Demographics, Capital Flows and Exchange Rates

Demographics and External Linkages

Demographics has been shown to affect all aspects of domestic growth in individual economies, with significant potential implications for financial markets and investment behavior. Some analysis has been done on the cross-border implications of demographics and there are clear implications for external balances and capital flows. In a speech on 17 April 2007, William Poole, President of the St Louis Fed, highlighted that differential rates of aging across countries are responsible, in part at least, for the extraordinary patterns of current account balances and trade surpluses currently observed.

In this report, we focus on the effects of demographics on capital flows and exchange rates. We provide cross-country and individual country data for a group of developed countries and we evaluate some topical studies. We can show strong and direct links between demographic variables and cross-border macro-economic data, such as external balances. However, links to exchange rates are weak and are less direct.

- We provide an extensive review of papers that identified links between demographics and economic variables. We also present a qualitative evaluation of trends in key demographic variables and their possible effects on external macro-economic variables.

- We find evidence of statistically strong links between demographic variables and aggregate saving, aggregate investment and the current account balance.

- We present an empirical analysis examining demographics and exchange rates using the latest available data. Our findings cast doubt on the robustness of results that find links between demographics and exchange rates. Direct links with exchange rates are at best weak and the effects are not uniform across countries. However, for some countries, the effects on exchange rates are statistically significant and can be used to augment forecasts.

- We examine the correlations between selected demographic variables and macro variables. We find demographic variables can enhance explanatory performance of models for both real and nominal exchange rates if they are not strongly correlated with other macro variables.

Demographic variables have effects through multiple routes such as relative GDP, inflation, cross-border capital flows and financial asset prices. Investors should consider demographic variables as part of their broader investment analysis, in our opinion.
Demographics, Capital Flows and Exchange Rates

In this report we provide an extensive literature review of how demographic changes and variables affect domestic and external macro variables. We discuss open-economy macroeconomic relationships within the national income and balance of payments accounting frameworks. We assess a few recent papers that find links between exchange rates and demographic variables by considering alternative demographic variables as potential explanations. Next, we conduct qualitative analysis by examining patterns and relationships of different demographic variables (on a relative basis for select countries) to exchange rates and macro variables. We also present our empirical analysis examining demographics and exchange rates, and demographics and capital flows, using the latest available data. We assess demographic variables as augmenting macro variables in explaining exchange rates. Finally, we present a demographic data appendix that includes cross-country and country-specific charts for selected countries.

Demographics, Consumption and GDP

A higher population in a country in general is supposed to lead to greater consumption of goods and services than a lower population. Simply put, holding other things constant, more people consume more. However, that is a very simple approach which focuses merely on the number of people. The Malthusian resource shortages theory was one such theory driven by population numbers.

Economic historian Angus Maddison in "Explaining the Economic Performance of Nations 1820-1989" highlights the role of demographics, labour quality and labour quantity in influencing both GDP growth as well as speed of convergence of GDP. In other papers and books too, Maddison highlights the demographic factors of population growth, human capital status and immigration as explaining economic growth across most countries.

In the World Economic Outlook (2004), IMF staff economists show that demographic changes impact GDP per capita growth, saving, investment, current account balances and budget balance, all as a share of GDP using panel data estimations for 115 countries over 40 years. They find that per capita GDP growth is positively correlated with changes in working age population growth and saving and that current account balances rise with the share of working age population.

Recent research from the ECB (2006) also documents the relatively greater importance of demographic change (as captured by working age population growth) to real GDP growth in the US between 1960-2000 relative to the EU. The European Commission and the Economic Policy Committee predict that potential real GDP growth is likely to be about 1% lower than current levels of GDP growth due to future decreases in working age population growth.

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1 We try to replicate the results in a recent paper by Andersson and Osterholm (2006) that finds demographic structure has direct significant explanatory power for exchange rates.
2 We conduct empirical analysis in similar spirit to the main results of Higgins (1998) while relating those also to the papers and speeches by Dekle and Poole.
3 See chapter 6 of Maddison "A long run perspective on saving" where demographic changes are stated to influence long-run saving.
5 See Credit Suisse Demographics Research "Global Demographic Change and Sector Implications (2007)" for the underlying demographic variables.
6 See Madalloni, Musso, Rother et. al. (2006) to look at macroeconomic implications of demographic developments.
7 See also Credit Suisse Research (2001), Demographics, Technology and Productivity where a similar point is made.
We believe and have stressed so in our earlier demographics research\(^8\) that it is not merely population numbers that matter. Rather, other characteristics such as age, sex, number of family members, exposure to risk taking within the family, education, migrant status etc are equally, if not more, important. The common interpretation is that age is the only demographic characteristic that matters. While age is very important, we believe that other demographic characteristics influence aggregate consumption and inter-temporal saving too. That is the main reason why merely extrapolating numbers of people of different age groups or consumers in age groups may not necessarily capture appropriately the demographic effects and may lead to erroneous conclusions. Understanding behavioural and other risk characteristics of individuals is very important too. While such data may be available for select population groups and for surveys, it is not available for the total population.

### National Income Accounting and BOP Accounting: Relating Savings, Current Account and Capital Account\(^9\)

This section examines the relationships between macroeconomic variables and external variables within the National Income Accounting and BOP Accounting frameworks. The differences between closed and open economies are also highlighted.

We believe that demographics affects each component of the National Income Identity\(^10\) for an open economy \(C + I + G + (X – IM) = Y\) where \(C\) denotes consumption expenditures, \(I\) denotes investment expenditures, \(G\) denotes government expenditures, \(X\) denotes exports, \(IM\) denotes imports on an aggregate basis and \(Y\) denotes real GDP. The last component of GDP in the equation above \((X-IM)\) is called net exports or the trade balance. It equals the current account under the simplifying assumption that net unilateral transfers are zero. Under this assumption, a country has a current account deficit when a country's imports exceed its imports.

The current account is important in open economy macroeconomics because \((X – IM)\) affects real output or GDP and is therefore associated with changes in employment or labour required to produce the GDP. The current account also measures the size and direction of international borrowing. A country's current account balance is therefore equal to the change in its net foreign wealth.

When imports exceed exports, a country has a current account deficit that can be financed by borrowing from foreigners or by increasing its net foreign debts. Only by borrowing abroad can a country use more output than it is producing, i.e. have a current account deficit. The current account (with no transfers), denoted by \(CA\) can also be written as follows: \(CA = Y – (C + I + G)\). The sum \((C + I + G)\) is also called domestic absorption and a current account surplus is referred to as the difference between GDP and absorption.

The National Income identity helps us define national saving \(S\) as the part of GDP not consumed by households \((C)\) or purchased by government \((G)\). In a closed economy, national saving always equals investment because \(S = Y – (C + G)\) but \(I = (Y – C – G)\) and therefore \(S = I\). Therefore in a closed economy, wealth can be increased only by accumulating new capital. In an open economy, \(S = I + (X – IM)\) or \(S = I + CA\) which highlights that a country can save by either investing in its capital stock or by acquiring foreign wealth\(^11\).

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\(^{8}\) See "Global Demographic Change and Sector Implications", Credit Suisse Demographics Research, May 8, 2007

\(^{9}\) See latest edition of textbook "International Economics" by Paul Krugman and Maurice Obstfeld.

\(^{10}\) See Credit Suisse Demographics Research (July 18, 2006) "Why Demographics Matters? And How?" for details of how demographics affects the individual aggregates.

\(^{11}\) This is a very important difference between open and closed economies. A closed economy can save only by building up its capital stock.
Private saving ($S_p$) is in turn defined as disposable income less consumption, where disposable income is GNP net of taxes (T): $S_p = Y - T - C$. Further, government saving ($S_g$) in turn is defined as: $S_g = T - G$. Private and government saving add up to national saving. National saving ($S$) = $S_p + S_g = I + CA$ which can be re-arranged as follows:

$$S_p = I + CA + (G - T)$$

This connects the budget deficit and the current account surplus to private saving. The intuition from the above is that a country’s private saving can take one of the following three forms (a) budget deficit, purchase new government debt (b) purchase of foreign wealth from foreigners and (c) investment in domestic capital.

The balance of payments (BOP) account for a country tracks both its payments to and receipts from foreigners. A transaction that results in a payment to foreigners is entered in the BOP as a debit (negative sign) whereas a receipt from a foreigner is a credit (positive sign).

Two types of international transactions are recorded in the BOP.

1. transactions involving exports or imports of a goods and services which enter directly through the current account
2. transactions that involve the purchase (negative sign) or sale (positive sign) of assets. The difference between the exports and imports of assets is called the capital account balance.

Note from the above that (i) is also accounted for in the National Income accounts. Most transactions in BOP are paired book keeping entries, with every credit matched by an equal and opposite debit. Due to the offsetting entries in the balance of payments, the capital account must equal in opposite sign the current account balance, i.e., Current account + capital account = 0. Because the capital account is the change in the country’s net foreign assets, the current account equals the difference between the country’s purchase of assets from foreigners less sales of assets to them, i.e. capital account preceded by a negative sign.

When the US borrows $1 from foreigners (Rest of World denoted by ROW), it is selling them an asset, a promise that they will be repaid $1, with interest in the future, such a transaction enters the capital account with a positive sign and is a capital inflow. When the US lends to foreigners or ROW, a payment is made and the capital account is debited, involving the purchase of an asset from foreigners and is called a capital inflow.

Savings, Economic Growth and Demographics

In the context of the above discussion on National Income and Balance of Payments accounting, it is important to study the links between savings, economic growth and demographics. We discuss below some of the important studies that have analyzed the relationships between demographic variables and macro economics.

