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Abstract

One common denominator observed in global financial regulation is the tendency to allow pension funds to invest more in infrastructure. Considering this, our study analyses what regulatory changes are currently taking place from a global perspective and what are the relevant factors that impacts on pension fund's decisions to invest in infrastructure. Our results show that although financial restrictions on pension funds to invest in infrastructure could be important, there are other more significant factors such as the institutional framework and other variables related to the depth and strength of the financial markets. Geographical considerations have also been revealed to be important.

Keywords: Pension fund, investment, infrastructure, regulation

JEL classification: G23, G28, H54, C38, C24

1: This working paper is a previous version of the chapter 10 titled "Pension Fund Investment in Infrastructure and Global Financial Regulation" of the book "Retirement System Risk Management: Implications of the New Regulatory Order" (edited by Olivia S. Mitchell, Raimond Maurer, J. Michael Orszag), Oxford University Press, Oxford, 2016, ISBN 978-0-19-878737-2.

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Pension Funds and Infrastructure Projects

The global financial crisis has laid wide open the problems which pension systems have been facing for several decades. Many of these, particularly the pay-as-you-go (PAYG) systems, have already been suffering problems of financial sustainability, by offering generous benefits using parametric assumptions which were not aligned with demographic trends, the reality of financial markets, growth conditions and the structure of their labor markets. As a result, many governments have had to take giant steps to make their pension systems sustainable, making reforms which have sought to bring them into line with financial equilibrium by reducing pension benefits, but also transferring the responsibility for dealing with these challenges to the private sector. In this new environment, pensions reforms around the world are taking action to make saving easier, by using different private pension schemes with the aim of enabling people to increase their diminished rates of future replacement.

With the greater importance of private pensions, one of the topics which is attracting most attention in recent global regulatory discussions is the possibility that private pension funds could invest in alternative assets, particularly infrastructure projects². Several considerations have been aligned. First, the attraction of these assets in terms of profitability-risk and the apparent successful experience of pension funds in some geographies, such as Australia and Canada, investing intensively in these instruments. In second place are the arguments about the suitability of investments in long-maturity assets, like infrastructure, given institutional investors' long-term horizons. Finally, there is a criterion of the need to fund infrastructures in a context in which the state has budgetary limitations and banks are forced to disinvest in these assets, under the current changes in its regulation.

On the understanding that a range of different factors has been driving greater thought to the idea that pension funds should join in the funding of infrastructure projects, this paper has two aims, understand the key global regulatory trends on this issue, and carry out a quantitative analysis with the aim of shedding some light on the different explanatory variables which might affect whether or not pension funds invest in infrastructure, among them regulatory factors.

The structure of this paper is as follows. After this introduction, in Section 2 we explain the potential reasons why pension funds should invest in infrastructure projects. In Section 3 we set out the general factors defining the appetite for financing infrastructure projects. In Section 4, we focus on financial regulatory aspects that interact with pension fund investments in infrastructure in different geographies. Then, in Section 5, we apply econometric analysis to assess which factors are currently the most influential on pension funds investing in infrastructure. Finally, the key conclusions from the study are set out in Section 6.

2: At the recent meeting of the International Organisation of Pension Supervisors (IOPS) and the International Organisation of Pension Funds Supervisory Authorities (AIOS) in San José, Costa Rica, on February 2015, this topic took a starring role in the discussions.

Why Should Pension Funds Invest in Infrastructure?

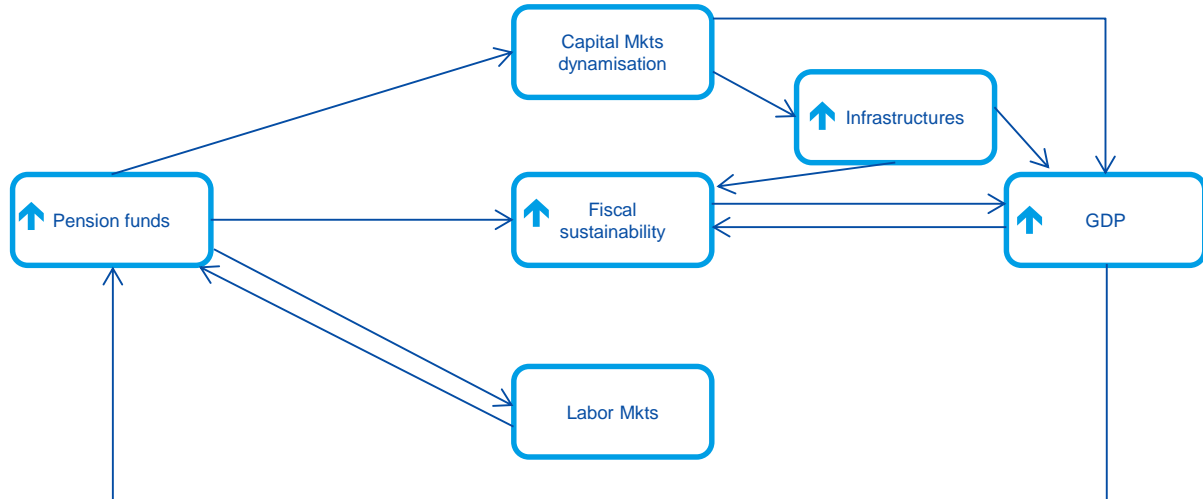
Various reasons are cited by the literature as justification for greater pension fund investment in infrastructure (Alonso et al, 2009). These can be reduced to six basic concepts: i) there is a neat fit between the long-term time horizon for infrastructure projects to mature and the pension fund portfolio; ii) infrastructure tends to operate like a natural, regulated monopoly, and there is no competition which might cause its asset value to fluctuate wildly; iii) there is a low correlation between the assets in infrastructure projects and all the other financial asset classes which normally track the vicissitudes of the economic cycle; (iv) it provides protection against inflation; (v) there is a good risk-return trade-off; and (vi) infrastructure asset has greater cash-flow stability when the project has matured. In a nutshell, infrastructure offers an improved portfolio efficient frontier (Andrews and Wahba, 2007; Weber and Alfen, 2010; Sawant, 2010).

In spite of these apparently very reasonable factors aside, in practice, there is a lack of statistical data, which thwarts attempts to examine this issue in greater depth. Some studies have tried to weigh up the virtues of investing in infrastructure by taking advantage of the fact that the country which provides most information on this matter is Australia. Peng and Newell (2007), Bird et al. (2012), Connolly (2012) and Inderst (2014) all report high risk-adjusted returns and low correlations with other asset classes. Inderst (2014) states that some aspects require deeper analysis as many of these studies make their estimates using small samples and valuations of unlisted infrastructure assets that are based on expected values, which tends to underestimate volatility and correlations to listed instruments, while overestimating potential portfolio diversification.

