LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

MASTER

MONETARY AND FINANCIAL ECONOMICS

MASTER´S FINAL WORK

DISSERTATION

PENSION FUNDS ASSET ALLOCATION - AN INTERNATIONAL ANALYSIS

MARCO ANTÔNIO RODRIGUES

OCTOBER - 2019

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MARCO ANTÔNIO RODRIGUES

SUPERVISION:
MARIA TERESA MEDEIROS GARCIA

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To my parents.

GLOSSARY

CIS – Collective Investment Schemes.

DB – Defined Benefit Pension Plan.

DB – Defined Benefit Pension Plan.

GDP – Gross Domestic Product.

IASB – International Accounting Standards Board.

NDC – Notional Defined Contribution.

PAYG – Pay–As-You-Go.

OECD – Organisation for Economic Co-Operation and Development.

USD – United States Dollar.

ABSTRACT, KEYWORDS AND JEL CODES

A wide-ranging amount of papers on the topic of this dissertation were published in the last decades, and the importance of this subject has taken great proportions in the global debate. The fiscal challenges faced by governments around the world, the relative fragility of the global financial system, the ageing of the population and even the evolution of labour activities are arguments of strong impact on the challenge of post-retirement income assurance. In this context, the assignment of engaging pension funds in the complex compliance of their liabilities - the central pillar of the raison d'être of such funds, is even more evident.

This dissertation provides new insights on the essential question about pension fund asset allocation and its consistency with the fundamental economic theory assumptions. The research consists of an empirical confirmation through linear regression calculations, where the investment rate of return was established as the central variable and dependent on the indicative variables of asset allocation in equity and asset allocation in bills and bonds, using ten years' worth of data, specifically for the period from 2008 to 2017 and hereinafter recalculating for a longer period of fifteen years, i.e. from 2003 to 2017.

The most reliable results suggest that for a specific group of countries, where defined benefit (DB) type of pension funds represents the majority of assets, in a long-term scenario with widespread crisis damage, it is possible to construct an explanatory model where the investment rate of return responds positively to higher asset allocation in equity. Nonetheless, this finding is inverted when we consider the imbalances and distortions in the market resulting from financial crises. Still for this specific group of countries, higher bonds supply plus losses in stock markets may lead to portfolio rebalancing, with better results in this case for assets allocation in bonds.

KEYWORDS: Pension funds; Assets allocation; Production Function.

JEL CODES: F02; F36; J11; J32.

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Finally, I am grateful to my sister Ana Paula Rodrigues for the inspiration and for making me proud every day.

And although I have had the opportunity to study for several years in internationally recognized institutions, to work and negotiate with large multinational business groups, to travel to various countries and to live with great teachers, the most important knowledges that I have ever learned in my life, I learned from a farmer and a school cook. From the farmer I learned the value of hard work and effort, and from the school cook I learned the value of true love… for life, for people, for living. Thank you so much to my father and mother, Dirceu Rodrigues and Clerícia Santos.

PENSION FUNDS ASSET ALLOCATION - AN INTERNATIONAL ANALYSIS

By Marco A. Rodrigues

1. INTRODUCTION

The heterogeneity of pension funds around the world is very significant, both in terms of asset size and the manner these assets are invested. There are countries where these assets represent a small fraction of Gross Domestic Product (GDP), while there are economies where pension fund assets are more than twice the total size of whole GDP. This heterogeneity is formerly explained by main factors such as age structure of the population, financial system maturity or stability, legislation, specifically regulation of the social security system and even by cultural behaviour of the society in question.

There is also diversity in the strategy of asset allocation among countries with the main investments being in equities, bills and bonds and mutual funds, which are in general composed for equities or bills and bonds, as well. To a lesser extent, pension funds usually invests in other business categories such as real estate, unallocated insurance contracts, hedge funds, loans, private equity funds, land and buildings, or remains under cash and deposits.

Extensive amount of papers on the topic of this dissertation were published in the last decades, and the importance of this subject has taken great proportions in the global debate. The fiscal challenges faced by governments around the world, the relative fragility of the global financial system that is constantly at risk of collapse, the ageing of the population and even the evolution of labour activities are arguments of strong impact on the challenge of post-retirement income assurance. In this context, the assignment of engaging pension funds in the complex compliance of their liabilities - the central pillar of the raison d'être of such funds, is even more evident.

The adopted asset allocation dynamics by these funds is therefore noticeably relevant, and the understanding of the construction of these portfolios on an international scale is the main motivation for the dataset study conducted hereby. The essential question we pursued to answer is whether pension fund asset allocation was consistent with the fundamental economic theory assumptions.

Two leading papers served as a theoretical basis for this study, the classic Asset Allocation Dynamics and Pension Fund Performance (Blake, Lehmann and Timmermann, 1999) and the most contemporary Asset Allocation Dynamics of Pension Funds (Bams, Schotman and Tyagi, 2017). The purpose of this research consisted of an empirical confirmation through linear regression calculations, where the investment rate of return was established as central variable and dependent on the indicative variables of asset allocation in equity and asset allocation in bills and bonds.

Chapter 2 is an overview of the funded and private pension systems, contains a literature review on this topic and introduces a couple of relevant consolidated facts. Chapter 3 covers data collection and preliminary analysis, followed by the methodology of this investigation. We present the empirical results in Chapter 4, and the conclusion in Chapter 5.

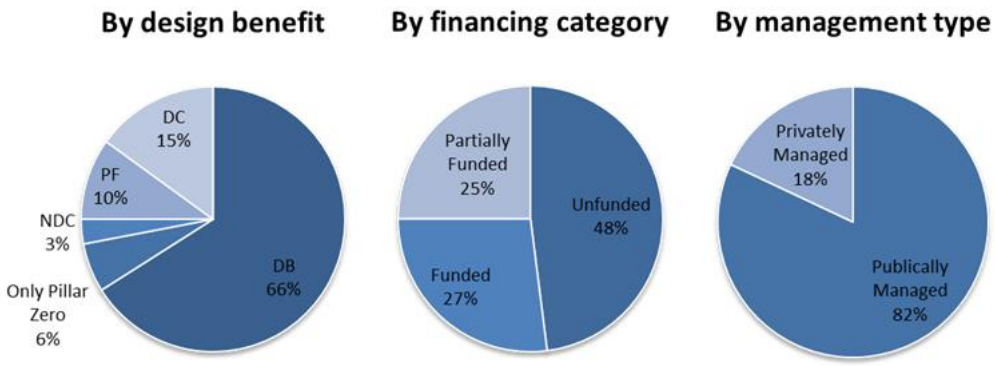
2. Overview of Funded and Private Pension Systems

According to several authors and definitions from international organizations, we can distinguish pension systems around the world in countless ways. The main criteria for this classification are conventionally regarding the how benefits are calculated, how benefits are financed, or who manages the system. From the macroeconomic point of view we can classify the countries by pension modalities, by how many pension pillars they have, or by whether they have integrated pension systems.

More specifically, Pallares-Miralles, Romero and Whitehouse (2012) in a work paper of the World Bank establish that the essential architecture of pension systems may be defined considering particular fundamental points. These are basically: (i) The basic form of the benefit promise - whether the systems is Defined Benefit (DB), Defined Contribution (DC) or a hybrid arrangement such as Notional Defined Contribution (NDC) systems; (ii) How the benefits are financed – whether this is done on a full or partial Pay–As-You-Go (PAYG) basis or if they are Fully Funded (or capitalized) in advance, or (iii) Whether the system is managed by Public or Private Institutions.

Given this classification, their report indicates that around 65 percent of all mandatory national pension systems worldwide are DB systems and more than 70 percent of all national pension systems are publicly-managed. Nonetheless many countries have been moving towards multipillar pension systems worldwide, notably for DC scheme.

In order to illustrate this composition worldwide, Figure 1 shows the distribution in terms of the three primary classification criteria. The data are from 2005 and was taken from another work paper also on behalf of the Word Bank, by Holzmann and Hinz, referred in Pallares-Miralles, Romero and Whitehouse (2012), based on 176 observations of national mandatory pension schemes.



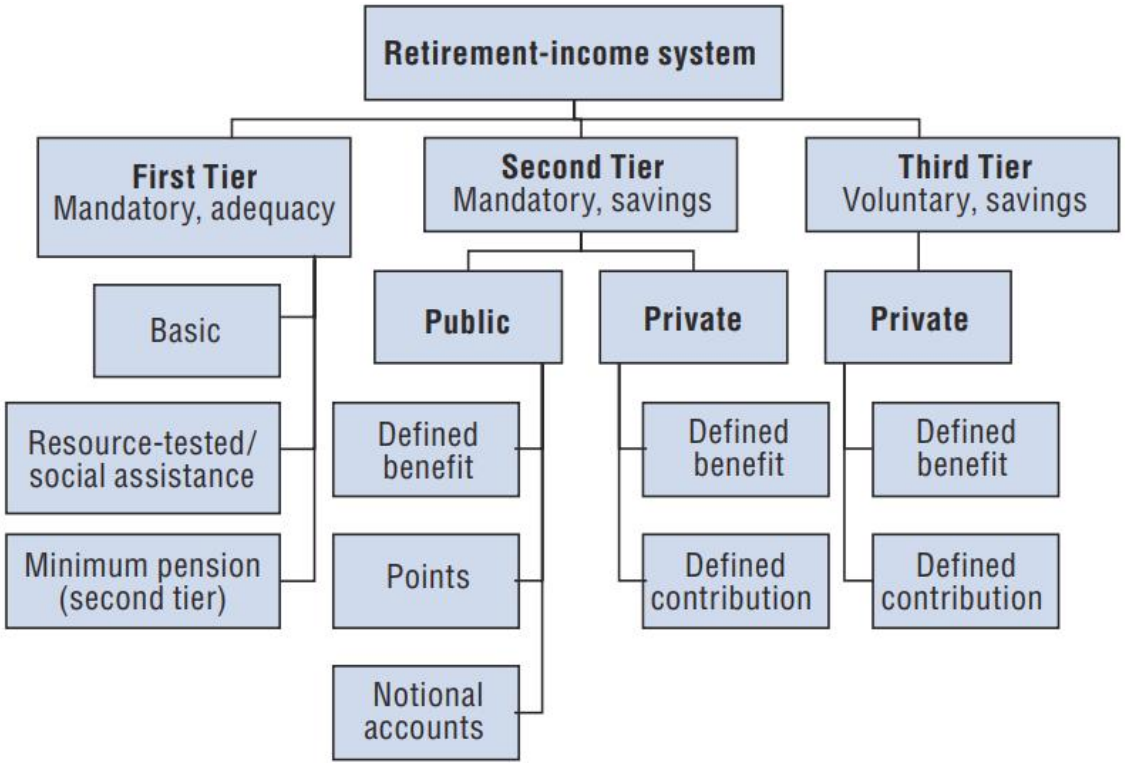
Source: Pallares-Miralles et al., 2012, p. 35.

