CHARLES UNIVERSITY
FACULTY OF SOCIAL SCIENCES
Institute of Economic Studies

The stock market from the perspective of a Czech investor and equity home bias

Bachelor's thesis

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Year of defense: 2024

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Prague, July 31, 2024

Jakub Bachorik

Abstract

This thesis examines equity home bias in the Czech equity market, utilizing the Markowitz portfolio optimization model applied through a rolling window approach on U.S., European, and Czech equity indices. A dynamic cumulative wealth model assessed various investment strategies, revealing that longer window lengths and exchange rate volatility detract from the predictive power of mean-variance optimization. The portfolios of the most successful strategies were mainly composed of the U.S. index, however, in the later years of our dataset, the Czech index gained appreciable importance. This indicates that international diversification and regular portfolio revision has a significant impact on its performance. Survey results from Czech equity investors show that only 14.2% primarily invested in domestic equities. With an average domestic equity weighting of 20% across portfolios, we are unable to detect the presence of a equity home bias in our sample. The preference for U.S. equities suggests that diversity of foreign markets and perceived superior return potential dominate investment choices over local stocks.

JEL Classification	G11, G15, G17, G41, G51, G53
Keywords	equity home bias, portfolio optimization, exchange rate risk, rolling windows

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Abstrakt

Tato práce zkoumá předpojatost k domácímu kapitálu na českém akciovém trhu za použití Markowitzova modelu optimalizace portfolia aplikovaného pomocí přístupu klouzavého okna na americké, evropské a české akciové indexy. Dynamický model kumulativního bohatství posoudil různé investiční strategie, což odhalilo, že vyšší délky oken a volatilita směnného kurzu snižují prediktivní schopnost optimalizačního modelu. Porfolia nejúspěšnějších strategií byla tvořena zejména americkým indexem, avšak v pozdějších letech našeho datasetu získal na významu i český index. To indikuje, že mezinárodní diverzifikace a pravidelná revize portfolia má signifikantní vliv na jeho výkonnost. Výsledky

průzkumu mezi českými akciovými investory ukazují, že pouze 14.2% investovalo převážně do domácích akcií. S průměrným podílem domácích akcií 20% napříč portfolii nejsme schopni detekovat přítomnost předpojatosti k domácímu kapitálu v našem vzorku. Preference amerických akcií naznačuje, že diverzita zahraničních trhů a vnímaný potenciál vyššího výnosu dominují investičním rozhodnutím nad místními akciemi.

Klasifikace JEL	G11, G15, G17, G41, G51, G53
Klíčová slova	předpojatost k domácímu kapitálu, optimizace portfolia, kurzové riziko, klouzavá okna
Název práce	Akciový trh z pohledu českého investora a předpojatost k domácímu kapitálu
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Acknowledgments

The author is grateful especially to Mgr. Petr Polák, M.Sc., Ph.D.for his meaningful comments.
Typeset in FSV LaTeX template with great thanks to prof. Zuzana Havrankova and prof. Tomas Havranek of Institute of Economic Studies, Faculty of Social Sciences, Charles University.

Bibliographic Record
Bachorik, Jakub: *The stock market from the perspective of a Czech investor and equity home bias.* Bachelor's thesis. Charles University, Faculty of Social Sciences, Institute of Economic Studies, Prague. 2024, pages 49. Advisor: Mgr. Petr Polák, M.Sc., Ph.D.

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Chapter 1

Introduction

A variety of factors influence the behavior of a retail investor in constructing their portfolio. Some of these factors are grounded in rational decision-making, such as information costs and institutional barriers, while others are more behavioral, like cultural familiarity or uncertainty avoidance. These aspects may also influence the degree of investors' diversification into foreign markets. If investors show an excessive preference for the domestic market, we consider them to be home biased.

The literature confirms the occurrence of this phenomenon in different countries: in the US, it was French & Poterba (1991) and Lewis (1999); in Sweden, Dahlquist & Robertsson (2001); in Finland, Grinblatt & Keloharju (2001); and in Germany, Oehler *et al.* (2007). Many studies have raised possible explanations, such as transaction costs (Tesar & Werner 1995), currency rate risk, or limited information (Fidora *et al.* 2007)(Ahearne *et al.* 2004). However, more recent research has also focused on behavioral aspects such as geographical or cultural proximity and individuality (Beugelsdijk & Frijns 2010)(Anderson *et al.* 2011). Our paper aims to provide evidence from the Czech Republic and uncover potential motivations of domestic investors for equity home bias.

We employed the rolling window method and mean-variance optimization to model diverse investment strategies and allocations across US, European, and Czech stock markets, which were represented by their benchmark indices: S&P 500 , STOXX 600 and PX. By analyzing the cumulative returns of individual portfolios over time, we measured their performance. This approach enabled us to determine the extent of international diversification benefits for Czech investors. Our findings also contributed to the discussion on the influence of currency exchange rates on investment decisions and answered the question

of how prioritizing recent data impacts the efficiency of mean-variance optimization. To test whether recent observations have greater influence on model predictive ability we analysed the impact of different lengths of time frames, which model uses to generate optimal portfolio weights. The expectation was that by increasing the time windows the impact of short-term shocks would be suppressed, which would improve the efficiency of the model, but at the same time the adjustment to the trend would be slower due to the inclusion of older data, which may result in a missed opportunity.

Moreover, a survey was administered to Czech retail equity investors to help us investigate the degree and possible explanations of equity home bias. Finally, we performed a similar analysis for various industries of the indices to identify which sectors are leading the stock markets.

The thesis is organized as follows: Chapter 2 reviews the existing literature on equity home bias. Chapter 3 outlines the methodology utilized in this study. Chapter 4 details the survey structure and describes the dataset used. Chapter 5 presents and discusses the results obtained from the analysis. Lastly, Chapter 6 provides the conclusion, summarizing the findings and overall contributions of the thesis.

Chapter 2

Literature review

Equity home bias occurs when investors in a particular country hold a disproportionately high percentage of domestic equities, despite the evident losses from not diversifying into foreign equities. The added value of international diversification was studied as early as the end of the 1960s by Herbert Grubel, who used data on the returns of 11 industrialized countries from 1959 to 1966 to demonstrate that U.S. investors are better off holding an efficiently diversified portfolio of international assets than a domestic portfolio alone (Grubel 1968).

Similarly, Levy & Sarnat (1970) employed the Markowitz model to demonstrate that investors could achieve superior risk-return combinations by including international securities in their portfolios. Using Japan as an example, they argued that despite the significant standard deviation with inadequate returns, it is desirable to include Japanese stocks in the portfolio due to their negative correlation with other countries' markets.

French & Poterba (1991) were the first to conceptualize the reluctance to diversify as a behavioral phenomenon. Notably, in 1989, American investors held 93.8% of their portfolios in domestic stocks, Japanese investors 98.1%, and British investors 82%. By modeling the investor utility function, they demonstrated substantial cross-country differences in return expectations, with domestic investors expecting higher returns from their own markets. The study referred to surveys that gathered return expectations from portfolio managers in the US and Japan, reaching similar conclusions (Shiller *et al.* 1991). Tesar & Werner (1995) built on French's model and revealed that although investors' positions in foreign markets were small, they were frequently reallocated. Thus, the high transaction costs associated with trading foreign securities could not

justify the investor bias towards domestic equities. Lewis (1999) also proved the existence of equity home bias using portfolio theory and CAPM and presented possible explanations such as hedging home risks with home equity and diversification costs exceeding the gains.

Research from the early 2000s suggested that this bias is influenced more by behavioral implications than by institutional barriers Fellner & Maciejovsky (2003) and Magi (2009). The role of non-economic factors like patriotism and cultural familiarity in influencing investment decisions is notable, suggesting that psychological and sociocultural elements play significant roles alongside economic factors in shaping portfolio choices (Grinblatt & Keloharju 2001) (Morse & Shive 2011). Fidora *et al.* (2007) provided an interesting linkage between the volatility of currency rates and equity and bond home bias. Apparently, countries with higher exchange rate volatility and emerging economies exhibit a greater preference for domestic investments. Despite globalization, factors like higher information costs and limited information advantages seemed to contribute to the home bias, although these factors alone did not fully explain the phenomenon (Choe *et al.* 2005) (Ahearne *et al.* 2004). Glassman & Riddick (2001) concluded that no single factor fully explains home bias and suggested that a combination of several factors might be necessary.

