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Does population transition influence real exchange rate? Empirical evidence from Australia

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Does population transition influence real exchange rate? Empirical evidence from Australia

Abstract

This paper utilizes the empirical findings that age structure 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 1970–2009. Unit root and cointegration analyses with structural break indicate that Australia's real exchange rate is cointegrated with terms of trade, government expenditure, working age and old age population. Cointegrating vectors estimated by Fully Modified OLS (FMOLS) show that in the long run, terms of trade and government expenditure have appreciating and the two demographic variables have depreciating effects on Australia's real exchange rate.

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 different 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 increases more than four times, 524 million or 6.9 percent of total population. By 2050 it will exceed 1510 million or 16 percent of total population. Ageing problem is more acute in developed countries than less developed ones. By 2050, 25.7 percent of total population in the developed countries will be aged 65 years or above compared to 14.7 percent in less developed countries and only 7 percent in least developed countries (Appendix Table A1).

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 increases to 13.4 percent in 2010 and it is projected to be 23.10 percent in 2050. This demographic transition in Australia is driven mainly by two forces. First, the 'baby boomer' generation has started leaving the workforce. Australian Bureau of Statistics (1999) defines the term 'baby boomer' generation as that segment of the population born in Australia between 1946 and 1965. Accordingly this generation will continue increasing the share of elderly population for the next couple of decades. The second reason is lower fertility. Total fertility starts falling since 1960 after its highest rate of 3.41 percent during 1955 – 1960. The rate again shows upward trend in 2000 – 2005, however, since then it remains almost stable at around 2% (see Figure A1). Due to this lower fertility rate share of young cohort (aged 0 -14 years) continues to fall. In 1950 this share was 26.6 percent of total population, while this share is projected to fall to 17.9 percent in 2050. Share of economically active population (aged 15 – 64 years) continues to increase until baby boomers starts leaving work force in 2010. After 2010 share of this age group shows declining trend. The demographic transition in Australia that will take place over several decades to come will result in an ageing population, which is clearly portrayed in Appendix Table A2. Over the period 2010 – 2050, share of Australia's young and working age cohorts in total population will fall by 2.3 and 7.6 percentage points, while share of elderly people will increase by nearly 10 percentage points.

Australia's demographic transition into an ageing population has significant economic and policy implications. Population ageing, in 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.[1] Smaller 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.[2]

Thus Australia's ageing population has been focused by the 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. Dynamics of population ageing has significant influence on saving, investment, capital flows and thereby on the real exchange rate. Very few studies have looked into this issue in the context of developed countries. Ageing and the real exchange rate nexus is an emerging issue of research in 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 steady-state net foreign indebtedness when the birth/death rate changes. On 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 dissave, have an appreciating effect on the real exchange rate, while 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 countries (Andersson and Österholm, 2006) yields similar results.

Recently Aloy and Gente (2009) theorize that if a country is a creditor one, a fall in population growth will increase financial wealth, whereas financial wealth will decrease in case of a debtor country. An increase (decrease) in financial wealth followed by fall in population growth leads to increase (decrease) in consumption causing real exchange rate appreciation (depreciation). Using the bilateral real exchange rate between Japanese Yen and the US dollar over the period 1966-2001 they find significant empirical support.

[1] Intergenerational Report 2010.
[2] Intergenerational Report 2010.

Given the demographic transition in Australia, it is important to examine the effect of its ageing population on the real exchange rate. Australia's real exchange rate has historically been influenced by its terms of trade shocks. This is because in a major commodity exporting small open economy like Australia, the real exchange rate responds significantly to the movements in such real fundamentals as the terms of trade (Gruen and Wilkinson, 1991). This has been supported by a number of empirical studies, such as Bundell-Wignall and Gregory (1990), Freebairn (1991), Gruen and Wilkinson (1991), Koya and Orden (1994), Lee *et al.* (2002). 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 macroeconomic balance approach Dvornak *et al.* (2005) conclude that 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, majority of the studies points to the contrary, for example Corbae and Ouliaris (1991); Lee *et al.* (2002); Henry and Olekalns (2002); Darné and Hoarau (2007 & 2008). These papers lend support to the findings of those studies that find economic fundamentals have permanent impact on Australia's real exchange rate.

