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INVESTMENT DECISIONS IN CRISES – A STUDY OF PRIVATE PENSION FUND INVESTMENTS

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Private pension funds were thought to be an important pillar of old-age provision when they were introduced throughout (Emerging) Europe. As different as these funds are in different countries with regards to their regulation, their ownership structure and operation, none were immune to the sub-prime led financial crisis. The Hungarian private pension funds are unique amongst the defined contribution (DC) funds. With their decade old recent history, they are maturing to the payout period in a few years' time; however, their demise appears ever more realistic by means of political decision. This makes uncovering their investment policy during the crises very timely. Examining such a period is of importance in shedding light on the behaviour of traditional financial concepts in periods of stress. In this paper, we assess the optimality of diversification, hedging and short sales decision possibilities of the Hungarian pension funds in the equity investments environment. Was the net asset value (NAV) erosion suffered by the Hungarian private pension funds a result of their investment decision? We examine this question of diversification through a hypothetical simulation of model investment portfolios. Our results show that international diversification yields better risk-adjusted returns only in case of perfect hindsight of future market movements. The high correlation of the stock indices globally in times of crises limits the benefits of diversification.

Keywords: financial crises, pension funds, portfolio performance, Hungary

JEL classification indices: G01, G23, C38

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INTRODUCTION

None of the pension schemes were immune to the effects of the credit crisis of 2007–2009; however, the impact of a crisis depends on the maturity of the funds (Whitehouse 2009). The sub-prime led financial crisis caused massive losses in net asset value (NAV) across the global investments arena. A prudent investment policy, however, could optimise the return-risk trade-off. In this paper, we examine the effects diversification and short selling constraints could have had on the Hungarian private pension funds (PPF) in such a period of negative returns. The methodology used to measure risk and performance of investment portfolios is overviewed in this paper.

It is generally acknowledged in the financial literature that diversification in investment portfolios is beneficial with regards to lowering idiosyncratic risk (Markowitz 1952). Moreover, international diversification aims at lowering exposure to a single country's systemic risk. This effect of lowering the portfolio's risk depends on the combination of assets selected into the portfolio. The lower the correlation between asset returns, the better the hedge achieved from combining them into a single investment portfolio (Wagner – Lau 1971). Notwithstanding that, correlation coefficients are not stable in time (Boness et al. 1974) but are rather observed to tend to one in times of crisis and economic shocks (Sheikh – Qiao 2010). Our simulation exercise shows evidence to corroborate this. Contagion is related to the high correlation coefficient in times of economic crisis. In this paper, we look at the question of international diversification from the perspective of the Hungarian investors, i.e. the PPFs, in the period spanning a decade between 1998–2009 and witnessing the century's most dramatic financial crisis. The peculiarity of the financial crisis was that it was centred on the financial system. Previous crises were merely linked to the financial intermediary sector but did not originate from it. The sub-prime led crisis shed light on the fundamental problems of our modern financial system. Examining such a period is of importance in exploring the behaviour of traditional financial concepts in periods of stress.

One of the questions of research is to examine whether private pension funds should follow a policy of international diversification or should their investing activity be limited to the domestic market. The second question is with regards to limiting short selling. Both questions will be examined through the optimisation of model investment portfolios.

Arguments in support of limiting diversification to the domestic market could be explained by the foreign-currency risk, the risk of contagion from foreign markets and by indirect benefits such as externalities of supporting the local economy and job creation that eventually benefit the pensioner to-be. Furthermore, in the case of a highly indebted country like Hungary, Hungarian investments abroad would further contribute to financial instability (Mosolygó 2010). On the other hand, alleviating constraints on international investments for private pension funds appears to be more aligned with arguments supporting free market economy and deregulation. An important aspect is the disruption of market equilibrium that leads to the inefficient allocation of resources. Short sale constraints are favoured due to lowered risk taking; however a global optimum on a risk-return surface could be missed if the constraints apply.

In section 1 of this paper, we take an overview of the Hungarian private pension funds. Section 2 presents a global overview of the performance of the world's private pension funds based on reports made by the IMF and the OECD. In section 3 we explain the performance measurements in times of crises. Section 4 details the methodology applied in our empirical work of portfolio optimisation based on a tailor-made performance measure that is appropriate for crises periods. Then, in section 5 we present empirical results of applying international diversification and short selling with the purpose of finding the optimal model portfolios. In section 6 we evaluate the results of the optimisation exercise and give our final conclusion regarding the investment policies of the Hungarian private pension funds.

1. THE HUNGARIAN PRIVATE PENSION FUNDS

The Hungarian private pension funds (PPF) are part of the three-pillared pension system in Hungary that was created in 1997.[1] In that new system employees joining the labour market were obliged to join a PPF, and approximately 25% of their whole pension contribution was paid to the private pension system. Those entering the labour market had to join the mixed system. Accordingly, when reaching retirement age, pensioners would be entitled to social security benefit (w.r.t. the monopillar benefit) in the measure of their former contribution (75%), which is complemented with their own savings at the private pension fund accounts. It should be noted that those who voluntarily joined the system lost retrospectively the right to one-fourth of their pension promissory accrued up to 1998. Assuming zero return in real terms on the private pension investments, an accumulation period of 40 years is needed for the pension deriving from the multi-pillar system to equal that of the pay-as-you-go, or the pure social security system (Matits 2009).

The private pension funds are a Hungarian speciality by their own right, a *'Hungaricum'* of the country. This applies to their current form of existence, as the ownership structure in the form of a cooperative pension fund owned by the

[1] The role and extensiveness of the private pension pillar has dramatically changed in the 2011 pension reform.

members themselves is peculiar in its own way, not resembling any other pension system.

The decade long history of these funds looks back on a hefty period characterised by years of rapid economic growth, and then struck by a financial crisis probably the most severe that history has witnessed so far after 1929–1933. Moreover, this newly reformed system is peculiar also because in the case of Hungary the erosion of private pension savings was critical for members nearing retirement age, aggravated by the short accumulation period. At the start of the system in 1998, the entry into a private pension fund – that meant a switch of 25% of the future pension benefit away from the public pension scheme – was not age restricted. This resulted in having as much as 5.1% of the members retiring within the coming 10 years based on data of the year 2009 after a very short accumulation period.

The Hungarian pension system is burdened by a low retirement age and high replacement ratio, relative to the international average. In order to maintain the sustainability of the system, reforms that encourage increasing the ratio of self-provision are necessary.

