envest

Optimal Alternative Asset Allocation for Swiss Pension Funds

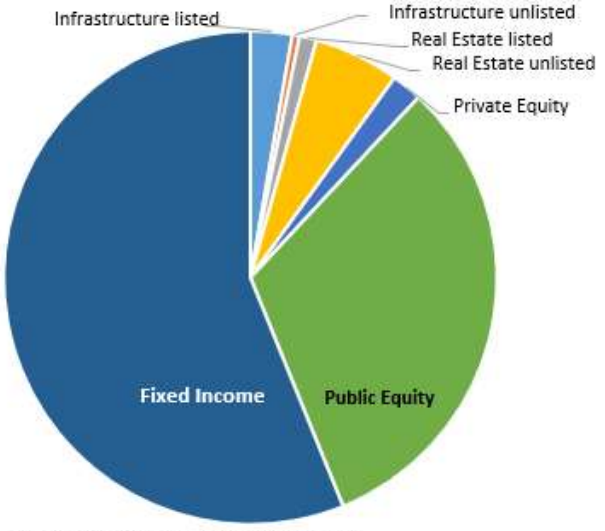
1 Overview

The objective of this report is to determine potential for the asset management of Swiss pension funds. The low level of interest rates and the high Swiss franc reduced the performance of the third contributor and led to a consolidation of the industry and the development of investment opportunities. By international comparison, the high proportion of Swiss assets (PPCmetrics 'Home Bias') and the low proportion of alternative investments (excluding real estate) is striking. This is due on the one hand to historical habits and on the other hand to different market environments and structures. In the following, this will be firstly described in detail and interpreted and secondly possible solutions for asset management and its regulation will be presented.

The size of the Swiss asset market shares is at about identical as the global market (MSCI as per Graph 1). Regarding infrastructure investments, the 0.5% allocation of Swiss pension funds are well below the accordingly global share. Canadian pension funds, for example, have a larger share of 7.7% as per Graph 2. The Canadian asset market offers certainly more local opportunities and the pension funds have well established investment know how. Nevertheless, in addition to listed companies with its subsectors such as railway, airport, Utility, Communication- and Grid, two specific collective insurance investment funds are available in Switzerland. Since the Swiss infrastructure market is also partly privatized, it would be necessary to build up similar know how as it persist with direct Swiss Real Estates for Swiss pension funds.

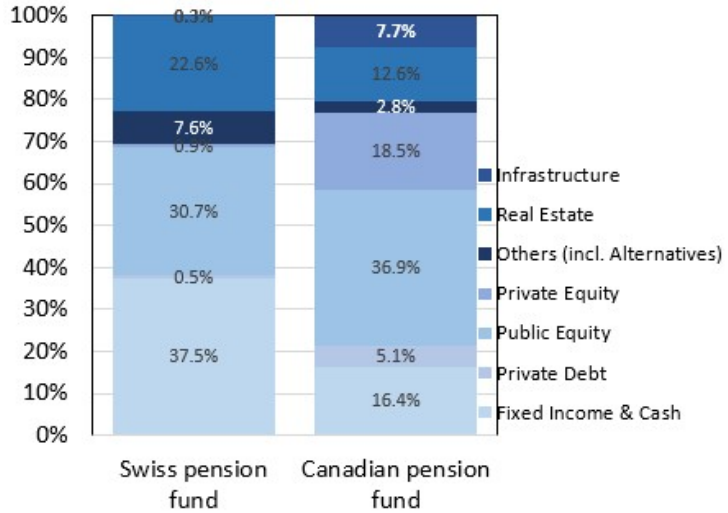
To determine the optimal asset and currency allocation, the chosen method is the commonly deployed Mean Variance Optimization (MVO). In the follow, a typical Swiss pension fund portfolio with its Swiss federal Ordinance on Occupational Old-Age, Survivors' and Disability Benefit Plans (OOB2) recommended allocation limits is discussed. This includes also the aspect of allocation in foreign investments and its currency hedging as well as the optimal share of illiquid unlisted assets.

Graph1: Investable Globale Market Portfolio 2015



MSCI Globale Market Report 2015

Graph2: Comparison of different asset allocations by pension funds



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2 Reference portfolio

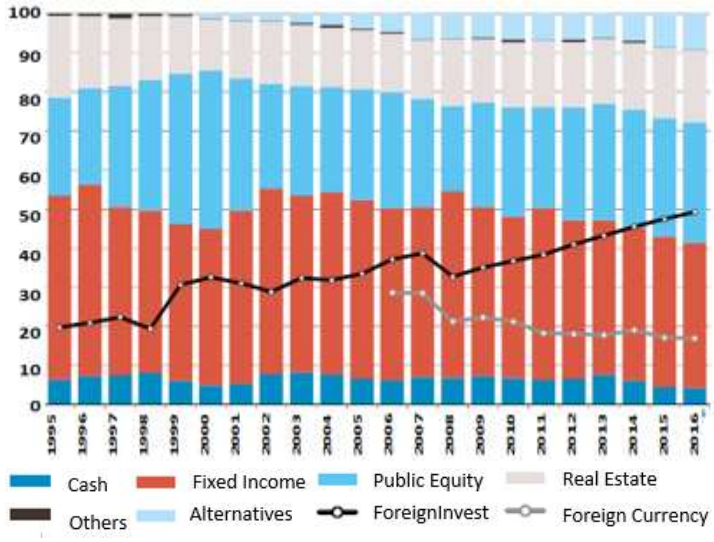
As a basis for the evaluation of the infrastructure's impact, the reference portfolio of the two Swiss pension fund reports from Complementa and Swiss Canto (Annexe 1, Table3) are due to transparency consulted. Asset classes and the limit guidelines are defined by the OOB2. In the past, fixed income assets have been continously replaced with Swiss real estates (Table4 2016: 21,9%) and with alternative investments (Table4 2016: 6,3%). The alternative asset class as per OOB2 consists of sub classes such as Hedge Fund, Private Equity, Infrastructure Equity, Commodities and Private Debt

and its allocation is currently to 15%. Furthermore, Real assets make up 18.3 % and unlisted assets are allocated 17.4% in the reference portfolio.