More recent work showed that equity home bias persists in factors such as uncertainty avoidance, cultural distance, and individualism (Beugelsdijk & Frijns 2010). Countries with high uncertainty avoidance exhibit a stronger home bias, while those with high scores in individualism and masculinity display greater foreign diversification. Furthermore, the findings across these studies suggest that cultural proximity facilitates international investments more than economic indicators alone would predict (Anderson *et al.* 2011) (Mishra & Ratti 2013). This challenges conventional portfolio theories that overlook cultural factors. Another reason for the persistence of equity home bias, despite globalization and the lowering of institutional barriers, may have been the high cross-border comovements of equity markets. The benefits of diversification diminish as market correlation increases, thus even a very small difference in diversification costs rationalizes a very large home bias (Levy & Levy 2014).

Evidence from many countries confirms the presence of equity home bias. Dahlquist & Robertsson (2001) examined it in Sweden with the help of corporate governance. Firms that had stronger corporate governance attracted more foreign investors and reduced equity home bias. Research in Finland showed that investors prefer stocks of companies that are geographically closer, share

the same language, and have similar cultural backgrounds. These preferences highlight the importance of familiarity and informational advantages in shaping investment behavior (Grinblatt & Keloharju 2001). Oehler *et al.* (2007) and Choe *et al.* (2005) provided evidence from Germany and South Korea. Mutual funds from Germany exhibited a Europe bias; European companies were overrepresented compared to Japanese or American ones. However, research dealing specifically with Czech investors is very limited. Báťa & Šmíd (2010) built on the model of Lewis (1999) and measured that the optimal ratio of domestic equities in the portfolio of Czech investor should be within the range of 63-86% depending on the risk aversion. Thus, they were unable to prove the existence of an equity home bias for the Czech market.

Data from the Czech National Bank show that Czech households allocate 70% of their investments in equity/mutual fund shares to assets issued by domestic companies or financial institutions. In contrast, financial institutions hold about half of their equity portfolio in shares issued by non-residents (Czech National Bank 2024). Press releases from the Capital Market Association of the Czech Republic also reveal that domestic funds are twice as popular among Czechs as foreign ones, with equity funds constituting about a quarter of their investments in collective funds (AKAT 2023). Obviously, these funds invest in both domestic and foreign markets; however, the popularity of Czech fund managers may indicate overconfidence in domestic institutions. There was no publicly available data on the exact composition of domestic investors' equity portfolios; the only usable information on the share of domestic and foreign stocks was found in the Patria finance newsletter from May 2023, which stated that their clients' investments were dominated by titles from the United States, with a share of around 60%, and about a quarter of their clients invested in Czech stocks, mostly in CEZ.

Our paper extended previous work in three aspects. First, the model included not only risky assets but also risk-free assets specific to the Czech market. We chose the 2-week REPO rate as the risk-free asset because, although with some lag, it reflects the evolution of bank short-term deposit rates. Second, we tested whether the incorporation of the exchange rate and longer intervals into the Markowitz model had a positive impact on its performance. We proposed a dynamic model for the calculation of cumulative wealth, which models the investment cycle of an average Czech investor over an 18-year horizon and assumes regular long-term investing at an amount equivalent to one-tenth of the average Czech monthly salary. Finally, we constructed a questionnaire

that examined portfolio selection among active equity investors to determine the degree of equity home bias in the Czech Republic.

Chapter 3

Methodology

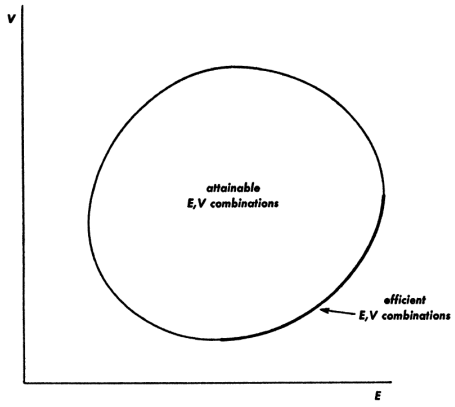
3.1 Assumptions

To ensure the effectiveness of our approach, we made several assumptions. Firstly, we assumed that the investor bases decisions solely on historical prices and aims to maximize the Sharpe ratio. Investments are made regularly at the beginning of each month, based on the average Czech gross monthly wage for the respective year. Portfolio weights are recalculated annually to mitigate potential transaction costs from frequent asset reallocations. At the start of each year, the portfolio is reviewed, utilizing a subset of data corresponding to the employed window size. Additionally, we introduced a lower bound on portfolio weights to prevent short selling. Other assumptions include no barriers to entering foreign markets, no exchange rate spread, immediate reinvestment of dividends, and disregarding capital income taxation and the investor's level of risk aversion.

3.2 Portfolio contruction

To construct the optimal risk portfolio, we used the well-known portfolio theory of Markowitz (1952), later refined by Sharpe (1964). According to Markowitz's portfolio theory, investors select the so-called optimal investment portfolio, which has the highest expected return among a set of portfolios with the same risk. This implies that for each level of risk, there is exactly one portfolio that achieves the highest expected return. A set of efficient portfolios, known as an efficient frontier, can be constructed from a set of these portfolios with different

values of risk. The investor then chooses from the following portfolios according to their ability to bear risk.



Source: Markowitz (1952).

Sharpe later enhanced the model with the return of a risk-free asset and constructed a capital allocation line, which indicates the investment opportunity set with a risky asset and a risk-free asset in the expected return-standard deviation plane. The objective is to maximize the slope of this line, which determines the ratio between the risk premium and the standard deviation of the returns of the risky asset. This measure is referred to as the Sharpe ratio. Given the set of risky portfolios, the Sharpe ratio achieves its peak value when it is tangent to the efficient frontier. The tangent point, therefore, represents the optimal risk portfolio, which according to theory every investor should hold.

To maximize the Sharpe ratio, we solved the following optimization problem:

$$\max_{w_i} S_p = \frac{E(r_p) - r_f}{\sigma_p}$$

where expected return and variance of the portfolio are calculated as follows

$$E(r_p) = \sum_{i=1}^{n} w_i E(r_i)$$

$$\sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \mathrm{Cov}(r_i, r_j)$$

$$\sum_{i=1}^{n} w_i = \langle 0, 1 \rangle$$

Logarithmic returns were used when performing portfolio optimization $r_t = \ln p_t - \ln p_{t-1}$.

Since we imposed boundary on weights, SLSQP method was used to solve

the equation. Sequential Least Squares Programming is numerical optimization technique suitable for solving nonlinear optimization problems with any combination of bounds and equality constraints (Kraft & Dieter 1988).

We utilized a rolling window approach to derive the time series of weights. This approach involves repeatedly applying a statistical or econometric model to consecutive subsets (windows) of a dataset over time to understand the dynamics and improve the predictability of the model under different conditions. In the context of portfolio optimization, we used a window of a fixed size—defined by a specific time period—that moved through the dataset from the beginning to the end. We repeated this method 7 times for different window sizes variing from 3 to 8 years to obtain sets of optimal weights. The last size of the window was 18 years, which represented our full dataset. The idea behind the application of this procedure was to test whether older observatoins improve the predict capability of the model.

3.3 Wealth Calculation Model

We present a dynamic model for the calculation of cumulative wealth, taking into account daily asset returns, periodic wage additions, and changing asset weights over time. The model is structured to update daily, with wage contributions occurring only on the first day of each month.

Let:

- W_t represent the wealth at the end of day t,
- w represent the periodic average czech monthly wage added,
- ω_t represent the vector of asset weights in the portfolio at day t,
- r_t represent the vector of simple asset returns for day t computed by the equation $r_t = \frac{p_t - p_{t-1}}{p_{t-1}}$,
- δ_t be a binary indicator that is 1 on the first day of the month and 0 otherwise.

The wealth at the end of day t is given by:

$$W_t = \left(W_{t-1} + \delta_t \cdot \frac{w_t}{10}\right) \cdot \left(1 + \omega_t^T \cdot r_t\right)$$

This formulation allows for the precise modeling of wealth accumulation in a portfolio that receives periodic contributions and experiences daily returns. The aim of the approach used is not to examine the theoretical yield, but to look at the actual development of potfolios. Simultaneously, the objective is to investigate the possible effects of exchange rate differences, which influence the real returns of the Czech retail investor and are difficult to hedge at a small scale.

It is important to note the discrepancy in return types used in our model. When calculating the weights we decided to use logarithmic returns instead of simple returns. Both methods are often used in financial research, but as Hudson & Gregoriou (2015) pointed out, their results using the same framework are different. The use of logarithmic returns is advantageous when considering returns over multiple periods because the continuously compounded logarithmic return is time additive, meaning that the return over multiple periods is the sum of the returns over a single period. Since we annualized returns when calculating the sharpe ratio, this feature was important to us. However, when calculating total wealth, logarithmic returns are unsatisfactory because they do not fully match the simple returns and the resulst would be deviated.

