Black holes and Revelations
Demography and the Net International Investment Position

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Abstract

This purpose of this paper is to explain the long and short run development of the Net International Investment Position (NIIP) using age structure data. Following the financial globalization, the development of the NIIP has diverged from the path of accumulated current account flows. A subsequent consequence is that despite sustained current account surpluses, NIIPs of small developed countries remain small or negative. The situations are referred to as so-called “black holes”. The reason for this development seems to be valuation which has gained importance for the determination of the NIIP at the expense of the current account. Valuation consists of (i) asset prices and (ii) real exchange rates. In this paper, demography is argued to be a determinant of assets prices, real exchange rates and the current account and hence an underlying factor with negative effects on the NIIP. Contrary to theory and previous research this paper finds a positive long-run relationship between the NIIP and population ageing in small developed countries and non-OECD countries. An annual adjustment mechanism of 12 percent is identified for small developed countries and of 27 percent for non-OECD countries.

Keywords:
NIIP, Valuation Channels, Demography, Panel Cointegration
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Introduction

The Net International Investment Position (NIIP) has gained interest among economists during the last two decades when NIIPs of developed countries have diverged from their expected path given past current account positions. This new development of NIIPs has given rise to the puzzle of “dark matter” and “black holes”. The puzzle entails that despite a sustained current account deficit in the US the American NIIP remains stable while the Netherlands who pursue a government policy to build up a strong NIIP in anticipation of a future demographic burden are failing to do so. Regardless of successive Dutch current account surpluses their NIIP remains small. The two NIIPs are referred to as the American “dark matter” and the Dutch “black hole”. Other developed countries share the experience. The NIIP of large countries tend to behave as black matter while the NIIPs of small developed countries such as Finland and Sweden are black holes, i.e. running current account surpluses to different degrees without accumulating large NIIPs (Blomberg & Falk, 2006).

The NIIP is the net value of a country’s foreign assets and debts at a point in time. It represents the sum of all past current account flows, valuation effects and errors and omissions. Accumulated current account flows are direct influences on the NIIP. Valuation changes affect the value the gross stocks of foreign assets and debts indirectly.

\[ \Delta NIIP_t = CA_t + \text{valuation effects + errors and omissions} \]

The answer to the question of black holes and dark matter seems to be valuation which has gained importance due to the fact that gross international capital flows and cross-border claims now dwarf the net position. As a consequence, the volatility of the gross positions increasingly impacts the net position.

Valuation depends on (i) the prices of assets and liabilities that the NIIP consists of and (ii) real exchange rate fluctuations between the unit of account of the Balance
of Payments (BoP) and the currencies claims are made out of. In this paper the unit of account of the BoP is assumed to be the domestic currency.

Demographic age structure is an important determinant of the current account, asset prices and real exchange rates. When linking together research of economic effects of demographic age structure with the research of the NIIP one can conclude that ageing populations in itself should have adverse effects on the NIIP. The most obvious link goes through the current account. In addition indirect adverse effect of prices and exchange rates may undermine a policy such as that of the Netherlands and create black holes.

In this paper arguments for age structure being an underlying factor for the current account as well as valuation changes are presented. The conclusion is that age structure data can be used to explain past developments and serve to reveal the future paths of the NIIP. The relationship between the dependency rate, i.e. the ratio of the non-working population to the working population, and the NIIP is suggested to be negative with the largest effects for small developed countries.

The aspect of demography has not sufficiently been brought to attention in the previous literature of the NIIP. In exploring the relationship of demography and the NIIP this paper joins together the strands of literature treating determinants of the NIIP and the role of demography for the current account, asset prices and for real exchange rates. By acknowledging that the link between the NIIP and age structure is threefold and by estimating this link using modern panel data methods this paper contributes to the body of literature. The data set used comprises of 177 countries over 42 years.

The following research questions are posed:

1. Can black holes be explained by population ageing?
2. Is the correlation between demography and the NIIP different for developed and developing countries?
Formal definition

The NIIP shows the net external assets and liabilities of a country at a given point in time. The unit of account is the domestic currency. This section presents the formal definitions of the NIIP and the relevant parts of the Balance of Payments (BoP) following the standards set out by the International Monetary Fund (IMF) (2007).

The external financial assets of an economy are defined as gold and monetary reserves, Special Drawing Rights (SDR) held by the monetary authority and claims on nonresidents. Claims include foreign bonds, stocks, loans and Foreign Direct Investment (FDI) abroad. SDRs are created by the IMF and can be exchanged for the currency of any IMF member country when the authorities holding them so wish. Liabilities are similarly defined as claims of foreigners on the domestic economy.

The difference between the gross positions, i.e. the stock of assets and the stock of liabilities, make out the NIIP. The position is negative when liabilities exceed claims and positive when claims exceed liabilities. The NIIP should not be confused with the net worth of the economy since non-financial assets are not included. Usually the value of non-financial assets exceed the value of all financial assets combined.

The current account is the component of the BoP of largest importance to the NIIP. Trade surpluses and investment incomes, i.e. yields on financial assets abroad, are registered on the current account. If the gross stocks of assets are very large, investment incomes accrued from the positions will be large too. The second component of importance for the NIIP is the capital account where financial transactions such as foreign aid are registered. However, the capital account is of negligible size.

A current account surplus must be followed by an outflow of financial capital or an increase in the foreign exchange reserve. Both cases result in an increase of the
NIIP. In parallel, a current account deficit leads to financial inflows causing the NIIP to deteriorate. The flow arising from the current account position is registered on the financial account\(^1\). The financial account is, in absence of errors and omissions, equal to the current account but with opposite signs.

Other factors affecting the NIIP are changes in the stocks of SDRs, monetization or demonetization of gold, write-offs and declassifications although they can all be considered quantitatively insignificant.

Only changes in gross claims and no valuation changes through either price or exchange rate channels are registered on the BoP.

\(^1\)The reader should note that the official BoP accounting system set by the IMF changed the name of the capital account to financial account in 1997. Some literature still refers to the financial account as the capital account confusing the structure of the BoP. In this study I use the current terminology used by the IMF.
**Theoretical background**

The economic theory which underpins the role of demography and domestic savings is primarily formulated in the Life Cycle Hypothesis (LCH) of consumption and saving. The ensuing effects on the international economy are commonly formalized in the so-called overlapping generations (OLG) model.

Fisher (1930) first established the notion of individuals who maximize life-time utility by choosing between consumption in the present and the future. Modigliani and Brumberg (1954; 1980) used this to formulate how individuals make decisions about consumption and saving at different phases of life and founded the LCH. The LCH implies that private aggregate savings are determined by the relative sizes of the age cohorts currently at different phases of the life cycle and in particular the share of dependents, i.e. non-working, in the economy. The young and retired are suggested to have negative savings rates and the working population should have positive savings rate. Consequently the ratio of dependents is negatively correlated with savings according to the LCH.

Fisher (1930) also laid the foundation for the OLG model which was later modified by Samuelson (1958) and Diamond (1965). The NIIP functions as the intertemporal budget constraint in the model meaning that the present value of all future current account positions must be equal to the NIIP. Hence the NIIP limits the possibilities to save or consume in the economy. The OLG model uses the LCH by allowing different savings pattern for different generations. An outflow of goods occurs when savings exceed the need for investment. Export registers as a surplus on the current account. Conversely, the current account shows a deficit when the savings rate is low and capital flows in. Hence the relationship between savings and the NIIP is positive.

For the purposes of this paper, the important notion from the LCH and OLG model is that the dependency rate is negatively correlated with the NIIP through savings rates and the current account.
The standard OLG model does not incorporate valuation changes to the NIIP but there are examples of more sophisticated models that have been developed recently. Gourinchas and Rey (2005a) construct an OLG model where the NIIP can be affected by stochastic capital returns on asset and liabilities. However they do not let the exchange rate affect the NIIP or allow demographics to affect anything but the savings rate.

OLG models that allow for changes to the NIIP besides the current account (where capital returns register), i.e. valuation changes, or that allow demographics to influence economic factors other than the savings rate are non-existent to the best of my knowledge. Lane and Milesi-Ferretti (2002b) confirm that a theoretical model of the long run dependence of the NIIP on the real exchange rate is lacking and Obstfeld (2004) states the need for open economy models that incorporate valuation changes.