FIGURE 1 – Pension Schemes by benefit design, financing category, and management type, 2005.

In 2005 the World Bank proposed a classification for pension system components into five pillars: (i) a non-contributory, called "zero pillar"; (ii) a mandatory earnings based, "first pillar"; (iii) a mandatory saving based, "second pillar"; (iv) a complementary voluntary, "third pillar"; and (v) a non-financial "fourth pillar". The middle three pillars are the most important to understand the global architecture of pension system.

The "zero pillar" is addressed to poverty prevention, the "first pillar" is characterized for being publicly managed pension schemes with defined benefits and Pay-As-You-Go (PAYG) finance, and the "second pillar" can be private or public arrangements, even so they are nearly exclusively fully-funded privately. These are distinguished from other complementary voluntary savings systems by their mandatory nature and by being explicitly organized as specialized pension savings schemes rather than general contractual savings vehicles. The last two are voluntary arrangements that are not formally integrated into most mandatory social security systems.

FIGURE 2 below shows the World Bank multi-pillar framework simplified schematically. For purpose of our empirical study, only the second and third pillars will be treated in this dissertation, more specifically, only funded pension system. Funded pension plans are on the other hand occupational or personal pension plans that accumulate dedicated assets to cover the plan's liabilities. Assets assigned by law or contract to the pension plan, being their use restricted to the payment of pension plan benefits.



Source: Onoda & Reilly, 2017, p. 87.

FIGURE 2 – World Bank multi-pillar framework

All these definitions and classification might vary according to the institution or according to the publication date of documents. We attempt to contemplate the most current terms and definitions, and from international institutions, such as World Bank and OECD.

2.1. Defined Contribution and Defined Benefits Plans

The classification of plans by benefit design is one of the most elementary in all literature on the subject. Within the funded and private pension systems group this is the main distinction between plans. The most common are the so-called DC, the DB and hybrid or mixed plans that are a sort of associate of the first two, as mentioned previously.

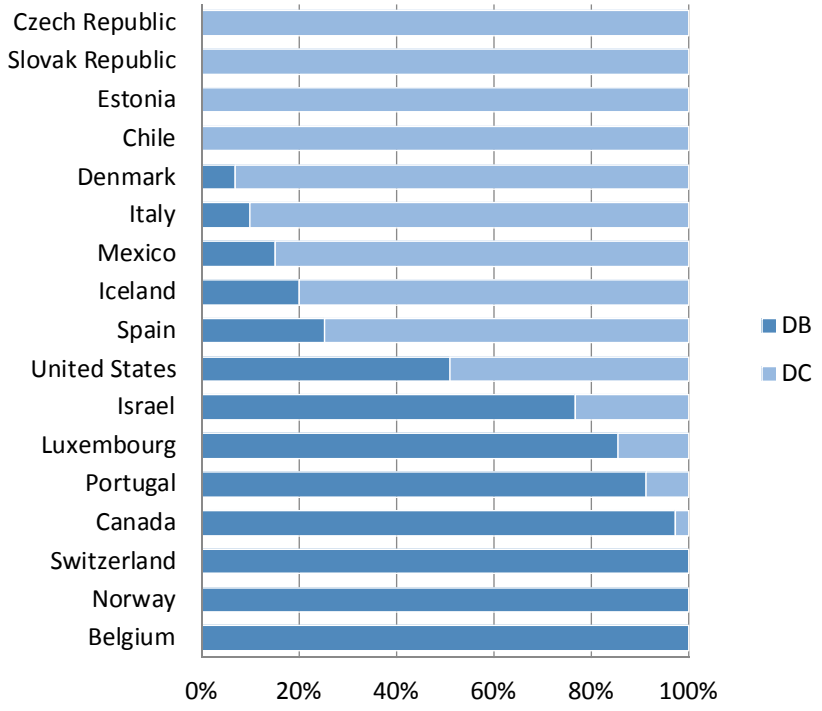
Plans may be personal or occupational, the latter being more common because of their remunerative characteristics. These plans are managed by regulation intended to protect employee benefits and they may offer tax advantages to the employer and employee to encourage sponsorship and participation respectively.

According to OECD definition, in line with the IASB's definition, DC occupational pension plan are basically occupational pension plans under which the plan sponsor pays fixed contributions and has no legal obligation to pay further contributions to an ongoing plan in the event of unfavourable plan experience. In other words, the value of the contributions is settled but there is no specifically statement about the accrued future value other than the principal itself and interest (OECD, 2005).

To continue, DB are occupational plans other than defined contributions plans, classified into one of three main types, "traditional", "mixed" and "hybrid" plans. The "Traditional" is a plan where benefits are linked through a formula to the members' wages or salaries, length of employment, or other factors. There is extensive legislation that is aimed to assure members the payment of the accrued benefits. According to the definition by Broadbent et al. (2006), workers accrue a commitment of monthly payment from the date of their retirement until their death, or, in some cases, until the death of their spouse. The promised life annuity is generally based on a formula linked to an employee's wages or salary and years of tenure at the sponsoring firm. Such annuities are linked to inflation rates and minimum legal guarantees. As well as social security all systems are correlated to demographic factors and have several rules like for early retirement, benefit of dependents and deferred benefit. Sponsors, in turn, need to provide actuarial calculations in order to meet their liability which they aim to cover in the asset management.

By the OECD (2005) definition, "Hybrid" DB plan in its turn are plans where the benefits depend on a rate of return incident to contributions and this rate of return is either established in the plan statement, independently of the actual return on any assets, or is calculated with reference to the actual return of any supporting assets and a minimum return guarantee specified in the plan rules. And finally, "Mixed" DB plans are plans that have two separate DB and DC components but which are treated as part of the same plan.

The preferences in terms of type of design around the world may change widely. We can see in FIGURE 3 the geometric mean of the split of pension fund between DB and DC plans in selected OECD countries, as percentage of total assets, regarding to fifteen years, from 2003 to 2017.



Source: Calculated from OECD data.

FIGURE 3 – Split of pension funds between DB and DC, 2003-2017 (as a percentage of total assets).

The selected countries are those for which we have split information between the two types of plans for the period indicated, within the list of countries already chosen for the main calculations. It is noteworthy that many countries have their unique composition of one type of plan, either DB or DC, and also many others presenting both in their composition. This dispersion is also noticeable in a larger group of countries, besides those selected here. Nevertheless it should be noted that there is nowadays a full range of plans between traditional DB plans and individual DC, for which the features may be closer to these but all have some risk sharing components between the different parties.

There is no automatic indication of preference given to a particular characteristic of the country under study and for purpose of this dissertation, such preference is not relevant, at least in a first moment. Nonetheless there are indications that can justify these trends or at least suggest, with changes in the regulation of pension funds industry being the main motivator.

Several countries have recently undergone reforms to their social security systems and many more reforms are expected in the coming years as population structure changes, as well as due to various other factors such as the nature of occupations, replacement of workers by robots or even old problems as fiscal challenges in the public budget. As regard to the movement already observed, a significant increase in the DC planes is noticeable, while the DB planes have been showing unchanged levels or declines, showing a great inclination for a displacement in this direction.

The main feature regarding to this transition from DB to DC plans in private sector pensions is that this movement is shifting investment risk from the corporate sector to households. Households are therefore becoming increasingly exposed to financial markets, and retirement income may be subject to greater variability than before. According to Broadbent et al. (2006), in an IMF study, this is not only the case in countries with a mature occupational pension system, but also in emerging markets, where pension reforms are adopting a structure predominantly based on that of DC or hybrid schemes.

Broadbent et al. (2006) say:

> Countries that have recently moved to funded occupational pensions (e.g., Spain and Italy within the OECD and Poland, Czechoslovakia and Hungarywithin eastern Europe) have tended to favour a system based on DC or hybrid arrangements. Within emerging market countries Malaysia has recently adopted a DC arrangement and Chile and Singapore are noteworthy in having longstanding DC pension systems.
>
> In: Broadbent et al. (2006) p. 11.

2.2. Asset Allocation of pension funds

Similarly to the points already mentioned so far about the dispersions in specific characteristics of pension funds around the world, their asset allocation strategies are also quite variable. The main investments are essentially in equities in the financial market, bills and bonds issued by government or corporates, and mutual funds, which are in general composed for equities or bills and bonds, as well. To a lesser extent, pension funds usually invests in other businesses category such as real estate, unallocated insurance contracts, hedge funds, loans, private equity funds, land and buildings, or remains under cash and deposits.

The work published by Blake, Lehmann and Timmermann (1999) is a pioneer in analysing the domination of managed portfolio returns by the component attributed to the strategic asset allocation decision. In the immediate initial lines of their publication, the authors quote the chairman and founder of the Vanguard Group of mutual funds, the North American Jack Bogle.

Bogle (1994) quoted by Blake, Lehmann and Timmermann (1999) said:

> The most fundamental decision of investing is the allocation of your assets. How much should you own in stocks? How much should you own in bonds? How much should you own in cash reserves? According to a recent study, that decision has accounted for an astonishing 94 percent of the differences in total returns achieved by institutionally managed pension funds.
>
> In: Blake, Lehmann and Timmermann (1999) p. 1.

The study that Bogle referred to in his book, and quoted above, is one of only two in-depth on the topic at that time. Since then, several other authors have contributed on this regard, and the publication by Blake, Lehmann and Timmermann (1999) is still quite referenced today. The main point in their study is precisely to measure the impact of pension funds asset allocation strategy on their performance, or namely on their real rate of return on investment.

The publication by Blake, Lehmann and Timmermann (1999) restricts his study to a database uniquely regarding to UK pension funds, and thus highlights some specific features of that country's pension fund industry at that time, which in fact cannot be said to be similar to the characteristics of the pension fund industry of the other countries analysed here.

According to the authors, at that time, UK pension fund managers undoubtedly experienced the smallest set of externally-imposed restrictions and regulations on their investment behavior of any group of institutional investors anywhere in the world. So they were unconstrained by the pension funds liabilities, which in turn had large actuarial surpluses until almost the end of the studied period. In addition, trustee sponsors interfered very little in their asset strategy allocation, unlike many of their counterparts in continental Europe and elsewhere. Appropriately they say that the empirical regularities

they observe in those data were consequence of the incentives arising from the industrial organization and regulatory environment facing the UK pension fund industry.

Having made such considerations, the conclusion in their paper was an existence of little cross-sectional variation in average *ex post* returns to strategic asset allocation, market timing, and security selection.

Nevertheless, modelled long-run asset allocations, account widely for the time series variation in returns, which provide more empirical support for the quote they refer at the beginning of the paper, and which replicated here. Notwithstanding, they believe that this finding reflect more on managerial behavior than on the economic role of asset allocation decisions (Blake, Lehmann and Timmermann, 1999).

