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Abstract Using threshold effects we find that as countries experience an increase in old-age dependency rates, countries with lower domestic saving rates, moderate current account deficits, and are more open to trade can actually experience an increase in GDP growth rates. These countries have greater access to capital markets which will allow them to sustain economic growth in light of substantial increases in their old-age dependency rates. Countries with a lower savings rate are able to rely on domestic consumption and more importantly can rely on foreign investment to offset the decline in worker productivity caused by exodus of domestic workers. Although the effects of an increase in the old-age dependency rate on GDP growth rates are smaller for countries with lower saving rates, these countries also have significantly lower growth rates prior to the increase in the old-age dependency rate. We conclude the effects of population ageing for many high saving countries will depend on their desire to reduce saving rates at old-age dependency rates begin to increase. The ability for lower saving countries to maintain stable growth rates hinges on their ability to sustain current account deficits.

JEL Classification: J11, O40, O57

Keywords Dependency Rates · Growth · Ageing · Saving Rates · Capital Mobility

1 Introduction

Over the past several decades, OECD countries have experienced an increase in old-age dependency rates due to extended life expectancy and increasing birth rates during the middle of the 20th century. As the first cohort of baby boomers

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are beginning to leave the work force several economies with already high old-age dependency rates will face further increases in their old-age dependency ratio. In the next twenty years the old-age dependency ratio (measured relative to the working age population) will nearly double for the United States and many western European countries. As the ratio of retirees to the working age population increases, economic growth and national saving rates will by impacted. Many economists agree that national savings rates will decline in response to increasing old-age dependency as the ratio of dissavers to savers increases commensurate with the increases in the old-age dependency ratio. In theory, few economists would dismiss this demographic change as insubstantial in terms of the impacts to economic growth. The primary aim of this paper is to answer the question: To what extent does an population ageing, as seen through growth in the old-age dependency ratio, affect GDP growth rates conditional on a country's level of saving, capital mobility, and access to foreign capital markets?

Using a threshold procedure following Hansen (1999) we test for the existence of threshold effects in the relationship between population ageing and GDP growth rates. We find significant thresholds for domestic saving rates, current account balances, and trade openness. After controlling for these thresholds the effects of population ageing on economic are positive for countries with a lower domestic savings rates, moderate current account deficits, and more open to trade. We attribute the positive relationship as a country's population moves out of the labor force, saving rates decline which causes consumption to increase. More importantly countries with moderate current account deficits are able to attract foreign investment from higher saving countries.

The rest of the paper is organized as follows. Section 2 will outline the relevant literature relating to economic growth and population ageing and the effects of population ageing on country saving rates. Section 3 will review the threshold procedure outlined in Hansen (1999) and the baseline growth regressions used throughout the analysis. Section 4 will review the results. Finally, section 5 will conclude.

2 Literature Review

At the center of this demographic analysis are two separate yet related groups of empirical studies. In the first tier, researchers have studied the correlation between old-age dependency rates and domestic saving rates. Modigliani and Sterling (1983), Horioka (1992), and Graham (1987) confirmed the negative correlation between old-age dependency rates and the domestic saving rates initially posited in the life-cycle theory of consumption. Following the seminal work of Leff (1969), many empirical studies, including those of Bilsborrow (1979), Weil (1994), and Li et al (2007), have studied the effects of demographic transitions on savings. In general, the empirical studies conducted to extrapolate the effects of age dependency on savings yield a negative correlation. These results are robust to time spans, countries, and empirical specifications considered within the literature.

In the second tier of the literature, empirical studies have been directed at the link between old-age dependency rates and real economic growth. Despite a small number of dissenters that claim demographic changes are too subtle to affect economic growth, there is a relative consensus within the economic literature regarding the negative correlation between old-age dependency rates and economic growth. Using a human-capital augmented Solow growth model, Modigliani (1970) found a negative correlation between the population share for old-age dependents and the per worker growth rate of real GDP over a panel of the OECD countries. Lindh and Malmberg (1999), Masson et al (1998), and Graham (1987) confirm the results found by Modigliani (1970) using aggregate, time-series data in cross-country studies. This result is consistent with mainstream economic theory: fewer workers in the economy will result in a slowdown in production and a decline in GDP growth. Lindh and Malmberg (1999) find a positive effect on economic growth for an increase in the 50-64 year old-age group but a negative effect for an increase in the 65+ age grouping.

Contrary to the work of Modigliani (1970), Cutler et al (1990) show an optimal response to population ageing maybe a reduction in national saving rates for the United States. Their arguments center on a slowdown in the rate of population growth which will require less investment in capital to equip the shrinking working age population. This will further allow for greater inflows of foreign capital. The results found by Cutler et al (1990) are dependent on a country's ability to access foreign capital. Elmendorf and Sheiner (2000) first examine the optimal path of consumption for an ageing population under the assumptions of a small open or a large closed economy. They find the optimal response for a small open economy is to smooth consumption, which will possible lead to an increase in domestic saving rates. For a large closed economy they find the optimal response is a decrease in saving, which is consistent with Cutler et al (1990). Finally, Guest (2006) expands on the results of Elmendorf and Sheiner (2000) by allowing for differing degrees of capital market openness. Under the assumption of imperfect capital mobility he finds a small responsiveness in domestic interest rates to foreign capital is sufficient to generate optimal consumption and saving paths similar to that of the closed economy.

The work by Cutler et al (1990), Guest (2006), and Elmendorf and Sheiner (2000) analyze how a country should respond, preemptively, to an ageing population. Instead of searching for the optimal responses in consumption and saving, we are interested in understanding the effects of ageing on growth rates conditional on a countries level of saving. While researchers have conducted many empirical studies to gauge the proper magnitude of the resulting shock on economic growth, we feel that these results may be inaccurate and misleading, as the body of economic literature does little to compensate for the diverse levels of domestic savings, current account balances, and levels of openness within the OECD grouping. Given the varying degrees of key economic variables it is difficult to conclusively state whether the impact of ageing on GDP growth will be of the same magnitude for all countries. Intuition suggests that countries with a high-savings profile will be better prepared to absorb the impacts of an ageing population, while the countries with a low-savings profile may suffer more dire consequences as an already low savings rate declines further. This is often cited when discussing the current low savings rate in the United States. Conversely, Japan's national savings rates are above 35% and according to conventional logic was in position to absorb the large number of retirees without a slowdown in growth. Ultimately, the high saving rates did not shield the country from a growth slowdown.

Most empirical research has been limited to the relationship between savings caused by an ageing population or the effects of ageing on GDP growth rates. By conducting a threshold analysis on savings, capital mobility, and trade openness within a standard growth regression we will control for the varying degrees of these key economic variables. Through this paper, we hope to expand the literature on the economic consequences of ageing by utilizing a non-dynamic threshold analysis procedure created by Hansen (1999). This approach will allow us to illuminate the effects of ageing on GDP growth conditional on the level of savings, capital mobility, and openness in a country. By utilizing this threshold approach, we will divide the OECD sample into regimes based on a particular threshold variable (saving rate, current account balances, or trade openness). By establishing these regimes, we are able to isolate the economic impacts of ageing on GDP growth rates among the various OECD countries.

We find the effects of ageing on real GDP growth is positive for countries that have low domestic saving rates, negative current account balances, and are more open to trade. We attribute these findings to an increase in consumption upon retirement that counteracts the loss in initial productive capacity that is actualized by a smaller workforce. These results are consistent with the hypotheses of Cutler et al (1990), Elmendorf and Sheiner (2000), and Guest (2006). We also find within the high-saving regime, the impacts of an increase in the old-age dependency ratio on real GDP growth is significant and negative. We attribute this negative relationship to the fact that countries with a high level of national savings forgo this consumption boost due to cultural factors that increase the inertia of savings at the individual level - such as cultural expectations for families to financially provide for the elderly or expectations of the elderly to leave large bequests. Consequently, the high-savers suffer the consequences of a reduced workforce without significant changes in consumption. Although, for low saving countries, our results show a positive relationship between growth and old-age dependency ratio, this does not imply a high rate of growth. Countries in the lowest saving threshold have an average growth rate of 1.6%, whereas countries in the high saving threshold have an average growth rate of 2.9%.

3 Empirical Methodology

Recent research (e.g. Guest (2006), Hock and Weil (2011), and Cervellati and Sunde (2011)) focuses on how domestic saving rates should respond to an ageing population not how GDP growth responds to a change in population ageing for a given level of saving (or capital mobility and trade openness). To test the latter we implement a non-dynamic panel threshold testing procedure that allows us to model the relationship between population ageing and GDP growth while simultaneously controlling for country specific factors. Most growth regressions assume a constant coefficient on population ageing (see Li et al (2007)), but it is reasonable to suspect the coefficient on ageing will vary based on a countries level of saving, current account balances, and trade openness. One approach to control for differing levels of saving, current account balances, and trade openness would be an ad hoc exogenous grouping. A more optimal approach would be to search for the break point among the variable of interest (i.e. saving rates, current account balances, and trade openness) that minimizes the residual sum of squares.