So it is seen that there is a good number of studies that investigate the nature and determinants of Australia's real exchange rate. However, no study has yet been done to examine the link between demographic variables and the real exchange rate. As mentioned above, Australia's population is ageing and the consequences of this ageing population has been examined in other areas of the economy, such as fiscal balance, productivity, and GDP growth, except the real exchange rate. In this paper an attempt is made to unfold the link between Australia's real exchange rate and its demographic structure.

The paper is structured in five sections as follows. Section 2 presents a theoretical framework to analyze the relationship between population age structure and the real exchange rate. Section 3 discusses some other factors that affect the real exchange rate. Section 4 contains data sources, estimation and analyses of results, followed by conclusion 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 is greater than the proportion of the young or old dependents, saving will be greater than dis-saving. If aggregate saving does not exactly match domestic investments, there will be international capital flows, which will affect current account (Andersson and Österholm, 2005). This, in turn, will influence the real exchange rate.
"In the early stage of demographic transition per capita income growth is diminished by large youth dependency burdens and small working-age adult shares. There are relatively few workers and savers. As the transition proceeds, per capita income growth is promoted by smaller youth dependency burdens and larger working-age adult shares. There are relatively many workers and savers. The early burden of having few workers and savers becomes a potential gift later on: a disproportionately high share of working-age adults. Still later on, the economic gift evaporates, perhaps becoming a burden again, as elderly share rises" (Williamson, 2001: 263). Thus a country, having larger share of elderly people in the population, lacks capital for investment, imports foreign capital and cause the real exchange rate to appreciate. In addition to saving, demography can also work through investment channel. Young dependents place investment 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 price of non-tradables relative to tradables leading to real depreciation. Although the net effect depends on the relative magnitudes of consumption effect and saving effect, Figure A2 in Appendix A clearly shows that the young dependents have appreciating effect on the real exchange rate, that is, in Australia saving effect outweighs consumption effect.

The impact of old dependents on real exchange rate is not so clear-cut. This is because, although they do not participate in the current production, they have their savings that they accumulated during their working-age period of life. Therefore, their consumption does not have any impact on the saving behavior of the working age people. However, as their saving is a part of private saving, the pattern of the use of their saving for consumption may affect total saving.

Although 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.

Several explanations are forwarded for this observed puzzling saving behavior of the aged people. A bequest motive may be one plausible explanation for this behavior. When the bequest motive dominates the consumption motive, people continue to save because the marginal utility of the aged people of leaving a dollar for their children is greater than the marginal utility of dollar used for their own consumption (Danziger *et al*, 1982-83). However, empirical studies suggest that the dis-saving pattern is mostly influenced by the concern over health condition in the old age. Palumbo (1999) finds that during the retirement period consumption of the elderly people is largely influenced by the potential future shocks to their wealth level, the shock being the out-of-pocket expenses to finance health care. The possibility of a person living past her/his life expectancy also affects the consumption behavior. Nardi *et al* (2006 and 2009) also find that longevity and the risk of high medical expenses during the old age significantly explain why the elderly people run down their wealth so slowly.

The above empirical studies suggest that the old dependents are unlikely to exert negative effect on saving. They may even have positive effect on saving and thereby capital flow instead. If this is the case, then the old dependents will have depreciating effect on real exchange rate. Scatter plot of log of real exchange rate and the share of old dependents in Figure A3 in Appendix A supports the finding that the old dependents have positive effect on saving and thereby causes capital outflow and real depreciation.

The size of the working age cohort of population may also have significant effect on the real exchange rate. This is the cohort that mainly contributes to the private saving in the economy. If the share of working age people in total population increases total private saving will rise. This will lead to capital outflow and real depreciation. Conversely, declining share of working age people will cause private saving to fall, which will cause capital inflow and real appreciation.

There is another channel through which working age population can affect the real exchange rate. Higher working age population or higher labor force raises marginal product of capital and hence attracts investment. It will cause capital inflow and real appreciation. However, it also lowers marginal product of labor and hence wage and saving. In this case too, capital inflow will take place to fill the gap and the real exchange rate will appreciate. The magnitude of relative changes in investment and saving determine the net effect on the real exchange rate. If saving increases relative to investment, capital will be exported and the real exchange rate will be depreciated. Scatter plot in Figure A4 clearly supports the saving channel, that is, higher share of working age cohort of the population increases saving leading to capital outflow and real depreciation. Statistical significances of these relationships are reported in Table A3 in Appendix A.

