

Commodities To Solve For The Swedish Pension Fund Deficit

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Abstract

Currently there is a deficit in the unfunded Swedish pension system that according to forecast will remain for a steady future. The Swedish pension (AP) funds act as buffer funds and thereby have the mission of covering this deficit. Therefore, it is crucial that the targets of the AP funds are met. Currently that is not the case. Our conjecture states that one of the limiting factors for achieving their targets is the current AP fund regulation, which prohibits investments in commodities. By analyzing the effects of adding commodities to the portfolio, our goal is to conclude if this, in retrospect, would have been advantageous, and if this will be beneficial for the future. An AP portfolio was synthetically replicated, followed by a flexible model, which enabled the simulation of new AP portfolios including commodity exposure. All commodity indices added in this study proved to increase return and lower the risk in the AP portfolio. Our conclusion is that, in order to make it possible for the AP funds to fulfill their goals, the regulation should be changed to allow for commodity investing.

Keywords: Commodities, Swedish AP Funds, Regulation, Portfolio Simulation

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2 Introduction

The Swedish AP funds have been struggling to reach their targets (KPI +4 % returns per year)¹ since inception, without success. The performance target is set to cover the deficit in the pension system and it is therefore crucial to accomplish. Over 850 billion SEK is currently managed by the AP funds², which should be invested in the most efficient way in order to maximize the well fare for the Swedish population. inefficient use of the hard worked labor capital efficiently is not only irresponsible, but also equal to destroying the well fare for the retirees. The expectations of people that have worked hard and are looking forward to a certain amount of living standards in their well-deserved retirement should be met.

Portfolio theory aims to maximize returns and minimize risk, in other words, to hold the most efficiently diversified portfolio. Not allowing the pension funds to invest in all assets classes reduces diversification.³ Currently Swedish pension funds are not allowed to invest in commodities.⁴ This implies that their returns might not be optimized at their given volatility level. Commodity trading markets today are highly liquid and highly developed⁵, and should therefore be a great candidate for diversification.

This thesis aims to investigate whether integrating commodities in Swedish government owned pension⁶ fund portfolios would have been beneficial for their performance.

Integrating commodities into portfolios is a highly discussed topic within financial markets worldwide. Leading international financial magazines, such as The Wall Street Journal⁷, Financial Times⁸ and Reuters⁹ have been cover-

¹Annual report AP2 fund

²Annual report AP1-AP6

³Schneeweis, T Karavas, V Georgiev, G. (2002). p2f.

⁴Regulated in: The National Pension Insurance Funds (AP Funds) act (SFS 2000:192), Section 12

⁵You, Leyuan Daigler, R.T (2010)

⁶There are 6 different buffer funds within the Swedish pension system. The first to fourth AP funds are investing heavily in equities and bonds. AP5 was merged with the first four during 2001. The AP6 fund is specialized in private equity. The thesis is only replicating the first four AP funds since they manage the major part of the capital and are identical regarding their investment objectives.

⁷The Wall Street Journal (2011)

⁸Financial Times (2010)

⁹Reuters (2010)

ing the subject. Easing the restrictions of the investment regulations, thereby allowing commodities in pension fund portfolios, is an ongoing debate in Sweden.¹⁰ Mexico, for instance, recently allowed commodity investing in their pension funds, which was a result of the ongoing debate. Due to the recent discussions, the Swedish government has currently launched an investigation of the AP funds investment rules, amongst others, the inquiry of allowing commodity investments. This investigation is to be presented in September 2012.¹¹

2.1 Literature Review

Previous research within the fields of commodity investing is wide spread. The benefits of commodities in comparison to traditional asset classes have been covered and demonstrated in several financial papers and essays.

Due to the nature of commodities the correlation to traditional asset classes is low, and therefore makes it a suitable candidate for diversification in portfolios.¹² For the individual investor, investing in commodities is considered to be associated with high risk.¹³ However, this is not the case for an investor holding an already well diversified portfolio, such as a pension fund.¹⁴

2.1.1 Commodities as an Asset Class

Since commodities are real asset, they provide a better hedge against unanticipated inflation, since real assets prices are strongly correlated with the inflation rate. Traditional asset classes, such as equities and bonds are nominal assets since they generate fixed income streams and are not fixed in supply in opposite to real assets.¹⁵

¹⁰Dagens Industri (2012)

¹¹Investigation of AP-funds regulation (Original title in Swedish: Översyn av AP-fondernas regelverk), Dir 2011:84. Ministry of Finance, Sweden

¹²The negative correlations contribute to the lowered standard deviation, i.e. increased diversification which can be observed in the portfolio variance formula:

$$\sigma^2 = \omega^2 \sigma_1^2 + (1 - \omega)^2 \sigma_2^2 + 2\omega(1 - \omega)\rho\sigma_1\sigma_2$$

Low or negative correlation lowers the value of the variance and thereby increases diversification.

¹³Risk is defined as the volatility in returns, measured by the standard deviation, which is commonly used within the financial industry. A definition is provided in the methodology. The risk partly stems from the difficulty to invest for individual investors.

¹⁴Ankrum, E./Hensel, C. (1993): p. 22

¹⁵Greer, R. J. (2005): p. 24

Negative correlation between commodities and traditional asset classes is according to Gorton and Rouwenhorst due to different behavior in the business cycles.¹⁶ When markets plummet, investors tend to see commodities as a safe haven. This leads to a negative correlation in bearish markets, providing a diversification benefit. However, evidence show that this might not be true for short periods of time.¹⁷ For example this was seen during the recent financial crisis during 2008 when we were not only experiencing systematic risk but also systemic risk.

Also worth noting is that, as for all assets, the mentioned benefits provided above varies over time. Erb and Harvey showed this in a study in 2005, where they could see that commodities measured during the time period from 1969 to May 2004 has higher return and lower volatility than S&P 500 while the opposite is true for the time period from 1975-2005.¹⁸

2.1.2 Commodities in Fund Portfolios

Satyanarayan and Varangis, two World Bank researchers, contributed to the debate in 1994 by showing that the efficient frontier of a portfolio including commodities always exceeds a portfolio without commodities.¹⁹ The shift in the efficient frontier is likely to occur from the fact that commodities provide a hedge against inflation and have a negative correlation to traditional asset classes, as discussed above. This further enhances the result showing the benefits of having commodities in a portfolio.

One of the largest pension funds in Europe, the Dutch PGGM²⁰, conducted an internal study in 2005 about investing in commodities. They reached the conclusion that including commodities into their current portfolio could increase return and at the same time decrease the overall volatility of their portfolio.²¹

¹⁶Gorton G./Rouwenhorst G. (2005): pp. 12ff.

¹⁷Lummer, S.L./Siegel, L.B. (1993): pp. 75ff. Gorton G./Rouwenhorst G. (2005): pp. 12ff.

¹⁸Erb, C.B./Harvey, C.R. (2005): p. 2

¹⁹Satyanarayan, S./Varangis, P. (1994): p. 19

²⁰<http://www.watsonwyatt.com/europe/pubs/gim/render2.asp?id=15491>

²¹Beenen J (2005): pp 18ff.

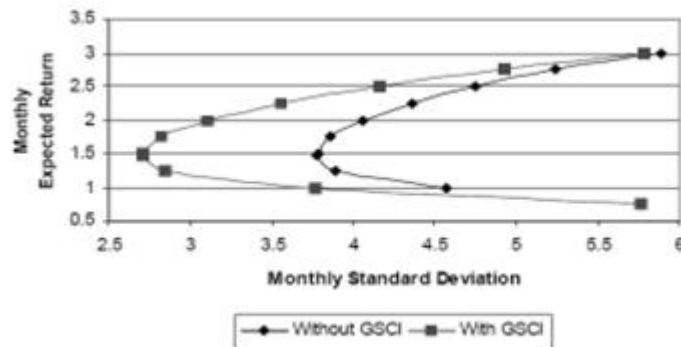
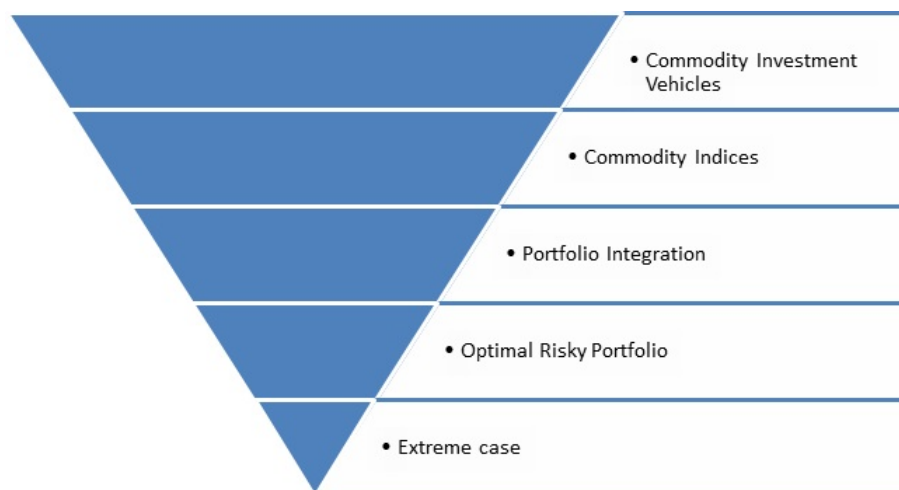


Figure 1: Efficient frontier improvement when including GSCI (Source: Satyanarayan, S./Varangis, P. (1994): p.19)

2.1.3 Thesis Contribution

As clarified by earlier studies there is a strong case for integrating commodities into diversified portfolios. This thesis contributes to the research field by showing how a Swedish AP funds portfolio performance could have looked like, if they would have been allowed to invest in commodities. The thesis first investigates the general effect of integrating a couple of commodity indices. It will then go deeper into finding the optimal combination of the chosen commodity indices and the original AP portfolio. As well as look into an extreme case scenario. Even though this study is limited to Sweden and the time between 2000 and 2012, this thesis aims to act as a guideline for future investment decisions.