Before implementing the threshold testing procedure we develop five simple growth regressions applied to OECD countries.[1] Focusing on highly developed economies will help control for hard to measure factors that plague large country panel datasets. One such measure would be the development of a country's financial system. Most OECD countries have a highly developed financial system and are able to borrow through domestic and external channels. Using only OECD countries our baseline empirical specification follows closely from Barro and i Martin (2003) and Li et al (2007):

$$\begin{aligned} g_{y_{it}} = \mu_i &+ \alpha_1 log(age_{working})_{it} + \alpha_2 log(1 + labor\,force\,growth)_{it} \\ &+ \alpha_3 log(1 + population\,growth)_{it} + \alpha_4 log(per\,capita\,income)_{i,t-1} \\ &+ \alpha_5 log(S/Y)_{i,t-1} + \alpha_6 log(G/Y)_{i,t-1} + e_{it}, \end{aligned} \tag{1}$$

where $g_{y_{it}}$ is the growth rate measured as per capita, U.S. dollars, and $(S/Y)_{i,t-1}$ and $(G/Y)_{i,t-1}$ are domestic saving rates and government consumption as a percentage of GDP, respectively. Following the growth literature we expect $\alpha_1 > 0$, $\alpha_2 > 0$, $\alpha_3 < 0$, $\alpha_4 < 0$, $\alpha_5 > 0$, and $\alpha_6 < 0$.[2] GDP growth rates are typically increasing in the size of the labor force which we capture by including the working age population and labor force growth rates. Since we are measuring the growth rate of GDP per capita, it follows that population growth will have a negative effect on growth rates. Higher income countries tend to lie closer to their steady state levels of capital (i.e. lower marginal product of capital), while lower income countries tend to have faster growth rates due to a higher marginal product of capital. This effect is captured through α_4, the coefficient on lagged per capita income. Next we included domestic saving rates, we can also see this as a proxy for investment as the two are highly correlated. Following the growth literature we expect the coefficient on domestic saving rates to be positive.[3] Finally, we include government consumption as a fraction of GDP. We expect government consumption to have a negative effect on GDP which follows from Barro (1991).

The next step is to isolate the effects of young-age and old-age workers on GDP growth rates. To do this we estimate equation (1) replacing $log(age_{working})$ with $log(age_{old})$ and $log(age_{young})$. The model becomes:

$$g_{y_{it}} = \mu_i + \alpha_{11} log(age_{old})_{it} + \alpha_{12} log(age_{young})_{it} + \cdots + e_{it}. \tag{2}$$

Equation (2) will separate the effects of the working age population into the young and old-age dependency rates, respectively. For robustness the next step is to capture the effects of trade and financial openness on growth rates by incorporating a trade openness measure that captures a countries dependency on foreign markets. Trade openness is measured as exports plus imports expressed as a percentage of gross domestic product. This is standard in the growth literature. To control for financial openness we incorporate a measure by Lane and Milesi-Ferretti (2007). Financial openness is measured as total foreign assets plus total foreign liabilities expressed as a percentage of gross domestic product. These are de facto measures

[1] Our sample includes 22 countries: Australia, Austria, Canada, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and United States.

[2] These signs are consistent with the models of Li et al (2007) and Attanasio et al (2000).

[3] To avoid a causality debate between saving and GDP growth we include the lag of domestic saving.

of openness. They do not necessarily control for whether a country is open or closed as a matter of law, but instead measure the amount of goods, services, and financial assets flowing across the borders. Next we incorporate human capital, life expectancy, and birth rate measures. Human capital is taken as the percentage of primary school enrollment. Finally, we incorporate decade specific dummy variables and country specific fixed effects.

The baseline regressions will help shed light on the bias that results from the failure to control for the effects of an increase in the working age population on growth by separating the equation in young and old-age dependent. Nonetheless, the regression does not provide much insight into the effects of an increase in the old-age dependency ratio will have on GDP growth conditional on a country's level of domestic saving, current account, or trade openness. The threshold variables are selected in accordance with the research of Cutler et al (1990), Elmendorf and Sheiner (2000), and Guest (2006).[4] In order to better understand the relationship between growth and an ageing population we proceed to develop the non-dynamic threshold model by Hansen (1999). The next step requires estimating equation (2) for threshold effects in domestic saving rates, current account balances, and trade openness.

The threshold procedure requires comparing the residual sum of squares from the restricted regression, equation (2), to the unrestricted regression which allows for a single threshold:

$$\begin{aligned} g_{y_{it}} &= \mu_i + \beta_0 log(age_{old})_{it} I(q_{it} \leq \gamma) + \beta_1 log(age_{old})_{it} I(q_{it} > \gamma) \\ &\quad + \theta x_{it} + e_{it} \end{aligned} \tag{3}$$

where q_{it} is a scalar threshold variable (saving rates, current account balances, or trade openness), x_{it} represents additional control variables from equation (1), and $I(\cdot)$ is the indicator function that takes a value of one when the threshold condition in the bracket is satisfied, zero otherwise. The error term is assumed to be independent and identically distributed with mean zero and finite variance σ^2. Mean deviations are taken to control for country specific effects measured by μ_i.

The sample is trimmed by 15 percent, the bottom and top 7.5 percent are omitted during the search. Additionally, a threshold regime is restricted to be at least size $0.075 \times N$ observations. Restricting the threshold regimes to be at least 7.5 percent of the total observations helps to minimize potential bias caused by outliers. The optimal threshold value is selected by minimizing the residual sum of squares. After selecting the optimal threshold value, γ_1, it is important to determine if a threshold effect is statistically significant. The null hypothesis of no threshold effect is:

$$H_0 : \beta_0 = \beta_1,$$

where $\beta_0 = \beta_1$ is tested by a likelihood ratio test. The likelihood ratio test for the first stage threshold estimate is:

$$F_1 = \frac{S_0 - S_1(\hat{\gamma}_1)}{\hat{\sigma}^2} \tag{4}$$

[4] We also considered other measures of capital mobility which included the financial openness measure by Lane and Milesi-Ferretti (2007), correlations from the saving-investment regressions by Feldstein and Horioka (1980), and other de jure measures of capital mobility.

where $\hat{\sigma}^2 = \frac{1}{n(T-1)} S_1(\hat{\gamma}_1)$, S_0 are the residual sum of squares from the restricted regression, $S_1(\hat{\gamma}_1)$ are the residual sum of squares from the unrestricted regression, and $\hat{\gamma}_1$ is the threshold parameter that minimizes the residual sum of squares. The null hypothesis is rejected for large values of the likelihood ratio test statistic. Once the single threshold is estimated the process of estimation extends easily to models with two and three thresholds breaks.

To determine the second threshold break, the following model is estimated:

$$\begin{aligned} g_{y_{it}} &= \mu_i + \beta_0 log(age_{old})_{it} I(q_{it} \leq \gamma_1) + \beta_1 log(age_{old})_{it} I(\gamma_1 < q_{it} \leq \gamma_2) \\ &\quad + \beta_2 log(age_{old})_{it} I(\gamma_2 < q_{it}) + \theta x_{it} + e_{it} \end{aligned} \tag{5}$$

Assuming the first threshold is given, the optimal second-stage threshold estimate is found by minimizing the residual sum of squares for equation (5). The likelihood ratio test of one versus two thresholds is based on the statistic:

$$F_2 = \frac{S_1(\hat{\gamma}_1) - S_2(\hat{\gamma}_2)}{\hat{\sigma}^2} \tag{6}$$

where $\hat{\sigma}^2 = S_2(\hat{\gamma}_2)/n(T-1)$. In order to insure a large enough sample within each threshold the second break point is restricted to be at least 7.5 percentile points larger or smaller than the first threshold value. The null hypothesis of $\beta_0 = \beta_1 = \beta_2$ is rejected for large values F_2. The asymptotic distributions for F_1 and F_2 are non-standard. Under the null hypothesis the thresholds are not identified, Hansen suggests a bootstrapping procedure to simulate the asymptotic distribution and p-values for the likelihood ratio test.[5]

Since our interest is primarily with the relationship between old-age dependency and GDP growth rates we restrict the thresholds effects to only be interacted with old-age dependency rates. The data are separated into regimes according to the threshold variables in relation with the optimal threshold values. We estimate each growth model outlined previously for thresholds effects.[6]

4 Data and Results

Data are from three sources: Penn World Table 7.0 (Heston et al (2006)), World Development Indicators, and Lane and Milesi-Ferretti (2007). National income data which includes real GDP per capita, saving rates, government consumption, and trade openness are from Penn World Table 7.0. Population growth and labor force growth are also from the Penn World Table. Demographic variables which include age dependency ratios, life expectancy, birth rates, infant mortality, and primary school enrollments are from the World Development Indicators. The old-age dependency rate refers to the population older than 65 relative to the middle age population between the ages of 15 and 64. The young-age dependency rate is defined in a similar manner for those under the age of 15. Financial openness measures are from Lane and Milesi-Ferretti (2007). The data set spans from 1970

[5] See Hansen (1999) for complete details of the threshold procedure and test statistics. Graphs of confidence intervals are available upon request.