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, to avoid model misspecification other variables are added to equation (1) above. Factors that have frequently been suggested in the literature as the determinants of the real exchange rate include productivity differential, terms of trade, net foreign assets, government expenditure, and interest rate differential. The rationales of including these factors are briefly discussed below.

Productivity differential: Balassa (1964) and Samuelson (1964) provide convincing explanation of the long-run behavior of the real exchange rate. According to Balassa-Samuelson (BS) hypothesis productivity differential between traded and non-traded goods sector can significantly explain the long-run movements of the real exchange rate. They argue that higher productivity in traded goods sector relative to non-traded goods sector tends to cause real appreciation. A number of studies have found empirical evidence of this productivity effect on the real exchange rate. Due to the difficulty of drawing distinct line between traded and non-traded goods, different proxies for the BS effect have used in the literature. For example, Edison and Klovan (1987) and Mark (1996) use relative per capita GDP as a proxy for BS effect. 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 BS effect we use four productivity measures, such as real GDP growth rate, per capita real GDP growth rate, growth rate of real GDP per person employed and growth rate of GDP per hour worked.

Terms of trade: Terms of trade is an important determinant of the real exchange rate. However, the effect of terms of trade on the movement of the real exchange rate is ambiguous (Amano 1995). As the price of tradables is a weighted average of the prices of exportables and importables, the effect of TOT on the real exchange rate is cannot be determined *a priori* (Elbadawi and Soto, 1994). This is because two contrary effects, namely, *income effect* and *substitution effect*, work in opposite directions. An improvement in terms of trade, either through higher exportable prices or lower importable prices, raises the income of the economy. This *income effect* increases the demand for non-tradables and their prices, which in turn, reduces the relative price of tradables and appreciates the real exchange rate. Thus the final effect of terms of trade improvement/deterioration hinges upon the relative strength of these two effects. For example, Elbadawi and Soto (1994) study seven developing countries and find that for three of them terms of trade improvements lead to the real exchange rate appreciation, while for the four others, it leads to real depreciation.

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). Interest rate differential works through its effect on capital flows. When world interest rate is higher than domestic interest rate, capital will flow out until they are equalized and the vice versa. This link is robust in the business cycle domain, instead of lower frequencies (Edison and Pauls, 1993; Baxter, 1994).

Government expenditure: Government consumption on non-tradables is another fundamental variable that affects the movements of the real exchange rate. Higher government expenditure on non-tradables bid 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. As Edward (1988) notes that this is a poor proxy as it is possible for the total government expenditure to increase with the share of actual consumption of non-tradables going down. In this case larger share of government expenditure will fall on tradable and real exchange rate may depreciate. This depreciation does not come through changes in tradable prices, as that is determined in the world market and a small open economy cannot affect that. When larger share of government expenditure falls on tradable goods, demand for non-tradable goods falls and hence their prices, which depreciate the real exchange rate. So, the effect of this variable may be positive or negative.

Net foreign asset position of a country is considered to be an important determinant of the real exchange rate (MacDonald and Ricci, 2003; Lane and Milesi-Ferretti, 2000 & 2001). However, demographic variables are found to have major influence on the net foreign asset position of a country (Lane and Milesi-Ferretti, 2001). It can, therefore, be safely argued that net foreign asset position exerts its influence on the real exchange rate through, among other channels, demographic variables. Given 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; it will create the problem of endogeneity if both are included in the same regression equation. In this paper, 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:

$$\text{rer} = f\left(\underset{+}{productivity}, \underset{+}{tot}, \underset{+}{indiff}, \underset{+/-}{govex}, \underset{+/-}{pop} \right) \qquad (1)$$

where, *productivity* = productivity differential variable to capture BS effect, *tot* = index of net barter terms of trade, *intdiff* = interest rate differential, *govex* = government expenditure (% of GDP) and *pop* = population age structure variables. The following section empirically estimates and analyses the model.

4. Data sources, estimation and analyses

Data sources: World Development Indicator 2010 provides all data, except real effective exchange rate (REER) and interest rate, for the period 1970-2009. 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. The index of the real exchange rate is such that an increase in the index represents real appreciation. Log of terms of trade and real exchange rate indices are used in the estimation.