OLG models with more finely tuned demographic considerations than the usual two generations are found in Fougére and Mérette (1998), Brooks (2000), Feroli (2005) and Karras (2009). However, none of these authors explore the subject of valuation channels or allow the dependency rate to influence asset prices or the real exchange rate.
Literature review

The current account and valuation channels are the two sources of change to the NIIP. The increase of gross cross-border claims has caused the current account to become a relatively less important determinant and valuation to gain in importance. The current account is a well-researched source of change but that of valuation fluctuations is less so. As Obstfeld (2004) and Gourinches and Rey (2005a) point out the valuation channels are both unexplored to a large extent although both channels accounts for a large share of the change of the NIIP. Valuation consists of (i) the price channel and (ii) the exchange rate channel. Previous empirics of valuation channels are presented below followed by arguments linking demographic age structure to the current account and the valuation channels.

The price channel

The price channel works in a straight-forward way by affecting the value of gross positions. If the prices of assets increase the NIIP increases too and if liabilities become more expensive the effect on the NIIP is negative.

If foreigners own stocks from the domestic stock exchange a rise in the domestic stock market is equivalent to an increase in the value of liabilities. An increase in foreign stock markets results in increasing value of assets owned abroad by domestic residents. The same principle applies to FDI made by foreign residents in the domestic economy and by domestic residents abroad respectively (IMF, 2007).

Issues emerging for the price channel are mainly measurement problems. For different components of the NIIP, different methods must be employed. Equity and FDI are affected by price fluctuations but it is hard to estimate the effects due to lack of comparable data across nations. Some methods are available and presented in Lane and Milesi-Ferretti (2001).
The exchange rate channel

The real exchange rate is closely correlated to the current account and carries indirect effects on the NIIP through gross positions. The NIIP is also a long-run determinant of the real exchange rate. Here, studies examining the case where the causality goes from the exchange rate to the NIIP are presented first. Secondly studies treating the case of the reversed causality, i.e. from the NIIP to the real exchange rate, are presented. The first case is of interest in this study, but both scenarios are presented here in order to give the reader a clear picture.

Deterioration of the current account involves a fall of net exports and hence currency appreciation. Assets denominated in foreign currencies effectively loose value measured in the domestic and the NIIP deteriorates as a consequence. Debt instruments and currency reserves are components of the NIIP who are affected mainly by the exchange rate channel (Lane & Milesi-Ferretti, 2001).

In Lane and Milesi-Ferretti (2005) the authors consider 22 developed countries and 21 developing countries and develop a conceptual framework for the exchange rate channel. They find that appreciation has a short run effect of capital loss on the NIIP through the rates of return of almost one-to-one for developed countries with Finland as the most extreme case with a coefficient of -1.8. The effect is the smallest for the US (-0.37) which suggests that the US and the US dollar has a special standing. The authors motivate this with the fact that a large proportion of the US international assets are denominated in dollars which offsets the exchange rate channel to a large degree. For developing countries the authors found that depreciation had negative effects on the NIIP, contrary to the developed countries who experience capital loss following appreciation. Again, the answer lies in the currency composition and the fact that developing countries cannot lend or borrow in their domestic currency to the same extent as developed countries.

The findings regarding currency composition is supported by Lane and Shambaugh (2010) who construct an index of external currency composition for 117 countries for 1990-2004. They find that historically many developing countries have had a
negative position in foreign currencies. Consequently depreciation of the home currency results in negative wealth transfers. For example if an incurred debt is denominated in US dollars and the domestic currency depreciates more units of the domestic currency are necessary to repay the debt. Developed countries however have had such rapidly growing gross positions that they are vulnerable to sudden currency movements even if the net position is stable. The exchange rate effects on the NIIP are found to be significant and not readily reversible.

The findings presented above indicate that the currency composition is of importance for the effect of exchange rate fluctuations on the NIIP. Developed countries are more likely to have assets denominated in the domestic currency and liabilities in foreign currencies while developing countries are more likely to have assets and liabilities both denominated in foreign currencies. However, the US has a special standing as established in Lane and Milesi-Ferretti (2005). The same result is found by Obstfeld (2004) who also shows that American liabilities often are denominated in US dollars with the consequence that exchange rate fluctuations are muted.

Two propositions can be made. Firstly that exchange rate effects depend on the currency composition of the NIIP. Secondly that there are structural differences in currency composition with regards to the level of development and economic size. As a consequence developed countries should experience positive effects from depreciation, developing countries should experience adverse effects on their NIIPs from depreciation and the US and possibly other large economies with vehicle currencies are to some degree “immune” to the effects.

The causality between the NIIP and the real exchange rate is also reversed. Faruqee (1995) identifies the NIIP as a long-run determinant of the real exchange rate using data for the US and Japan for the postwar period. Faruqee links together the depreciation of the dollar with the negative American NIIP and the appreciation of the yen with a positive Japanese NIIP.
Similarly, Lane & Milesi-Ferretti (2004) find cross-sectional and panel evidence for a correlation between a negative NIIP and depreciated exchange rates for 64 high- and middle income countries.

Lane and Milesi-Ferretti (2002b) decompose the relationship between the NIIP and the exchange rate through the current account. The authors provide empirical proof for a correlation between a negative NIIP and depreciated exchange rates for a selection of OECD countries for 1970-1998 through a current account surplus. The NIIP is identified as a long run determinant of the real exchange rate.

Evidently, the relationship between the NIIP and exchange rates is a two-way street. In the long run, the NIIP is a determinant of the real exchange rate but in the short run the exchange rate channel affects the NIIP. For developed countries, abstracting from the US, the short run effect entails capital gains following depreciation and for developing countries the effect is the opposite.

Alongside the endogenous relationship of the exchange rate and the NIIP and the many factors that play in to this relationship, the picture can be made even more complicated. Exchange rates also affect asset prices (Bekaert and Hodrick, 1992; Yang and Doong, 2004). However, both Bodart and Reding (2001) and Solnik and Freitas (1988) argue that currency movements and asset prices do not interact. This paper looks at the ultimate determinants of the NIIP and does not inquire into the intermediate links involving the exchange rate.

**Demography**

The links between demographics, aggregate savings and the current account are well-grounded theoretically and empirically acknowledged. The following sections describe how demographic age structure is related to the current account, asset prices and the real exchange rate.
The current account
As stated in the section treating theoretical considerations, the dependency rate should be negatively correlated with the NIIP through savings rates and the current account. The support of the theoretical proposition is plentiful.


The subsequent effects on the current account are well documented. Taylor & Williamson (1994) look at capital flows from the UK to so-called “New World” from 1870 to 1913. Results show that the difference in dependency rates between the old and new countries served as a determinant for the current account imbalances.

Using more recent data, Herbertson and Zoega (1999) use a data set of 84 countries for the period 1960-1990 and establish that the current account tends to deteriorate when the country experience population ageing. The authors conclude that the finding is a result of well-functioning and integrated financial markets.

Kim and Lee (2008) estimate the effects of ageing on the current account of the G-7 countries and identified a negative relationship. The list of similar studies can be further extended, but these examples illustrate the strong empirical proof of a negative correlation between dependency rates and the current account.

Asset prices
A small amount of research of the correlation of asset prices and demography has been carried out. Nevertheless, empirics support that asset prices increase as large cohorts enter their asset accumulation phase before retirement and fall as the cohorts enter retirement and sell financial or real assets.
The so-called baby-boom generation born after the Second World War in the US had a significant effect on the housing market in the 1970’s when they were in the age of starting families (Mankiv & Weil, 1989). In the 1990’s the baby boomers started accumulating assets preparing for retirement and as a consequence, the stock market rose (Passel, 1996).

These findings indicate a relationship between the demographic age structure and asset prices with a negative relationship between the dependency rate and asset prices in the short run. Since domestic asset prices only affect prices of liabilities of the NIIP due to foreign presence, the link between the dependency rate and the NIIP is found to be positive. However, the research in this field is undeveloped. Compared to the link between dependency rates, the current account and exchange rates, this link is considered minor.