Looking beyond the major considerations which investing in infrastructure might present for private pension funds, there is another argument related with the potential impact of pension funds' investments in infrastructure on the economy as a whole. Figure 1 shows the interaction between private pension funds and economic growth through various channels of transmission, foremost among these being financial, fiscal and labor market mechanisms. The same figure highlights the role fulfilled by infrastructure and its impact on growth and how, via the financial market, pension funds could become the backers of infrastructure projects and their effect on growth. A study by Alonso et al. (2009) reveals that growth elasticity in relation to infrastructure could in fact vary between 7.0 percent and 13.5 percent.

Figure 3

Pension Funds and Infrastructure: The theoretical virtuous circle



Source: BBVA Research

Also in Figure 1, it is also important to focus on the fiscal channel, which could be positively affected, as the presence of the private system means a lower public borrowing requirement, thus reducing its vulnerability, and a boost to growth. Likewise, capital markets play a major role through pension fund financing, by bringing more resources to economic agents, greater efficiency and improving fiscal sustainability.

It should be pointed out that for such a “virtuous circle” between pension funds and infrastructures to really crystallize there must be well-defined and sound projects, a good financing vehicle for them, and an institutional framework that enables all the interests on board in carrying out infrastructure projects to be harmoniously aligned in pursuit of the success of the investment. Were this not the case, such a virtuous circle could potentially metamorphose into a “vicious” circle, in which, if the project ends up funding a “white elephant”, the multiplier effect will only be reduced to a mere short-term Keynesian phenomenon, but one which in the long run could come to compromise the public budget if this has been used as the guarantor of last resort of the whole raft of risks which an infrastructure project can entail, thus ratcheting up the implied debt (World Bank, 2010).

In addition to these economic factors that potentially justify pension fund investment in infrastructure, there is a set of global trends which tempt one to consider this alternative investment. On one hand, there is the current economic and financial crisis, which has underlain major changes in the growth patterns of several countries and prompted changes to the regulatory environment within the international financial system. As a result, the spectacular rise in the public deficit in certain geographical areas has led to the implementation of fiscal tightening in a bid to balance the public accounts in the short to medium term. On the other hand, the heavy leveraging of corporate and household finances, and the problems associated with a generally under-capitalized banking industry, have given rise to solvency issues at many banking institutions, which has cast doubts on the financial system as a whole. Consequently, the credit on offer to the productive sector has been choked off, exacerbating the financial hardship of cash-starved companies and families. With public accounts

now shored up and other specific reforms having been implemented in each country, as well as the succession of recommendations to become Basel III-compliant within the banking sector, a gradual exit from the crisis is now discernible worldwide, though in the form of very low rates of economic growth. The straitjacketing of public spending has in many countries suppressed the infrastructure funding which is so vital to economic growth even though, according to the OECD (2006), the infrastructure gap worldwide up to 2030 amounts to some USD50trn. A further estimate, by the European Commission (2011), suggests that Europe will need to raise funds for infrastructure investment up to 2020 of EUR1.5-2trn and that the United States will have to find USD1.7-3trn by the same date.

Given the problem of funding factors of production such as infrastructure, the European Commission (2014a; 2014b) seeks formulas for co-financing by the private sector. It nonetheless finds that the traditional agent which had fulfilled this role (which was the banking sector) is currently facing problems in continuing to provide such funding, owing to the restrictions imposed under Basel III. Under the Capital Requirement Regulation (CRR), the increased buffer that is needed to cover very long-term asset risk and the higher cost of matching long-term assets with liabilities with a similar duration have greatly disincentivised banking sector involvement in projects of this nature, and the Commission considers the insurance and pension fund industry to be the ideal candidate to replace it.

Likewise, the current environment of low interest rates could become an incentive for investing in infrastructure assets, in order to counterbalance the negative effect of lower interest rates in defined contribution and defined benefit schemes. In the case of defined contribution, the low interest rate scenario will directly impact on the accumulation process of pensions, which it is already threatened by the higher longevity risk. On the other hand, systems with defined benefit pension will have difficulties to comply their commitments with lower interest rates.

How have pension funds been allocating investments from a global perspective? The OECD (2012) estimates that the world's 10 largest pension funds lifted their allocation in on-portfolio alternative assets from 17.6 percent to 19.5 percent between 2010 and 2013. Within this category, infrastructure is an asset class which, for the reasons cited, stands out as an ideal alternative.

The patterns of how pension funds have been investing in infrastructure vary from one geographical area to another, as do the investment regimes. In a database built for 72 pension funds across 21 countries where their investment spectrum includes investing in infrastructure, taking data between 2010 and 2013 (see Table 1), for those countries in which there is active investment in infrastructure, this averages 5.6 percent. However, this average is influenced by two of the countries with pension funds which actively invest in infrastructure, namely Canada and Australia. Indeed, the Canadian pension funds included in the database allocate an average of 6.6 percent to this, while in Australia the average is 8.6 percent. Within the sample there are a dozen pension funds which invest between over 10 percent and 31 percent of their portfolio in unlisted infrastructure assets.

Table 1

% Infrastructure			
	Actual	Target	Year
Aust-Ausfund	0	10.0	2010
Aust-BUSS (Q)	17.9	0.0	2010
Aust-Care	6	0.0	2010
Aust-Catholic	0	5.0	2010
Aust-Cbus	14.1	0.0	2010
Aust-Firstsuper	0	7.5	2010
Aust-First State SA	3.5		2011
Aust-Future	8	0.0	2013
Aust-Health Super	4.6		2009
Aust-AusGov Superfund	6.7		
Aust-Hesta	0.8	10.0	2010
Aust-Hosplus	0	4.0	2009
Aust-Military	9	0.0	2010
Aust-MTAA	31.1	25.0	2010
Aust-Q Super	6.2		2011
Aust-QIC	4	0.0	2010
Aust-State Super	1.9	0.0	2010
Aust-Sun Super	5.1	5.0	2013
Aust-Australian Super	9.8	14.0	2013
Aust-Retail Employees	13.8		2011
Aust-Reward	13.8		2011
Aust-Telstra	3	0.0	2010
Aust-Unisuper	4.4	6.5	2010
Aust-VIC	5.5	0.0	2010
Aust-West Schem	17.9	0.0	2010
Argentina-Sustainability Guarantee Fund	13.6	20.0	2013
Bras-Pension Funds	1.0	0.0	2010
Brasil-Previ	6.9	0.0	2013
Brasil-Funcef	6.9	0.0	2013
Brasil-Fapes	0.0	0.0	2013
Can-CPP Alberta	6.1		2012
Can-Caisse de Depo	1.4	8.8	2010
Can-CPP	6.1		2012
Can-CPPIB	5.5	0.0	2010
Can-OMERS	14.9	21.5	2013
Can-OTTP	8.4	8.5	2013

Continued on next page

Table 1

% Infrastructure (cont.)