[6] Each model was also tested using three, five, and ten-year rolling averages to control for business cycle variability, the results were similar.

to 2007 for 22 OECD countries for a total of 814 observations. A complete data guide is available in Table 1.[7]

Detailed descriptive statistics are presented in Table 2. Table 2 presents the mean, standard deviation, minimum, and maximum values of each variable. Additionally the 10th, 25th, 50th, 75th, and 90th percentiles are also reported.

4.1 Baseline Growth Regressions

Results for the baseline growth regressions are available in Table 3. All regressions include country specific fixed effects and are reported using White's robust standard errors to correct for heteroscedasticity. In the first model we present the results for the baseline specification, equation (1). The baseline model assumes a constant coefficient on the working age population. All variables appear with the expected signs. With the exception of government consumption, the variables are significant at the five percent level. We can interpret the coefficient of 0.097 on $log(age_{working})$ as the percentage increase in growth rates for a one percent increase in the working age population. In other words, in order to increase growth rates by 1%, the ratio of working age residents to the total population would need to increase by 0.01/0.097 or approximately 10.3%.[8]

As expected the coefficient on saving rates is positive and significant at the five percent level. The coefficient of 0.021 on saving rates implies that a one percent increase in saving rates will increase growth by 0.021 percentage points. This means in order to increase growth rates by one percentage point domestic saving rates must be increased by 0.01/0.021 or 47.1%. The coefficient -0.023 on income per capita also appears with the expected sign and is significant at the one percent level. The negative coefficient on lagged income per capita is consistent with past literature and reflects the convergence in GDP growth rates as incomes increase. The coefficients on labor force growth rates, 0.221, and population growth rates,, -0.965 enter with the expected signs and are significant at the one percent level. Since growth rates are measured as the percent change in real GDP per capita we expect the coefficient on population growth to be near one. A one percent increase in population growth should result in an equal decline in GDP growth rates, all else equal. The coefficient on labor force growth rates is also large in magnitude. A one percent increase in the labor force growth rate will result in a 0.221 percentage point increase in GDP growth rate. An increase in the labor force growth rate will correspond with a decrease in the young and/or old population groups.[9] In order to increase GDP growth by one percentage point it will take an increase of 4.5% in the labor force (0.01/0.221).

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[7] For some countries during the early 1970's the data for demographic variables were only available every five years. Since the threshold procedure requires a balanced panel we interpolated the variables for which we were missing observations. This was primarily used for life expectancy, birth rates, infant mortality, and primary school enrollments. The variance in the measures we ipolated are rather low, so it is likely the interpolation will not lead to data smoothing errors.

[8] The semi-log coefficients can be interpreted as $\partial Y = \alpha_i \frac{\partial X}{X} = \alpha_i \% \Delta X$. In order to increase growth rates by 1% the percent change in X needs to be $0.01/\alpha_i$.

[9] There is potentially a multicollinearity issue between variables controlling for age dependency rates, labor force growth, and population growth. When the model is estimated without labor force and population growth rates the results are quantitatively similar.

In model (2) we separate the effects of the working age population into the young and old-age dependency rates. The coefficients on the young and old-age dependency rates appear with the expected signs -0.039 and -0.016, respectively. Only the coefficient on the young-age dependency rate is significant. We can interpret these coefficients as a one percent increase in the young (old) age dependency rate will decrease GDP growth by 0.039 percentage points (0.016). Collectively, both terms are relatively small in magnitude. This is not surprising given our hypothesis that the effects of ageing on growth will be dependent on a country's level of saving, current account balance, and level of openness. We expect the coefficients on the old-age dependency rate to change significantly after controlling for the appropriate thresholds. The coefficients on the other variables remain nearly unchanged.

In model (3) we incorporate measures of trade and financial openness. The coefficients on trade openness, 0.040, and financial openness, 0.002, appear as expected and are significant at the one percent level. The coefficient on old-age dependency rates decreases to 0.001 while there is little change in the coefficient on young-age dependency rates. With the exception of the coefficients on domestic saving rates, which is no longer significant, and government spending, which is negative and significant, at the ten percent level the inclusion of both openness measures largely leave the results unchanged.

Model (4) includes additional demographic control variables. The coefficient on life expectancy appears with the expected sign 0.280 and is significant at the one percent level. Coefficients on primary school enrollments, mortality rates, and birth rates are insignificant. The coefficients on the other key variables remain nearly unchanged. Coefficients on domestic saving rates and old-age dependency rates are now significant at the ten percent level.

Finally, following Lindh and Malmberg (1999) we include decade dummy variables. These results are shown in model (5). The coefficients on the decade dummy variables can be interpreted relative to the 2000-2007 period which was omitted from the regression. The 1970's had significantly higher growth rates than the 2000's. The coefficient on old-age dependency rates is significant at the five percent level and financial openness is no longer significant.

Overall, the inclusion of additional control variables has little affect on the significance and magnitude of the key variables. Across all five models, the coefficients on old and young-age dependency rates, labor force growth rates, population growth rates, income per capita, saving rates, and government consumption largely remain unchanged and retain significance. The coefficient on old-age dependency rates is largest, in absolute value, for model (5). The coefficient of -0.033 suggests a one percent change in old-age dependency rates will reduce GDP growth by 0.033 percentage points. In the big picture, a coefficient of -0.033 may appear relatively small in magnitude, in order for growth rates to fall by one percentage point we would need an increase of 30 percent in the old-age dependency ratio. For comparison, for the United States the current ratio of old-age dependents to the working age population is approximately 19 percent (for every 100 people in the labor force we have 19 people above the age of 65) but with the coming retirement of the baby boomers the old-age dependency rates will increase to nearly 35 percent by 2030 and over 40 percent by 2055. By 2030 the old-age dependency ratio will increase by 84 percent, all else equal, this will imply nearly a three percentage point reduction in GDP growth rates. With such profound and potentially harmful effects on GDP growth it is necessary to better understand how old-age dependency rates affect GDP growth.

4.2 Thresholds in Saving Rates

The baseline model is fairly standard within the growth literature (see Barro and i Martin (2003)). One area the growth literature has not explored is the effects of ageing on GDP growth conditional on a countries level of saving. There has been a large amount of research that emphasizes how a country should adjust their savings rate in response to an ageing population, but this ignores the contemporaneous effects of ageing on growth. For example, it might be advisable for some countries to focus on increasing domestic saving rates, but this could force policymakers into tough decisions. The threshold approach will allow policymakers to fully understand the costs of their decisions. The first extension to the baseline model is to test the relationship of an ageing population on GDP growth rates conditional on a country's current savings rate.[10]

The test statistics for the existence of a single, double, and triple threshold in saving rates are reported in Table 4. We report the likelihood ratio test statistics, the percentiles and savings values for each threshold, number of observations within each regime, p-values for the related test statistics, and the critical values obtained via a bootstrapping procedure.

For the case of a single threshold break, all four models display strong evidence of a threshold and reject the null hypothesis of no threshold at the one percent level. Further, all four models jointly conclude the threshold break occurs at 11th percentile with a savings rate 16.5 percent. The relationship between old-age dependency rates is unique for extremely low saving countries. Given the significance of a single threshold we proceed to estimate a double threshold model.

The results for the double threshold model are also consistent across models. All four models have a test statistic that rejects the null hypothesis at the five or ten percent levels. Similar to the single threshold model, the double threshold model finds a consistent break across all four models. The second threshold occurs at the 59th percentile with a savings rate of approximately 24.2 percent. This threshold occurs slightly above the mean savings rate of 23.5 percent. There are 94 observations in the first regime (lowest saving countries), 383 observations in the second regime (lower saving countries), and 337 countries in the third regime (higher saving countries). Finally, we estimate a triple threshold model and find some evidence of a third threshold in models (1) and (2), but no evidence in the richer models. The third threshold is found at the 67th percentile, which is just outside the minimum number of observations we restricted each regime to contain. This suggests a small number of outliers causing the test statistics to be significant in the first two models.

We proceed under the assumption of two thresholds for all four models. The results for these regressions are presented in Table 5. For the complete model (model 4), Table 6 shows the countries by year for each regime and Table 13 presents the mean values of GDP growth, percent of the population above 65%,

[10] We also tested the relationship conditional on a country's average saving rate over the previous five and ten years. The results are quantitatively similar.

savings, consumption, current account balances, and government consumption by regimes.

The results are rather striking. Across all four models the coefficient on old-age dependency rates for the lowest saving threshold is positive and significant at the one percent level. In other words, an increase in the old-age dependency rates has a positive effect on growth for the lowest saving countries. The coefficient on the old-age dependency rates across all four models ranges from a low of 0.109 to a high of 0.132. The old-age coefficient for the lower saving countries in the second regime is positive but statistically insignificant from zero in models (1) and (2) and negative but statistically insignificant from zero in models (3) and (4). Finally, the old-age coefficient for the highest saving countries ranges from -0.003 and insignificant in model (2) to -0.043 and significant at the one percent level in model (4). The coefficients on the other variables are consistent with the baseline model we presented in Table 3. Additionally, we report the F-test statistics for equality among the coefficients on old-age dependency rates. Across all four models the test statistics reject the null hypothesis of constant coefficients for all three regimes.