Economic historian, Angus Maddison (1995) studied long run histories of aggregate savings for 11 countries that accounted for nearly half the world’s GDP and savings. He states that “the importance of countries in the international savings markets depends not only on their savings rate but also on the absolute size of the country, its propensity to invest abroad and the extent to which its exchange rate deviates from Purchasing Power Parity (PPP)”. He finds that saving rates are inversely related to levels of per capita GDP. He does not find a clear link between the savings patterns (including the timing) and aging populations of the advanced countries. He states that institutional arrangements have led to a massive increase in the governmental role in the economy, reflected in government expenditures on goods, services and transfers. According to him this increased government role in retirement provision leads to lower individual saving.
Lindh (2004), Lindh and Malmberg (1999) examine the age structure of the population and find it useful in forecasting medium-term inflation and growth, while confirming that the mechanisms behind age-structure effects is not fully clear.

James Tobin (1967) and Nathaniel Leff (1969) studied aggregate saving in relation to population growth using the life cycle framework. Their frameworks considered two routes through which population growth or related demographic factors affect aggregate saving. At the household level, reduced fertility rates and the declining cost of child-rearing leads to lower consumption and higher saving. Concurrently, the population aging which accompanies reduced fertility increases the relative share of older households, which have lower savings rates. The first effect, the "dependency effect" suggests that population growth leads to lower savings whereas the latter effect termed the "rate of growth" effect, implies that rapid population growth encourages saving. The net effect of the population growth rate on savings depends on which effect dominates. Due to variation in both consumption and earnings over the household life cycle, they state that income does not need to match expenditure in any particular period. Income typically varies over the life cycle (based on demographic characteristics) and so does consumption but not as much as income.

Mason (1988) states that while life cycle saving for a household is matched by corresponding future dissaving, the profile of aggregate saving over the life cycle is less clear. At any point in time, the level of aggregate saving would equal the saving by currently working households net of the dissaving by older households. With population growth the number of working households increases too, with their current life cycle saving exceeding current life cycle dissaving, leading to positive aggregate life cycle saving. If income is growing, working households will be relatively wealthy over their lifetimes and again net aggregate life cycle saving will be positive. However if the rate of growth of total income (the sum of the rate of population growth and per capita income growth) is zero, life cycle saving will perfectly offset life cycle dissaving leading to zero aggregate life cycle saving.

How do reduced dependency ratios affect aggregate saving? Mason (1988) says that if a decline in the number of children reared increases the percentage of lifetime earning households devote to estate saving, then aggregate saving will increase in like fashion. If a decline in the number of children affects life cycle saving, by shifting consumption from childrearing years to post-childrearing years, aggregate saving will increase to the extent that aggregate income is growing. Changes in the youth dependency ratio will affect aggregate saving directly if changes in childbearing affect estate saving but will do so interactively with the rate of growth of income if changes in childbearing affect life cycle saving. Fertility changes influence aggregate saving through the rate of growth effect. Declining population growth decreases the number of saving households relative to the number of dissaving households. He states that in theory the dependency effect will be offset by the growth rate effect but that the relationship requires more detailed analysis.

Bryant, Faruque, Velculescu and Arbatli (2004), study the demographic transition over time due to reduced mortality rates and fertility declines on the age structure of developed and developing countries. They model youth dependency, elderly dependency and size of labour force as well as population as endogenous. They consider integrating children and child support in their models finding profound effects on consumption-savings behaviour. They find that youth dependency matters for transitional dynamics of family resource allocation and ignoring youth dependency assumes away a source of macroeconomic effects. Jimenez and Murthi (2006) advocate reasons for investing in selected developing countries to take advantage of the youth bulge, suggesting countries could outsource factories to developing countries if their labour markets are flexible and skilled.

Ralph Bryant at the 2004 Kansas City Fed Symposium in Jackson Hole opined "... in the last two decades there has been a significant lowering of the correlation between domestic investment and national saving, or equivalently, a tendency for current-account imbalances to become larger and more variable. This tendency in turn reflects the fact that cross-border and cross-currency adjustments to policy and non-policy shocks have risen relative to purely domestic adjustments.
Batini, Callen and McKibbin (2006) find that while aggregate growth will be lower in industrial countries due to aging, the demographic effects through savings, investment and capital flows will show up in asset prices and global trade balances.

Connecting with the discussion of the papers above, we present charts that show the differential patterns of population growth and population composition in six major developed countries (henceforth referred to as G6). Exhibit 1 shows the differential population growth rates for these countries until 2050. Population growth rates display a declining trend across all countries and Germany exhibited a minor population shrinkage in the 1980s. The US has by far the highest population growth rate currently in the G6 with Italy and Japan having the lowest population growth rates. Japan, Italy and Germany are projected to face shrinking populations owing to negative population growth rates beyond 2010.

Exhibit 2 shows the varying total dependency ratios (the number of young and old dependents per person of working age between 15-64), for the six countries between 1950-2050. The charts highlight that the combination of dependency ratio effects and growth effects are not very uniform, either over time for a country or across countries at a point in time. The projected dependency burdens of Japan and Italy are the highest. Exhibit 1 and Exhibit 2 suggest that Japan, Italy and Germany face not only declining populations but also a higher burden of dependents in the G6.

The net effect of dependency and growth rates on savings will be an issue that we discuss later. Our qualitative analysis section and Appendix 1 present further charts showing cross-country demographic comparisons as well as country-specific demographics (six-charts per country per page) in relation to economic variables such as saving and exchange rates.

Demographics, Economic Geography and International Factor Mobility

In a globalized world, where labour is increasingly mobile, the demographic effects and projections for any individual country can be offset by labour mobility. As our focus is on external linkages and their relationship with demographics, it is important to understand whether the causes and consequences of demographic changes are local, national or global. In this section, we survey some research that directs attention on how economic geography, demographics and factor mobility interrelate.
In the 2004 Kansas City Fed Symposium at Jackson Hole, Joseph Helliwell reviewed the linkages between international factor mobility and demographic changes, finding significant effects of demographics on both migration and the current account. However, he concludes that neither increased migration nor international transfers of saving will allow for coping with the variety of demographic transitions over the next 50 years. He examines briefly the effects of demography on the factor content of international trade, as exemplified by offshore provision of back-office and other services. He states that changes in the structure of trade in goods and services may provide a mutually beneficial way to mediate demographic differences without requiring the large scale relocation of established communities. When considering effects of international capital movements and migration, he proposes broadening the focus from the usual economic variables such as GDP and employment, to explicit wellbeing which depends on more than economic variables.

An interesting question in today's globalized world is: are international linkages (average or marginal) as strong as those within nations? If they are, then national boundaries could be considered as being irrelevant for those linkages. Based on findings from researchers that intra-provincial trade intensities in Canada were more than an order of magnitude larger than corresponding intensities between Canadian provinces and US provinces, Helliwell states that national boundaries are still important. Also, consumer price change linkages were much tighter between Canadian cities than between Canadian and US cities. Based on combined international and national data, Helliwell states that international mobility of capital is far less than that between regions within a single country. This is supported by researcher findings that portfolios are much less internationally diversified than would be expected if capital markets were perfectly integrated.

Feldstein and Horioka in the early 1980s first established that national saving and domestic rates tend to be highly correlated across OECD countries, leading them to conclude that international capital mobility was far from perfect. Thereafter many researchers, and prominent amongst them Obstfeld and Rogoff (2000), suggested the need for a fresh approach to international economics. Also, gravity based modeling of people migration has shown that those born in one country are far more likely to move elsewhere in the same country than to move to another country. This is less surprising to economic theorists who assume factor and capital mobility but restricted people mobility in their models. But, in today's world, migration flows are more policy-determined than those of goods, services and capital—thus making them harder to predict.

Helliwell shows that correlation between national saving and domestic investment weakens over time as international linkages deepen in the market for goods, services and capital using data on saving and investments for 100 countries from the World Development Indicators database. He also finds that historically the pattern of the intensity of international linkages displays a U-shaped pattern suggesting that international trade intensities around the middle of the 20th century were lower than at the beginning and at the end of the 20th century. Most earlier studies find that immigration rates are higher from poorer to richer countries. However, immigration rates are low from countries with widespread poverty. He suggests that while international factor movements are small relative to those within countries, there is past and current evidence that demographic pressures have in some circumstances led to significant international factor movements. He further conducts regressions which seek to explain net international migration rates by population shares and PPP GDP per capita. Per capita incomes take way from the demographic push variable effects. He acknowledges that recent and current patterns of international migration rates are determined by events and policies complex enough to prevent demographic influences appearing clearly in simple tests.

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12 See Obstfeld and Rogoff (2000) in a Jackson Hole Fed conference on OECD Economic Integration and Implications for the Current Account. They argue that current account deficit adjustments can have significant short run nominal exchange rate effects.

13 See McCallum (1995) and Engel and Rogers (1996) which find support for stronger linkages of trade and prices within national boundaries.


15 Helliwell (1998, pp 85-86) finds this even after adjusting for economic size and distance.

Fehr, Jokisch and Kotlikoff (2004) model a 3-region developed world (US, Japan and EU) considering costs of financing healthcare and pensions while evaluating effects of doubled immigration from developing countries. Gallup and Sachs (1998) study the complex relationship between geography and macroeconomic growth. They analyze ways in which economic geography matters for economic growth while controlling for economic policies and institutions as well as studying the effects of economic geography on policy choices and institutions. They find that location and climate have large effects on income levels and income growth through their effects on transport costs, disease burdens and agricultural productivity. They find that countries without coastlines or navigable rivers tend to have less urbanization and less growth, across a sample of 128 countries.

The above findings and papers all argue the case that economic geography and international factor mobility affect the demographic effects that might occur in a globalized world. With the increasing pace of globalization, demographic effects have a cross-border or international dimension that varies with economic geography.