	Actual	Target	Year
Can-PSP	6.1		2012
Can-Quebec Pension Plan	4.0	5.0	2013
Chil-AFP	1.2	0.0	2010
Chil-Provida	0.0	0.0	2013
Chil-Habitat	0.2	0.0	2013
Chil- Pension Reserve Fund	0.0	0.0	2013
Col-AFP	0.7	0.0	2010
Den-PFA	0.8	0.0	2013
Finland-Ilmarien	0.3	0.0	2013
Finland-Keva	0.0	0.0	2013
Israel-Menora-Mitvachim	2.9	0.0	2013
Japan-Pension Fund Association	0.1	0.0	2013
Mex-AFORE	4.8	0.0	2010
Mex-AFORE XXI Banorte	0.3	5.0	2013
Mex-Banamex	1.8	2.5	2013
Ned- ABP	1.5	3.0	2013
Ned- PFZW	2.4	3.0	2013
Ned-PGGM	0.8	0.0	2010
Ned-PMT	0.6	1.0	2013
New Zealand-Superannuation Fund	1.9	0.0	2013
Per-AFP	3.7	0.0	2010
Portugal-BPI Pension Fund	3.3	0.0	2013
Portugal-CGD Staff's Pension Fund	1.6	1.6	2013
RSA-Gov Employees	0.1	0.0	2013
Swe- AP Fonden	0.8	0.0	2010
Swe- AP 4	0.0	0.0	2013
Swe- AP 3	1.4	2.0	2013
Spain-Endesa	0.0	0.0	2013
Spain-Fonditel	0.1	0.0	2013
Turkey -Oyak	4.4	0.0	2013
UK-USS	4.4	5.0	2013
USA-Alaska PFC	0.0	18.0	2010
USA-Calpers	0.0	3.0	2010
USA-MERS	0.0	5.0	2010
USA-Calsters	0.0	2.5	2010
USA-NYC Combined Retirement Service	0.0	0.0	2013

Source: Inderst (2014), OECD (2014), Tuesta (2013), Weber and Alfen (2010), Future Fund Board (2011), Infrastructure Partnerships Australia (2010), Macquarie (2009)

General Aspects Determining Infrastructure Investment

In spite of the good theoretical expectations for pensions fund to play a more active role in the private-sector financing of infrastructure, the OECD (2012) estimates that only 1 percent of pension funds have invested in infrastructure projects, excluding indirect investment via shares in, or other quoted assets of, infrastructure development companies.

The availability of good projects

Pension funds face a combination of factors that disincentivise infrastructure investment that they have in common with other private-sector financing agents. These limitations are principally characterized by the relation of the concession (or project finance) process, and the different conditions in each country's domestic financial market. There are other series of barriers more specific to the sector, that are related to the technical capacity of these to evaluate investment in this type of asset and the country-specific regulation that they have to deal with to be able to invest in these projects. Project finance projects contain inherent risks that the intervening agencies have to deal with. As noted by the OECD (2014d), a good project should provide details of the associated risks and suggest the most appropriate tool for mitigating them. For greenfield projects, the risks are apparent at the time the project is conceived, and the construction risk can cause deviations in the costs of the project. In the operational phase, there can be supply risks, operating risks and market risks. The latter are the most recurrent and appear when the expectations of the use of the infrastructure fall to much lower levels than those initially estimated, which affect the profitability of the operation. There are also other risks, inter alia regulatory risk, legal risk and credit risk.

However, there is also the fact of the scant availability of quality investment projects: although estimates by international institutions indicate a broad availability of potential investment projects in the world, the fact is that in reality the opportunities available are much more limited. In Europe infrastructure investment is a local market where the most usual procedure is that it is the local development companies themselves that undertake domestic infrastructure projects. Depending on the country, there are enormous differences in the tradition of private-sector financing. There are countries like Spain and Germany where the bulk of the toll roads are financed by the public sector, while in others, such as Portugal and France, they are financed by the private sector. In addition, in the developed countries, the majority of the more profitable infrastructure projects have already been completed. Those still pending are those that involve more risk and more uncertain profitability. In this context, one of the proposals made by the European Commission (2014a; 2014b) to mitigate this problem is the creation of a pipeline of infrastructure projects at a European level that makes the necessary information available, such that any potential institutional investor in any country can participate in financing a project.

Rule of law

Other equally important elements are those related to legal uncertainties regarding contracts. As stated in OECD (2014), investors in public infrastructure need clear and stable regulations, together with efficient contractual procedures. This has not always been the case, and some governments have changed the contractual terms of the concessions. For example, in Spain the government has not complied with the

contracts signed (e.g. in solar electricity generation), and the developers have seen a cut in the price per kwh generated. This type of failure to comply can have an enormous impact on the financial return of a project.

Mitigation risk tools

As we indicate below, in the present regulatory framework for the financial sector (Basel II and III and Solvency II), which prioritize the need to measure these risks and provide the necessary capital to cover them, this complexity is a disincentive to these institutions to finance infrastructure to the same extent as they were doing previously.

Traditional insurers such as monoline companies collapsed in the last financial crisis. Without the support of this type of insurance, the risk assessment of many infrastructure projects carried out by the rating agencies could be insufficient to be acceptable to private investors. For example, the use of project bonds has shrunk since 2008 due to the lower ratings on the monoline companies that were insuring them (OECD ,2014d).

In this new scenario, the participation of international financial institutions such as the World Bank, the International Development Bank or the EIB become fundamental for articulating the tools for mitigating risk. At the same time, public-private partnerships can be seen as basic elements in incentivizing the participation of the private sector in financing infrastructure (World Bank, 2011). Many projects might be not viable from a financial point of view, but might nonetheless be socially viable or generate positive externalities that make them very necessary. The private sector would never undertake this type of project on its own unless it had some kind of guaranteed minimum level of earnings that would ensure an appropriate return on investment. At the same time, the government has to ensure that the conditions for the infrastructure investment provide value for money for the country in relation to the construction costs and underwriting the risks.

Global Financial Regulation and Pension Fund Investment in Infrastructure

Global financial regulation

Another important point to mention is the set of barriers faced by financial agents. When Basel II came into effect in 2004, it forced lending institutions to have sufficient capital to cover operating risks and market risk. Basel II allows the entities to use internal models to calculate their risk-weighted assets. The financial crisis in 2007-08 revealed the weaknesses of the system due to the high leverage of the lending institutions, their liquidity problems and the low level and quality of their capital. Basel III is the consequence of this, and obliges the institutions to improve the quality and quantity of their capital, improve their risk management systems, reduce leverage, increase liquidity and take counter-cyclical measures.

