young dependents increase consumption demand, mainly through consumption of non-traded goods (such as education, health care), without making any contribution to saving. This may give rise to two opposite effects on the real exchange rate. On the one hand, young dependents reduce saving leading to capital inflow and the real appreciation. On the other hand, higher demand for non-tradable may result in higher prices of non-tradables relative to tradables leading to real depreciation. The net effect, which depends on the relative magnitudes of relative price effect and saving effect, is explored in the empirical analysis below.

The impact of old dependents on the real exchange rate is also ambiguous.- Although the life-cycle hypothesis predicts that aged people use up their saving to finance their consumption, empirical evidence suggests to the contrary. For example Mirer (1979) uses data from 1968 survey of the Demographic and Economic Characteristics of the Aged in the USA to examine the saving behavior of the aged people and finds that the wealth of the elderly rarely declines. In a similar study with 1972-73 Consumer Expenditure Survey data in the USA, Danziger *et al* (1982-83) conclude that elderly people spend less than the nonelderly at the same level of income and the oldest people have the lowest average propensity to consume.

The above empirical studies suggest that the old dependents are unlikely to exert a negative effect on saving. They may even have a positive effect on saving and. if the size of old dependents at home relative to the rest of the world is larger, this saving will result in capital outflow. In this case, then the old dependents will have depreciating effect on real exchange rate.

3. Other determinants of the real exchange rate

The main focus of this paper is to examine the effect of population structure on the real exchange rate. However, other variables are also considered to avoid model misspecification. Factors that have frequently been suggested in the literature as the determinants of the real exchange rate include productivity differential, net foreign assets, government expenditure, and interest rate differential.[2] The rationales of inclusion ~~ding~~of these factors in our model are briefly discussed below.

Productivity bias: Balassa (1964) and Samuelson (1964) provide convincing explanations of the long-run behavior of the real exchange rate. According to Balassa-Samuelson (BS) hypothesis, the productivity differential between traded and non-traded goods sectors can significantly explain the long-run movements of the real exchange rate. Productivity differences across countries are mainly observed in traded goods, rather than in non-traded goods sectors (Officer 1976). In this case currency of the country with higher productivity will appear to be overvalued (Balassa 1964). A number of studies have found empirical evidence in favor of this productivity bias hypothesis (Bahmani-Oskooee and Nasir, 2005).

The empirical difficulty in testing the productivity bias hypothesis is the measure of productivity. Balassa (1964) uses per capita Gross National Product (GNP) as a measure of productivity. However, as GNP includes output produced by the home factors of production abroad, it does not truly reflect the productivity of a country. From that viewpoint per capita Gross Domestic Product (GDP) is a better proxy for productivity. Grunwald and Salazar-Carrilo (1972), Edison and Klovland (1987) and Mark (1996) use per capita GDP as a measure of productivity. De Gregorio, Giovannini, and Wolf (1994) and Chinn and Johnston (1996) use total factor productivity in 20 sectors. Canzoneri *et al.* (1996) use the average labour productivity in six sectors, two of which are considered tradable. To capture the effect of productivity bias on the real exchange rate we use Australian per capita GDP relative to the USA per capita GDP. USA per capita GDP is used as a proxy for the rest of the world.

Interest rate differential: The role of the real interest rate differential is highlighted in many exchange rate models, for example Dornbusch (1976); Mussa (1984); Grilli and Roubini (1992) and Obstfeld and Rogoff (1996). The interest rate differential works through its effect on capital flows. When the world interest rate is higher than the domestic interest rate, capital will flow until they are equalized. This link is robust in the business cycle domain, but not in lower frequencies (Edison and Pauls, 1993; Baxter, 1994).

---

[2] The terms of trade has ~~have~~ also been mentioned as an important determinant of the exchange rate, but this influence is thought to be transitory depending on the world commodity price cycle. As such, the terms of trade should not influence the long-run real exchange rate as modelled in this paper.

Government expenditure: Government consumption of non-tradable goods is another fundamental variable that affects the movements of the real exchange rate. Higher government expenditure on non-tradables bids up their prices and appreciates the real exchange rate. However, as the precise estimate of non-tradable consumption by the government is not available, the ratio of government total consumption expenditure to GDP is used as a proxy for this variable. However, when a larger share of government expenditure falls on tradable goods, demand for non-tradable goods falls and so do their prices, which depreciate the real exchange rate. Overall, the effect of this variable may be positive or negative.

Net foreign asset position: A country's net foreign asset position is considered to be an important determinant of the real exchange rate (MacDonald and Ricci, 2003; Lane and Milesi-Ferretti, 2001a). However, demographic variables are found to have major influence on the net foreign asset position of a country (Lane and Milesi-Ferretti, 2001b). It can, therefore, be safely argued that demographic variables exert their influence on the real exchange rate through, among other channels, the net foreign asset position. The empirical evidence on the relationships between (a) demographic variables and net foreign asset position, and (b) net foreign asset position and the real exchange rate suggests that inclusion of net foreign assets along with demographic variables will create the problem of endogeneity. In this paper, the demographic variables are taken to be the exogenous influences and the net foreign asset position of a country is, therefore, not included in the model of the real exchange rate.

