

# Exploring the Relationship between Population Age Structure and Real Exchange Rate in OECD Countries

Ruhul Salim\* and Kamrul Hassan

## Abstract

*This article examines the impact of population age structure on the real exchange rate. Data on a panel of 23 OECD countries over 1980-2009 period are used to estimate the empirical model. The results show that the shares of working age and old dependent population have significant appreciating effects while the share of young dependent has a significant depreciating effect on the real exchange rate. These results have important policy implications given the fact that population is aging in almost all the OECD economies these days.*

**Key words:** Population structure, real exchange rate, saving, investment, panel data model.

**JEL Classification:** J1, F3, E2

## 1. Introduction

The real exchange rate is an important consideration in open economy macroeconomics. It is commonly used as a measure of competitiveness of the tradable goods sector and even as a measure of the standard of living in one country relative to another (Dwyer and Lowe, 1993). It influences consumption and resource allocation decisions between tradable and non-tradable goods, and also represents a country's comparative advantage. Different real (i.e. terms of trade, productivity) and nominal (i.e. money supply) shocks cause the real exchange rate to deviate from its equilibrium value, temporarily or permanently. There is an impressive body of empirical literature that examines the influence of real and nominal shocks on the real exchange rate. Terms of trade, interest rate differential, inflation differential, international capital flows, productivity differential, current account, etc. are found to have significant power to explain the movements in equilibrium RER in developing as well as developed countries. Recently, demography has been subjected to empirical research to examine its influence on the real exchange rate in a few studies. Although demography has been analyzed to explain the behavior of savings, capital flows and current account (Higgins, 1997; Serge, Guest and McDonald, 2000), the theoretical as well as empirical relation between the real exchange rate and demography is not so developed. Gente

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\*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  
Kamrul Hassan, Department of Finance and Banking, Rajshahi University, Bangladesh

(2001) shows that in a two-sector, two-period overlapping generations model, a fall in the birth rate leads to a long-run real exchange rate appreciation. On the empirical side, Andersson and Österholm (2005) find that, in Sweden, demographic structure has significant explanatory power in explaining the movements of the real exchange rate. These authors also find the similar findings in their subsequent study in the context of OECD countries (Andersson and Österholm, 2006).

Previous studies in this area consider only age structures as the independent variables. So, a complete model of the real exchange rate incorporating population dynamics is warranted for understanding the impact of population age structure on the real exchange rate. Due to falling fertility, population is ageing around the globe. However, the problem is more acute in developed countries. In 2010 the share of old aged people (65+) in the total population in major OECD countries was 16.36%, whereas, this share will rise to 27.80% in 2050 (see Table A7 in Appendix A). Such an incredible increase (more than 11 percentage point) in the elderly population will put huge pressure on internal and external balance through their influence on domestic saving and investment. Hence, it is high time to examine the effect of population age structure on the real exchange rate, along with other usual determinants. Although the empirical studies on exchange rate determination are diverse, but there is no comprehensive study that incorporates most determinants, including population age structure in the same framework. This article intends to fill this gap and as such makes a contribution to the literature. The objective of this paper is to estimate a model of the real exchange rate with different cohorts of population as additional independent variables and examine whether demographic variables have any significant influence on the movements of the real exchange rate. The novelty of this paper lies in the fact that unlike previous studies in this area, it not only considers saving effect, but also investment and consumption demand sides of population age structure. Another distinguishing feature of this paper is that it considers, in addition to population age structure, other determinants of the real exchange rate. Finally, the finding of this paper makes significant addition to the Purchasing Power Parity (PPP) literature as well.

The rest of this paper is organized as follows. Section two contains a critical review of the related literature. Impact of population age structure on the real exchange rate is discussed in Section 3, followed by discussions of other determinants of the real exchange rate in Section 4. Section 5 deals with sample, data, estimation and analyses of results. The paper concludes in Section 6.

## 2. Review of Relevant Literature

There is a large body of literature on the determinants of the real exchange rate. A wide range of factors have been identified in these studies as responsible for the equilibrium value of the real exchange rate. These factors include the terms of trade (Chowdhury, 2000; Mkenda, 2001; Choudhri and Khan, 2004), capital inflow (Chowdhury, 2000), real interest rate differential (Athukorala and Rajapatirana, 2003; Chortareas and Driver, 2001), relative productivity (Alexius, 2000), government consumption (Chowdhury, 2000; Mkenda, 2001), labor productivity (Choudhri and Khan, 2004) and oil price (Wang and Dunne, 2000).

In addition to these factors, recently research attention has focused on population age structure of an economy that has an important influence on the real exchange rate. One channel of influence is the impact the population structure on saving and consumption behavior as postulated in the Life Cycle Hypothesis (LCH) of Modigliani and Brumberg (1954).<sup>1</sup> An economy's savings and thereby, capital formation partly depends on the size of different cohorts of population. Working age people save everywhere in the world. In a study on OECD countries, Lindh and Malmberg (2004) find that age effects on saving are similar across a world sample over the period 1960-1995. Age structure of population also has influence on the economies' investment through saving. Lindh and Malmberg (1999) find that investment behavior displays different patterns of response to age structure across the sample of OECD countries. They find that a young working age people invest more in housing, whereas a middle-age working people invests in business. The housing investment is rationalized by the tendency of population to settle down by the formation and acquisition of permanent shelter during youth; however the latter investment behavior is left without any solid explanation.

A more formal and direct link between age structure and investment can be found from the standard production function, which demonstrates that a fall in the number of workers raises the wage and decreases return to capital by raising the marginal product of labor and decreasing the marginal product of capital, respectively. Ludwig *et al* (2007) find that due to aging population, productivity of capital in major industrialized

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<sup>1</sup> Over the last couple of decades, population growth rates in developed countries have slowed down. During 1950-1955 population growth rate in the developed countries was 1.20 percent, whereas this growth rate declined to 0.36% during 2000-2005. A projection by the United Nations shows that over the period 2005-2050, the share of the population aged 15-59 will decline from 62.9 percent of the total population of the developed countries to 52.2 percent (World Population Prospect: The 2006 Revision).

countries will fall and wage will rise. Their simulation results show that the rate of return on capital can be expected to fall by about 80 to 90 basis points until 2050 with a corresponding increase of wage. As in the world of free capital mobility, capital flows from low-return to high-return locations (Chatterjee and Naknoi, 2007); fall in return on capital would cause capital outflow and the real exchange rate to depreciate.