Table1: Allocation reference & guideline of Swiss pension fund

Asset & Currency 2016	Complementa 2016	OBB2 guideline limit
Cash CHF	5,1%	100,0%
Foreign bonds hCHF	10,7%	
Swiss bond CHF	21,7%	100,0%
Foreign corp bond USD	0,0%	
Swiss unlisted mortgage title CHF	1,2%	50,0%
Swiss listed equity CHF	13,1%	
Foreign listed equity hCHF	0,0%	50,0%
Foreign listed equity USD	17,6%	
Swiss listed RE CHF	12,0%	30,0%
Swiss unlisted RE CHF	9,9%	
Foreign listed RE hCHF	1,9%	
Foreign RE USD	0,0%	10,0%
Alternative: Infrastructure equity	0,3%	15,0%
Other Alternatives	6,0%	
Other	0,5%	
Foreign Currency	19,0%	30,0%
Foreign hedged Investments	13,0%	100,0%

Graph3: Reference Portfolio's historical allocation



2.1 Listed and unlisted Real Assets

But infrastructure equity allocation in 2016 for example has been only 0,9% in average due to difficult direct access, the lack of accordingly investment vehicles and specific investment know how. The majority of infrastructure investments are in public hands. Compared to pension funds as investors, the Australian and Canadian pension funds account for the largest share of the portfolio. At 0.5%, the Swiss pension funds are below the 3.2% share in the global and Swiss market portfolios. The Performance and Diversification of the collective insurance investment funds …

Graph 4: Overview of collective insurance investment funds on KGAST

Graph 5: Performance of collective insurance investment funds on KGAST

2.2 Other unlisted Assets and Liquidity (PE, HF,…)

By taking into account unlisted direct or indirect investments, the impact on liquidity must also be examined. The liquidity risk of the Swiss pension funds is controlled on the one hand by the liquidity requirements of PKST and on the other hand by the limit for direct mortgages and the 15% limit on alternative investments. The biggest challenge is the quantification of the liquidity risk. The method recommended by the responsible organisation PKST is the 95% shortfall comparison with the technical reserves. PKST recommends applying the respective liquid reference indices available for the same asset sub-class. On the one hand, return and correlation are thus presented more conservatively, but on the other hand the overall liquidity risk is not considered. Nevertheless, based on the reference portfolio holdings of 17.4% in non-listed assets, the Swiss pension funds are not overly invested in unlisted assets. The Swiss unlisted real

estates, which are not considered as an alternative investment under OBB2, account for the largest unlisted investment allocation of 9.9% and a large share of 45% on total real estates. These holdings in Swiss real estates have a tradition going back more than 20 years, which is why pension funds have built up extensive investment know-how. In summary, the pension funds are adequately invested in unlisted real estates, but there is a home bias and an insufficient risk management for unlisted assets liquidity risk.

2.3 FOREIGN CURRENCY ALLOCATION

According to the CS report, the average foreign currency position of the pension funds in 2016 consists mainly of USD (7.06%), EUR (3.4%) and residual currencies. Although the share of foreign investments has increased to 49,3% (Table4 2016) over the last 10 years, the unhedged position has decreased to 17%. Foreign equity investments in particular remained unhedged. The OBB2 guideline limits the portfolio's foreign currency exposure to 30%, whereas total foreign hedged investments are unlimited. This is even more surprising as the Swiss Franc has become overvalued and Cash holdings in Swiss Franc are penalized. This is mainly due to the preference for Swiss assets (home bias PPCmetrics) and the limited availability of KGAST vehicles.

Graph 6: Home Bias by PPCmetrics	

3 Infrastructure Indices

Infrastructure indices with foreign assets are comparable with the range of available real estate indices according to the index overview of Table 9. For the Swiss Market, a tailormade approximation via SPI subsectors is required, since Swiss infrastructure indices are inexistent. The evaluation with the reference portfolio is performed with the global listed and unlisted equity indices as well as a listed debt index as per overview. Of this, the global S&P and DJB listed infrastructure index series are most transparent, have most variants of sub-indices and focus on the main infrastructure benefits such as income and diversification. As per historical correlation and performance table, infrastructure yield-driven selection indices show competitive Total Return with better diversification and above average dividend yield. Therefore, the better performing S&P high income infrastructure index serves for evaluation. For the main infrastructure bond maturity of 5-7 Year, the DJB global Infra Broad Corporate Bond 5-7 Year is best performing. Regarding illiquid investments, the most suitable unlisted Indices for Swiss Pension Funds should have funds investing in Switzerland or Europe to reflect economic and physical proximity. But the best available unlisted equity infrastructure index is the Preqin global Fund Index, which has a 10-year history with quarterly pricing and some heteroskedasticity. Summarized, the chosen three global indices are best available and sufficient approximations.

3.1 UNLISTED INFRASTRUCTURE INDICES

The following is a comparison of the various unlisted indices and their suitability for the MVO. There are three global unlisted indices from Preqin, EDHEC und MSCI shown in the Indices overview of Table9. The MSCI shows autocorrelation as known from real estate appraising and an insufficient history of 8 years. Although the EDHEC European infra equity and bond index have more than 10 years of history and are heteroskedastic (Annexe1), those indices are also not suitable due to yearly pricing. The remaining Preqin global Fund Index, which has a 10-year history with quarterly pricing and heteroskedasticity (Annexe2), is therefore chosen for basic evaluation and comparison. As an

interesting future alternative for addressing the illiquidity more appropriate, two potential but not considered approaches are described in Annexe 4.

Table 9: Index overview

	Infrastructure	Real Estate	
	Global/ Regional	Global/ Regional	Switzerland
Asset Level	• MSCI Glb Infra Asset • EDHEC European unlisted Infra equity • EDHEC European unlisted Infra debt	• NCREIF Property (US) • IPD (Global & UK)	•SIX-IAZI direct Real Estate IREALC
Fund Level	• Preqin Glb unlisted Infrastructure Fund • MSCI Infrastructure Fund (Australia)	• INREV (Europe) or ANREV (Asia) • IPD Glb Fund • NCREIF Fund (US) • Preqin Glb unlisted Real Estate Fund • Dow Jones Brookfield Glb REITs&REOCs	•SXI listed Real Estate® Funds TR (SWIIT) •KGAST unlisted Invest foundations
Public Market	• Dow Jones Brookfield Infrastructure • FTSEGlobal Core Infra 50/50 • Macqurie Glb Infra • MSCI World Core Infra • S&P Glb Infra	• FTSE EPRA/NAREIT Glb Real Estate • GPR Glb • MSCI Glb listed Real Estate • UBS Glb Investors	•SIX Real Estate Share Index
Absolte Return	•10-12% •Inflation + 5% •Long nominal yield + 4,5% •Inflation-linked yield + 4% •Cost of capital + adjustment for risk	•8%-10% •Inflation + 5% •Bonds + x% •GDP + x% •Cost of capital + adjustment for risk	

*Complemented list from MSCI: Alerian MLP and Renewable YLCO Indices are excluded due to small size and sector focus