Based on above analyses an empirical model of the real exchange rate is specified as follows:

$$\ln RER = f\left(\underset{+}{\text{prod}}, \underset{+}{\text{indiff}}, \underset{+/-}{\text{govex}}, \underset{+/-}{\text{pop}}\right) \quad (1)$$

where, *lnRER* = log of Australian real exchange rate index, *prod* = ratio of Australian productivity to the productivity of the USA measured by the respective GDP per capita; *indiff* = interest rate differential between Australia and USA, *govex* = government expenditure (% of GDP) and *pop* = population age structure variables. Three population age structure variables are used in this paper as follows. *rydep* = Size of Australian population cohort aged between 0 -14 years relative to the USA; *rwapop* = Size of Australian population cohort aged between 15 -64 years relative to the USA; *rodep* = Size of Australian population cohort aged 65 years and above relative to the USA. The following section empirically estimates and analyses the model.

4. Data sources, estimation and results

Data sources

World Development Indicators 2012 provides all data, except the real effective exchange rate (REER) and interest rate, for the period 1970-2011. Australian REER data are available only from 1980 and interest rate data are available from 1975. Therefore, two other sources are used to collect these data. Quarterly data on REER are obtained from Reserve Bank of Australia (RBA) website (www.rba.gov.au). Arithmetic averages of these quarterly figures are then used to arrive at annual observations for 1970 to 1980. The index of the real exchange rate is such that an increase in the index represents real appreciation. The natural logarithm of this real exchange rate index is used in the estimation.

The difference between the real short-term interest rate of Australia and the USA is used as *indiff*. The nominal short-term interest rate is adjusted for inflation in each country to arrive at the real short-term interest rate. These data are taken from *Thomson Datastream*. However, the original source of these data is the *OECD Economic Outlook*.

Estimation

Before estimating Equation (1), great care is taken to examine time series properties of the underlying series. Stationarity of the variables are examined first. Although augmented Dickey-Fuller (ADF) test is widely used for this purpose, DeJong *et al.* (1992) note that it has low power against the alternative hypothesis. Elliot, Rothenberg and Stock (ERS) (1996) develop a feasible point optimal test, called the DF-GLS (ERS) test, which relies on local GLS de-trending to improve the power of the unit root test. The DF-GLS (ERS) test (reported in Table A1 in the Appendix) indicates that variables are integrated to different orders; some are I(0), while some are I(1).

One limitation of these traditional unit root tests is that they cannot identify the structural breaks in the underlying time series data. Therefore, the traditional unit root test results may not be valid for series having structural breaks. Zivot and Andrews (1992), and latter Perron (1997), further develop a unit root test that considers the break point as endogenous. A large number of empirical studies have allowed structural breaks in the series in question in recent years (Salman and Shukur, 2004; Hacker and Hatemi-J, 2008; Salim and Bloch 2009). However, one problem with the Perron (1997) test is that it assumes that there is no break under the unit root null against the alternative of a structural break. Therefore, rejection of null hypothesis implies rejection of unit root without break, which does not remove the possibility of unit root with structural break. The danger of this type of test with a break under the null is that 'researchers might incorrectly conclude that rejection of the null indicates evidence of a trend-stationary time series with breaks, when in fact the series is difference stationary with break' (Lee and Strazicich, 2003:1082).

To overcome this problem Lee and Strazicich (2003) develop a Lagrange Multiplier (LM) test (henceforth LS unit root test) that allows for breaks under both the null and alternative hypothesis. Therefore, when this LM test rejects the null it unambiguously implies a trend stationary process. Given the mixed results of DF-GLS (ERS), we next employ this LS unit root test to examine if the variables are integrated to the same order when structural break is taken into consideration. Test results reported in Table A2 in the Appendix show that the variables are not integrated to the same order. With these mixed results, both without and with structural break, we cannot apply the residual-based or system-based reduced rank procedure of cointegration.

We follow Pesaran *et al.* (2001) who suggest an alternative technique, namely ARDL (Auto Regressive Distributed Lag) model to test the existence of long-run relationship between variables in levels that is applicable irrespective of whether the regressors are purely I(0), purely I(1) or mutually cointegrated. Another advantage of this approach is that it is unbiased and efficient. Besides, this method can estimate the short-run and long-run components of the model and addresses the problem of omitted variables and autocorrelation (Narayan and Narayan, 2006). However, the approach requires the dependent variable to be I(1). To implement this method we specify Equation (1) in an Auto Regressive Distributed Lag (ARDL) form as follows:

$$\Delta \ln rer = \alpha_0 + \beta_1 \ln rer_{t-1} + \beta_2 prod_{t-1} + \beta_3 pop_{t-1} + \beta_4 indiff_{t-1} + \beta_5 govex_{t-1} + \sum_{i=0}^{p} \delta_i \Delta \ln rer_{t-i} + \sum_{j=0}^{q} \delta_j \Delta prod_{t-j} + \sum_{k=0}^{r} \delta_k \Delta pop_{t-k} + \sum_{l=0}^{s} \delta_l \Delta indiff_{t-l} + \sum_{m=0}^{u} \delta_m \Delta govex_{t-m} + \varepsilon_t \quad (2)$$

where α_0 is a drift parameter and ε_t is a white noise error. The long-run multipliers are represented by the coefficients of the lagged level variables β_1, β_2, β_3, β_4, and β_5, while short-run impacts of the independent variables on the dependent variables are represented by the coefficients δ_i, δ_j, δ_k, δ_l and δ_m.

The next step is to test the null hypothesis of no cointegration by restricting all estimated coefficients of lagged level regressions equal to zero, that is, $H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$ against the alternative hypothesis of cointegration, that is, $H_1 : \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$. Two asymptotic critical value bounds provide a test for cointegration when regressors are I(d) (where $0 \leq d \leq 1$). The lower value assumes that the regressors are I(0), while the upper bound assumes that the regressors are purely I(1). If the test statistic exceeds the upper bound critical value then the null hypothesis is rejected and we may conclude that a long-run equilibrium relationship exists. If the test statistic falls below the lower bound critical value then we cannot reject the null of no cointegration. However, if the test statistic falls between these two bounds then the result is inconclusive.