3 Background

3.1 Investments in Commodities

3.1.1 Commodities: Definition

In the narrow sense commodities are defined as non-financial assets, such as biological resources and natural elements. These are generally divided into hard and soft commodities. Were biological resources are defined as soft commodities and include agriculture and livestock. The hard commodities include precious metals, industrial metals and energy.

Furthermore, there are also semi-finished goods that are classified as commodities, for example electricity, orange juice and steel. Additionally, there are also so called “negative commodities” such as emissions which limits the usage and production of other commodities (e.g. emission credits). In recent years, modern commodities have emerged due to technical innovations, such as bandwidth which is usually referred to as a commodity.^{22 23}

3.1.2 Investment Vehicles

There are many ways to gain exposure to commodities. Below the most commonly used investment vehicles are defined.

Investing in the Physical Commodity Taking a long position in the asset directly (e.g. buying gold). This is usually inefficient since it generally requires high storage and maintenance cost. The financial industry rarely trades the physical commodities.²⁴

Commodity-Linked Equity is when the investor takes a position in a company which has its core business in a certain commodity (e.g. oil refinery or a mining company).²⁵ However, this is generally not an efficient investment to gain exposure to commodities, since the companies usually hedge a great ratio of their own commodity exposures. Therefore, equity linked commodities might have a low or negative correlation to commodity prices. Even if the commodity related company does not hedge their commodity exposure the equity might not reflect the performance of the underlying commodity due to management risk.²⁶

²²Demidova-Menzel, N./Heidron, T (2007): pp. 5f.

²³The reader should be aware that there is not really a clear definition of commodities. However, the definition provided above is generally accepted within the financial industry.

²⁴Pulvermacher, K. (2005a): p. 6

²⁵Gorton, G./Rouwenhorst, K.G. (2004): pp. 26f.; Pulvermacher, K. (2005a): p. 6

²⁶CISDM (2005): pp. 17f.

Financial Derivatives with Commodities as the Underlying Asset

Forwards and futures are contracts that make it possible for the investor to gain exposure to commodities by agreeing on certain amounts and prices today. Futures are exchange traded derivatives, while forwards are generally traded over-the-counter (i.e. not exchange traded).

Commodity Linked Notes A commodity linked note is by definition a strip (zero-coupon) bond together with an option in an underlying commodity. This type of investment vehicle is a safer way of investing in a commodity since the strip bond acts as insurance, since the investor still has the bonds value even if the commodity fails to reach the strike price. In the event that the option becomes in-the-money the investor also earns the premium between the strike price in the linked option and the actual price of the commodity. Also worth noting is that the maturity of the option and the strip bond has to be exactly the same. This type of investment limits the downside risk, but still provides exposure to commodities.

Commodity Swap The most common commodity swaps are total return swaps. Were the investor pays a fixed fee that consists of the risk-free rate plus a premium in return, for the return, of a single commodity or a basket of commodities. The benefits of using a swap to get commodity exposure is mainly because of the zero tracking error that follows from this instrument, since the counterparties pays the actual total returns. This type of instrument is traded OTC.

Futures Commission Merchant (FCM) An investor with an FCM account has the power to invest directly in options, futures contracts and other derivatives through a commodity exchange. This type of investment vehicle is one of the most direct ways of investing in commodities. However, this method is only suitable for sophisticated investors with knowledge of the industry.

Commodity Trading Advisors (CTA) Since it can be difficult to invest in commodity contracts as an individual, a licensed manager can take exposure in future contracts for a client's account. The CTA licensing is a thorough process involving several government authorities approvals in order to verify that the person is suitable for commodity investments on behalf of clients. CTAs can take exposure in any type of future for a client, but the original purpose was for investments in commodities and therefore the name.

Commodity Pool Operator (CPO) Analogous to the CTA, the CPO is responsible for investing on behalf of a client in the commodity futures market. However, the CPO can “pool” the assets in one account and invest the entire masse. By pooling the assets, the CPO has increased purchasing power and increased ability to use leverage.

Master Limited Partners (MLP) MLPs are private partnerships that are traded on public exchanges, focusing on energy infrastructure. The fact that it is a partnership implies that they only pay tax on an individual level, and therefore avoid any corporate tax. The other advantage is that it delivers all of its cash flows directly to the shareholders, which yields a higher return for the investor.

Exchange Traded Funds (ETFs) This type of investment vehicle is easy to use for investors since the funds are privately run and traded on public exchanges. The ETF tracks individual commodities or commodity indices.

Commodity Mutual Funds Mutual funds aim at tracking the performance of commodity indices or companies dealing with commodities. Commodity mutual funds are suitable for traditional investors who are used to investing in for example equity mutual funds but want exposure to commodities.

Commodity Indices Commodity indices have the same goal as traditional equity indices, i.e. to track commodities for benchmarking and investing purposes. Financial institutions construct and provide the indices. The index construction methodology is different depending on the financial institution and index. An investor can access the indices through ETFs or through the futures market.²⁷

3.1.3 Exchanges

Commodity exchanges provide a liquid market for commodity trading. CME group is the leading operator of commodity derivative exchanges. It was formed during the 2007 merger when the Chicago Mercantile Exchange merged with Chicago Board of Trade and formed the largest futures and derivatives exchange in the world. They currently own and operate four of the leading commodity exchanges; NYMEX (New York Mercantile Exchange), CBOT (Chicago Board of Trade), CME (Chicago Mercantile Exchange) and

²⁷CME Group Educational Resources, Glossary

COMEX (Commodity Exchange, Inc).²⁸ The benefit from the usage of exchange traded contracts is amongst others increased liquidity and reduction in counterparty risk in comparison to over-the-counter contracts.

3.2 Background Study

To complement previous research findings presented in the introduction part, we have conducted a background study. This aims to describe commodities as an asset class in relation to traditional asset classes over the time period that is going to be used in the portfolio replication.

Background Study

Index	Monthly Return	Yearly Return	Monthly St.Dev	Yearly St.Dev	Monthly Sharpe Ratio	Yearly Sharpe Ratio
Merrill Lynch Government Bonds	0,56%	6,8%	2,1%	7,0%	0,263	0,968
MSCI Sweden (SEK)	0,12%	2,9%	6,9%	29,9%	0,016	0,093
MSCI World	-0,01%	0,8%	4,9%	21,6%	-0,003	0,035
S&P500	0,04%	0,6%	4,7%	19,1%	0,007	0,025
Bloomberg Europe Real Estate	0,09%	7,4%	7,9%	39,7%	0,011	0,184
S&PGSCI Commodities	0,61%	8,8%	7,1%	28,1%	0,084	0,311
DJUBS Commodities	0,59%	8,1%	5,1%	20,8%	0,113	0,388
MLM Commodities LongNeutral	0,75%	9,6%	3,2%	12,4%	0,229	0,772

Table 1: Performance measures for indices representing different asset classes (Data source: Bloomberg).

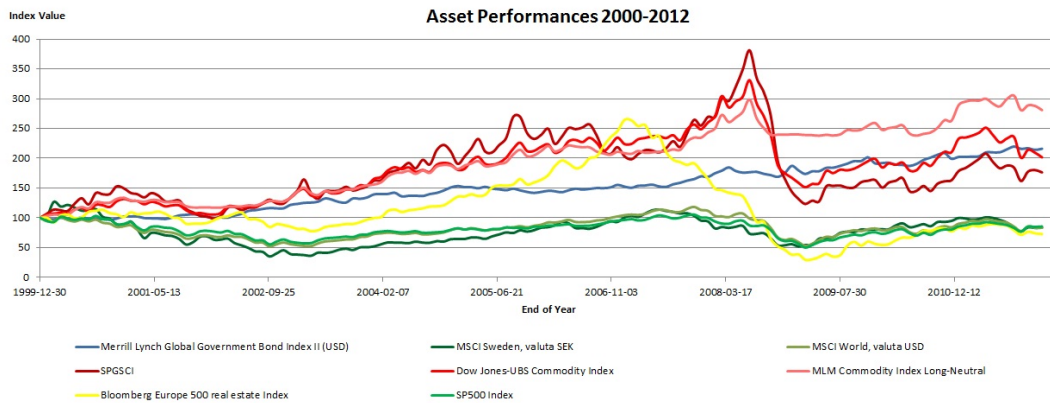


Figure 2: Performance measures for indices representing different asset classes. (Data source: Bloomberg)

On a monthly basis, commodities as an asset class (represented by three commodity indices) have the highest return. The best performing commodity

²⁸CME (2005): p.10

index had an average return of 0,75% (MLM) per month in comparison to for example the equity indices ranging between -0,01% and 0,12%. Real estate had a performance similar to equities, while the bond market performed second to best with a return of 0,56% on average per month. On a yearly level, the trend in performance amongst the asset classes is the same. However, real estate had a return close to bonds and commodities on a yearly basis.

Regarding the standard deviation, commodities had a higher risk than bonds, but a similar risk as equities, with slight variations depending on the index. Comparing for example the best commodity index (MLM) with a low risk at 3,2%, to the least volatile equity index at 4,7 % (S&P500) it is clear that the commodity index has been a safer investment. The difference is also noticeable regarding the returns at 0,75% (MLM) to 0,04% (S&P 500) on a monthly basis.

The risk adjusted return, measured by the Sharpe ratio, shows that bonds had by far the highest Sharpe ratio, both on a monthly and yearly basis. However the turbulent financial markets during the end of the last decade have probably contributed to the high Sharpe ratio. This is probably related to the risky environment during this time period where investors were looking for safe havens. However, the three commodity indices outperformed real estate and equities on a Sharpe ratio basis.