The juvenile three-pillar Hungarian pension system faced the financial crisis with an accumulation period less than a decade old. The sub-prime mortgage led financial crisis spread from overseas, and the collapse of the financial markets eroded 20–30% of the Hungarian pension savings. The basis for the safe operation of funded pension systems is the preservation of net asset value in real terms to ensure sufficient income for the members during payout years. The Hungarian private pension funds, however, did not preserve even the nominal value of the members' incoming payments. The crisis thus shed light on the structural problems that lay in the decisions taken by the investment managers.

The most important question in the operation of a pension fund is its investment policy, as it determines the return ensured by the fund. Naturally, performance measures are affected by the timing of the shift towards equities. Most of the countries benefited from the surge in equity markets before the 2007 crisis. However, the Hungarian example was less fortunate, as shift towards equity investments came at the time of the market collapse. According to Hungarian Financial Supervisory Authority (HFSA) and Association of Hungarian Investment Fund and Asset Management Companies (Bamosz) data, the share of the pension funds' foreign investments within the equity universe of Hungarian pension fund portfolios was 64% by 2009. The most important argument supporting international investments is its diversification effect, which makes the whole portfolio independent from the home country – specific risk.

2. INTERNATIONAL ENVIRONMENT OVERVIEW

As the value of financial assets and therefore pension savings substantially eroded in the global markets, the potential erosion of the net asset value of future pensions became a real threat for most of the developed countries. The study of Gillingham et al. (2009) aimed at addressing the fiscal risks deriving from the losses incurred by the pension funds by examining the effect of the crisis on pension investments in 43 countries.

Up to 2007, global pension fund net asset value was on the rise in both nominal value terms and in relation to GDP. According to information made available by IMF, total assets of pension funds exceeded USD 26,853bn, corresponding to 35% of GDP on average by the end of 2007. *Figure 1* below depicts the distribution of pension fund assets according to country of origin: USA makes up roughly two-thirds, and the shares of seven further countries are outstanding.

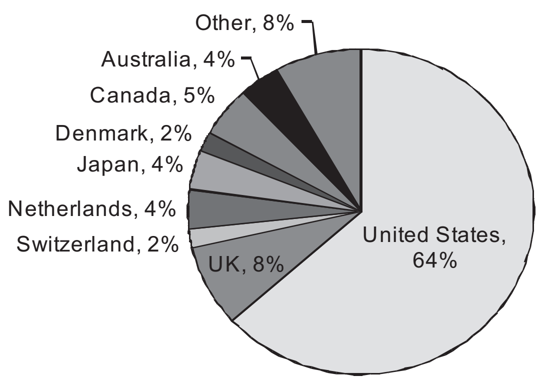

Figure 1. Distribution of pension fund assets

Source: Gillingham et al. (2009).

By converting the figures to relative values in relation to the countries' GDPs, it becomes clear that a quarter of the countries have a high (i.e. above 50%) pension savings/GDP ratio *(Figure 2)*. In almost two thirds of the countries, this ratio is below 20%, but the tendency is a growing one for the funded part in the pension system. The bull markets of the early 2000s and the general rise in risk appetite resulted in equity investments dominating investment portfolios of pension funds. In the UK and the USA, portfolios were made up of 58% equity, while in the other countries the weight of equity was around 34% (IMF).

The average stock market decline weighted by the value of pension fund assets was 34.6% in the countries examined between end-2007 and 30th June, 2009. The

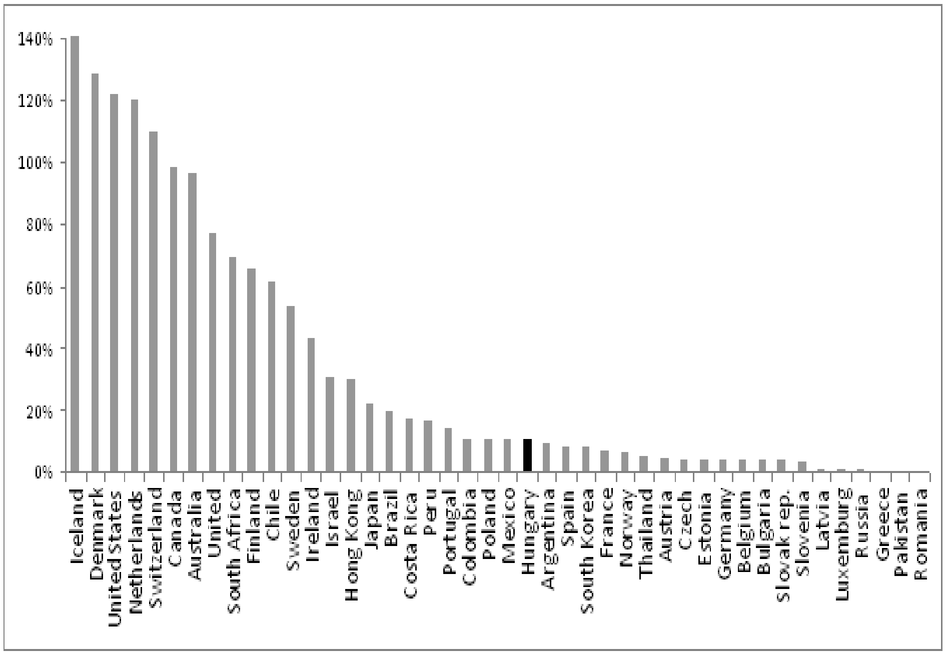

Figure 2. Pension Funds' assets as a % of GDP

Source: Gillingham et al. (2009).

exchange rate depreciation against the dollar caused a further 5% decline in reported figures in USD terms. Thus, the total loss on equity amounted to USD 5.874 bn, 21.88% of the 2007 figure.

With these figures indicating immense asset erosion, the question arises whether private pension funds were a victim of badly made investment decisions? We will attempt to answer this question by looking at the hypothetically possible investment outcomes of the past 10 years. We analyse whether the losses of the Hungarian private pension funds were justifiable by the global market movements or were a result of asset mismanagement, and how could they have avoided the sharp fall of their value of their investments.

3. INVESTMENT STRATEGIES

In this section, we analyse the effects of investments strategies on the performance equity investments of pension portfolios. We first address the issue of diversification, and then the "common evil" as dubbed by many, namely short selling. We investigate this through taking country indices to proxy well-diversified country investment portfolios. We choose the following five markets for our empirical analysis with corresponding index notations used by Bloomberg: US (DJI), UK (UKX), Germany (DAX), Hungary (BUX) and Japan (NKY).