~~In case~~ If the null hypothesis is rejected with evidence of cointegration, the next steps involve estimating long-run conditional ARDL model and the short-run error correction model associated with long-run estimates. The long-run model takes the following form.

$$\ln rer = \alpha_0 + \sum_{i=0}^{p}\phi_i \ln rer_{t-i} + \sum_{j=0}^{q}\phi_j prod_{t-j} + \sum_{k=0}^{r}\phi_k pop_{t-k} + \sum_{l=0}^{s}\phi_l indiff_{t-l} + \sum_{m=0}^{u}\phi_m govex_{t-m} + \varepsilon_t \quad (3)$$

The ARDL specification of the short-run dynamics can be derived by constructing the error correction model (ECM) of the following form:

$$\Delta \ln rer = \alpha_0 + \sum_{i=0}^{p}\delta_i \Delta \ln rer_{t-i} + \sum_{j=0}^{q}\delta_j \Delta prod_{t-j} + \sum_{k=0}^{r}\delta_k \Delta pop_{t-k} + \sum_{l=0}^{s}\delta_l \Delta indiff_{t-l} + \sum_{m=0}^{u}\delta_m \Delta govex_{t-m} + \gamma ECM_{t-1} + \varepsilon_t \quad (4)$$

Where ECM_{t-1} is the error correction term defined as under:

$$ECM_{t-1} = \ln rer - \alpha_0 - \sum_{i=0}^{p}\phi_i \ln rer_{t-i} - \sum_{j=0}^{q}\phi_j prod_{t-j} - \sum_{k=0}^{r}\phi_k pop_{t-k} - \sum_{l=0}^{s}\phi_l indiff_{t-l} - \sum_{m=0}^{u}\phi_m govex_{t-m} \quad (5)$$

Results

The above ARDL approach of cointegration is applied to Equation (1) and the results are reported in Table 1. The graphs of the log of real exchange rate (Figure A1 – A3) indicate that there is no trending pattern in the series. Therefore, no trend is included in the equation. Three equations are estimated including one demographic variable in each equation separately[3]. Accordingly three test statistics are reported in Table 1. The results show that the real exchange rate and its determinants are cointegrated in the long run. In equations with *rydep* and *rwapop* the real exchange rate is cointegrated at 5% significance level, and in equation with *rodep* it is cointegrated at 10% level.

[3] Table A3 in Appendix A shows that demographic variables are highly correlated (correlation coefficients are above 0.91). To avoid multi-colinearity at a time one demographic variable is included in the equation.

Table 1: Results of ARDL cointegration test with variables in Equation (1) (*rydep, rwapop* and *odep* are demographic variables)

Test statistics	*rydep*	*rwapop*	*rodep*	95% lower bound	95% upper bound	90% lower bound	90% upper bound
F-statistic	5.2889	4.1344	3.8296	2.5069	3.8433	2.0499	3.2281
W-statistic	26.4447	20.6718	19.1480	12.5345	19.2167	10.2495	16.1407

Note: The critical value bounds are computed by stochastic simulations using 20000 replications.

With this cointegrated relationship, we next examine the short-run and long-run impacts of the independent variables on the real exchange rate. To examine long-run impact we estimate Equation (2) and tabulate the results in Table 2. Estimation results in Table 2 indicate that in the long run government expenditure and interest rate differential have no significant impact on the real exchange rate. In all three specifications, differential productivity is found to have highly significant effect on the real exchange rate. The results indicate that higher Australian productivity relative to the USA has a strong appreciating impact on the Australian real exchange rate. Among demographic variables, only *rydep* is found to have a significant appreciating effect on the real exchange rate in the long run. This suggests that the saving effect of young dependents dominates their effect on relative prices of tradables and non-tradables.

Table 2: Estimated Long-run Coefficients Using the ARDL (1,0,0,0,0) Model, Based on Schwarz Bayesian Criterion

Regressors	Long-run coefficients		
	Rydep	*Rwapop*	*rodep*
prod	2.7508* (0.3761)	2.8153* (0.6556)	3.5588* (0.4717)
indiff	0.000915 (0.00177)	-0.00103 (0.00186)	0.00119 (0.00277)
govex	-0.00613 (0.0101)	-0.00905 (0.0150)	0.00331 (0.0124)
rydep	0.4386*** (0.2551)		
rwapop		0.4398 (0.5320)	
rodep			-0.2515 (0.3046)

Note: * and *** indicate significant at 1% and 10% level, respectively. Figures in the parentheses are standard errors.

Next we examine the short-run effects of the independent variables on the real exchange rate by looking at the error correction representation of the ARDL model specified in Equation (4). Estimation results of Equation (4) are reported in Table 3.

Table 3: Error Correction Representation of the ARDL(1,0,0,0,0) Model, Based on Schwarz Bayesian Criterion.

Regressors	Short-run coefficients		
	Rydep	*Rwapop*	*rodep*
$\Delta prod$	1.3160* (0.3035)	-1.1202* (0.3312)	1.4071* (0.3795)
$\Delta indiff$	0.0004382 (0.0008257)	-0.000410 (0.00081t0)	0.000474 (0.00107)
$\Delta govex$	-0.002934 (0.004571)	-0.00360 (0.00566)	0.001311 (0.00515)
$\Delta rydep$	0.2092 (0.1483)		
$\Delta rwapop$		0.1750 (0.2222)	
$\Delta rodep$			-0.0994 (0.1256)
EC_{t-1}	-0.4784* (0.1321)	-0.3979* (0.1161)	-0.3954* (0.1151)

Note: * indicate significant at 1% level. Figures in the parentheses are standard errors.