Chapter 4

Data

4.1 Financial data

All financial data was obtained from Datastream using Refinitive Eikon software. Our dataset spanned 18 years, starting in 2006 and ending in mid-2024. The source for the 2-week REPO rate was the Czech National Bank and for the average Czech monthly salary the Czech Statistical Office.

For our analysis, we selected three indices that most accurately represent the US, European, and Czech equity markets:

- S&P 500: This is a quarterly reviewed, value-weighted index. To be eligible for inclusion, a company must have a market capitalization of at least $8.2 billion, exhibit high liquidity, and have a public float of at least 50% of its outstanding shares. The index aims to maintain sector balance in alignment with the overall market composition.

- STOXX Europe 600: Analogous to the S&P 500, this is a value-weighted and quarterly reviewed index. Inclusion criteria include high market capitalization, trading volume, and liquidity. The index encompasses various sectors across different European countries, ensuring broad market representation.

- PX Index: A value-weighted index comprising the most liquid stocks. Inclusion criteria involve a company's market capitalization and liquidity. Typically consisting of approximately 14-17 companies, it does not fully represent all sectors of the Czech economy.

The S&P 500 sectoral indexes are based on the Global Industry Classification Standard (GICS) and comprise 11 industries: Consumer Discretionary,

Consumer Staples, Energy, Financials, Health Care, Industrials, Information Technology, Materials, Real Estate, Telecommunication Services, and Utilities (S&P 2024). The STOXX Europe 600 Index is divided into 20 Supersectors according to the ICB industry classification. Due to its limited scope, the PX index does not facilitate a sectoral division (STOXX 2024).

It is possible that at certain points, the PX and STOXX indices might have contained the same stock. However, the market capitalization of European companies is multiple times that of Czech companies, therefore the weight of such a company in the STOXX index would be negligible.

Since we assumed that dividends are reinvested, Total Return Indices (TRIs) were used. The calculation of the TRI begins with dividing the dividends paid over time by the divisor, which is used to find the points of the index. This process yields the dividend value per point of the index, as represented by the following equation:

$$D_t = \frac{D}{\psi}$$

where D_t denotes the indexed dividend, D represents the dividend paid, and ψ is the divisor. The next step involves adjusting the price return index for the day by incorporating both the dividend and price change indices:

$$PR_t = \frac{P_t + D_t}{P_{t-1}}$$

Here, PR_t is the adjusted price return index for the day, P_t is today's price return index, D_t is the indexed dividend, and P_{t-1} is the previous day's price return index. Finally, the total return index is determined by applying these adjustments to the price return index, reflecting the complete history of dividend payments. This adjusted value is then multiplied by the previous day's TRI index, as shown below:

$$TRI_t = TRI_{t-1}\left[1 + (PR_t - 1)\right]$$

where TRI_t represents today's total return index, TRI_{t-1} is the previous day's total return index and PR_t is the adjusted price return index.

The rationale behind using Total Return Indices lies in the differing prevalence of dividend stocks between the Czech, European, and US markets. Utilizing classic price indexes would underestimate the Czech equity market, where

dividend-paying companies constitute a significant portion. For simplicity, we assumed that an investor immediately reinvests dividends into the same index.

In our model, we chose the average gross Czech monthly salary as the basis for regular investments. Since we are modelling a Czech investor, this seemed like a good proxy. According to the CNB, the long run average (2012-2019) of saving rate of Czech households is 12%. Therefore we set 10% of the average salary as a regular investment. A summary of the amounts invested can be found in Table 4.1.

Table 4.1: Amounts invested over time

Year	Monthly amount	Total amount
2006	2029	12172
2007	2095	37309
2008	2259	64419
2009	2335	92443
2010	2386	121073
2011	2445	150415
2012	2506	180491
2013	2503	210527
2014	2576	241439
2015	2658	273337
2016	2776	306644
2017	2963	342194
2018	3204	380646
2019	3457	422132
2020	3618	465543
2021	3827	511464
2022	3992	559369
2023	4312	611107
2024	4394	641866

Note: In the last year, there were only 7 investments and in the first only 6 due to the nature of our dataset.

4.2 Questionnare

We constructed a questionnaire to collect data on the diversification preferences of Czech equity investors, which helped us to confirm or refute the hypothesis of the presence of equity home bias. We decided not to distribute the questionnaire among students to achieve an unbiased intergenerational distribution among respondents. The questionnaire was posted to several groups dedicated to Equity Investing and Trading on a well-known social network. We received a sample of 148 respondents with age group distributions of 18-32, 33-46, 47-60, and 60+, which accounted for 41.2%, 46.6%, 11.5%, and 0.7% of the total, respectively. The main questions were related to portfolio allocation across markets and investor sentiment. Following Shiller's example, we asked if stock prices seemed too high, low, or reasonable compared to the actual fundamental or investment value in each market (US, Europe, CZE). The goal of this question is to find out if the investors think the markets are overpriced or underpriced (Shiller *et al.* 1991).

The second part of the questionnaire explored the reasons for domestic or foreign market preferences based on the previous answer. The respondent had the options of Agree, Somewhat Agree, Somewhat Disagree, and Disagree. The investor holding the majority of the portfolio in domestic stocks rated the following statements as the reason for this decision:

- The home environment gives me an information advantage. – Choosing "Agree" supports information asymmetry as an explanation of equity home bias.
- Foreign markets are more volatile. - The investor is risk averse, and finds the domestic market safer.
- Expected appreciation of domestic stocks is higher compared to foreign stocks. – The investor expects domestic stocks to grow faster.
- The expected dividend yield of domestic stocks is higher compared to foreign stocks. – The investor prefers dividend-paying titles.
- Exchange rate volatility increases the risk of foreign investment. – If investors agree, the currency risk is one of the factors for them to be biased towards the domestic market.

- Transaction costs are higher when buying foreign stocks. – Transaction costs were one of the potential explanations for equity home bias, however, as the literature shows, this effect has almost completely disappeared over time.
- Domestic equities are a hedge against domestic inflation. – This exposure arises from deviations from purchasing power parity. However, Cooper & Kaplanis (1994) rejected this as an explanation for home bias.
- Domestic companies are more trustworthy. – This statement relies on information asymmetry and social identity as possible explanations for home equity bias. (Fellner & Maciejovsky 2003)

For the investor with the largest share of foreign shares, the proposition was as follows:

- The expected appreciation of foreign stocks is higher compared to domestic stocks.
- The expected dividend yield of foreign stocks is higher compared to domestic stocks.
- There is low liquidity in the domestic market, hence the high spread.
- The range of companies on the domestic market is very limited / Home companies are not representative of the industry I want to invest in.
- I prefer investments in foreign currency.
- Foreign traded companies are more trustworthy.
- The domestic market is too risky.

The last question asked the respondent to select the most interesting sectors from the 11 Global Industry Classification Standard (GICS) industries in terms of investment potential. The purpose of this question was to assess the respondent's choice by comparing it with the mean-variance optimization results.

Chapter 5

Results

5.1 Correlations of indices and optimal portfolio weights

The correlation tables reveal that the PX index is the least correlated with the S&P500 index. This figure ranges between 0.33 and 0.4 in all time periods.

Table 5.1: Correlation Matrices

2006-2012			
Asset	SPX	$STOXX$	PX
SPX	1.00	0.63	0.37
STOXX	0.63	1.00	0.67
PX	0.37	0.67	1.00

2012-2018			
Asset	SPX	$STOXX$	PX
SPX	1.00	0.56	0.33
STOXX	0	1.00	0.60
PX	0	0	1.00

2018-2024			
Asset	SPX	$STOXX$	PX
SPX	1.00	0.61	0.40
STOXX	0	1.00	0.62
PX	0	0	1.00

The lower correlation suggests an opportunity to reduce the overall portfolio

risk by diversifying without necessarily reducing the expected return. Interestingly, the correlations between indices did not show a notable upward trend. However, historical data indicate that towards the end of the last century, the average correlation between the US and European markets was less than 0.4 (Lewis 1999).

Considering the average annual returns and standard deviations, we observed that the European index only occasionally outperformed the others. The standard deviations were very similar for all indices, with the S&P 500 appearing to be the most volatile recently. Notably, the Czech index suffered the most during the great financial crisis, and the S&P 500 experienced the most significant decline in 2022. Simple returns in the currencies of the corresponding indices were used for Figure 5.1 and simple returns of indices denominated in the Czech koruna for Figure 5.2. The main differences in expected returns due to exchange rate differences in the first two years were caused by the steep decline of the Czech crown during the Great Financial Crisis.