The background study confirms that commodities indeed have higher risk-adjusted return in comparison to traditional asset classes during the time period. As earlier mentioned, this is of course heavily dependent on the time period. Therefore, the result does not have to be true for another time period. However, the purpose with this study is not to show that commodities are a superior asset class, but rather to show the diversification effect when included in a portfolio. However, it is important for the reader to know how the asset classes have performed over the time period. The positive effects of diversification effect is more consistent over time.

Correlation Matrix									
Correlation Matrix	Government Bonds	MSCI Sweden	MSCI World	S&P500	Real Estate	S&PGSCI	DJUBS	MLM LN	
Merrill Lynch Government Bonds	1,00								
MSCI Sweden (SEK)	0,18	1,00							
MSCI World	0,22	0,87	1,00						
SP&P500	-0,03	0,86	0,95	1,00					
Bloomberg Europe Real Estate	-0,17	0,42	0,66	0,65	1,00				
S&PGSCI Commodities	0,40	0,23	0,59	0,43	0,52	1,00			
DJUBS Commodities	0,71	0,33	0,62	0,39	0,42	0,90	1,00		
MLM Commodities LongNeutral	0,96	0,28	0,36	0,11	-0,02	0,57	0,83	1,00	

Table 2: Correlation matrix for the indices in table 1, between 1999-12-31 and 2011-12-31.

None of the commodity indices have a correlation higher than 62 % with the equity or real estate indices. The systemic risk was high during the financial crisis which occurred in the chosen time period; The commodity

indices therefore have a bit higher correlation, than suggested in the previous literature.

Crisis Correlation	
Indices	MSCI World
GSCI	0,981
DJUBS	0,978
MLM	0,759

Table 3: Correlation matrix between commodities and equities for the time period: 2008-06-30 - 2009-04-30

The negative correlation that normally would have been expected during the crisis period could therefore not be observed. For example the correlation was close to 1 (0,98) between the GSCI index and the MSCI World index during the crisis period (2008-06-30 - 2009-04-30), this has contributed to the overall correlation during the full time period. Therefore, Rouwenhorst and Gortons motivation of the negative correlation due to different behavior during business cycles does not seem to apply to the full extent.

However, the MLM index had a low correlation (between 0,36 and 0,11) in relation to the equity market. This study cannot clearly support the previous literature, since negative correlation cannot be observed. However, the correlation is low, which is also suggested by previous studies. One of the explanatory factors could be due to the option of the MLM index to go neutral during time of crises. The only negative correlation effect that is visible, is between the MLM and the European Real Estate market (-0,02). Generally the GSCI and DJUBS are highly correlated, while the MLM has a low correlation to the two other commodity indices. An interesting finding is that the MLM index had a very high correlation (0,96) to the bond market. This is likely to have occurred from the fact that investors saw both asset classes as safe havens during the financial crisis. The findings have slight differences in comparison to earlier studies. However, the time period is much shorter than those used in previous research, therefore not as many business events and cycles are covered, which might affect the results.

The graph (Figure2) visualizes the indexed performance for traditional asset classes and commodity indices. Over time, commodities (red color scale) have outperformed traditional asset classes. Equities have in general had a negative performance since inception. The only steady asset class, not object to cyclical changes are bonds. Furthermore, bonds have not only had steady performance, but also the next to highest total return at the end of the time period, only beaten by the MLM long-neutral index. An interesting finding is that real estate does not follow the same trend as equities, bonds or commodities. The higher volatility seen in commodity markets is visualized

by the high variations over time, especially during the 2008 financial crisis. This relates to earlier studies which suggest that commodities as an asset class are riskier than equities, for an individual investor. As stressed in previous studies, commodities add a diversification effect to an already well diversified portfolio. This is why this type of investment should be perfect to, for example, a pension fund.

3.3 Swedish Pension Funds

3.3.1 Definition and Purpose

The current labor force is funding the public pension system, which implies that no assets are set aside from the time the retirees constituted the labor force. In the event that the ratio of retirees to the labor force increases, a deficit will occur. The discrepancy between the outgoing payments and the inflow of capital is covered by the buffer funds, which in Sweden are called the AP-funds (In Swedish: Allmänna Pensionfonderna). In order to guarantee that the gap is sufficiently covered; the AP funds should always strive to maximize returns.²⁹

A large part of the population that is currently contributing to the system, have recently gone into retirement. Therefore, these individuals have stopped contributing, and started receiving money from the system. According to forecasts produced by the Swedish Pension Authority (In Swedish: Pensionsmyndigheten), net outflows will continue to be negative until the middle of the 2040s. The pension system debt is usually adjusted for with the increase in the income index. Therefore the assets in the pension system needs to grow at least as much as the income index in order to match the liabilities.^{30,31}

3.3.2 Regulation of Investment Plan

According to the national pension insurance funds (AP funds) act (SFS 2000:192) chapter 4 section 1, the objective of the funds is to manage the assets in such a manner that they will achieve the highest possible return. The investments should also have a low risk characteristic, invested with a long time perspective. As long as the regulations stated below are followed, the APs can be flexible in their investment decisions. Section 3 to 18, chapter 4, entails the detailed investment rules.

²⁹Annual report 2011, AP3 fund

³⁰Annual report 2011, AP4 fund

³¹Annual report 2011, AP1 fund

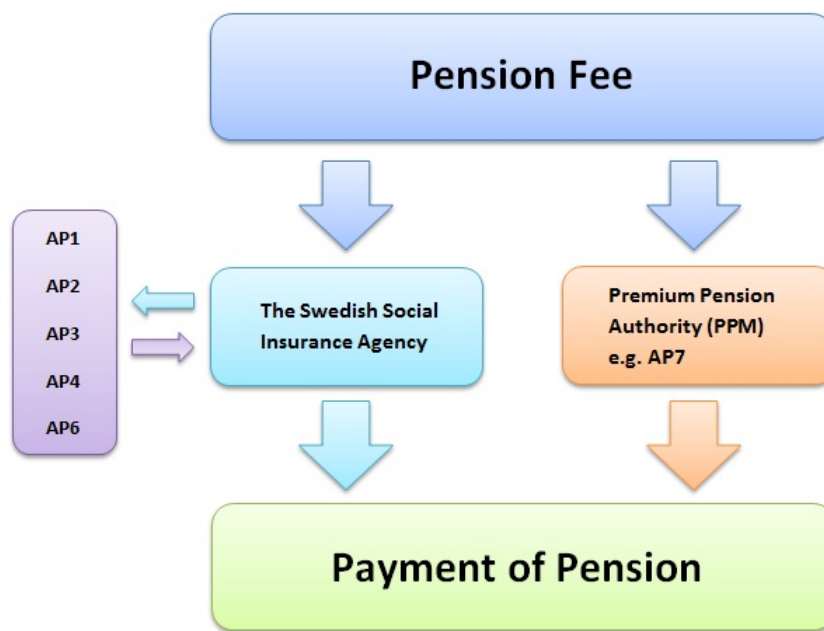


Figure 3: The Swedish Pension System.

“Section 12: The First to Fourth AP Funds may not invest fund assets in options, futures, or other similar financial instruments for which commodities constitute the underlying asset.”

Other investment rules are summarized in figure 3:

- Investments may occur in any instruments on the capital market as long as it is liquid and noted on an exchange.
- At least 30 % of the fund’s assets have to be placed in fixed income assets with low credit and liquidity risk.
- Not more than 40 % of the asset may be exposed o currency risk.
- Not more than 10 % of the fund’s assets may be exposed to more than one issuer or one group of issuers with a close relationship.
- The fund may not hold more than 2 % of the market capitalization of one single Swedish exchange traded company.
- Not more than 5 % of the fund’s assets may be placed in non-exchange traded assets.

- These assets have to be acquired through private equity companies or such. Exceptions are stocks or other holdings in companies within the real estate.³²

³²The National Pension Insurance Funds (AP Funds) act (SFS 2000:192)

4 Methodology

4.1 Data Collecting

The main source of data was provided from the Bloomberg database. This database is used by many professionals worldwide within the financial industry. The study was constructed in such a way that investment managers easily can replicate it and apply it in their endeavor to increase risk-adjusted returns.

In this study we will analyze the benefit loss of the regulation that came into effect in the beginning of 2000, the data was collected for the time period 1999-12-31 to 2011-12-31. After discussion with the Vice President in one of the Swedish AP funds³³, we together reached the conclusion that an average rebalancing period is approximately one month. This was why we decided to use monthly data. Closing prices for the last trading day in each month was used.

During the discussion with the AP fund, one of the major topics that came up was whether to use the exact holdings in the AP funds in opposite to replicating with indices. Using actual data would have included alpha from the portfolio manager, alpha that we would have decreased when including commodities. In each rebalancing period, the portfolio managers at the AP funds made active choices with respect to the future expectations at the time of the decision, which has added an alpha. In order to add commodities in an unbiased way, indices were used to synthetically replicate the AP portfolio which removes all alpha.

Due to the strict regulation of the AP funds, they all invest their assets in a similar way. A general AP fund can therefore be replicated using their benchmarks indices, which was discussed as an excellent solution to use in opposite to the actual AP portfolio.

The following indices were used:

- Merrill Lynch Swedish Governments (SEK) The index tracks Swedish government bonds, hedged in Swedish Krona.
- Merrill Lynch Global Government Bond Index II (USD) The index follows different government bonds worldwide, denoted in USD.
- MSCI Sweden (SEK) An index representing the Swedish stock market, where their largest holdings are also the largest market capitalized stock in Sweden (For example; H&M, Ericsson, Nordea and Volvo).