Results in Table 3 show that only the productivity variable has a significant impact on the real exchange rate in the short run. Although results reported in Table 1 indicate that the real exchange rate and its regressors are cointegrated, short-run and long-run coefficients of the regressors reported in Tables 2 and 3, respectively indicate that *rwapop*, *rodep*, *govex*. and *indiff* variables have neither short-run nor long-run significant impact on the real exchange rate. Therefore, the ARDL model ~~with~~ incorporating productivity differential and the relative size of young dependents appears to be the appropriate model to explain the movements of Australian real exchange rate in the long run. Accordingly a model of the real exchange rate with relative productivity is specified as follows:

$$\ln RER = f\left(\underset{+}{prod}, \underset{+}{rydep}\right) \qquad (6)$$

As the variables entering into equation (6) are integrated to different orders, we continue to use ARDL method to examine the cointegrating relation between *lnrer* and its regressors. The results reported in Table 4 indicate that the real exchange rate is cointegrated with relative productivity and the relative size of young dependents. Given this cointegrating relation, next the long-run and short-run coefficients are estimated and reported in Table 5.

Table 4: Results of ARDL Cointegration Test with Variables in Equation (6)

	Test statistics	95% lower bound	95% upper bound	90% lower bound	90% upper bound
F-statistic	8.9539	2.8394	4.1153	2.2541	3.3380
W-statistic	26.8616	8.5182	12.3459	6.7623	10.0140

Note: The critical value bounds are computed by stochastic simulations using 20000 replications.

Table 5: Long-run and Short-run Coefficients of the Real Exchange Rate Using ARDL (1,1,0) Model Based on Schwarz Bayesian Criterion.

Regressors	Long-run Coefficients
prod	2.7754* (0.2337)
rydep	0.3081** (0.1458)
	Short-run coefficients
$\Delta prod$	0.9131* (0.3792)
$\Delta rydep$	0.2003 (0.1210)
ECM_{t-1}	-0.65024* (0.1403)

Note: * indicate significant at 1% level. Figures in the parentheses are standard errors.

The results in Table 5 indicate that productivity differential is the only variable that affects the real exchange rate both in the short run and long run. This finding coupled with non-stationarity of the real exchange rate lends support to the Balassa-Samuelson hypothesis that purchasing power parity does not hold because of differential productivity. The results also show that there is a significant long-run effect of the relative size of young dependents on the real exchange rate, while the short-run impact of this age cohort on the real exchange rate is statistically weak (the *p* value is 0.106).

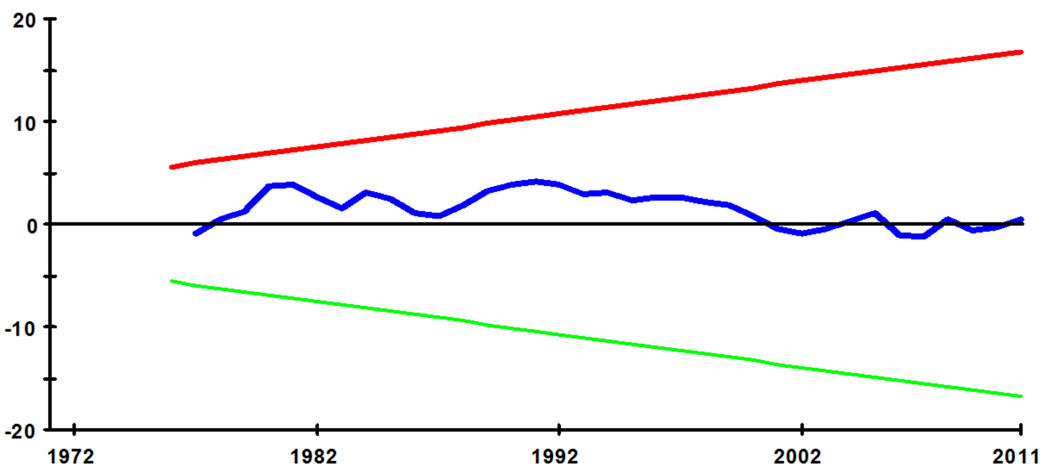
Diagnostic tests of the above model are reported in Table 6 and confirm that the model behaves very well. The results show that the residuals are homoscadastic, normally distributed and free from serial correlation. The results also confirm that the null of linear functional form of the model is not rejected.

Table 6: Diagnostic tests

Test statistics	Lagrange Multiplier (LM) test		F-test	
Serial correlation	$\chi^2(1) =$	0.00158 (0.968)	F(1,35) =	0.00138 (0.971)
Functional form (Ramsey's REST test)	$\chi^2(1) =$	0.0102 (0.919)		
Normality	$\chi^2(2) =$	1.5257 (0.542)	Not applicable	
Heteroskedasticity	$\chi^2(1) =$	0.1813 (0.670)	F(1,38) =	0.1730 (0.680)