The consequences for infrastructure finance were immediate. First, the financing entities became more risk-averse, which meant that any project where the risks were not adequately guaranteed ceased to be of interest. In the case of the level of coverage of letters of credit, some countries have established a Liquidity Coverage Ratio (LCR) of 50 percent, which practically eliminates this type of asset. Second, the degree of coverage is very dependent on the time horizon. The longer the time horizon is, the higher the consumption of capital. As

financing infrastructure construction and operation is long-term, this has provided a further disincentive to continuing investment.

In addition to the global legislation, there are also local regulations that can also have a negative impact on the development of products linked to infrastructure. Infrastructure funds have been unsuccessful in Spain because the solvency requirements for these funds when tendering for PPP projects present an obstacle, as they normally manage funds that are not in themselves corporate. The tenders are normally designed for construction companies CEOE (2013).

Pension fund investment in infrastructure and its regulation

Infrastructure regulation is complex. First, there is the problem of defining infrastructure. Second, there is insufficient historical data to enable the regulation and evaluation of the possible impact of this regulation. As these are assets that are supported by physical installations, their characteristics will determine a specific type of project finance. A project for investment in a toll road is not the same as for a photovoltaic electricity generating plant or a hospital. Nor is a toll road connecting, for example, the two principal cities in a country directly comparable with one connecting relatively unpopulated areas. In addition to the different types of infrastructure, the type of investment project has to reflect whether this is a greenfield investment, or whether it is for the maintenance or improvement of a previously existing asset (brownfield). Then, the financing project should consider whether the investment will be based on shares or debt, and also whether or not these instruments are traded in an organized market, and whether the investment will be directly in the infrastructure itself, or indirectly through other financial vehicles. Investments that have a direct link include, for example, pension fund loans to the developer through project bonds, obligation bonds, or by taking an equity stake in one or several specific infrastructure assets through greenfield shares. Indirect investments would be made by buying shares in quoted companies involved in infrastructure development, or by buying into an infrastructure investment fund, whether quoted or not. Given this wide range of possibilities, the ideal would almost be to establish specific regulations for each project, although this is evidently impossible, and therein lies the difficulty of specifying general regulations.

In each country, the pension funds that have decided to invest in infrastructure assets have done so within the limitations imposed by their respective financial investment regulations, the degree of sophistication of their respective capital markets, that allow or forbid this type of investment, and the pension fund's technical possibilities of accessing infrastructure financing, either direct or indirect.

Individual countries can adopt three different regulatory stances to this complexity: the first relies on the total flexibility of pension funds' investment in infrastructure; the second considers the possibility of investment by means of certain vehicles, with restrictions; and the third is to prohibit this type of investment absolutely.

Geographies with extremely flexible financial regulation

The countries that have completely flexible regulations probably find that legislating for investment in this type of asset is too expensive, given the enormous diversity of the potential projects. They assume that the best entities to assess the risks of the project are the investors themselves, and as such, only establish that the investments should be "prudent" and well planned (OECD, 2014).

Adopting this model implies that the pension funds should have the necessary knowledge to successfully evaluate each project. This group typically comprises the Anglo-Saxon countries (the United Kingdom, the United States, Australia and Canada), plus Belgium and the Netherlands, which establish no quantitative limits on infrastructure investment.

Within this group, there is also a significant diversity in terms of the investment policy adopted. For example, in the cases of Canada and Australia, the instruments selected vary considerably. Canada has an interesting combination of direct investment in unlisted infrastructure asset projects; it has one of the most developed project bond markets and at the same time invests a significant proportion of its infrastructure portfolio abroad. Meanwhile, Australia has developed great expertise in packaging the risks in special financing vehicles, managed by infrastructure funds, and recently has been more actively investing in unlisted assets. Also, note that while pension fund investment in Australian infrastructure was incentivized by the introduction of an obligatory defined contribution pension system, in the case of Canada this boost came from very mature private defined benefit pension funds (Inderst, 2014).

Regulation of infrastructure investment by means of limits or conditionality

Regulation in countries that set limits on pension fund investment in infrastructure is tremendously varied. For example, a third of the countries analyzed in OECD 2014 do not allow investment in private investment funds or in direct loans. On the other hand, although the majority of the countries that allow investment in private bonds that could be infrastructure bonds, the limit is eventually almost always lower than for holdings of government bonds. In terms of investment in shares, the majority of countries does not allow investment in unlisted instruments and have limits for quoted assets. This is the case, for example, in various Latin American countries. In this geography there are at least five countries that are at present developing ways to allow pension funds to invest in infrastructure. According to Tuesta (2015), Latin America (Brazil, Chile, Colombia, Mexico and Peru, the countries with the most important private pension schemes in the region) is investing around 2.6 percent of its total portfolio in infrastructure. Mexico is of particular note, which to date is investing an average of 4.8 percent of its portfolio in infrastructure projects.

A look at the regulatory experience of these countries shows that it is very limited, with its origin in the first infrastructure bonds, under the monoline scheme first developed in 1998 in Chile, which enabled the financing of that country's key infrastructure. However, later on, this scheme had to be dropped due to the monoline crisis, and the current investments in these assets are concentrated in participation in infrastructure funds. In this century, it is Mexico that is leading the way in the development of packaged instruments for pension fund investment in these projects, with instruments such as the so called Fibra (Real Estate Investment Trusts) and CKD (Development Capital Certificate), focusing on an appropriate risk-sharing between all the parties concerned and very vigilant regulation. Colombia, meanwhile, has developed infrastructure bonds with limited government financing, while Peru has opted for trust funds to invest in infrastructure, set up by the pension funds themselves, in taking stakes in infrastructure funds where they play an active role on the board, and in the development of the so called CRPI (Work in Progress Certificates) for mega infrastructure projects, that are more like public works, as they have substantial guarantees from government tax revenues.

All the infrastructure investments in Latin America have some type of quantitative limitation, either direct, in the case of identifying the special vehicle itself, or indirect, such as the general quantitative cap for any type of debt or equity instrument. Countries such as Colombia and Mexico have set limits on their infrastructure investment vehicles that vary depending on the risk profile of the workers participant in pension funds and of the portfolios in which the funds are invested (Tuesta, 2015). In the case of Mexico, these can be up to 12 percent, while in Colombia the limit is 7 percent of certain portfolios.

The case of Europe

In the case of Europe, recurrent attempts have been made to encourage institutional infrastructure investment in recent years (European Commission, 2014a; 2014b). Nonetheless, the enormous diversity of pension systems has so far prevented regulation of a common infrastructure investment market. Within the European Union (EU), national legislation predominates, with significant differences between the least restrictive countries regarding such investments (Belgium, with 10.58%) and the strictest (Spain, 6.06%) (see methodology of the index in the technical appendix 1 and results in Table 2).