Table 10: Historical correlation and performance

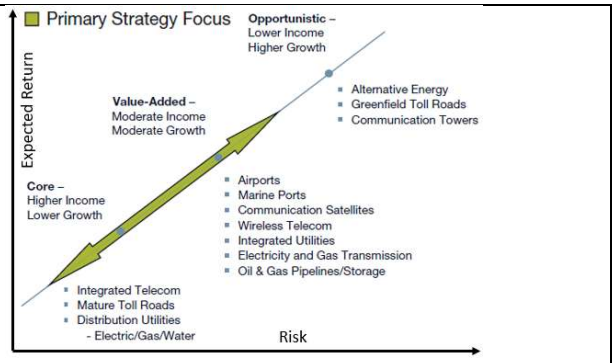
	Selection	DJB Global composite TR hCHF	DJB Glb Infra Yield TR hCHF	S&P Global Infra TR hCHF	S&P High Inc Infra TR hCHF	Preqin global unlisted fund hCHF	DJB Glb Infra Broad Corp Bond 5-7 Y hCHF	DJ Glb Select REIT TR hCHF	SXI Real Estate Selected Funds CHF	SXI Real Estate Broad TR CHF	S&P Glb corp bond hCHF	SIX Swiss corp bond CHF	S&P Glb listed equity hCHF	SPI TR CHF
listed infra	DJB Global composite TR hCHF	1,0	1,0	0,9	0,8	0,4	0,5	0,7	0,1	0,2	0,2	0,0	0,7	0,6
	DJB Glb Infra Yield TR hCHF	1,0	1,0	0,9	0,9	0,2	0,4	0,7	0,2	0,3	0,3	-0,1	0,7	0,7
	S&P Global Infra TR hCHF	0,9	0,9	1,0	0,9	0,3	0,4	0,8	0,2	0,3	0,3	-0,2	0,8	0,7
	S&P High Inc Infra TR hCHF	0,8	0,9	0,9	1,0	0,1	0,3	0,7	0,2	0,3	0,3	-0,3	0,7	0,8
Unlist	Preqin global unlisted fund hCHF	0,4	0,2	0,3	0,1	1,0	0,3	0,1	-0,2	-0,2	0,0	0,2	0,1	-0,1
	DJB Glb Infra Broad Corp Bond 5-7 Y hCHF	0,5	0,4	0,4	0,3	0,3	1,0	0,3	0,2	0,0	0,7	0,3	0,3	0,1
	DJ Glb Select REIT TR hCHF	0,7	0,7	0,8	0,7	0,1	0,3	1,0	0,3	0,5	0,3	0,0	0,7	0,8
	SXI Real Estate Selected Funds CHF	0,1	0,2	0,2	0,2	-0,2	0,2	0,3	1,0	0,8	0,1	0,3	0,2	0,2
	SXI Real Estate Broad TR CHF	0,2	0,3	0,3	0,3	-0,2	0,0	0,5	0,8	1,0	-0,1	0,2	0,2	0,3
	S&P Glb corp bond hCHF	0,2	0,3	0,3	0,3	0,0	0,7	0,3	0,1	-0,1	1,0	0,2	0,2	0,2
	SIX Swiss corp bond CHF	0,0	-0,1	-0,2	-0,3	0,2	0,3	0,0	0,3	0,2	0,2	1,0	-0,3	-0,4
	S&P Glb listed equity hCHF	0,7	0,7	0,8	0,7	0,1	0,3	0,7	0,2	0,2	0,2	-0,3	1,0	0,6
	SPI TR CHF	0,6	0,7	0,7	0,8	-0,1	0,1	0,8	0,2	0,3	0,2	-0,4	0,6	1,0
	10 Year History (Q3.2007 - Q3.2017)													
	TR	1,5%	1,4%	0,8%	1,4%	1,3%	0,7%	0,8%	1,5%	1,8%	0,4%	0,8%	0,6%	0,8%
	δ	14,4%	15,3%	13,6%	15,0%	11,6%	6,7%	21,8%	6,4%	6,8%	7,3%	3,2%	20,4%	14,5%
	SR	0,10	0,09	0,06	0,09	0,11	0,10	0,03	0,24	0,27	0,06	0,26	0,03	0,06
	DD	-21%	-22%	-22%	-21%	-13%	-7%	-39%	-5%	-8%	-8%	-3%	-26%	-18%
	5 Year History (Q3.2012 - Q3.2017)													
	TR	2,1%	2,2%	2,8%	3,6%	2,2%	1,2%	2,1%	1,3%	1,4%	0,8%	0,4%	2,7%	3,0%
	δ	11,7%	11,6%	8,5%	9,2%	6,9%	5,2%	12,0%	6,9%	6,9%	6,4%	3,0%	10,9%	9,0%
	SR	0,18	0,19	0,33	0,39	0,31	0,22	0,17	0,18	0,20	0,13	0,14	0,25	0,33
	DD	-8%	-7%	-7%	-5%	-4%	-5%	-12%	-5%	-6%	-8%	-3%	-14%	-9%
	Yield/a	3,8%	4,0%	4,2%	5,8%									

4 Infrastructure benefits and risks

Infrastructure is an attractive investment alternative because it primarily provides elevated Sharpe Ratios, Yields with long-term investment horizon and portfolio Diversification. But infrastructure investments are heterogenous, and some benefits and risks vary strongly depending on infrastructure sectors, asset location, investment styles and investment vehicles. For example, the propagated inflation protection is mainly a benefit of inflation protected debt instruments or small monopolistic utilities, whereas large sized infrastructure firms are inflation neutral (Rödel and Rothballer (2012), Liem and Thorp (2012)). One reason is the business cycle sensitivity of the different infrastructure sectors depicted in table 4. Another reason is the active hedging of large firms. For the reference portfolio, suitable investments are broad diversified and primarily focused on the core and added-value investment style as per table 4. The specific investments are described in the next chapter.

Table3: Business cycle sensitivity of infrastructure sectors/ Table4: Investment styles of infrastructure sectors

	Business cycle and Infrastructure sectors			
	Recession	Early stage recovery	Expansion	Early stage contrac-tion
Overweight	•Integr. Telco. •Distr. Utilities	•Toll Roads •Marine Ports •Oil&Gas Trsp •Integr. Utilities	•Airports •Marine Ports •Wireless Telco. •Comm. Tower •Oil&GasTrsp	•Integrated Telco •Distr. Utilities •Integr. Utilities

Underweight	•Airports •Marine Ports •Toll Roads •Comm. Tower	•Integr. Telco. •Wireless Telco	•Distr. Utilities	•Oil&Gas Trsp	

Source: Duff & Phelps Investment Management Co.: Infrastructure Investing throughout the economic cycle

Table4: Benefits and risks

	Equity		Debt	
	Listed	Unlisted	Listed	Unlisted
Benefits	•Higher yields than real estates & current bonds •Growth potential •Diversification •Highly liquid listed infra-structure investments •Potential Inflation/ deflation hedge	•Above average yields •Growth potential •Lower volatility than public equity •Low correlations to other asset classes •Potential Inflation/ deflation hedge	•Yields comparable to corporate bonds •Very low default and loss risk •Highly liquid, $3.7 trillion market •Broad sector diversify-cation •30-year bond availability to match long liabilities	•Higher yield than equities and public debt •Low default risk •Low loss risk (Seniority & governance cove-nants) •Relatively stable returns
Risk	•Market (Volatility) •Operational&regulatory	•Illiquidity •Payout variation •Sector (direct) •Operational&regulatory	•Duration •Market (Volatility) •Operational&regulatory	•Illiquidity •Duration •Sector (direct) •Operational&regulatory

Source: Nuveen/TIAA: Infrastructure Opportunity for yield and diversification

5 Infrastructure investments

Whereas the majority of infrastructure equity investments are traditionally listed, infrastructure debt investments are mostly individual senior private contracts. That's because senior debt investments have lower volatility and can be tailored with very long maturities and inflation-links for individual projects. Infrastructure equity investments are heterogenous not only when comparing listed and unlisted investments but also when comparing sectors and geographical origins. Summarized, listed equity historically provided high dividend yields whereas the unlisted equity and debt investments performed historically with higher returns.