3.1. Diversification

The general rule is to diversify. Financial theory assumes well-diversified investments to be efficient. Orszag – Stiglitz (1999) name this as a dilemma of private pension funds, however, they use it in the context of diversifying away from bonds, into equities. Their resolution is indefinite in this matter. They regard the question as being subject to the risk appetite of pension contributors. However, by this they implicitly assume that equity investments are all efficient. Certainly, if we accept market efficiency in capital markets, then the choice of moving along the capital allocation line (CAL) in a capital asset pricing model (CAPM) context is subject to individual utility functions and risk aversion. The matter of the fact is, however, that investment choices world-wide are far from efficient, and therefore diversification, as a tool to mitigate excess risk, has to be undertaken by the individual pension funds to ensure efficient investments. The question whether to diversify or not can be examined empirically by looking at correlations of index returns. *Table 1* below shows that the Hungarian main stock index (BUX) has a significant positive correlation with the international indices. However, the correlation is semi-strong, which gives grounds for investigating the effects of diversification. It is also interesting to note that correlations are not stable in time and do

Table 1

Index return correlations

Years	ρBUX, UKX	ρBUX, DJI	ρBUX, DAX	ρBUX, NKY	ρUKX, DJI	ρUKX, DAX	ρUKX, NKY	ρDJI, DAX	ρDJI, NKY	ρDAX, NKY
1999	0.38	0.41	0.55	0.26*	0.53	**0.69**	0.39	0.59	0.48	0.44
2000	0.54	0.24	0.57	0.27	0.55	**0.62**	0.40	0.50	0.43	0.40
2001	**0.61**	0.60	**0.72**	0.49	**0.83**	**0.91**	0.44	**0.83**	0.35	0.48
2002	0.43	0.45	0.58	0.31	**0.78**	**0.84**	0.25	**0.82**	0.30	0.35
2003	0.39	0.37	0.47	0.47	**0.84**	**0.83**	0.36	**0.80**	0.37	0.48
2004	0.34	0.35	0.55	0.58	**0.76**	**0.83**	0.53	**0.83**	0.55	**0.66**
2005	0.48	0.42	0.38	0.30	**0.65**	**0.81**	0.57	**0.71**	0.52	**0.62**
2006	**0.68**	0.54	**0.65**	0.40	**0.69**	**0.87**	**0.62**	**0.80**	0.49	**0.69**
2007	0.52	0.54	0.52	**0.68**	**0.82**	**0.91**	**0.76**	**0.76**	**0.70**	**0.67**
2008	**0.66**	**0.61**	**0.71**	**0.70**	**0.87**	**0.96**	**0.86**	**0.86**	**0.75**	**0.88**
2009	**0.67**	**0.71**	**0.75**	**0.63**	**0.86**	**0.91**	0.59	**0.87**	**0.61**	**0.61**

Notes: Figures with * are statistically insignificant. Bolded figures mean correlations above 0.6.
Source: Authors' calculation based on Bloomberg data.

get stronger in times of crises. The years 2001, and 2008–09 have high correlations in most cases.

Most of the figures are significant on a 5% significance level based on the t-test. It can be observed that correlation coefficients are very strong (above 0.9) during the years 2008–2009 of the financial crisis. This empirical finding is corroborated by Sheikh – Qiao (2010) who give account for this phenomenon that during times of distress correlations tend to 1, thereby instigating contagion.

Figure 3 depicts the returns of the BUX and the UKX indices and the range of maximum and minimum returns of the 5 indices for the period 1999–2009 is shaded. It graphically shows the reverse relationship between asset returns and return correlations.

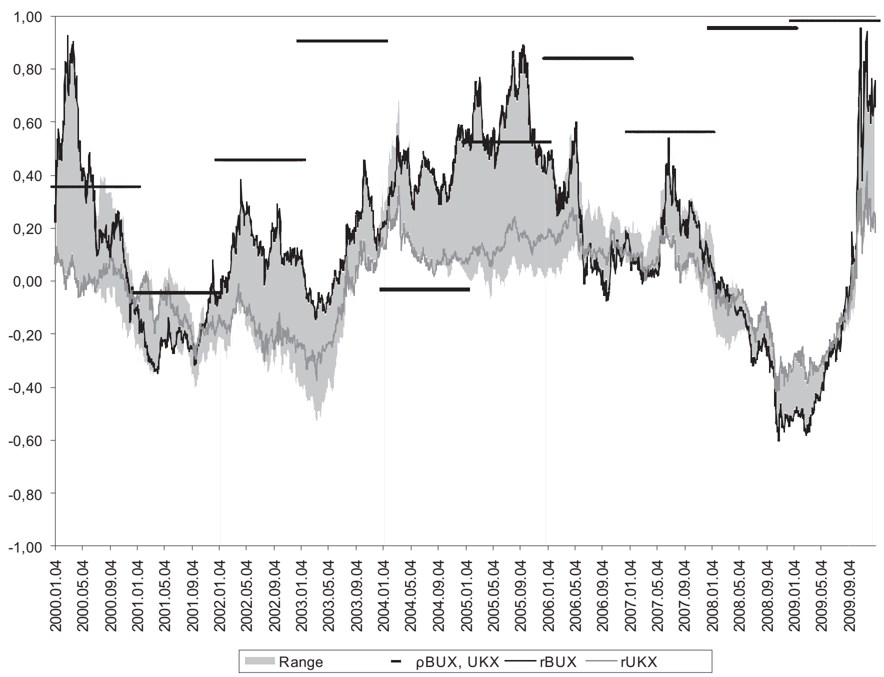

Figure 3. Returns of the BUX and UKX index with an illustration of the correlation between the returns

The question of asset allocation between risky and risk-free assets is investigated by Haberman – Vigna (2002). They establish that the distribution of assets should be based on risk appetite and the time left until retirement. The longer the time to retirement and the greater the risk appetite, the higher asset risk may be taken. The OECD suggests a similar life-cycle investment-strategy, reducing the ratio of risky assets as the member approaches retirement age (Whitehouse 2009).

The Hungarian portfolio allocation system conforms to this principle by categorising members based on age into three levels of risk portfolios. The members may opt for a lower risk category than their initial default categorisation, however, they may not enter a higher risk category.

Now, we take a look at measuring performance in a risk-return trade-off framework.