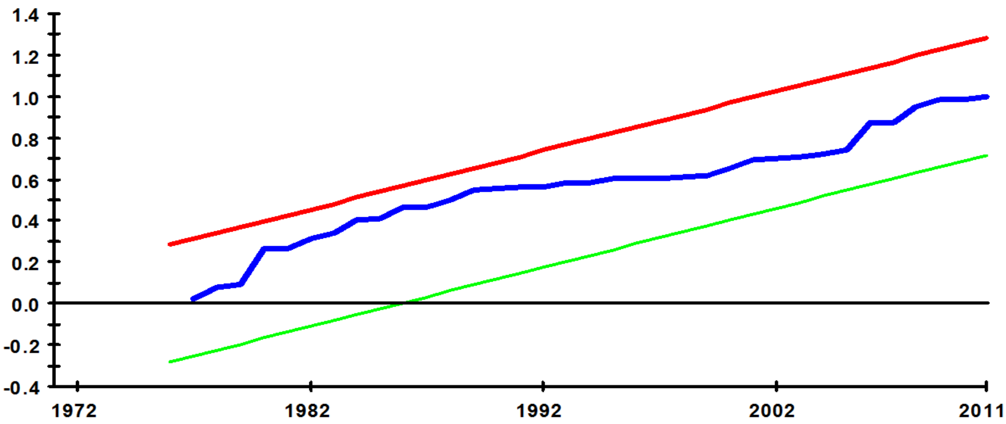
Finally we check the stability of the long-run coefficients together with the short-run dynamics. To do so Wwe plot cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) proposed by Brown *et al* (1975). The CUSUM test uses the cumulative sum of recursive residuals based on first set of *n* observations and updated recursively and plotted against break points. If the plot of CUSUM statistics stays within the critical bound at, say, 1% or 5% level, then the null hypothesis that all coefficients are stable cannot be rejected. A similar procedure is used to carry out CUSUMSQ test, which is based on squared recursive residual. CUSUM and CUSUMSQ statistics are plotted in Figures 1 and 2, respectively. Neither CUSUM nor CUSUMSQ plot crosses the critical bounds at 5% significant level, indicating no evidence of any significant structural instability.

Figure-1: Plot of Cumulative Sum of Recursive Residual (CUSUM)



The straight lines represent critical bounds at 5% significance level

Figure-2: Plot of Cumulative Sum of Squares of Recursive Residual (CUSUMSQ)



The straight lines represent critical bounds at 5% significance level

In summary, we conclude that in the long run the Australian real exchange rate is determined mainly by two factors. These are the productivity differential and the relative share of young dependents in the population. Further, the correction to this long-run relation in the short-run is substantial (see Table 5), with more than 65% of discrepancy corrected each year. This speed of adjustment of real exchange rate towards the long run equilibrium rate appears to be reasonably faster than those found in previous studies, such as, Elbadawi and Soto (1997), whoere find the error correction term is found to be of 50%.; hHowever, they did not include demographic variables and productivity differential in their estimation. The higher adjustment speed in our case may be attributed to the strong influence of young cohort and productivity differential on the real exchange rate in the long run.

The findings of the analysis above suggest an important source of deviation from the Purchasing Power Parity (PPP) doctrine. In addition to the productivity bias, this paper finds that the relative size of a population age cohort influences the real exchange rate. In the Australian case, relative size of the young dependents cohort has a positive effect on the real exchange rate in the long run, that is, an increase (decrease) in the relative share of this cohort appreciates the real exchange rate in the long run. Although higher share of young dependents increases the relative price of non-tradables through higher demand for non-tradables leading to real depreciation, it seems that in Australia this effect is less powerful than the downward effect on saving from the extra spending on young dependents. Our finding is consistent with previous studies, for example, Andersson and Österholm (2005) on Swedish data and Andersson and Österholm (2006) on OECD countries. These studies, like the present one, also support the view that young dependents exert downward pressure on saving causing capital inflow and real appreciation.

5. Conclusion

The objective of this paper is to investigate the direction and magnitude of the influence of Australia's population age structure on its real exchange rate. Using time series econometric methods, the paper finds that the real exchange rate bears long-run cointegrating relation with productivity differential and a demographic variable, namely, the relative size of young dependents cohort. The findings of this paper accord closely with those of previous studies (such as Corbae and Ouliaris, 1991; Lee *et al.,* 2002; Henry and Olekalns, 2002; Darné and Hoarau, 2008) that find that Australia's real exchange rate does not show mean-reversion and economic fundamentals have permanent impact on it. The contribution of this paper is that in addition to productivity bias, it unveils another influence, namely population cohort that has a long-run permanent influence on the real exchange rate. Using an ARDL-based cointegration approach, the paper finds that in the long run, an increase in the size of Australian young dependents (aged 0-14 years) in total population relative to the rest of the world appreciates its real exchange rate.

The findings of this paper have significant policy implications for the external competitiveness of Australian economy. Due to falling fertility, the young cohort in the total population is getting smaller and smaller. This implies, given the productivity differential, population age structure will have depreciating effect on the real exchange rate. Therefore, while making projections about the future economic performance with reference to age-related factors, ageing-induced improvement in the exchange rate should also be taken into consideration.

References:

Andersson, Andreas and Pär Österholm 2005. Forecasting real exchange rate trends using age structure data - the case of Sweden. *Applied Economics Letters*, 12(5): 267-277.

Andersson, Andreas and Pär Österholm 2006. Population age structure and real exchange rates in the OECD. *International Economic Journal*, 20(1): 1-18.

Bahmani-Oskooee, M. and A.B.M. Nasir 2002. Corruption, law and order, bureaucracy and real exchange rate, *Economic Development and Cultural Change*, 50: 1021-1028.

Bahmani-Oskooee, M. and A.B.M. Nasir, 2005. Productivity bias hypothesis and the PPP: A review article. *Journal of Economic Surveys*, 19: 671–696.

Balassa, Bela 1964. The purchasing power parity doctrine: A reappraisal. *Journal of Political Economy*, 72(6): 584-596.