**Real exchange rates**

If population age-structure is a determinant of the current account, the assumption that real exchange rates are affected does not seem far-fetched. Only a limited amount of research has been done in the area but a significant relationship has been identified.

The exchange rate should appreciate when dependency rates rise and savings fall, provoking an inflow of capital. This is what happens as large cohorts retire and stop accumulating assets and instead start to live off their savings. Assuming that the savings fall faster than investment, the country needs to import capital which gives rise to an appreciating pressure on the exchange rate. Conversely, falling dependency rates should have depreciating effects on the exchange rate.

An empirical approach to the issue has been made by Andersson and Österholm (2005) using Swedish data and by Andersson and Österholm (2006) using panel data for OECD countries and six age groups. Both papers find that the exchange rate develops in accordance with what can be expected from the LCH in the medium and long term, i.e. that rising dependency rates lead to lower savings and capital inflows causing appreciation.
Hassan and Salim (2012) use data for OECD countries from 1980 to 2009 and use shares of the population for young (0-15), working (15-64) and old (65+) as the independent variables and the real exchange rate as dependent variable. They show significant results that the shares of the population who are working or old have appreciating effects while the young dependents exert a depreciating effect on the real exchange rate.

An ageing population should result in appreciating pressures on the exchange rate as soon as the large cohorts retire and they become negative net savers. An exception is that if the country is already a large debtor in which case rising savings rates can lead to appreciation (Cantor & Driskill, 1999).

Based on the papers presented above a relationship between the dependency rate and the exchange rate through the current is considered established. A relationship between rising dependency rates and deterioration of the NIIP can be deduced, assuming assets are denominated in foreign currencies and liabilities in the domestic currency which is the case for small developed countries.

**The NIIP and Demography**

The NIIP and demography are directly connected through the current account, and indirectly through the price- and the exchange rate channel. I now turn to the limited literature that have conducted outright estimations of the determinants of the NIIP with the inclusion of demographic considerations.

Masson, Kremer and Horne (1994) study the United States, Germany and Japan using data covering 1950-1990. They estimate the long run relationship of NIIP, public debt and demographic variables using ratios of the young (below 15 years) and the supposedly retired (above 65 years) to the working population relative to the ratios in the other G-7 countries. The results show that there indeed is a cointegrating relationship between NIIP as a ratio of GDP, public debt as a ratio of GDP and the dependency rate relative to that of the G-7 countries although with
some notable short term deviations. The relation to public debt was negative and the relation to dependency rates was positive, contrary to the findings of earlier research. The authors don’t develop the interpretation of the positive coefficient as demographics was not the main focus of their study. However, the period studies is mainly previous to financial globalization which took off in the mid-nighties (Obstfeld, 2004). Consequently, demography may not have had the large impact as can be expected today. Even if valuation channels were as significant as they are today, the sample of the world’s (at the time) largest economies also plays a role for the positive estimate due to currency composition.

In the paper “Long term capital movements”, Lane and Milesi-Ferretti (2002a) use a data set with 66 countries and the period 1970-1998. They apply panel fixed effects methods and find a long-run relationship between NIIP as a ratio to GDP and GDP per capita in logarithmic form, public debt and demographic age structure. They use twelve age groups to describe the population and simplify the measurement by pooling the data to three cohorts in the estimation by restricting the groups to follow so called cubic polynomial. In this study, contrary to the earlier one, demography affects the NIIP in the expected way in developed and developing countries. Age groups younger than 15 and older than 64 both exert a negative influence on the NIIP. The age group younger than 65 but reaching retirement shows a positive relationship with the NIIP. GDP varied positively with the NIIP in developed countries but negatively in developing countries. The relationship between public debt and the NIIP was negative for both developed and developing countries although the effect was stronger for developing countries. In a VECM they establish a short run relationship.
Data and descriptive statistics

Data about the NIIP is generally hard to find. The traditional data sources for macroeconomic variables fall short. The data used here for the NIIP and its components is taken from the data set developed by Lane and Milesi-Ferretti (2007). This data set is constructed relying on official data sources and the authors behind it point out some problems with the data. Underreporting of exports and outflows of capital is prevalent in official data sources. The authors refer to this problem as the “world current account deficit” which amounted to USD70 billion in 1998 (Lane & Milesi-Ferretti, 2002a). Despite this issue the data is considered adequate for the purposes of this paper. The measurements are in current US dollars. The measurement of the NIIP used here is NIIP as a percentage of GDP. It is a common way to account for economic size and is convenient for the interpretation.

The demographic data comes from the United Nations World Population Prospects, 2012 Revision and contain six age groups; 0-14, 15-29, 30-44, 45-59, 60-74 and 75 plus. Observations are made with five year intervals and the age data has been linearly interpolated to yearly data points. The dependency rate is constructed based on the data according to the following definition:

\[ \text{depre} = \frac{age014 + age6074 + age75}{age1529 + age3044 + age4559} \]

The three age groups 0-14, 60-74 and 75 plus are assumed to be part of the non-working population, the dependents. The remaining age groups, i.e 15-29, 30-44 and 45-59, represent the working part of the population. This approximation is far from perfect. It is unlikely that people stop being dependents at age 15 as well as it is unlikely that people stop working at age 60. However, it is a close enough approximation given the available data.

A list of countries included in the data set is available in Appendix A. The time period covered ranges from 1970 to 2011 and observations are annual. References to all data sources can be found in the list of references.
The countries are separated into groups of OECD and non-OECD members. This distinction serves three purposes, (i) due to lacking data for currency composition of NIIPs OECD membership serves as a proxy for countries with liabilities in the domestic currency while non-OECD countries are assumed to have liabilities in foreign currencies, (ii) the OECD membership is also a proxy for integration in the global financial system which is vital for the possibility to export excess capital and import capital and (iii) too much variation between the individuals makes estimates hard to interpret. A third group of adjusted OECD countries leaving out the largest economies, the US and Japan, is constructed. The reason is that the US dollar is the dominating world currency and the American balance sheet contains mostly dollars. Japan is in a similar situation with the Japanese yen.

**Control variables**

Previous empirical work shows that more factors affect the NIIP besides the price channel and the exchange rate channel and must hence be controlled for in the regression analysis. While valuation channels and the current account affect the NIIP primarily in the short run, GDP per capita and public debt are long term determinants of the NIIP.

Output per capita should have a positive long run relationship with the NIIP. The savings rate is expected to rise following a rise of GDP. The savings rate may rise temporarily but the effect on the NIIP is permanent (Lane & Milesi-Ferretti, 2002a). Lane and Milesi-Ferretti (2005) also link GDP growth to the NIIP.

Public debt is negatively associated with the NIIP as established by Masson, Kremers and Horne (1994). Lane and Milesi-Ferretti (2002a) attributes the link to failure of Ricardian equivalence.

Data over public debt comes from the QoG (Quality of Government) Institute database of Gothenburg University (Dahlberg, Holmberg, Rothstein, Hartmann, & Svensson, 2015) and is complemented certain years with data from the OECD for
the USA, Slovakia and Hungary (OECD, 2015). The definition of public debt used here is that of the general government which is the same definition employed in similar studies (Lane & Milesi-Ferretti, 2002a). Public debt contains many missing values, especially before 1990, making the panels unbalanced. The missing values will be the limiting factor for the number of years to be included in the empirical investigation of the data. The measurements of GDP per capita and public debt are in current US dollars.

More variables are possible candidates as control variables, for example measurements of risk and return that Calderón, Loayza and Servén (2000) use as determinant of the NIIP. Another possible control variable could be the type of pension system employed in the country. However, previous research has found that the pension system is irrelevant for the effect of demographics on the current account and hence it is left out of the analysis (Boersch-Supan, Ludwig, & Winter, 2001). This analysis is restricted to GDP per capita, public debt and dependency rate as independent variables.