3.2 Risk-adjusted performance measures

In the context of classical portfolio theory, investment decision criteria are made along the risk-return trade-off; investors aim to maximise returns on their investments while minimising the risks incurred. Most investment criteria measures are based on a return-risk ratio. Despite the variations, essentially all ratios attempt to capture a measure of asset returns against a measure of risk. These are collectively called mean-variance analysis (MVA) and the most common of these is the Sharpe ratio (1966). Other variations include the Treynor ratio, Jensen's alpha, and the appraisal ratio. This school of investment decision making attempts to capture excess return of the asset over a benchmark. This benchmark is often the risk-free asset's return. The risk measures in these models are represented by the variation in returns. Variability makes returns unpredictable, and susceptible to unfavourable movements, which makes it a generally accepted proxy of risk. However, the Sharpe ratio has suffered from significant drawbacks due to several of its restraining assumptions, including the instability of correlation matrices through time.

It has been shown that assumptions regarding the 4^{th} moment relative to the square of the variance, kurtosis, predict less extreme results than what has been empirically observed (Rachev – Menn – Fabozzi 2005). Extreme outcomes have a low probability of occurrence but have severe effects once they happen. This property has been coined in finance as the 'fat-tail' distribution of returns. The significance of this fact brought attention to risk management which prompted the birth of the "at risk" measures (Jorion 2007). The concept was to derive a simple measure of the amount at stake – whether it be value or cash flow – within a specified time frame at a given confidence interval. The origin of "value at risk" models was preceded by the need to capture possible negative outcomes.

Similar concerns arose when a revision of the traditional performance measures was being overviewed. The question was whether standard deviation of returns is a suitable proxy for risk. The very underlying assumptions of the traditional asset pricing models were deemed too strict, and the fact that they did not hold up drew attention to their deficiency. The assumption of normality of returns caused underestimation of the frequency of high returns in both directions. Furthermore, too large positive returns were considered similarly risky as large losses. Unexpected large gains do not cause as much of a disturbance in handling them, which makes their treatment in risk measurement unfair. An asymmetric measurement of return-risk was being called for not long before Rom – Ferguson (1994) of the Pension Research Institute at San Francisco State University coined the phrase of downside risk (DR), thereby insinuating that the measure of variance to model risk is biased. This was corroborated by empirical evidence that supported the view that the standard deviation risk measure and the use of the Sharpe ratio works well in an up-market. Nevertheless, traditional investment performance measures consistent with modern portfolio theory (MPT) fail to capture the risk asymmetry between positive and negative extreme returns. During times of recession, when asset prices are falling and returns are concentrated in the left range of the distribution, the deficiency of the standard deviation-based risk measures becomes especially ailing.

This promoted the use of the newly introduced DR amongst researchers, and foreran the development of the *post-modern portfolio theory* (PMPT). Price – Sortino (1994) were leading researchers to use the new concept in the ratio that became a special case of the Sharpe ratio. In the numerator, instead of looking at excess return above the riskless rate, the Sortino ratio replaces the risk-free return used in the Sharpe version with a benchmark return set by the investment fund and calls it minimal acceptable return (MAR) or the threshold. This is a convenient solution as it allows freedom to set one's own MAR at the level that serves the purpose of one's performance measurement criteria. In the case of pension funds, since we are examining the equity investments in solitude, no comparison is made to the bond market; therefore we set our own benchmark at zero return. The denominator contains DR, a risk measure capturing dispersion in the downside and not penalising returns in the upside. Therefore, downside risk satisfies the need for a tailored risk measure.

A similar measure used in the literature is semi-variance, which is congruent with DR. With similar aims as DR, the two measures coincide when MAR equals the mean. Semi-variance penalises returns below the mean, while DR allows for the arbitrary choice of the benchmark performance.

$$\text{Semi-variance} = \frac{1}{n} * \sum_{r_t < \bar{r}} (\bar{r} - r_t)^2$$

where n is the number of observations (weekly returns) that satisfy the $\mathbf{r_t < \bar{r}}$
r_t is the weekly return in time t

We now move on to the application of this risk measure in the evaluation of the performance of portfolios.

4. PORTFOLIO EVALUATION

There are several pitfalls for applying traditional investment performance evaluation techniques to portfolios that were managed during financial crises when asset prices witness sharp falls. Some of these were presented in the literature review. In this section, we present our results for the simulated optimal investment portfolios, optimised according to modern and post-modern performance measures.

4.1 Portfolio constituents

When carrying out the simulation, we represent each country as a single pension fund. Furthermore, portfolio selection is made once a year at the beginning of each year. The choice of portfolio elements was confined to indices of countries according to the criteria of investibility. This is a mixture of having a suitable investment environment, low regulatory risk, reasonable history of investment culture, developed financial and legal system and sufficient volume of trade to provide adequate liquidity. Taking these criteria into consideration, we choose 5 markets including Hungary. These markets are London, Frankfurt, New York, and Tokyo, represented by the FTSE-100, Deutscher Aktienindex (DAX), Dow Jones Industrial, and the Nikkei indices, respectively.

We assume that investment decisions are made annually, by allocating funds to be invested in equity-type of investments, amongst the above mentioned indices. Reallocation of the portfolios occurs at the beginning of each fiscal year. To analyse the performance of the portfolios, we calculate the annual effective returns of the indices and in case of foreign currency investments we adjust for the foreign exchange rate effect by creating a hypothetical hedging policy. For hedging, a covered interest rate parity approach is used, according to which the *Libor* (London Interbank Offered Rate) differences in the currencies are added to the returns, assuming that all foreign investments are hedged through forward agreements on a day-by-day basis. Maurer – Valiani (2007) showed the dominance of forward hedge on hedging through put options, however, investigating other hedging possibilities is beyond the scope of this paper. We have chosen forward hedge as it is a simple method to follow.

For the 10 year period examined we assume a domestic investment strategy that is based on the largest market capitalisation and most liquid stocks traded on the Budapest Stock Exchange. These are well-represented by the BUX index, the primary capitalisation-weighted index. We compare the performance of the domestic investment portfolio to the alternative portfolios having the possibility to invest into four other indices as well.

Figure 4 shows the relative performance of the five indices taking the start date 7th January, 1999 as the base. Daily returns are calculated in comparison to the base. We see that all foreign indices remain in the range of –50% to +150%. The BUX index's behaviour is an exception rising four-fold and then halving from the peak. Here, movements are more hectic and volatility exceeds the peers by far.