Research work on population dynamics and the real exchange rate is very limited. So far, a few studies have been conducted in the context of developed countries. Andersson and Österholm (2005) use Swedish age structure data over the period 1960-2002 to forecast the real exchange rate. The authors find that the age structure has significant explanatory power on the real exchange rate and their out-of-sample, medium-term forecasts of the real exchange rate perform well. Findings of this paper indicate that in an aging economy population growth has appreciating effect on the real exchange rate.

Latter, Andersson and Österholm (2006) estimate a reduced-form equation where the real exchange rate is regressed on different cohorts of population of 20 OECD countries over the period 1971-2002. They divide the total population into six groups: children (0-14), young adults (15-24), prime aged (25-49), middle aged (50-64), young retirees (65-74) and old retirees (75- and above). Their results show that different age groups affect the real exchange rate differently. The prime and middle age group (25-49 and 50-64 years respectively) have a depreciating impact, as they are productive and save for their retirement, which causes capital outflow. On the other hand, the study finds that young adults and retirees (15-24 and 65-above years respectively) have an appreciating effect. This is because these groups are not productive, they are dependent and they dissave, so they seem to cause capital inflow and depreciation. The authors, however, do not include other factors in their regression model.

Aloy and Gente (2009) also find significant appreciating impact of falling population growth in Japan on Yen/US dollar bi-lateral real exchange rate. This paper employs an overlapping generations (OLG) model linking the population growth to real exchange rate. However, they do not consider the USA-Japan bi-lateral trade balance, which has been identified as one of the major factors for yen's real appreciation against the US dollar (Rahman *et al*, 1997).

Ross *et al*. (2009) analyze the link between demography and the real exchange rate from a different viewpoint. They argue that a drop in fertility is associated with lower child-rearing cost, which increases saving. A smaller populace due to lower fertility

causes investment to fall. Thus higher saving and lower investment improve the current account and depreciate the real exchange rate. Using panel data covering 87 countries over 1975 – 2005, they find empirical support in favor of their hypothesis. However, their hypothesized link between fertility, saving and investment needs careful attention. A fall in investment due to a fall in fertility could take longer time than a rise in saving. If the changes in saving and investment are not contemporaneous, then the proposed changes in the current account, and hence the real exchange rate, may not follow.

Very recently Du and Wei (2011) relates sex ratios to the real exchange rate. Higher sex ratio creates current account surplus and capital outflow, which causes real exchange rate depreciation. They argue that countries with higher sex ratios appear to have a low value of the real exchange rate and current account surplus. Their study focuses on Chinese economy and finds that sex ratios and other factors, such as, dependency ratio, Balassa-Samuelson effect, exchange rate regime, and financial underdevelopment contribute to the undervaluation of Chinese real exchange rate by 2-8%.

From the above discussion it is clear that the relationship between population age structure and the real exchange rate has mostly been examined in terms of the saving effects of different cohorts of population. However, different cohorts of population also place demand for tradable and non-tradable goods at varying degrees. Besides, changes in population age structure have significant implication for labor supply and hence marginal productivity of labor and capital (Ludwig *et al*, 2007). These factors have not been considered in previous studies, which create a huge gap in this area of research. Moreover, only a handful studies addressing this issue empirically, remains inadequate for policy purposes. Thus, it is worthwhile to examine the impact of population age structure on the real exchange rate. The present paper makes an effort to accomplish this task.

### **3. 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 dissaving 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 dissaving. 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 and 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-traded goods may result in their higher prices relative to traded goods leading to real depreciation. The net effect depends on the relative magnitudes of saving effect and 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 dissaving 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.

The size of the working age cohort of population should also have significant effect on the real exchange rate. This is the cohort that mainly contributes to the private saving in an 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. Existing studies on demography and the real exchange rate do not take this channel of influence into consideration. Developed countries are

passing through notable changes in their demographic composition, which make these countries likely candidates for a study on demography and the real exchange rate.

From the above discussion it is clear that the demographic structure should have significant effect on the real exchange rate, however, the direction of this effect is not clear *a priori*.

#### **4. Other determinants of the real exchange rate**

The main focus of this paper is to examine the effect of population age structure on the real exchange rate. However, only population age structure cannot be the sole determinant of the real exchange rate. Other 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 been used in the literature. For example, Edison and Klován (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, Cumby, and Diba (1996) use the average labor 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 terms of trade on the real exchange rate 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.

*Net foreign assets:* The effect of net foreign assets on the real exchange rate can be analyzed in terms of *wealth effect*. An improvement in net foreign assets raises national wealth of an economy, thereby inducing larger expenditure on and therefore, the price of non-tradable goods, which, in turn appreciates the real exchange rate (MacDonald and Ricci, 2003). Wealth effect may also work by changing labor supply. Higher wealth may reduce labor supply to the non-tradable sector, leading to an increase in the relative price of non-tradables and the result is appreciated real exchange rate (Lane and Milesi-Ferretti, 2004). It is therefore, expected that net foreign assets will have an appreciating effect on the real exchange rate.

*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). When world interest rate is higher than domestic interest rate, capital will flow out and real exchange rate will be depreciated and it will appreciate when domestic interest rate is higher than the world interest rate.

*Government expenditures:* 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, it is proxied by the ratio of government total consumption expenditure to GDP. 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 tradables and the 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.