Bams, Schotman and Tyagi (2017) in their turn investigated the dynamics of asset allocation focusing on portfolio rebalancing. This is an important point to keep in mind, once past return influence the pension fund portfolio allocation, i.e. realized returns on different asset classes will lead to changes in actual portfolio weights.

To Bams, Schotman and Tyagi (2017), if pension funds chose not to fully rebalance such mechanical variations, they would then be, as they say, "moving with the market" or behaving pro-cyclically. Papaioannou *et al.* (2013) find out that US Pension funds engaged in pro-cyclical investment action during the financial crisis, started in 2008. In a detrimental strategy for their performance, they were selling equities when the equity prices were low and expected returns were high.

Furthermore, considering that pension funds as huge institutional investors represent a bulk part of the economy, being their assets as large as the GDP of the country, the described behaviour can trigger off serious consequences for the stability of the financial system, as well as, can be detrimental for all the real economy (Bams, Schotman and Tyagi, 2017).

After crisis, at the beginning of 2009, we can find the following in an OECD report:

> Pension funds can have a role as "market stabilisers", smoothing out fluctuations in prices by selling when markets are high and buying when they are low. However, in this latest crisis, some pension funds have sold part of their equity portfolios. In some countries, pension funds have reacted to the crisis by allocating new pension contributions to bank deposits and other instruments with government guarantees until the situation in capital markets stabilises.

In: OECD (*OECD Private Pensions Outlook 2008*, 2009), p. 20.

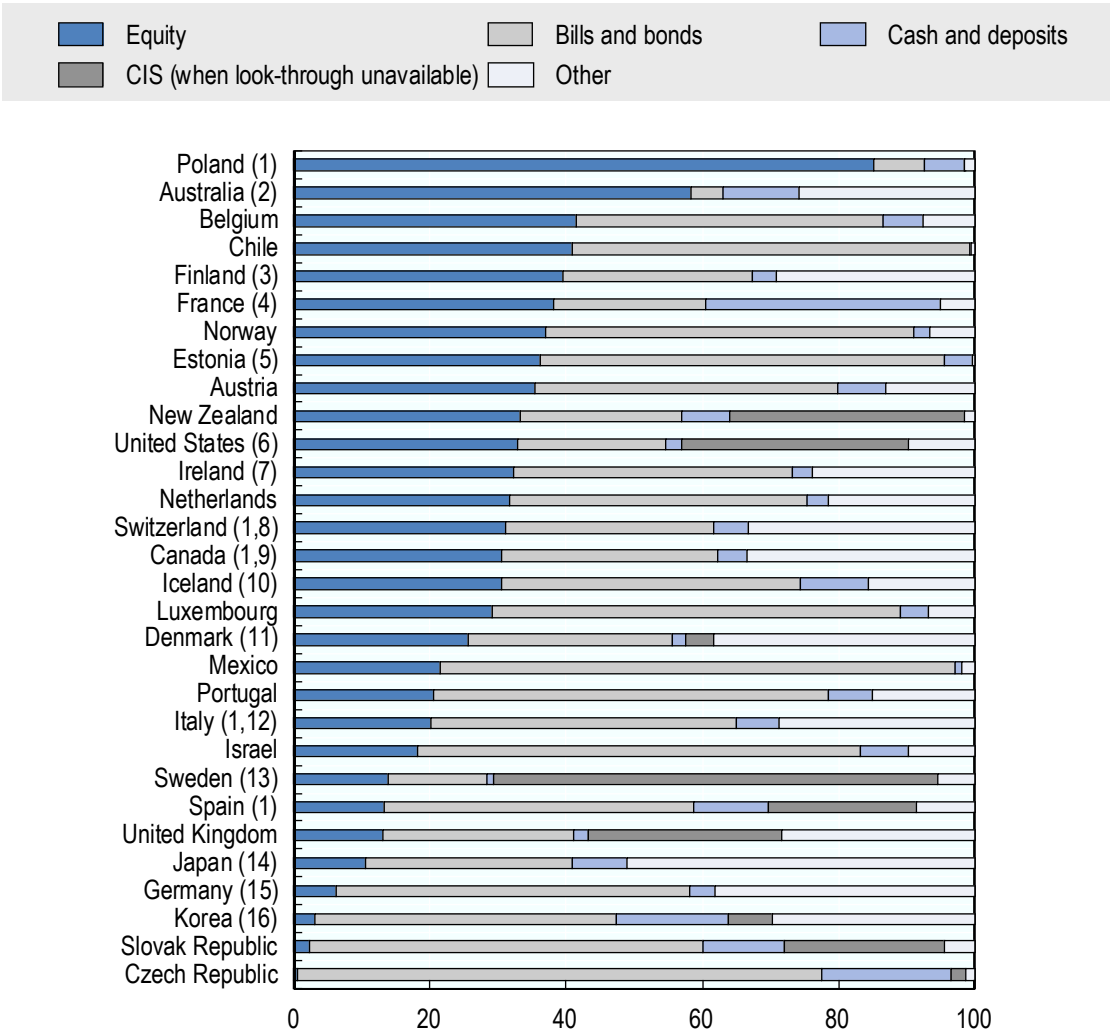
Raddatz and Schmukler (2012), mentioned by Bams, Schotman and Tyagi (2017), find that mutual funds transmit shocks internationally by their pro-cyclical behavior. However lastly, pension funds in particular can benefit from being contrarian as they have long investment horizons. As stated in Raddatz and Schmukler (2012), managers adjust country weights over time actively, although there is significant short-run pass-through from returns to these weights. Moreover, according to them, capital flows from mutual funds do not suggest to have a stabilizing role and therefore make vulnerable to foreign shocks those countries in their portfolios.

Yet as reported by Bams, Schotman and Tyagi (2017), annually pension funds rebalance on average about 80, 90% of the passive equity variation in the portfolio. However, part of the change in equity weights can be associated to passive change due to realized returns. They also find that on average between 10 and 20% of passive change is not rebalanced and contributes for the actual change in the equity portfolio weight. In line with what we already mentioned, they observe strong rebalancing following shocks like those of 2001 and 2008. In those case, it is suppose that funds choose to rebalance their portfolio to ensure that actual asset allocation match strategic asset allocation. In an alternative scenario they can choose not to rebalance the portfolio in attempt to capitalize on any perceived change in the time-varying investment opportunity set.

An important point we have noticed in the calculations, and what will be better addressed in the next session, is the difference in results when taking into account groups of countries with different characteristics as for instance the relevance of the industry, namely in terms of pension funds' assets as a percentage of the GDP, or the prevalence of plans classified by type, namely being DB or DC. At this point, Bams, Schotman and Tyagi (2017), say that they only find statistically qualified support for cross-sectional differences in rebalancing speeds. Their results indicate also that US and defined benefit funds are less likely to rebalance fully and they did not find evidence that the size of a pension fund is a determining factor.

The composition of the pension fund portfolio has changed so that it reflects risk aversion over a given period. We can see the allocation of pension assets in selected countries in FIGURE 4 below, as it was in the end of 2017. The preference in most countries

for allocation in equities or bills and bonds is evident, although of course some countries like France and Japan choose to keep their assets in cash and deposits or another categories.



Source: Pension Markets in Focus No.15, 2018 - OECD[1].

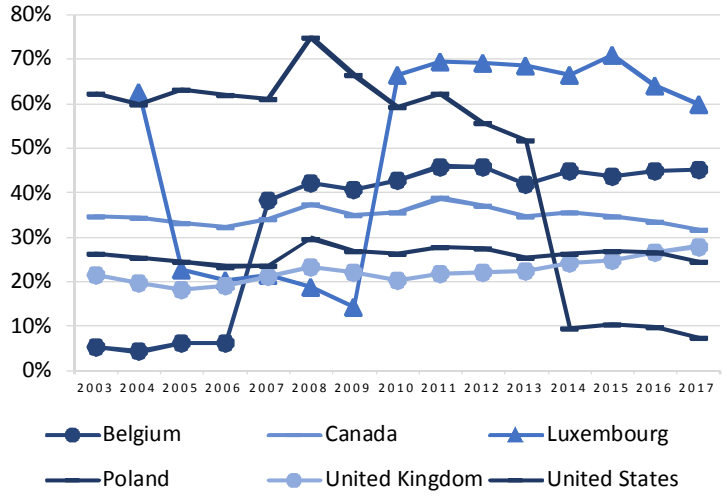
FIGURE 4 – Allocation of pension assets in selected investment categories, 2017

(as a percentage of total investment)

We can see the trajectory of the percentage of pension funds' assets allocated in bills and bonds issued by public and private sector, as well as, the percentage regarding to the assets allocation in equities in FIGURE 5 and FIGURE 6, respectively[2]. There is large fluctuation in the period related to the financial crisis as expected (first signs in 2006),

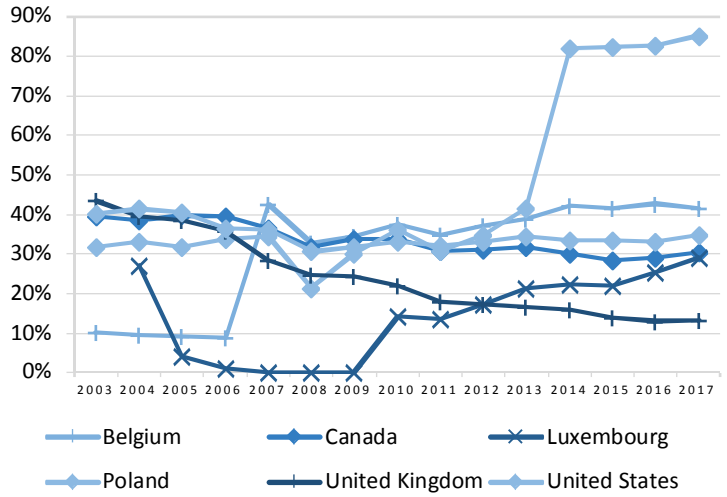
[1] Extensive methodological notes by OECD are in the document referred in References.
[2] The asset definition used, in line with OECD parameter, will be better detailed in the next section.

although situations such experienced by Poland, in 2013, namely a reform in the public pension system may represent huge influence in the shape of the portfolio. On that occasion, the size of the Polish pension funds industry decreased, along with the proportion of assets to GDP falling down from 18.3% in 2013 to 8.8% in 2014 (OECD, 2019).



Source: OECD Global Pension Statistics.