Real interest rate data for Australia are not available from 1970. Therefore, the difference between the real short-term interest rate of Australia and the USA is used as *intdiff*. Nominal short-term interest rate is deflated by consumer price indices to arrive at the real short-term interest rates. These data are taken from **Thomson Datastream.** However, the original source of these data is **OECD Economic Outlook.**

Estimation and analyses: 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 DF-GLS (ERS) test, which relies on local GLS de-trending to improve the power of the unit root test. Accroding to DF-GLS (ERS) test (reported in Table A3 in Appendix A) *lnrer* is I(1) with intercept and I(0) with intercept and trend. Among other variables, *lntot, govex, wapop* and *odep* are found to have one unit root and *intdiff, gdpgr, pcgdpgr* and *ydep* are found to be stationary processes.

One limitation of these traditional unit root tests is that they cannot identify the structural breaks in the underlying time series data, if there are any. 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 an 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; Narayan and Smyth, 2005; Salim and Bloch 2007; Hacker and Hatemi-J, 2008). 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 structural break. Therefore, rejection of null 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 break under 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 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. In this paper rely on Lee and Strazicich (2003) unit root test to get unambiguous results. Table A4 in Appendix A reports the results. According to this test *lnrer, lntot, wapop* and *odep* are first difference stationary with structural breaks and *intdiff, gdpgr* and *pcgdpgr* are level stationary variables. Stationary variables are, therefore, excluded from the model and cointegration analyses are carried out with following two sets of variables: (*lnrer, lntot, govex, wapop*) and (*lnrer, lntot, govex, odep*).[3] As the variables are I(1) with structural breaks, it is instructive to accommodate structural breaks in the analysis of the long-run relationship among those variables too. Gregory and Hansen (1996) introduce a methodology to test for cointegration in the presence of structural breaks.[4] Three models are estimated to test for the null of no cointegration against the alternative of cointegration with structural breaks. The first model allows change in the intercept

Model 1: $Y_t = \mu_1 + \mu_2\psi_{tk} + \alpha_1 X_t + \varepsilon_t$ (2)

The second model allows change in the intercept with trend

[3] Table A5 in Appendix A shows that the correlation coefficient between *wapop* and *odep* is 0.9138.Because of this high correlation, these two variables are included in the real exchange rate model separately.
[4] Although multivariate cointegration test proposed by Johansen (1991 & 1995) is widely used to test for cointegration relationship among a set of variables, it does not allow for structural break(s). However, because of its popularity, we perform this test and the results are reported in Table A6 & Table A7 in Appendix A. The results show that there are three cointegrating relationships among the four variables.

Model 2: $Y_t = \mu_1 + \mu_2\psi_{tk} + \beta_1 t + \alpha_1 X_t + \varepsilon_t$ (3)

The third model allows change in the intercept and slope coefficient

Model 3: $Y_t = \mu_1 + \mu_2\psi_{tk} + \alpha_1 X_t + \alpha_2 X_t \psi_{tk} + \varepsilon_t$ (4)

In each equation above, Y is dependent and X is the vector of independent variables, t is the time subscript, ε is the error term, k is the break data and ψ is a dummy variable such that

$\psi_{tk} = 0 \; if \; t \leq k$, and $\psi_{tk} = 1 \; if \; t > k$

The break date is found by estimating the cointegration equation for all possible break dates in the sample. For all possible break dates, the ADF corresponding to the residuals of the above models are computed and smallest value is selected as the test statistic, which is the most favorable for the rejection of null hypothesis. Cointegration test results for two set of variables are reported in Table 1.

Table 1: Gregory-Hansen (1996) cointegration test with structural break

Model	With *lnrer, lntot, govex, wapop*		With *lnrer, lntot, govex, odep*	
	Test statistics	Break date	Test statistics	Break date
(1)	-5.74561 **	1994	-5.64281**	1982
(2)	-5.79292 **	1999	-5.35574***	1996
(3)	-5.7500***	1981	-5.82041***	1990

(1) Critical values are with 3 (three) regressors are (a) Model (1): -5.77(1%), -5.28(5%), -5.02(10%); (b) Model (2): -6.05(1%), -5.57(5%), -5.33(10%); and (c) Model (3): -6.51(1%), -6.00(5%), -5.75(10%) (Gregory and Hansen, 1996).