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

$$RER = f \left( \underset{+}{Productivity}, \underset{+}{tot}, \underset{+}{nfa}, \underset{+}{intdiff}, \underset{+/-}{govex}, \underset{+/-}{pop} \right) \quad (1)$$

Where, *productivity* = productivity differential variable to capture BS effect, *tot* = terms of trade, *nfa* = net foreign assets, *intdiff* = interest rate differential, *govex* = government expenditure, and *pop* = population age structure variables. The following section empirically estimates and analyses the model.

## 5. Sample, data and estimation

A panel of 23 OECD countries<sup>2</sup> is selected based on the availability of data. The study covers a period of 30 years, from 1980 to 2009.<sup>3</sup> However, some observations on some variables are missing and as such we estimate an unbalanced panel data model. Four measures of productivity are used to proxy for productivity differential: real GDP growth rate (*gdpgr*), per capita GDP growth rate (*pcgdpgr*), growth rate of GDP per person employed (*gdpppegr*) and GDP per hour worked (*gdpphw*). Terms of trade (*tot*) is the net barter or commodity terms of trade, which is the ratio of the export price index to the import price index. Difficulty arises in selecting interest rate differential (*intdiff*) variable. As there is no unique interest rate that can be termed as world interest rate, the variable poses a problem as to what rate should be taken as a proxy for it. Theoretically, the world interest rate is given for a small open economy, that is, a small

<sup>2</sup> Country list is given in Appendix B

<sup>3</sup> Data sources are detailed in Appendix B

open economy cannot influence this rate. All small open economies are affected by a change in world interest rate. From this point of view, the real interest rate of the USA is taken as a proxy for the world interest rate, because any change/shock in the US economy affects other countries in the world. For this reason, the USA economy is used in the analysis of large open economy textbook model (for example Mankiw, 2007). Net foreign assets, government expenditure, trade openness (sum of import and export) are measured as percentage of GDP.

With regard to population structure, three cohorts of population are used; 0 -14 years old (young dependents or *ydep*), 15 – 64 years old (working age population or *wapop*) and 65 and above (old dependents or *odep*). All these cohorts are measured as percentage of total population.

Before estimating the regression, careful attention is given to identify all possible time series properties of the data set. First of all we examine whether there is any cross-sectional dependence in the data set. It is possible that a common shock affects all the cross-section units in the sample. Presence of cross-sectional dependence reduces the reliability of panel unit root tests. We employ the general diagnostic test for cross-sectional dependence in panels proposed by Pesaran (2004). Table-A2 in Appendix A reports cross-sectional dependence (CD) test results. The results fail to reject the null of cross-sectional dependence at 1% significance level.

Having being confirmed the cross-sectional dependence, the analysis next proceeds to check the stationarity properties of the variables. Several methods have been proposed to test stationarity in panel data among which three methods are widely used: Im, Pesaran and Shin (2003) [hereafter IPS], Levin, Lin and Chu (2002) [hereafter LLC] and Maddala and Wu (1999) [hereafter MW]. All these tests have their own limitations, such as LLC is applicable for homogeneous panel, where the autoregressive (AR) coefficients for unit roots are assumed to be the same across cross-sections. Although IPS allows heterogeneous panels, a major criticism of both LLC and IPS tests is that they both require cross-sectional independence. Maddala and Wu (1999) find that MW test is more robust than LLC and IPS tests to the violation of this assumption. However, MW test is not designed to directly address this problem. Pesaran (2007) proposed a new panel unit root test that allows the presence of cross section dependence. We employ both MW and Pesaran (2007) tests. However, before performing panel unit root test, we make a visual inspection of the data to see if any series experiences abrupt

change in intercept or trend or both. We find that except Poland, variables in other countries do not exhibit any sign of significant structural change in intercept or trend or both.<sup>4</sup> We therefore exclude this country from panel unit root tests and the report the results for 22 countries in Table-1 below.

The results show that all series, except *govex* and *nfa*, are  $I(0)$  under both tests. *govex* is  $I(1)$  under Pesaran (2007) and  $I(0)$  under MW test, while *nfa* is  $I(1)$  under both the tests.<sup>5</sup> As Pesaran's (2007) test directly addresses the cross section dependence issue, we accept the results given by this test and exclude *govex* and *nfa* from the model as they are integrated to a different order.

Before we proceed further some observations are in order. Both Pesaran (2007) and MW test indicate that the real exchange rate is  $I(0)$ . This result bears significant relevance to the Purchasing Power Parity (PPP) literature. The PPP theory states that the real exchange rate is mean-reverting, that is, any shock to it is temporary. However, Balassa (1964) and Samuelson (1964) note that differential in relative productivity of tradable over non-tradable sector between countries induces the real exchange rate to deviate permanently from its equilibrium value. According to this Balasaa-Samuelson (BS) effect the real exchange rate series should be random walk. Table-1 shows that the real exchange rate is stationary, which implies productivity differential does not have any impact on it. So we exclude the productivity variable from the model.

**Table-1: Panel unit root test**

Variables	Pesaran (2007) panel unit root test		Maddala and Wu (1999) Panel Unit Root test	
	Without trend	With trend	Without trend	With trend
Inrer	-2.599* (0.005)	-2.406* (0.008)	63.918** (0.041)	61.420*** (0.064)
Intot	-1.511*** (0.065)	-2.419* (0.008)	77.195* (0.003)	64.267** (0.039)
govex	2.054 (0.980)	2.532 (0.994)	65.561** (0.031)	58.996*** (0.095)
nfa	0.249 (0.598)	0.740 (0.770)	39.830 (0.727)	43.103 (0.594)
intdiff	-3.009* (0.001)	-6.337* (0.000)	111.398* (0.000)	77.762* (0.002)
gdpgr	-4.566* (0.000)	-3.558* (0.000)	129.668* (0.000)	97.164* (0.000)
pcgdpgr	-3.804* (0.000)	-3.139* (0.001)	183.004* (0.000)	138.757* 0.000
productivity	-4.206* (0.000)	-3.407*	202.681*	212.079*

<sup>4</sup> We do not produce these plots due to space limitation

<sup>5</sup> Unit root tests of *govex* and *nfa* in their first differences are reported in Table-A3 in Appendix A.