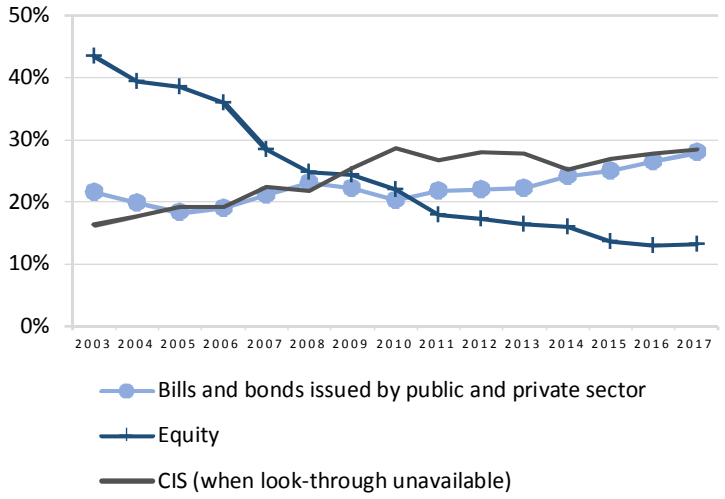
FIGURE 5 – Percentage of pension funds' assets allocated in **Bills and Bonds** issued by public and private sector



Source: OECD Global Pension Statistics.

FIGURE 6 – Percentage of pension funds' assets allocated in Equities

Lastly, in a more localized analysis, FIGURE 7 shows the behaviour of the portfolio in the United Kingdom, for illustration. We can see an evident transition in preferences, by shifting equities investment to bills and bonds, with the reversal point around the year of 2009, although emphasizing an earlier tendency.



Source: OECD Global Pension Statistics.

FIGURE 7 – Pension funds' assets allocation in the United Kingdom

3. DATA AND METHODOLOGY

3.1. Data Collection

The adopted data to carry out this study are those available in the OECD database. They were obtained through two main ways: the main variable managed in this investigation, namely real geometric average annual investment rates of return of pension assets, net of investment expenses, over the last ten and fifteen years was obtained in the annual report named Pension Markets in Focus No. 15, 2018. Further data, such as allocation of pension assets, total assets in funded and private pension arrangement as a percentage of GDP and split of pension assets by type of plan, were extract directly from the data base available online. A few reasonable adjustments were made in the raw data in order to accommodate the calculation, howbeit carefully in line with the methodology and classification applied in the OECD reports, and detailed afterwards in this section.

The criteria for selecting countries in pursuance of investigation was precisely the availability of the required information. The countries in the central sample are twenty-one selected countries from the mentioned main report, and those with poor information were discarded in order to build a statistically solid sample base.

Furthermore, auxiliary reports annually published by OECD, such as "Pensions Outlook", "Pension at Glance", "Pension Markets in focus", "Pension Funds in figures", and their parallel data base were likewise taken into consideration towards endorsement of raw data and some conclusions.

3.2. Preliminary data analysis

Starting with reading the geometric average annual investment rates of return of pension assets of selected countries in the OECD report, shown in FIGURE 8, we can notice that there are no major cross-sectional divergences between those economies, especially when considering longer-term data. Canada is responsible for the best performance reported with a real annual rate of 5.5%, while the worst performance is that related to Latvia, which has an annual average decrease of 0.5%, a difference of only six percentage points.

A couple of preliminary notes are appropriate. The first is that there are few countries with negative performance among those selected. In the ten-year analysis there are only three cases and if we look at the short term, for five years, only two. The second observation is that the difference between countries' nominal and real rates of return is not significantly large, suggesting that the selected countries are relatively similar in terms of price stability in the economy.

	Nominal			Real		
	5-year annual average	10-year annual average	15-year annual average	5-year annual average	10-year annual average	15-year annual average
Australia	9.6	4.9	6.7	7.5	2.5	4.2
Austria	4.8	2.9	4.0	3.3	1.1	2.0
Belgium	6.4	3.9	6.1	5.1	2.1	4.0
Canada	8.1	5.6	7.3	6.5	4.0	5.5
Chile	7.5	5.1	7.4	4.0	2.0	4.1
Czech Republic	1.1	1.6	2.3	-0.1	-0.1	0.2
Denmark	5.3	5.8	6.3	4.6	4.4	4.7
Estonia	3.2	1.0	3.0	2.1	-1.3	-0.2

Finland	6.3	..	..	5.6	..	..
Germany	4.0	3.9	4.1	2.9	2.6	2.6
Hungary	6.8	..	..	5.9	..	..
Iceland	7.1	5.6	8.1	4.8	0.8	3.2
Israel	6.0	5.5	..	5.9	4.0	..
Italy	3.5	3.0	3.7	3.0	1.7	2.0
Korea	3.5	4.0	4.1	2.3	1.8	1.6
Latvia	2.9	2.6	3.5	2.0	0.5	-0.5
Lithuania	4.8	..	..	3.7	..	..
Luxembourg	3.9	2.9	..	2.9	1.3	..
Mexico	4.8	6.2	..	0.7	1.9	..
Netherlands	7.1	6.0	6.9	6.0	4.4	5.3
Norway	7.0	5.3	6.7	4.6	3.2	4.7
Portugal	4.1	2.1	4.5	3.5	0.9	2.8
Slovak Republic	2.1	1.2	..	1.7	-0.3	..
Slovenia	6.0	5.9	..	5.5	4.6	..
Spain	4.4	3.0	..	4.0	1.7	..
Switzerland	4.9	3.0	3.9	5.1	3.0	3.5
Turkey	8.1	9.9	..	-0.8	1.3	..
United States	5.7	2.1	3.9	4.2	0.5	1.7

Source: OECD Global Pension Statistics.

FIGURE 8 – Nominal and real geometric average annual investment rates of return of pension assets, net of investment expenses, over the last 5, 10 and 15 years (from Jan2013/2008/2003 to Dec2017 - In per cent)

Regarding the size of the industry, as we can see in FIGURE 9 in the appendix, among the thirty-six countries of the organization, the total assets in funded and private pension represents on average half the size of the economy's total GDP (the simple average is specifically 50.7%). Eight countries have total assets greater than the total GPD, and Denmark's total funded and private pension assets represent more than twice the total GDP of that country. In general, the countries with highest GDP per capita stand out with larger amounts of pension funds' assets, both in nominal terms and in comparison to the total size of the economy, although as already mentioned, several other factors are relevant in the association of this magnitude.

In fact, the industry does move a considerable amount of resources. The amount invested was over one trillion of USD in seven OECD countries in 2017, as we can see in TABLE I in the appendix which also shows the amounts of the historical sequence over the last ten years. In 2017, the total of investment represented more than USD 43 trillion, which reinforces the argument of how representative the sector is in the global economy.

For the purpose of this investigation, the calculations were made in four different scenarios (TABLE II). Conductive to group countries with similar characteristics, four sample combinations were tested first using data from the last 10 years (from 2008 to 2017) and recalculated hereafter using data from the last 15 years (from 2003 to 2017) when available. The attribute elected for this grouping are evidently within the universe of pension funds and were designed as follows:

TABLE II

SPLIT OF SCENARIOS – FIRST OBSERVATION (10 YEARS)

Scenario	Countries	Feature
1	21	All sample
2	8	Pension funds' assets represent more than 40% of GDP
3	8	DB Plans represent more than 50% of total assets
4	8	DC Plans represent more than 75% of total assets

For simplicity and also because of the ambiguity that may exist regarding the definition or classification framework, the last two characteristics, namely the prevalence of a type of plan or another are at first relevant only for the combination of sampling. Therefore, they were not handled as explanatory variables in any calculation performed.

Finally, FIGURE 10 explains the investigated countries in each scenario. As already explained, the selected countries are those with the highest data availability. To ensure a statistically favourable condition, a large sample is more appropriate. Notwithstanding as we know, unfortunately this is not always possible given the unavailability or inadequacy of data.

Canada	Chile	Netherlands
Israel	Denmark	Austria
Switzerland	Iceland	Germany
United States	Czech Republic	Slovenia
Belgium	Estonia	Spain
Luxembourg	Italy	
Norway	Mexico	
Portugal	Slovak Republic	

FIGURE 10 – Selected countries for calculations

For research with data for fifteen years, some information was not available for all sampled countries and for this reason these countries were either set aside or replaced. All data management is properly explained in the next chapter corresponding to the results.

3.3. Methodology

In order to find out the interference relation or impact of the asset allocation strategy on the pension funds real investment rates of return, we embrace to perform simple linear regression and multiple linear regression tests using the specialized software Stata. The intention was to identify investment return patterns across countries being a dependent variable on the investment portfolio designs of their assets. Additionally we include in some simulations the variable that measures the size of the pension fund industry of each country, assessing the hypothesis that the investment rates of return may be dependent on the relevance of the sector. The mathematical representation is thus as follows:

(1) $Y = \alpha + \beta X + \varepsilon,$

where Y represents the variable explained (dependent), which is the real investment rate of return of pension assets; α is a constant, which represents the intersection of the line with the vertical axis; β is the inclination (angular coefficient) in relation to the explanatory variable, and is what we are looking for; X stands for the explanatory variable (independent), which in its turn is the percentage of assets invested in equities, the percentage of assets invested in bills and bonds, or the pension funds' assets as a percentage of GDP. And finally ε, which represents all residual factors plus possible measurement errors.

In addition to the regression test, we calculated the correlation index between all variables and interpreted the confidence tests inferred by the software to confirm the statistical relevance of each conclusion presented.

The first step was to obtain data on asset allocation. In the available OECD database we can find the allocation percentages for each type of investment. In our case, the types of investments that interest us are investments in equities and investments in bills and bonds. The database also gathers information on investments in Collective Investment Schemes (CIS) and the look-through of these investments in equities, bills and bonds, cash and deposits and other. For classification purposes, and in line with the OECD approach, data on asset allocation include both direct investment in equities and bills and bonds, and indirect investment through CIS when the look-through of CIS investments is available.

Further on the principal investments that really matter to our investigation, pension funds as well as the above mentioned mutual funds (CIS) may allocate their resources to a wide range of alternative investments which in our case are not relevant. Therefore these investments were categorized all as "CIS (when look-through unavailable)" or merely "other".

The data collected in the OECD database are in annual values and to make them fit for the regression test we calculated the geometric mean of each variable for all countries with respect to ten years, specifically for the period from 2008 to 2017. In the next round of regression, we recalculated the geometric mean of all variables for a longer period, regarding to fifteen years, i.e. from 2003 to 2017. FIGURE 11 shows the calculated geometric mean for the sample of countries, towards to both sets of periods investigated.