5.1 LISTED AND UNLISTED EQUITY INVESTMENTS

Total Return and Yield depend on sector belonging, on the asset location and on the investment type. The dispersion of the yearly return of the worst performing listed ports sector and the best performing listed communication sector showed a remarkable 15%/a. This doesn't include the alternative energy sector since this sector is still not eligible for major infrastructure indices. Furthermore, although regulation risk varies strongly with geographical origin, the performance dispersion of 4%/a between the three continents is rather small. Specialized funds might achieve a better performance in selected countries, but they also take much higher political, regulatory and liquidity risk, which is not suitable for the reference portfolio. Considering listed and unlisted infrastructure investments, the three unlisted indices (Preqin global, EDHEC Europe project and corporations) show 2% to 5,5% higher yearly Return and at least 2,5 times higher Sharpe Ratio in comparison with the listed S&P global high-income index. This dividend-driven index performed with a 5,7%/a dividend yield over the last 10 years. In contrast, the unlisted EDHEC equity index achieved a 5,0% dividend yield/a with high volatility range between 1,8% and 12,6%. Recent research has shown that unlisted infrastructure firms exhibit significant less stable payout ratios because they tend to be smaller, they tend to exhibit

higher leverage and therefore they are more sensitive to fluctuations in performance. As expected, unlisted infrastructure equity offer higher risk-adjusted return and listed infrastructure equity offers in average slightly higher dividend pay-out.

Table5: Risk/Return of listed global infrastructure sectors and regional infrastructures

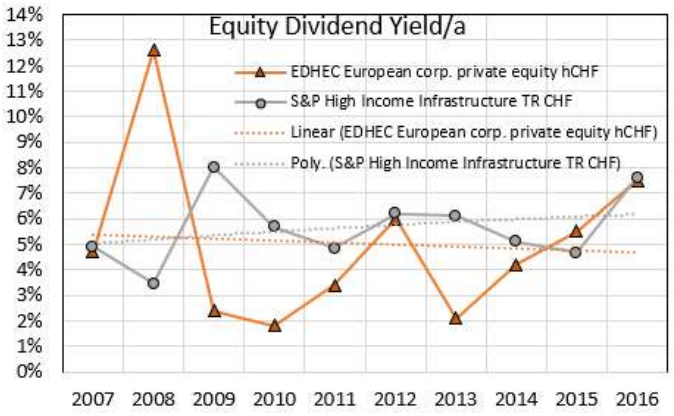
	DJB Water Infra TR hCHF	DJB Toll Roads Infra TR hCHF	DJB Airports Infra TR hCHF	DJB Comm Infra TR hCHF	DJB Oil/Gas Storage & Trans Infra TR hCHF	DJB Electricity Transmission & Distri Infra TR hCHF	DJB Ports Infra TR hCHF
10 Year History (Q3.2007 - Q3.2017)							
TR/a	5,3%	2,5%	8,4%	9,6%	6,2%	5,8%	-5,3%
δ/a	15,9%	18,5%	19,9%	17,7%	16,9%	15,2%	25,7%
SR/a	0,33	0,13	0,42	0,54	0,37	0,38	-0,21
DD	-24%	-20%	-24%	-25%	-21%	-23%	-44%
5 Year History (Q3.2012 - Q3.2017)							
TR/a	9,5%	14,8%	20,3%	12,7%	7,2%	10,0%	3,5%
δ/a	13,2%	10,3%	10,1%	9,5%	15,2%	12,3%	15,0%
SR/a	0,72	1,44	2,01	1,34	0,47	0,81	0,23
DD	-7%	-6%	-4%	-6%	-15%	-7%	-21%

	DJB Americas Infra hCHF	DJB Europe Infra hCHF	DJB Asia-Pacific Infra hCHF
10 Year History (Q3.2007 - Q3.2017)			
TR/a	6,7%	2,9%	3,1%
δ/a	16,0%	15,0%	18,5%
SR/a	0,42	0,20	0,17
DD	-20%	-22%	-28%
5 Year History (Q3.2012 - Q3.2017)			
TR/a	9,0%	11,0%	10,8%
δ/a	13,0%	8,7%	11,5%
SR/a	0,69	1,25	0,94
DD	-8%	-7%	-7%

Table7: Listed and unlisted equity Risk/Return

	EDHEC European project private equity hCHF	EDHEC European corp. private equity hCHF	Preqin glbl Infra funds private equity TR hCHF	S&P High Income Infrastructure TR CHF
8 Year History (2008 - 2016)				
TR/a	6,9%	9,6%	6,3%	4,1%
δ/a	9,6%	10,8%	11,6%	23,0%
SR/a	0,72	0,89	0,55	0,18
DD	-9%	-7%	-16%	-36%
5 Year History (2011 - 2016)				
TR/a	9,2%	11,4%	12,5%	14,8%
δ/a	7,4%	8,2%	3,5%	12,7%
SR/a	1,23	1,39	3,58	1,16
DD	0%	0%	9%	-4%

/Graph1: Listed and unlisted equity Dividend Yield



5.2 DEBT INVESTMENTS

Infrastructure debt is characterized by stable cash flow profile and long-term liability matching characteristics while simultaneously limiting volatility. Most of investment opportunities are executed in the private market with typically 5-7-year floating rate loans. Although liquidity premiums represent more than half of the excess return, default rates are relatively low and recovery rates are relatively high. That's why BBB rated infrastructure debt show comparable default rates to A rated corporate debt, whilst also showing lower rating volatility. With the EDHEC institute's index representing the private debt market and the DJB's Index representing the public market, potential investment opportunities for the Swiss pension reference portfolio are mentioned.

Table8: Characteristics of listed and unlisted debt

Liquid public corporate bonds

	DJB Infra Corp index	Global Agg Corp	BBB Corp	A Corp
Return p.a.	4.4%	3.9%	5.0%	
Volatility p.a.	7.3%	7.2%	7.8%	
Sharpe ratio	0.5	0.4	0.5	
Average credit rating	BBB	A-	BBB	A
Average maturity	14.5	9.0	9.1	9.1
Duration	6.9	6.6	6.5	6.7
Yield to worst	2.9%	2.7%	3.1%	2.5%
Credit spread	1.7%	1.3%	1.6%	1.0%

Source: S&P, Schroders, Barclays. Return, volatility and Sharpe ratios calculated over 30 November 2006-31 December 2016. All other data as at 31 December 2016.