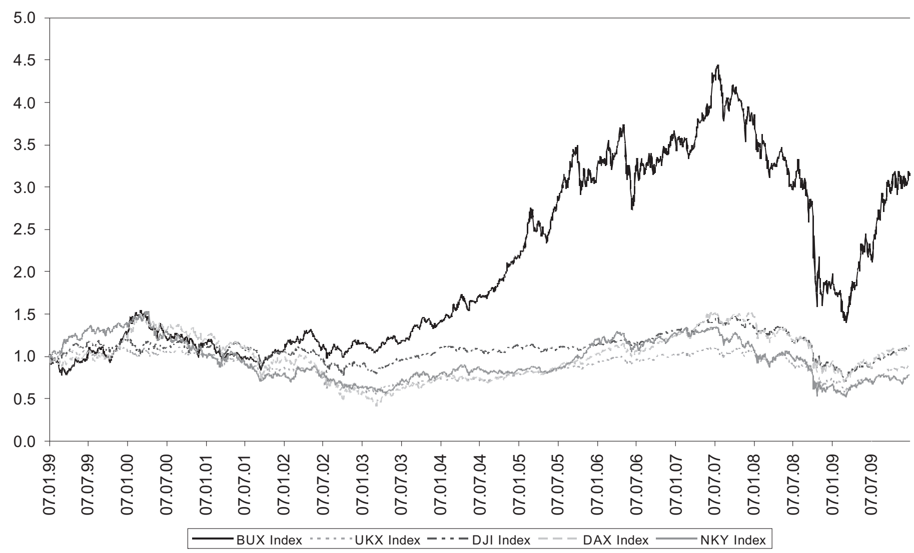

Figure 4. Relative performance of indices (January 1999 – December 2009).

Source: Bloomberg data.

4.2 Short selling

An important aspect of investment policy concerns permitting short selling. The issue is controversial and the literature on the subject is extended. Short selling is a position taken at the vendor side of a transaction, when the undertaker is not in possession of the assets being sold. This problem can be overcome by borrowing the assets from the broker who will guarantee the underlying asset. As a guarantee, the short seller is required to fill up a margin account that maintains a minimum amount sufficient to close the position should the asset price rise to levels that the margin account does not cover. So far, there is nothing peculiar about this.

The eyes of the regulators turned towards another type of short selling, one in which the selling party does not possess the underlying asset, and does not borrow it at the time of the transaction. These *naked short sales* were responsible for allowing the derivatives market to outgrow the underlying assets. Put in simple terms, the number of contracts on derivatives was in excess of the amount of underlying assets during the sub-prime crisis. If all the participants wanted to close-off their positions at the same time, there would have been no sufficient underlying assets to deliver. The infamous Volkswagen case[2] that took place in the autumn 2008 was the practical manifestation of a *short squeeze*. The risks incurred by shorting a stock stems from the asymmetric risks incurred by the long and the short positions. Since the spot price can theoretically increase to infinity; the loss function of the short position can reach infinity. However, the drop in asset price is limited to the current spot price i.e. a stock can be worth zero, in the worst case, but cannot be a liability for those who own it. Therefore, the maximum loss incurred by the holder of long positions is the spot price itself, which is a limited amount. On the contrary, the upside for the long position is unlimited. Despite all the risks, limiting short selling in investment allocations will mathematically lead to only local optimums. Caroenrook – Daouk (2008) showed empirically that allowing short sales improves market efficiency by reducing volatility and increasing liquidity.

The practice of short selling in Hungary was always confined to covered deals, therefore Hungarian funds were never exposed to the risky naked short positions as opposed to the U.S. and Western Europe. However, we were still able to benefit from this to enhance portfolio optimisation on the long term without taking on excessive risks. Currently, regulation in Hungary requires disclosure of opened short positions ever since a mistaken order by a broker caused a price sway during the final years of the crisis. The practice itself, however, is not very efficient as the closure of these short positions does not require reporting to the financial watchdog.

2 The German car-making industry was seen to be coming to a downturn at the beginning of the post-Lehman period, therefore hedge funds mostly had reason to speculate on the short term price fall of automobile stocks. Large short positions were opened on these stocks amongst them the share of Volkswagen (VW). The manufacturer of the Beetle was however spotted as an acquisition target by rival Porsche, which had purchased a sizeable amount of VW shares. When this was announced to the market, investors in the short positions were unable to close their positions due to the lack of liquidity, sufficient supply of the stock on the market, a phenomenon called a short squeeze. The price of VW shot up to EUR 900 within hours of trading and became the single most expensive company world-wide. The DAX index in which VW is a constituent was thrashed to highs as it is a capitalisation-weighted index. In 2008, while the car-manufacturing industry was ailing, Porsche reported (1H 2008/2009) a net profit of EUR 7 bn, mostly driven up by the financial gain on the VW trades, not by car sales (Gregoriou 2011).

4.3 Diversification

International diversification is proxied by four portfolios that are constructed according to different optimisation strategies. These optimal portfolios assume perfect knowledge of the future outcome of the markets. In other words, they represent the highest returns attainable – with respect to the risk factor – that is known with hindsight. Our strategies involve optimising ex-post return versus risk based on the Sharpe and the Sortino ratios; we also handle the question of imposing short selling constraints. The combination of these considerations yielded the four optimal portfolios based on the optimising strategies:

- Sortino long only (LO)
- Sortino long/short (L/S)
- Sharpe long only (LO)
- Sharpe long/short (L/S)

In our empirical tests, we measure the performance of these portfolios against the BUX index.

The five indices available for investment were moulded into portfolios using optimisation criteria according to the possibility of short selling and whether we considered risk as the variance of the whole spectrum of possible returns or regarded downside risk as the primary risk measure.

The optimisation problem thus resulted in asset weights to be used in the portfolios. In long/short portfolios, asset weight was limited to –100% of the stock. This constraint is arbitrary, but necessary. As shown by Kondor – Varga-Haszonits (2008) with no limit to the weight of the single indices, and when returns are negative for some assets and positive for others, the ex-post optimal weights will tend toward ± infinity. Applying the constraints results in an optimum along the constraint line; therefore the choice of the limit will determine the optimal weights. Although mathematically restraining, from an economics point of view, the assumption of a given limit is more realistic.

4.4 Optimisation criteria: Sharpe ratio versus Sortino's ratio

The optimisation along the risk-return trade-off is chosen according to two criteria: the Sharpe and the Sortino ratios. Both measure return versus risk, but differ in the definition of risk. Traditionally, the Sharpe ratio was used first as it chronologically preceded the Sortino measure. Sharpe (1966) came up with a ratio to measure excess return per unit of risk. He measured risk with the variability of stock returns, i.e. standard deviation. The Sharpe ratio is defined as:

$$Sharpe = \frac{r_i - r_f}{\sigma_i}$$

where r_i is the weekly return for asset i
r_f is the risk-free rate of return
σ_i is the standard deviation of returns of asset i.