Countries	10 years					15 years				
	Asset Allocation				Assets as share of GDP	*Asset Allocation*				Assets as share of GDP
	Equities	Bills and Bonds	CIS (when look-through unavailable)	Other		Equities	Bills and Bonds	CIS (when look-through unavailable)	Other	
Austria	30%	49%		21%	5%	30%	50%		21%	5%
Belgium	38%	44%		17%	5%	29%	28%	75%	17%	5%
Canada	31%	35%		33%	69%	33%	35%		33%	64%
Chile	40%	57%		2%	63%	31%	53%	32%	2%	61%
Czech Republic	0%	84%	2%	13%	7%	1%	83%	1%	13%	6%
Denmark	15%	63%	3%	19%	46%	18%	60%	4%	19%	40%
Estonia	34%	50%		15%	9%	35%	51%	2%	15%	6%
Germany	5%	50%		45%	6%	6%	49%		45%	5%
Iceland	25%	51%		23%	132%	28%	49%		23%	125%
Israel	6%	73%	3%	17%	49%	6%	77%	1%	17%	40%
Italy	15%	46%	9%	35%	5%	13%	43%	10%	35%	4%
Luxembourg	8%	50%	48%	14%	2%			61%	14%	2%
Mexico	19%	79%		1%	14%		81%		1%	11%
Netherlands	35%	44%		22%	141%	37%	42%		22%	129%
Norway	33%	58%		9%	8%	31%	58%		9%	8%
Portugal	20%	51%		28%	10%	21%	47%	22%	28%	10%

Slovak Republic	1%	66%	6%	22%	9%				22%	
Slovenia	2%	60%	14%	21%	5%	2%	63%	9%	21%	4%
Spain	10%	54%	10%	24%	9%	12%	55%	10%	24%	8%
Switzerland	28%	35%		37%	111%	24%	32%	27%	37%	108%
United States	33%	27%	26%	14%	75%	34%	26%	26%	14%	75%

Source: OECD Global Pension Statistics.

FIGURE 11 – Geometric means for asset allocation and size of pension funds industry

Since the rates are geometric means over the years, the total sum of the distribution of assets might not be exactly 100%, especially for the longer period, where it may be more outlying of this value. In contempt of this consideration, the approach still seems appropriate forasmuch as the real investment rates of return are likewise represented as geometric means.

4. RESULTS

The first observation was built from the complete sample, with twenty-one countries, for a period of ten years. The result of the linear regression test issued by Stata indicates modest statistical confidence and it is therefore inconsistent for any conclusions to be drawn. In FIGURE 12 in the appendix we can see a negative coefficient for the allocation of assets in equities, which could suggest a worse performance of funds with higher allocation in this category and this conclusion could be justified by the sub-prime crisis around 2008, beginning of the sample period, when the financial market showed large losses. Nevertheless, the confidence tests, namely F (3,17) and P> | t |, indicate very low suitability in this conclusion. The r-squared of 0.1046 is likewise quite insignificant and the correlation indices are practically zero.

The same regression test was repeated twice using only the equity allocation data in one assessment and only the bill and bond data in the other, with the intention of eliminating the collinearity problem since these are very close variables – i.e. the increase in asset allocation in one may represent the decrease in the other. The results even in this scenario are equally fragile from a statistical point of view.

What may be more suitable concluded is that there is bulky heterogeneity among countries and the investment rate of return in general, and noteworthy in an *ex ante* assessment, was not consistently dependent on the type of allocation of these investments.

We must also give emphasis to the fact that the impacts of the subprime crisis were certainly distinct for each country.

For the fifteen-year observation, the tests indicate slightly higher confidence but still not statistically strong enough. Due to unavailability of data six countries were removed from the sample, namely Israel, Luxembourg, Mexico, Slovak Republic, Slovenia and Spain.

FIGURE 13 in the appendix shows the results expressed and we may note a suggestion that countries with higher equity allocation tend to have higher rates of return on investment, while higher resource allocation in bills and bonds represents worse performance. The correlation indices replicated in TABLE III below also show an inversely similar relationship between allocations in equities and bills and bonds. Here we may also identify that there was a relative relevance of the size of the sector in its performance, larger than the allocation strategy, and the size of the industry being more strongly correlated with the achieved return on investment rates.

TABLE III

CORRELATION BETWEEN VARIABLES (15 YEARS SCENARIO)

	Investment rate of return	Assets in equities	Assets in bills and bonds	Size of the industry
Investment rate of return	1.0000			
Assets in equities	0.3702	1.0000		
Assets in bills and bonds	-0.3062	-0.5506	1.0000	
Size of the industry	0.4364	0.4346	-0.3443	1.0000

Source: Calculation with data from OECD

The second scenario evaluated is precisely grouping the eight countries with the highest proportion of assets as share of GPD. In this case were considered only those countries where pension fund assets account for more than 40% of the total product of the economy.

In both ten-year and fifteen-year observations, the results performed do not have strongly relevant indicative of confidence yet. Saying that, we can notice for the ten-year

period in FIGURE 14 in the appendix that there is a correlation, however low, perfectly inverse for the relationship between investment rate of return and asset allocation in equities (-0.37) and investment rate of return and asset allocation in bills and bonds (0.37). Whereas unlike the first scenario, there is a negative and low correlation to the relevance of industry size.

Looking at the fifteen-year period (FIGURE 15 in appendix), this correlation is by that time quite different, and there is then a better performance in the allocation of equity assets. Due to deprivation of data it was imperative to make two substitutions in the sample, namely Denmark in place of Israel, and Portugal in place of Mexico, to keep the sample with a reasonable number of eight countries (using the initial criteria, namely ranking countries by size of industry). Anyhow we also performed the calculations with the sample containing only six members for which we had data, with no replacement and the results were similar to those described above, with low statistical relevance, as well.

Finally, regarding the third scenario, namely countries with the majority of pension funds allocated in the DB type, it was possible to find out greater statistical relevance in the study. FIGURE 16 in the appendix shows the results.

In the first observation with eight countries, F (3,4) equal to 2.01 together with P> | t | of 0.085 begin to suggest more support, certainly by selecting the sample more consistently, grouping countries with more similar characteristics of the sector. Given the forcefulness of the 2008 financial crisis, the best performance was noticed for those countries with the higher allocation of funds in bills and bonds.

In the scatterplot shown in FIGURE 17 below, we can clearly recognize this relationship, even clearer when we remove Canada from the sample which acts as an outlier in this scenario.

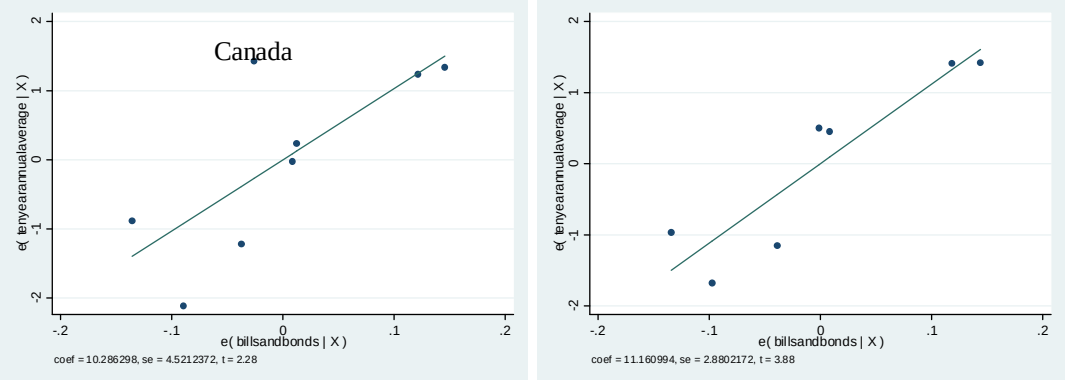


FIGURE 17 – Scatterplots (all sample and removing Canada) – Ten-year period.

Returning to the result whose extract we replicate in FIGURE 18 below, we note that the removal of all outliers (Canada and Portugal) brings considerable statistical consistency to the evaluation. From there we may assume that the performance of pension funds in these countries must have been strongly affected by the sub-prime crisis, being the return on investments for those assets allocated in equities the worst performing and the reverse for those with assets allocated to bills and bonds. The sample without outliers consists except of Israel, in rich European countries plus the United States, and the most governments of these countries intervened strongly in their economies during the post sub-prime crisis period, including by heavily increase in indebtedness through bond issues, and followed by the Quantitative Easing, ongoing asset purchase programme of the European Central Bank (ECB). These facts can be staunchly associated to our results.

Koijen et al. (2016) studied the impact of the European Quantitative Easing on the dynamics of risk exposures and on asset prices and their results suggest that the foreign sector sells most in response to the programme, followed by banks and mutual funds, while the purchases of insurance companies and pension funds were positively related to purchases by the ECB. Their suggestion is that the inelastic demand, or even upward-sloping demand, of insurance companies and pension funds may be due to their desire to hedge the interest rate risk of the liabilities.

```
. correlate tenyearannualaverage equities billsandbonds
(obs=6)
```

	tenyea~e	equities	billsa~s
tenyearann~e	1.0000		
equities	-0.2558	1.0000	
billsandbo~s	0.7331	-0.6087	1.0000

```
. regress tenyearannualaverage equities billsandbonds assetsasshareofgdp
```

Source	SS	df	MS	Number of obs	=	6
				F(3, 2)	=	5.58
Model	7.55256505	3	2.51752168	Prob > F	=	0.1557
Residual	.902435177	2	.451217588	R-squared	=	0.8933
				Adj R-squared	=	0.7332
Total	8.45500023	5	1.69100005	Root MSE	=	.67173

tenyearannualave~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
equities	4.833399	2.887057	1.67	0.236	-7.588605	17.2554
billsandbonds	10.58542	2.69851	3.92	0.059	-1.025332	22.19617
assetsasshareofgdp	1.877	.7940454	2.36	0.142	-1.539502	5.293501
_cons	-4.671874	2.025019	-2.31	0.147	-13.38483	4.04108

`tenyearannualaverage:` Investment rate of return – ten-year average.
`equities`: Percentage of assets allocated in equities.
`billsandbonds`: Percentage of assets allocated in bills and bonds.
`assetsasshareofgdp`: Pension funds assets as a share of GDP.

FIGURE 18 – Correlate and regress calculated by Stata, using OECD data.

As expected, the result in FIGURE 19 in the appendix is quite different in the fifteen-year assessment. In consonance with Blake, Lehmann and Timmermann (1999), we found a new better performance associated with more assets allocated in equities, although again facing a problem of statistical confidentiality, aggravated by the shortage of data available for the countries in this sample. To preserve the sample with a reasonable number of eight countries we proceed with two substitutions, Iceland in place Luxembourg, and Italy in place Israel (again ranking the countries to keep the initial criteria).

Finally, for scenario 4, considering countries where there is a prevalence of DC plans, in line with the other scenarios that we investigated, we noticed minor statistical confidence in the asset allocation analysis. In this case however we can easily explain this fact by the great disparity between the countries of this sample, where we find economies quite distinct from each other.

Harmonious with this hypothesis and with better statistical confidence, we detect a strong correlation between the industry size and the investment rate of return, as we can see in the latest results replicated in FIGURE 20 in the appendix. Even clearer conclusion in the sample with the five original countries for which we have data for the fifteen year period. This conclusion is also easily ascertained by looking at the raw data from these five countries, where we discern poor results for poorer countries where the sector is not too relevant, and better performances for richer countries with more significant assets as a percentage of GDP (in this scenario, the sample with eight countries – preserving the initial criteria to select them, and fifteen-year period has Iceland, United States and Portugal in place of Slovak Republic, Mexico and Spain).