Private infrastructure debt (Corp. & project)

	Core	Higher Yielding	Long Duration
Maturity (years)	5-10	5-7	10-30
Fixed/floating	Mainly floating	Floating and fixed	Fixed
Bonds/loans	Mainly Loans	Loans or Bonds	Bonds
Rank	Senior	Subordinated	Senior
Credit risk (average)	[BBB]	[BB]	[BBB]
Credit spread (basis points)	200	400+	150-200
Annual issuance in Europe and UK (€bn, estimate)	50	5	10

Source: Schroders, January 2017, for illustrative purposes only.

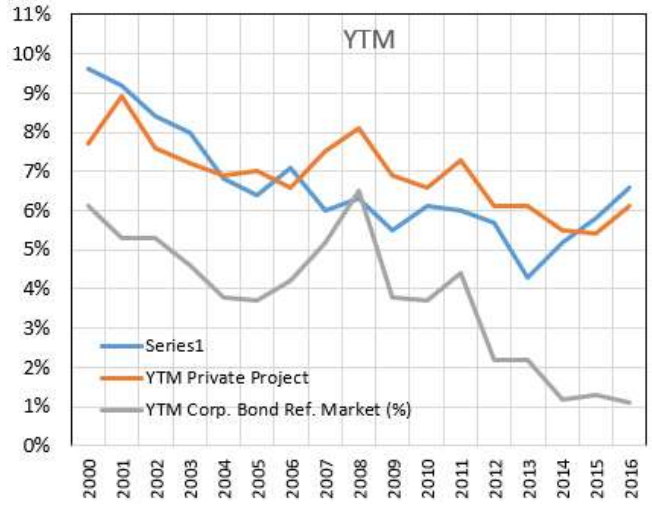
5.2.1 Public corporate bond

Infrastructure corporate bonds are a small subset of the broader corporate bond market. The DJB index spans investment grade (87%) and high yield debt (13%) with an average credit rating around BBB. Risk-adjusted returns have been slightly better than the broad market but only in line with corporate bonds of equivalent credit rating. Global Infrastructure yields have been persistently lower than comparably rated corporate bonds due to greater exposure to the low yielding European and Japanese markets. Credit spreads have varied relative to the market but at the end of 2016 liquid infrastructure corporate bonds offered only a slight pick-up over comparably rated bonds. Altogether, public infrastructure corporate bonds offered historically no performance advantage, but they are an alternative with for longer maturities.

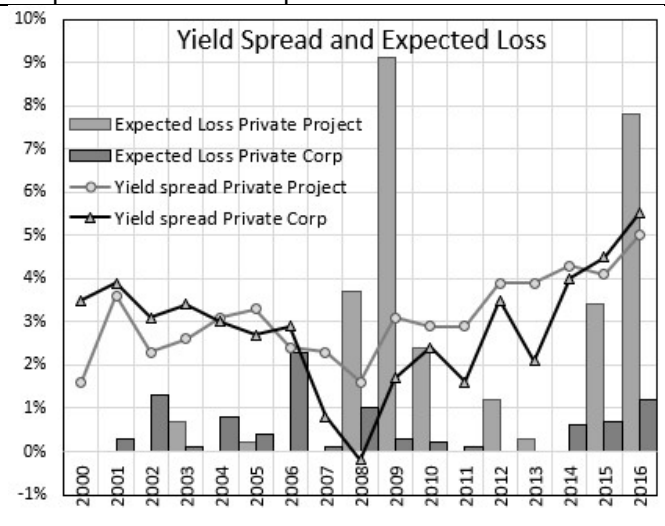
5.2.2 Private debt

Private debt investments are commingly known as an attractive alternative for investment grade bonds. Due to its lower risk profile and its economic and physical proximity, European private debt is a potential alternative for bonds of the Swiss pension reference portfolio. The EDHEC's European broad market senior infra-structure index is the most representative index with detailed transparency over a 16 years history. Due to a significant yield spread, the index outperforms the European corporate bond debt index. Examining the behavior of its two EDHEC project and corporate debt sub-indices allows a more detailed understanding. On the one hand, the private corporate debt sub-index shows higher spread volatility due to expected credit loss and a constantly decreasing duration. On the other hand, the private project debt sub-index shows a spread increase since 2013 due to expected credit loss and less volatility. A spread range between 2% and 4 % looks historical justified without taking too much credit risk > IRR