Figure 5.1: Properties of returns in index currencies

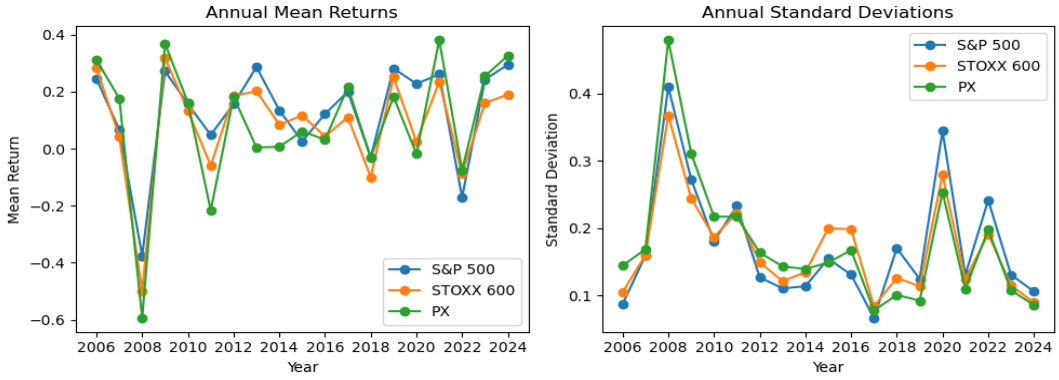
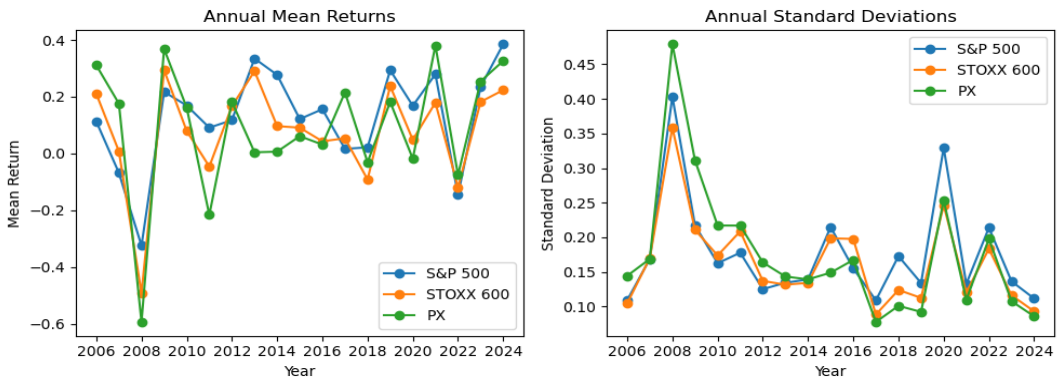


Figure 5.2: Properties of returns denominated in CZK



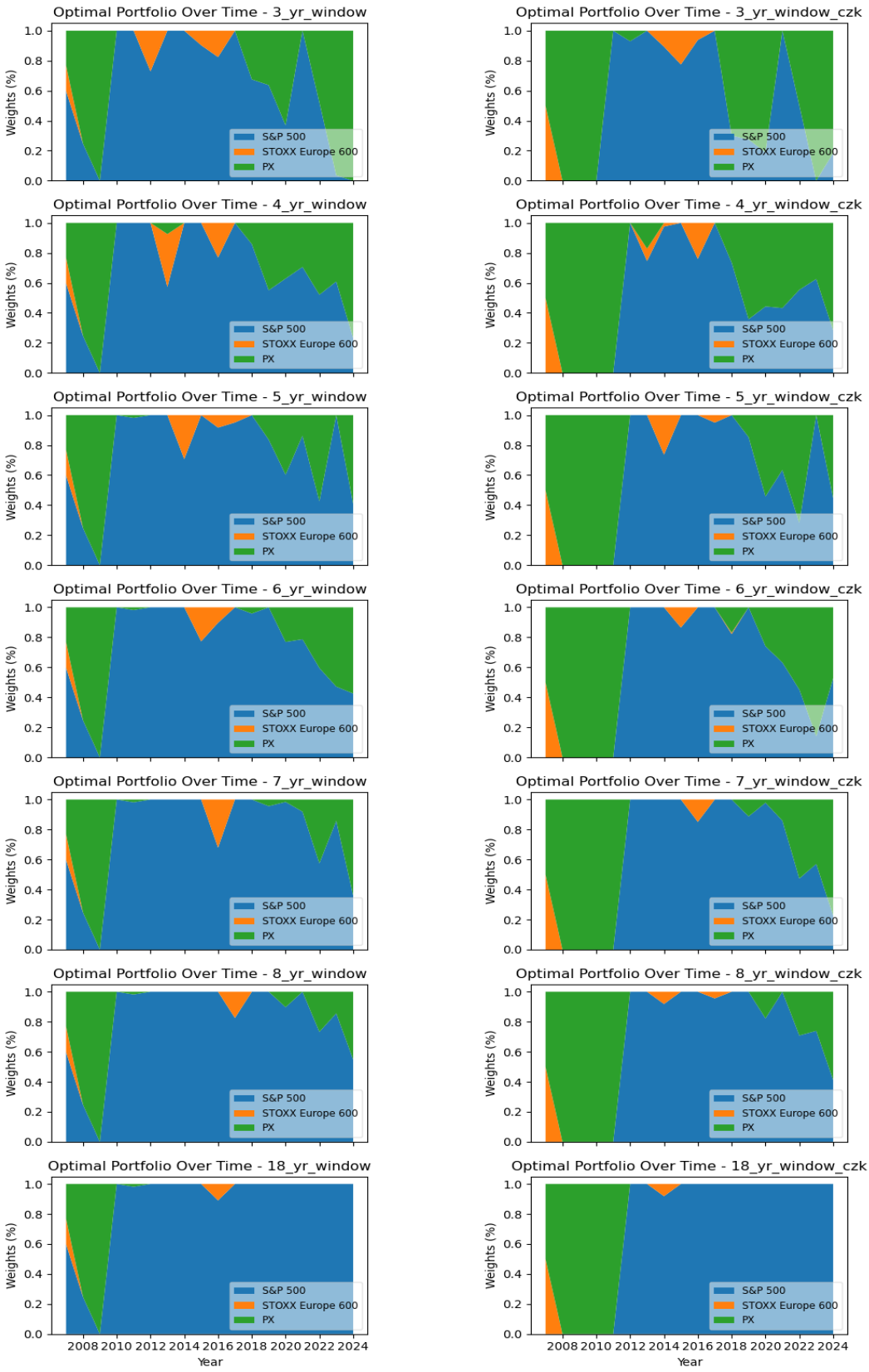
In Appendix A, a comparison of annualized simple mean returns with annualized logarithmic mean returns is shown. Especially with short observation intervals, different return measures are likely to lead to noticeable differences in mean results, although the standard deviation is almost independent of the return type used (Hudson & Gregoriou 2015).

In Figure 5.3, you can see the time series of the optimal weights according to the increasing window. On the left-hand side are graphs of the optimal portfolio layout using returns in the currency of the underlying index and on the right-hand side the same using returns denominated in the Czech koruna. In both cases, logarithmic returns were used. The consequence of the exchange rate volatility can be seen in particular in the representation of the PX index. The increased proportion of the Czech index in the optimal portfolios on the right side may result from three factors: an increase in the mean of the returns, a decrease in the variance of the returns, or a decrease in the correlation between the index returns.

The fact that the exchange rate significantly affected the correlation between the indices can be verified by comparing the correlations in base currencies with those converted in CZK. We observed that the correlation between the PX and the S&P 500 decreased by as much as 14 percentage points between 2006 and 2012 (see Appendix B). This, combined with the significant exchange rate appreciation of the Czech crown between 2006 and 2008, explained the increased proportion of the Prague index in optimal portfolios.

Note that the first three years of the optimization results were the same in all graphs on each side, since the model only had data from July 1, 2006. This may seem like a major disadvantage for an optimal portfolio strategy, but by gradual investments and annual rebalancing, the final deviation was minimized. Further observation revealed that as the window length increased, the proportion of the US index fell in favor of the Czech index towards the end of the observation period.