		(0.000)	(0.000)	(0.000)
pcgdpppegr	-5.797* (0.000)	-5.286*	240.885*	241.044*
		(0.000)	(0.000)	(0.000)
wapop	-16.793*	-14.662*	763.340*	956.974*
	(0.000)	(0.000)	(0.000)	(0.000)
odep	-12.131*	-11.156*	238.151*	670.368*
	(0.000)	(0.000)	(0.000)	(0.000)
ydep	-11.431*	-11.156*	790.363*	851.325***
	(0.000)	(0.000)	(0.000)	(0.000)

Note: \*,\*\* and \*\*\* indicate significant at 1%, 5%, and 10% levels.

One empirical problem with panel data model is to choose between fixed effect and random effect model. Although there are econometric tests to decide on which method to apply, theoretically the choice hinges upon the nature of inferences the researchers want to make. In case of fixed effect model researchers make inferences that are conditional to the particular cross-section unit in the sample. In case of random effect model the inferences are unconditional with respect to the population of all effects (Hsiao, 2003). In other words, when some effect is modeled as random, it is meant that the researcher wishes to draw inferences about the population from which the observed units were drawn, whereas, in case of fixed effects, the inferences drawn are specific to those particular units. From this point of view, the model under consideration should be a random effect model. The relationship between demographic structure and the real exchange rate is a phenomenon that is expected to hold in all economies, it is modeled not only for OECD countries. The OECD countries are chosen to test the hypothesis and draw inference about the impact of demographic variables on the real exchange rate in general. It is not expected that the relationship will be confined to the OECD countries only. Therefore, from theoretical point of view, it is appropriate to study the modeled relationship between the real exchange rate and demographic structure in terms of a random effect model.

However, as there are formal econometric tests to identify a model as 'fixed' or 'random', it is worthwhile to employ those tests and proceed accordingly. Model selection test is carried out in two steps. In the first step, Breusch and Pagan (1980) test is conducted to ascertain whether the regression model with a single constant term is appropriate or there is individual effect in the model. In the second step, the Hausman (1978) test is performed to identify whether the effect is fixed or random. The results (reported in Table-A4 in Appendix A) indicate that 'random effect' is appropriate for the model under consideration. Accordingly regression equation (1) is estimated (with

I(0) variables excluding productivity) with random effect and the results are reported in column (1) of Table-2. As the shares of three cohorts of population sums to 1, including all three will create perfect multi-collinearity. Therefore we include two of them. The choice of two, out of three demographic variables is dictated by the correlation among them. The correlation matrix is presented in Table-A5 in the Appendix. The results indicate that there is high significant negative correlation between *odep* and *ydep* (-0.801 with *p* value 0.000) and between *wapop* and *ydep* (-0.566 with *p* value 0.000). Whereas, the correlation between *wapop* and *odep* is statistically not different from zero (-0.404 with *p* value 0.330). We therefore include *wapop* and *odep* in our model.

**Table-2: Estimation results of REM and PCSE**

Independent variables	REM (1)	REM excluding Korea & Hungary (2)	PCSE with common time dummies (3)	PCSE with common time dummies & <i>ydep</i> (4)
Intot	0.9756* (0.1062)	0.6569* (0.0795)	0.7987* (0.1074)	0.7749* (0.1075)
intdiff	0.0061* (0.001)	0.0052* (0.0010)	0.0033* (0.0007)	0.0033* (0.0008)
wapop	-0.0175* (0.0039)	0.0107* (0.0032)	0.0130** (0.0057)	
odep	-0.0004 (0.0034)	0.0065* (0.0025)	0.0257** (0.0061)	
ydep				-0.0197* (0.0043)
Time dummy			-0.0042* (0.0015)	-0.0040* (0.0015)
Constant	3.8228* (0.3067)	2.4246* (0.2318)	1.7925* (0.4419)	3.4481* (0.2274)
$R^2$ : Within	0.1635	0.2435	$R^2 = 0.9783$	$R^2 = 0.9781$
Between	0.0097	0.0610		
Overall	0.0617	0.1672		
Wald $\chi^2$	99.61* (0.000)	151.41* (0.000)	82.15* (0.000)	80.06* (0.000)

The results show that all variables, except *odep* are highly significant. However, before discussing the results it is essential to examine if the model produces well behaved residuals. Figure-A1 in Appendix A plots residuals from the above RE model. The plot clearly shows that Poland and Hungary are two countries giving rise to abnormal residual values. To obtain well-behaved residuals and avoid the problem of having outliers, RE model is re-estimated with these two countries excluded from the panel and the results are reported in column (2) of Table-2. Results show that all variables are

highly significant. However, signs of *wapop* and *odep* change from negative to positive. Before delving into these results, we examine the residuals once again. This time residuals show much better behavior (Figure-A2 in Appendix A). However, strong sign of autocorrelation is found from the scatter plot of current period residual against one period lagged residual (Figure-A3 in Appendix A). Woolridge's (2002) test for first order autocorrelation in linear panel model ( $F$  statistic of 350.217 with  $p$  value 0.000) also confirms that the residuals suffer from first order serial correlation.

Unequal variances of the error terms pose another problem for efficient estimation of the parameters.. Greene (2000) proposes a test to examine constancy of variance in fixed effect model. However, there is no test available for random effect models. As heteroskedasticity is the result of characteristics unique to each cross-section unit, it is likely that the error variances are unequal across cross-sectional units. If this is the case, then the estimation without accounting for this heteroskedastic errors will produce inefficient parameter estimates.

As there is no test available to examine heteroskedasticity in random effect model, plotting squared residual against the predicted values of the dependent variable may give a rough idea of the nature of heteroskedasticity in the error terms (Gujarati 2003:401). Figure-A4 in Appendix A presents such a plot which shows that residual variance is high when predicted values of the dependent variable range between 4.5 and 4.6. It signals that the residual variances are not constant across countries.