Demographics, Current Account and Capital Flows: Japan as a Case Study

This section presents studies that have looked at the relationship among demographics, current account and capital flows. Given the recent US current account deficits and the fact that Japan is both its main competitor as well a major trading partner, it is no surprise that many studies have sought to link an aging Japan to its future capital flows.

Poole (2005) argues that when a population can be characterized as middle-aged, then the economy should have a higher saving rate than when characterized as old. Thus as a country's population ages, going from middle-aged to old, one can expect the saving rate to decrease. Unless the investment rate moves identically, foreign capital flows and current account balances will be affected. The decline in workers as countries age will tend to reduce investment demand and the decline in saving will eventually exceed the decline in investment causing a country's current account to decrease. He argues that the timing of the relative changes in investment and saving are likely to vary and individual countries' saving-investment balances will probably evolve in complex ways. The impact of aging on saving-investment will also vary across countries but at the world level the sum of current account balances must be zero. This suggests that relative aging is what matters for an individual country.

Exhibit 3: Old Dependency Ratios

World and the G-6 countries

<table>
<thead>
<tr>
<th>Year</th>
<th>People 65+</th>
<th>People 15-64</th>
<th>Old Dependency Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>0.1</td>
<td>0.3</td>
<td>0.333</td>
</tr>
<tr>
<td>2000</td>
<td>0.14</td>
<td>0.3</td>
<td>0.466</td>
</tr>
<tr>
<td>2020</td>
<td>0.17</td>
<td>0.3</td>
<td>0.533</td>
</tr>
</tbody>
</table>

Source: Credit Suisse, UN
Exhibit 3 shows the differential relative aging effects across the G6 in terms of old dependency ratios, the number of people aged 65+ relative to those of working age (15-64). The relative effects of advanced aging in Japan and Italy can be seen clearly above. France and Germany also have a noticeable increase in the ratio of retirees to number of potential workers.

For the first time, the old dependency ratio in many developed countries exceeded the child dependency ratio (the number of people aged under 15 per person of working age) in 2000. While this hasn’t happened in some countries it is predicted to do so in the near future. For most developed countries, the total dependency ratio is currently around 0.5, meaning there are two people of working age for every person of non-working age. This ratio is projected to rise sharply in the coming years, and by 2050 is expected to be in the region of 0.9 for Japan and Italy.

Poole states that there are three drivers for the current account of a country in the long run (a) demographics (b) growth of labour productivity and (c) growth in per capita domestic demand for goods and services. The important demographic characteristics that influence the labour force size are: the size of the working age population, the size of total population and fraction of working age population that is employed.

The amount of labour available multiplied by output per worker determines potential domestic output of goods and services, i.e. real GDP. However, per capita absorption (C + I + G), multiplied by the total population size determines the total domestic demand for goods and services. The difference between domestic demand and the amount of output that can be produced within the economy will generate a current account balance. If domestic demand is less than domestic output, then excess output may be sold abroad and the current account balance will show a surplus, and vice versa for a current account deficit. As discussed earlier, a deficit can only arise if the country can borrow abroad or run down assets accumulated earlier.

Poole shows the demographic transition underway in Japan highlighting a shrinking and aging population along with a constant ratio of employed to working age persons. He shows that output per capita will grow slower than output per worker, due to the aging and shrinking population effects. The average growth rate of output per capita in Japan over 2003-2050 is projected to be 0.84% and if the current account were to be balanced, this would be the limit to growth in absorption per capita. Although, growth of per capita absorption can be increased above domestic production using past accumulated claims on the rest of world to buy foreign output.

If instead, Japan were to import sufficient goods and services such that absorption grows at labour productivity growth rates of 1.26% (1990-2002), the Japanese current account will turn negative before 2010, fall to -10% of GDP by 2025 and decline sharply further after 2035. Under what we regard as plausible scenarios Poole argues that the Japanese current account will be in deficit in the relatively near future and the deficit will continue growing. His appealing logic is that in an aging Japan why should we not expect the elderly Japanese to use their substantial assets accumulated abroad to support consumption in excess of domestic production.

DeKle (2000) studied the impact of demographic change on the Japanese saving-investment balance and found similar results to Poole. Using government projections, he found that saving rate of the Japanese will fall from 31% (2000) to 20% (2040) with the investment rate remaining close to 29%. Thus the current account balance will steadily decrease and turn negative after 2035. He projects consumption per capita to grow until 2010 and under most scenarios fall after 2010.

Ito and Tsuri (2002) also examine Japanese saving rates by age brackets and aggregate saving while further simulating the current account based on the investment-saving balances of households, corporations and governments. They forecast the current account
using demographic data, their estimates of savings rates and estimates of interest payments on government bonds. They find that the current account can stay positive if Government bond issues stay constrained by fiscal sustainability.

Higgins (1998) studies the role of substantial demographic changes in determining national savings and investment rates. He then projects how savings and investment rates are likely to get affected in the future by even more dramatic demographic changes. He undertakes an econometric investigation of the links between national age distributions and savings and investment rates, using cross-section and time-series data for 100 countries. He finds substantial demographic effects with increases in both youth and old-dependency ratios associated with lower savings rates. Demographic effects on national savings rates have been of the order of 7% of GDP over last 3 decades. Demographic effects on savings rates and investment rates have been different thus pointing to a demographic role in influencing the residual current account balance. He finds that the estimated demographic effect on the CAB exceeds 4% of GDP over the last three decades for many countries.

Brooks (2003) uses a multi-region overlapping generations (OLG) model and Cutler, Poterba, Summers and Sheiner (1990) use an infinite horizon planning solution to study the impact of demographics on capital flows.

Brooks (2003) finds that retirement savings by aging baby boomers will raise capital supply substantially above investment in the EU and North America causing both regions to export capital to Latin America and Africa. However, beyond 2010 baby boomers will dissave causing the EU and North America to become capital importers. Despite severe population aging, Brooks' model predicts Japan will remain a substantial capital exporter beyond 2030. Feroli (2003) simulates a multi-region OLG model finding similar results to Cutler et. al while predicting size and timing of US current account deficits as well as Japanese current account surpluses.

Bryant (2007) studies how heterogeneous demographic patterns of development affect resulting capital flows between developed countries (north) and developing countries (south). He argues that demographic forces are likely to diminish flows of northern savings to the south as a fraction of the southern economy. This is regardless of the speed of demographic transition. Kim and Lee (2007) analyzed the links between demographic changes, savings and current account balances in east Asia in a Vector Autoregressive framework finding that the elderly dependency rate significantly lowers savings rates and subsequently worsens current account balances.

In summary, demographic effects on capital flows have been studied extensively in a number of different theoretical and empirical frameworks. The main route through which demographics affects capital flows is through the aggregate savings and investment levels which depend on the relative numbers of savers and spenders in an economy. Some authors model strong links theoretically and others estimate the extent to which demographics has affected the current account balance.

Demographics and Exchange Rates

Exchange rates (nominal and real) are quite volatile for most market economies and are influenced by macro fundamentals, news, political shocks, commodity shocks etc. While theoretical links and empirical studies have confirmed the relationships between demographics and capital flows, until very recently there was hardly any research on the relationship between demographics and exchange rates.

Andersson and Osterholm (2005) forecast the real exchange rate for Sweden using the age structure of the population. They make the statement, "if demographic effects on the current account are present we should be able to detect effects on real exchange rates explained by changes in age structure". They empirically test for this and do find evidence
that age structure has significant explanatory power on the real exchange rate in a reduced form estimation framework. They therefore conclude that age structure could be useful to forecast medium and long run trends in the real exchange rate.

Andersson and Osterholm (2006) then extend their analysis to predict real exchange rates across a panel of 25 OECD countries between 1971-2002. They find that demographic structure significantly explains the real exchange rate, supporting the life cycle hypothesis age structure effects story. They state that macroeconomic theory predicts that variations in population cohort sizes will lead to demographically induced real exchange rate movements. We are not aware of any published macroeconomic theory papers asserting direct and explicit links with real exchange rates\textsuperscript{17}, rather the links are via life cycle savings, capital flows and current account as in the many references cited earlier.

A recent working paper by Rose and Supaat (June 2007) uses 5-yearly data for 87 countries from 1975 to 2005 to examine how fertility rates affect the REER. They assert that theoretically a declining fertility rate for a country would be associated with higher savings, lower investment, a current account surplus and therefore a real depreciation. They find a statistically significant and robust link between fertility and the REER and conclude that a decline of fertility of 1 child per woman is associated with a depreciation of about 0.15% in the REER.

Data used in Empirical Analysis

To examine and establish whether there is indeed a direct link between demographic variables and foreign exchange rates, we created models in the same spirit as Andersson and Osterholm (2006) and Rose and Supaat (2007). Our sample for the estimations covered between 13 and 25 countries in different estimations. We obtained data from various sources for (i) exchange rates (ii) macroeconomic variables and (iii) demographics.

We used real effective exchange rates (REERs) and nominal exchange rates in our research. The REER data were sourced from (a) Credit Suisse (b) IMF (c) OECD and (d) Andersson and Osterholm (the data used in their estimations). IMF, Credit Suisse and OECD calculate REERs using fairly similar methodology, however the input data used can differ. REERs are trade weighted indices which take into account trading linkages (through trade weights of partners), relative inflation as captured by differences in the consumer price indices of the countries, and the nominal exchange rate. The nominal exchange rates (bilateral) were obtained from Credit Suisse and market data sources such as Bloomberg and Reuters.

Macroeconomic data on Investments, Savings, GDP, PPP etc came mostly from the Penn World Tables version 6.2, a standard data set used by academic researchers and policy makers. The demographic data for population numbers, age distributions, dependency ratios and fertility rates for different countries were obtained from the UN.

Qualitative Analysis: Demographics and Other Variables

This section presents qualitative data analysis that examines relationships and patterns using univariate and bivariate charts as well as tables. This is to facilitate eye-balling the data in order to hypothesize potential relationships between demographic variables and economic variables.