Graphs 1 and 2 show how the average change in GDP per capita and the average change in NIIP over the period 1990-2010 for each OECD country are correlated to each other. A positive relationship between GDP per capita and NIIP is visible in graph 1 and a negative relationship between public debt and the NIIP is presented in graph 2. The outlier country furthest down in the graph is Iceland which following the financial crisis accumulated a massive negative NIIP and hence shows a deviating pattern of the NIIP. Graph 3 show that there is a positive correlation between the dependency rate and the NIIP from 1990 to 2010. This is the same relationship Masson, Kremers and Horne (1994) found but the opposite of what Lane and Milesi-Ferretti (2002a) found. I continue on with regression analysis before I draw any conclusions of my own.
Graph 1: Descriptive statistics of GDP/cap

Graph 2: Descriptive statistics of public debt

Graph 3: Descriptive statistics of dependency rate
Empirical approach

Theory and empirics support the prevalence of correlation between age structure and the NIIP through direct effects of the current account and indirect effects through prices and the real exchange rate. For a short reminder to the reader the relationships and the time horizons are visualized in Figure 1 and 2.

Figure 1 illustrates the time horizons. Demography can be expected to affect the NIIP through the price channel and the exchange rate channel at the short time horizon and through the current account in both the long and short run.

Figure 2 provides a stylized illustration of the interaction between the dependency rate and the NIIP through the current account, price channel and exchange rate channel. The figure is based on a country with assets denominated in foreign currencies and liabilities in either the domestic currency or foreign currencies. This excludes the US and other countries with world currencies. The countries that tend to become black holes share that assets are denominated in foreign currencies and that liabilities are denominated in the domestic currency.
The currency composition of the NIIP clearly matters for how the dependency rate affects the NIIP. In the empirical analysis this is controlled for by separating between developing and developed countries using OECD and non-OECD countries. By excluding large economies (the US and Japan) from the OECD sample a third sample of adjusted OECD countries is created. The third sample is of largest importance to this study since countries where NIIPs have turned into black holes are present. The distinction of the samples is made based on the findings of Lane and Milesi (2005) and Lane and Shambaugh (2010).

An assumption made through-out the empirical analysis is that investments remain stable so that effects of a changing savings rate are not off-set by changing demand. The assumption is reasonable and necessary for this analysis. Nevertheless, the notion of sustained levels of investment is not uncontested. Fougère and Mérette (1998) found evidence in some OECD countries that a rising dependency rate did not necessary lead to a deteriorating current account. Their explanation was that the demand for investment decreased at the same rate or faster as the savings rate which in some cases led to improvement of the current account. For sake of simplicity, this paper assumes constant level of investments.

The research questions posed are the following:
1. Can black holes be explained by population ageing?
2. Is the correlation between demography and the NIIP different for developed and developing countries?

**Model specification**

A nested and integrative general-equilibrium model is a possible way to model the NIIP and the many variables that affect the NIIP directly and indirectly. This type of model lies beyond the scope of this paper. Based on findings presented above the following reduced form model is assumed:

\[
NIIP_{it} = f \left( \text{Dependency rate}, \frac{GDP}{\text{capita}}, \text{Public debt} \right) + \varepsilon_{it}
\]

Rising dependency rates are expected to cause deterioration of the current account and hence the NIIP. An appreciating pressure stemming from an ageing population will cause a deterioration of the NIIP for developed countries and the opposite effect for developing countries. The underlying assumption is that developed countries have liabilities denominated in the domestic currency and that developing countries have liabilities in foreign currencies while both have assets in foreign currencies. Asset prices are expected to fall as the dependency rate rises resulting in a strengthening of the NIIP. However, this link is considered quantitatively minor. The total effect of the dependency rate is expected to be negatively correlated with the NIIP for small developed countries. Developing countries are expected to have a weaker negative or positive correlation. GDP per capita should vary positively with the NIIP and public debt should have a negative relationship based on the findings in the literature.

The relationship between the dependency rate and the NIIP is furthermore expected to hold in the long run and short run.

In estimating the relationship between the variables the Engle-Granger two-step method is applied. Variables are assumed to be I(1) and hence the Engle-Granger
method is sufficient. The first step consists of identifying and estimating the long run relationship or cointegrating model and in the second step the cointegrating model is used for estimating the short run relationship. The same method is used in Lane and Milesi-Ferretti (2002a) but the method is extended with controls for cross-sectional correlation here.

The long run relationship

Panels with large N and T (number of countries and time dimension), as in my data set, are often cross-sectionally dependent, i.e. correlated over the cross-sectional dimension. In this study the cross-sectional units are countries. Cross-sectional dependence can lead to incorrect inference or inconsistent estimators, depending on the type and strength of the correlation (Chudnik & Pesaran, 2013). The later problem arises when the source of the correlation also is correlated with the regressors. Conventional unit root tests can yield results with large size distortions. No previous literature has to the best of my knowledge investigated the determinants of the NIIP taking cross-sectional correlation into consideration. This fact may have caused previous estimates of the relationship of the NIIP and its determinants to be biased.

The Breusch-Pagan Lagrange Multiplier (LM) test is a standard for testing cross-sectional dependence. However, the proposed test performs less well when N>T which is the case in my sample. The cross-sectional (CD) test developed by Pesaran (2004) performs well when N>T and is suitable for a variety of data, including non-stationary panels, and hence seem appropriate for the data set used here (Baltagi, 2013, ch. 8). An overview of the test is available in Appendix C. The results of the CD-test are presented in table 1 and show that cross-sectional dependence is present over all sub-groups and variables.
A simple way to eliminate the issue of cross-sectional dependency is the Common Correlated Effects (CCE) procedure suggested by Pesaran (2006) which assumes one shared source of cross-sectional dependency for the sample. I apply the CCE procedure by manipulating the variables in subtracting the sample mean from each observation. The procedure is repeated for all sub-samples. An overview of the procedure is presented in Appendix B.

With the CCE-corrected variables, I can move on with the Engle Granger method. An Augmented Dickey-Fuller (ADF) test is performed to test for presence of unit root. Results are presented in table 2 and the “CD” in front of each variable shows that the variable has been corrected for cross-sectional dependence.

<table>
<thead>
<tr>
<th>Table 1: Pesaran (2004) CD test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>NIIPGDP</td>
</tr>
<tr>
<td>lnGDPcap</td>
</tr>
<tr>
<td>pubdebt</td>
</tr>
<tr>
<td>deprate</td>
</tr>
</tbody>
</table>

H0: Cross-sectional independence. P-values in brackets

<table>
<thead>
<tr>
<th>Table 2: Augmented Dickey-Fuller unit root test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>CDNIIPGDP</td>
</tr>
<tr>
<td>CDlnGDPcap,</td>
</tr>
<tr>
<td>CDpubdebt</td>
</tr>
<tr>
<td>CDdeprate</td>
</tr>
</tbody>
</table>

H0: All panels contain unit roots Ha: At least one panel is stationary
p-values in brackets
Failure to reject the null hypothesis indicates the presence of unit roots. In most cases the null cannot be rejected. The exceptions are GDP per capita and dependency rates in OECD countries, public debt in non-OECD countries and GDP per capita in the adjusted OECD sample.

### Table 3: Hadri LM test z-statistic

<table>
<thead>
<tr>
<th></th>
<th>Whole sample</th>
<th>OECD</th>
<th>non-OECD</th>
<th>OECD (adjusted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDNIIPGDP</td>
<td>96.815 (0.000)</td>
<td>31.194 (0.00)</td>
<td>90.522 (0.000)</td>
<td>20.623 (0.000)</td>
</tr>
<tr>
<td>CDlnGDPcap</td>
<td>98.316 (0.000)</td>
<td>40.200 (0.000)</td>
<td>93.025 (0.000)</td>
<td>27.870 (0.000)</td>
</tr>
<tr>
<td>CDpubdebt</td>
<td>47.274 (0.000)</td>
<td>21.253 (0.000)</td>
<td>38.253 (0.000)</td>
<td>18.920 (0.000)</td>
</tr>
<tr>
<td>CDdeprate</td>
<td>251.017 (0.000)</td>
<td>116.488 (0.000)225.264 (0.000)</td>
<td>27.755 (0.000)</td>
<td></td>
</tr>
</tbody>
</table>

H0: All panels are stationary  Ha: Some panels contain unit roots

p-values in brackets

A complementary Hadri (2000) LM test with fixed effects (without a time trend) is performed with the null hypothesis of stationarity in all panels and the alternative hypothesis is of unit root in some panels. The results in table 3 show that there are no panels which are completely stationary.