So the residuals from the RE model appears to be non-spherical. Under this situation, the options that are available to obtain unbiased and efficient parameter estimates are: (i) Feasible Generalized Least Square (FGLS); (ii) Panel Corrected Standard Errors (PCSE). One problem with FGLS, developed by Park (1967) is that it is applicable in 'short and wide' data set (i.e.  $T < N$ ). In this paper we have 'long and narrow' data set (i.e.  $(T=30) > N(=21)$ ). FGLS applied to this type of data set produces biased standard errors (Beck and Katz, 1995). As an alternative to FGLS, Beck and Katz (1995) advocate the method of Panel Corrected Standard Error (PCSE), which is suitable for 'long and narrow' data set. In PCSE coefficients are estimated by OLS and then standard errors are corrected for non-spherical distribution of the disturbance term.

As the present model suffers from the problem of non-spherical disturbances, PCSE is employed to tackle the problem of serial correlation and possible heteroskedasticity. Before checking unit root we checked cross-sectional dependence among the variables

and found a high degree of dependence. If the residuals of a regression model also suffer from cross-sectional dependence, it is usual practice to include a common time dummy to capture this dependence. Pesaran's (2004) CD test on the residual indicates high degree of dependence in the residual (please see Table-A6 in appendix A). A common time dummy is therefore included in the PCSE estimation and the results are reported in column (3) of Table 2.<sup>6</sup>

The PCSE estimation result shows that all variables are highly significant with expected signs. The elasticity of real effective exchange rate (*reer*) with respect to terms of trade (*tot*) indicates that 1% increase in the *tot* index appreciates REER index approximately by 0.80%. As the coefficient is less than one, it can be inferred that the real exchange rate is inelastic to the changes in terms of trade. The interest rate differential (*intdiff*) coefficient indicates that higher domestic interest rate relative to the world appreciates the *reer*. 1% increase in *intdiff* appreciates the *reer* index by 0.33%. This finding is consistent with the international finance theory that capital flows to higher return economy.

Positive coefficient of *wapop* indicates that larger share of working age population has appreciating effect on the real exchange rate. For 1% increase in the working age cohort, *reer* index appreciates by 1.30%. A higher share of working age people increases the number of workers. An increased number of workers raises the marginal product of capital and hence return on capital. An increased number of workers also decreases the marginal product of labor and hence wage. On the one hand, wage decreases in such a way that the aggregate saving falls, and the higher return on capital attracts capital, on the other hand. These two effects, lower saving and higher return on capital, combined causes capital inflow and the real exchange rate to appreciate. This finding is in sharp contrast to the existing view that higher share of working age population increases saving and depreciates the real exchange rate (for example, Andersson and Österholm, 2005 & 2006). Andersson and Österholm (2005 & 2006) consider only the impact on the saving channel and ignore the labor and capital

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<sup>6</sup> Our model contains variables both in log form and in percentage form; we need to be careful in interpreting the results. Among independent variables, only the terms of trade (TOT) is in logarithmic form. Therefore, the coefficient of *Intot* is the elasticity of REER with respect to TOT. The other variables are in percentage form. In these cases the interpretations of coefficients are that of log-linear model, where only dependent variable is in logarithmic form. In log-linear model, a slope coefficient indicates relative change in dependent variable for one unit change in an independent variable. Thus, when the coefficient is multiplied by 100, it is interpreted as the percentage change in dependent variable for a unit change in independent variable (Stewart, 2005:233). Therefore, all coefficients, except the coefficient of *Intot*, are multiplied by 100 to express percentage change in REER index.



productivity avenues that have significant influences on capital flows and therefore, on the real exchange rate.

Coefficient of *odep* supports the traditional view that larger share of older population decreases saving and appreciates the real exchange rate. 1% increase of the size of this cohort appreciates the real exchange rate by 2.57%. This effect is even larger than *wapop*. This finding is in line with Andersson and Österholm (2005 and 2006), however, it does not lend any support to the recently claimed view that older people increases saving, for example Palumbo (1999) and Nardi *et al* (2006 & 2009).

So far we examined the effects of *wapop* and *odep* on the real exchange rate and did not include *ydep* because of its high correlation with *wapop* and *odep*. Now the model is estimated with *ydep* to see how this cohort of population affects the real exchange rate. PCSE result with *ydep* is reported in column (4) of Table-2. The result shows that there is no noticeable change in the coefficient values of other variables. Significant negative coefficient of *ydep* indicates that this cohort of population has depreciating effect on the real exchange rate. This indicates that the consumption effect of this cohort outweighs its saving effect. The young cohort reduces saving through consumption without any contribution to income. However, consumption effect that comes through demand and therefore, relative price of non-tradables, is greater than the saving effect, which causes real exchange rate to depreciate. Coefficient of *ydep* indicates that 1% increase in the share of young dependents depreciates the real exchange index rate by 1.97%. Like *wapop*, this finding also contradicts with previous studies of similar type, i.e. Andersson and Österholm (2005 & 2006). In their study they postulate that young cohort<sup>7</sup> do not earn any income and reduce saving, however, they ignore the fact that young population mainly consume non-tradable goods and thereby tend to increase their prices relative to tradables and depreciates the real exchange rate.

Given the rapidly ageing scenario (Table-A7) finding of this paper bears significant policy implications for the OECD countries in particular and for the world in general. It is found that the share of old aged people has the largest impact on the real exchange rate among the three age cohorts. This cohort reduces saving, causes capital inflow and appreciates the real exchange rate. Working age cohort is also found to have

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<sup>7</sup> In Andersson and Österholm (2005 & 2006) young cohort is defined as the share of population aged group between 15 to 25, and they call them 'young adult'. However, it does not seem to be a plausible assumption in terms of developed countries, where young adults start earning from college.

appreciating effect on the real exchange rate. Only young dependent are found to have real depreciating effect. However, due to falling population growth current young cohort will enter into working age cohort in the next decades and current working age cohort will also enter old age cohort in a couple of decades time. It is, therefore, unlikely that the appreciating effects of working age and old age cohorts will be offset by the depreciating effect of the young cohort.