Baxter, M. 1994. Real Exchange Rates and Real Interest Rate Differentials: Have we Missed the Business Cycle Relationship? *Journal of Monetary Economics*, 33, 5-37.

Brown, R.L., J. Durbin and J.M. Evans 1975. Techniques for testing the constancy of regression relationships over time. *Journal of the Royal Statistical Society*, 37(2): 149 – 163.

Cantor, Richard and Robert Driskill 1999. Effect on the real exchange rate of demographic and fiscal policy-induced changes in national savings: Is the conventional academic wisdom always right? *Economic Research Paper No. 16***,** Department of Economics, Loughborough University.

Canzoneri, Matthew, Robert Cumby, and Behzad Diba 1996. Relative Labor Productivity and the Real Exchange Rate in the Long Run: Evidence for a Panel of OECD Countries. NBER Working Paper No. 5676, Cambridge, MA: NBER

Chinn, Menzie and Louis Johnston 1996. Real Exchange Rate Levels, Productivity and Demand Shocks: Evidence from a Panel of 14 Countries. NBER Working Paper No. 5709. Cambridge, MA: NBER.

Corbae, Dean and Sam Ouliaris 1991. A test of long-run purchasing power parity allowing for structural breaks. *Economic Record*, 67(196): 26 – 33.

Danziger, Sheldon, Jacques Van Der Gaag, Eugene Smolensky and Micheal K. Taussig. 1982-83. The life-cycle hypothesis and the consumption behavior of the elderly. *Journal of Post Keynesian Economics*, 5(2): 208-227.

Darné, Olivier and Jean-François Hoarau 2008. The purchasing power parity in Australia: evidence from unit root test with structural break. *Applied Economics Letters*, 15(3): 203 – 206.

De Gregorio, Jose, Alberto Giovannini and Holger Wolf 1994. International evidence on tradables and nontradables inflation. *European Economic Review*, 38: 1225–1244.

Dejong, David N., John C. Nankervis, N.E. Savin, and Charls H. Whiteman 1992. The power problem of unit root tests in time series with autoregressive errors. *Journal of Econometrics*, 53(1-3): 323-343.

Dornbusch, R. 1976. 'Expectations and exchange rate dynamics', *Journal of Political Economy*, 84: 1161-76.

Dvornak Nikola, Marion Kohler and Gordon Menzies 2005. Australia's medium-run exchange rate: a macroeconomic balance approach. *Economic Record*, 81(253): 101 – 112.

Edison, Hali and Jan-Tore Klovland 1987. A quantitative reassessment of the purchasing power parity hypothesis. *Journal of Applied Econometrics*, 2: 309–333.

Edison, Hali J., and B. Dianne Pauls 1993. A re-assessment of the relationship between real exchange rates and real interest rates: 1974-1990, *Journal of Monetary Economics*, 31(2): 165-187.

Elbadawi, I. and R. Soto 1997). Capital Flows and Long-Term Equilibrium Real Exchange Rates in Chile, *Revista de Analisis Economico*, 12(1): 35-62.

Elliott, G., T. Rothenberg, and J. Stock 1996. Efficient tests for an autoregressive unit root. *Econometrica*, 64(4): 813-836.

Grilli, V. and N. Roubini 1992. Liquidity and exchange rates, *Journal of International Economics,* 32: 339-352.

Gruen, David W.R. and Jenny Wilkinson 1991. Australia's real exchange rate – is it explained by the terms of trade or by real interest rate differentials? Research Discussion Paper No. 9108, Reserve Bank of Australia, Sydney.

Grunwald, Joseph, and Jorge Salazar-Carrillo 1972. Economic integration, rates of exchange, and value comparisons in Latin America. In D. J. Daly, ed. *International Comparisons of Prices and Output*, National Bureau of Economic Research, New York: 227-80.

Hacker, R. Scott and Abdulnasser Hatemi-J 2008. Optimal lag-length choice in stable and unstable VAR models under situations of homoscedasticity and ARCH. *Journal of Applied Statistics*, 35(6): 601-615.

Hassan, AFM Kamrul and Ruhul Salim 2011. Purchasing power parity (PPP) of Australian dollar: Do test procedure matter? *Economic Analysis and Policy*, 41(1), 71 – 81.

Henry, Ólan and Nilss Olekalns 2002. Does the Australian dollar real exchange rate display mean reversion. *Journal of International Money and Finance*, 21(5): 651 – 666.

Intergenerational Report 2010. Australia to 2050: Future Challenges. Commonwealth of Australia, Canberra, Australia. (www.ag.gov.au/cca)

Lane, P. R. and G. M. Milesi-Ferretti 2001a. External wealth, trade balance and the real exchange rate. *IMF Working Paper No. 51* (Washington, DC: International Monetary Fund).

Lane, P. R., and G. M. Milesi-Ferretti 2001b. Long-term capital movements. *NBER Macroeconomics Annual*, 16: 73-116.

Lee, Junsoo and Mark C Strazicich 2003. Minimum Lagrange multiplier unit root test with two structural breaks. *Review of Economics and Statistics*, 85(4): 1082-1089.

Lee, Minsoo, Mudziviri Nziramasanga and Sung K. Ahn 2002. The real exchange rate: An alternative approach to the PPP puzzle. *Journal of Policy Modeling*, 24(6): 533 – 538.

Lowe, Philip 1992. The impact of real and nominal shocks on Australian real exchange rate. *Discussion paper no. 9201,* Reserve Bank of Australia, Canberra.

MacDonald, Ronald and Luca Ricci 2003. Estimation of the equilibrium real exchange rate for South Africa. *IMF Working Paper No. 03/44* (Washington: International Monetary Fund).