³³Gustaf Hagerud, Phd. Head of Asset Management at the AP3 fund

- MSCI World A global stock index with over 1600 “world” stocks included. The stocks are from 24 different developed markets (i.e. there are no emerging markets included in the index). This is one of the worlds most common proxies for the world stock markets also used by the Swedish pension fund AP3.
- USDSEK Exchange rate The FX ratio between USD and SEK.
- Standard and Poors Goldmans Sachs Commodity Index (GSCI) Is one of the most common commodity indices which currently comprises of 24 different commodities in precious metals, livestock, energy, agriculture and industrial metals with a high exposure to energy (currently above 78% and more than 40% of crude oil). Prices are quoted in USD and it is a passive index only that since they invest in future contracts they have to roll them forward each month.
- DJUBS (Dow-Jones UBS commodity Index) It is a well diversified index with the goal to minimize the concentration to one single commodity or sector. It currently compromises of 19 commodities in seven different sectors. None of the commodities have less than 2% or more than 15% of the weight in the index. Prices are quoted in USD.³⁴
- Mount Lucas Management Long/neutral index (MLM) It is an equally weighted index consisting of 11 different commodities. It only takes long positions in markets that are determined by Mount Lucas to be rising while it is neutral otherwise.³⁵ The collected data was verified by comparison to data presented in the AP funds annual reports.

4.2 Data Analyzing

4.2.1 Currency Conversion

Since the indices were exported in different currencies, United States Dollars (USD) and Swedish Krona (SEK), the USDSEK spot FX ratio was used to convert the index values to SEK only. The AP funds present their results in SEK, why it was important to convert all foreign indices to SEK to make the results comparable.

The commodity indices used were quoted in USD and were converted back to SEK. The fact that the indices are priced in USD, the FX exposure in the AP portfolio increases.

³⁴Bloomberg Corporation.(Data and descriptions exported from Bloomberg terminal)

³⁵<https://www.mtlucas.com/Content.aspx?content=CommIndexCommodityLN>

4.2.2 Performance Calculations

Performance was calculated in two currencies. When calculating the performance for the background study, the original currencies were used. The reason for using the original currencies was to exclude any impact (i.e. FX-risk) on performance, which was not relevant for describing the asset class.

We also calculated performance in SEK, since the local currency performance is relevant for replicating the return of the AP and commodity portfolios.

The performance was calculated monthly and yearly. During the discussions with the AP funds a representative rebalancing period for the general AP fund indicated to be on a per month basis, therefore monthly data was used. Furthermore, monthly data for the 12 year period gives a more significant amount of data (144 observations) than if yearly data would have been used.

Since the industry standard is to measure and present return and risk figures on a yearly basis, this was also included into the performance calculations. Furthermore, a yearly rebalancing period, in opposite to a monthly, includes larger variations. This also implies that asset classes that perform well get a bigger weight in the portfolio for a longer period of time and vice versa.

Performance was calculated by dividing the spot index value with the index value in the observation prior to the spot (formula below).

$$Return = \frac{I_t}{I_{t-1}} - 1 \quad (I = Index\ value)$$

4.2.3 Portfolio Replication and Simulation

To replicate the AP portfolio the weights had to be divided into the major asset classes, which are; equities, fixed income and alternative investments. First the weights were split up between equities and fixed income, to make it possible to include commodity exposure as the alternative investment. During discussions with the AP funds the actual portfolio weights for a general AP portfolio were determined; this was also compared and verified against the annual reports. 55 % of the capital was allocated to equities and 45 % into fixed income. Within equities, 25 % was allocated to Swedish equity (synthetically replicated with the MSCI Sweden equity index) and the remaining 75% was allocated to equity markets outside of Sweden (synthetically replicated using the MSCI world equity index). Since the AP funds manage over

850 Billion Swedish Krona³⁶ and have the objective to produce as high return with as low risk as possible and the Swedish market is small, they have to diversify their equity exposure to different equity markets worldwide. Within fixed income, half of the assets are invested in Swedish Government bonds (synthetically replicated with the Merrill Lynch Swedish Governments bond index); the second half is invested in foreign government bonds (synthetically replicated with the Merrill Lynch Global Government Bond Index II).

According to the Swedish regulation a maximum of 40 % of the portfolio can be exposed to FX risk. The model therefore adjusts the hedge ratio so that the FX exposure does not exceed 40 % of the total portfolio. Hence, the hedge ratio is adjusted and not fixed in order to be compliant with the regulation. To replicate the portfolio return, the return of each index in each time period was multiplied by the portfolio weight given to that particular index. The sums of these multiplications were added in order to get the portfolio return in each time period (monthly and yearly). No transaction fees were included in the calculations. However, transaction fees should be considered when implementing this strategy in reality, since monthly rebalancing would add 12 times the transaction fee in comparison to yearly rebalancing.

The original AP portfolio had to be adjusted in order to include commodity exposure. In order to include a weight we had to multiply the original portfolio with one minus the wanted exposure, so that the total exposure would add up to 100%. The USD exposure was not included in the multiplication in order to keep the currency hedge at a constant level. Therefore, the hedge is always at a constant level, disregarding if it is a commodity portfolio or not. This means that the commodity portfolios have a higher USD exposure, since the commodity indices are quoted in USD. This assumption was made in order to only prove the commodity effect and not the FX effect. When adding the commodity exposure, the SEK return of an index was multiplied by the desired weight, and then added to the reduced original AP portfolio. Return, risk and Sharpe ratio were calculated on a monthly and yearly basis.

The return and risk measures were calculated using the below formulas: Sample standard deviation was calculated by squaring the sum of each return value subtracted by the average return, on a monthly and yearly basis. The total sum is then divided by the number of observations minus one, in order to adjust for the fact that it is a sample. The sample standard deviation is a common industry measure for risk and is therefore applied in the study. The

³⁶Total assets under management for the first to fourth AP fund, calculated from figures presented in the annual reports. Exact figure: AP1 (213b SEK), AP2 (217b SEK), AP3 (214b SEK), AP4 (213b SEK), figures as of 2011-12-31. (Source: Annual report AP1-AP4)

calculations were repeated for the three commodity indices and for the two weights.

$$s = \sqrt{\frac{1}{N-1} \sum_{i=1}^N (r_i - \bar{r})^2}$$

Average return was calculated by dividing the sum of the return values by the number of observations. This measure is also recognized by the industry as valuable measure for return and is therefore applied in the essay.

$$\bar{r}_{arithmetic} = \frac{1}{n} \sum_{i=1}^n r_{arith,i} = \frac{1}{n} (r_{arith,1} + \dots + r_{arith,n})$$

Total return was used in order to compare, both graphically and numerically, the replicated commodity portfolios.

$$r_T = \sum_{i=1}^T (1 + r_i) * r_{i-1}$$

Sharpe ratio is a risk-adjusted return measure used in order to compare the efficiency in the portfolios. However, the portfolio evaluation has to include several perspectives, and not only the Sharpe ratio in order to get a diversified view and conclusion.

$$Sharpe\ ratio = \frac{r - r_f}{s}$$

4.2.4 Portfolio Weights

After careful consideration and comparisons between different large pension funds which are allowed to invest in commodities, a reasonable amount to invest was determined to be about 5 %. The largest pension fund in Europe, PGGM, invests almost 7 %³⁷ of its assets in commodities. In order to simulate the portfolios realistically, 5 % of commodity exposure was used as the first weight. To show the effects more clearly the second weight was set to 15 %. The AP3 fund has 17 % in alternative investments why 15 % in commodities was a reasonable amount.³⁸ In order to replicate the AP portfolio, benchmark indices used by the Swedish pension funds were used. To replicate the equity exposure the MSCI World and MSCI Sweden indices were applied. The MSCI World was chosen since it covers stock markets in

³⁷Investments and Pensions Europe(2007)

³⁸Beenen J (2005): pp 18ff.

24 countries, which means that it reflects the world stock markets to a high extent. These indices are commonly used and recognized by the financial industry. Since they include a multiple of stocks they can be considered to be diversified and a good proxy for the stock market. Furthermore, the MSCI world does not invest in emerging markets which makes the index applicable in our case since pension funds aim at investing at a low risk, when emerging markets are generally characterized by higher risk.

To replicate the fixed income exposure, the “Merrill Lynch Swedish Government Bonds” and “Merrill Lynch Global Government Bond Index II” were used. These indices are also used as benchmark indices by the Swedish AP funds, which makes them a good proxy when replicating the general AP portfolio. Since the AP funds are aiming at investing at a low risk with a long investment horizon, they therefore mainly invest in government bonds. The two bond indices were therefore considered to be representable for the original portfolio.

The FX ratio between USD and SEK has been used to hedge and convert the currency exposure, since all indices except MSCI Sweden are denoted in USD. According to Swedish regulations, the AP funds may not have foreign currency exposure exceeding 40%.

In order to get a full and fair view of a commodity portfolio, three different commodity indices were used. GSCI and DJUBS are two of the most commonly used commodity indices, with a wide exposure to different commodities. Investing in GSCI and DJUBS index funds is straight forward since they are exchange traded. From a liquidity perspective the index funds are very efficient, why pension funds may realistically invest in commodities. Since these indices provide such an easy access to commodities this is a reasonable way for a pension fund to gain exposure to commodities.

Some major differences between DJUBS and GSCI are that GSCI invests more heavily in energy related commodities. In opposite to the GSCI, DJUBS has a more diversified view where the index tries to minimize the concentration in one single commodity or sector. Since our study aims to replicate a commodity portfolio it is necessary to include several indices to get a broader view. Furthermore, it is easier to see the general trends when commodities are included and not observing the investment strategy of the indices themselves.

The MLM index chosen was a Long/neutral index and differs from the two other indices by the fact that the management of the index might choose to not go long in a commodity and be neutral over time. When the market is determined to go up, the index takes a long position and a neutral position otherwise. It is therefore a good proxy for a fund that makes active decisions.