Graph10: EDHEC European Private Debt



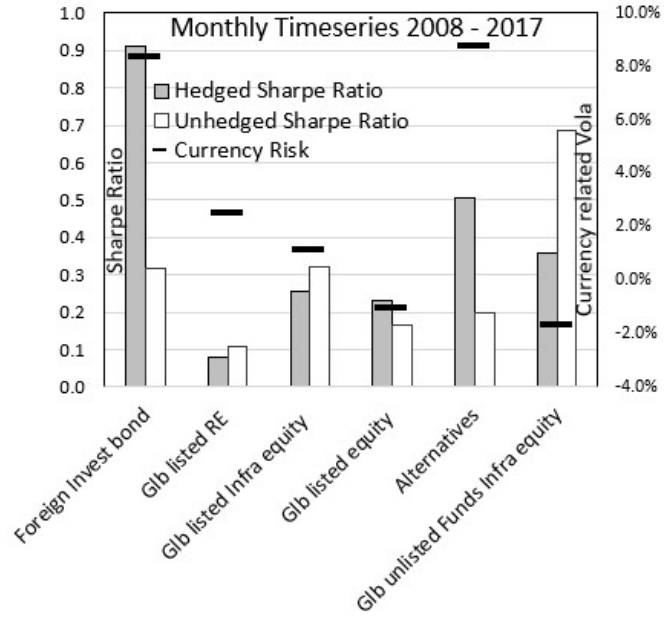
Graph11: EDHEC European Private Debt



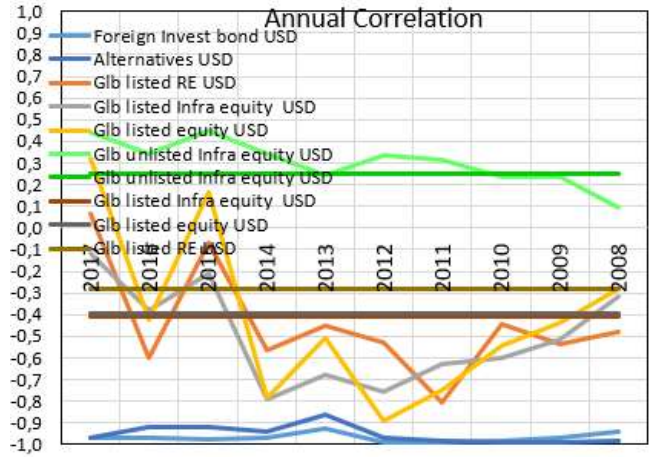
6 Foreign currency allocation

In the following, the currency impact on individual sub-asset classes and the portfolio allocation using the MVO method with infrastructure indices are shown. For this purpose, the historical time series of the hedged and unhedged foreign sub-asset classes were compared in USD. The comparison of the individual asset indices in Graph 11 and Graph 12 shows that, despite large fluctuations, there are three groups with regard to foreign currency risk and risk-adjusted return. First, bonds in particular have a high foreign currency risk due to the influence of interest rates. Secondly, especially equities, real estates and listed infrastructure show a low need for hedging despite historical fluctuations. Due to this annual fluctuation of the correlation, hedging ratios with bandwidths should be defined. Finally, the unlisted infrastructure indices perform best without USD hedging. However, since the indices are not tradable and such direct investments can have varying cash flows, a project-specific analysis and generally a conservative hedging is recommended. Overall, these observations are consistent with the allocation of the reference portfolio.
The overall effect of infrastructure investments on the allocation of a MVO portfolio with maximized Sharpe Ratio is shown in Graph 13. These selected indices show the proportion of hedged and unhedged foreign USD investments. Excluding infrastructure allocation, the total USD share was just under 5% and the total foreign investment share reached 35%. As expected, the optimization led to the lowest hedges for equities and the highest hedges for bonds. Furthermore, the optimisation of the portfolio including infrastructure investments resulted in a higher proportion of foreign investments of 47% and a USD stake of 10%. This is also in line with expectations, with no need to change overall OBB2 limit recommendation in foreign currencies and foreign assets.

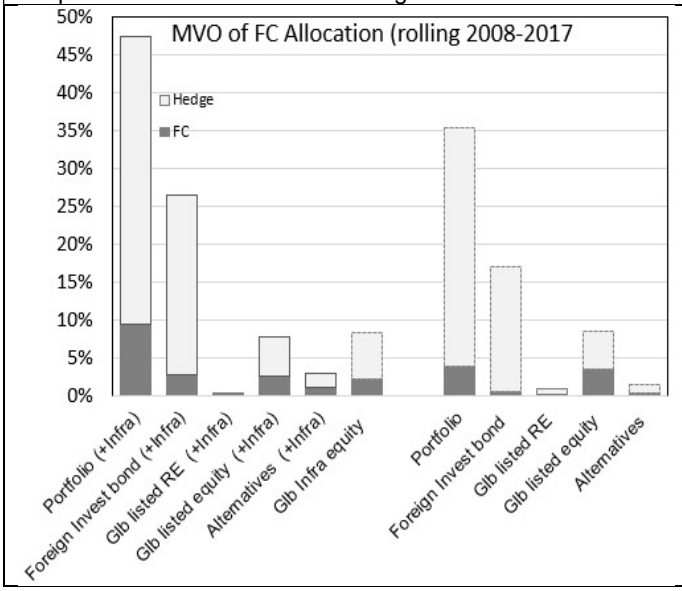
Graph 11: Historical CHF risk & hedged Return of single assets



Graph12: Portfolioallocation of foreign investments and USD



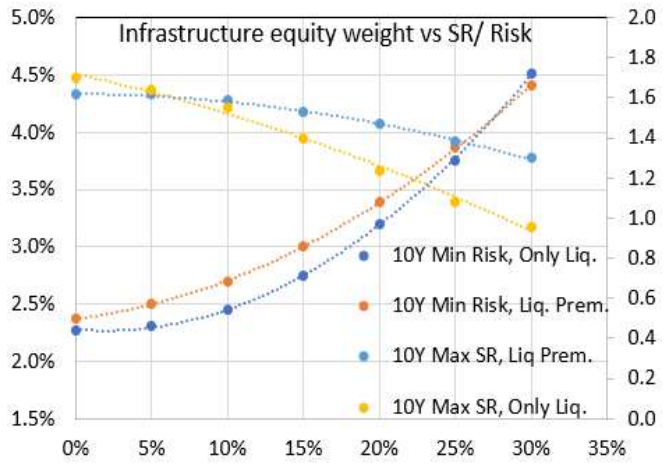
Graph13: Portfolioallocation of foreign investments and USD



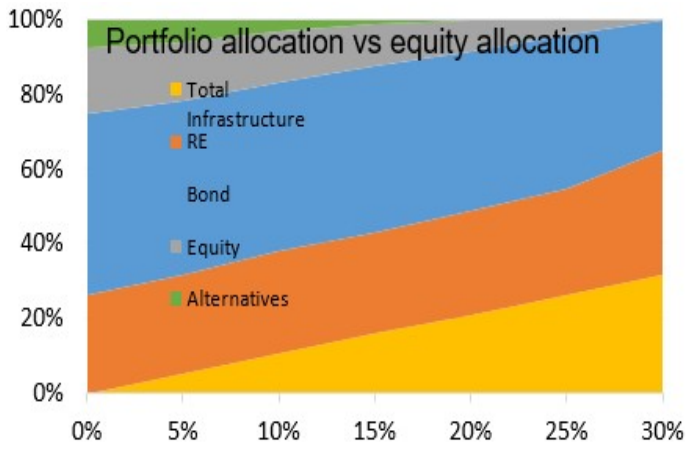
7 Optimum infrastructure and asset allocation

The optimal infrastructure and asset allocation is determined with maximized risk-adjusted return and minimal risk as follows. In order to evaluate the optimal infrastructure allocation, the 10-year MVO is carried out with the selected indices and the reference portfolio. By gradually increasing the infrastructure equity allocation, the best portfolio effect is achieved with an allocation of up to 5% infrastructure equity as shown in Graph 14. In this graph, both illiquid reference approaches are presented as described under Infrastructure Indices, while only the maximized Sharpe ratio provides different results. Therefore, both approaches with a liquidity risk premium penalty and with exclusive application of the liquidity index make sense. When considering the impact on total asset allocation, it can be seen on Graph 15 that only real esates aren't replace by infrastructure investments. In fact, the optimal allocation on real assets ranges between 25% and 31% which is more than the reference portfolios 18.3%. Furthermore, the unlisted assets are allocated 19.5% not much more than the reference portfolio's 17.4%. In addition, the observed portofolio income yield increases with this allocation to 2%. Current initiatives towards higher infrastructrue allocation limits either via alternatives or via real assets in the OBB2 guidelines are therefore justified.

Graph14: Total Portfolio optimization with infra equity weights



Graph15: Single asset allocation



8 Conlusion

The discussion of the optimum allocation of infrastructure investments and its impact on a typical Swiss pension fund involved also clarification on foreign currency hedging and the illiquid unlisted infrastructure investment.

Second, currency hedging
Finally infrastructure and overall impact OOB2… The optimization computes an optimal allocation range between 0% and 5%.
In addition, the observed portofolio income yield increases with this allocation to 2%.

Im folgenden sind die resultate insbesondere bezüglich infrastruktur investments zusammengefasst und weitere mögliche Studien aufgezeigt. Erstens bestätigen die

the illiquid unlisted assets are allocated 19.5% not much more than the reference portfolio's 17.4%. Real assets ranges between 25% and 31% which is more than the reference portfolios 18.3%.