The groups of interest are the non-OECD countries and the adjusted OECD samples and the variables of interest are NIIP as a percentage of GDP and the dependency rate. Since stationarity cannot be concluded in these panels, the analysis can now move on to searching for a cointegrating relationship.

Four scenarios are possible for the cointegrating relationship. There may be no cointegration at all between my variables and hence regressions would be spurious. If cointegration is present, it may be in the form of heterogeneous or homogeneous panel cointegration. In the former case, the cointegrating relationships are specific for each individual country and in the latter case, the cointegrating relationship is the same for all individuals. The fourth scenario postulates that both the cointegrating relationship is both heterogeneous and homogeneous. In this analysis
it is assumed that the relationship of the data is homogeneous which is not uncommon nor unrealistic, especially as the sub-samples contain countries who are similar to each other. This assumption should not have any serious implications for the interpretation of the results. Due to the assumption of a homogenous cointegrating relationship the analysis can move on with pooled methods.

The Kao (1999) unit root test for cointegration is used by Lane and Milesi-Ferretti (2002a) and is the analogue of the Engle-Granger cointegration test. The following regression where $\gamma_{it}$ are individual fixed effects is estimated with OLS and the residuals are diagnosed by a Fisher test.

$$C咤NPΓDP_{it} = \beta_0 CDlnGDP_{cap_{it}} + \beta_1 CDpubdebt_{it} + \beta_2 CDdeprate_{it} + \beta_3 \gamma_{it} + \varepsilon_{it}$$

A complementary Hadri (2000) LM stationarity test is performed on the residuals of a model with intercept and time trend. An overview of the Kao and Hadri tests are available in Appendix C.

### Table 4: Pooled cointegration tests

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Whole sample</td>
<td>OECD</td>
</tr>
<tr>
<td><strong>Inverse chi-squared</strong></td>
<td>350.254 (0.103)</td>
<td>71.519 (0.362)</td>
</tr>
</tbody>
</table>

*H0: All panels contain unit roots Ha: At least one panel is stationary*

<table>
<thead>
<tr>
<th></th>
<th>Whole sample</th>
<th>OECD</th>
<th>non-OECD</th>
<th>OECD (adjusted)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>z-statistics</strong></td>
<td>44.487 (0.000)</td>
<td>22.075 (0.000)</td>
<td>39.019 (0.000)</td>
<td>20.494 (0.000)</td>
</tr>
</tbody>
</table>

*H0: All panels are stationary Ha: Some panels contain unit roots*  
*p-value in brackets*
Results from both tests are presented in table 4. In order to confirm cointegration the residuals should be stationary.

The results show that neither the whole sample nor the OECD countries have long run relationships. However, non-OECD countries and the adjusted OECD sample do have a long run relationship.

The long-run relationship can now be estimated for the non-OECD countries and the adjusted sample of OECD-countries. Ordinary Least Squares (OLS) is a consistent estimator in this case but the standard errors produced are not valid due to a second order asymptotic bias (Lee G., 2007). The Dynamic OLS (DOLS) [-1,1] by Stock and Watson (1993) is used for estimating the cointegration relationship in NIIP literature (Lane & Milesi-Ferretti, 2002a), return valid t-statistics and is suitable in the presence of I(1). An overview of the estimator is found in Appendix D. This method regresses the dependent variable on levels of the independent variables from the same time period, the leads and lags of their first differences and a constant using OLS. Generalized Least Squares (GLS) is an alternative estimator proposed by Stock and Watson (1993) but here I employ only OLS as both OLS and GLS yield asymptotically equivalent estimates.

Wagner and Hlouskova (2010) test several estimators of cointegration and find that DOLS (when cointegration is one-dimensional) is the best and most robust for unit roots close to the unit circle, cross-sectional correlation and cross-unit cointegration and presence of I(2). Kao and Chiang (2000) argue that DOLS is superior to the Fully Modified (FM) OLS estimator which is proposed by Pedroni (2000). Variables in this estimation are likely to be endogenous to each other as is clear from the literature review, but DOLS is consistent when variables are endogenous. The standard errors applied are heteroscedasticity and autocorrelation (HAC) robust.

In order to avoid omitted variable bias time dummies and country-specific dummies are included in the model. The dummies capture country specific traits that affect
the NIIP and common trends over time, business cycles for example. The model is the following:

$$CDNIIP_{it} = \beta_0 + \beta_1 CDlnGDPCap_{it} + \beta_2 CDpubdebt_{it} + \beta_3 CDdeprate_{it} + \beta_4 X + \beta_5 \theta_t + \beta_6 \mu_i + \epsilon_{it}$$

$$X = \Delta CDlnGDPCap_{it+1} + \Delta CDpubdebt_{it+1} + \Delta CDdeprate_{it+1}$$

$$+ \Delta CDlnGDPCap_{it-1} + \Delta CDpubdebt_{it-1} + \Delta CDdeprate_{it-1}$$

The X represents leads and lags of the first difference of the independent variables. The variables $\theta_t$ and $\mu_i$ denote time and country fixed effects respectively.

**Sensitivity analysis**

To test the robustness and sensitivity of the results, some variations of the variables and of the data are explored.

Several ways of treating the variable describing demography are present in the literature. One example is to decompose the dependency rate into the different age categories. By employing six age groups with age brackets 0-14, 15-26, 30-44, 45-59, 60-74 and 75 and above and repeating the above analysis the same signs of unit root and cointegration as with dependency rates are present and the cointegrating relationship can hence be estimated. Age groups which are net savers, i.e. working, are expected to exert positive pressure on the NIIP and dis-savers, i.e. young and old, should have a negative effect on the NIIP.

An alternative way to treat demographics is the deviation from average dependency rate which is the measurement employed in the study of Masson, Kremers and Horne (1994). This measurement is not possible due to the Pesaran CCE-procedure which use the sample means as a proxy for the shared factor causing the correlation. Estimates would be identical to the baseline regression.
Some research has found that the starting position of a country as debtor or creditor affect the way changing dependency rates affect the exchange rate. If a country is a large debtor increasing savings can cause appreciation and hence lead to the opposite effect on the NIIP as rising savings otherwise should have (Cantor & Driskill, 1999). By excluding large debtors from the data set these effects can be avoided. The definition of debtor used here entails a negative NIIP position 1985-1990 and I investigate only the time period from 1990 to 2011.

Due to uncertainty of the linearity of the relationship between the NIIP and GDP per capita, a variable with squared GDP is added in order to find whether that improves the model.

The group of non-OECD countries is very heterogeneous and hence further examination of the sample is done by dividing the countries by geographic location to see if the relationship is different depending on spatial parameters. The distinctions are Asia, Africa, South America and the Caribbean and Middle East and North Africa (MENA).

Finally, the data set contained a large amount of missing values due to lacking data of public debt. In an attempt to increase the number of observations, the variable public debt is left out.

Results from the complete sensitivity analysis are presented in column b-e in Appendix E.

**Model suitability**

In order to investigate how well the model specification suits the data, actual values and fitted values from the baseline model for the long-run relationship for some OECD (using the adjusted sample of OECD countries) and non-OECD countries are visualized in graphs 4-12 and 13-21. The space between the graphs can be interpreted as the residual and is of varying size. Considering high values of R-
Graphs 4-12: Actual values and fitted values for selected OECD countries

- **Canada**
- **Finland**
- **France**
- **Germany**
- **Greece**
- **Iceland**
- **Spain**
- **Switzerland**
- **United Kingdom**
- **Finland**
Graphs 13-21: Actual values and fitted values for selected non-OECD countries

- Armenia
- Brunei Darussalam
- China
- Congo
- Colombia
- Equatorial Guinea
- Jordan
- Malaysia
- St Vincent and the Grenadines

Actual vs. Fitted values for various non-OECD countries over different years.
squared (see table 5), the spaces between the two graphs should be small. However, in some cases there are notable deviations in the short run relationship.