We believe the positive coefficient on old-age dependency rates is largely attributed to a country having a larger share of consumption. Further, we suspect these countries also have the ability to borrow abroad. Looking at Table 13 we can see countries with lower saving rates have significantly higher consumption rates and an average current account balance of -5.5 percent of GDP. It is also important to note that the average GDP growth rate for these countries is 1.4 percent which is significantly lower than the average GDP growth rate of 2.6 percent for the higher saving countries. Some countries in the lowest saving regime are Greece (1982-2007), United Kingdom (1972-2007), and United States (1982-1987).

Comparing the coefficients on old-age dependency rates between the second, -0.012, and third, -0.043, regimes suggests a slightly different story. Both regimes have a large number of observations, consumption rates are higher for the lower saving regime but GDP growth is slightly higher for the higher saving regime. For countries in the second regime, those with saving rates between 16.5% and 24.2%, it will take an 83 percent increase in the old-age dependency rates for GDP growth rates to fall by one percentage point. The United States is currently in the second regime and is expecting an 84 percent increase in old-age dependency rates. For the highest saving regime it will only take an increase of 23 percent in the old-age dependency rates to reduce growth by one percentage point.

4.3 Thresholds in Current Account

The next step is to analyze how an increase in old-age dependency rates affects GDP growth conditional on a country's current account balance. Controlling for thresholds in a country's current account balance allows for a better understanding on how access to foreign financial markets will impact the effects of population ageing on growth. Following from Cutler et al (1990), Elmendorf and Sheiner (2000), and Guest (2006) we expect coefficients on old-age dependency rates for countries with current account deficits to be similar to the results found for the low saving countries. Results for the threshold tests are presented in Table 7. All four models reject the null hypothesis of no threshold effect at the one percent level.

The threshold occurs at the 29th percentile with a current account value of -0.014. There are 294 observations in the regime associated with large current account deficits and 520 observations in the regime for countries that run current account surpluses. Similar to saving rates, there is evidence to suggest a second threshold is present. Tests for a second threshold show models (1) and (4) reject the null hypothesis of one threshold at the one and ten percent levels, respectively. Models (2) and (3) fail to reject the null hypothesis. Models (1) and (2) find the second threshold at the 82nd percentile with a value of 0.041, but models (3) and (4) find the second threshold at the 8th percentile with a value of -0.078. To maintain consistency across models we assume there are two threshold effects in a country's current account balance.

Regression results for the double threshold model are presented in Table 8. Unlike the saving threshold regressions, the optimal threshold values are not consistent across models. This makes it difficult to compare across models. In models (1) and (2) the thresholds occur at 29th and 82nd percentiles. There are 294 observations in regime one (current account deficits), 379 observations in regime two (current account balances around zero), and 141 observations in regime three (large current account surpluses). For these models, the coefficient on old-age dependency rates is positive and significant for regimes one and three. In other words, an increase in the old-age dependency rate will have a positive effect on growth rates for countries with a current account deficit larger than -0.014 percent of GDP or a current account surplus in excess of 0.041 percent of GDP.

Because of the differences in the optimal threshold values we cannot compare directly across models. Models (3) and (4) have thresholds at the 8th and 29th percentiles. There are 62 observations in the first regime (large current account deficits), 232 observations in the second regime (moderate current account deficits), and 520 observations in the third regime (current account surpluses). For countries in the first regime the coefficient on old-age dependency rates is positive and significant at the five percent level. The coefficient on old-age is positive but insignificant for the second regime. Finally, the coefficient on old-age dependency rates for the third regime is negative and significant at the one percent level. The F-tests strongly reject the null hypothesis of equality across the coefficients on old-age. Across all four models the additionally explanatory variables appear with the same signs and similar magnitudes as the baseline regressions in Table 3.

It is a fairly safe to assume many of these countries in the first regime also have low saving rates. Looking at Table 13 we can see specifically for model (4) the average saving rate for the first regime is 0.170 compared with 0.255 in the third regime. Despite the large deviation in saving rates and current account balances, growth rates are nearly identical across regimes. Countries with low domestic saving rates have larger current account deficits which shows they have access to foreign capital markets allowing them sustain GDP growth in light of substantial increases in the old-age dependency rates. These countries have lower saving rates which allow them to increase domestic consumption, but more importantly can rely on foreign investment to offset the negative effects on GDP growth rates caused by the decline in worker productivity.

Table 9 displays the countries within each regime. Countries in the first regime (high current account deficits) include Greece (1982-2007), Iceland (2005-2007), and Portugal (1997-2007). Prior to the financial crisis all three countries were able to sustain current account deficits but recently have found foreign financing difficult to obtain. Countries in the second regime include Australia (1997-2007), New Zealand (2004-2007), Spain (2000-2007), United Kingdom (1998-2007), and United States (1983-2007). Prior to the financial crisis all five of these countries had fairly sound finances and access to foreign capital markets. This seems to be especially true for the United States. One reason the effects of ageing on GDP growth may be minimized for the United States dependents on their access to cheap foreign capital. Being able to borrow at low interest rates will allow the United States to increase domestic consumption or fund retirement programs at extremely low costs. Of course, these results hinge on the state of a country's fiscal balances. Recently Greece, Iceland, and Portugal have all needed some form of a bailout following the financial collapse in 2007. Barring a Greek tragedy, the United States should be able to minimize the negative impact associated with a drastic increase in the old-age dependency ratios by maintaining an open channel for foreign investment.

4.4 Thresholds in Trade Openness

After controlling for thresholds in domestic saving rates and current account balances we have shown the coefficient on old-age dependency rates to vary greatly. The coefficient is positive for countries with low saving rates and current account deficits, but negative for countries with a high savings rate and current account surpluses. The next step in our analysis is to analyze how the coefficient changes conditional on measures of trade openness.[11] We expect the coefficient on old-age dependency rates to be negative and larger in absolute value for countries that are relatively closed. Countries that are more open have greater access to financial markets and can resort to foreign investment to maintain higher levels of GDP growth.

The results for the threshold tests are reported in Table 10. For the case of one threshold, all four models strongly reject the null hypothesis of no thresholds. The threshold occurs at the 35th percentile with a value of 0.505. There are 289 observations in the first regime (relative closed countries) and 525 countries in the second regime (relative open countries). We also find evidence of a second threshold. Models (1), and (2) reject the null of a double threshold at the five percent level, while the test statistics for models (3) and (4) lie just outside the ten percent critical value. The second threshold occurs at the 21st percentile with an openness value of 0.420. This suggests the coefficient on old-age dependency rates is unique for closed countries (regime 1), relatively closed countries (regime 2), and relatively more open countries (regime 3). There are 207 observations in the first regime, 112 observations in the second regime, and 525 observations in the third regime.

The regression results for the double threshold model are presented in Table 11. The coefficient on old-age dependency rates for regime one is negative and significant at the five percent level for model (4) and the ten percent level in models (1) and (3). Interestingly, the coefficient is also negative and significant for the second regime. The coefficient is larger in absolute value for the regime

[11] We also tested the model for thresholds in the financial openness measure, there was evidence of one threshold. The results were similar in that more financial closed countries had a negative coefficient on old-age dependency rates.

two. The coefficient in the first regime ranges from -0.005 in model (2) to -0.037 in model (4). The coefficient in the second regime ranges from -0.049 in model (2) and -0.079 in model (4). As expected the coefficient is significantly smaller for the more open countries. The coefficient for the third regime is positive but statistically insignificant from zero in models (1) and (2), the coefficient becomes negative in models (3) and (4) but is statistically insignificant from zero. The F-test for equality across coefficients rejects the hypothesis that the coefficients are equal, although the level of significance falls to ten percent for the coefficients on old-age dependency rates in regimes two and three. It is also worth noting that countries in regimes one and three have similar average GDP growth, savings rate, and current account balances (see table 13).

Countries with a high level of trade openness are both net debtor and creditor countries. Although, the results are consistent with our previous example, we are unable to jointly control for a high level of trade openness and low saving rates and/or a current account deficit. For example, countries in the relatively more open group include countries that were also in the high current account deficit regime: Greece (1997-2007), Portugal (1997-2007), and Iceland (1971-20007) and the low saving regime: Greece (1982-2007) and United Kingdom (1972-2007), while countries in the current account surplus regime are also considered open. Some of these countries include Canada (1979-2007), New Zealand (1974-2007), and many other European countries. Further, many countries are also jointly in the high saving and more open regimes. For a complete list of countries by regime see table 12. Countries in regime one (lowest measures of trade openness) include Australia (1971-2007), Japan (1971-2007), and United States (1971-2007).