Annex 1 Reference Portfolio

Table3: Available data sources

Year of Report: 2016	AUM [MCHF]	No. Of Funds	Beneficiaries [Mio]	10Y Detailed Allocation	Detailed Total Cost	Other
PCC Metrics:	601	310	3,3	(x)	(x)	> highest AUM/ fund; balanced fund basis
Analyse der Geschäftsberichte						> detailed quantified & standardized info
von Pensionskassen						> focused on total pensionplan/-insurance
						> annual publication
Swiss Canto:	650	507	3,6	x	x	> low AUM/ fund; most mid size funds
Schweizer Pensionskassenstudie						> broad information with sporadic issues
						> focused on total pensionplan/-insurance
						> annual publication
Complementa:	563	412	NA	x	(x)	> medium AUM/ fund; most small size funds
Complementa Risiko Check-up						> broad information with sporadic issues
						> focused on total pensionplan/-insurance
						> annual publication
Credit Suisse:	120	130	NA	x	---	> lowest AUM/fund; client data base
Swiss Pension Fund Index						> detailed quantified & standardized info
						> focused on index and asset side
						> quarterly publication of monthly data

Table4: Rate of Return

Verzinsung der Vorsorgekapitalien (1996 – 2017) Abbildung 6.3

Die Verzinsungen der aktiv Versicherten liegen seit 2003 unter denen der Rentner.

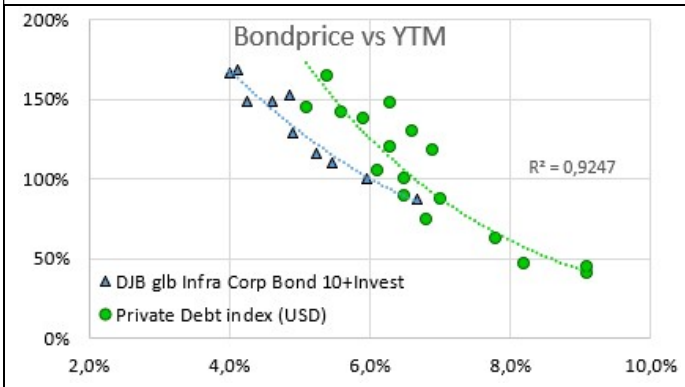
Annex 2 EDHEC **broad market infrastructure** debt Index

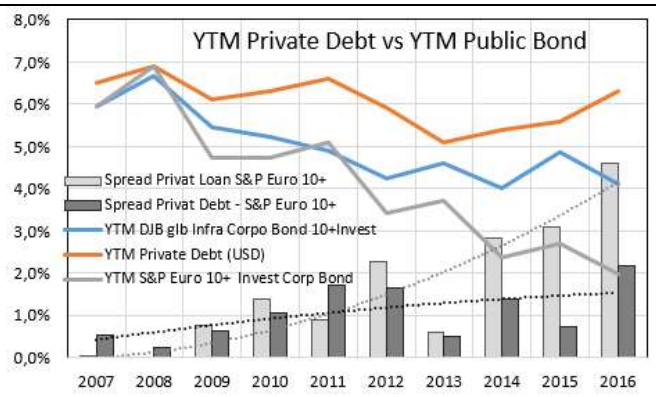
Index Method:

- Actual European private corporate bonds and private brownfield projects loan
- Yearly Valuation and rebalance
- DCF Method with Yield curve
- Initial Contract value and price, coupon and maturity
- Comparable transactions taking place each year

The risk-adjusted performance of the senior debt of each firm in the index sample is derived by forecasting cash flows to debt holders, taking into account future scenarios of default and restructuring, and discounting them on the basis of the volatility of future payouts and available price information.

Private Bond





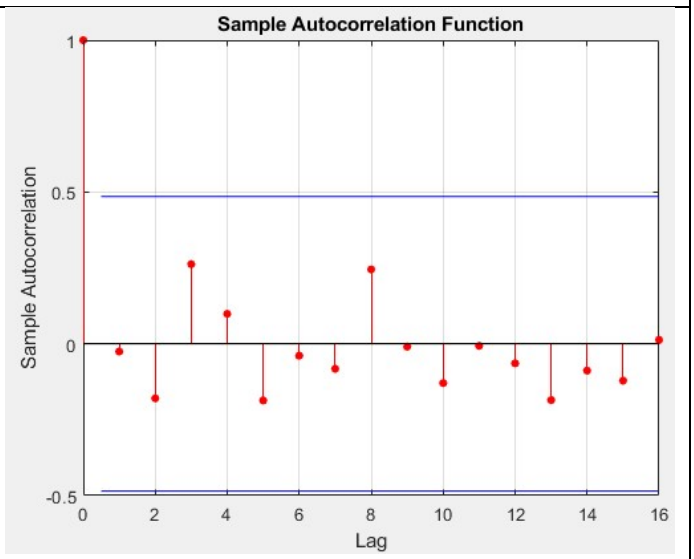
EDHEC Autocorrelation Statistics

```
ARIMA(2,0,1) Model:
--------------------
Conditional Probability Distribution: Gaussian

                              Standard          t
 Parameter       Value          Error       Statistic
-----------   -----------   ------------   -----------
 Constant       0.143806      0.103417        1.39055
    AR{1}      -0.339357       1.03273      -0.328601
    AR{2}      -0.402093      0.203989       -1.97115
    MA{1}       0.313939       1.23055       0.255121
 Variance     0.00131662   0.000633641        2.07787

Mdl =

ARIMA(2,0,1) Model:
--------------------
Distribution: Name = 'Gaussian'
           P: 2
           D: 0
           Q: 1
    Constant: 0.143806
          AR: {-0.339357 -0.402093} at Lags [1 2]
         SAR: {}
          MA: {0.313939} at Lags [1]
         SMA: {}
    Variance: 0.00131662
```



Annex 3 Preqin **globale infrastructure funds** Index

Index Method:

- A
- Y

Preqin Infrastructure equity	

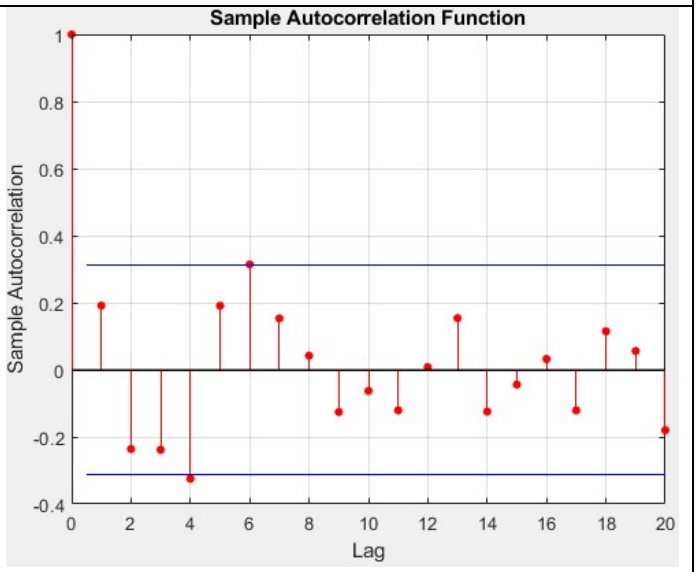
Preqin Infrastructure equity Autocorrelation Statistics	

```
    ARIMA(2,0,1) Model:
    --------------------
    Conditional Probability Distribution: Gaussian

                                 Standard          t
     Parameter       Value          Error       Statistic
    -----------   -----------   ------------   -----------
     Constant      0.0112167    0.00689669        1.62639
        AR{1}       0.675448      0.295706        2.28419
        AR{2}      -0.401486      0.168707       -2.37978
        MA{1}      -0.480434       0.35912       -1.33781
     Variance     0.00277482   0.000720887        3.84918

estmdl =

    ARIMA(2,0,1) Model:
    --------------------
    Distribution: Name = 'Gaussian'
               P: 2
               D: 0
               Q: 1
        Constant: 0.0112167
              AR: {0.675448 -0.401486} at Lags [1 2]
             SAR: {}
              MA: {-0.480434} at Lags [1]
             SMA: {}
        Variance: 0.00277482
```