In our adaptation of the Sharpe ratio, we omit the subtraction of the risk-free rate for several reasons. From an economics perspective, we are examining the equity portfolio of pension funds; therefore no benchmark is set against the bond market returns. Also, the performance of the portfolios is measured in the same currency (HUF), so we are neglecting the risk-free rate as we are investigating risky investments, represented by equities. From a technical point of view, the Hungarian government bond yield exceeded those of the stock market during the period of the sub-prime crisis, making the Sharpe ratio not meaningful. Our adaptive Sharpe measure is defined as:

$$adaptive\ Sharpe = \frac{r_i - 0}{\sigma_i}$$

The rationale behind our adaptive measure is to measure nominal return, vis-à-vis the excess mean return above a certain threshold as used by other measurement criteria. We emphasise maintenance in nominal terms by deducting zero, indicating that this is a variation of indicators that incorporate a deduction of a certain threshold (risk-free return in the case of the Sharpe measure, and minimum acceptable return for the Sortino measure).

The shortcoming of the Sharpe ratio is that it cannot be defined for negative returns. For this reason, the Sortino ratio takes return in excess of a threshold set by the fund management and is not linked to the risk-free rate as in the case of the Sharpe ratio. The Sortino measure follows a different interpretation of risk. This risk-adjusted measure penalises variability of returns only those below the threshold. In our case, the threshold is zero. Therefore, the risk measure is replaced by downside risk that considers only negative returns to be risky.

$$Sortino = \frac{r_i - t}{dr},$$

where

$$dr = \sqrt{\frac{1}{n} \sum_{r<MAR} (MAR - r_t)^2}$$

t is the threshold, zero in our case
n is the number of observations (weekly returns) that satisfy $r_t < MAR$
r_t is the weekly return in time *t*
MAR: minimum acceptable return.

5. PORTFOLIO ANALYSIS

Thus, optimal portfolios were created according to four optimisation criteria with posterior knowledge. The annualised returns of the indices were taken into each portfolio according to their respective optimal weight vectors obtained for each year. We maintain portfolio composition for one year and allow reselection at the beginning of the fiscal year. First, we examine the case where foreign exchange risk is controlled by hedging. Second, we examine the case where the currency changes are incorporated in the performance results.

5.1 Performance of portfolios

Figure 5 demonstrates the performance (in returns) of the BUX index against the range of minimum and maximum returns of four selected investment strategies (filled with grey). It can be observed that the performance range is contoured by the BUX returns, indicating that in most of the times the single-index investment is out-performing or under-performing the other portfolios. Such extreme behaviour is what we aim at reducing. We argue that diversification reduces the hectic movements in returns. This benefit is empirically bolstered.

By analysing weekly returns, diversification results in higher returns for all four optimisation cases. The risk-adjusted performance of the diversified portfolios proved to be statistically better in comparison to the BUX index during the examined period *(Table 2)*. The *ex-post* optimal portfolios offered not only a significantly more stable performance – which is trivial by definition – but a higher return level as well.

With regards to the correlation of returns, the BUX index returns' correlation with the diversified portfolios' returns is medium (between 0.52 and 0.68), giving a sound reason for further analysis *(Table 3)*.

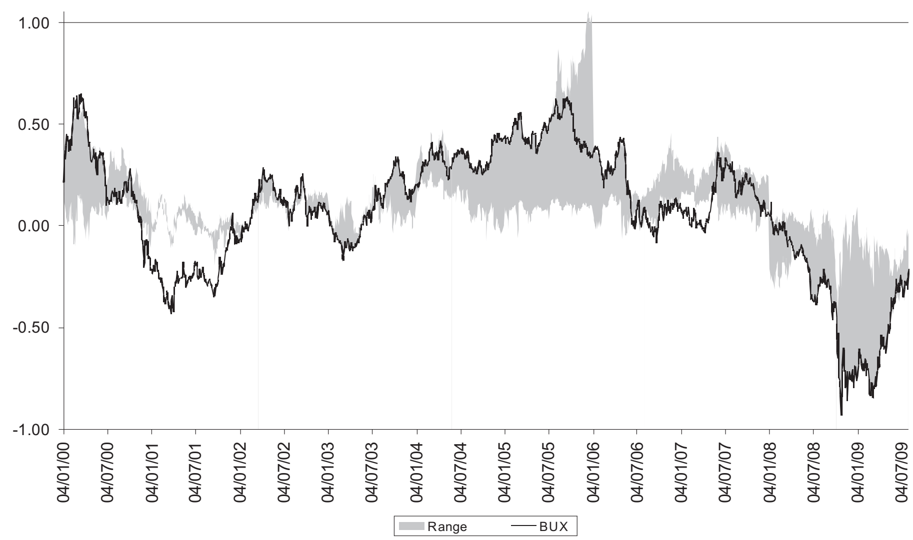

Figure 5. Performance range of model portfolios against the BUX index (annual returns)

Source: Authors' calculation.

Table 2

T-test for equality, p-values[3]

	Sortino LO	Sortino LS	Sharpe LO	Sharpe LS
Hedged average weekly returns against BUX	0.014	0.026	0.021	0.016
Hedged risk-adjusted performance against BUX	0.004	0.001	0.002	0.000
Unhedged average weekly returns against BUX	0.040	0.116	0.044	0.016
Unhedged risk-adjusted performance against BUX	0.008	0.014	0.003	0.001
Hedged risk-adjusted performance against unhedged	0.491	0.039	0.200	0.186

Source: Authors' calculation.

Table 3

Correlation matrix of portfolio returns

	Sortino LO	Sortino LS	Sharpe LO	Sharpe LS	BUX
Sortino LO	1	0.831	0.995	0.863	0.673
Sortino LS	0.831	1	0.833	0.978	0.519
Sharpe LO	0.995	0.833	1	0.869	0.680
Sharpe LS	0.863	0.978	0.869	1	0.595
BUX	0.673	0.519	0.680	0.595	1

Source: Authors' calculation.

3 The null-hypothesis of the test is that the expected values are equal. Low p-values (under 0.05) mean the rejection of H_0.