(2) *, ** and *** indicate significant at 1%, 5% and 10% levels respectively

The test results in Table 1 show that both set of variables are cointegrated under all three specifications. In all six cases the null of no cointegration is rejected at the conventional significance levels. It, therefore, indicates that even if the variables experience structural breaks, their linear combinations are stationary However, the problem with Gregory-Hansen (1996) cointegration test is that it is a residual-based test and hence does not provide with the cointegrating vector(s). As the objective of this paper is to examine the effect of demographic variables on the real exchange rate, we need to estimate the long-run cointegrating equation to see the directions and magnitudes of these effects. To do so, we estimate Fully Modified OLS (FMOLS) originally developed by Phillips and Hansen (1990) and Hansen (1992) to estimate cointegrating regression. It corrects the least square to accommodate serial correlation effects and also for the endogeneity in the regressors that results from cointegrating relationship (Phillips, 1995). The estimated cointegrating vectors using FMOLS are reported in Table 2.

Table 2: FMOLS estimation results with *wapop* and *odep*

Variable	Coefficient	*p*-values	Coefficient	*p*-values
lntot	0.428957* (0.069144)	0.0000	0.504292* (0.093577)	0.0000
govex	0.022259* (0.004776)	0.0000	0.015320** (0.006444)	0.0232
wapop	-0.040172* (0.003639)	0.0000		
odep			-0.024737* (0.003647)	0.0000
C	3.434709* (0.345287)	0.0000	1.018043* (0.300329)	0.0018
R^2	0.808519			0.765945
R^2	0.791624			0.745293

Note: (a) Figures in the parentheses are estimated standard errors (b) * and ** indicate significant at 1% and 5% levels.

The cointegrating vectors show that the demographic variables are highly significant with anticipated signs. In the long-run, 1% increase in the share of working age population and old dependents depreciate the real exchange rate index by 4.01% and 2.47% respectively. Other two variables are also highly significant with anticipated signs. Positive coefficients of terms of trade indicate that in the long run income effect outweighs the substitution effect, which reduces relative price of tradables and appreciates the real exchange rate. Positive coefficients of government expenditure indicate that Australian government consumption expenditure is dominated by non-tradable goods, which causes prices of non-tradables to rise and appreciate the real exchange rate.

5. Conclusion

The objective of this paper has been to track down the direction and magnitude of 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 terms of trade, government expenditure and demographic variables, namely, working age and old age population. Interestingly, real GDP or per capita real GDP growth rate, used as a proxy for productivity differential, are found I(0) and hence not cointegrated with the real exchange rate. This may be due either to the quality of the proxy being poor or to the fact that productivity differential really does not have any effect on the real exchange rate. 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, 2007 & 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 to unveil a factor-demographic shock-that has long-run permanent influence on the real exchange rate. Using Fully Modified OLS, the paper finds that if the share of working age and old age cohort in total population increase by 1 percent, Australia's real exchange rate index depreciates by respectively 4.01 and 2.47 percent in the long run. In addition to demography, terms of trade and government expenditure shocks are also found to have significant power in explaining the permanent departure of the real exchange rate from its equilibrium value.

Finding of this paper has significant policy implication for external competitiveness of Australian economy. Due to population ageing, increase in the old age population will be greater than the decrease in working age population in the coming decades. This implies, other factors held constant, population age structure will have net depreciating effect on the real exchange rate, which will improve the trade balance. Therefore, while making projections about the future economic performance with reference to ageing population, ageing-induced improvement in trade balance should also be taken into consideration, which may ameliorate the projections.

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Table A1: Population ageing around the world

Year	World		More developed countries		Less developed regions		Least developed countries	
	Population aged 65 or over (mil)	Percentage aged 65 or over (%)	Population aged 65 or over (mil)	Percentage aged 65 or over (%)	Population aged 65 or over (mil)	Percentage aged 65 or over (%)	Population aged 65 or over (mil)	Percentage aged 65 or over (%)
1950	130.489	5.2	63.965	7.9	66.524	3.9	6.419	3.3
2000	421.684	6.9	170.538	14.3	251.145	5.1	21.514	3.2
2010	524.364	7.6	197.044	15.9	327.321	5.8	28.368	3.4
2030	976.111	11.7	290.024	22.4	686.087	9.8	56.085	4.5
2050	1510.567	16.2	337.213	25.7	1173.355	14.7	121.572	7

Source: World Population Prospect: 2010 Revision

Table A2: Australia's demographic trend (2010 – 2050)