Our results show that countries with a low domestic savings rate, moderate current account deficits, and are more open to trade will be more prepared to handle the upcoming shift in population demographics. By no means are we suggesting countries should lower their saving rates, countries with lower saving rates also have significantly lower GDP growth rates. Further, a low domestic savings rate and large current account deficits could result in serious financial repercussion. This is especially true for countries with large levels of government debt.

4.5 Country Cases

The United States has a relatively low domestic savings rate and high current account deficits. In our model we show these factors will allow the United States to sustain a stable growth rate, and perhaps increase GDP growth rates, with the coming retirement of the baby boomer generation. The reasoning is fairly straightforward, countries with a low savings rate are able to sustain a higher level of consumption while being able to borrow from foreign sources. Of course, one needs to account for potential shifts in investor preferences. Three other countries, Greece, Iceland, and Portugal also had high current account deficits, but unfortunately following the financial crisis in 2007 these countries had difficulty retaining foreign capital and ultimately needed emergency lending. In order for the United States to minimize the effects of an ageing population it is imperative for the United States to maintain creditworthiness in the eyes of foreign investors.

With the coming retirement boom countries with a relatively lower savings rate that are more open and have access to foreign capital markets might be best in terms of sustaining GDP growth rates. These countries include France, New Zealand, Spain, and the United Kingdom. France, New Zealand, and Spain appear in the second regime for saving rates (moderate saving), second regime for current account balances (moderate deficit), and third regime for openness (fairly open). The only difference for United Kingdom is that they are in the lowest saving regime. The low savings rate, combine with high foreign investment could potentially position the United Kingdom to sustain current growth rates despite a large increase in old-age dependency rates on the horizon. The ultimate outcome for these countries comes down to the desire for high saving countries to continue financing low saving countries.

5 Conclusion

The effects of an increase in old-age dependency rates will create substantial shifts in GDP growth rates across nearly every OECD country. Understanding the effects of an increase in old-age dependency rates on GDP growth is imperative for policymakers to prepare for the shift. Using a non-dynamic panel threshold effects procedure following Hansen (1999) we isolate the effects of an increase in old-age dependency rates on GDP growth conditional on a country's savings rate, current account balance, and level of trade openness.

As it stands, countries with a moderate current account deficit and lower savings rate are in the best position to absorb the demographic shift as many countries experience a near doubling of their old-age dependency rates. This ultimately leads to a bigger question outside the scope of our paper: Will countries that are currently running a current account surplus shift into deficit countries or will they continue to finance the spending of countries current running large deficits (Australia, United Kingdom, and the United States). This will ultimately determine the effects of an increase in old-age dependency rates on GDP growth rates. Standard economic theory suggests net savers will sell off financial assets and become debtors when labor forces shift into old-age. For countries with a current account deficit the effects of an increase in the old-age dependency rates will depend on their ability to retaining foreign financing and whether creditor countries will continue to finance net debtors. For many of these countries they might be well suited to increase domestic saving and use the saving to offset the loss in productivity under population ageing.

References

Attanasio OP, Picci L, Scorcu AE (2000) Saving, growth, and investment: A macroeconomic analysis using a panel of countries. The Review of Economics and Statistics 82(2):182–211, URL http://www.jstor.org/stable/2646815

Barro RJ (1991) Economic growth in a cross section of countries. The Quarterly Journal of Economics 106(2):407–443, DOI 10.2307/2937943, URL http://qje.oxfordjournals.org/content/106/2/407.abstract, http://qje.oxfordjournals.org/content/106/2/407.full.pdf+html

Barro RJ, i Martin XS (2003) Economic Growth, 2nd Edition, MIT Press Books, vol 1. The MIT Press, URL http://ideas.repec.org/b/mtp/titles/0262025531.html

Bilsborrow RE (1979) Age distribution and savings rates in less developed countries. Economic Development and Cultural Change 28(1):pp. 23–45, URL http://www.jstor.org/stable/1153266

Cervellati M, Sunde U (2011) Life expectancy and economic growth: the role of the demographic transition. Journal of Economic Growth 16:99–133, URL http://dx.doi.org/10.1007/s10887-011-9065-2, 10.1007/s10887-011-9065-2

Cutler DM, Poterba JM, Sheiner LM, Summers LH, Akerlof GA (1990) An aging society: Opportunity or challenge? Brookings Papers on Economic Activity 1990(1):pp. 1–73, URL http://www.jstor.org/stable/2534525

Elmendorf DW, Sheiner LM (2000) Should america save for its old age? fiscal policy, population aging, and national saving. The Journal of Economic Perspectives 14(3):pp. 57–74, URL http://www.jstor.org/stable/2646919

Erlandsen S, Nymoen R (2008) Consumption and population age structure. Journal of Population Economics 21(3):pp. 505–520, URL http://www.jstor.org/stable/40344687

Feldstein M, Horioka C (1980) Domestic saving and international capital flows. The Economic Journal 90(358):314–329, URL http://www.jstor.org/stable/2231790

Flodann M (2003) Public saving and policy coordination in aging economies. The Scandinavian Journal of Economics 105(3):pp. 379–400, URL http://www.jstor.org/stable/3440947

Futagami K, Nakajima T (2001) Population aging and economic growth. Journal of Macroeconomics 23(1):31 – 44, DOI DOI: 10.1016/S0164-0704(01)00153-7, URL http://www.sciencedirect.com/science/article/pii/S0164070401001537

Graham JW (1987) International differences in saving rates and the life cycle hypothesis. European Economic Review 31(8):1509 – 1529, DOI DOI: 10.1016/S0014-2921(87)80024-7, URL http://www.sciencedirect.com/science/article/pii/S0014292187800247

Graham JW (1989) International differences in saving rates and the life cycle hypothesis : Reply and further evidence. European Economic Review 33(7):1499 – 1507, DOI DOI: 10.1016/0014-2921(89)90062-7, URL http://www.sciencedirect.com/science/article/pii/0014292189900627

Guest RS (2006) Population ageing, capital mobility and optimal saving. Journal of Policy Modeling 28(1):89 – 102, DOI DOI: 10.1016/j.jpolmod.2005.05.010, URL http://www.sciencedirect.com/science/article/pii/S0161893805001092

Hansen BE (1999) Threshold effects in non-dynamic panels: Estimation, testing and inference. Journal of Econometrics 93:345–368

Heston A, Summers R, Aten B (2006) Penn world table version 6.2. Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania

Hock H, Weil D (2011) On the dynamics of the age structure, dependency, and consumption. Journal of Population Economics pp 1–25, URL http://dx.doi.org/10.1007/s00148-011-0372-x, 10.1007/s00148-011-0372-x

Horioka CY (1992) Future trends in japan's saving rate and the implications thereof for japan's external imbalance. Japan and the World Economy 3(4):307 – 330, DOI DOI: 10.1016/0922-1425(92)90001-7, URL http://www.sciencedirect.com/science/article/pii/0922142592900017

Kelley AC, Schmidt RM (1996) Saving, dependency and development. Journal of Population Economics 9(4):pp. 365–386, URL http://www.jstor.org/stable/20007516

Lane PR, Milesi-Ferretti GM (2007) The external wealth of nations mark ii: Revised and extended estimates of foreign assets and liabilities, 1970-2004. Journal of International Economics 73(2):223–250

Leff NH (1969) Dependency rates and savings rates. The American Economic Review 59(5):pp. 886–896, URL http://www.jstor.org/stable/1810683

Li H, Zhang J, Zhang J (2007) Effects of longevity and dependency rates on saving and growth: Evidence from a panel of cross countries. Journal of Development Economics 84(1):138 – 154, DOI DOI: 10.1016/j.jdeveco.2006.10.002, URL http://www.sciencedirect.com/science/article/pii/S0304387806001817

Lindh T (1999) Age structure and economic policy: The case of saving and growth. Population Research and Policy Review 18:261–277, URL http://dx.doi.org/10.1023/A:1006123514049, 10.1023/A:1006123514049

Lindh T, Malmberg B (1999) Age structure effects and growth in the oecd, 19501990. Journal of Population Economics 12:431–449, URL http://dx.doi.org/10.1007/s001480050107, 10.1007/s001480050107

Masson PR, Bayoumi T, Samiei H (1998) International evidence on the determinants of private saving. The World Bank Economic Review 12(3):483–501, DOI 10.1093/wber/12.3.483, URL http://wber.oxfordjournals.org/content/12/3/483.abstract, http://wber.oxfordjournals.org/content/12/3/483.full.pdf+html

Modigliani F (1970) The life cycle hypothesis of saving and intercountry differences in the saving ratio. in (W Eltis, M Scott and J Wolfe, eds) Induction, Growth and Trade, Essays in Honor of Sir Roy Harrod pp 197–225

Modigliani F, Sterling A (1983) Determinants of private saving with special reference to the role of social security - cross country tests. in Modigliani F and Hemming, R (Eds), The Determinants of National Saving and Wealth pp 24–55

Ram R (1982) Dependency rates and aggregate savings: A new international cross-section study. The American Economic Review 72(3):pp. 537–544, URL http://www.jstor.org/stable/1831554