The population age structure, therefore, will have net appreciating effect on the real exchange rate. This will pose threat both to the internal and external equilibrium. Internal equilibrium will be in trouble when higher share of old aged people will reduce domestic saving significantly, giving rise to saving-investment disequilibrium. This disequilibrium will affect capital market and asset prices. To correct for this disequilibrium capital will flow in with real appreciation. Real appreciation will lead to external disequilibrium through higher import and lower export. The ageing developed countries will thus experience current account deficit in the decades to come. This result is consistent with the prediction of Buiter's (1981) overlapping generations model. However, the real exchange rate is  $I(0)$ , its effects are not permanent and there is scope for policy intervention to correct for this internal and external disequilibrium.

## **6. Conclusion**

This article examines the relationship between population age structure and the real exchange rate of 23 OECD countries. Three demographic and other usual variables are considered in the empirical specification of the real exchange rate model. The results show that the proportion of working age and the proportion of old dependent population have appreciating effects on the real exchange rate. Contrary to the recent findings on the elderly saving behavior, as discussed in section 3, it seems that elderly people exert negative pressure on saving and put higher investment demand relative to their saving leading to real appreciation. This finding is in line with those of previous studies (Andersson and Österholm, 2005 & 2006). However, the appreciating effect of the working age cohort and depreciating effect of young dependent cohort contrast with the findings of previous studies. This is because the present study considers broader avenues through which age structure affects capital flows and the real exchange rate. Previous studies consider only the saving channel, whereas this study considers the investment channel too. Thus our empirical results show that when both saving and investment channels are taken together into consideration, the impact of age structure

on the real exchange rate change significantly. Since the change in age-structure is a long-run phenomenon, the relationship found in this study could effectively be used to analyze behavior of the real exchange rate in the long-run. The findings of this paper also have significant policy relevance. Ageing population in developed world will affect internal and external balances through its effects on saving, investment and the real exchange rate. As the real exchange rate is mean-reverting, the internal and external effects are not permanent and policy intervention can cure those imbalances.

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## Appendix A

Table-A1: Descriptive statistics

Variables		Mean	Standard Deviation	Observations
lnREER	Overall	4.6583	0.1767	584
	Between		0.1149	
	Within		0.1357	
lnTOT	Overall	4.5960	0.1311	571
	Between		0.0856	
	Within		0.0991	
G	Overall	18.6078	4.8178	584
	Between		4.6362	
	Within		1.3173	
NFA	Overall	5.1080	16.3101	584
	Between		12.4321	
	Within		11.0456	
WAPOP	Overall	66.4895	2.4460	584
	Between		1.9229	
	Within		1.5341	
YDEP	Overall	20.2161	4.5725	584
	Between		3.8602	
	Within		2.3379	
ODEP	Overall	13.2944	3.3508	584
	Between		3.0187	
	Within		1.3264	
DEPWAPOP	Overall	50.6134	5.8518	584
	Between		4.5541	
	Within		3.7026	

Table-A2: Pesaran's (2004) cross-sectional dependence (CD) test

Series	CD test statistic	Correlation	Series	CD test statistic	Correlation
lnrer	14.06* (0.000)	0.427	gdpg	16.53* (0.000)	0.382
lnTOT	3.65* (0.000)	0.577	pcgdpg	17.55* (0.000)	0.397
govex	6.57* (0.000)	0.437	gdpppeg	14.88* (0.000)	0.268
nfa	3.63* (0.000)	0.483	gdpphw	4.24* (0.000)	0.207
intdiff	30.23* (0.000)	0.531			



Table-A3: Panel unit root test for  $\Delta govex$  and  $\Delta nfa$ 

Variables	Pesaran (2007) panel unit root test		Maddala and Wu (1999) Panel Unit Root test	
	Without trend	With trend	Without trend	With trend
$\Delta govex$	-4.384* (0.000)	-4.108* (0.000)		
$\Delta nfa$	-3.909* (0.000)	-2.378* (0.003)	163.221* (0.000)	127.243* (0.000)

Note: \* indicates significant at 1% levels.

Table-A4: Breusch-Pagan and Hausman test results

Breusch and Pagan test statistics	Hausman test statistic
662.98 (0.000)	1.35 (0.9296)

Note: Figures in the parentheses are  $p$  values

Table-A5: Correlations among demographic variables

	WAPOP	ODEP	YDEP
WAPOP	1.0000		
ODEP	-0.040 (0.330)	1.0000	
YDEP	-0.566 (0.000)	-0.801 (0.000)	1.0000

Note: Figures in the parentheses are  $p$  values.

Test results show that the Breusch-Pagan test statistic is highly significant, that is, the null hypothesis of no country specific effect is rejected. Highly insignificant Hausman test statistic indicate that the null hypothesis that random effect estimator is consistent cannot be rejected. This implies that country specific effects are not correlated with the exogenous variables.

Table-A6: Cross-sectional dependence test on residual (RE model without Korea and Hungary)

Series	CD-stat	Correlation
Residual	8.39* (0.000)	0.437

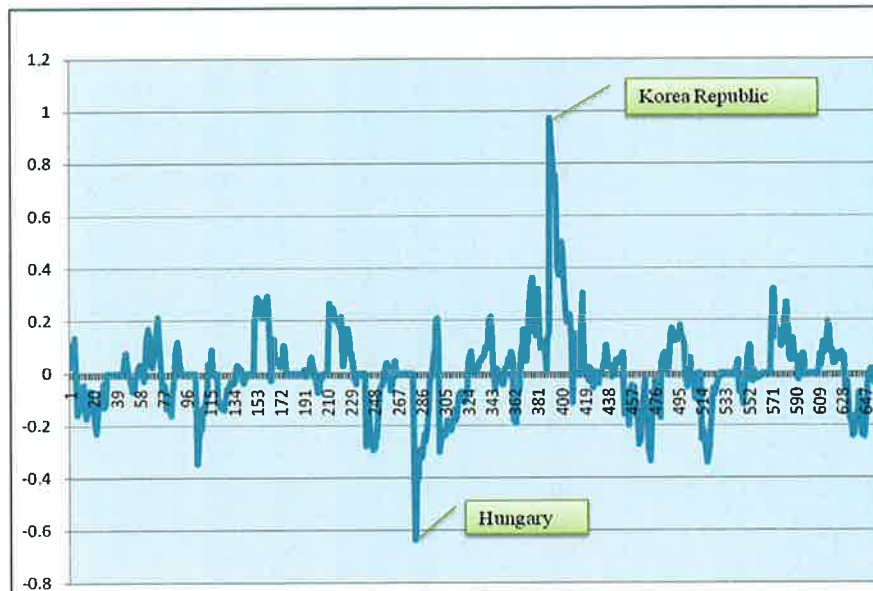
Note: Figure in the parenthesis is  $p$  value