Table 2

Index of regulatory liberalization for the investment of pension funds in infrastructure

Country	Index	Country	Index	Country	Index	Country	Index
Belgium	10.58	Sweden	7.93	Mexico	6.04	Nigeria	4.57
Canada	10.58	Germany	7.93	Iceland	6.01	Romania	4.57
Gibraltar	10.58	Korea	7.78	Jordan	6.01	Czech Republic	4.33
Ireland	10.58	Portugal	7.61	Brazil	5.68	Albania	4.18
Netherlands	10.58	United States	7.59	Switzerland	5.68	China	4.18
Malawi	10.22	Denmark	7.54	Poland	5.50	Colombia	4.18
Australia	9.86	Hungary	7.22	Bulgaria	5.50	Pakistan	4.18
United Kingdom	9.86	Greece	6.80	Slovak Republic	5.32	Russian Federation	3.98
Israel	9.85	Mauritius	6.79	Armenia	5.31	Maldives	3.79
New Zealand	9.83	Austria	6.74	Costa Rica	5.29	Egypt	3.74
Norway	8.71	Italy	6.47	Slovenia	5.29	Dominican Republic	3.38
Japan	8.41	Turkey	6.47	Tanzania	5.29	Chile	3.07
Estonia	8.36	France	6.43	Peru	5.29	Uganda	3.02
Jamaica	8.31	Thailand	6.10	Kenya	4.93	India	2.30
Malta	8.12	Trinidad and Tobago	6.07	Republic of Macedonia	4.93	Ukraine	2.25
Luxembourg	7.95	South Africa	6.07	Namibia	4.91		
Finland	7.94	Spain	6.06	Zambia	4.91		

Source: OECD (2014a)

The calls on EIOPA to define a more favorable framework for infrastructure investment have been repeated in recent years (European Commission, 2014a; 2014b). On 29 April 2009, the European Commission proposed a directive on Alternative Investment Fund Managers (AIFMs) with the objective of creating a regulatory and supervisory framework for AIFMs at a European level, which would make the management of these funds more transparent for both the authorities and investors.

The body responsible for regulating pension funds in Europe (EIOPA) proposed the IORP and IORP II directives to homogenize national legislation on occupational pension funds with the requirements of Solvency II. Thus, the European focus prioritizes solvency and active risk management through models that allow the appropriate evaluation of the associated risks, not forgetting the required pillar of control and reporting.

Although EIOPA recognizes the importance of infrastructure to economic growth and the potential advantages to pension funds, it cautions that more work needs to be done and consultations carried out before any common legislation could be included in IORP. In this respect, EIOPA (2013) proposed a discussion paper which first establishes how the various infrastructure and other long-term assets should be treated within the Solvency II framework, and for what type of financial investor. EIOPA considers that the preferred type of investment for insurance companies³ in long-term assets would be direct project finance (bonds, loans or equity), infrastructure investment funds (listed and unlisted) and infrastructure loan securitization vehicles.

The most advanced initiative that tries to mitigate the problems noted above is the Europe 2020 project bond initiative under the auspices of the EIB. The role to be played by the EIB itself would be that played previously by the former monoline insurers, covering greenfield infrastructure risks, and providing the projects with an adequate credit rating. More specifically, the principal characteristics are as follows: limiting loss coverage below 20%]; aiming for an “A” rating for the project, which is the minimum requirement for pension funds and insurance company asset portfolios; the possibility of subordinated loans from the EIB based on their financial situation and rating; selecting the project finance or PPP projects that are well designed and which are available for audit by the EIB itself.

On 4 February 2015, EIOPA created a working group that will help to define a type of infrastructure investment that offers predictable cash flows in the long term with well-identified risks. It will also explore possible criteria for the new types of good quality infrastructure assets that include transparency and standardization criteria and analyze how those would fit with the criteria of Solvency II, focusing on the specific risk profile.

What variables have influenced pension fund investment in infrastructure? The empirical evidence

As we have noted throughout the document, there is a set of regulatory and non-regulatory factors that may be encouraging / discouraging the participation of pension funds in infrastructure funding. In this section we propose a model to quantify which of these factors are relevant through the use of an econometric strategy.

3: It does not specify if this would also apply to pension funds.

Data

The databases come from several sources: the investment regulation of pension funds and its institutional and business environment has been created by relying on several OECD publications and a World Economic Forum USA's report. The aim was to determine which variables could affect the investment of pension funds in infrastructure. For that purpose, we have differentiated three groups of variables in order to explain this relationship.

The first group of variables was collected from the OECD (2014a), with data as of December 2013. This report contains information about all forms of restriction and legal regulation on different pension funds. The variables contained in this first group refer to the limits on OECD and selected non-OECD pension funds investment in several asset categories (equity, real state, bonds, retail investment funds, private investment funds, loans and bank deposits). In particular, two groups are differentiated depending on whether the assets are domestic or foreign.

The second group of variables was published by the World Economic Forum USA (2012) and they concern different categories such as: institutional and business environment, financial stability, non-banking financial services and financial access in some OECD and non-OECD countries. Specifically, we have included three groups of variables. The first group is constituted by the capital account liberalization and the quality of overall infrastructure, which both are standardized on a scale from 1 (least) to 7 (most).

The second set is formed by the strength of legal right index, the strength of investor protection index and the financial strength indicator, and these three factors take values from 0 (worst) to 10 (best).

The third group includes the number of procedures to enforce a contract (in number of days) and the share of total number of securitization deals (as a percentage of total deals).

A supplementary group of variables has been collected from the OECD (2014c). They review trends in the financial performance of pension funds (assets, investments and industry structure). In particular, variables selected refer to the importance of pension fund assets as a share of GDP, the percentage of non-financial corporate bonds with respect to total bonds and the amount of defined benefits (DB) pension plans' assets as a percentage of total assets.

Concerning the dependent variable mentioned previously, the investment of pension funds in infrastructure, we turned to the OECD (2014b). In this report, the total investment in infrastructure (including assets belonging to sectors such as transport, telecommunications, utilities and energy) is mentioned for several pension funds from the countries analyzed. Pension funds can access infrastructure through different channels and the infrastructure investment (as a percentage of total investment) can be distinguished by three different categories: unlisted equity, listed equity and debt. We consider the total amount of infrastructure investment (Total infrastructure investment = unlisted equity + listed equity + debt) in this study.

The observation of the database used in this section is the pension fund, not the country. Given the legislation of several countries (in alphabetical order, Armenia, Bulgaria, Czech Republic, Estonia, Finland, Germany,

South Korea, Luxembourg, Malta, Nigeria, Poland, Russia Federation and Slovak Republic), these countries have different types of pension funds with different conditions of financial regulation and levels of investment.

In order to study the effect of the financial regulation and the institutional framework on the weight of the investment of pension funds in infrastructure, a Tobit model is implemented. The use of this model is conditioned by the particular characteristics of the dependent variable.