Weil DN (1994) The saving of the elderly in micro and macro data. The Quarterly Journal of Economics 109(1):55–81, DOI 10.2307/2118428, URL http://qje.oxfordjournals.org/content/109/1/55.abstract, http://qje.oxfordjournals.org/content/109/1/55.full.pdf+html

Zhang J, Zhang J (2004) How does social security affect economic growth? evidence from cross-country data. Journal of Population Economics 17(3):pp. 473–500, URL http://www.jstor.org/stable/20007922

Table 1 Data Sources

Variable	Data Sources	Calculation
GDP Growth Rates (per capita)	Penn World Table 7.0	Levels
Age 15-64 as a % of Total Population	World Development Indicators	$log(age_{working})_{it}$
Age 65+ as a % of Working Age Population	World Development Indicators	$log(age_{old})_{it}$
Age 0-14 as a % of Working Age Population	World Development Indicators	$log(age_{young})_{it}$
Labor Force Growth	Penn World Table 7.0	$log(1 + labor\ force\ growth)_{it}$
Income per capita	Penn World Table 7.0	$log(per\ capita\ income)_{i,t-1}$
Population growth	Penn World Table 7.0	$log(1 + population\ growth)_{it}$
Government Spending % of GDP	Penn World Table 7.0	$log(G/Y)_{i,t-1}$
National Saving % of GDP	Penn World Table 7.0	$log(S/Y)_{i,t-1}$
Trade Openness	Penn World Table 7.0	$(Exports_{it} + Imports_{it})/GDP_{it}$
Financial Openness	Lane and Milesi-Ferretti (2007)	$(Total\ Assets_{it} + Total\ Liabilities_{it})/GDP_{it}$
Life Expectancy at birth (male and female)	World Development Indicators	$log(life\ expectancy)$
Primary School Enrollment	World Development Indicators	Levels
Mortality Rate below age five	World Development Indicators	Levels
Birth Rate	World Development Indicators	Levels

Table 2 Summary Statistics

Variable	Mean	Std Dev	Minimum	p10	p25	Median	p75	p90	Maximum
GDP Growth Rates	0.021	0.022	-0.086	-0.005	0.011	0.022	0.034	0.046	0.107
$log(age_{working})$	4.184	0.035	4.054	4.138	4.164	4.188	4.212	4.224	4.247
$log(age_{old})$	2.586	0.196	1.970	2.318	2.444	2.615	2.733	2.819	3.040
$log(age_{young})$	3.018	0.183	2.607	2.780	2.888	3.012	3.143	3.265	3.462
$log(1 + labor\ force\ growth)$	0.011	0.016	-0.057	-0.003	0.004	0.009	0.017	0.027	0.200
$log(per\ capita\ income)$	9.802	0.415	8.503	9.215	9.534	9.839	10.098	10.335	10.643
$log(1 + population\ growth)$	0.006	0.006	-0.047	0.001	0.003	0.005	0.010	0.013	0.037
$log(S/Y)$	3.124	0.264	1.952	2.773	2.986	3.145	3.296	3.464	3.764
$log(G/Y)$	2.218	0.266	1.180	1.794	2.136	2.251	2.364	2.456	2.864
$(Exports + Imports)/GDP$	0.634	0.299	0.113	0.287	0.444	0.584	0.738	1.049	1.843
Financial Openness	2.091	2.563	0.184	0.459	0.699	1.262	2.380	4.166	25.731
$log(life\ expectancy)$	4.331	0.035	4.215	4.282	4.306	4.332	4.357	4.376	4.413
Primary School Enrollment	1.025	0.064	0.813	0.973	0.993	1.017	1.051	1.096	1.274
Mortality Rate below age five	0.088	0.056	0.019	0.039	0.051	0.073	0.108	0.157	0.511
Birth Rate	0.132	0.028	0.082	0.099	0.113	0.127	0.148	0.168	0.227

Data set includes 22 countries from 1971-2007

All variables have 814 observations with the exception of enrollment rates.

Enrollment rates for Germany are from 1990-2007

Table 3 Regression Results - Baseline Models

	Model 1	Model 2	Model 3	Model 4	Model 5
$log(age_{working})_{it}$	0.097				
	(2.255)				
$log(age_{old})_{it}$		-0.016	-0.001	-0.027	-0.033
		(1.348)	(0.105)	(1.849)	(2.123)
$log(age_{young})_{it}$		-0.039	-0.033	-0.043	-0.052
		(2.518)	(2.173)	(2.299)	(2.748)
$log(1 + labor\ force\ growth)_{it}$	0.221	0.220	0.179	0.179	0.174
	(2.564)	(2.555)	(2.292)	(2.228)	(2.188)
$log(per\ capita\ income)_{i,t-1}$	-0.023	-0.029	-0.054	-0.067	-0.057
	(4.553)	(4.127)	(6.245)	(6.029)	(4.551)
$log(1 + population\ growth)_{it}$	-0.965	-0.962	-1.038	-1.038	-1.135
	(2.883)	(2.777)	(2.858)	(2.396)	(2.564)
$log(S/Y)_{i,t-1}$	0.021	0.023	0.014	0.018	0.016
	(2.152)	(2.384)	(1.478)	(1.819)	(1.564)
$log(G/Y)_{i,t-1}$	-0.018	-0.020	-0.025	-0.020	-0.017
	(1.419)	(1.519)	(1.952)	(1.673)	(1.432)
$Trade\ Openness_{it}$			0.040	0.036	0.043
			(3.664)	(3.298)	(3.777)
$Financial\ Openness_{it}$			0.002	0.001	0.001
			(2.597)	(1.513)	(0.906)
$log(life\ expectancy)_{it}$				0.280	0.404
				(3.082)	(3.909)
$Primary\ School\ Enrollment_{it}$				-0.008	-0.005
				(0.395)	(0.244)
$Mortality\ Rate\ below\ age\ five_{it}$				0.101	0.106
				(1.634)	(1.671)
$Birth\ Rate_{it}$				-0.087	-0.044
				(0.941)	(0.467)
$Dummy_{1970-1979}$					0.018
					(2.655)
$Dummy_{1980-1989}$					0.008
					(1.591)
$Dummy_{1990-1999}$					0.006
					(2.064)
$Constant$	-0.181	0.441	0.642	-0.356	-0.969
	(1.201)	(3.408)	(4.586)	(0.998)	(2.118)
N	814	814	814	814	814
R^2	0.0945	0.0969	0.1399	0.1587	0.1714

White standard errors are calculated, absolute t-values in parentheses

Table 4 Threshold Test Results - Saving Rates

	Model 1	Model 2	Model 3	Model 4
	Tests for a single threshold			
F_1	29.7	34.6	47.0	43.9
Percentile	11.7	11.7	11.7	11.7
Value	0.165	0.165	0.165	0.165
N_1, N_2	94, 720	94, 720	94, 720	94, 720
P-value	0.000	0.001	0.000	0.001
10%, 5%, 1%	5.4,7.4, 12.9	6.5, 9.4, 18.9	6.5, 8.9, 15.9	8.5, 12.7, 22.3
	Tests for a double threshold			
F_2	3.8	4.8	7.3	6.3,
Percentile	59.0	59.1	58.7	58.7
Value	0.243	0.244	0.242	0.242
N_1, N_2, N_3	94, 385, 335	94, 386, 334	94, 383, 337	94, 383, 337
P-value	0.063	0.078	0.066	0.095
10%, 5%, 1%	3.2, 4.3, 7.7	4.2, 6.0, 11.2	5.4, 8.9, 16.1	6.1, 9.2, 15.2
	Tests for a Triple threshold			
F_2	6.5	6.4	2.1	2.7
Percentile	67.8	67.8	67.8	67.8
Value	0.255	0.255	0.255	0.255
N_1, N_2, N_3, N_4	94, 385, 72, 263	94, 386, 71, 263	94, 383, 74, 263	94, 383, 74, 263
P-value	0.033	0.030	0.269	0.247
10%, 5%, 1%	3.6, 5.3, 10.9	3.7, 5.4, 9.8	4.8, 7.1, 14.7	5.8, 8.0, 16.5

600 bootstrap replications were used for each test

π is selected to be 0.075.