Since real commodity prices tend to fall over time³⁹ a long neutral strategy might provide a better inflation hedge than the always-long strategy itself. This index is therefore a good alternative to passive only indices. Since the index includes active management it might be a good alternative for pension funds that lack the experience or do not have the competence needed for investing in commodities. Furthermore, these indices were also approved by the head of portfolio management at AP3 as good proxies for a general AP fund.

In order to perform the analysis, a flexible excel model was created, which could take into account all the investment rules; the weights, hedge ratios, fixed income exposure, risk free rate and also the possibility to calculate the portfolios based on either excess or total return. This made it easier to verify that all the different angles were covered, in this way we could easily handle massive amounts of data swiftly.

4.3 Portfolio Optimization

Markowitz developed the modern portfolio theory, we apply his definition of return and risk, as defined below:

$$E(r) = \omega E(r_{AP}) + (1 - \omega)E(r_C)$$

$$\sigma^2 = \omega^2 \sigma_{AP}^2 + (1 - \omega)^2 \sigma_C^2 + 2\omega(1 - \omega)\rho\sigma_{AP}\sigma_C$$

$$-1 \leq \rho \leq 1$$

In the thesis, the first asset is defined as one of the commodity indices, and the second asset as the original AP portfolio. Markowitz second contribution was the theory of diversification. The diversification principle (defined below) states that: “The standard deviation of the combination is less than the combination of the standard deviations”.

$$[\omega\sigma_{AP} - (1 - \omega)\sigma_C]^2 \leq \sigma^2 \leq [\omega\sigma_{AP} + (1 - \omega)\sigma_C]^2$$

$$\rho < 1 \quad \rightarrow \quad \sigma \leq [\omega\sigma_{AP} + (1 - \omega)\sigma_C]$$

The diversification effect is interpreted as holding a portfolio that eliminates the individual risk and only holds the market risk, i.e. β . The literature

³⁹MLM Corporation (Index Description)

review suggests that integrating commodities into the AP portfolio gives a diversification effect. Hence the individual risk was minimized in the new portfolios in comparison to the original AP portfolio. Below the diversification effect is differentiated:

Suppose: $\omega_i = \frac{1}{n}, i = 1, \dots, N$

$$\sigma^2 = \sum_{i=1}^n \sum_{j=1}^n \frac{1}{n^2} \sigma_{ij} = \frac{1}{n^2} \sum_{i=1}^n \sigma_{ii} + \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1, j \neq i}^n \sigma_{ij} = \frac{1}{n^2} \sum_{i=1}^n \sigma_i^2 + \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1, j \neq i}^n \sigma_{ij}$$

$$n \rightarrow \infty$$

$$\overline{\sigma_{ij}} = \frac{1}{n^2 - n} \sum_{j=1}^n \sum_{j=1, j \neq i}^n \sigma_{ij}, \quad \frac{1}{n^2} \sum_{j=1, j \neq i}^n \sigma_{ij} = \frac{n^2 - 1}{n^2} \overline{\sigma_{ij}} \rightarrow \overline{\sigma_{ij}}$$

The differentiation above proves that when the number of assets increases towards infinity, the systematic risk remains. In order to not only analyze whether commodities can improve the AP portfolio, but also determine to what extent they would be included, Markowitz Mean-Variance Portfolio Analysis is applied.

First the Minimum Variance Frontier is obtained as the solution to:

$$\text{Min}_{\omega} \text{Var} = (\tilde{r}_p) = \text{Var} \left(\sum_{i=1}^N \omega_i \tilde{r}_i \right)$$

$$\text{s.t. } E(\tilde{r}_p) = E \left(\sum_{i=1}^N \omega_i \tilde{r}_i \right) = \sum_{i=1}^N \omega_i E(\tilde{r}_i) = \bar{r}$$

$$\sum_{i=1}^N \omega_i = 1$$

$$\omega_i \geq 0 \quad i = 1, \dots, N \text{ (No Short selling Constraint)}$$

Solving the above problem for different values of r gives different points in the chart, connecting the points give the minimum variance frontier. Important to note is that in the case study, the two assets which were combined in this model were the original AP portfolio and commodity index. The

model was set up in Excel, which calculated for the different weights. When excluding the first constraint ($E(\tilde{r}_p) = \bar{r}$) the Minimum Variance Portfolio (MVP) was obtained.

By using the minimum variance frontier, the Optimal Risky Portfolio (ORP) was obtained by solving the following:

$$\max_{\omega} \frac{E(\tilde{r}_p - r_f)}{\sigma(\tilde{r}_p)}$$

$$s.t. \quad E(\tilde{r}_p) = \omega E(\tilde{r}_{AP}) + (1 - \omega)E(\tilde{r}_C)$$

$$\sigma(\tilde{r}_p) = \sqrt{\omega^2 \sigma^2(\tilde{r}_{AP}) + (1 - \omega)^2 \sigma^2(\tilde{r}_C) + 2\omega(1 - \omega)Cov(\tilde{r}_{AP}, \tilde{r}_C)}$$

Differentiating with respect to ω and setting to zero, the solving for ω gives:

$$\omega^* = \frac{[E(\tilde{r}_{AP}) - r_f]\sigma^2(\tilde{r}_C) - [E(\tilde{r}_C) - r_f]Cov(\tilde{r}_{AP}, \tilde{r}_C)}{[E(\tilde{r}_{AP}) - r_f]\sigma^2(\tilde{r}_C) + [E(\tilde{r}_C) - r_f]\sigma^2(\tilde{r}_{AP}) - [E(\tilde{r}_{AP}) - r_f + E(\tilde{r}_C) - r_f]Cov(\tilde{r}_{AP}, \tilde{r}_C)}$$

The weight obtained from the equation gives the weight in the commodity index; the remaining weight will be in the original AP portfolio. This combination maximizes the Sharpe ratio and is the portfolio which every investor should hold, regardless of their level of risk aversion.

According to the separation theory, the asset allocation problem can be divided into two problems. First the optimal risky portfolio is determined as above. Second the combination between the risk-free asset and optimal risky portfolio is determined, this is known as the investor problem:

$$U(r) = E(r) - \frac{1}{2}A\sigma^2(r)$$

However, determining the risk aversion (A) cannot be simulated since it is based on arbitrary beliefs. Therefore, the investor problem is never solved, to avoid any bias. We assume that the optimal risky portfolio is held to 100 %. Hence, the optimal risky portfolio is the portfolio which is tangent to the efficient frontier and located on the capital allocation line and gives the highest Sharpe ratio, since it is the slope of the line. The CML is given by:

$$E(r_i) = r_f + \frac{[E(r_M) - r_f]}{\sigma_M} \sigma_i M$$

4.4 Extreme Case Scenario

To be able to show what returns the AP funds could have had, an extreme scenario was created. In the simulation, the weight obtained for the optimal risky portfolio in the best performing portfolio was used. By borrowing or investing at the risk-free rate it was possible to create an extreme case portfolio with the same risk as the standard AP portfolio. This was obtained by dividing the standard deviation from the AP portfolio over the standard deviation for the optimal risky portfolio which yielded the leverage ratio. This ratio was then multiplied with the return of the optimal risky portfolio for each month to include interest on interest effects. The cost of borrowing was then deducted from the return on a month per month basis.

5 Results

5.1 Monthly Performance 5%

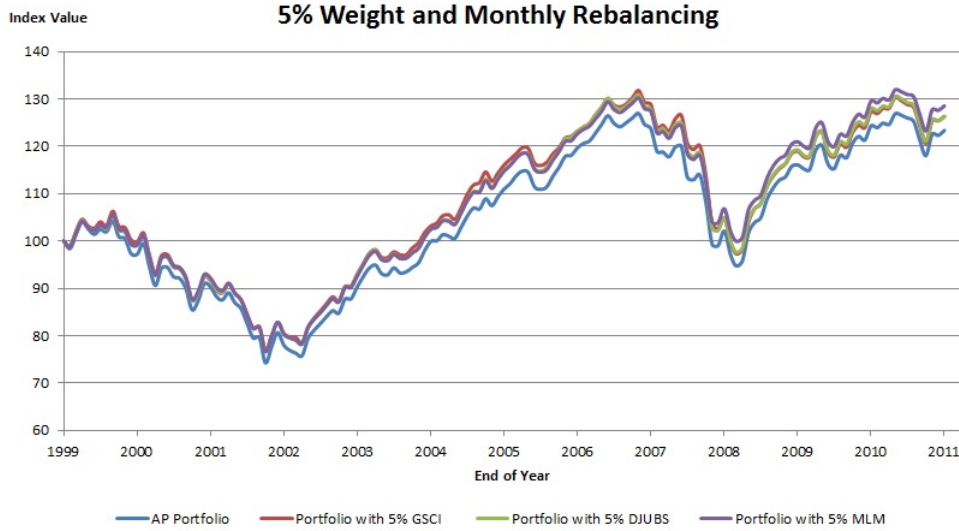


Figure 4: Portfolio performance for the replicated commodity portfolios with 5% weight in commodities, benchmarked against the original AP portfolio.

5% Weight, Monthly						
Portfolio Simulation	Return	St.Dev	Sharpe Ratio	Total Return	Draw-Down	Draw-Up
AP Portfolio	0,174%	2,355%	0,071	23,36%	-0,082	0,062
GSCI	0,190%	2,304%	0,079	26,34%	-0,090	0,057
DJUBS	0,188%	2,289%	0,079	26,25%	-0,086	0,058
MLM	0,199%	2,219%	0,086	28,55%	-0,074	0,058

Table 4: Performance measures for the commodity portfolios with a 5% weight in commodities, benchmarked against the original AP Portfolio.