\textsuperscript{17} We are unable to replicate their 2006 paper for a panel of countries with any relevant recent data. Please see our section on empirical results for Demographics and Exchange Rates.
Exhibit 4: Fertility Rates
Number of children per woman of child-bearing age.

<table>
<thead>
<tr>
<th>Country</th>
<th>Fertility Rate (2005)</th>
<th>Peak</th>
<th>Peak Year</th>
<th>Trough</th>
<th>Trough Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>1.79</td>
<td>3.41</td>
<td>1955</td>
<td>1.76</td>
<td>2000</td>
</tr>
<tr>
<td>Canada</td>
<td>1.53</td>
<td>3.9</td>
<td>1955</td>
<td>1.52</td>
<td>2000</td>
</tr>
<tr>
<td>France</td>
<td>1.89</td>
<td>2.85</td>
<td>1960</td>
<td>1.71</td>
<td>1990</td>
</tr>
<tr>
<td>Germany</td>
<td>1.36</td>
<td>2.49</td>
<td>1960</td>
<td>1.31</td>
<td>1990</td>
</tr>
<tr>
<td>Ireland</td>
<td>1.96</td>
<td>3.98</td>
<td>1960</td>
<td>1.9</td>
<td>1995</td>
</tr>
<tr>
<td>Italy</td>
<td>1.38</td>
<td>2.5</td>
<td>1960</td>
<td>1.21</td>
<td>1995</td>
</tr>
<tr>
<td>Japan</td>
<td>1.27</td>
<td>2.75</td>
<td>1950</td>
<td>1.33</td>
<td>2000</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.42</td>
<td>2.51</td>
<td>1960</td>
<td>1.4</td>
<td>2000</td>
</tr>
<tr>
<td>UK</td>
<td>1.82</td>
<td>2.81</td>
<td>1960</td>
<td>1.66</td>
<td>2000</td>
</tr>
<tr>
<td>US</td>
<td>2.05</td>
<td>3.71</td>
<td>1955</td>
<td>1.79</td>
<td>1975</td>
</tr>
</tbody>
</table>

Source: Credit Suisse, UN

Exhibit 4 presents how fertility rates have changed over time in 10 developed countries. For each country, we present the peaks and troughs of fertility rates, along with the years that they occurred in.

Fertility rates in the major developed countries peaked in the mid 1950s to 1960 although the levels that they peaked at ranged from 2.49 to 3.98 children/woman. The troughs for fertility rates across these countries also vary both in terms of their levels and when they occurred. Fertility rates in Canada and Ireland were the highest and reached nearly four children per woman in the late 1950s. Japan’s fertility rate was as high as 2.75 in the early 1950s but quickly dropped to 2.08 (below the replacement rate of 2.1 children per woman) by the late 1950s and had fallen to 1.33 by 2000. As a result of these differences the population growth rates, age structures, median ages and dependency ratios have also varied over time and across countries.

Exhibit 5 and Exhibit 6 present median age profiles over time for selected countries. Note the steep increase in median age for Japan and Germany, two of the largest economies in the world. The median age of the Japanese population was 42.9 years in 2005, very high compared to Ireland's 34.2 years and the US's 36.1 years. However in 1980, the median age of the Japanese population was over ten years lower at just 32.6, lower than other developed countries such as Italy, Germany and the UK. The very low birth-rate and the recent increases in life expectancy encountered by Japan have resulted in much more rapid population ageing than in other countries.
Exhibit 7 and Exhibit 8 display median age differences (relative to the US) for six large developed economies in 1950 and also in 2000. The contrast between the two charts is evident for Japan and Italy, which go from being amongst the youngest major countries in 1950 to the oldest in 2000. In comparison France, Germany and the UK have not displayed such a dramatic change in their median age (relative to the US) over the same period.

Exhibit 9 and Exhibit 10 present changing age shares (as share of total population) of three important age groups in Canada and Japan\(^{18}\). The 20-34 age group are the young workers, the 35-49 age group are the middle workers and the 50-64 age group are the old workers. Age shares capture similar dynamics to the dependency ratios by providing information on what proportion of the population is in a given age range. The saving and spending behaviour of people in different age groups is expected to differ as per the standard life cycle hypothesis, with 20-34 year olds hardly saving, 35-49 years olds saving a little and 50-64 year olds being strong savers.

For Canada, the young worker share exhibits a steady decline since the early 1980s whilst the middle worker share peaked in the early 2000s. The old worker share exhibits a sharp increase with a tapering off beyond 2015. The age shares for Japan exhibit a very much more varied pattern than that seen in Canada with the notable feature being a sharp drop in young worker’s age shares from the mid 1990s onwards. Three factors contribute to these differences: historical fertility rate patterns, life expectancy and immigration patterns.

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\(^{18}\) The age shares for certain other major countries are available on request to the authors.
In some of the papers we referred to, demographic variables were posited to have an influence on savings and investment rates. Exhibit 11 and Exhibit 12 show the cross-country variation in aggregate savings vs. aggregate investment, as a percent of GDP. The decrease in savings in Japan could be linked to an ageing population. Likewise, the increase in both savings and investment in Ireland during the 90s could be the result of more favourable demographic features—birth rates, life expectancy and immigration (reverse as well as inwards) all contributing to it. We shall examine this in more depth later in this report.

Exhibit 13 presents the REER profiles for selected countries using the OECD REER series. Our estimations (presented later) will try to investigate if demographic variables can explain the variation in the REERs. While the REER for Australia decreased quite significantly between 1975 and 2000, Japans REER increased. Canada experienced declines in its REER that were similar in magnitude to Australia, both of these countries have a younger population than Japan.
Empirical Results: Demographics and Exchange Rates

In this section, we report results from our estimation exercises initially motivated by replicating and extending the results of Andersson and Osterholm (2006). We conduct a number of estimations trying to establish quantitative links between exchange rates and different demographic variables.

The Andersson and Osterholm\(^{19}\) (referred to as A&O henceforth) paper investigates the relationship between demographic variables and foreign exchange rates under the premise that the composition of savers or spenders in a population will affect international capital flows. The theory behind this is the life cycle hypothesis which presumes that saving behaviour changes over the life course, with young and old people dissaving and middle aged people saving. Consequently, when a large portion of the population is made up of people who are middle aged and saving this will result in net capital flows out of the country, which in turn has a depreciating effect on the exchange rate.

Using a panel of 25 countries and annual data over 1971-2002, with the REER as the dependent variable. A&O found that demographic structure has significant explanatory power for real exchange rates. The reduced form pooled OLS regression produced an $R^2$ of 0.273 and an F-test statistic of 17.46, which is significant at the 5% level.

In their model specification the estimates for young adults (aged 15-24) and young retirees (aged 65-74) were statistically insignificant at the 5% level. The remaining three parameter estimates for prime aged adults, middle aged adults and older retirees were significant at the 5% level and consistent with the predictions of the life cycle hypothesis. These results suggest that the share of prime aged and middle-aged adults have a depreciating effect on the exchange rate, as per the theory which suggests that these groups are saving and creating net capital outflows from the country. The older retiree estimates were significant but of the opposite sign to the prime aged and middle aged adults, which supports the theory that they are dissaving and producing net capital inflows to the country thereby having an appreciating affect on the exchange rate.

---

\(^{19}\) International Economic Journal Vol.20, No.1, 1-18, March 2006
In our initial estimation we set up a model in the same fashion as A&O, but we used a different group of countries, an REER series created by Credit Suisse and more up to date population data from the UN. The Credit Suisse REER series only runs from 1975, rather than 1971, but if the model is robust none of these changes should affect the results materially.

Our first estimation yielded much weaker results, the $R^2$ was much lower, at 0.045 versus 0.273, and only the constant was statistically significant at the 5% level. The coefficients for the 25-49 and 20-64 year olds were negative suggesting they have a depreciating effect on the exchange rate. This supports the theory of the life cycle hypothesis that these groups are saving and creating net capital outflows from a country. However, the coefficients for the 15-24 and 75+ year olds were also negative, contradicting the theory of the life cycle hypothesis.

Our findings (presented in greater detail in the Appendix 2) indicate that demographic factors do not have significant explanatory power when predicting exchange rates across a panel of 22 countries. This can be partly explained by the fact that we used 5-yearly data for demographic variables which we interpolated to get the annual data points. These were then used to create age shares as regressors to explain the real effective exchange rates across a group of countries. If demographic age share variables explain real effective exchange rates, they ought to be related to one or all of the three underlying constituents of real effective exchange rates: nominal exchange rates, trade weights and relative inflation. While it is hard to intuitively argue that demographic variables do not explain any of the above variables, it is harder still to show theoretically a direct relationship that might then be tested empirically.

The bottom-line is that we do not find a robust direct relationship between demographic variables (age group ratios, population growth, dependency ratios or median age) and exchange rates when we conduct panel data estimations for a group of countries. There are significant relationships between the exchange rates and demographics for a few individual countries but there isn’t a definitive pattern across the major countries.

In their 2005 paper, A & O used a similar set of regressions to show the significant effect of Swedish demographic structure on Swedish real exchange rates over 1960-2002. They found that using the same demographic variables, they got reasonable success in forecasting the Swedish exchange rate. In a footnote, they do not rule out the possibility of a spurious regression, rather they attribute the low DW stat to an incomplete specification. This highlights the shortcomings of ad hoc specifications using demographic variables as complete explanatory variables for exchange rates, rather than as additional or marginal explainers.

**Empirical Results: Fertility Rate and Real Exchange Rates**

In a very recent working paper, Rose and Suppat (2007) investigated the link between fertility rates and the real effective exchange rate.