The graphs show that the model fits reasonably well for most OECD-countries in the figure. For large economies, the model tend to over-predict the values and for smaller countries the fit is better.

The model seems less well suited for the non-OECD countries. Congo and Equatorial Guinea have a good fit but for Armenia, China, Colombia and Malaysia the deviations are noteworthy.

**The short term relationship**

The second step of the Engle-Granger two-step method is the Error Correction Model (ECM). The diagrams depicting actual and fitted values show a good fit for the long run relationship model but with short term deviations. I hence move on to estimate the short run relationship and error correction for the sub-groups where I have identified a cointegrating relationship.

The ECM model includes first-differences of all variables, a lag of the independent variable in first-difference and a speed-of-adjustment variable.

\[
\Delta NIIPGDP_{it} = \sigma' \Delta Z_{it-1} + \eta \Delta NIIPGDP_{i,t-1} + \lambda (EC_{t-1}) + \nu_{it}
\]

Where \(Z_{i,t-1}\) are the differences between the dependent variables in time \(t\) and the previous period. The coefficient \(\lambda\) is the error correction coefficient in front of the error correction component of the model, i.e. residuals from the cointegration model of the prior period. This coefficient captures the speed of which the NIIP adjusts to the equilibrium following deviations from the long run model. The coefficient \(\sigma\) captures the short run effect, i.e. effects of the independent variables of the previous time period on the dependent variable in the current period.

The short run effects of the dependency rate is expected to be negative, especially for the adjusted OECD sample. Public debt and GDP per capita on the other hand are not expected to have significant short run effects. Judging from the graph 4-21,
the error correction of short term deviations from the long run relationship is not very fast.

To maintain a parsimonious model specification I keep the same sub-samples for which a cointegrating relationship is established analysis, i.e. the adjusted OECD sample and non-OECD countries.

Results
The estimates for the cointegrating relationship of the baseline regression are presented in table 5 and the complete results for the long-run relationship are presented in Appendix E. The cointegrating relationship of the adjusted sample of OECD countries have significant estimates for public debt and dependency rate and the cointegrating relationship of non-OECD countries have significant estimates for GDP per capita and public debt. GDP and public debt have the expected signs for all samples. However, the estimate for the coefficient of the dependency rate is positive for the whole sample and the sub-samples. Very high R2-values are suspect and may be signs of spuriousness in the regressions, most notably for the non-OECD countries.

Exchanging the dependency rate for age groups provided some more detail. The estimates for the oldest age group have a negative sign for both samples. On the other hand estimates for the second oldest group, age 60 to 74, have a positive sign. For the adjusted OECD sample the age group 30-44 was the only other group with a negative estimate. For non-OECD countries, the same group was the only one besides the age group 60-74 with a positive estimate. In non-OECD countries the estimates for GDP per capita and public debt remained the same but for the adjusted OECD sample, the estimate for GDP per capita turned negative.

Regardless of any measure taken in the sensitivity analysis, the estimates for the effects of the dependency rate remain larger for the adjusted OECD sample than for non-OECD countries.

---

2 The model specification DOLS[-2,2] yielded results similar to those of DOLS[-1,1].
The cointegrating relationship for the geographic subgroups within the non-OECD group show that the dependency rate has a positive correlation with the NIIP in similarity with the rest of the estimates.

When excluding debtor countries the estimates for the dependency rate were still positive and of even larger size. However, the sign of the estimate for public debt changed for OECD countries and the sign of the estimate for GDP per capita changed for developing countries. The result hence shows that creditor countries in the OECD have positive effects from both GDP per capita and public debt and non-OECD creditor countries experience negative effects from public debt and GDP per capita.

The results remain largely unchanged even when the square of GDP per capita is included.

With the risk of omitted variable bias the variable public debt is left out with the purpose of adding more observations. The number of observations more than doubled. When regressing the NIIP on only GDP per capita and dependency rates (with country- and time fixed effects) estimates were clearly lower, both for GDP per capita and dependency rates.

The results from the error correction specification are presented in table 6. Short run effects of the dependency rate on the NIIP are positive in all cases except for Asian non-OECD countries. However, the coefficient is not significant at a five

<table>
<thead>
<tr>
<th></th>
<th>OECD (adjusted)</th>
<th>non-OECD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDlnGDPcap</td>
<td>0.01355 (0.126)</td>
<td>0.0454 (0.026)</td>
</tr>
<tr>
<td>CDpubdebt</td>
<td>-0.00655 (0.006)</td>
<td>-0.0082 (0.000)</td>
</tr>
<tr>
<td>CDdeprate</td>
<td>10.2093 (0.010)</td>
<td>3.792 (0.196)</td>
</tr>
<tr>
<td>Centered R2</td>
<td>0.6724</td>
<td>0.932</td>
</tr>
<tr>
<td>Observations</td>
<td>598</td>
<td>1374</td>
</tr>
</tbody>
</table>

p-values in brackets
Dynamic OLS[-1,1] estimation with time and country fixed effects
percent level except for non-OECD countries in South America and the Caribbean. Short run effects of GDP per capita are not significant in any sample. A negative short run effect of public debt is significant for non-OECD countries. When breaking the group down in geographic sub-groups, it stands clear that the effect is significant only in Asia and MENA countries.

The error correction component is significant for all samples and indicates a correction to the long run relationship of between 12 to 37 percent per year. The correction mechanism is the slowest in non-OECD countries and the fastest in Asian non-OECD countries.

**Table 4.6: Results of Error Correction Model**

<table>
<thead>
<tr>
<th></th>
<th>OECD (adjusted)</th>
<th>non-OECD</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D.CDlnGDPcap$</td>
<td>-0.004 (0.828)</td>
<td>0.004 (0.603)</td>
</tr>
<tr>
<td>$D.CDpubdebt$</td>
<td>-0.001 (0.773)</td>
<td>-0.001 (0.006)</td>
</tr>
<tr>
<td>$D.CDdeprate$</td>
<td>4.038 (0.352)</td>
<td>3.355 (0.055)</td>
</tr>
<tr>
<td>Error Correction</td>
<td>-0.122 (0.000)</td>
<td>-0.268 (0.000)</td>
</tr>
<tr>
<td>Adjusted R2</td>
<td>0.110</td>
<td>0.117</td>
</tr>
<tr>
<td>Panels (unbalanced)</td>
<td>597</td>
<td>1374</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Africa</th>
<th>Asia</th>
<th>South America and the Caribbean</th>
<th>MENA</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D.CDlnGDPcap$</td>
<td>0.018 (0.246)</td>
<td>-0.054 (0.496)</td>
<td>-0.004 (0.558)</td>
<td>-0.015 (0.300)</td>
</tr>
<tr>
<td>$D.CDpubdebt$</td>
<td>-0.001 (0.063)</td>
<td>-0.005 (0.042)</td>
<td>5.21E-05 (0.956)</td>
<td>-0.002 (0.021)</td>
</tr>
<tr>
<td>$D.CDdeprate$</td>
<td>6.038 (0.166)</td>
<td>-2.192 (0.676)</td>
<td>10.265 (0.006)</td>
<td>3.573 (0.248)</td>
</tr>
<tr>
<td>Error Correction</td>
<td>-0.186 (0.000)</td>
<td>-0.371 (0.000)</td>
<td>-0.193 (0.000)</td>
<td>-0.256 (0.000)</td>
</tr>
<tr>
<td>Adjusted R2</td>
<td>0.055</td>
<td>0.186</td>
<td>0.115</td>
<td>0.097</td>
</tr>
<tr>
<td>Panels (unbalanced)</td>
<td>435</td>
<td>327</td>
<td>290</td>
<td>210</td>
</tr>
</tbody>
</table>
Discussion

The estimated coefficient for the effect of age structure on the NIIP in the long run relationship was positive, i.e. the opposite of the expected sign.

The measurements of age structure used here are all present in the literature of NIIP and demography (Lane & Milesi-Ferretti, 2002; Masson, Kremers & Horne, 1994) but no discussion has been carried out regarding the appropriateness of each measurement. Judging from the results here the effect of age structure on the NIIP can be adequately estimated regardless of the way age structure is presented. The decomposition into age groups provides more detail to the analysis which may be preferred. However, the interpretation of a single measurement such as the dependency rate is more straight-forward.