	2010	2015	2020	2025	2030	2035	2040	2045	2050	Percentage points change from 2010 to 2050
ydep	18.9	18.5	18.2	17.9	17.5	17.2	16.8	16.7	16.6	-2.3
wapop	67.2	65.8	64.5	63	61.8	60.9	60.3	60	59.6	-7.6
odep	13.9	15.7	17.3	19.1	20.7	21.9	22.9	23.3	23.8	9.9

Source: World Population Prospect: 2008 Revision

Table A3: 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)
lntot	-0.7558 (0)	-3.1401 (1)	-4.9075* (1)	-4.898* (1)
intdiff	-2.2494** (0)	-3.8531* (1)		
govex	-1.3978 (0)	-1.7584 (0)	-4.2324* (0)	-4.6634* (0
gdpgr	-3.4848* (0)	-4.5398* (0)		
pcgdpgr	-3.7385* (0)	-4.9214* (0)		
wapop	-0.4319 (4)	-1.4467 (2)	-3.3537** (1)	-6.0227* (1)
odep	0.386 (2)	-1.9132 (0)	-3.987* (1)	-6.2894* (1)
ydep	-2.3893** (3)	-5.4157* (3)		

Note: (a) Critical values (with intercept) at 1% and 5% level are respectively -2.6965 and - 1.9544. (b) Critical values (with intercept and linear trend) at 1% and 5% level are respectively – 3.7700 and - 3.1900. (c) Figures in the parentheses are optimum lag length selected by SIC. (d) * and ** indicate significant at 1% and 5% levels respectively.

Table A4: 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	-4.7891	-6.1203*
		1994		
lntot	3	1979	-5.1720	-6.4206*
		1999		
intdiff	3	1977	-6.0164*	
		1986		
govex	3	1974	-3.8094	-6.1073*
		1980		
gdpgr	3	1984	-7.6026*	
		1992		
pcgdpgr	3	1984	-8.1927*	
		1992		
wapop	3	1984	-1.9219	-5.8609*
		1993		
odep	3	1978	-5.2582	-6.1790*
		1991		
ydep	3	1993	-5.7615**	
		1995		

(a) * and ** indicate significant at 1% and 5% levels respectively.
(b) For LS test critical values are -5.823(1%) and -5.286(5%) (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 A5: Correlation matrix

	lnrer	*wapop*	*odep*	*ydep*
lnrer	1.000			
wapop	-0.8423 (0.000)	1.000		
odep	-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 A6: Johansen cointegration test[5] with *lnrer, lntot, govex, wapop*

Hypothesized No. of CE(s)	Trace Statistic	p-values	Max-Eigen Statistic	p-values
$r = 0$	65.17661*	0.0005	27.67678**	0.0487
$r \leq 1$	37.49983*	0.0053	21.56024**	0.0435
$r \leq 2$	15.93959**	0.0428	15.18551**	0.0357
$r \leq 3$	0.754081	0.3852	0.754081	0.3852

Note: (a) Lag length 5 is selected by Akaike information criterion (AIC); (b) Trend assumption: linear deterministic trend in data and intercept (no trend in coinetragting equation) (c) *, ** and *** indicate significant at 1%, 5% and 10% levels respectively

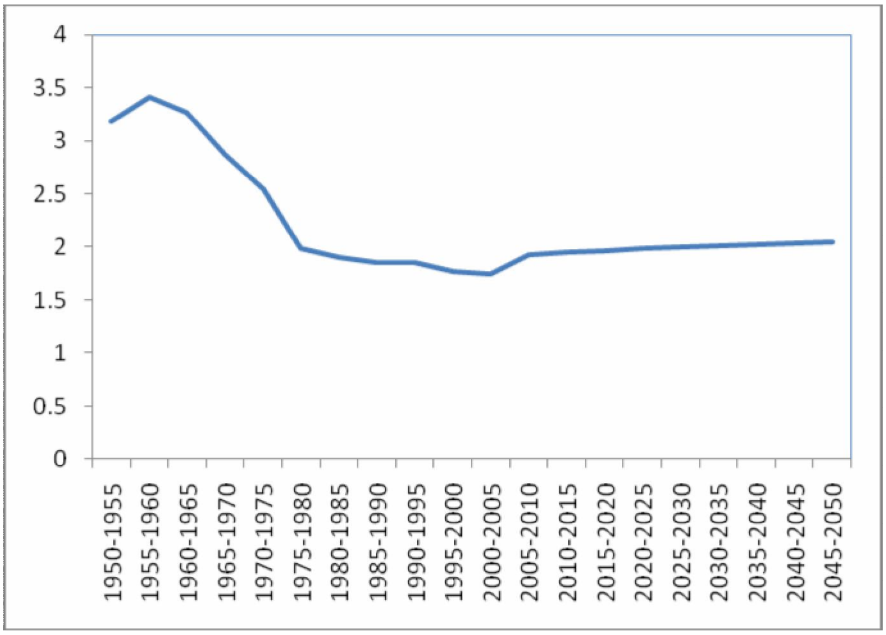
Table A7: Johansen cointegration test with *lnrer, lntot, govex, odep*