Mark, Nelson 1996. Fundamentals of the real dollar-pound data 1971–1994. In Jerome Stein and Ronald MacDonald (eds.), *Equilibrium Real Exchange Rates*. Kluwer (Amsterdam): 45–62.

Mirer, Thad W. 1979. The wealth-age relation among the aged. *American Economic Review*, 69(3): 435-443.

Modigliani, Franco, and R. Brumberg 1954. Utility analysis and the consumption function: An interpretation of cross-section data. In K.K. Kurihara (ed.) *Post-Keynesian Economics* (Chapter 15), Rutgers University Press, New Brunswick, NJ: 388-436.

Mussa, M. 1984, The theory of exchange rate determination', in J.F.O. Bilson and R.C. Marston (eds), *Exchange Rate Theory and Practice*, NBER Conference Report, Chicago University Press, Chicago: 13–58.

Narayan, Paresh Kumar and Narayan, Seema 2006. Savings behaviour in Fiji : an empirical assessment using the ARDL approach to cointegration, *International Journal of Social Economics,* 33(7): 468-480.

Obstfeld, Maurice and Kenneth Rogoff 1996. *Foundations of International Macroeconomics.* The MIT Press, Massachusetts.

Officer, Lawrence H. 1976. The purchasing power theory of exchange rates: A review article. *IMF Staff papers* 23(March): 1 – 60.

Olekalns, Nilss and Nigel Wilkins 1998. Re-examining the evidence for long-run purchasing power parity. *Economic Record* 74(224): 54 – 61.

Perron, Pierre 1997. Further evidence on breaking trend functions in macroeconomic variables. *Journal of Econometrics* 80(2): 355-85.

Pesaran, M. Hashem, Yongcheol Shin and Richard J. Smith 2001. Bound testing approaches to the analysis of level relationship. *Journal of Applied Economics*, 16(3):289 – 326.

Salim, R. A and H. Bloch 2009. Business expenditure on R & D and trade performance in Australia: Is there a link? *Applied Economics*, 41: 351-361.

Salman, A. K. and G. Shukur 2004. Testing for Granger causality between industrial output and CPI in the presence of regime shift Swedish data. *Journal of Economic Studies*, 31: 492-99.

Samuelson, Paul A. 1964. Theoretical notes on trade problems. *Review of Economics and Statistics*, 46(2):145-154.

Schwert, G. William 1989. Tests for unit roots: A Monte Carlo investigation. *Journal of Business & Economic Statistics*, 7(2): 147 – 159.

Tawadros, George B. 2002. Purchasing power parity in the long-run: Evidence from Australia's recent float. *Applied Financial Economics*, 12(9): 625 – 631.

World Bank 2012. *World Development Indicators 2012*, World Bank, Washington, DC.

Zivot E. And Donald W.K. Andrew 1992. Further evidence on the great crash, the oil price shock, and the unit-root hypothesis. *Journal of Business & Economic Statistics*, 10(3): 251-270.

Table A1: DF-GLS (ERS) unit root test

Series	Test statistic at level		Test statistic at first difference	
	With intercept	With intercept & trend	With intercept	With intercept & trend
lnrer	-1.1442 (0)	-3.758** (2)	-5.0187* (0)	-5.9439* (0)
indiff	-2.2494** (0)	-3.8531* (1)		
productivity	-1.4808 (0)	-2.1805 (0)	-6.0045* (0)	-4.6634* (0
gdpgr	-3.4848* (0)	-4.5398* (0)		
pcgdpgr	-3.7385* (0)	-4.9214* (0)		
rydep	-0.1433 (4)	-1.7118 (4)	-1.6313*** (3)	-5.4619* (1)
rwapop	-4.3753* (3)	-6.4864* (3)		
rodep	-3.7934* (3)	-4.0330* (3)		

Note: (a) *, ** and *** indicate significant at 1%, 5% and 10% levels.—(b) Figures in the parentheses are optimum lag length selected by SIC.

Table A2: Lee and Strazicich (2003) unit root test with two structural breaks

Series	*k*	T_B	LM stat at level	LM stat at 1st diff.
Lnrer	3	1976 1994	-4.7891	-6.1203*
Indiff	3	1977 1986	-6.0164*	
Govex	3	1974 1980	-3.8094	-6.1073*
Productivity	3	1984 1992	-4.1157	-7.0424*
Rydep	3	1984 1993	-10.5646*	
Rwapop	3	1978 1991	-9.2940*	
Rodep	3	1993 1995	-4.9293	-10.9563*

(a) * and ** indicate significant at 1% and 5% levels respectively.
(b) For LS test critical values are -5.823(1%) and -5.286(5%) and -4.989 (10%) (Lee and Strazicich, 2003)
(c) Lag length *k* = 3 is selected according to $[4(T/100)^{1/4}]$ suggested by Schwert (1989)
(d) T_B is break dates, first one is for break in level and the second one is break in trend.