Fertility rates are interesting because they have a direct effect on future population growth. Also, there are strong implications for population growth rates when fertility rates drop below replacement rates. Fertility rates affect labour force growth too, after a lag of 20 years or so (assuming net immigration is zero) which in turn affects GDP growth. However, the first effect that comes in to force when fertility rates change is a change in the youth dependency ratio. If fertility rates increase then (with no net immigration the youth dependency ratio increases, savings decrease and investment increases. Imports also tend to increase during this phase, causing further pressure on the current account balance.

As shown in Exhibit 4, fertility rates in developed countries were high after WWII, peaking in most countries in the 1950s and early 1960s. When using fertility data to explain changes in exchange rates, we hope to exploit the cross country differences of the timing...
and magnitudes of the peaks, and the subsequent declines. For our estimations, we constructed a panel of 13 countries with no fixed effects, including just fertility rates and PPP as explanatory variables in a reduced form specification. We interpolated the 5-yearly fertility data provided by the UN to obtain an annual series. We did not include the many controls that Rose et al used in their paper, as previous research has not found a definitive answer as to how significant the effect of these variables is on exchange rates.

Exhibit 14 displays the results of estimations using PPP and fertility rates, it is evident from the very low $R^2$ and the values for the estimate of the constant and the fertility coefficients that the relationship between fertility and the REER is not very strong. We also conducted other estimations using lagged fertility rates but did not find much added significance except at a lag of 5 years. Even then the added explanatory power only improved by 1%.

We also conducted a panel estimation with fixed effects, the results are shown in Exhibit 15, which gave us a much higher $R^2$ of 0.60. However, when we introduced fixed effects to the equation the sign of the fertility coefficient changed from positive to negative. While the new model appeared to have strong explanatory power, the t-statistic for the constant is much higher than that for the fertility coefficient, which leads us to believe that the majority of the explanatory power comes from the intercept term rather than from fertility rates or PPP.

Exhibit 14: Fertility & Exchange Rates- no fixed effects

<table>
<thead>
<tr>
<th>Dependent Variable: Log REER</th>
<th>Sample (adjusted): 1970 2004, 13 Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>4.57</td>
</tr>
<tr>
<td></td>
<td>(258.26)</td>
</tr>
<tr>
<td>Fertility</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>(5.05)</td>
</tr>
<tr>
<td>PPP</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(-1.30)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.01</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.01</td>
</tr>
<tr>
<td>F-statistic</td>
<td>2.86</td>
</tr>
<tr>
<td>Prob(F-statistic)</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Source: Credit Suisse. Coefficients in bold are significant at the 5% level

Exhibit 15: Fertility & Exchange Rates- fixed effects

<table>
<thead>
<tr>
<th>Dependent Variable: Log REER</th>
<th>Sample (adjusted): 1970 2004, 13 Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>4.74</td>
</tr>
<tr>
<td></td>
<td>(186.88)</td>
</tr>
<tr>
<td>Fertility</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
<td>(-3.88)</td>
</tr>
<tr>
<td>PPP</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(-0.46)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.61</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.59</td>
</tr>
<tr>
<td>F-statistic</td>
<td>47.71</td>
</tr>
<tr>
<td>Prob(F-statistic)</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Source: Credit Suisse. Coefficients in bold are significant at the 5% level

An issue with using fertility rates to determine exchange rates (as affected by the current account), or trends in savings and investment, is that in periods of stable or unchanging fertility rates countries may still experience population growth or shrinkage. This growth or shrinkage in the population will affect dependency ratios and age shares. Also, the lagged effects of fertility rates imply that one needs data over very long periods to adequately capture all the effects. The primary effect of the fertility rate peak in the 1950s was an increase in investment, but the impact of the fertility peak in the 1950s will be different when the baby boomer group reach retirement age and start spending their retirement pot. The question to be answered is: if there is a decrease in investment now is it due to the current low fertility rate or is it the result of the baby boom generation born 60 years ago and now retiring?

For example, when the current baby boom generation retires (between 2011 and 2029) the share of the population aged over 65 will increase dramatically and there will be a large increase in the proportion of net spenders in the economy. If fertility rates were to remain stable, around the replacement level, the ratio of people aged over 65 would eventually decline to a more normal level. This is because the baby boom generation would retire, spend their savings, grow old and die. Theoretically these changes in the
spender/saver ratio would be expected to have an effect on capital flows and exchange rates, however the fertility rate might not have changed at all. Therefore, we believe that the fertility rate would not be as good an explanatory demographic variable to use in predicting exchange rates. Age shares, dependency ratios and median age have been used in many previous studies and are likely to have more information content in explaining exchange rates.

**Empirical Results: Demographics and Capital Flows**

We next focused our attention on the paper by Higgins (1998), which demonstrated that demographics affects savings rates and the current account balance. According to him demographic effects on the current account balance for some countries exceeded 6% of GDP over 30 years or 0.2% of GDP annually. He states that the magnitude of the effect is likely to be larger in the future as countries progressively age. Abstracted results from his paper are presented in Exhibit 16 and discussed below.

**Exhibit 16: Higgins (1998) Abstracted Results**

100 Countries, Panel estimation

<table>
<thead>
<tr>
<th>Higgins Results (Table 4)</th>
<th>Higgins Results (Table 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variable: Current Account</strong></td>
<td><strong>Dependent Variable: Savings</strong></td>
</tr>
<tr>
<td>Variable</td>
<td>Coefficient</td>
</tr>
<tr>
<td>RPI</td>
<td>-5.13</td>
</tr>
<tr>
<td>(4.06)</td>
<td>(6.13)</td>
</tr>
<tr>
<td>GROWTH</td>
<td>0.07</td>
</tr>
<tr>
<td>(0.336)</td>
<td>(2.10)</td>
</tr>
<tr>
<td>D1</td>
<td>-1.85</td>
</tr>
<tr>
<td>(1.86)</td>
<td>(0.773)</td>
</tr>
<tr>
<td>D2</td>
<td>0.41</td>
</tr>
<tr>
<td>(2.22)</td>
<td>(0.139)</td>
</tr>
<tr>
<td>D3</td>
<td>0.02</td>
</tr>
<tr>
<td>(0.02)</td>
<td>(0.661)</td>
</tr>
<tr>
<td>Adj R²</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Coefficients in bold are significant at the 1% level. Coefficients in bold are significant at the 5% level. Coefficients in bold are significant at the 1% level. T-values in parentheses. T-values in parentheses. T-values in parentheses.


Higgins also uses cross-section analysis as he focuses on 100 countries and tries to explain cross-country differences based on differing age distributions across countries. The estimations are done for shares (relative to nominal GDP) of investment, savings and current account being explained by a vector of demographic variables $D_1$, $D_2$ and $D_3$. The other regressors include relative price of investment goods (RPI) and growth of labour productivity (GROWTH), the variables were corrected for serial correlation. The results in Exhibit 16 indicate strong demographic effects on investment savings and the current account balance, and the demographic variables are jointly significant at the 1% level.

To explore the relationship between demographic variables and macroeconomic variables we set up four pooled OLS regressions which were corrected for autocorrelation. In our estimations, similar to those of Higgins’s, we find significant effects of demographic variables on investment, savings and current account balance.

The macroeconomic data was mainly sourced from the Penn World Tables and runs from 1950-2004. The exception, Net Factor Income, was obtained from the International Financial Statistics and was used to create the savings and the current account balance series. We created data for 13 countries, as our interest is in the main countries with important exchange rates: Australia, Canada, Denmark, France, Germany, Ireland, Italy, Japan, New Zealand, Sweden, Switzerland, UK and US.

The variables used in the estimations and their definitions are as given below:

---

20 Appendix 1 presents demographic variables for most of these countries, showing 6 charts per country.

---
(a) Dependent macro variables: Current Account Balance, Savings, Investment and Net Exports, each expressed as share of GDP

(b) Independent macro variables: RPI (price level of investment/price level of consumption), Growth (Real GDP chain per worker\(_{t1}\) / Real GDP chain per worker\(_{t0-1}\))

(c) Demographic variables: age shares of the population for the groups 25-49, 50-64 and 65+, the young and the old dependency ratios and the median age of the population.

Exhibit 17: Credit Suisse Estimations: Demographics and Savings, Investment, Net Exports and the Current Account

### Credit-Suisse Results for Regressions with Macro-Economic Variables

<table>
<thead>
<tr>
<th>Dependent Variable: Current Account Balance</th>
<th>Dependent Variable: Net Exports</th>
<th>Dependent Variable: Savings</th>
<th>Dependent Variable: Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>C -0.01</td>
<td>C -0.06</td>
<td>C 0.00</td>
<td>C 0.01</td>
</tr>
<tr>
<td>(-6.35)</td>
<td>(-2.98)</td>
<td>(0.47)</td>
<td>(2.00)</td>
</tr>
<tr>
<td>RPI -0.14</td>
<td>RPI 0.00</td>
<td>RPI -4.16</td>
<td>RPI 0.06</td>
</tr>
<tr>
<td>(-9.96)</td>
<td>(-7.64)</td>
<td>(-0.64)</td>
<td>(3.05)</td>
</tr>
<tr>
<td>GROWTH -0.08</td>
<td>GROWTH -0.13</td>
<td>GROWTH 0.19</td>
<td>GROWTH 0.32</td>
</tr>
<tr>
<td>(-1.97)</td>
<td>(-3.94)</td>
<td>(3.30)</td>
<td>(6.79)</td>
</tr>
<tr>
<td>Age Share 25-49</td>
<td>Age Share 25-49</td>
<td>Age Share 25-49</td>
<td>Age Share 25-49</td>
</tr>
<tr>
<td>0.03</td>
<td>0.21</td>
<td>0.65</td>
<td>0.39</td>
</tr>
<tr>
<td>(0.64)</td>
<td>(4.85)</td>
<td>(9.69)</td>
<td>(5.38)</td>
</tr>
<tr>
<td>Age Share 50-64</td>
<td>Age Share 50-64</td>
<td>Age Share 50-64</td>
<td>Age Share 50-64</td>
</tr>
<tr>
<td>0.91</td>
<td>0.05</td>
<td>0.95</td>
<td>0.24</td>
</tr>
<tr>
<td>(10.4)</td>
<td>(1.36)</td>
<td>(8.88)</td>
<td>(2.68)</td>
</tr>
<tr>
<td>R(^2) 0.33</td>
<td>R(^2) 0.13</td>
<td>R(^2) 0.65</td>
<td>R(^2) 0.56</td>
</tr>
<tr>
<td>F-statistic 52.69</td>
<td>F-statistic 23.81</td>
<td>F-statistic 192.87</td>
<td>F-statistic 210.66</td>
</tr>
<tr>
<td>Prob (F-statistic) 0.00</td>
<td>Prob (F-statistic) 0.00</td>
<td>Prob (F-statistic) 0.00</td>
<td>Prob (F-statistic) 0.00</td>
</tr>
</tbody>
</table>

Coefficients in bold are significant at the 5% level

Source: Credit Suisse, Penn World Tables, UN, IMF. Variables corrected for autocorrelation using Newey-West standard errors.