The samples of OECD and non-OECD countries showed a positive long run relationship of NIIP and population ageing. Signs of coefficients for GDP per capita and public debt were the expected and also proved robust. A long run relationship was confirmed for non-OECD countries and the OECD countries excluding the US and Japan.

The separation of OECD and non-OECD countries is made in order to control for currency composition and integration in the global financial system. The result of such a division should be a larger negative estimate for the OECD countries and a smaller negative estimate for non-OECD countries. Nevertheless, results of the analysis were the opposite of the expected signs.

The non-OECD countries are assumed to be less integrated in the global financial system hampering their opportunity to trade consumption over time, which is what international financial claims really are. Integration in the financial system is a vital assumption for demography to impact international capital flows and the lack of it should result in a weaker effect. In addition, the exchange rate channel contributes to the positive effects in non-OECD countries due to the assumption of negative positions in foreign currencies. The positive estimate for non-OECD countries is less surprising than the positive estimate for the OECD sample.

Furthermore, some developing countries have a very young population who start their working life quite early compared to western countries but stop working earlier
too. This can cause an upward bias of my estimates due to the inclusion of people already working in the measurement of the dependency rate.

The positive estimate for the dependency rate is more difficult to understand for the OECD countries. A plausible explanation to the unexpected sign lies in the assumption of sustained levels of investments implicit throughout the analysis. If this does not hold and investments fall faster than savings following rising dependency rates the positive effect of dependency rates on the NIIP is understandable. Fougère and Mérette (1998) found that investments can fall faster than savings which strengthens the credibility of this explanation.

Lane and Milesi-Ferretti (2002a) identified negative effects of population ageing on the NIIP. In their analysis they did not control for cross-sectional correlation. If the factor causing correlation over the cross-section is negative that may have caused downward bias of their results.

This data analysis has controlled for cross-sectional correlation and has assumed that the source of correlation stems from a single source per sample. The controls have not been extended to account for other types of cross-sectional correlation. There are signs of sustaining cross-sectional correlation in the data which indicates that there are other sources of correlation which may bias the results.

The measure of the dependency rate used here is far from perfect. A more correct measurement of how the dependency rate actually looks would benefit the analysis.

Data over public debt has brought serious limitations to the applicability of the results in this study. Due to missing data for many years and many countries, only a small part of all observations could be included in the regressions. Data is a problem also when it comes to the NIIP. The data set by Lane and Milesi-Ferretti (2007) used here is built on official data sources of assets and liabilities but the estimates constructed by the researchers differs more often than not from the official NIIP.

Data limitations make an analysis taking the currency exposure of each country into consideration impossible to perform. The currency exposure determines what effect a depreciation will have on the NIIP depending on which foreign currency the
domestic currency depreciates against. In order to account for the real exchange rate effects properly, a specific measurement of demography could be constructed. The variable describing the age structure of the population should in that case be put in relation to the age structure in the country to which the currency exposure is the largest. To continue the analysis of the NIIP while accounting for exact currency composition lies beyond the scope of this paper but the issue remain and makes estimates problematic to interpret.

The short run adjustment mechanism was 12 percent for the adjusted OECD sample and 27 percent for non-OECD countries. This indicates that disturbances are corrected with 12 and 27 percent respectively in one year’s time.

Short run effects of the dependency rate on the NIIP were positive which is in line with the long run relationship. For the adjusted OECD sample, the short run effect was smaller than the long run effect. This fact supports the explanation of falling levels of investment off-setting adverse effects of ageing. Assuming that investment decisions are made with inertia, the off-setting effect should increase with time causing positive effects of population ageing to increase with time.
Conclusions

This study has tied together strands of literature regarding the NIIP and economic effects of demographic age structure in order to provide some explanation to the prevalence of black holes. The research questions posed in the introductory chapter were:

1. Can black holes be explained by population ageing?
2. Is the correlation between demography and the NIIP different for developed and developing countries?

Firstly, the dependency rate has been found to have a positive long run relationship with the NIIP with a rather slow adjustment mechanism. Hence ageing populations cannot be concluded to cause black holes for small developed countries through neither direct nor indirect effects.

Secondly, both OECD countries (exempt from the US and Japan) and non-OECD countries have a cointegrating relationship between the NIIP and age structure. The relationship between the dependency rate and the NIIP has a larger positive coefficient for the adjusted sample of OECD countries than non-OECD countries.

The findings are in contrast to the body of earlier research.

A possible explanation to the surprising estimates is the assumption of stable levels of investments. Statistical issues such as lacking data, the problematic definition of the dependency rate and remaining signs of cross-sectional correlation also offer explanations.

The results of this study underline the importance of continued research of the NIIP, valuation effects and demographics. The need of a theoretical model which includes valuation changes to the NIIP and allow demographics to influence real exchange rates is evident.
References


## Appendix A: Countries

### OECD countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Country</th>
<th>Country</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
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Appendix B: Pesaran’s (2006) CCE procedure

An example of a panel model with cross-sectional dependence can look like this:

\[ y_{ut} = \alpha' d_t + \beta' x_{it} + u_{it} \]  
(B.1)

Where: \( u_{it} = \gamma_{i1} f_{1t} + \gamma_{i2} f_{2t} + \ldots + \gamma_{im} t_{mt} + e_{it} = \gamma_i f_t + e_{it} \)  
(B.2)

Here \( d_t \) is a vector of common and unobserved factors at time \( t \) and \( x_{it} \) are observed variables for each country \( i \) at time \( t \). In this case the observed variables are GDP per capita, public debt and the dependency rate. The unobserved factors can be common business cycles, shocks or seasonal disturbances. The error term contains \( f_t \) which are also unobserved common factors with \( \gamma_i \) as a vector of factor loadings while \( e_{it} \) can be weakly cross-sectionally dependent. For the interested reader, a survey of the literature of cross-sectional dependence is available in Chudnik and Pesaran (2013).

Pesaran’s (2006) Common Correlated Effects (CCE) procedure consists of assuming a linear combination of the unobserved factors that cause the cross-sectional dependency and approximating it with averages across the cross-section. The approach assumes that the cross-sectional dependency comes from a common factor rather than idiosyncratic factors in each country assuming this model for the observed variables:

\[ x_{it} = A'_i d_t + \tau'_i f_t + \nu_t \]  
(B.3)

In combining (B.1), (B.2) and (B.3) I achieve a system of equations which supports linearity of the unobserved common factors. Hence I can use cross-sectional averages for approximating the linear common factor and manipulate the variables according to the following:

\[ x_{CCE_{it}} = x_{it} - \bar{x}_t \]

This is repeated for every variable in each sub-sample.
Appendix C: Specification tests

Appendix C.1: Pesaran (2004) cross-section dependence (CD) test

The test can be used for cross-sectional dependence of any order. It is built on pair-wise coefficient of correlation of OLS residuals from regressions of the individuals in the panel.

The following panel model is assumed:

\[ y_{it} = \alpha_i + \beta_i'x_{it} + u_{it}, \quad i = 1,2 \ldots, N, \quad t = 1,2, \ldots T \]

Where \( \alpha_i \) are individual intercepts and \( x_{it} \) are observed and time-varying regressors (stationary or non-stationary and may contain lagged observations of \( y_{it} \)) where \( i \) is the cross-sectional dimension and \( t \) is the time dimension. The error term \( u_{it} \) is assumed IID for all time periods but cross-sectional dependence is allowed in \( u_{it} \) and \( u_{jt} \) when \( i \neq j \). The cross-sectional dependence can be spatial, dependent on unobservable common factors or be pair-wise idiosyncratic. The test is furthermore applicable to model specifications of both fixed and random effects.

The test use pair-wise correlation coefficients:

\[
CD - \sqrt{\frac{2T}{N(N-1)} \left( \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \right)}
\]

For fixed values of \( N \) and \( T \), the mean of this statistics will be zero in many panel data models, including the one used in this paper.