Figure 5.3: Portfolio weights using returns in index currencies and denominated in czk



5.2 Assessment of different strategies

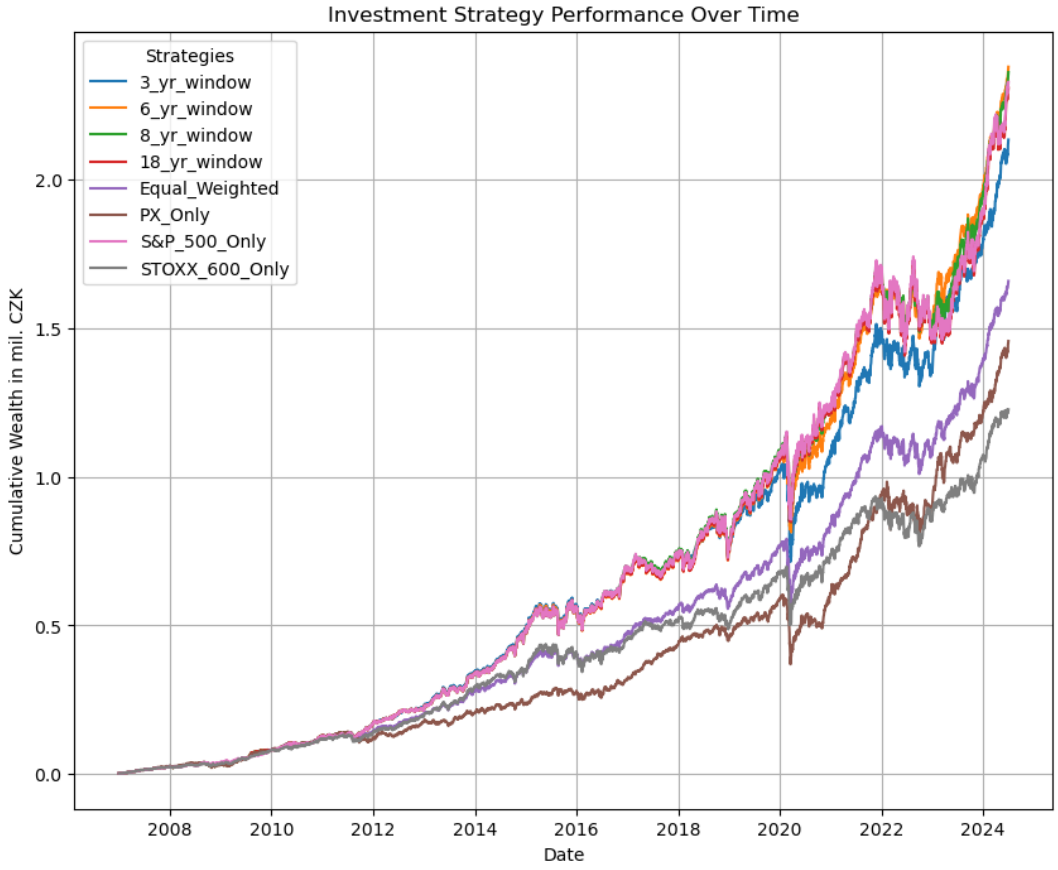
To compare strategies, we constructed a model of the cumulative wealth of the average Czech investor. The basic assumptions were that the investor invests continuously for seventeen years, which includes our entire dataset, always one-tenth of the average Czech monthly salary. We computed the evolution of his wealth for each day from the beginning of 2007 until mid-2024. In addition to the strategies in Figure 5.3 that use mean-variance optimization, we also added four artificially constructed strategies: the PX only, the S&P 500 Only, the STOXX 600 Only, and the Equal-weighted portfolio, which combines all three indices in equal weights.

All strategies that used base currency index returns and medium or large window lengths had similar performance over time, as shown in Figure 5.4. To make the graph easier to read, we omitted the strategies with 4, 5, and 7-year windows and included the 3-year strategy to represent the short window length, the 6 and 8-year strategies to represent the medium window length, and the 18-year full window strategy to represent the long window.

Table 5.2: Annual mean returns of strategies

Period	3 yr	6 yr	8 yr	18 yr	Equal	PX	S&P	STOXX
2007	0.4	0.4	0.4	0.4	4.1	17.6	-6.4	1.2
2008	-52.7	-52.7	-52.7	-52.7	-47.1	-59.4	-32.3	-49.7
2009	37.1	37.1	37.1	37.1	29.2	36.8	21.5	29.1
2010	17.0	17.0	17.0	17.0	13.8	16.1	17.0	8.1
2011	9.1	8.5	8.5	8.5	-5.8	-21.6	9.1	-4.7
2012	13.1	11.8	11.8	11.8	15.6	18.2	11.8	16.8
2013	33.5	33.5	33.5	33.5	21.0	0.4	33.5	29.1
2014	27.7	27.7	27.7	27.7	12.6	0.6	27.7	9.6
2015	11.9	11.5	12.2	12.2	9.1	6.1	12.2	9.1
2016	13.6	14.4	15.6	14.4	7.7	3.1	15.6	4.3
2017	1.7	1.7	2.3	1.7	9.5	21.5	1.7	5.4
2018	0.5	1.9	2.2	2.2	-3.4	-3.1	2.2	-9.2
2019	25.3	29.4	29.4	29.4	23.8	18.2	29.4	23.8
2020	5.0	12.5	14.9	16.8	6.6	-1.8	16.8	4.8
2021	28.0	30.1	28.0	28.0	28.0	38.1	28.0	18.0
2022	-11.2	-11.8	-12.7	-14.6	-11.4	-7.6	-14.6	-11.9
2023	25.4	24.5	23.8	23.5	22.4	25.4	23.5	18.2
2024	32.6	35.1	35.9	38.5	31.2	32.6	38.5	22.3
Full	11.5	12.3	12.4	12.3	8.6	7.2	12.3	6.5

Figure 5.4: Cummulative wealth of strategies in index currencies



It was the 3-year strategy that consistently had the greatest performance, with 1,403 days having the largest wealth, 31% of the entire measurement period. However, this was only between 2013 and 2017, after which it began to experience considerable attrition. The other two short-window strategies (four and five years) were not nearly as successful, recording the highest wealth on only 6% of all days. In contrast, strategies with medium window lengths peaked 28% of the time, especially in the last years of the period when cumulative wealth had started to increase exponentially. The strategy with an 8-year window also had the largest average annual appreciation of 12.4%, as shown in Table 5.2. The only other strategy that experienced long-term prosperity was the S&P 500 Only, having the highest wealth 19% of the time. In contrast, the other artificially created strategies performed very poorly. Hence, it is evident that the main driver of returns is the US index and the other two serve primarily to reduce the variance in the optimal portfolio.

Strategies using index returns denominated in Czech crowns performed significantly worse for all window lengths. As observed in Figure 5.5, none of the optimal portfolio strategies managed to outperform the S&P 500 Only. Also, the average annual yield decreased for medium and long window sizes by more than 1 percentage point as shown in Table 5.3. As the combination of strategies in Figure 5.6 showed us, the inclusion of the exchange rate in the portfolio selection according to mean-variance optimization had a negative effect on model performance. The main cause was inaccurate covariance calculation, which was biased by exchange rate volatility. Our simulations on historical data also revealed that longer intervals do not increase the predictive power of the Markowitz model. The 18-year window strategy did not show any improvement in performance and at no point did it manage to exceed the others in terms of investors' wealth.

Table 5.3: Annual mean returns of CZK strategies

Period	3 yr czk	6 yr czk	8 yr czk	18yr czk
2007	9.4	9.4	9.4	9.4
2008	-59.3	-59.3	-59.3	-59.3
2009	37.1	37.1	37.1	37.1
2010	16.3	16.3	16.3	16.3
2011	9.1	-21.7	-21.7	-21.7
2012	12.2	11.8	11.8	11.8
2013	33.5	33.5	33.5	33.5
2014	25.8	27.7	26.2	26.2
2015	11.5	11.7	12.2	12.2
2016	14.9	15.6	15.6	15.6
2017	1.7	1.7	1.8	1.7
2018	-1.5	1.2	2.2	2.2
2019	21.3	29.4	29.4	29.4
2020	1.7	12.0	13.5	16.8
2021	28.0	31.7	28.0	28.0
2022	-11.1	-10.8	-12.6	-14.6
2023	25.5	25.2	24.0	23.5
2024	33.7	35.8	35.1	38.5
Full	11.0	10.9	10.6	10.7