Annex 4 Illiquidity premium and asset allocation

Because the indices of nonlisted investments are all not tradable and therefore illiquid, it's questionable whether portfolio MVO with the required historical return, volatility and correlation is meaningful. In general, there are two approaches to cope with illiquidity in portfolio optimization. First, there are is a bottom up approach with estimated liquidity premium per asset sub-class which affects return or risk and correlation. The liquidity premium is estimated to be 5.5 % (Table8) for an average holding period of 7.5 years. As this already restricts and penalizes illiquid assets, the main disadvantage is the accuracy and the variation of the premium itself, which has led to question the existence of the liquidity premium itself. The second approach is to treat the illiquid asset like an equivalent liquid asset with its more conservative MVO metrics. This way, the allocation is mainly guided by the investment selection process, which might lead to big differences in allocation due to different investment know how. To limit illiquid allocation in both cases, an overall limit on the portfolio, asset class or the asset-sub class needs to be applied. The accordingly maximum limit is at about 51.9% (Table9) independent on the investor's objectives and restrictions and for pension funds it's even lower at about 35% (Graph10) due to liability needs. In order to have a proper overview, both approaches are compared for this study.

Table: Required yearly Liquidity Premium

Expected turnover [years]	Required liquidity premium/a
10	6.0%
7.5	5.5%
5	4.3%
2	2.0%
1	0.9%
0.5	0.7%
0	0.0%

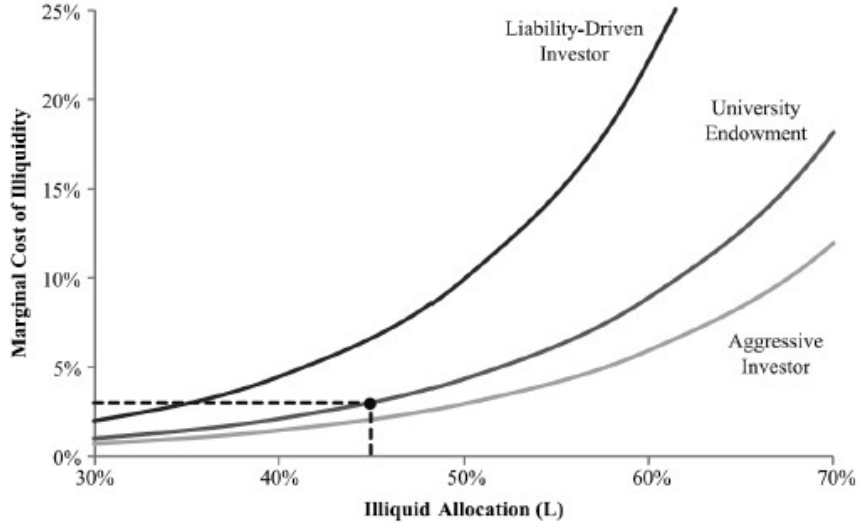
Andrew Ang, Dimitris Papanikolaou and Mark M Westerfield (2014)

Table: Infrastructure allocation and portfolio incomce

Expected turnover [years]	Optimal allocation consumption	Optimal allocation without consumption
10	4.8%	51.8%
7.5	5.0%	51.9%
4	13.2%	52.0%
2	25.1%	52.3%
1	37.3%	52.7%
0.5	44.2%	53.5%
0	59.3%	59.3%

Andrew Ang, Dimitris Papanikolaou and Mark M Westerfield (2014)

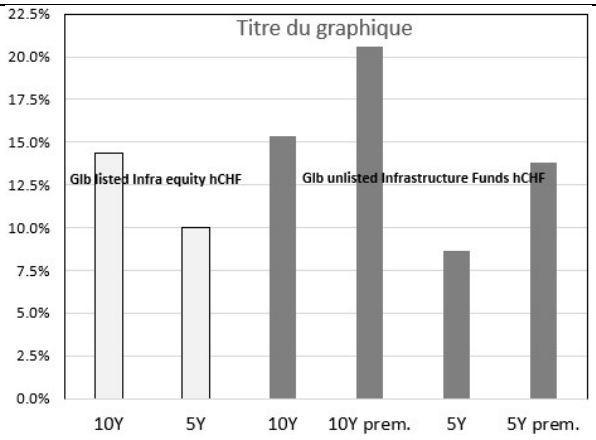
Graph 7: Investor depending allocation

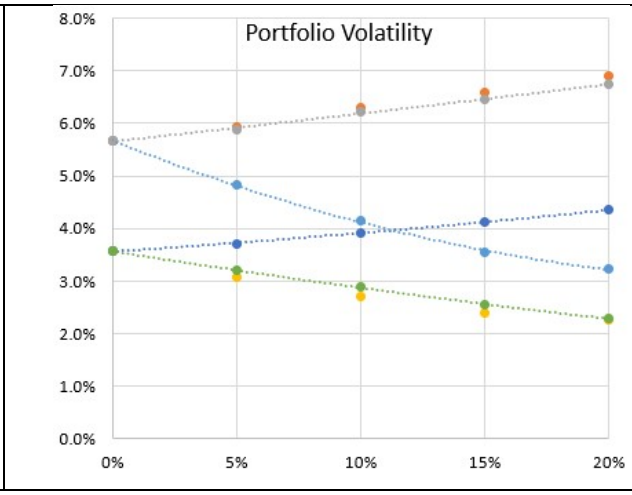


Hayes, Primbs, and Chiquoine (2015)

Graph 8: Risk of iliquid & liquid infrastructure

Graph 9: Protfoliorisk of iliquid & liquid infrastructure


Titre du graphique
22.5%
20.0%
17.5%
15.0%
12.5%
10.0%
7.5%
5.0%
2.5%
0.0%
Glb listed Infra equity hCHF
Glb unlisted Infrastructure Funds hCHF
10Y
5Y
10Y
10Y prem.
5Y
5Y prem.


Portfolio Volatility
8.0%
7.0%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
0%
5%
10%
15%
20%