The necessary assumptions and proofs of the robustness of the test in presence of structural breaks are available in Pesaran (2004).
Appendix C.2: Kao (1999) cointegration test

The Kao (1999) test is an Augmented Dickey-Fuller (ADF) test on the residuals with the null hypothesis of no cointegration. Consider the panel data least-squares dummy variable (LSDV) model:

\[ y_{it} = \alpha_i + \beta x_{it} + e_{it}, \quad i = 1, ..., N, \ t = 1, ..., T \]

Compared to the Dickey-Fuller (DF) test which is an OLS regression of \( \hat{e}_{it} = \rho \hat{e}_{it-1} + v_{it} \) this test uses:

\[ \hat{e}_{it} = \rho \hat{e}_{it-1} + \sum_{j=1}^{p} \phi_j \Delta \hat{e}_{it-j} + v_{itp} \]

With \( p \) and chosen so that the residuals are serially uncorrelated. The ADF test statistics is:

\[ t_{ADF} = \frac{(\hat{\rho} - 1)[\sum_{i=1}^{N}(e'_i Q_i e_i)]^{1/2}}{s_v} \]

And \( \hat{\rho} \) is the estimate of \( \rho \) from using OLS. The further development of the test is available in Kao (1999).

The test is residual based and tests the null hypothesis of stationarity around a deterministic time trend or level for the time series of every cross-sectional unit \(i\).

The alternative hypothesis is that the series contain at least one unit root.

Hadri (2000) assumes the following model:

\[ y_{it} = r_{it} + \varepsilon_{it} \]  \hfill (C3:1)

and

\[ y_{it} = r_{it} + \beta_t + \varepsilon_{it} \]  \hfill (C3:2)

And \(r_{it}\) is a random walk:

\[ r_{it} = r_{it-1} + u_{it} \]  \hfill (C3:3)

Where \(u_{it}\) and \(\varepsilon_{it}\) are independent of each other with normal distributions and i.i.d. over \(i\) and \(t\).

The model (C3:1) is regressed on an intercept and (C3:2) is regressed on an intercept and a linear trend term. Their respective residuals are \(\hat{\varepsilon}_{it}^\mu\) and \(\hat{\varepsilon}_{it}^\tau\). A consistent estimator of the error variance is:

\[ \hat{\sigma}_{\varepsilon}^2 = \frac{1}{N(T-1)} \sum_{i=t}^N \sum_{t=1}^T \hat{\varepsilon}_{it}^{2\mu} \]

And

\[ \hat{\sigma}_{\varepsilon}^2 = \frac{1}{N(T-2)} \sum_{i=t}^N \sum_{t=1}^T \hat{\varepsilon}_{it}^{2\tau} \]

The partial sum process of the residuals is:

\[ S_{it}^l = \sum_{j=1}^t \hat{\varepsilon}_{ij}^l, \quad l = \mu, \tau \]

The LM statistics is:

\[ LM_t = \frac{\frac{1}{N} \sum_{i=1}^N \frac{1}{T-2} \sum_{t=1}^T S_{it}^{2\mu}}{\hat{\sigma}_{\varepsilon}^2} \]

The test statistics proposed by Hadri is a standardized version:

\[ Z_\mu = \frac{\sqrt{N}(LM_t - \xi_\mu)}{\zeta_\mu} \rightarrow N(0,1) \quad \text{and} \quad Z_\tau = \frac{\sqrt{N}(LM_t - \xi_\tau)}{\zeta_\tau} \rightarrow N(0,1) \]

Mean and variance of the random variable \(Z_\mu\) are \(\xi_\mu = \frac{1}{6}\) and \(\zeta_\mu^2 = \frac{1}{45}\) and for the random variable \(Z_\tau\) the mean and variance is \(\xi_\tau = \frac{1}{15}\) and \(\zeta_\tau^2 = \frac{11}{6300}\).
Appendix D: Dynamic OLS estimator

The DOLS estimator proposed by Stock and Watson (1993) is suitable for I(d) variables with component of general deterministic nature. The model for the cointegrated systems is a triangular representation. The authors motivate the estimator as Gaussian Maximum Likelihood Estimations (MLE) and employ their own parameterization of the representation compared to the estimators previously proposed. The estimator is asymptotically equivalent to the Johansen- and Ahn-Reinsel estimator.

Variables are here assumed to be I(1) and hence share one cointegrating vector. In this case, the dependent variable is regressed on simultaneous levels of the other variables, leads and lags of the first difference of all independent variables and a constant. The model presented here is for I(1) variables, an extension to the case of I(d) is available in the paper by Stock and Watson (1993). The paper provides a more detailed description of the data generation process, assumptions and the estimator which is recommended for the interested reader as this overview does not go into detail.

We have an n-dimensional time series where the r individual elements are I(1) and denote this n x r matrix $y_t$. Assume $E(\Delta y_t) = 0$ and further that the r cointegrating vectors are $\alpha = (-\theta, I_r)'$. $\theta$ represent the unknown parameters in the $r \times (n-r)$ submatrix and $I_r$ is the $r \times r$ identity matrix. The matrix of $y_t$ is separated as $(y_t^1, y_t^2)$ where $y_t^1$ is $(n-r) \times 1$ and $y_t^2$ is $r \times 1$. The term $u_t$ is $(u_t^{1'}, u_t^{2'})'$ and is a stationary, linearly regular and stochastic process. The variable $u_t$ is further supposed to be Gaussian for the moment in order to allow the development of $\theta$ to be Gaussian MLE.

The two-sided triangular representation can be described as follows.

\[
\Delta y_t^1 = u_t^1 \quad \text{(D.1)}
\]
\[
y_t^2 = \mu + \theta y_t^1 + u_t^2 \quad \text{(D.2)}
\]

Assuming that the error in (D.2) is independent of $u_t^1$, the regression equation can be rewritten:
\[ y_t^2 = \mu + \theta y_{t-1} + d(L)y_{t-1} + v_t^2 \quad (D.3) \]

where \( v_t^2 = u_t^2 - E(u_t^2|\{u_t^2\}) \) \hspace{1cm} (D.3:1)

Making some additional assumptions, the Gaussian likelihood is factored following this notation:

\[ f(Y^1, Y^2|\theta, \lambda_1, \lambda_2) = f(Y^2|Y^1, \theta, \lambda_2)f(Y^1|\lambda_1) \quad (D.4) \]

Where \( \lambda_1 \) denotes parameters of the distribution of \((u_1^1, ..., u_T^1)\) and \( \lambda_2 \) denotes \( \mu \), the parameters of \( d(L) \) and of the parameters of \((v_1^2, ..., v_T^2)\). The conditional mean of \( y_t^2 \) incorporates past and future values of \( y_t^1 \). Estimation and inference can be made in the Gaussian system of expressions (D.3) and (D.4). Hence, by making the assumption of no restrictions between \( \lambda_1 \) and \( [\theta, \lambda_2] \) making \( Y^1 \) auxiliary to \( \theta \), inference can be made conditional on \( Y^1 \). By maximizing \( f(Y^2|Y^1, \theta, \lambda_2) \) the MLE of \( \theta \) is obtained. This allows for \( \theta \) in the regression equation (D.3) to be estimated using OLS (due to asymptotic equivalence to the GLS).

The estimator can be generalized to the I(d) scenario in which case the estimator is denoted as:

\[ \hat{\delta}_{DOLS} = \left[ \left( \sum_t z_t z_t' \otimes I_{k_1} \right)^{-1} \left( \sum_t z_t \otimes I_{k_1} \right)(\Delta^{d-l+1}y_t^1) \right]^{-1} \]
Appendix E: Estimation Results

Dynamic OLS[-1,1] estimation with time and country fixed effects

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Africa, Asia, South America and the Caribbean, MENA

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<td>11.211 (0.003)</td>
<td>2.436 (0.575)</td>
</tr>
<tr>
<td>(\text{Centered R2})</td>
<td>0.868</td>
<td>0.959</td>
<td>0.857</td>
<td>0.948</td>
<td></td>
</tr>
<tr>
<td>(\text{Observations})</td>
<td>435</td>
<td>327</td>
<td>290</td>
<td>210</td>
<td></td>
</tr>
</tbody>
</table>