Figure 5.5: Cummulative wealth of strategies in CZK

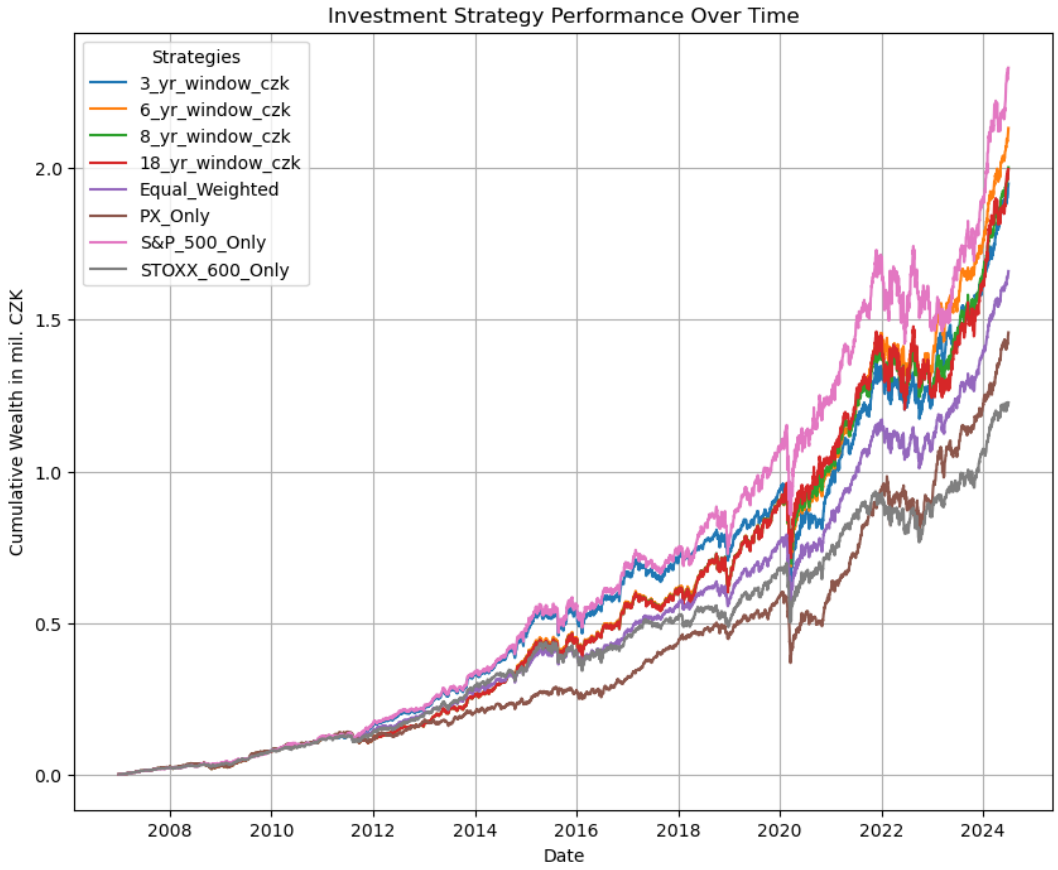
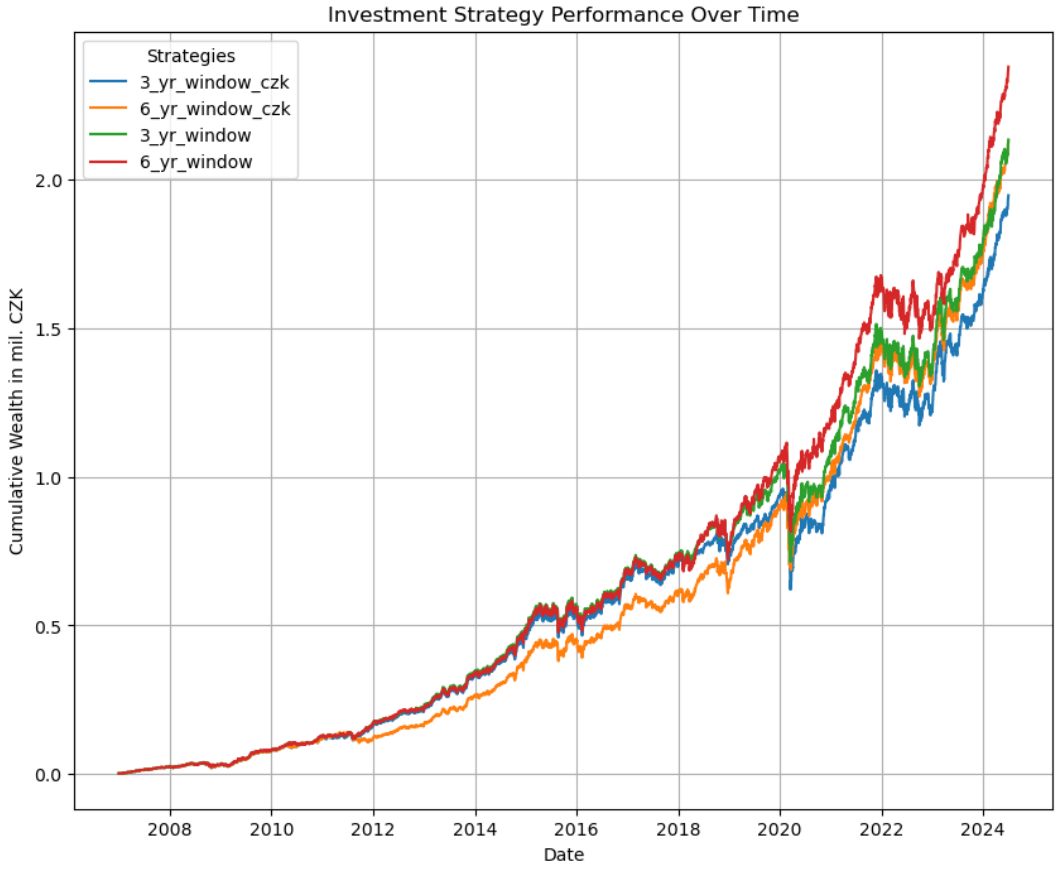


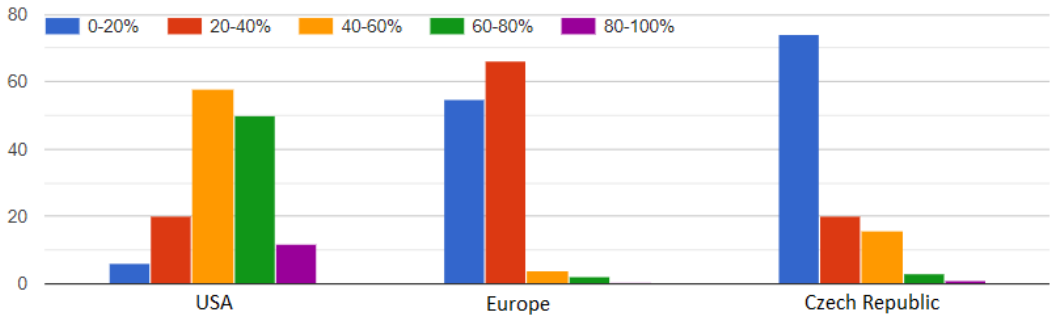
Figure 5.6: Comparison of strategies



5.3 Questionnaire data evaluation

The results of the questionnaire clearly showed that Czech investors prefer the US market. As many as 81.8% of all respondents had US companies as the primary component of their stock portfolio, while only 14.2% invested mainly in Czech stocks. On average, Czechs held 56% of US stocks, 22% of European stocks, and 20% of Czech stocks.

Figure 5.7: Portfolio allocation of respondents



A question on the overpricing of markets yielded interesting results. Almost half of the respondents who had the majority of their portfolio in foreign stocks (over 90% of which were in US stocks) thought that US stock prices were 'too high'. In contrast, Czech and European stocks were considered 'reasonable' by the same group. A paradox has therefore arisen, where investors buy and hold shares that they think are overpriced. Respondents with the majority of their portfolio in Czech stocks expressed similar sentiments; two-thirds thought US stocks were 'too high' and the majority thought European and Czech stocks were 'reasonable' or 'too low'. This conclusion more or less correlates with the findings of Shiller *et al.* (1991), who claimed that US investors see the foreign market as more overpriced than the domestic one, with the difference that his interviewees allocated the vast majority of their portfolio to domestic equities.

As explanations for their preference for the foreign market over the domestic market, most investors agreed with the statements that "The expected appreciation of foreign stocks is higher than domestic stocks" and "The choice of companies in the domestic market is very limited / the companies do not represent the sector I want to invest in". Only 10 blue-chip companies could be traded on the Prague Stock Exchange at the time of the publication of this thesis, hence the narrow scope of the local market was a valid explanation for the foreign market preference. Other reasons for preferring the foreign market

were low liquidity in the domestic market and distrust of domestic companies. 31% percent of respondents agreed and 38% mostly agreed with the statement "Foreign traded companies are more trustworthy". Only a fraction of investors with a majority of their portfolio in Czech stocks agreed with the opposite statement "Domestic traded companies are more trustworthy", and 67% said they disagreed or somewhat disagreed. The main reasons for respondents' preference for the home market were the informational advantage of the home market, dividend yield, and exchange rate risk. 90% of home equity-favoring investors agreed or somewhat agreed with the statement The home environment gives me an informational advantage" and more than two-thirds thought that "Exchange rate volatility increases the risk of foreign investment".