If an investor would have invested in the portfolios including commodity indices from the beginning of the year of 2000, the investor would have outperformed the original AP portfolio. Table 4 shows the total return for the time period. It is clear that the commodity portfolios have higher total returns than the original AP portfolio. For example the MLM portfolio had a total return exceeding the AP portfolio with 519 basis points. Between the beginning of 2000 until the end of 2002 the commodity portfolios performed very similar to the AP portfolio. However, from the end of 2002 until the end of 2007 the commodity portfolios performed considerably better than the

original portfolio and from the end of 2007 until the end of 2008, the commodity portfolios dropped more than the original portfolio. However, the portfolios still managed to maintain their already accrued higher return. In the recovery from the beginning of 2009, the commodity portfolios once again performed better than the AP portfolio. The findings imply that integrating commodities, improves the AP portfolio over time, due to the diversification effect.

Looking at the table, the higher total return mentioned above, is reflected in the monthly returns where all commodity portfolios have higher returns than the AP portfolio. For example the MLM portfolio has on an average 25 basis points higher return each month. The risk measured by the standard deviation shows that the commodity portfolios have lower risk than the original AP portfolio. The higher return and lower risk is reflected in the Sharpe ratio which is higher for all the commodity portfolios in comparison to the AP portfolio. The performance figures further support the theory that the AP portfolio is improved when integrating commodities. Decreased standard deviation and increased return concretizes the diversification effect and implies that there are more efficient portfolios. The AP portfolio has lower drawn-down and higher draw-up in opposite to the previous positive effects in the commodity portfolios (except for the MLM at -0,074 draw-down).

5.2 Monthly Performance 15%

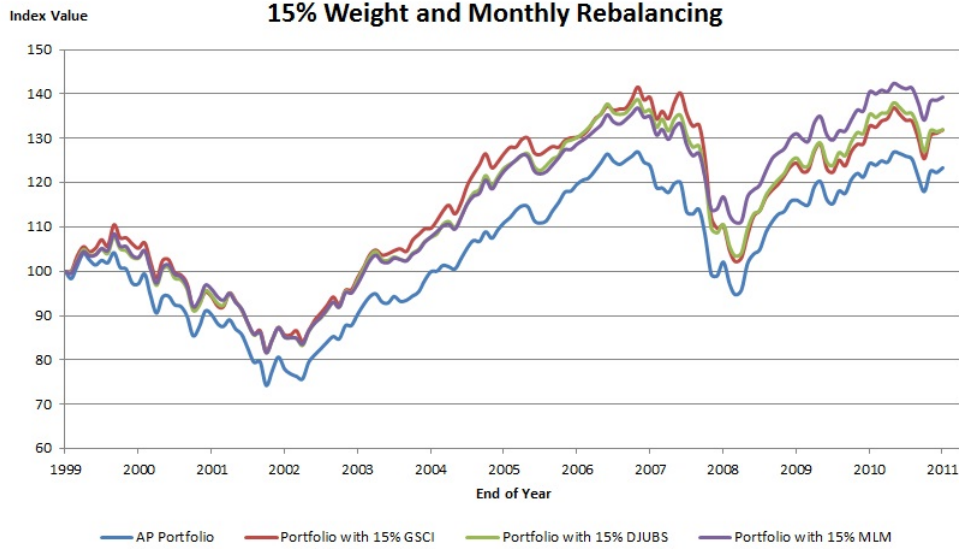


Figure 5: Portfolio performance for the replicated commodity portfolios with 15% weight in commodities, benchmarked against the original AP portfolio.

15% Weight, Monthly						
Portfolio Simulation	Return	St.Dev	Sharpe Ratio	Total Return	Draw-Down	Draw-Up
AP Portfolio	0,174%	2,355%	0,071	23,36%	-0,082	0,062
GSCI	0,222%	2,341%	0,091	31,91%	-0,106	0,049
DJUBS	0,217%	2,220%	0,095	31,93%	-0,094	0,051
MLM	0,250%	1,988%	0,122	39,30%	-0,058	0,050

Table 5: Performance measures for the commodity portfolios with a 15% weight in commodities, benchmarked against the original AP Portfolio.

Figure 5 has the same trend as the 5% weight graph, only with larger fluctuations due to the larger weight in commodities. However, the positive effects of commodities are more clearly seen in the large gap between the commodity portfolios and the AP portfolio over time. Regarding the monthly return, the returns for the commodity portfolios are not only higher than the AP portfolio but also higher than the commodity portfolios with the 5% weight. Interesting to note is that the standard deviation is not only lower for the commodity portfolios but also lower for the DJUBS and MLM portfolios in comparison to the 5% portfolios, indicating that the minimum variance portfolio is closer to 15% than 5% for the DJUBS and MLM. Since the Sharpe ratios are also higher for the 15% portfolios in comparison to the

5% portfolios, this also supports that these portfolios are closer to the optimal risky portfolio. The total return was considerably higher in comparison to the AP, not only for the MLM portfolio (15,94%) but also for the DJUBS (8,57%) and GSCI (8,55%). Regarding the draw-up and draw-down the trend is the same; however the draw-down for the DJUBS and GSCI portfolios are higher than the AP portfolio, while the MLM portfolio still has a lower draw-down.

5.3 Yearly Performance 5%

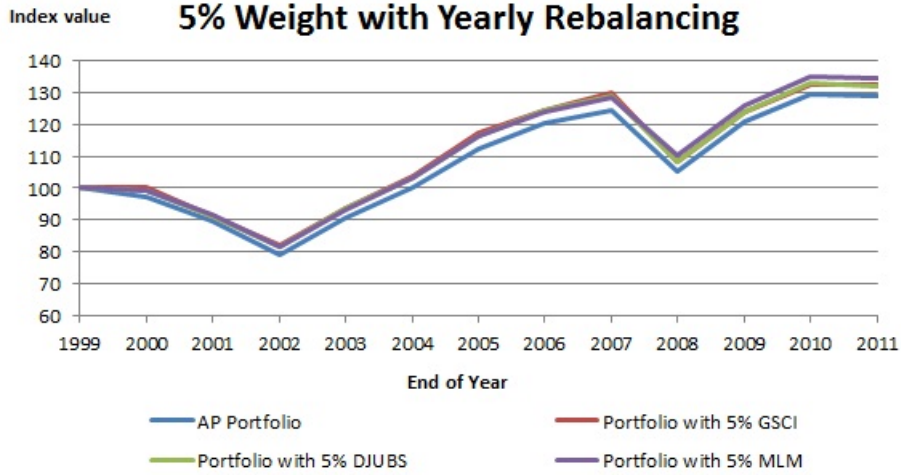


Figure 6: Portfolio performance for the replicated commodity portfolios with 5% weight in commodities, benchmarked against the original AP portfolio.

5% Weight, Yearly						
Portfolio Simulation	Return	St.Dev	Sharpe Ratio	Total Return	Draw-Down	Draw-Up
AP Portfolio	2,634%	10,190%	0,250	29,14%	-0,152	0,147
GSCI	2,852%	10,255%	0,269	32,34%	-0,166	0,143
DJUBS	2,816%	10,170%	0,268	31,94%	-0,160	0,144
MLM	2,941%	9,728%	0,293	34,58%	-0,139	0,141

Table 6: Performance measures for the commodity portfolios with a 5% weight in commodities, benchmarked against the original AP Portfolio.

The graph visualizes the indexed returns for the AP portfolio and the commodity portfolios. As for the monthly rebalanced portfolios, an investor who invested in the commodity portfolios would have outperformed the AP portfolio during the time period.

With yearly compared to monthly rebalancing the trend for the portfolio measures are the same (i.e. increased return and decreased standard deviation, implying a higher Sharpe ratio) when comparing the commodity portfolio to the AP portfolio.

With yearly rebalancing the total return for the 5% portfolios is higher in comparison to the monthly rebalanced portfolios with the same weight. For example, the GSCI portfolio with yearly rebalancing (5%) performed 6,03% better than the monthly rebalanced portfolio. Therefore, the increase

in the total return with yearly rebalancing implies that the return per time period (year) is higher in relation to the monthly return. The difference in the rebalancing period implies that it is not beneficial to rebalance frequently, but instead keep the assets that perform well for a longer time period and earn the returns. Furthermore, the changed rebalancing supports the fact that commodities actually have a correlation effect and can act as a diversifier and add to the AP portfolios return.

5.4 Yearly Performance 15%

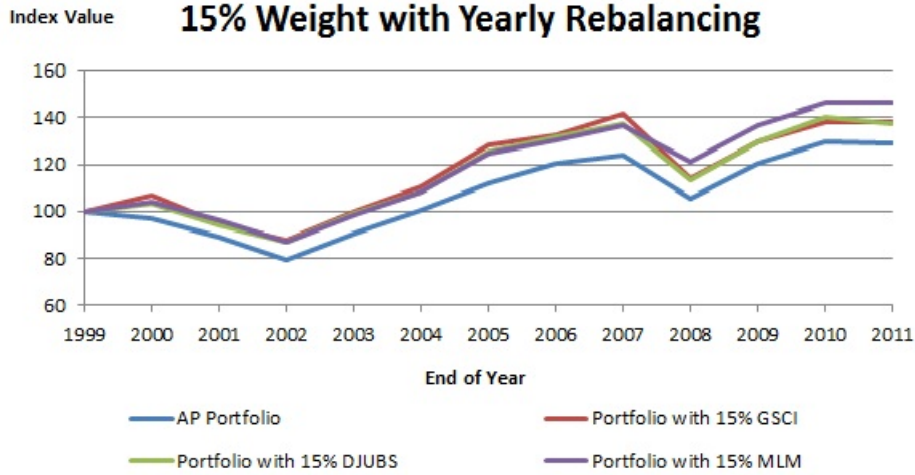


Figure 7: Portfolio performance for the replicated commodity portfolios with 15% weight in commodities, benchmarked against the original AP portfolio.