Table A3: Correlation matrix

	lnrer	*rwapop*	*rodep*	*ydep*
lnrer	1.000			
rwapop	-0.8423 (0.000)	1.000		
rodep	-0.8038 (0.000)	0.9138 (0.000)	1.000	
ydep	0.8398 (0.000)	-0.9748 (0.000)	-0.9814 (0.000)	1.000

Table A4: Results of cointegration test with all variables in ARDL model (demographic variables is *rydep* and *odep*)

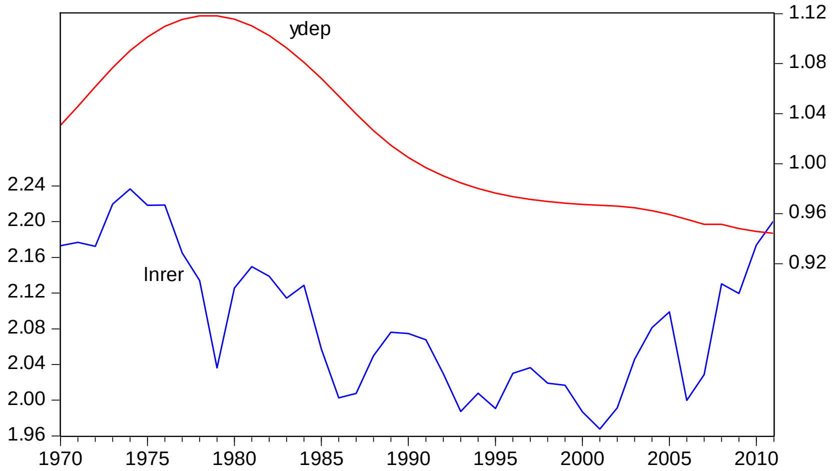
Test statistics	*rydep*	*rodep*	95% lower bound	95% upper bound	90% lower bound	90% upper bound
F-statistic	5.7411	4.7344	2.5069	3.8433	2.0499	3.2281
W-statistic	28.7056	23.6718	12.5345	19.2167	10.2495	16.1407

Table A5: Long-run coefficients from ARDL using all variables

Regressors	Coefficients	*p*-values	Coefficients	*p*-values
prod	2.6817 (0.28947)	0.000*	3.4296 (0.34561)	0.000*
rydep	0.40274 (0.21742)	0.073***		
odep			-0.23877 (0.22251)	0.291
govex	-0.00134 (0.00787)	0.865	0.00721 (0.00889)	0.423
indiff	0.00179 (0.00162)	0.277	0.00098 (0.00199)	0.492

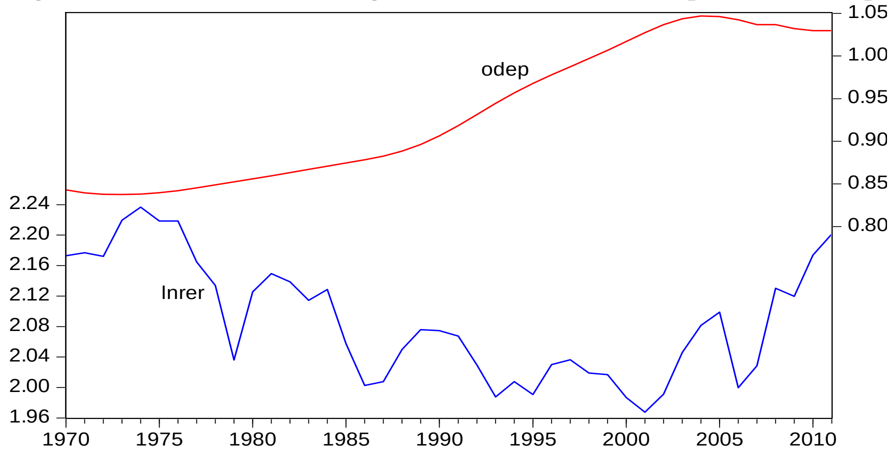
Note: (1) Lag orders for models with *rydep* and *rodep* are respectively (1,1,0,1,0) and (1,1,0,0,0) and the lags are selected by AIC; (2) * and *** indicate significant at 1% and 10% levels respectively. (2) Figures in the first parentheses are standard errors.

Figure A1: Log of Real effective exchange rate (*lnrer*) and young dependents (*ydep*), 1970 – 2011



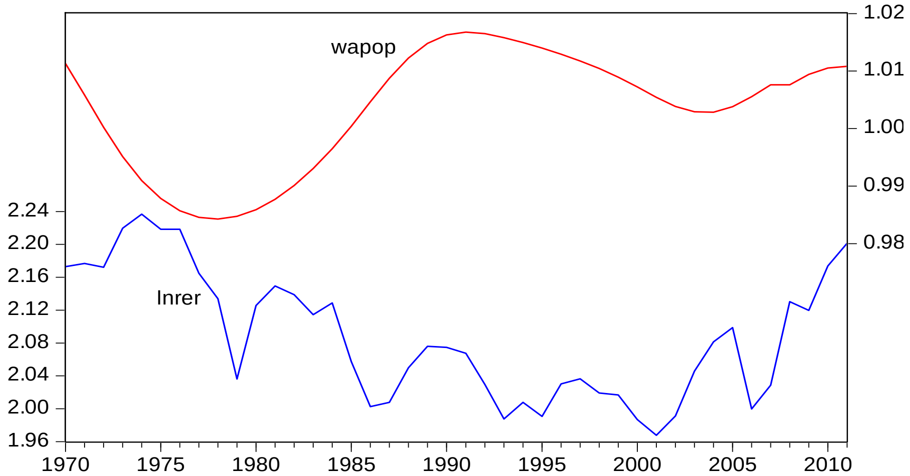
Source: World Bank, 2012 and Reserve Bank of Australia, 2012.

Figure A2: Log of Real effective exchange rate (*lnrer*) and old dependents (*odep*), 1970-2011



Source: World Bank, 2012 and Reserve Bank of Australia, 2012.

Figure A3:Log of Real effective exchange rate (*lnrer*) and working age (*wapop*), 1970-2011



Source: World Bank, 2012 and Reserve Bank of Australia, 2012.