Figure 5.8: Sentiment of foreign equity investors

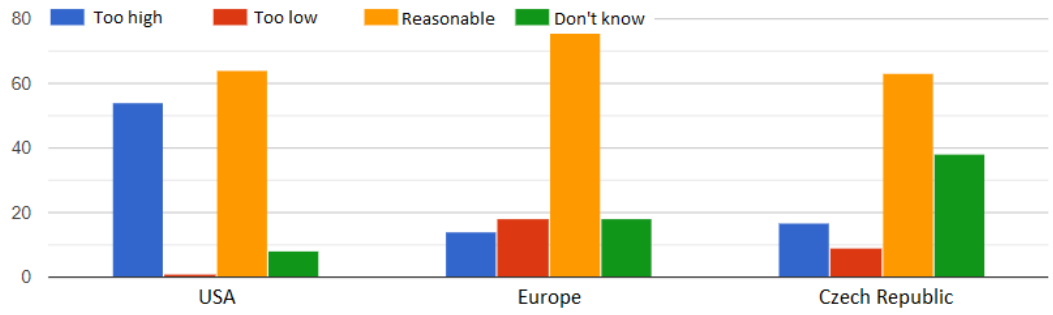
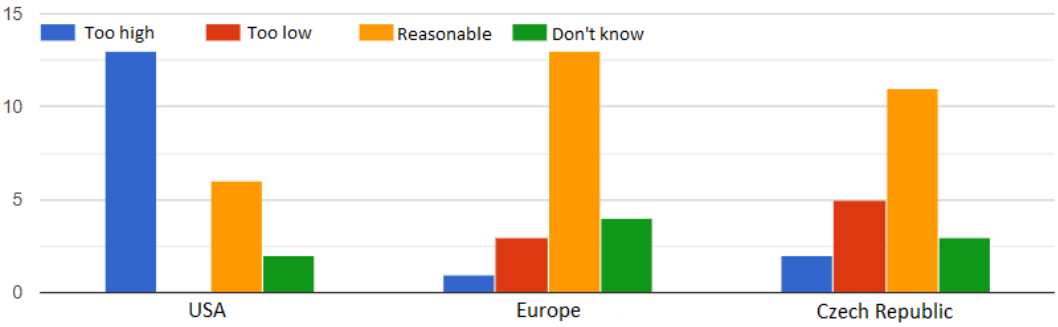


Figure 5.9: Sentiment of home equity investors



Note: The question was formulated as follows: "The stock prices compared to the actual fundamental or investment value in these markets are:"

5.4 Equity Home Bias Examination

The results of the portfolio analysis revealed that the optimal portfolio allocation between the S&P 500, STOXX 600, and PX indices varies significantly depending on the strategy used. Using the cumulative wealth model, we were able to eliminate underperforming strategies, nevertheless, we could not determine the exact optimal portfolio allocation. The weighting of the PX index should be in the range of 0-58% for 2024, with the S&P 500 index accounting for the rest. The mean value of the share of Czech stocks in the portfolio held by the surveyed investors was 20%, therefore we could not confirm the existence of equity home bias in our sample. However, it should be taken into account that our questionnaire was filled out mainly by people actively interested in investing. According to the Household Finance and Consumption Survey (HFCS), only 3.8% of Czechs invested in tradable market shares in 2021 and 6.1% owned a mutual fund. Thus, it is possible that equity home bias is occurring among Czech household investors through mutual funds, but we were not able to ascertain this within the scope of this thesis.

The questionnaire results indicated that the information advantage of the domestic market and exposure to exchange rate risk could be potential explanations for the preference for the domestic market. This is consistent with the findings of Fidora *et al.* (2007) and Choe *et al.* (2005). As confirmed by our portfolio analysis, the incorporation of exchange rate risk contributed to the increase in the share of domestic stocks. In contrast, geographic closeness and cultural proximity proved to be insignificant factors for our group of participants. Only a very small proportion of respondents invested primarily in European companies, and the Czech market was considered 'less trustworthy' by the majority. Some respondents even gave us their reasons in a voluntary open-ended question and expressed their dissatisfaction with the regulatory environment: "High political risk in the CR", "The main reason is Windfalltax and the CEZ lex and the unpredictability of the legal environment in general". Therefore, we concluded that incentives to prefer the foreign stock market over the domestic one are more prevalent in our sample.

5.5 Portfolio analysis of sectoral indicies

We performed the same analysis for each sector of the S&P 500 and STOXX 600 index. Dividing the PX index into sectors did not make sense due to its limited scope, so we included it in its entirety. The classification of the individual industries of the S&P 500 index and the supersectors of the STOXX 600 index can be found in the respective methodology reports (S&P 2024) (STOXX 2024). In Figure 5.10, the evolution of the weights for the 4 main window lengths can be seen. We decided to start the graph in 2010 because the first three years of optimization had the same result for all strategies due to the length of our dataset starting in 2006.

Upon initial inspection, it is clear that the short-window strategy assigns greater importance to short-term trends than the medium- or long-window strategies. The 3-year strategy contained 16 indices over its lifetime since 2010, while the full window strategy contained only 5. As the window size increased, the following indices gained weight: the S&P 500 Consumer staples, which led the first half of the time frame, the STOXX 600 Chemicals, the STOXX 600 Health care, and the S&P 500 Information technology, which has made up the majority of the portfolio in recent years. Also worthy of our attention is the PX index which appeared in the upper right corner of the charts of the short and medium window strategies. Consistent with portfolio optimization for benchmark indices, the PX took up the largest weightings towards the end of the observation period (see Figure 5.3).

After calculating the cumulative wealth, we found that strategies with a medium window size performed best in the long run. In particular, the six-year strategy consistently outperformed the others from 2020 onwards. The strategy with a three-year window only led between 2017 and 2020, as can be seen in Figure 5.11, after which it started to suffer losses. The full window strategy did not gain an advantage over the others at almost any point during the analysis, but its final wealth is significantly higher than that of the three-year window strategy. This suggests that the long windows are unable to catch the trend early, while the short ones overestimate and create 'bubbles'. Comparing the evolution of wealth with the benchmark indices in Figure 5.4, we observe that up to 2023 the behaviour has been very similar with a slight advantage for market-wide indices. Strategies built on sector indices eventually outperformed the all-market ones, mainly due to the impact of the S&P 500 Informational technologies index.