Lastly, exclusive for confirmation, we have elected Canada for the same investigation but in an individual scale. The results in FIGURE 21 in the appendix are regarding to nine years, enclosed by 2009 and 2017, intentionally excluding the sub-prime crisis period. In a crisis-free scenario, with more homogeneous pension fund data, we can observe with considerable statistical confidence and also in alignment with Blake, Lehmann and Timmermann (1999) that pension funds' performance, as measured here by investment rates of return, are better achieved for those portfolios constituted majority for equities than for any other investment classes.

5. CONCLUSION

The first finding in this paper was the ample heterogeneity concerning to the interrelation between asset allocation dynamics of pension funds and investment rate of return in a group of countries that at first glance might seem to have more similarities to each other. As a result of this dispersion, convergence in results has only emerged more clearly when we analysed specific scenarios, defined by grouping countries by relevant characteristics to the pension fund universe.

We also observed relevant divergences in results when we investigated data for different periods. Data for the shorter ten-year period clearly reflect the prejudice caused by the subprime crisis, while for the fifteen-year period this materiality is less evident.

The most reliable results suggest that for the group with countries where DB type pension funds represent the majority of assets, in a long-term scenario with widespread crisis damage, it is possible to construct an explanatory model where the investment rate of return responds positively to the majority asset allocation in equity. Nonetheless, this finding is inverted when we consider the imbalances and distortions in the market resulting from financial crisis. Higher bond supply by the governments of the countries under analysis, plus losses in stock markets may lead to portfolio rebalancing, with better results in this case for assets allocation in bonds. However, further analysis is needed in order to address possible problems of multicollinearity and goodness of fit.

The main limitations in this study were the absence of data from many countries when seeking information for longer periods of time and the lack of clarity among some definitions used that may lead to some confusion in interpreting the split of pension plans by type, for instance.

For future research, the issues related to financial crisis turmoil, as well as the dynamics of the pension fund industry's response to economic policy stimuli seem quite pertinent, complementing future discussions that should arise. In addition, in order to improve the accuracy and statistical confidence, panel data regression must be considered.

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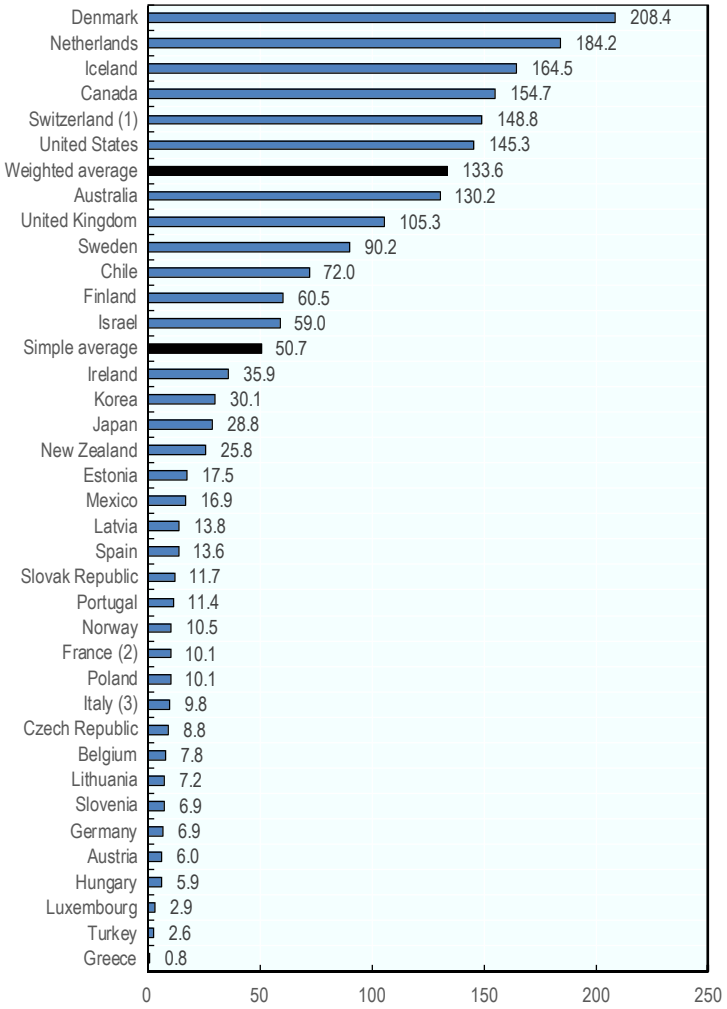
APPENDIX

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OECD countries											
Australia	1,014,341	1,095,339	867,429	1,017,082	1,437,784	1,426,024	1,482,946	1,681,786	1,517,613	1,532,849	1,760,107
Austria	19,359	17,460	20,259	20,333	19,103	21,514	25,173	23,276	22,393	21,980	26,772
Belgium	21,775	15,875	19,879	17,783	20,225	22,753	27,213	27,561	26,337	30,612	40,879
Canada	1,957,321	1,384,402	1,718,689	2,055,865	2,149,428	2,323,931	2,404,868	2,446,621	2,225,732	2,378,020	2,636,401
Chile	111,277	74,313	118,052	148,437	134,962	162,021	162,988	165,432	154,711	174,480	210,512
Czech Republic	9,249	9,909	11,753	12,395	12,413	14,337	14,951	14,854	15,028	15,684	20,920
Denmark	469,955	501,045	528,882	553,049	581,495	636,211	661,173	655,857	598,574	611,895	721,674
Estonia	1,331	1,282	1,687	1,772	1,806	2,326	2,843	3,087	3,226	3,656	4,839
Finland (1)	209,057	183,160	214,595	219,258	128,723	141,541	159,314	148,855	132,905	134,867	162,380
France (2)	162,964	168,895	222,564	225,935	224,217	241,799	271,357	226,372	212,254	242,592	278,287
Germany	170,371	165,634	187,938	187,280	192,912	221,112	236,932	236,204	220,177	227,312	270,728
Greece (3)	36	47	65	71	95	113	1,350	1,322	1,236	1,254	1,605
Hungary (4)	16,026	13,662	18,142	19,001	4,406	5,029	5,506	5,043	4,819	7,040	8,770
Iceland	28,097	14,679	15,460	18,199	18,579	19,892	24,547	24,244	26,651	32,359	40,256
Ireland (5)	127,487	88,399	104,011	100,883	93,549	106,212	126,188	136,535	122,324	107,781	126,571
Israel	58,235	80,751	94,678	112,423	112,840	130,095	153,613	154,305	165,228	177,293	215,030
Italy (6)	87,511	88,422	107,690	113,502	119,887	141,035	163,359	162,889	154,991	165,238	200,850
Japan	1,313,074	1,601,330	1,569,730	1,754,619	1,843,824	1,704,407	1,442,168	1,328,630	1,349,538	1,343,221	1,395,298
Korea	76,221	62,333	87,652	161,459	192,246	249,408	292,753	326,909	343,315	364,634	485,939
Latvia	639	1,065	1,643	1,785	1,826	2,192	2,650	2,813	2,917	3,340	4,448
Lithuania	..	..	..	1,515	1,564	1,887	2,221	2,330	2,376	2,713	3,613
Luxembourg	550	542	1,215	1,067	1,076	1,190	1,323	1,801	1,572	1,659	1,941
Mexico	112,399	98,125	116,944	146,062	142,650	181,574	194,770	195,521	175,939	156,503	185,638
Netherlands	1,137,127	932,779	979,401	1,015,666	1,055,652	1,229,054	1,335,092	1,282,009	1,266,434	1,360,625	1,627,799
New Zealand	14,100	15,384	12,371	19,275	23,929	28,406	33,831	39,788	39,529	45,110	52,986
Norway	29,655	21,934	30,310	33,135	33,627	39,454	40,908	37,380	34,210	36,899	42,103
Poland (7)	58,453	47,493	64,137	75,846	67,590	89,244	102,911	47,052	40,470	41,038	57,642
Portugal (8)	37,158	30,453	33,686	28,262	18,546	20,433	22,268	22,469	21,288	21,092	26,430
Slovak Republic	3,366	4,417	5,713	6,523	7,503	8,994	9,926	9,645	8,750	9,523	11,965
Slovenia	1,823	2,006	2,582	2,828	2,882	2,995	3,209	3,110	2,927	2,963	3,591
Spain	194,787	175,805	192,369	179,583	172,642	180,437	199,630	183,600	168,044	164,241	189,361
Sweden	274,643	236,822	242,122	280,019	322,190	377,350	399,517	383,674	374,146	389,264	505,464
Switzerland (9)	537,946	506,274	581,203	661,168	664,571	734,001	907,735	880,703	892,586	909,681	1,019,654
Turkey	3,895	4,185	6,047	7,652	7,291	11,005	11,877	15,694	15,886	16,547	21,073
United Kingdom	2,266,070	1,412,247	1,820,742	2,018,041	2,232,598	2,529,995	2,810,564	2,784,630	2,741,924	2,607,820	2,903,324
United States	17,705,449	13,973,474	16,229,923	17,963,027	18,140,098	19,983,714	22,781,169	23,977,517	24,027,423	25,402,370	28,168,971

Source: OECD Global Pension Statistics.

TABLE I – Total investment of providers of funded and private pension arrangements, in millions of USD, 2007-2017.



Source: OECD Global Pension Statistics.

FIGURE 9 – Total assets in funded and private pension arrangements, 2017 (as a percentage of GDP).

Notes by OECD: The weighted averages in and outside the OECD area are calculated by using weights based on the share that pension assets in a given country represent compared to the overall amount of pension assets in the area considered. (1) Data for personal plans for 2017 refer to 2016 instead. (2) Data on PERCO plans for 2017 come from the French Asset Management Association (AFG) and refer to end 2017. Data on pension insurance contracts for 2017 refer to 2016 instead. (3) Net technical provisions are taken as a proxy of pension assets in book reserves. (4) Data refer to 2016. (5) Data refer to 2013. (6) Values for personal plans refer to the total amounts of assets of all companies whose retirement savings products represent the majority of their premium revenues. A part of these amounts may however include assets related to non-pension products. (7) Data refer to 2012. (8) Data refer to some occupational voluntary pension schemes only. (9) Data refer to 2015.

```
. correlate tenyearannualaverage equities billsandbonds assetsasshareofgdp
(obs=21)
```

	tenyea~e	equities	billsa~s	assets~p
tenyearann~e	1.0000			
equities	0.0086	1.0000		
billsandbo~s	-0.0538	-0.5762	1.0000	
assetsassh~p	0.2957	0.4284	-0.3971	1.0000

```
. regress tenyearannualaverage equities billsandbonds assetsasshareofgdp
```

Source	SS	df	MS	Number of obs	=	21
				F(3, 17)	=	0.66
Model	5.86303162	3	1.95434387	Prob > F	=	0.5868
Residual	50.1950638	17	2.95265081	R-squared	=	0.1046
				Adj R-squared	=	-0.0534
Total	56.0580954	20	2.80290477	Root MSE	=	1.7183

tenyearannualave~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
equities	-1.770449	3.66097	-0.48	0.635	-9.49442	5.953522
billsandbonds	.0910072	3.419984	0.03	0.979	-7.124529	7.306543
assetsasshareofgdp	1.338305	.9667536	1.38	0.184	-.701367	3.377976
_cons	1.839659	2.375045	0.77	0.449	-3.171248	6.850567

`tenyearannualaverage`: Investment rate of return – ten-year average.
`equities`: Percentage of assets allocated in equities.
`billsandbonds`: Percentage of assets allocated in bills and bonds.
`assetsasshareofgdp`: Pension funds assets as a share of GDP.