The dependent variable is observed only over some interval of its support. The sample is a mixture of observations with zero and positive values. Therefore, the likelihood function has to take into account this particularity and involves additional computational complications. The econometric model applied in this section is known as the "Tobit model". Further details of the Tobit model and assumptions established to control for the particular characteristic of the observations are included in the technical appendix 2.

The financial regulation is associated to the financial product considered. The high number of variables compared to the small number of observations and the limitations derived from the information of the variables recommend the use of principal components methodology. The principal components procedure allows aggregating the information in two indicators, the portfolio limit in domestic asset categories and the portfolio limit in foreign asset categories (see technical appendix 1).

Geographic binary variables are also included in the model. Several areas are considered: Anglosphere countries in a broad sense (those countries in which English is the first language of the majority of the population and those countries with substantial English knowledge dating back to the British Empire), EU countries, EFTA countries, and Latin-American and Caribbean countries.

Table 3 presents the main descriptive statistics of the variables used in this section.

Table 3

Descriptive Statistics

	Mean	Standard Deviation	Min	Max
Total Infrastructure investment (as a % of total investments)	3.104	8.843	0	51.30
Portfolio limit in domestic asset categories	5.847	2.800	0	10.58
Portfolio limit in foreign asset categories	1.891	2.515	0	9.85
Capital account liberalization	5.199	2.026	1	7
Quality of overall infrastructure	5.033	1.042	2.83	6.64
Strength of legal rights index	6.456	2.105	3	10
Strength of investor protection index	5.825	1.368	3	9
Number of procedures to enforce a contract	32.930	5.454	21	46
Importance of pension funds relative to the size of the economy in the OECD	24.105	35.449	0	166.30
DB pension plans' assets as a % of total assets	20.329	35.506	0	100
Financial strengths indicator	4.561	2.044	0	9
Non-financial corporate bonds to total bonds and notes outstanding (%)	6.722	11.297	0	36.21
Share of total number of securitization deals	2.130	7.270	0.02	53.63
Anglosphere countries (broad version)	0.123	0.331	0	1
EU countries	0.474	0.504	0	1
EFTA countries	0.018	0.132	0	1
Latin-American and Caribbean countries	0.105	0.310	0	1

Source: OECD (2014a, 2014b, 2014c) and World Economic Forum USA Inc.

Pension funds can access infrastructure through different channels. Following the OECD (2014b), the infrastructure investment considers separately unlisted equity, listed equity and debt. In order to analyze this variable we aggregate the three parts to obtain the total infrastructure investment as a share of total investments. The average value shows that the investment of pension funds in these assets represent a small part of the total. However, this situation varies widely depending on the country considered. Several countries do not invest anything in infrastructure, whereas countries like Portugal, Canada, Brazil and Australia have a significant participation in infrastructure among pension funds' investments.

Focusing on the portfolio limits in domestic and foreign asset categories, the results suggest that the investment of pension funds in domestic asset categories overtake the investment in foreign assets. The regulation for domestic categories is deeper than the existing for the foreign ones, where in some cases no regulation can be found.

Regarding the capital account liberalization, which measures the degree of capital account liberalization within a country, the mean shows that the liberalization degree is quite high (a value of 5.2 with 7 as the maximum value). However, there is high inequality, as shown by the value of the standard deviation.

The quality of overall infrastructure takes into account the business environment and assesses the infrastructure (transport, telephony, energy, etc.) in the country. An index standardized on a scale from 1 (extremely underdeveloped) to 7 (extensive and efficient) is used. The mean shows, in general, the infrastructure in the countries analyzed is developed (5.8, and 6.64 is the maximum value), but it does not reach high levels of efficiency. The countries with the best performance in this index are Switzerland and Finland. On the other hand, Romania, Tanzania and Nigeria would be examples of countries with the highest levels of underdevelopment.

The strength of legal rights index refers to the degree to which collateral and bankruptcy laws protect the rights of borrowers and lenders and thus facilitate lending). In the case of the first variable, the protection of the rights of borrowers and lenders is similar to the average (6.5). However, given the results of the standard deviation, significant inequalities among the countries are observed. Countries like Kenya, South Africa and United Kingdom have a high level of protection and thus access to credit. Others countries like Brazil, Egypt, Indonesia, Italy, Portugal and Russian Federation presents a low index indicating vulnerability and difficulties in accessing credit.

In relation to investor protection, the average value shows that the majority of the countries are around the mean (6.0). We can highlight the position of some countries such as Canada, Colombia and Ireland, where the protection index almost reaches the maximum, while others countries, such as Austria, Greece and Switzerland, present low values of this index.

The number of procedures to enforce a contract measures the number of procedures from the moment the plaintiff files a lawsuit in court until the moment of payment. The mean value shows that almost 33 procedures are needed. In general, all the countries need between 30 and 40 procedures except some extraordinary cases (such as Ireland which only requires 21 procedures, whereas Pakistan and India need 46 procedures).

In relation to the value of pension funds relative to the size of the economy in the OECD, the result of the mean value confirms a generally small size. However, analyzing the existing standard deviation and the maximum value, the difference among countries is remarkable. In most countries, pension funds represent less than 10 percent of the size of the economy while there are others where the situation is totally opposite. This is the case of countries like Australia, Iceland, Netherlands and United Kingdom, where the relative size of pension funds to the economy exceeds 100 percent.

The DB pension plans' assets as a percentage of total assets shows the importance that these pension plans, which identify the specific benefit that will be payable to the beneficiary at the retirement, represents over the total. As with the previous factor, the mean value of this variable shows that this type of pension fund has a low relevance compared to the total assets, but the standard deviation confirms high differences among countries.

The financial strengths indicator is the weighted average of the financial strengths rating by bank assets, and shows a mean value near to the arithmetic average value (4.56). The financial strength rating for the majority of the countries is between 4 and 6. Only a few countries such as Canada and Australia present a highlighted position.

Concerning the non-financial corporate bonds as a share of the total bonds and notes outstanding, the figures generally present a very low percentage and high variability. For countries like the Russian Federation and South Korea, these products represent 30 percent of the total, while for the other countries this percentage is much lower.

The share of total number of securitization deals shows the three-year average of the sum of asset-backed securities, mortgage-backed securities, high-yield bonds and highly leveraged loans deals as a percentage of total deals. As the mean and the standard deviation suggest, there is a huge disparity among the countries analyzed because the securitization deals represents less than one percent of total deals for the majority of them. This percentage reaches 53.63 percent in United States.

The model

Taking into account the information provided of the descriptive statistics of the variables, the results of the models are presented in Table 4.