15% Weight, Yearly						
Portfolio Simulation	Return	St.Dev	Sharpe Ratio	Total Return	Draw-Down	Draw-Up
AP Portfolio	2,634%	10,19%	0,250	29,14%	-0,152	0,147
GSCI	3,290%	10,92%	0,293	38,08%	-0,195	0,163
DJUBS	3,181%	10,38%	0,298	37,33%	-0,175	0,156
MLM	3,557%	9,010%	0,385	45,71%	-0,113	0,147

Table 7: Performance measures for the commodity portfolios with a 15% weight in commodities, benchmarked against the original AP Portfolio.

As seen with the 5% portfolio, the returns increase even more when the portfolios have exposure to commodities included. As for the standard deviation, the MLM portfolio decreases while the DJUBS and GSCI increases slightly to 10,38% and 10,92%. This implies that the minimum variance portfolio has less than 15% in commodities, with yearly rebalancing. However, the Sharpe ratios for all the commodity portfolios have increased. The increase in Sharpe ratio implies that even though the standard deviation increases above the AP portfolios standard deviation, the increase in return is able to compensate for it.

Furthermore, a concrete evidence of the effect of yearly rebalancing is seen in the total return which is heavily improved. This implies that it is more beneficial to keep an asset which has performed well in the past.

Something that is also visible with 15% weight is that the MLM managed to avoid the 2008 crisis better than the other portfolios. The MLM portfolio has an even lower draw-down than with 5% weight. The biggest increase in Sharpe ratio can be seen with the MLM index which is 54% higher than for the AP portfolio and 31% higher than the 5% MLM portfolio. MLMs ability to minimize the downside during the financial crisis is explained by the long-neutral strategy, which is not used by the other commodity indices. Therefore, the long-neutral strategy clearly proves its benefits.

One important thing to notice is that the commodity portfolios have a higher exposure to the USD than the AP portfolio. The model was created to only add the commodity effect, and not take into account the currency effect. Since the USDSEK FX-rate has declined by around 20% over the time period, the actual performance could be even higher for the commodity portfolios. The most realistic case would be to hedge the currency exposure related to the commodity indices, which in this case would have increased the returns even more.

5.5 Portfolio Optimization

Correlation	
Stand Alone Index	AP Portfolio
GSCI	0,052
DJUBS	0,067
MLM	-0,259

Table 8: Correlation matrix between the different commodity indices and the original AP portfolio.

The correlation between GSCI and DJUBS compared to the AP portfolio is noticeably low. Between the DJUBS and the AP portfolio the correlation is 0,067 and GSCI to the AP portfolio at 0,052. The correlation between MLM and the AP portfolio is negative at -0,259. Low or negative correlation with the AP portfolio should add a correlation effect, i.e. to increase the diversification of the portfolio and increases its Sharpe ratio. These findings are seen in figure 4-7 and table 4-7 and are in line with previous literature and our expectations.

Global Minimum Variance Portfolios						
Index	Weight Commodity	Weight AP	Portfolio St.Dev	Return	Sharpe Ratio	
MLM	30,4%	69,6%	1,8%	0,33%	0,181	
DJUBS	22,0%	78,0%	2,1%	0,24%	0,110	
GSCI	10,8%	89,2%	2,2%	0,21%	0,092	

Table 9: Global minimum variance portfolios for the three different commodity indices.

The commodity weights in table 9 are obtained when minimizing the portfolios standard deviation, i.e. obtaining the global minimum variance portfolios located on the minimum variance frontier. The efficient frontier is based on the portfolios with monthly rebalancing periods. The standard deviations are lower than for the AP portfolio by 58,9 basis points in the MLM portfolio and 24 and 11,3 basis points for the DJUBS and GSCI portfolio. Comparing the portfolios above with the AP portfolio, it is clear that the returns are higher and standard deviations are lower. The global minimum variance portfolio strongly supports the theory that there are more efficient portfolios than the AP portfolio, regardless of which commodity index that is integrated.

The table 10 is obtained when maximizing the Sharpe ratio, i.e. obtaining the weights in the commodity index that yields the optimal risky portfolio.

Optimal Risky Portfolios

Index	Weight Commodity	Weight AP	Portfolio St.Dev	Return	Sharpe Ratio
MLM	47,7%	52,3%	2,0%	0,41%	0,203
DJUBS	43,2%	56,8%	2,3%	0,29%	0,122
GSCI	25,4%	74,6%	2,4%	0,25%	0,101

Table 10: Optimal risky portfolios for the different commodity indices.

Comparing the Sharpe ratio to the minimum variance portfolio, and to the AP portfolio the optimal risky portfolios always have a higher Sharpe ratio. Figures 8-10 visualize that the optimal risky portfolios have a higher return with a slightly higher standard deviation. The Sharpe ratio for the MLM portfolio increases by 187% in comparison to the AP portfolio with monthly rebalancing. The Sharpe ratio of the DJUBS portfolio increased by 72% and the GSCI increased with 43%.

The evidence that integrating commodities creates more efficient portfolios is heavily supported by the optimal risky portfolio, with Sharpe ratios much higher than the original AP portfolio. In financial theory, the optimal risky portfolio should always be held, regardless of risk aversion. The AP portfolio is clearly not the best diversified portfolio and therefore not investing in the best interest of the shareholders, i.e. the Swedish population.

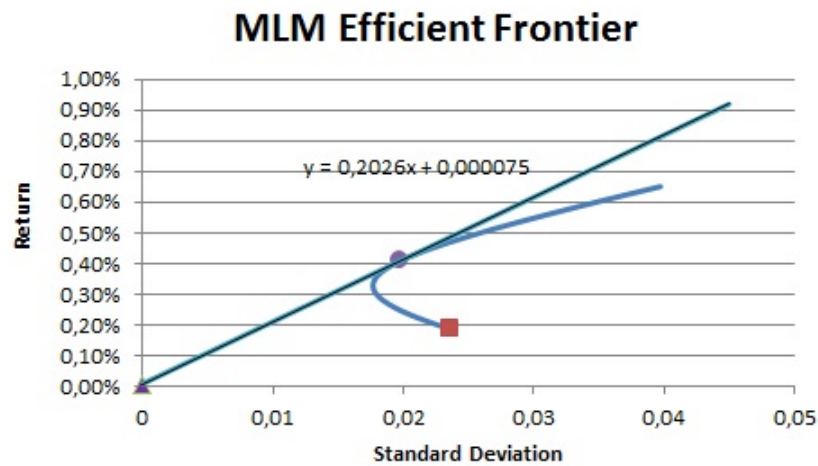


Figure 8: Efficient frontier for an AP portfolio including the MLM index at different weights.

The efficient frontier for the different commodity portfolios are visualized in figures 8-10. The red square represents the AP portfolio today, the triangle represents the current risk-free rate and the circle represents the optimal risky

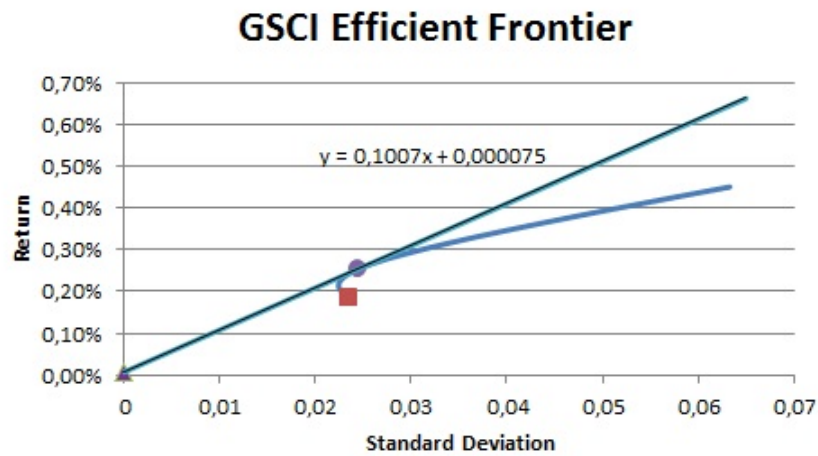


Figure 9: Efficient frontier for an AP portfolio including the GSCI index at different weights.

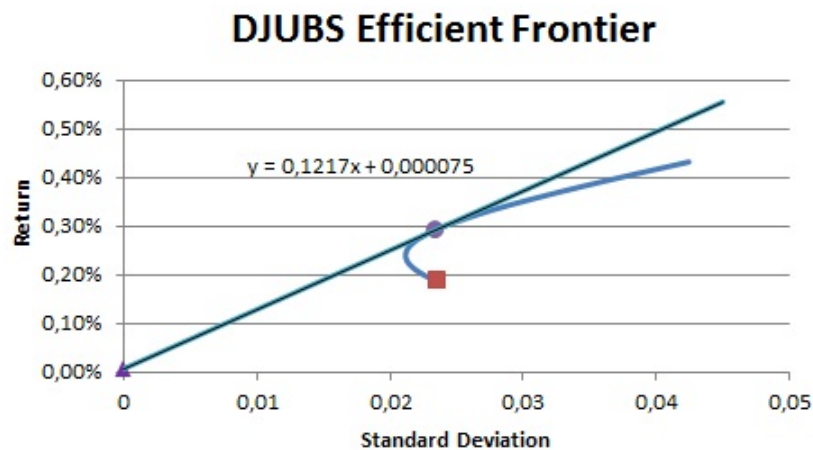


Figure 10: Efficient frontier for an AP portfolio including the DJUBS index at different weights.

portfolio. The slope of the capital allocation line, tangent to the optimal risky portfolio, is the same as the Sharpe ratio. We can see that for all indices the curve is shifted to the left showing the decrease in standard deviation and the increase in return that is possible. The GSCI is the only index that has an optimal risky portfolio that has higher standard deviation than the standard AP portfolio.