Table 5 Regression Results - Threshold Saving Rates

	Model 1	Model 2	Model 3	Model 4
$log(age_{old})_{it}I(s_{it} < \gamma_1)$	0.109	0.132	0.126	0.117
	(4.316)	(5.284)	(4.832)	(4.328)
$log(age_{old})_{it}I(\gamma_1 < s_{it} \leq \gamma_2)$	0.007	0.024	-0.005	-0.012
	(0.425)	(1.522)	(0.263)	(0.658)
$log(age_{old})_{it}I(\gamma_2 < s_{it})$	-0.018	-0.003	-0.038	-0.043
	(1.439)	(0.233)	(2.546)	(2.840)
$log(age_{young})_{it}$	-0.014	-0.004	-0.023	-0.029
	(0.929)	(0.295)	(1.333)	(1.654)
$log(1 + labor\ force\ growth)_{it}$	0.243	0.202	0.198	0.200
	(4.979)	(4.210)	(4.109)	(4.149)
$log(per\ capita\ income)_{i,t-1}$	-0.022	-0.047	-0.052	-0.050
	(3.220)	(5.734)	(5.196)	(4.874)
$log(1 + population\ growth)_{it}$	-0.789	-0.812	-0.697	-0.772
	(3.892)	(3.820)	(2.864)	(3.125)
$log(S/Y)_{i,t-1}$	0.021	0.012	0.014	0.012
	(3.575)	(2.028)	(2.250)	(2.052)
$log(G/Y)_{i,t-1}$	-0.014	-0.018	-0.009	-0.006
	(1.459)	(1.877)	(0.932)	(0.630)
$(Exports_{it} + Imports_{it})/GDP_{it}$		0.046	0.044	0.046
		(4.715)	(4.397)	(4.510)
$Financial\ Openness$		1.27E-03	2.94E-04	1.23E-04
		(2.117)	(0.453)	(0.184)
$log(life\ expectancy)_{it}$			3.70E-03	3.76E-03
			(3.699)	(3.738)
$Primary\ School\ Enrollment(t)$			0.008	0.009
			(0.379)	(0.418)
$Mortality\ Rate\ below\ age\ five(t)$			0.185	0.180
			(4.684)	(4.489)
$Birth\ Rate(t)$			-0.180	-0.170
			(2.388)	(2.250)
$Dummy_{1970-1979}$				-0.002
				(1.104)
$Dummy_{1980-1989}$				0.002
				(1.241)
$Dummy_{1990-1999}$				0.000
				(0.004)
N	814	814	814	814
R^2	0.1336	0.1800	0.2115	0.2148
$F_{test}\ \beta_0 = \beta_1$	20.55***	23.51***	33.23***	31.46***
$F_{test}\ \beta_1 = \beta_2$	3.77*	4.69**	6.99***	6.02**
$F_{test}\ \beta_0 = \beta_2$	32.90***	38.45***	51.93***	47.91***

White standard errors are calculated, absolute t-values in parentheses
*, **, *** denote significance at the 10%, 5%, and 1% levels, respectively

Table 6 Countries and Years by Saving Regimes

Regime 1 - $\beta_0 = 0.117$		Regime 2 - $\beta_1 = -0.012$		Regime 3 - $\beta_2 = -0.043$	
Country	Year	Country	Year	Country	Year
Denmark	1980-1981	Australia	1974-2001	Australia	1971-1973
Greece	1982-2007	Austria	1975-1998	Austria	1971-1974, 1999-2007
Ireland	1974-1976	Belgium	1977-1987	Belgium	1971-2007
New Zealand	1974-1981	Canada	1971-1998	Canada	1999-2007
Portugal	1974-1985	Denmark	1971-1979. 1982-1988	Denmark	1989-2007
Sweden	1981-1982	Finland	1991-1994	Finland	1971-1990, 1995-2007
United Kingdom	1972-2007	France	1971-2007	France	1971-1973
United States	1982-1987	Germany	1974-2005	Germany	1971-1973, 2006-2007
		Greece	1977-1981	Greece	1971-1976
		Iceland	1991-2000	Iceland	1971-1990, 2001-2007
		Ireland	1971-1973, 1977-1987	Ireland	1988-2007
		Italy	1980-1993	Italy	1971-1979, 1994-2007
		Netherlands	1975-1994	Japan	1971-2007
		New Zealand	1971-1973, 1982-2007	Netherlands	1971-1974, 1995-2007
		Portugal	1986-2007	Norway	1971-2007
		Spain	1975-1998, 2004-2007	Portugal	1971-1973
		Sweden	1971-1980, 1983-1999	Spain	1971-1974, 1999-2003
		United States	1971-1981, 1988-2007	Sweden	2000-2007
		Portugal	1971-1973	Switzerland	1971-2007

Table 7 Threshold Test Results - Current Account

	Model 1	Model 2	Model 3	Model 4
		Tests for a single threshold		
F_1	10.4	20.1	28.1	23.8
Percentile	29.2	29.2	29.2	29.2
Value	-0.014	-0.014	-0.014	-0.014
N_1, N_2	294, 520	294, 520	294, 520	294, 520
P-value	0.006	0.004	0.000	0.002
10%, 5%, 1%	3.9, 5.5, 8.9	4.1, 5.8, 11.4	4.9, 7.5, 13.8	5.9, 8.3, 14.6
		Tests for a double threshold		
F_2	12.7	2.7	6.2	7.8
Percentile	82.8	82.5	7.7	7.7
Value	0.041	0.041	-0.078	-0.078
N_1, N_2, N_3	294, 379, 141	294, 377, 143	62, 232, 520	62, 232, 520
P-value	0.000	0.133	0.119	0.088
10%, 5%, 1%	2.6, 3.8, 7.0	3.3, 4.8, 8.2	7.1, 11.2, 23.6	7.5, 11.3, 26.7
		Tests for a Triple threshold		
F_2	2.7	5.3	2.1	2.2
Percentile	70.7	70.7	82.5	82.5
Value	0.021	0.021	0.041	0.041
N_1, N_2, N_3, N_4	294, 281, 98, 141	294, 281, 98, 141	62, 232, 377, 143	62, 232, 377, 143
P-value	0.133	0.058	0.285	0.293
10%, 5%, 1%	3.3, 4.5, 9.6	4.0, 5.6, 8.8	4.9, 7.5, 13.9	6.2, 9.6, 18.2

1000 bootstrap replications were used for each test

π is selected to be 0.10.

Table 8 Regression Results - Threshold Current Account Balance

	Model 1	Model 2	Model 3	Model 4
$log(age_{old})_{it}I(ca_{it} < \gamma_1)$	0.018	0.047	0.064	0.059
	(1.104)	(2.804)	(2.717)	(2.321)
$log(age_{old})_{it}I(\gamma_1 < ca_{it} \leq \gamma_2)$	-0.030	-0.010	0.014	0.010
	(2.432)	(0.836)	(0.729)	(0.512)
$log(age_{old})_{it}I(\gamma_2 < ca_{it})$	0.043	0.024	-0.039	-0.042
	(1.999)	(1.134)	(2.590)	(2.748)
$log(age_{young})_{i,t-1}$	-0.032	-0.019	-0.036	-0.038
	(2.185)	(1.352)	(2.128)	(2.133)
$log(1 + labor\ force\ growth)_{it}$	0.209	0.170	0.172	0.177
	(4.273)	(3.531)	(3.532)	(3.633)
$log(per\ capita\ income)_{i,t-1}$	-0.031	-0.056	-0.063	-0.064
	(4.428)	(6.787)	(6.359)	(6.249)
$log(1 + population\ growth)_{it}$	-0.958	-1.039	-1.016	-1.066
	(4.772)	(4.965)	(4.165)	(4.301)
$log(S/Y)_{i,t-1}$	0.021	0.013	0.015	0.014
	(3.714)	(2.236)	(2.571)	(2.377)
$log(G/Y)_{i,t-1}$	-0.024	-0.031	-0.026	-0.023
	(2.405)	(3.202)	(2.565)	(2.225)
$(Exports_{it} + Imports_{it})/GDP_{it}$		0.041	0.045	0.048
		(4.085)	(4.411)	(4.575)
$Financial\ Openness$		1.60E-03	5.69E-04	5.94E-04
		(2.656)	(0.863)	(0.876)
$log(life\ expectancy)_{it}$			4.24E-03	4.17E-03
			(4.151)	(4.059)
$Primary\ School\ Enrollment(t)$			0.007	0.005
			(0.312)	(0.209)
$Mortality\ Rate\ below\ age\ five(t)$			0.186	0.186
			(4.475)	(4.341)
$Birth\ Rate(t)$			-0.096	-0.096
			(1.277)	(1.269)
$Dummy_{1970-1979}$				0.000
				(0.071)
$Dummy_{1980-1989}$				0.002
				(1.514)
$Dummy_{1990-1999}$				-0.001
				(0.805)
N	814	814	814	814
R^2	0.1225	0.1632	0.1913	0.1946
$F_{test}\ \beta_0 = \beta_1$	15.04***	21.77***	5.93**	5.38**
$F_{test}\ \beta_0 = \beta_2$	12.60***	2.70	14.83***	13.97***
$F_{test}\ \beta_1 = \beta_2$	1.30	1.00	26.22***	22.88***

White standard errors are calculated, absolute t-values in parentheses
*, **, *** denote significance at the 10%, 5%, and 1% levels, respectively