The results for all four regressions are shown in Exhibit 17 and in particular the results for Savings and for Investment were strong, with high R\(^2\). Interestingly, the co-efficient for the age shares of the 50-64 year olds was positive in all 8 regressions. This age group is one that, under the life cycle hypothesis, are expected to be net savers. If a larger portion of the population is saving there are multiple effects on investment: First, a surplus of savings should lead to low interest rates, which has a positive effect on investment. The second effect is on the economic accounting identity through consumption (lower) and net exports (higher) where GDP - C - G - NX = I. However, an older population could also lead to less investment as there are less productive workers and therefore less demand for infrastructure type investments, new buildings, new technology, schools and so-on. Although, other types of investments are needed for retired people.

The results of the regression imply that given a larger share of the population aged 50-64, investment will increase. The regression includes the relative price level of investment as an independent variable, which should control for its possible effects on savings supply and investment demand. Therefore, most of the effect on investment captured in this model should be exerted via the economic accounting identity.

### Statistical Prediction of Real and Nominal Exchange Rates using Demographic Variables

This is a purely statistical exercise where we try to predict some of the variability in exchange rates using either age shares or dependency ratios as independent variables. We conducted a number of estimations using different (i) explanatory variables (ii) lags of variables and (iii) AR specification.

Exhibit 18 presents the results of using dependency ratios, old as well as young, to predict nominal and real exchange rates. We use single country time-series to avoid cross-country variation or contamination of effects to check for statistical predictability. The dependent
variable used for the bilateral exchange rate estimations is the dependency ratio relative to the that of the country’s main trading partner (the US for Canada and Japan and Germany for Switzerland). Intuitively, an increase in the old dependency ratio means there are more dependents (who are also net spenders) relatively fewer people of working age (who are on aggregate both producing goods and saving). A side effect of this would be an increase in imports and an increase (decrease) in the current account deficit (surplus). In the case of the REER this would have a depreciating effect, as there would be net capital flows out of the country and a decrease in demand for the importing country’s currency.

For REERs and nominal exchange rates predicted using the dependency ratios, the $R^2$ indicates that the model is a good fit (see Exhibit 18). As the mixed signs of the coefficients indicate, problems arise when interpreting what effect a change in one of the independent variables has on the dependent variable.

**Exhibit 18: Results for country specific exchange rate estimations**

<table>
<thead>
<tr>
<th>Nominal Exchange Rates</th>
<th>REERs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Canada</strong></td>
<td><strong>Canada</strong></td>
</tr>
<tr>
<td>C</td>
<td>1.08</td>
</tr>
<tr>
<td>(9.28)</td>
<td>(3.66)</td>
</tr>
<tr>
<td>Old Dependency Ratio</td>
<td>(1.48)</td>
</tr>
<tr>
<td>(Domestic-US)</td>
<td>7.32</td>
</tr>
<tr>
<td>(3.53)</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.74</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.72</td>
</tr>
<tr>
<td>F-statistic</td>
<td>45.24</td>
</tr>
<tr>
<td>Prob(F-statistic)</td>
<td>0.00</td>
</tr>
</tbody>
</table>

| **Switzerland**        | **Switzerland**|
| C                      | 1.04           | C                      | 97.14  |
| (43.5)                 | (2.60)         | Old Dependency Ratio   | 193.64 |
| Old Dependency Ratio   | (-3.34)        | Old Dependency Ratio   | (1.47) |
| (Domestic-German)      | -10.87         | Young Dependency Ratio | -137.63|
| (-11.81)               |                | (Domestic-German)      | (-2.80) |
| $R^2$                  | 0.91           | $R^2$                  | 0.67   |
| Adjusted $R^2$         | 0.90           | Adjusted $R^2$         | 0.65   |
| F-statistic            | 154.09         | F-statistic            | 32.19  |
| Prob(F-statistic)      | 0.00           | Prob(F-statistic)      | 0.00   |

| **Japan**              | **Japan**      |
| C                      | 0.01           | C                      | 235.09 |
| (8.62)                 | (6.10)         | Old Dependency Ratio   | -190.86|
| Old Dependency Ratio   | (1.98)         | Old Dependency Ratio   | (-2.38) |
| (Domestic-US)          | -0.02          | Young Dependency Ratio | -441.60|
| (-1.30)                |                | (5.19)                |
| $R^2$                  | 0.70           | $R^2$                  | 0.78   |
| Adjusted $R^2$         | 0.68           | Adjusted $R^2$         | 0.76   |
| F-statistic            | 36.99          | F-statistic            | 56.26  |
| Prob(F-statistic)      | 0.00           | Prob(F-statistic)      | 0.00   |

Coefficients in bold are significant at the 5% level

Source: Credit Suisse. Newey West adjusted standard errors.

In the case of REER results, an increase in the youth dependency ratio in both Switzerland and Japan has a depreciating effect whereas for Canada it has an appreciating effect. Switzerland and Japan also exhibit advanced aging relative to other developed countries and therefore have higher old dependency ratios. Switzerland exhibits an appreciating effect whereas Japan (and also Canada) exhibit a depreciating effect on the REER.
The nominal exchange rate we used was quoted as the number of US dollars per unit of domestic currency for Japan and Canada whereas for the Swiss Franc we constructed a series relative to Deutschemark using cross-rates. A negative coefficient is equivalent to a depreciating effect on the domestic currency. While statistical significance in terms of $R^2$ and F-stats is high, we cannot find a common pattern across signs of the coefficients for dependency ratios expressed as differences from the US across Canada (both coefficients positive), Switzerland (both negative) and Japan (one positive and other negative).

This indicates that there isn’t a common pattern across either nominal exchange rates or real effective exchange rates in terms of their relationship with dependency ratios. A plausible reason is that changes in dependency ratios follow very similar patterns across countries while exchange rates follow very different paths. We look into this further in Exhibit 25 and Exhibit 26.

The UN project the underlying demographic data for the dependency ratios that we used, so it was possible to forecast the exchange rates using our reduced form models. Exhibit 19 to Exhibit 24 show the forecast bands for nominal exchange rates for Japan, Switzerland and Canada based on these estimations.

First we ran forecasts for the REERs of Japan, Canada and Switzerland, three countries with varying demographics. The actual, fitted and forecast results are presented in Exhibit 19, Exhibit 21 and Exhibit 23. The fitted data run until 2004 and the forecast data run beyond that until 2020. The regressors are the country-specific youth and old dependency ratios. For Canada and Japan we see a downward trend of the REER, whereas for Switzerland the trend of the REER projected until 2020 is upwards. Japan and Canada are strong trading partners of the US and may display a similar trend as older larger developed countries than Switzerland. Also, the coefficients for the youth dependency ratio are very different between Japan and Canada, which can be explained by differential fertility and migration patterns between those two countries.

Exhibit 19: Canada-REER Forecast

Exhibit 20: Canada-Nominal Exchange Rate Forecast
Using the results from Exhibit 18 we also forecasted the bilateral nominal exchange rates. Exhibit 20, Exhibit 22 and Exhibit 24 display these results for Canada, Switzerland and Japan respectively. Canada and Japan are expected to appreciate relative to the USD based on the specification we used whereas the Swiss Franc is expected to depreciate against the DM (or Euro).

Japan is a much older country than Canada, yet the estimations yielded similar forecasts for these two countries. In further examination, we looked at the REER trends across Canada and Japan relative to dependency ratio trends. As we can see in Exhibit 25 and Exhibit 26 the dependency ratio trends (rebased to 100 in 1970 for comparison purposes) are very similar. In both countries the youth dependency ratio declined from 100 to around 60 by 2000. The main difference is in the increase of the old dependency ratio, which has increased for both countries, but the increase in Japan has been more dramatic. In contrast the REER has trended downward for Canada and upward for Japan. We must
emphasize that REERs are a composite economic variable affected by factors that impact their three basic underlying components, and as such are unlikely to bear a strong relationship to demographic variables such as dependency ratios.

**Exhibit 25: Dependency Ratios and REER- Canada**
Old and young dependency ratios and REER re-based to 100 in 1970

**Exhibit 26: Dependency Ratios and REER- Japan**
Old and young dependency ratios and REER re-based to 100 in 1970

Source: Credit Suisse, OECD, UN

What Explains Exchange Rates? Macro Variables Or Demographic Variables Or Both Jointly

In the previous sections, we presented results of explaining (i) external variables and macro variables through demographic variables and (ii) statistically forecasting exchange rates using demographic variables. We also asserted that direct links from demographic variables to exchange rates are not validated regularly or statistically in the samples we tested. However, demographic variables explained net exports, current account, savings and investment relatively well.