Our analysis shows that international diversification improves the performance of the investment considered on a risk-return basis. All optimisation strategies resulted in a more stable portfolio performance than investing only in a single market index. The key element of our model was the assumption of full hedging of currency risk, and thereby the elimination of interest rate differentials between the Hungarian forint (HUF) and the other currencies. Unless the foreign currency risk was hedged, the returns on foreign investments would be significantly lower – even negative in many of the cases – than the Hungarian single index investment return. As a consequence, we question the positive effect diversification may have on performance.

We calculated the optimal portfolios according to the four optimisation criteria using the unhedged returns as well. In this case we converted the foreign currency denominated investments at the corresponding exchange rates to HUF. The new optimal portfolios showed similar returns as the hedged ones, except for the Sortino LS optimisation, where the hypothesis of equality cannot be rejected. In all other cases, the unhedged optimal portfolio-returns are significantly higher than the BUX index returns. Adjusting for risk, the performance of the unhedged diversified portfolios exceeded the BUX index in all optimisation cases.[4] The Sharpe/Sortino measures of the unhedged ex-post optimal portfolios are significantly higher than that of the BUX-returns.

Comparing the annual Sortino/Sharpe measures of the unhedged and hedged portfolios the hypothesis of equality cannot be rejected, except for the case of Sortino optimisation that allows short selling *(Table 2)*.

5.2 Portfolio concentration

The optimal portfolios show similar performance for both hedged and unhedged optimisation, but have differing compositions. We examined the portfolio weights according to two aspects: the relative value of the BUX index and concentration. The weight of the BUX index in the optimal portfolios is 58% higher on average, if the returns are not hedged. During the examined period the high interest rate difference in favour of the HUF came hand in hand with a stable performance of the foreign currencies: this implies that the purchasing power parity did not hold up. As the exchange rate depreciation stayed below the level anticipated by the covered interest rate parity, the benefit of diversification was smaller without hedging the exchange rate *(Table 4)*.

4 By definition, if correlations are less than perfectly positive.

Table 4

Comparing the composition of hedged and unhedged optimal portfolios

	Hedged portfolios, %	Unhedged portfolios, %	Hedged portfolios versus unhedged portfolios, p-values
Weight of BUX index	25	38	0.00
Average of HI-indices	79	80	0.36

Source: Authors' calculation.

In order to examine the effect of hedging on the concentration of the optimal portfolio weights we calculated the Herfindahl-indices (HI) for each year. As the HI index can be interpreted for positive values, we compared the index values of hedged and unhedged optimal portfolios using Sortino and Sharpe optimisation without short selling to avoid negative figures. The values of the HI were very high in most of the cases, and during several years the portfolios were composed of a single index, given the short sale constraint. According to *Table 6,* hedging, on the other hand, did not affect the level of concentration. Portfolio weights are shown in bar charts in the *Annex*.

5.3 Comparing performance of different realistic strategies

Optimal portfolios are modelled with posterior knowledge with the benefit of hindsight. We create portfolios for pension fund managers based on the knowledge of the yesteryear, that we label *pilot* portfolios. Keeping transaction costs at a minimum, we allow for portfolio element selection once a year at the beginning of that year. We use the optimal weights obtained for a certain year and we apply them in our investment strategy in the following year.

This strategy of using lagged weights for portfolio allocation results in lower returns than that of the BUX index for all optimisation methods, the differences however, are statistically insignificant in all cases *(Table 5)*.

Table 5

Comparing performance of strategies against BUX, p-values

	Sortino LO	Sortino LS	Sharpe LO	Sharpe LS	EW
Hedged pilot and equally weighted portfolios' weekly returns against BUX	0.206*	0.432*	0.203*	0.441*	0.350*
Hedged pilot and equally weighted portfolios' risk adjusted performance against BUX	0.226*	0.406*	0.373*	0.418*	0.238*

Note: Figures with * are statistically insignificant.
Source: Authors' calculation.

Testing the risk-adjusted performance measures of the pilot portfolios shows that portfolio allocation according to the performance of the previous year does not enhance performance *(Table 5)*.

In search for a passive investment strategy that aims at diversification but assigns no significance to index allocation could be an equally-weighted (EW) investment portfolio. This strategy also indicates insignificant differences in performance.

5.4 The effect of short sales constraints

Allowing short sales contributes to finding the optimum, but raises risk, as the loss potential of a short position is theoretically infinite (as shown in 4.2). In order to investigate the benefit of short selling, we compared the performance of the portfolios with and without short sales constraints. The risk-adjusted measures proved to be significantly higher in three cases, but for the pilot portfolio optimisation the long/short portfolios have not exceeded the constrained portfolios' performance *(Table 6)*.

Table 6

T-test for paired sample for equality of risk adjusted performance

	Long only portfolio	Long/short portfolio	p-values
Sortino ratio of hedged portfolios	0.321	0.399	0.014
Sharpe ratio of hedged portfolios	0.182	0.210	0.003
Sortino ratio of unhedged portfolios	0.321	0.306	0.247
Sharpe ratio of unhedged portfolios	0.172	0.197	0.005
Sortino ratio of pilot portfolios	0.125	0.139	0.403
Sharpe ratio of pilot portfolios	0.072	0.086	0.332

Source: Authors' calculation.

6. CONCLUSION

This paper does not concentrate on the problems concerning long term financial sustainability, nor on the demographic challenges. We skipped the choice between defined benefit and defined contribution pension systems, and have not listed arguments on the further increase of consumption or private pension savings as sources of GDP growth.

This paper investigates the effect of the investment policy, whether international diversification and short selling constraints do affect performance, especially in times of crises. The optimal share of riskless investments is beyond the subject matter of this paper. We compared the attributes of a portfolio consisting of Hungarian stocks (represented by the BUX index) with internationally diversified optimal portfolios. By analysing the returns of 5 stock indices (including the BUX) in the period of 1999–2009, we optimised model portfolios based on four performance measurement criteria using the Sortino and Sharpe ratios and both allowing and prohibiting short selling. We found that based on ex-post returns, diversified portfolios ensured higher return and better risk-adjusted performance than the single index investment. Assuming a dynamic perfect forward hedge in investment policy, we examined the effect of hedging on the portfolios' composition. Concentration proved to be independent of hedging policy. In reality, the best allocation is not foreseen; the optimal allocation is based on posterior performance. Using the ex-post best allocation of the yesteryear resulted in similar returns and risk-adjusted performance, as investment into the BUX index only, and so did the equally-weighted portfolios. Therefore, we conclude that without the benefit of hindsight, the use of international diversification becomes questionable especially that the foreign exchange risk aspect cannot be mitigated perfectly by hedging. Another conclusion of this paper is that allowing short sales results in significantly higher risk-adjusted performance (with a minor exception of unhedged Sortino).