Table 9 Countries and Years by Current Account Regimes

Regime 1 - $\beta_0 = 0.059$		Regime 2 - $\beta_1 = 0.010$		Regime 3 - $\beta_2 = -0.042$	
Country	Year	Country	Year	Country	Year
Greece	1971-1974, 1982-2007	Australia	1977-1989, 1998-2007	Australia	1971-1976, 1990-1997
Iceland	1974-1975, 2005-2007	Austria	1976-1981	Austria	1971-1975, 1982-2007
Ireland	1974-1981	Belgium	1977-1982	Belgium	1971-1976, 1983-2007
Norway	1976-1977	Denmark	1971-1980	Canada	1971-2007
Portugal	1974-1983, 1997-2007	Finland	1971-1976, 1989-1990	Denmark	1981-2007
		France	1974-1976, 1980-1991, 2005-2007	Finland	1971-1984, 1977-1988, 1991-2007
		Germany	1971-1985	France	1971-1973, 1977-1979, 1992-2004
		Greece	1975-1981	Germany	1986-2007
		Iceland	1971-1973, 1981-1982, 1998-2004	Iceland	1976-1980, 1983-1997
		Ireland	1971-1973, 1982-1984	Ireland	1985-2007
		Italy	1973-1976, 1980-1982	Italy	1971-1972, 1977-1979, 1983-2007
		Japan	1979-1980	Japan	1971-1978, 1981-2007
		New Zealand	1975-1985, 2004-2007	Netherlands	1971-2007
		Norway	1971-1975, 1986-1987	New Zealand	1971-1974, 1986-2003
		Portugal	1971-1973, 1984-1996	Norway	1976-1985, 1988-2007
		Spain	1974-1982, 1988-1992, 2000-2007	Spain	1971-1973, 1983-1987, 1993-1999
		Sweden	1976-1977	Sweden	1971-1975, 1978-2007
		United Kingdom	1973-1976, 1986-1993, 1998-2007	Switzerland	1971-2007
		United States	1977-1979, 1983-2007	United Kingdom	1971-1972, 1977-1985, 1994-1997
				United States	1971-1976, 1980-1982

Table 10 Threshold Test Results - Trade Openness

	Model 1	Model 2	Model 3	Model 4
		Tests for a single threshold		
F_1	17.1	9.8	8.7	9.5
Percentile	35.6	35.6	35.6	35.6
Value	0.505	0.505	0.505	0.505
N_1, N_2	289, 525	289, 525	289, 525	289, 525
P-value	0.001	0.018	0.043	0.046
10%, 5%, 1%	3.3, 4.8, 9.6	4.3, 6.0, 11.1	5.5, 7.9, 13.5	6.3, 9.2, 18.2
		Tests for a double threshold		
F_2	6.0	6.8	5.2	5.8
Percentile	21.8	21.8	25.5	21.8
Value	0.420	0.420	0.448	0.420
N_1, N_2, N_3	177, 112, 525	177, 112, 525	207, 82, 525	177, 112, 525
P-value	0.053	0.051	0.113	0.117
10%, 5%, 1%	3.8, 6.1, 12.5	4.5, 7.0, 17.2	5.6, 8.0, 13.7	6.5, 9.6, 17.9
		Tests for a Triple threshold		
F_2	6.1	5.0	4.9	4.3
Percentile	7.7	7.7	49.1	49.1
Value	0.260	0.260	58.2	0.579
N_1, N_2, N_3, N_4	62, 115, 112, 525	62, 115, 112, 525	207, 82, 113, 412	177, 112, 110, 415
P-value	0.051	0.078	0.126	0.185
10%, 5%, 1%	4.1, 6.2, 12.0	4.1, 6.4, 12.8	5.7, 8.4, 17.4	6.7, 10.2, 21.1

1000 bootstrap replications were used for each test

π is selected to be 0.10.

Table 11 Regression Results - Threshold Trade Openness

	Model 1	Model 2	Model 3	Model 4
$log(age_{old})_{it}I(open_{it} < \gamma_1)$	-0.022	-0.005	-0.029	-0.037
	-(1.751)	-(0.391)	-(1.831)	-(2.319)
$log(age_{old})_{it}I(\gamma_1 < open_{it} \leq \gamma_2)$	-0.064	-0.049	-0.072	-0.079
	-(3.400)	-(2.606)	-(3.232)	-(3.702)
$log(age_{old})_{it}I(\gamma_2 < open_{it})$	0.015	0.020	-0.004	-0.013
	(1.008)	(1.350)	-(0.214)	-(0.693)
$log(age_{young})_{i,t-1}$	-0.037	-0.033	-0.040	-0.050
	-(2.604)	-(2.337)	-(2.329)	-(2.843)
$log(1 + labor\ force\ growth)_{it}$	0.231	0.190	0.190	0.195
	(4.711)	(3.905)	(3.848)	(3.952)
$log(per\ capita\ income)_{i,t-1}$	-0.030	-0.053	-0.064	-0.066
	-(4.397)	-(6.489)	-(6.310)	-(6.300)
$log(1 + population\ growth)_{it}$	-1.113	-1.149	-1.077	-1.207
	-(5.471)	-(5.399)	-(4.396)	-(4.897)
$log(S/Y)_{i,t-1}$	0.021	0.014	0.017	0.016
	(3.636)	(2.427)	(2.815)	(2.645)
$log(G/Y)_{i,t-1}$	-0.023	-0.027	-0.022	-0.019
	-(2.382)	-(2.808)	-(2.166)	-(1.889)
$(Exports_{it} + Imports_{it})/GDP_{it}$		0.036	0.032	0.033
		(3.630)	(3.113)	(3.180)
$Financial\ Openness$		1.43E-03	9.60E-04	7.82E-04
		(2.368)	(1.465)	(1.155)
$log(life\ expectancy)_{it}$			3.12E-03	3.03E-03
			(3.015)	(2.909)
$Primary\ School\ Enrollment(t)$			-0.004	-0.002
			-(0.172)	-(0.097)
$Mortality\ Rate\ below\ age\ five(t)$			0.090	0.074
			(2.288)	(1.845)
$Birth\ Rate(t)$			-0.099	-0.095
			-(1.294)	-(1.231)
$Dummy_{1970-1979}$				-0.001
				-(0.426)
$Dummy_{1980-1989}$				0.004
				(2.693)
$Dummy_{1990-1999}$				0.001
				(0.783)
N	814	814	814	814
R^2	0.1225	0.1568	0.1715	0.1805
$F_{test}\ \beta_0 = \beta_1$	5.90**	6.75***	4.93**	5.52**
$F_{test}\ \beta_0 = \beta_2$	21.05***	16.28***	12.58***	14.34***
$F_{test}\ \beta_1 = \beta_2$	8.85***	3.90**	3.65*	3.25*

White standard errors are calculated, absolute t-values in parentheses
*, **, *** denote significance at the 10%, 5%, and 1% levels, respectively

Table 12 Countries and Years by Trade Openness Regimes

Regime 1 - $\beta_0 = -0.037$		Regime 2 - $\beta_1 = -0.079$		Regime 3 - $\beta_2 = -0.013$	
Country	Year	Country	Year	Country	Year
Australia	1971-2007	Canada	1971-1978	Austria	1971-2007
France	1971-1979, 1986-1987	Finland	1971-1973, 1988-1991	Belgium	1971-2007
Germany	1971-1979	France	1980-1985, 1988-1999	Canada	1979-2007
Greece	1971-1980	Germany	1980-1996	Denmark	1971-2007
Italy	1971-1975, 1986-1993	Greece	1981-1998	Finland	1974-1987, 1992-2007
Japan	1971-2007	Italy	1976-1985, 1994-2004	France	2000-2007
Spain	1971-1994	New Zealand	1971-1973	Germany	1997-2007
United States	1971-2007	Portugal	1971-1978	Greece	1999-2007
		Spain	1995-1996	Iceland	1971-2007
		Sweden	1971-1972	Ireland	1971-2007
		United Kingdom	1971-1973, 1981-1982, 1990-1993	Italy	2005-2007
				Netherlands	1971-2007
				New Zealand	1974-2007
				Norway	1971-2007
				Portugal	1979-2007
				Spain	1997-2007
				Sweden	1973-2007
				Switzerland	1971-2007
				United Kingdom	1974-1980, 1983-1989, 1990-2007

Table 13 Summary Statistics by Threshold Regime

Threshold	Regime	N	β	Pop. over 65	Growth	S/GDP	CA/GDP	$Open$	C/GDP	G/GDP
Entire Sample		792	-0.033	13.5%	0.021	0.235	0.002	0.634	0.670	0.095
	1	94	0.117	13.9%	0.014	0.140	-0.055	0.546	0.767	0.092
Saving Rates	2	383	-0.012	13.2%	0.019	0.210	-0.008	0.562	0.690	0.100
	3	337	-0.043	13.7%	0.026	0.291	0.030	0.739	0.619	0.090
	1	62	0.058	13.5%	0.022	0.170	-0.105	0.612	0.752	0.079
Current Account	2	232	0.010	12.9%	0.023	0.208	-0.030	0.513	0.700	0.091
	3	520	-0.042	13.8%	0.021	0.255	0.029	0.690	0.647	0.098
	1	177	-0.037	12.2%	0.022	0.238	-0.010	0.297	0.671	0.091
Openness	2	112	-0.079	13.6%	0.019	0.196	-0.018	0.465	0.705	0.099
	3	525	-0.013	13.9%	0.022	0.243	0.011	0.783	0.662	0.095

Summary statistics are reports corresponding to model 4.