Table 4

Results of the model	Dependent variable: Total Infrastructure investment (as a % of total investments)			
	Model 1	Model 2	Model 3	Model 4
Portfolio limit in domestic asset categories	2.577 **	-1.731	-2.791	-4.846
Portfolio limit in foreign asset categories	-0.399	-2.342 *	-4.660 **	-4.928
Capital account liberalization		6.395 **	12.872 ***	49.606 **
Quality of overall infrastructure		-5.955	-19.497 **	-65.177 **
Strength of legal rights index		4.241 *	4.841 **	15.035 **
Strength of investor protection index		-5.960 *	-11.725 ***	-38.669 **
Number of procedures to enforce a contract		-0.227	-1.615	-5.546 **
Importance of pension funds relative to the size of the economy in the OECD		0.193 *	0.09	-0.073
DB pension plans' assets as a % of total assets		0.040	0.010	0.386 **
Financial strengths indicator			9.000 **	32.405 **
Non-financial corporate bonds to total bonds and notes outstanding (%)			0.940 **	5.143 **
Share of total number of securitization deals			0.340 *	2.139 **
Anglosphere countries (broad version)				47.650
EU countries				140.591 **
EFTA countries				90.244 *
Latin-American and Caribbean countries				94.610 ***
Constant	-33.142 ***	0.628	69.281	29.451
Number of observations	57	57	57	57
Pseudo R ²	0.018	0.088	0.147	0.225
Log pseudolikelihood	-80.655	-74.884	-70.026	-63.679

Notes: ***, **, * denote estimates significant to 1%, 5% and 10% respectively.
 Source: OECD (2014a, 2014b, 2014c) and World Economic Forum USA Inc.

Model 1 considers only as regressors the financial regulation variables derived from the PCA process. The estimates of the coefficients of the portfolio limit in asset categories suggest that a reduction of the limits in domestic assets significantly improves the percentage of infrastructure investment in the total amount of investment. This effect is not statistically different from zero in the case of the limits for foreign assets. Therefore, the main restriction for infrastructure investment by pension funds comes from domestic assets. These results indicate that much work remains to be done in the field of financial regulation, and the extension of the limits to foreign assets is not relevant if the limits are not flexible enough inside the country.

Model 2 includes financial regulation variables as well as other variables associated with general regulation, legislation, institutional factors and pension characteristics. The effect of the financial regulation changes, and it is negative in both cases, but negligible in the domestic option and slightly significant for the foreign assets. The importance of other factors also determines the relationship between financial regulation and investment decisions, which do not exclusively depend on portfolio limits.

The relevant positive influence in the dependent variable comes from the degree of capital account liberalization (this variable measures the degree of capital account liberalization within a country), the strength of legal rights index (measuring the degree to which collateral and bankruptcy laws protect the rights of borrowers and lenders) and the importance of pension funds relative to the size of the economy. The strength of investor protection index (assessing the strength of investor protection) generates a negative and slightly significant effect on the percentage of infrastructure investment. A potential explanation comes from the tradeoff between protection level and investment opportunities of the pension funds compared with other investment agents in the context of infrastructures. A high level of protection of the investor in general terms may imply a smaller interest in infrastructures than in other interesting options of investment (with higher risk), given the use as dependent variable of the percentage of infrastructure investment of the pension funds in the total investment.

Other variables considered show an estimate not statistically different from zero. The DB pension plans' assets as a percentage of total assets have a positive estimate, and the estimates of the quality of overall infrastructure and the number of procedures to enforce a contract present negative values. A higher quality of overall infrastructure reduces the potential process of infrastructure investment by the pension funds, in the same way as a higher level of complication in the procedure to enforce a contract undermines the investment procedure in any kind of sector.

Further details related to financial system are incorporated to the previous group of variables in Model 3. The effect of the independent variables previously included increases in absolute value. Therefore, this new group of variables reinforces the qualitative comments of Model 2. Only the importance of pension funds relative to the size of the economy loses significance level, maintaining the positive effect.

The effect of the financial system instruments is positive and significant, establishing a direct relationship between flexibility, size and development degree of the financial markets and the level of infrastructure investment of pension funds. The effect of the financial strengths indicator is higher than the other two variables, due to the nature of these two factors.

The last group of variables considered in Model 4 is related to geographic areas. The results confirm the importance of all factors considered in Model 3, including geographic binary variables. The estimates from the geographic areas suggest the existence of intrinsic and particular country characteristics affecting the percentage of infrastructure investment of pension funds in total investment, especially in the case of the EU, EFTA and Latin American and Caribbean countries.

The financial regulation measured by the portfolio limit in domestic and foreign asset categories presents estimates that are not statistically significant. These results confirm that the existence of portfolio limits constitutes an additional step in the infrastructure investment decisions of pension funds. However, this specific measure in financial regulation has a relative importance if it is compared with other important aspects.

The estimates of Model 4 show the relevance of other topics associated with financial regulation in investment decisions by the pension funds, such as the development of financial protection, the progress in the stability and fairness of the legal rights laws, the improvement of quality and strength of financial institutions.

The degree of development in the financial markets (as has been presented by the capital account liberalization, the non-financial corporate bonds as a share of the total bonds and notes outstanding and the share of total number of securitization deals) also provides positive and significant effects on the percentage of infrastructure investment of pension funds in total investment.

Those aspects related to pension funds included in the models present mixed results. The importance of pension funds relative to the size of the economy does not generate significant effects, but the DB pension plans' assets as a percentage of total assets achieve positive and significant effects.

Conclusions

This research has explored the different aspects behind the decisions of pension funds' investments in infrastructure projects. We discussed the conceptual aspects behind investing in this type of asset, as well as the current trends that pension funds and the economy are facing and how they are gathering enormous interest from policy makers and regulators around the world. We mentioned that from the pension funds' perspective, investing in infrastructure could make, theoretically, a perfect match with their investment stance, in respect of maturity of the investment, less correlation with other financial assets in their portfolio, better risk-return equilibrium, among others. All these elements suggest an overall improvement in the efficiency of their investment decisions. If we consider that the current challenges to pension funds indicate that demographic factors and a long-term low-rate-of-return scenario are going to have a negative effect on pension revenues, the pressing need to find other financial alternatives that counterbalance this situation makes the argument for investing in infrastructure very persuasive.

From a more general perspective, the value that policy makers are starting to see in pension funds as adequate financing agents to take care of infrastructure projects was also highlighted, especially in a context in which governments are subject to limits on the fiscal side. Likewise, banks which tended to be traditional partners in PPP projects are now facing more stringent financial regulation, which disincentivises them from financing this type of long-term asset.

In this context, we have discussed how pension regulations are adapting to this stance of pension funds being more involved in investing in infrastructure projects. We have seen different regulatory approaches from the most restrictive to the most flexible, highlighting the case of Australia and Canada as two interesting models where the regulatory framework allows them to invest with enormous flexibility, and apparently with success. We have also highlighted the current regulatory discussion in Europe, in the context of the development of a Capital Market Union, which has to deal with the current domestic regulatory issues inside the individual countries belonging to the EU. There have also been interesting developments in this topic in Emerging Markets, particularly in Latin America where different specialized financial vehicles have been developed for pension funds to invest in infrastructure, especially in Mexico, which confirms the worldwide interest in the potential for this form of funding.