We present in Exhibit 27 the correlations across the explanatory variables. For Canada, we observe that the demographic variables exhibit high correlations among one another as well as the macroeconomic variables. The correlations are high between the exchange rate variables although we stress that “correlation does not imply causation”. For Japan, we see that the correlations of the demographic variables amongst themselves are high as expected although much lower with the PPP variable. The fertility rate displays a higher correlation with macroeconomic variables than in the Canadian case.

The regression results for the cases where demographic variables are highly correlated with macroeconomic variables do not show much additional explanatory power from inclusion of demographic variables. In contrast, lowly correlated demographic variables with macro variables do add a bit more explanatory power. Demographic variables do not have direct causal links to real effective exchange rates (which are a composite of trade weights, relative inflation and relative exchange rates) or to bilateral exchange rates (which are affected by higher frequency events).

---

21 Results available for 13 countries on request to authors. These start off with macro variables as regressors in an initial specification which are augmented by additional demographic variables.
Exhibit 27: Correlations between exchange rates, demographic variables and macro variables

A comparison of two countries: Japan and Canada. Dependent variable correlations highlighted in yellow.

<table>
<thead>
<tr>
<th></th>
<th>NER</th>
<th>REER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Canada</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal Exchange Rate</td>
<td>1.00</td>
<td>-0.95</td>
</tr>
<tr>
<td>REER</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Youth Dependency Ratio</td>
<td>1.00</td>
<td>-0.84</td>
</tr>
<tr>
<td>Old Dependency Ratio</td>
<td></td>
<td>0.97</td>
</tr>
<tr>
<td>Median Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertility Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP per Capita</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Japan</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal Exchange Rate</td>
<td>1.00</td>
<td>-0.96</td>
</tr>
<tr>
<td>REER</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Youth Dependency Ratio</td>
<td>1.00</td>
<td>-0.85</td>
</tr>
<tr>
<td>Old Dependency Ratio</td>
<td></td>
<td>0.95</td>
</tr>
<tr>
<td>Median Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertility Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP per Capita</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Credit Suisse

In summary, it appears that the data is inadequate to test whether high frequency variables are affected by low frequency measured demographic variables. These effects could be studied more completely in open macroeconomy general equilibrium set-up for countries or a set of countries. The limitations of some of those models are the scale, assumptions, structure as well as implementability of results from there to partial modeling frameworks.

Dependency Ratios vs. Population Growth Rates-An Examination

As discussed both in the literature and in our review above, there is ambiguity regarding which effect dominates—the rate of growth effect or the dependency effect on aggregate savings. To assess the relative strengths of these two opposing effects, we conducted a couple of estimations within a panel set up (without any fixed effects).

Exhibit 28: Savings & Dependency Ratios

<table>
<thead>
<tr>
<th></th>
<th>Dependent Variable: Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.67 (17.51)</td>
</tr>
<tr>
<td>RPI</td>
<td>-0.18 (-5.50)</td>
</tr>
<tr>
<td>GROWTH</td>
<td>0.23 (2.15)</td>
</tr>
<tr>
<td>Young Dependency Ratio</td>
<td>-0.38 (-9.25)</td>
</tr>
<tr>
<td>Old Dependency Ratio</td>
<td>-0.71 (-8.33)</td>
</tr>
<tr>
<td>R²</td>
<td>0.29</td>
</tr>
<tr>
<td>Adj R²</td>
<td>0.28</td>
</tr>
<tr>
<td>F-statistic</td>
<td>44.41</td>
</tr>
<tr>
<td>Prob(F-statistic)</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Source: Credit Suisse, Penn World Tables, IMF. Coefficients in bold are significant at the 5% level

Exhibit 29: Savings & Population Growth

<table>
<thead>
<tr>
<th></th>
<th>Dependent Variable: Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.44 (16.34)</td>
</tr>
<tr>
<td>RPI</td>
<td>-0.22 (-7.38)</td>
</tr>
<tr>
<td>GROWTH</td>
<td>0.20 (1.71)</td>
</tr>
<tr>
<td>Population Growth</td>
<td>0.63 (1.30)</td>
</tr>
<tr>
<td>R²</td>
<td>0.13</td>
</tr>
<tr>
<td>Adj R²</td>
<td>0.13</td>
</tr>
<tr>
<td>F-statistic</td>
<td>22.07</td>
</tr>
<tr>
<td>Prob(F-statistic)</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Source: Credit Suisse, Penn World Tables, IMF. Coefficients in bold are significant at the 5% level

The qualitative difference across the two estimations can be seen in Exhibit 28 and Exhibit 29. Savings is explained better by the dependency ratios which have negative coefficients that were statistically significant.
Conclusions

We conclude that historically unprecedented demographic change is affecting external balances of countries that are part of an increasingly globalized world. We strongly concur with Poole, Higgins, and others at IMF/ECB/Fed who argue that capital flows are affected by demographic changes.

Demographics affects savings, investment and growth which directly influence capital flows. We fail to provide any strong support to direct linkages between demographic variables and exchange rates on a pooled sample basis although we find some strong effects on an individual country basis. We acknowledge that demographic variables affect consumption and savings (at the micro and aggregate) level. However the relationships are complex and not always direct, therefore it would be optimistic to expect demographic variables by themselves only to explain exchange rates. Rather, they potentially have an indirect and augmenting role in determining exchange rates.

Basic exchange rate theory\textsuperscript{22} tells us that demand and supply of foreign currency determines the exchange rate. Demographic variables such as the number of consumers, the number of producers along with other variables such as their wealth/income and their productivity determine relative demands. Relative cross-country demand and supply affects both relative goods prices and wages, which ultimately affect exchange rates. However, changing demographic characteristics such as family structure, gender, education, migrant status etc have a major influence on consumption, savings and investment behaviour.

The inadequacy of macro data underlying these demographic characteristics makes it difficult to empirically test for their influence. The demographic data needs to be at higher frequencies, similar to exchange rates, if we are to conclusively find any evidence of explaining exchange rates. In sum, demographic changes relate better to both household and government savings and investment rates, that affect the external balances.

\textsuperscript{22} See basic International economics text by Krugman and Obstfeld or the Obstfeld and Rogoff International Macroeconomics text.
References


Credit Suisse Demographics Research (July 2006), Why Demographics Matters? And How? by Amlan Roy

Credit Suisse Demographics Research (June 2007), Global Demographic Change and Sector Implications by Amlan Roy and Aimi Price.


J.F. Helliwell (2004), Demographic Changes and International Factor Mobility, Kansas City Fed Jackson Hole Symposium, also NBER Working paper 10945.


A. Mason, Saving, Economic Growth and Demographic Change, Population and Development Review 14, No. 1., March 1988


W. Poole, Changing World Demographics and Trade Balances, April 16, 2007 speech.

W. Poole, A Perspective on the Graying Population and Current Account Balances, March 8, 2005 speech.


World Economic Outlook (September 2004), "How will Demographic Change Affect the Global economy?, by IMF, pp 137-181
Appendix 1. Demographic Chart Book

In this appendix, we present charts designed to help visualize the demographic pressures affecting some of the major developed countries in the world. We first present country-comparison charts for fertility rates and old dependency ratios for 12 countries, relative to the US. We then present six charts for each country, painting a demographic picture of the past, present and predicted situation.

Cross-Country comparisons, Exhibits 30-33

1) Fertility rate differences (Children per woman of childbearing age vs. the US, 1970-2004, annual)

Ireland's fertility rate was nearly double that of the US in the 70s. This should lead to higher population growth and higher youth dependency ratios than the US.

2) Old dependency ratio differences (No. of people aged 65+ per person of working age, vs. the US 1970-2004, annual)

The high fertility rate for Ireland in the 70s and 80s resulted in its old dependency ratio decreasing when that group reached working age in the 90s. Due to other factors, such as migration and changes in life expectancy, low fertility rates do not always lead to high old dependency ratios (for example Canada).

Country specific demographic landscape, Exhibits 34-105

1) Age group ratios (1975-2020, annual)

- The wave of baby boomers are shown moving through three working ages that have different spending patterns - young middle and old workers.
- Portrays the timing and magnitude of changes and is affected by fertility, immigration and life expectancy increases.
- Comparing Exhibit 34 to Exhibit 76 we see that Spain experienced a peak in the share of the population aged 20-34 much later than Canada.

2) Dependency ratios (1950-2050, 5 yearly)

- Decreases in the youth dependency ratio occurred at a time of economic expansion and growth in wealth for most countries.
- The total dependency ratios for both Italy and Japan are predicted to increase quite sharply in the near future.

3) Life expectancy and fertility rates (1950-2050, 5 yearly)

- These two together explain a large part of why and how fast a population is ageing.
- As life expectancy increases old dependency ratios increase more quickly than they would if it were just due to the wave of boomers retiring.
- The decrease in fertility rates decreases child dependency ratios, but later also slows labour force growth.

4) Population and labour force growth rates (1980-2020, 5 yearly)

- Due to cyclical factors labour force growth is more volatile than population growth.
- Population growth has been slowing recently, but there is a lag between population growth and labour force growth of about 20 years.
5) Population pyramids in 2000 and 2040

- The pyramids show the population structure at a snapshot in time. The general trend is towards an inverted pyramid (i.e. more old people than young people).
- The population pyramid for Japan in 2000 has two “humps” at age 25-29 and 50-54, this is due to the second smaller baby boom that Japan experienced in the early 70s.