5.6 Extreme Case

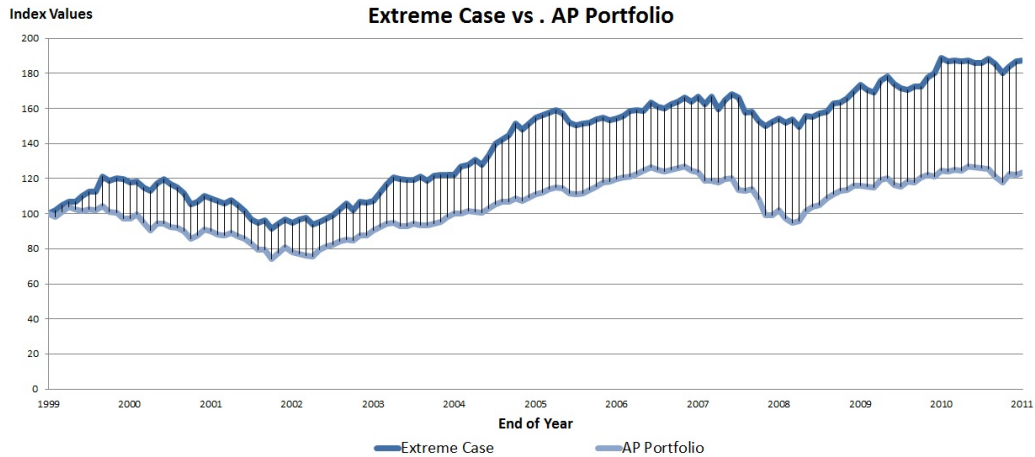


Figure 11: Extreme case scenario against the AP portfolio

The graph visualizes the effect when comparing the AP portfolio, and a portfolio with the same volatility, located on the capital allocation line. The weight in the MLM has been derived from the optimal risky portfolio and then levered with 0,223%. From the graph it is clear to see that there is a huge difference between the original AP portfolio, and the extreme case portfolio. The striped area visualizes where an AP funds returns could have been without increasing their risk. It is clear that this is indeed an extreme case; however it implies that the capital could have been managed in a much more efficient way.

Extreme Case

Measures	Extreme Case	AP Portfolio	Difference
Monthly Return	0,46%	0,17%	0,29%
Total Return	87,28%	23,36%	63,92%
St.Dev	2,36%	2,36%	0,00
Leverage Ratio	0,223%	0%	0,223%

5.7 Results Summary

When including commodities into the AP portfolio, it can be observed that for 5% and 15% weights and all rebalancing periods, the portfolios including commodities always have higher performance, measured in Sharpe ratio. Total return is always higher, standard deviation is almost always lower with few exceptions. The correlation between the stand alone commodity indices and the synthetically replicated AP portfolio is low. The Markowitz portfolio optimization proves that there are more efficient portfolios than the current AP portfolio. In an extreme case scenario, with the same standard deviation, the returns of the extreme case portfolio always exceeds the AP portfolio.

6 Conclusions

The purpose of this study was to see if the Swedish pension fund regulation, prohibiting AP funds from investing in commodities have affected their performance. We have concluded that the performance have been greatly reduced due to the regulation and should be changed to allow for commodity investing going forward.

By replicating a scenario where commodity investments are allowed we have shown that the AP funds over the last 12 years have missed out on 16,57% additional return which estimates around 92,8 billion SEK in extra revenue approximating around 46 000 SEK per pension taker⁴⁰. This is crucial amount of additional return that could have contributed to their goal achievement.

Except for the additional return, the risk, measured in volatility, could have been lowered. The minimum variance frontier is shifted to left when including commodities implying that the AP funds do not have the most efficient portfolio at the moment. The AP portfolio should therefore be allowed to invest in commodities in order to hold the most efficient portfolio, consequently complying with their goal to deliver steady and reliable returns for the Swedish population.

Hence, the essay managed to prove the theory that including commodities provides a diversification effect due to low or even negative correlation in comparison to traditional asset classes. The above findings are in line with the expectations stated in the introduction.

If the Swedish pension fund regulation continues to prohibit commodity investments, the reason for their existence is superfluous, since they currently cannot fulfill their own purpose. Their goal is set in order to guarantee the future welfare of the Swedish population. If the current system cannot reach the necessary goals, the capital should be allocated in a different way.

At present, the AP funds are destroying the Swedish pension capital by not being allowed to hold the most efficient portfolio, i.e. not investing in the best interest of the Swedish population. Investing in the most efficient portfolio should always be the goal of investment management and public authorities should not be an exception.

⁴⁰Based on initial value of 560 billion SEK and 15% weight in MLM with 2 million pension taker and no additional cash in or outflows. (Source: http://www.forsakringskassan.se/omfk/statistik_och_analys/pension/alderspension)

7 Ethics and CSR

Commodity investing is a highly debated topic within the financial industry, as mentioned in the introduction. The debate is constantly criticizing commodity investing and the effects commodity trading derivatives might have, especially harming the population in developing countries. Since the Swedish AP funds invest the populations capital, the ethical issues are of great importance.

The AP funds are investing in order to provide future consumption for the Swedish population. Therefore investing in commodities consumed by, or which are beneficial for, the Swedish population should be the optimal allocation of capital directed in commodities. For example Sweden has the 8th highest electricity consumption per capita in the world (2009).⁴¹ A rise in electricity prices would therefore greatly affect the consumption of not only electricity, since it is needed for heating, but also other goods that the population would have to give up to compensate for the higher price. If however a pension fund invested in commodities that the country is greatly dependent on, such as electricity in Sweden, a rise in that commodity price would be compensated for by a higher pension. This creates a more stable environment for the pension takers. Besides the obvious effect this has for the pension takers it will also stimulate, in this example, the energy sector which can ensure and lock in future revenues and thereby minimize their own risk. The investments are meanwhile compliant with the investment guideline, which is to have a long term investment horizon, which in turn provides long term benefits.

The financial market offers multiple investment vehicles for commodity investing. Commodity futures are widely used with different purposes. Swedish commodity producers can benefit from financial derivatives using commodities as an underlying asset in order to, for example, hedge their cash flows. This generates steady cash flows for commodity producers, benefiting not only the producers, but also the population by making it attractive and safe from an economical perspective to produce commodities and at the same time provide resources for Sweden.⁴²

The causality between prices of commodity derivatives and the underlying commodity prices themselves are minimal. When trading with derivatives, no physical commodities are added to or drawn from the market. Hence, the supply and demand structure cannot be affected. This concludes that trading with speculative purposes in commodity derivatives do not affect

⁴¹<http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC>

⁴²Head of Commodities at SEB, Torbjörn Iwarson. Discussions with the CSR department at SEB.

the real commodity market and thereby do not affect the population in a negative way.⁴³

Regarding the effect of commodity investing on food prices, which is one of the main ethical issues discussed, the criticism seems to be groundless. Studies conducted by the World Bank and the University of Wageningen have failed to prove that a connection between food prices and prices on commodity futures exists. This is one of the reasons why for example PGGM actively invests in commodities. Until there are sufficient and uniform evidence that commodity investing can affect food prices in a harmful way, the criticism should be seen as groundless.⁴⁴

The criticism from an ethical point of view directed towards commodity investing is, as discussed above, unsupported by facts. Of course, the ethical perspective is always important to keep in mind going forward, always making sure to invest the populations capital in a responsible way. However, it is important to not only to be critical of the asset class itself, but also the criticism directed towards it.

⁴³Responsible Investment, Annual Report 2011, PGGM

⁴⁴University of Wageningen (2008)

8 Problematization & Future Research

Since our results points towards that one observation depends on another. Yearly rebalancing improves our results compared to monthly rebalancing, implying that weak market hypothesis does not hold. Since our model depends on the previous observations return (interest on interest), the observations can not be regarded as independent. Hypothesis testing is heavily dependent on the assumption that all observations are independent, the commonly used t-test for hypothesis testing can therefore not be applied to our results.⁴⁵

The model used for replicating the portfolios is based on several assumptions, which the reader should be aware of. The AP funds have active investment management in each rebalancing period, which cannot be replicated in the study without being biased due to the fact that events during the time period could be exploited. The model therefore assumes passive investments to avoid the bias. Regarding the indices, the total return version is used in opposite to for example an excess return variant. Total return indices include all costs, making them representable as an investment vehicle. The reader should however be aware that there are differences between the index types, which could affect the outcome of the study.

It is important to notice that the study aims at showing a difference in portfolios and not the true replication of an AP portfolio. The AP portfolios have an active management which we could not replicate without being backward biased. Therefore our portfolio is likely to have performed slightly worse than a true AP portfolio. The AP funds also have alternative investments that we could not replicate due to several reasons. For example they have private equity that is not listed and therefore hard to replicate. We have therefore assumed no alternative investments in the standard AP portfolio.

When Sharpe ratios are calculated, the current short term risk free interest rate is used. The goal is not to calculate true Sharpe ratios, but rather to display for any differences in Sharpe ratios between the portfolios.

Traditional performance measures are used to compare the portfolios making the conclusions of the essay sensitive to the measures used. The outcome when applying a different analytic approach has not been tested and we can therefore not reject that another approach would give other results.

As discussed in the introduction, and seen in the results section, the outcome is heavily dependent on the time period used. The results could therefore fluctuate when applying it on another time period. These effects

⁴⁵Concluded in discussions with the Statistics Department at SSE

have not been tested and the extent of the impact is therefore unknown.

A hedge ratio of 40% is applied in order to keep the currency exposure within the 40% limit. Since the results must be calculated and presented in SEK, the conversion from USD indices into SEK is necessary. Using a currency hedge affects the results by gaining on any downside in the FX ratio.

Going forward this study could be developed by analyzing the effect of using different investment vehicles. As discussed in the background there are several way to invest in commodities, replicating the study with a different vehicle could change the results in a positive or negative direction.

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