**Table A7: Percentage of population aged 65 and over**

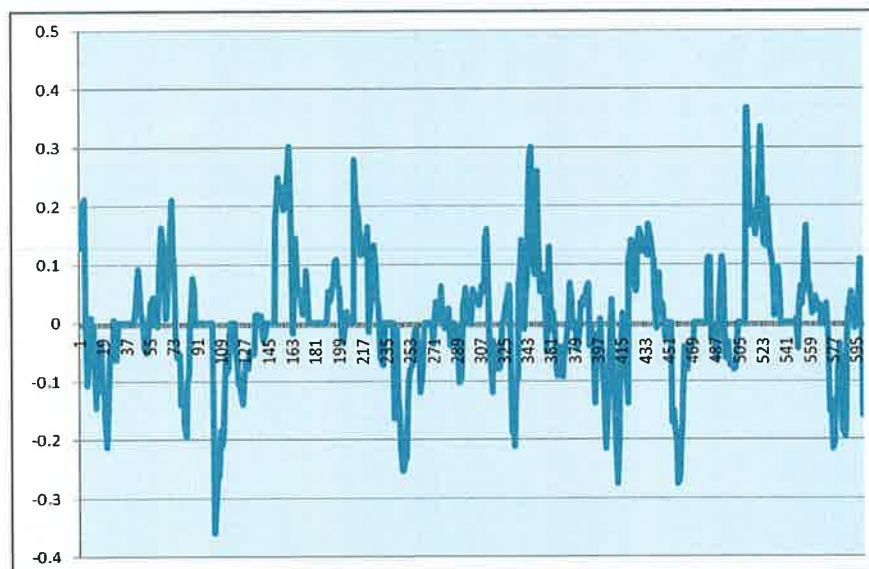
Country	Year									Percentage points change from 2010 to 2050
	2010	2015	2020	2025	2030	2035	2040	2045	2050	
Australia	13.9	15.7	17.3	19.1	20.7	21.9	22.9	23.3	23.8	9.9
Belgium	17.4	18.8	20.3	22.2	24.1	25.5	26.3	26.5	26.6	9.2
Canada	14.1	16	18.1	20.5	22.7	23.8	24.5	25	25.5	11.4
Czech Repub	15.3	17.5	19.5	20.5	21.4	22.3	24.4	26.7	27.6	12.3
Denmark	16.7	18.8	20.1	21.3	22.7	23.9	24.7	24.6	23.8	7.1
Finland	17.2	20.2	22.3	23.9	25.1	25.7	25.5	25.6	25.9	8.7
France	17	19.1	20.9	22.6	24.3	25.5	26.5	26.6	26.9	9.9
Germany	20.5	21.3	23	25.1	28.2	31	31.8	32.1	32.5	12
Greece	18.3	19.5	20.7	22.4	24	26.2	28.3	30.2	31.3	13
Hungary	16.4	17.4	19.3	20.3	20.4	21.2	22.8	25.1	26.1	9.7
Ireland	11.4	12.5	13.8	15.1	16.7	18.3	20.3	22.6	24.2	12.8
Italy	20.4	21.9	23	24.4	26.8	29.4	31.8	33.1	33.3	12.9
Japan	22.6	26.3	28.5	29.7	30.8	32.5	35.1	36.8	37.8	15.2
Korea Repub	11	13	15.4	19.3	23.2	26.8	30.2	32.2	34.2	23.2
Netherlands	15.4	17.8	19.7	21.7	23.8	25.6	26.3	26	25.6	10.2
New Zealand	13	14.5	16	18.1	20.3	21.8	22.5	22.7	23.2	10.2
Norway	15	16.6	18	19.4	20.7	22.3	23.4	23.7	23.8	8.8
Poland	13.5	15.4	18.3	21	22.4	23	24.5	26.9	29.9	16.4
Portugal	17.8	19.1	20.6	22.3	24.5	26.4	28.8	30.9	32.1	14.3
Spain	17.2	17.8	18.7	20.4	22.7	25.4	28.1	30.7	31.8	14.6
Sweden	18.3	20.1	21	21.7	22.6	23.6	24.1	24.1	24.1	5.8
Switzerland	17.3	18.8	20.2	21.9	24.1	25.7	26.3	26.2	26	8.7
UK	16.6	17.9	18.5	19.4	20.9	22.1	22.6	22.6	22.9	6.3
Average	16.36	18.08	19.70	21.40	23.20	24.78	26.16	27.14	27.80	11.44

Source: World Population Prospect: 2008 Revision, United Nations (last column and last row are authors' own calculations)