Hypothesized No. of CE(s)	Trace Statistic	p-values	Max-Eigen Statistic	p-values
$r = 0$	92.67126*	0.0000	43.61805*	0.0002
$r \leq 1$	49.05321*	0.0001	34.29779*	0.0004
$r \leq 2$	14.75542***	0.0644	14.65660**	0.0433
$r \leq 3$	0.098820	0.7532	0.098820	0.7532

Note: (a) Lag length 5 is selected by Akaike information criterion (AIC); (b) Trend assumption: linear deterministic trend in data and intercept (no trend in coinetragting equation), (c) *, ** and *** indicate significant at 1%, 5% and 10% levels respectively

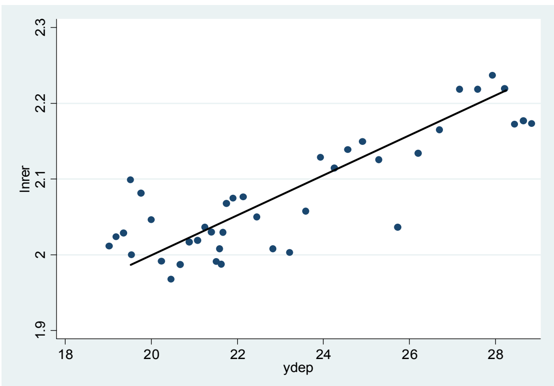
[5] Trend assumptions for cointegration tests in Table A5 & Table A6 are made according to Pantula (1989) suggested by Johansen (1992) and explained in Asteriou and Hall (2007)

Figure A1: Total fertility in Australia: 1950/55 – 2045/50



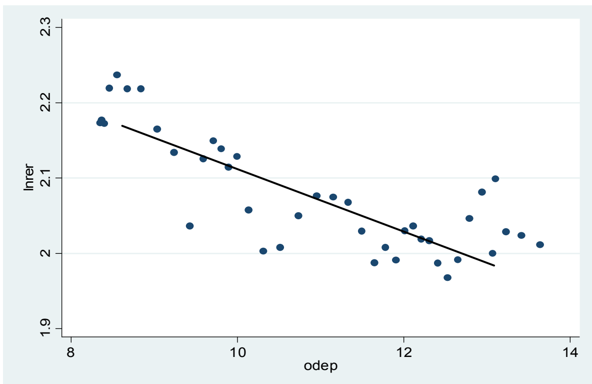
Source: World Population Prospect: 2010 Revision

Figure A2: Log of Real effective exchange rate (*lnrer*) and young dependents (*ydep*), 1970 – 2009



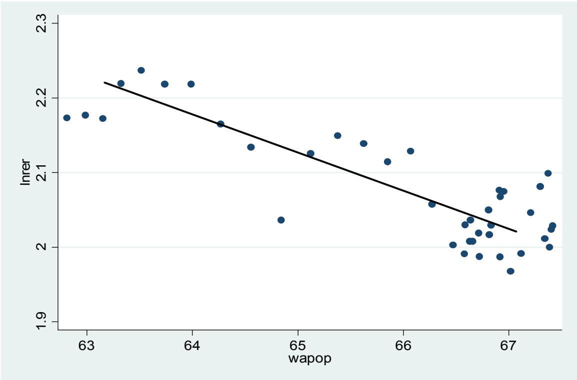
Source: World Bank, 2010 and Reserve Bank of Australia, 2010.

Figure A3: Log of Real effective exchange rate (*lnrer*) and old dependents (*odep*), 1970-2009



Source: World Bank, 2010 and Reserve Bank of Australia, 2010.

Figure A4: Log of Real effective exchange rate (*lnrer*) and old dependents (*wapop*), 1970-2009



Source: World Bank, 2010 and Reserve Bank of Australia, 2010.