FIGURE 12 – Correlation and Regression calculations – Scenario 1 (ten-year period)

```
. regress fifteen_yrateofreturn fifteen_yequities
```

Source	SS	df	MS	Number of obs	=	15
				F(1, 13)	=	2.06
Model	5.71654639	1	5.71654639	Prob > F	=	0.1744
Residual	35.9927864	13	2.76867587	R-squared	=	0.1371
				Adj R-squared	=	0.0707
Total	41.7093327	14	2.97923805	Root MSE	=	1.6639

fifteen_yrateof~n	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fifteen_yequities	5.912037	4.114399	1.44	0.174	-2.97658	14.80066
_cons	1.611089	1.104602	1.46	0.168	-.7752575	3.997436

```
. regress fifteen_yrateofreturn fifteen_ybillsandbonds
```

Source	SS	df	MS	Number of obs	=	15
				F(1, 13)	=	1.35
Model	3.91123354	1	3.91123354	Prob > F	=	0.2670
Residual	37.7980992	13	2.90754609	R-squared	=	0.0938
				Adj R-squared	=	0.0241
Total	41.7093327	14	2.97923805	Root MSE	=	1.7052

fifteen_yrateofreturn	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fifteen_ybillsandbonds	-3.733209	3.218761	-1.16	0.267	-10.68692	3.220501
_cons	4.829933	1.577229	3.06	0.009	1.422537	8.237328

```
. regress fifteen_yrateofreturn fifteen_ysharegdp
```

Source	SS	df	MS	Number of obs	=	15
				F(1, 13)	=	3.06
Model	7.94318604	1	7.94318604	Prob > F	=	0.1039
Residual	33.7661467	13	2.5973959	R-squared	=	0.1904
				Adj R-squared	=	0.1282
Total	41.7093327	14	2.97923805	Root MSE	=	1.6116

fifteen_yrateof~n	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fifteen_ysharegdp	1.597218	.9133474	1.75	0.104	-.3759487	3.570385
_cons	2.380486	.5745696	4.14	0.001	1.139204	3.621769

`fifteen_yrateofreturn`: Investment rate of return – fifteen-year average.
`fifteen_yequities`: Percentage of assets allocated in equities.
`fifteen_ybillsandbonds`: Percentage of assets allocated in bills and bonds.
`fifteen_ysharegdp`: Pension funds assets as a share of GDP.

FIGURE 13 – Correlation and Regression calculations – Scenario 1 (fifteen-year period)

```
. correlate tenyearannualaverage equities billsandbonds assetsasshareofgdp
(obs=8)
```

	tenyea~e	equities	billsa~s	assets~p
tenyearann~e	1.0000			
equities	-0.3779	1.0000		
billsandbo~s	0.3717	-0.6541	1.0000	
assetsassh~p	-0.2035	0.3889	-0.4188	1.0000

```
. regress tenyearannualaverage equities billsandbonds assetsasshareofgdp
```

Source	SS	df	MS		
				Number of obs	= 8
				F(3, 4)	= 0.27
Model	3.05212923	3	1.01737641	Prob > F	= 0.8421
Residual	14.8566213	4	3.71415532	R-squared	= 0.1704
				Adj R-squared	= -0.4518
Total	17.9087505	7	2.55839293	Root MSE	= 1.9272

tenyearannualave~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
equities	-3.315352	8.793594	-0.38	0.725	-27.73028	21.09958
billsandbonds	2.149773	6.336011	0.34	0.751	-15.44181	19.74136
assetsasshareofgdp	-.1114698	2.182879	-0.05	0.962	-6.172113	5.949174
_cons	2.835764	5.316351	0.53	0.622	-11.92479	17.59632

`tenyearannualaverage`: Investment rate of return – ten-year average.
`equities`: Percentage of assets allocated in equities.
`billsandbonds`: Percentage of assets allocated in bills and bonds.
`assetsasshareofgdp`: Pension funds assets as a share of GDP.

FIGURE 14 – Correlation and Regression calculations – Scenario 2 (ten-year period)

```
. correlate fifteen_yrateofreturn fifteen_yequities fifteen_ybillsandbonds fifteen_ysharegdp
(obs=8)
```

	fiftee~n	fifte~es	fifte~ds	fiftee~p
fifteen_yr~n	1.0000			
fifteen_ye~s	0.1413	1.0000		
fifteen_yb~s	0.3349	-0.5323	1.0000	
fifteen_ys~p	0.1363	0.5300	-0.2924	1.0000

```
. regress fifteen_yrateofreturn fifteen_yequities fifteen_ybillsandbonds fifteen_ysharegdp
```

Source	SS	df	MS		
				Number of obs	= 8
				F(3, 4)	= 0.47
Model	3.09973484	3	1.03324495	Prob > F	= 0.7190
Residual	8.78026517	4	2.19506629	R-squared	= 0.2609
				Adj R-squared	= -0.2934
Total	11.88	7	1.69714286	Root MSE	= 1.4816

fifteen_yrateofreturn	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fifteen_yequities	7.670019	11.06251	0.69	0.526	-23.04445	38.38448
fifteen_ybillsandbonds	6.581269	5.826864	1.13	0.322	-9.5967	22.75924
fifteen_ysharegdp	.2917534	1.580769	0.18	0.863	-4.097166	4.680673
_cons	-1.375668	4.659704	-0.30	0.783	-14.31308	11.56174

Alternatively with six countries:

```
. regress fifteen_yrateofreturn fifteen_yequities fifteen_ybillsandbonds fifteen_ysharegdp
```

Source	SS	df	MS		
				Number of obs	= 6
				F(3, 2)	= 0.19
Model	2.23930746	3	.74643582	Prob > F	= 0.8948
Residual	7.8090261	2	3.90451305	R-squared	= 0.2229
				Adj R-squared	= -0.9429
Total	10.0483336	5	2.00966671	Root MSE	= 1.976

fifteen_yrateofreturn	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fifteen_yequities	10.19034	19.23774	0.53	0.649	-72.58299	92.96367
fifteen_ybillsandbonds	5.020765	8.599498	0.58	0.618	-31.97989	42.02142
fifteen_ysharegdp	.202982	2.920508	0.07	0.951	-12.36295	12.76891
_cons	-1.478698	7.856372	-0.19	0.868	-35.28194	32.32454

`fifteen_yrateofreturn`: Investment rate of return – fifteen-year average.
`fifteen_yequities`: Percentage of assets allocated in equities.
`fifteen_ybillsandbonds`: Percentage of assets allocated in bills and bonds.
`fifteen_ysharegdp`: Pension funds assets as a share of GDP.

FIGURE 15 – Correlation and Regression calculations – Scenario 2 (fifteen-year period)

```
. correlate tenyearannualaverage equities billsandbonds assetsasshareofgdp dbplansasshare
(obs=8)
```

	tenyea~e	equities	billsa~s	assets~p	dbplan~t
tenyearann~e	1.0000				
equities	-0.0506	1.0000			
billsandbo~s	0.3837	-0.6345	1.0000		
assetsassh~p	0.2756	0.1651	-0.5104	1.0000	
dbplansass~t	0.4906	0.4684	-0.0127	-0.0612	1.0000

```
. regress tenyearannualaverage equities billsandbonds assetsasshareofgdp
```

Source	SS	df	MS	Number of obs	=	8
				F(3, 4)	=	2.01
Model	7.98258101	3	2.66086034	Prob > F	=	0.2549
Residual	5.29241929	4	1.32310482	R-squared	=	0.6013
				Adj R-squared	=	0.3023
Total	13.2750003	7	1.89642861	Root MSE	=	1.1503

tenyearannualave~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
equities	6.020325	4.850371	1.24	0.282	-7.446463	19.48711
billsandbonds	10.2863	4.521237	2.28	0.085	-2.266669	22.83926
assetsasshareofgdp	2.523901	1.272961	1.98	0.118	-1.010406	6.058207
_cons	-4.944341	3.326103	-1.49	0.211	-14.17908	4.290401

Alternatively removing Canada - Correlation and Regression calculations – Scenario 3 (ten-year period):

```
. correlate tenyearannualaverage equities billsandbonds assetsasshareofgdp
(obs=7)
```

	tenyea~e	equities	billsa~s	assets~p
tenyearann~e	1.0000			
equities	-0.1798	1.0000		
billsandbo~s	0.6350	-0.6112	1.0000	
assetsassh~p	0.1710	0.1122	-0.4654	1.0000

```
. regress tenyearannualaverage equities billsandbonds assetsasshareofgdp
```

Source	SS	df	MS	Number of obs	=	7
				F(3, 3)	=	5.45
Model	8.66756571	3	2.88918857	Prob > F	=	0.0986
Residual	1.58957739	3	.529859131	R-squared	=	0.8450
				Adj R-squared	=	0.6901
Total	10.2571431	6	1.70952385	Root MSE	=	.72791

tenyearannualave~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
equities	5.482626	3.076164	1.78	0.173	-4.307101	15.27235
billsandbonds	11.16099	2.880217	3.88	0.030	1.994858	20.32713
assetsasshareofgdp	2.189927	.8154069	2.69	0.075	-.4050618	4.784916
_cons	-5.355924	2.110589	-2.54	0.085	-12.07276	1.360912

`tenyearannualaverage`: Investment rate of return – ten-year average.
`equities`: Percentage of assets allocated in equities.
`billsandbonds`: Percentage of assets allocated in bills and bonds.
`assetsasshareofgdp`: Pension funds assets as a share of GDP.