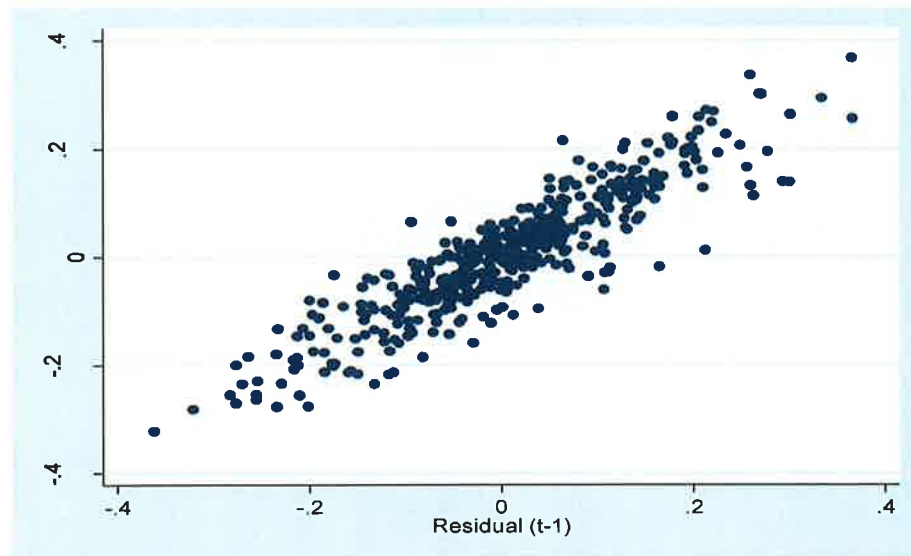
**Figure-A1: Plots of Residuals (22 countries)**



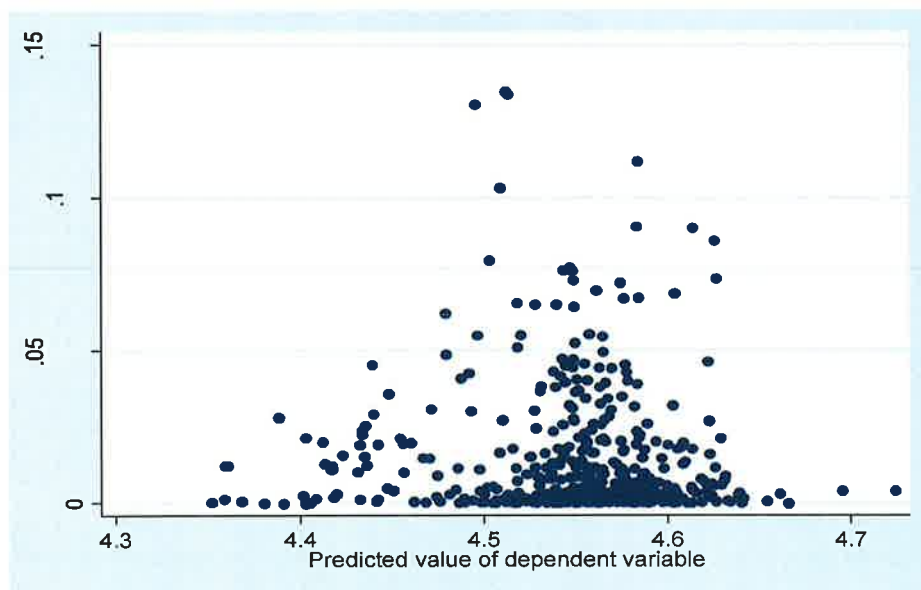
**Figure-2A: Plot of residuals excluding Korea and Hungary**



**Figure-A3: Scatter plot of Residual(t) and Residual(t-1)**



**Figure-A4: Scatter plot of squared residuals against predicted values of dependent variable**



## Appendix-B

### Country List

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1. Australia	13. Japan
2. Belgium	14. Korea Republic
3. Canada	15. Netherlands
4. Czech Republic	16. New Zealand
5. Denmark	17. Norway
6. Finland	18. Poland
7. France	19. Portugal
8. Germany	20. Spain
9. Greece	21. Sweden
10. Hungary	22. Switzerland
11. Ireland	23. United Kingdom
12. Italy	

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### Sources of data

The prime source of data is *World Development Indicators (WDI)-2010*, published by the World Bank. Where data are not available in WDI-2010, other sources have also been used such as, *Thomson Datastream*, *OECD.Stat*. Variable specific sources of data are discussed below:

**(i) Real effective exchange rate (reer):** REER data are collected from WDI-2010. Base year for nominal exchange rate (NER) is 2000 and weights for other currencies are given on the basis of trade in manufacturing goods. REER index is calculated from the NER and a cost indicator of relative normalized unit labor cost in manufacturing. An increase in REER index represents an appreciation of the local currency.

REER data for Korea republic are not available in WDI. REER for Korea is calculated using data from *OECD.Stat*. In calculating REER from NEER, consumer price index and producer price index for manufacturing are used as proxy for domestic and foreign price levels respectively.

**(ii) Terms of trade (tot):** Terms of trade data on the sample countries (except Czech Republic, Finland and Switzerland) are taken from WDI-2010. It is net barter or commodity terms of trade, which is the ratio of the export price index to the import price index. For Czech Republic, Finland and Switzerland, TOT data have been collected from Thomson Datastream, however, the original source of these data is *Economist Intelligent Unit* as reported in Datastream.

**(iii) Net Foreign Assets (nfa):** Net foreign assets data on all countries are collected from WDI-2010. NFA are the sum of foreign assets held by monetary authorities and deposit money banks, less their foreign liabilities. NFA are reported in local currencies. In the estimation procedure it has been measured as a percentage of Gross Domestic Product (GDP). The benefits of this conversion is twofold: first, the NFA data are uniform across countries, as all are measured as a percentage of GDP; second, conversion of national currency into Euro in 1999 in some of the OECD countries changes the NFA figures to a great extent. This problem has been eliminated by converting them into percentage of GDP form.

**(iv) Government Expenditure (govex):** Government expenditure data are also taken from WDI-2008 and expressed as a percentage of GDP. General government final consumption expenditure includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditure on national defense and security, but excludes government military expenditures that are part of government capital formation.

**(v) Interest rate differential (intdiff):** Interest rate differential is calculated as the difference between US and individual country's real lending interest rate. These are collected from WDI-2010. To get real lending interest rate, nominal lending interest rate is adjusted for inflation as measured by the GDP deflator.

**(vi) Demographic variables:** Data on demographic variables are also collected from WDI-2010.