In order to study the effect of financial regulatory and non-financial regulatory variables on pension funds' investment in infrastructure, a Tobit model is used as our econometric strategy. The results we presented tell

us that the financial regulation measured by the portfolio limit in domestic and foreign asset categories present estimates that are not statistically significant. These results confirm that the existence of portfolio limits constitutes an additional step in the infrastructure investment decisions of pension funds. However, this specific measure in financial regulation has a relative importance if it is compared with other aspects, such as the development of financial protection, the progress in the stability and fairness of the legal rights laws, the improvement of quality and strength of financial institutions.

Likewise, the degree of development in the financial markets (as has been presented by the capital account liberalization, the non-financial corporate bonds as a share of the total bonds and notes outstanding and the share of total number of securitization deals) also produces positive and significant effects on the percentage of infrastructure investment of pension funds in their total investments. Also revealed was the importance of intrinsic and particular country characteristics affecting the percentage of infrastructure investment by pension funds.

Appendix 1. Measuring the Regulatory Flexibility of Pension Fund Infrastructure Investment Through a Synthetic Index

In an attempt to homogenize and standardize the enormous diversity of regulations on pension fund infrastructure investment, we set out to create an index that measures how much of an opening or facility these funds have to make this kind of investment.

Principal component analysis (PCA) is a statistical technique used for data reduction. PCA uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components.

PCA is mathematically defined as an orthogonal linear transformation. This transformation is defined in such a way that the first principal component has the largest possible variance (and thus accounts for as much of the variability in the data as possible), and each succeeding component in turn has the highest variance possible under the constraint that it is orthogonal to the preceding components.

The principal components are orthogonal because they are the eigenvectors of the covariance matrix, which is symmetric. In addition to data reduction, the eigenvectors from PCA are often inspected to learn more about the underlying structure of the data.

The high number of products in terms of portfolio limits compared to the small number of observations and the limitations derived from the information of the variables recommend the use of principal components methodology.

The OECD (2014a) reports details of the regulation for each financial product describing different forms of restriction and legal regulation on pension funds. The products are Equity, Real Estate, Bonds, Retail Investment Funds, Private Investment Funds, Loans and Bank Deposits.

We use four different codes for each product (not allowed to invest, allowed with restrictions, allowed with restrictions and with exceptions in some particular cases, and allowed with no limit). Therefore, a higher value of this indicator (for any product) implies a higher degree of flexibility.

The legislation of each country also distinguishes between portfolio limits on pension fund investment in the own country (_in) or outside (_out) using these seven asset categories. The principal components procedure allows aggregating the information of the seven products in two indicators, the portfolio limit in domestic asset categories and the portfolio limit in foreign asset categories:

Portfolio limit in domestic asset categories = $0.3850 \times \text{Equity_in} + 0.3640 \times \text{Real Estate_in} + 0.3863 \times \text{Bonds_in} + 0.3896 \times \text{Retail Investment Funds_in} + 0.3832 \times \text{Private Investment Funds_in} + 0.3603 \times \text{Loans_in} + 0.3763 \times \text{Bank Deposits_in}$

Portfolio limit in foreign asset categories = $0.3992 \times \text{Equity_out} + 0.3439 \times \text{Real Estate_out} + 0.4142 \times \text{Bonds_out} + 0.4113 \times \text{Retail Investment Funds_out} + 0.3615 \times \text{Private Investment Funds_out} + 0.3111 \times \text{Loans_out} + 0.3927 \times \text{Bank Deposits_out}$

The values of the weights of these two formulas correspond to the results derived from the first principal component (eigenvector) for each set of products. The weights in both cases are similar among the financial products, although the differences seem to be higher in the foreign asset categories.

As we can see, the countries with regulations more open to pension fund investment in the financing of infrastructure are those of Anglo-Saxon origin, followed by those from northern Europe and Japan. There are a great many developed countries whose national legislations are far more restrictive than those mentioned, such as Spain, France, Italy and Switzerland, to name but a few. It is the developing countries, especially in Africa and one or two in Latin America, which present the most restrictive regulations.

We are currently undergoing a period of transition. Whereas the Anglo-Saxon countries are relatively satisfied with their current legislative structures, the countries in Europe are mainly waiting for EIOPA to pronounce on the specific regulation on the particular treatment of infrastructure assets in the IORP directive. The European Commission is putting pressure on the regulator to clarify its position, and to make some sort of move by advancing the Europe 2020 project bond initiative via the EIB to allay problems arising from the failure of monoline insurance companies and the disincentivisation faced by financial intermediaries from participating in new projects owing to the demands imposed by Basel II and III and the Solvency II directive. Consideration is thus being given to:

- Pension funds being able to take part in quality project finance ventures if the frameworks for risk cover by the IFIs and PPPs could permit adequate risk-return ratios, and they are not penalized in terms of capital commitment by the new regulation.
- As projects come through the pipeline, the possibility of infrastructure capital markets being brought in, which would provide the necessary liquidity for this asset class.
- Starting up a partnership between the banking industry and the pension funds by structuring financing projects that highlight their complementary aspects.

Appendix 2. Econometric Model Application: Tobit Model

Consider the observation i as the pension fund i , such that $i = 1, \dots, N$. Given the legislation of several countries, there are several pension funds with different conditions of financial regulation and levels of investment. Each pension fund can be assumed to have a different and independent behavior regardless of the belonging of the country. An alternative to relax this assumption is controlling in the estimation process for the country variable, as will be commented afterwards.

The Tobit model is a statistical model proposed by James Tobin (1958) to describe the relationship between a non-negative dependent variable y_i and K exogenous variables (or regressors) included in the vector x_i (of size $K \times 1$).

The model considers that there is a latent variable y_i^* , which is not completely observable. The relationship between y_i and y_i^* is the following:

$$y_i = \begin{cases} y_i^* & \text{if } y_i^* > 0 \\ 0 & \text{if } y_i^* \leq 0 \end{cases}$$

This latent variable depends on the regressors taking into account the following econometric structure:

$$y_i^* = \beta' x_i + u_i$$

Where β is the vector of parameters (of size $K \times 1$) defining the relationship between the latent variable and u_i is the error term such that follows a normal distribution $N(0, \sigma^2)$. In the estimation process, a variance-covariance matrix option are considered corresponding to the parameter estimates, in order to control for the strong assumption of the independence of the observations: the Huber/White/ sandwich estimator and the clustered sandwich estimator, using the country as cluster variable.⁴

4: For further details of the Tobit model and the variance-covariance matrix assumptions, see Wooldridge (2010). Using an alternative variance-covariance matrix option (the Huber/White/ sandwich estimator) the significance of the estimates provides similar conclusions.

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