FIGURE 16 – Correlation and Regression calculations – Scenario 3 (ten-year period)

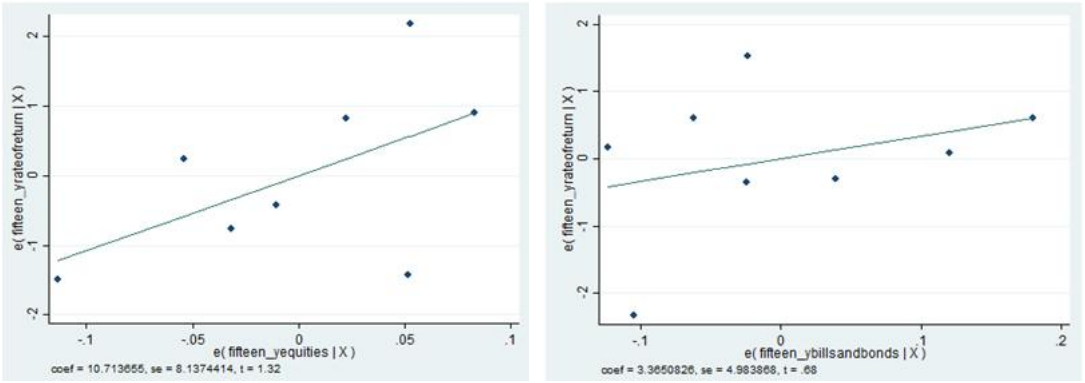
```
. correlate fifteen_yrateofreturn fifteen_yequities fifteen_ybillsandbonds fifteen_ysharegdp fifteen_ydboftotal
(obs=8)
```

	fiftee~n	fifte~es	fifte~ds	fiftee~p	f~boft~l
fifteen_yr~n	1.0000				
fifteen_ye~s	0.4609	1.0000			
fifteen_yb~s	0.1830	-0.2389	1.0000		
fifteen_ys~p	-0.0359	0.3151	-0.2080	1.0000	
fif~boftotal	0.6321	0.4749	-0.1803	-0.1921	1.0000

```
. regress fifteen_yrateofreturn fifteen_yequities fifteen_ybillsandbonds
```

Source	SS	df	MS		
				Number of obs	= 8
				F(2, 5)	= 1.09
Model	3.55574202	2	1.77787101	Prob > F	= 0.4048
Residual	8.15925737	5	1.63185147	R-squared	= 0.3035
				Adj R-squared	= 0.0249
Total	11.7149994	7	1.67357134	Root MSE	= 1.2774

fifteen_yrateofreturn	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fifteen_yequities	9.889084	7.102388	1.39	0.223	-8.368185	28.14635
fifteen_ybillsandbonds	3.625317	4.483185	0.81	0.455	-7.899076	15.14971
_cons	-.6555426	2.930111	-0.22	0.832	-8.187633	6.876548



`fifteen_yrateofreturn`: Investment rate of return – fifteen-year average.
`fifteen_yequities`: Percentage of assets allocated in equities.
`fifteen_ybillsandbonds`: Percentage of assets allocated in bills and bonds.
`fifteen_ysharegdp`: Pension funds assets as a share of GDP.

FIGURE 19 – Correlation and Regression calculations – Scenario 3 (fifteen-year period)

```
. correlate tenyearannualaverage equities billsandbonds assetsasshareofgdp dcplans
(obs=8)
```

	tenyea~e	equities	billsa~s	assets~p	dcplan~t
tenyearann~e	1.0000				
equities	0.0844	1.0000			
billsandbo~s	0.0125	-0.5644	1.0000		
assetsassh~p	0.2336	0.4211	-0.3593	1.0000	
dcplansass~t	-0.2592	-0.1351	0.2148	-0.6818	1.0000

```
. regress tenyearannualaverage equities billsandbonds assetsasshareofgdp
```

Source	SS	df	MS	Number of obs	=	8
				F(3, 4)	=	0.10
Model	1.46696915	3	.488989718	Prob > F	=	0.9585
Residual	20.4717813	4	5.11794532	R-squared	=	0.0669
				Adj R-squared	=	-0.6330
Total	21.9387504	7	3.13410721	Root MSE	=	2.2623

tenyearannualave~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
equities	.6354347	7.637497	0.08	0.938	-20.56966	21.84053
billsandbonds	1.737809	7.642304	0.23	0.831	-19.48063	22.95625
assetsasshareofgdp	1.037006	2.147044	0.48	0.654	-4.924143	6.998156
_cons	-.4243135	5.722283	-0.07	0.944	-16.31192	15.46329

`tenyearannualaverage`: Investment rate of return – ten-year average.
`equities`: Percentage of assets allocated in equities.
`billsandbonds`: Percentage of assets allocated in bills and bonds.
`assetsasshareofgdp`: Pension funds assets as a share of GDP.

```
. correlate fifteen_yrateofreturn fifteen_yequities fifteen_ybillsandbonds fifteen_ysharegdp fifteen_ydcoftotal
(obs=8)
```

	fiftee~n	fifte~es	fifte~ds	fiftee~p	f~coft~l
fifteen_yr~n	1.0000				
fifteen_ye~s	0.1288	1.0000			
fifteen_yb~s	-0.1405	-0.7103	1.0000		
fifteen_ys~p	0.4642	0.4785	-0.3383	1.0000	
fif~coftotal	-0.1368	-0.1461	0.4625	-0.0101	1.0000

```
. regress fifteen_yrateofreturn fifteen_yequities fifteen_ybillsandbonds fifteen_ysharegdp
```

Source	SS	df	MS	Number of obs	=	8
				F(3, 4)	=	0.40
Model	4.90639753	3	1.63546584	Prob > F	=	0.7598
Residual	16.2623512	4	4.0655878	R-squared	=	0.2318
				Adj R-squared	=	-0.3444
Total	21.1687487	7	3.02410696	Root MSE	=	2.0163

fifteen_yrateofreturn	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fifteen_yequities	-2.871302	9.942685	-0.29	0.787	-30.47662	24.73402
fifteen_ybillsandbonds	-1.09546	6.774984	-0.16	0.879	-19.90583	17.71491
fifteen_ysharegdp	2.077405	1.985029	1.05	0.354	-3.433921	7.58873
_cons	2.675136	5.232	0.51	0.636	-11.85123	17.2015

```
. regress fifteen_yrateofreturn fifteen_ysharegdp
```

Source	SS	df	MS	Number of obs	=	5
				F(1, 3)	=	7.74
Model	14.1636301	1	14.1636301	Prob > F	=	0.0689
Residual	5.48836856	3	1.82945619	R-squared	=	0.7207
				Adj R-squared	=	0.6276
Total	19.6519987	4	4.91299967	Root MSE	=	1.3526

fifteen_yrateof~n	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fifteen_ysharegdp	7.277467	2.615495	2.78	0.069	-1.046207	15.60114
_cons	.466139	.8581895	0.54	0.625	-2.265003	3.197281

```
. correlate fifteen_yrateofreturn fifteen_ysharegdp
(obs=5)
```

	fiftee~n	fiftee~p
fifteen_yr~n	1.0000	
fifteen_ys~p	0.8490	1.0000

`fifteen_yrateofreturn`: Investment rate of return – fifteen-year average.
`fifteen_yequities`: Percentage of assets allocated in equities.
`fifteen_ybillsandbonds`: Percentage of assets allocated in bills and bonds.
`fifteen_ysharegdp`: Pension funds assets as a share of GDP.

FIGURE 20 – Correlation and Regression calculations – Scenario 4

	realin~e	inequi~s	assets~e
realinvest~e	1.0000		
inequities	0.6052	1.0000	
assetsassh~e	-0.4030	-0.8481	1.0000

. regress realinvestrate inequities assetsasshare

Source	SS	df	MS	Number of obs	=	9
				F(2, 6)	=	2.08
Model	24.9332092	2	12.4666046	Prob > F	=	0.2059
Residual	35.946795	6	5.99113249	R-squared	=	0.4095
				Adj R-squared	=	0.2127
Total	60.8800042	8	7.61000053	Root MSE	=	2.4477

realinvestr~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
inequities	1.335131	.8425454	1.58	0.164	-.7265031	3.396765
assetsasshare	.0687344	.1036478	0.66	0.532	-.1848827	.3223515
_cons	-44.22725	38.95868	-1.14	0.300	-139.5557	51.10119

. regress realinvestrate inequities

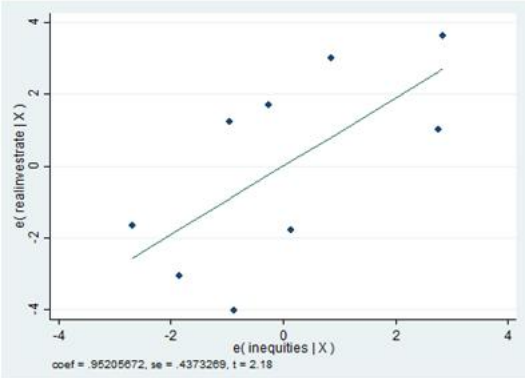
Source	SS	df	MS	Number of obs	=	9
				F(1, 7)	=	4.05
Model	22.2984765	1	22.2984765	Prob > F	=	0.0842
Residual	38.5815277	7	5.51164681	R-squared	=	0.3663
				Adj R-squared	=	0.2757
Total	60.8800042	8	7.61000053	Root MSE	=	2.3477

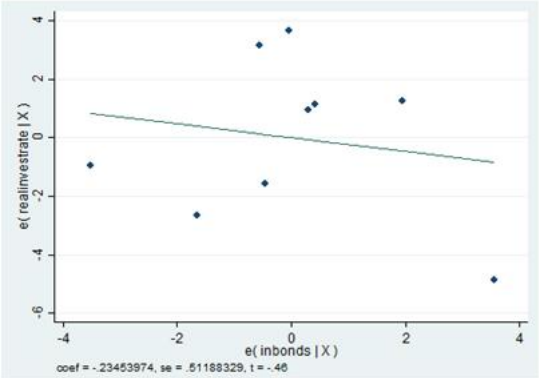
realinvest~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
inequities	.8612772	.4281994	2.01	0.084	-.1512535	1.873808
_cons	-20.09035	13.32573	-1.51	0.175	-51.60068	11.41999

. regress realinvestrate inbonds

Source	SS	df	MS	Number of obs	=	9
				F(1, 7)	=	0.21
Model	1.77269534	1	1.77269534	Prob > F	=	0.6607
Residual	59.1073089	7	8.44390127	R-squared	=	0.0291
				Adj R-squared	=	-0.1096
Total	60.8800042	8	7.61000053	Root MSE	=	2.9058

realinvest~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
inbonds	-.2345397	.5118833	-0.46	0.661	-1.444951	.9758719
_cons	14.93222	18.06557	0.83	0.436	-27.78606	57.65049





			Asset allocation	
Canada	assets as share of GDP	real invest rate or return	in equities	in bonds
~~**2007**~~	~~122.9~~	~~1.0~~	~~36.6~~	~~34.1~~
~~**2008**~~	~~102.6~~	~~-16.9~~	~~31.8~~	~~37.4~~
2009	114.8	10.3	33.9	35.1
2010	123.8	7.6	33.9	35.5
2011	124.0	1.8	30.9	38.7
2012	126.9	7.9	31.2	37.1
2013	134.8	9.8	31.8	34.6
2014	142.6	7.8	30.2	35.6
2015	154.4	5.1	28.3	34.7
2016	156.9	4.0	28.9	33.5
2017	154.7	5.7	30.5	31.7

FIGURE 21 – Correlation, Regression calculations and Raw data – Canada