Exhibit 30: High Fertility Rates (vs. US)
Fertility rate is the number of children per woman of childbearing age

Exhibit 31: Low Fertility Rates (vs. US)

Exhibit 32: Old Dependency Ratios (vs. US)
The old dependency ratio is the number of people aged over 65 per person of working age (aged 15-64)

Exhibit 33: Old Dependency Ratios (vs. US)
Exhibit 40: France- Population Ratios

Exhibit 41: Dependency Ratios

Exhibit 42: Life Expectancy and Fertility Rates

Exhibit 43: Demographic Growth Rates

Exhibit 44: Population Age Distribution—2000

Exhibit 45: Population Age Distribution—2040
Exhibit 46: Germany- Population Ratios

Exhibit 47: Dependency Ratios

Exhibit 48: Life Expectancy and Fertility Rates

Exhibit 49: Demographic Growth Rates

Exhibit 50: Population Age Distribution—2000

Exhibit 51: Population Age Distribution—2040

Source: Credit Suisse, UN
Exhibit 52: Ireland- Population Ratios

Ireland: Age Ratios

Ratio to Total Population

Source: Credit Suisse, UN

Exhibit 53: Dependency Ratios

Ireland: Dependency Ratios

No. of dependents per person of working age

Source: Credit Suisse, UN

Exhibit 54: Life Expectancy and Fertility Rates

Ireland: Life Expectancy and Fertility Rates

Fertility Rates (LHS)  Life Expectancy at Birth (RHS)

Source: Credit Suisse, UN

Exhibit 55: Demographic Growth Rates

Ireland: Population and Labour Force Growth Rates

Source: Credit Suisse, ILO, UN

Exhibit 56: Population Age Distribution—2000

Female Population by age cohort in red, male population in blue, unit '000s

Source: Credit Suisse, UN

Exhibit 57: Population Age Distribution—2040

Female Population by age cohort in red, male population in blue, unit '000s

Source: Credit Suisse, UN
Exhibit 70: Netherlands - Population Ratios

Netherlands: Age Ratios

Ratio to Total Population

Source: Credit Suisse, UN

Exhibit 71: Dependency Ratios

Netherlands: Dependency Ratios

No. of dependents per person of working age

Source: Credit Suisse, UN

Exhibit 72: Life Expectancy and Fertility Rates

Netherlands: Life Expectancy and Fertility Rates

Source: Credit Suisse, UN

Exhibit 73: Demographic Growth Rates

Netherlands: Population and Labour Force Growth Rates

Source: Credit Suisse, ILO, UN

Exhibit 74: Population Age Distribution—2000

Female Population by age cohort in red, male population in blue, unit '000s

Source: Credit Suisse, UN

Exhibit 75: Population Age Distribution—2040

Female Population by age cohort in red, male population in blue, unit '000s

Source: Credit Suisse, UN
Exhibit 76: Spain- Population Ratios

Spain: Age Ratios

Source: Credit Suisse, UN

Exhibit 77: Dependency Ratios

Spain: Dependency Ratios

Source: Credit Suisse, UN

Exhibit 78: Life Expectancy and Fertility Rates

Spain: Life Expectancy and Fertility Rates

Source: Credit Suisse, UN

Exhibit 79: Demographic Growth Rates

Spain: Population and Labour Force Growth Rates

Source: Credit Suisse, ILO, UN

Exhibit 80: Population Age Distribution—2000

Female Population by age cohort in red, male population in blue, unit '000s

Source: Credit Suisse, UN

Exhibit 81: Population Age Distribution—2040

Female Population by age cohort in red, male population in blue, unit '000s

Source: Credit Suisse, UN
Exhibit 88: Switzerland- Population Ratios

Exhibit 89: Dependency Ratios

Exhibit 90: Life Expectancy and Fertility Rates

Exhibit 91: Demographic Growth Rates

Exhibit 92: Population Age Distribution—2000

Exhibit 93: Population Age Distribution—2040

Source: Credit Suisse, UN

Source: Credit Suisse, ILO, UN
Appendix 2. Supplementary Estimation Results

Replicating Andersson & Osterholm results

As discussed in the Demographics and Exchange Rates section of the main text, Andersson and Osterholm (henceforth A&O) conducted estimations to quantify the relationship between exchange rates and demographic variables. We were unable to replicate A&O’s results and we detail here the steps we followed.

A&O assume that domestic age structure is the relevant demographic variable which influences the exchange rate. Their data was based on the population split into six age groups: child (those aged <15), young (15-24), lowmid (24-49), highmid (50-64), youret (65-74) and oldret (aged 75+). The child variable was excluded from the final equation to avoid perfect collinearity, as the age shares add to 1.

They developed reduced form models for (1) a pooled OLS regression, (2) a random effects (RE) model and (3) a fixed effects (FE) model. The pooled OLS equation is shown below, where $S_{XXYYi,t}$ refers to the population share of age group XX-YY for country i in period t and $Q_{i,t}$ refers to the dependent real effective exchange rate variable.

$$Q_{i,t} = \alpha + \beta_2 S_{1524i,t} + \beta_3 S_{2549i,t} + \beta_4 S_{5064i,t} + \beta_5 S_{6574i,t} + \beta_6 S_{75i,t} + \epsilon_{i,t}$$

We first conducted an estimation using REER data from Credit Suisse (1975-2005) and updated population data for 22 countries23. The results from this specification can be seen in the first panel in Exhibit 106. The $R^2$ was much lower 0.045 versus 0.273, and only the constant was statistically significant at the 5% level. The coefficients for the 25-49 and 20-64 year olds are negative suggesting that they have a depreciating effect on the exchange rate.

Initially, we conducted estimations using a different sample of countries compared to A&O. Therefore, we re-ran our estimations excluding any emerging markets countries which may contain outliers and skew the results. The second panel in Exhibit 106 shows the results from this regression, the $R^2$ was again very low. In addition, the coefficients for all age groups except the 65-74 year olds changed signs.

---

23 Very similar to the data used by Anderson and Osterholm although not identical. Data and analysis of country specific correlations across the 2 data series are available upon request.
To try and eliminate any doubt about there being an outlier in our data we constructed a group of countries identical to those that A&O used, replicating the time span and using the same source for the REER - the OECD. The results from this regression are presented in the third panel of Exhibit 106. However, with an \( R^2 \) of just 0.027 they were worse than the previous two estimations.

We next conducted two data experiments (a) used A&O’s demographic data with OECD REER data (b) used our demographic data from the UN with A&O’s REER data. As shown in Exhibit 107 we found that in case (a) we get very weak explanatory power and results but in case (b) we get much stronger results. For comparison the first panel in Exhibit 107 presents the results that A&O obtained. This experiment suggests that the stronger results detailed by A&O are driven largely by their REER series. Even though the A&O REER series are highly correlated with REER series from OECD, as well as those produced by Credit Suisse and the IMF, we weren’t able to replicate their results using these alternative series.

Exhibit 107: Estimations to check A&O results

First panel presents actual A&O results

<table>
<thead>
<tr>
<th></th>
<th>Andersson and Osterholm Results (Pooled OLS)</th>
<th>Dependent Variable: A&amp;O REER (Independent Variables: 2004 UN data)</th>
<th>Dependent Variable: OECD REER (Independent Variables: A&amp;O UN data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>195.11</td>
<td>204.82</td>
<td>54.55</td>
</tr>
<tr>
<td></td>
<td>(7.14)</td>
<td>(4.53)</td>
<td>(1.63)</td>
</tr>
<tr>
<td>Beta1</td>
<td>22.56</td>
<td>Age Share 15-24</td>
<td>Age Share 15-24</td>
</tr>
<tr>
<td></td>
<td>(0.32)</td>
<td>-7.94</td>
<td>192.10</td>
</tr>
<tr>
<td>Beta2</td>
<td>-160.48</td>
<td>Age Share 25-49</td>
<td>Age Share 25-49</td>
</tr>
<tr>
<td></td>
<td>(-4.41)</td>
<td>-166.99</td>
<td>(1.80)</td>
</tr>
<tr>
<td>Beta3</td>
<td>-322.59</td>
<td>Age Share 50-64</td>
<td>Age Share 50-64</td>
</tr>
<tr>
<td></td>
<td>(-5.08)</td>
<td>-344.72</td>
<td>-23.56</td>
</tr>
<tr>
<td>Beta4</td>
<td>-60.98</td>
<td>Age Share 65-74</td>
<td>Age Share 65-74</td>
</tr>
<tr>
<td></td>
<td>(-0.71)</td>
<td>-37.86</td>
<td>193.29</td>
</tr>
<tr>
<td>Beta5</td>
<td>270.87</td>
<td>Age Share 75+</td>
<td>Age Share 75+</td>
</tr>
<tr>
<td></td>
<td>(2.47)</td>
<td>246.56</td>
<td>51.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.38)</td>
<td>(0.28)</td>
</tr>
<tr>
<td>R²</td>
<td>0.27</td>
<td>0.28</td>
<td>0.03</td>
</tr>
<tr>
<td>F-statistic</td>
<td>17.46</td>
<td>F-statistic</td>
<td>F-statistic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>61.59</td>
<td>4.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prob(F-statistic)</td>
<td>Prob(F-statistic)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Source: Credit Suisse, A&O, OECD, UN. Coefficients in bold are significant at the 5% level

In each of the regressions discussed above we used the age shares of the population as the route through which changes in demographics affect exchange rates. However, for completeness we also ran similar estimations using either dependency ratios or population growth rates as explanatory variables. The results of these regressions did not provide any stronger support for a direct link between exchange rates and demographics and as such we have excluded the tables from this paper.

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24 Correlations across A&O’s REER series and others along with charts are available upon request.
Disclosure Appendix

Analyst Certification

Amlan Roy, Aimi Price, Joe Prendergast and Umberto Alvisi each certify, with respect to the companies or securities that he or she analyzes, that (1) the views expressed in this report accurately reflect his or her personal views about all of the subject companies and securities and (2) no part of his or her compensation was, is or will be directly or indirectly related to the specific recommendations or views expressed in this report.

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