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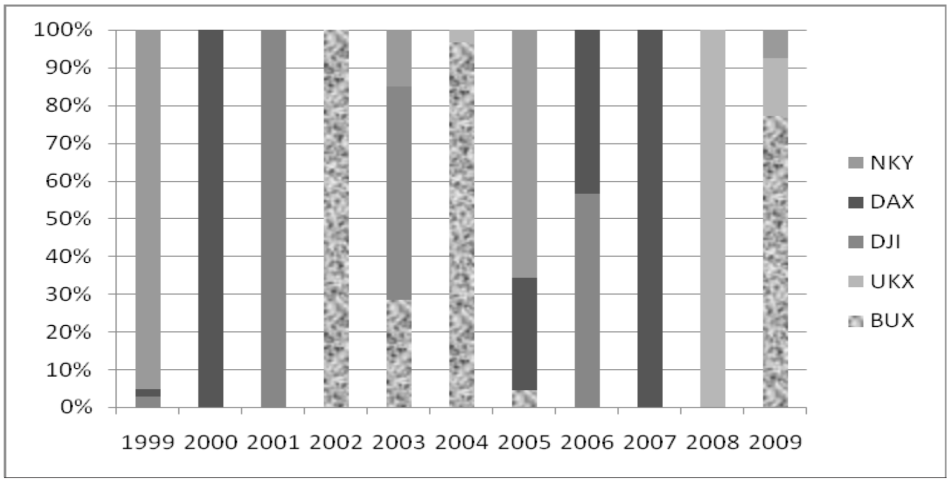
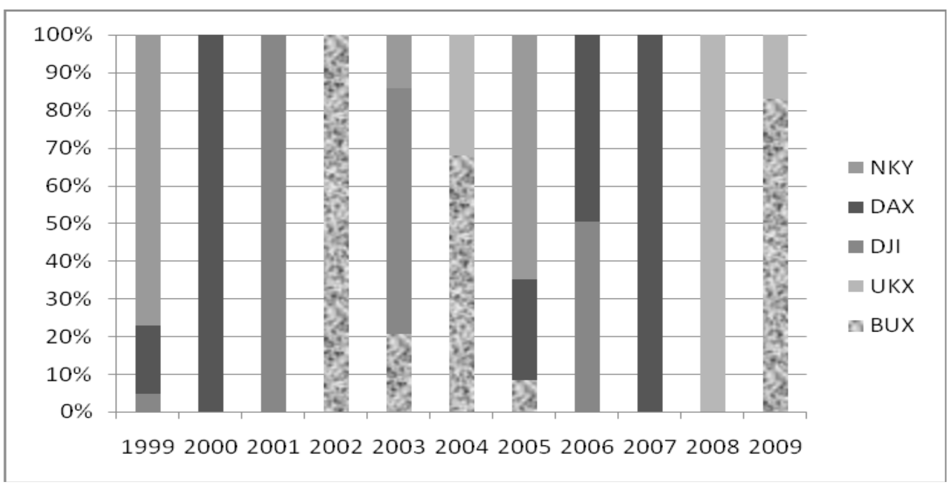
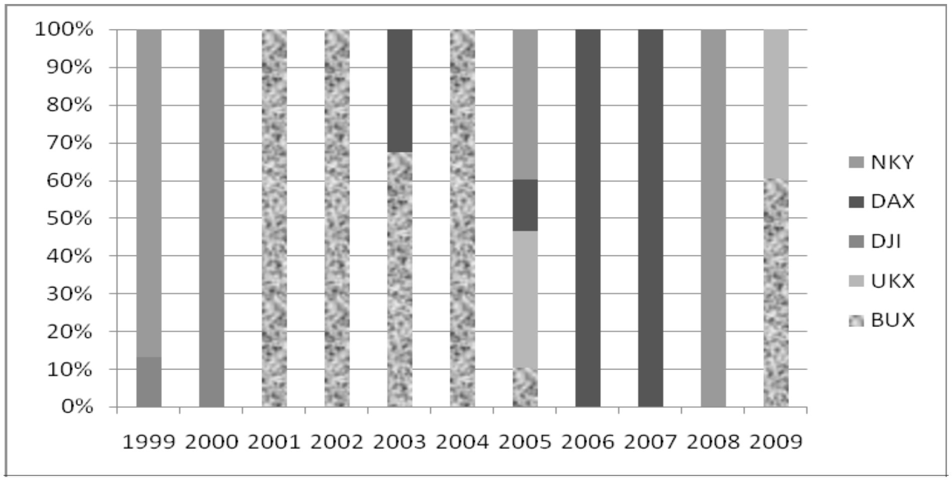
ANNEX



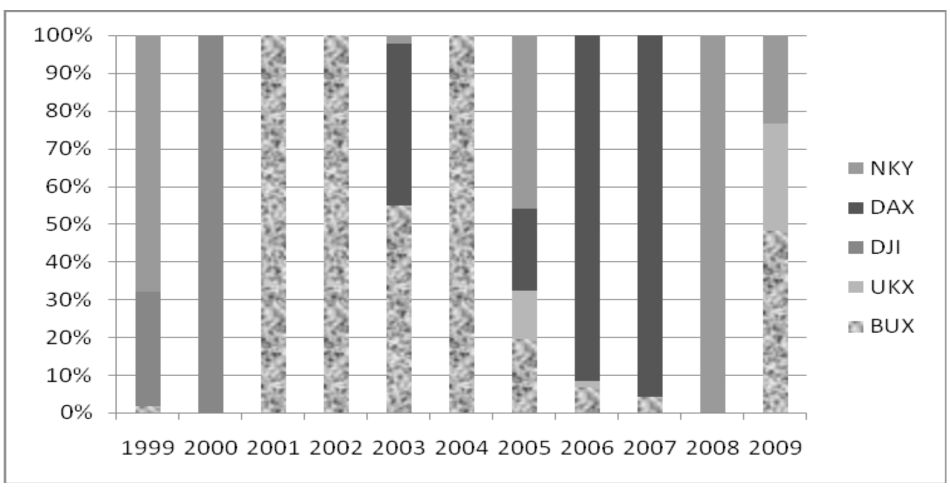
Optimal weights of hedged return, Sortino LO



Optimal weights of hedged return, Sharpe LO



Optimal weights of unhedged return, Sortino LO



Optimal weights of unhedged return, Sharpe LO