Figure 5.10: Portfolio weights using sectoral indicies

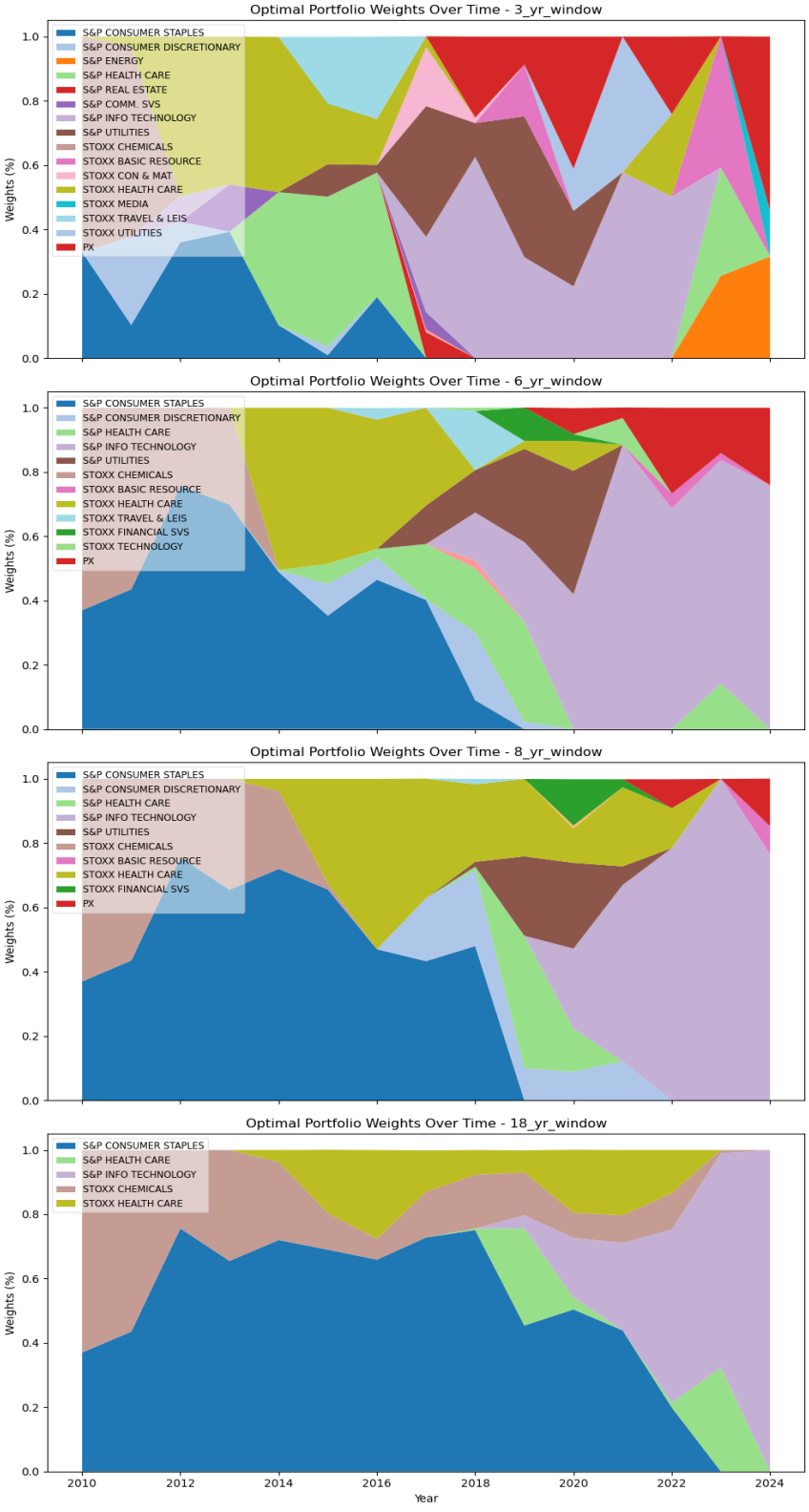
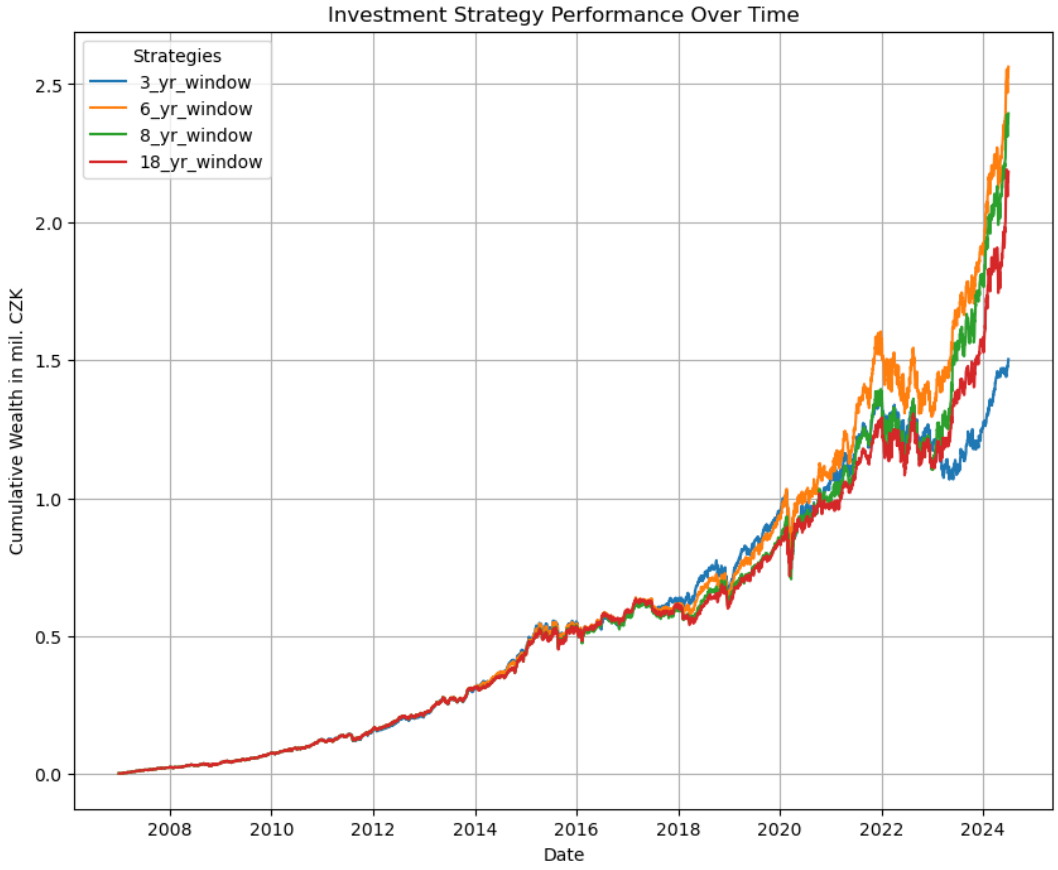


Figure 5.11: Cummulative wealth of sectoral strategies



When we compare our portfolio analysis with the results of the questionnaire, we find that Czech investors are following the information technology trend. As many as 84.3% of respondents said they find this sector interesting in terms of investment potential. Other popular sectors were: financials (64.6%), energy (55.9%), healthcare (46.5%) and real estate (44.9%). At the end of this section, it is important to note that unlike market-wide indices, investors would find it harder to follow our proposed strategy here. However, at the time of writing, exchange traded funds (ETFs) that approximate benchmark indices are already exiting.

Chapter 6

Conclusion

This thesis analyzed the phenomenon of equity home bias with a particular focus on the Czech equity market, using financial modeling and empirical analysis to explore how Czech investors allocate their investments between domestic and international equities. The concept of equity home bias, where investors disproportionately favor domestic equities, poses significant implications for portfolio diversification and risk management.

We applied Markowitz model through a rolling window approach on returns of three equity indicies representing the US, Europe and Czech stock market. With the help of our cumulative wealth model we assesed different portfolio strategies from the point of view of the Czech investor. In an effort to examine the equity home bias and understand its behavioral aspects, we conducted a questionnaire among Czech retail equity investors.

Our main contribution lies in the findings that longer window sizes and exchange rate volatility do not necessarily enhance the predictive power of the mean-variance optimization. In fact, our analysis showed that incorporating exchange rate volatility generally detracts from model performance, contrary to what might be expected. With regard to home equity bias, the portolio optimization indicated that in the long run investors are better off investing outside of their home equity. The portfolios of the most successful strategies over time invested mainly in the S&P 500 and a minor part in the PX index. The significance of the Czech index in the optimal portfolio became evident only in the later years of the examined time interval. The European index proved to be the weakest and the mean-variance optimization included it very infrequently in the optimal portfolio. Hence, a rational and informed investors would invest primarily in foreign stocks, particularly in US ones.

The survey revealed that only 14.2% of respondents primarily invested in Czech equities with an average domestic equity share of 20% across portfolios. Since our portfolio analysis suggested that the reasonable weight of Czech equities could be as high as 58% in 2024, there was no conclusive evidence of a equity home bias among the participants. Our sample of respondents included rather educated investors who are interested in financial markets, however, we can draw the conclusion from this characteristic that a well-informed Czech investor is not biased towards domestic equities due to diversification costs or behavioural factors.

The questionnaire also provided insights into Czech investors' perceptions of domestic versus foreign equities. Despite not viewing domestic stocks as overpriced, there was a marked preference for US equities. Along with the evidence that investors trust domestic companies less, this suggests that Czech investors may be skeptical about the potential of local stocks and that factors such as cultural familiarity or geographical proximity may not significantly influence investment decisions. Instead, the perceived higher quality and return potential of the US stock market appear to dominate investment choices.

Given the constrained scope of the participant sample in our questionnaire, further research could broaden the range of participants or employ longitudinal methods to capture shifts in investor behavior over time. Additionally, investigating the psychological and cultural factors influencing investment decisions could yield deeper insights into why investors do not display a predisposition to bias domestic stocks. Future studies might also explore the home bias among mutual fund managers, which could produce interesting results since most Czechs invest in equities through these funds.

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Appendix A

Difference between return-types used

As shown in the Table A.1 using the PX index as an example, the difference between the variances is almost insignificant when using simple and log returns (only twice it exceeded 4 decimal places). In contrast, the difference between the annualized mean returns is significant, especially for 2008. It can also be observed that the relationship between simple returns and log returns is dependent on the variance of simple returns. The equation can be expressed as follows :

$$\bar{x}_L = \bar{x}_S - 0.5\sigma_S^2 \tag{A.1}$$

Where mean logarithmic return (logarithmic) is $\bar{x}_L$, mean simple return (simple) is $\bar{x}_S$ and simple variance (simple) is σ_S^2.

Table A.1: Mean returns of PX index

Year	Mean	Mean_log	Var	Var_log	$(\bar{x}_S - \bar{x}_L) * 2$
2006	0.311	0.300	0.021	0.021	0.021
2007	0.176	0.162	0.028	0.029	0.029
2008	-0.594	-0.710	0.229	0.232	0.232
2009	0.368	0.320	0.097	0.097	0.097
2010	0.161	0.138	0.047	0.047	0.047
2011	-0.216	-0.240	0.047	0.047	0.047
2012	0.182	0.168	0.027	0.027	0.027
2013	0.004	-0.006	0.021	0.021	0.020
2014	0.006	-0.003	0.019	0.019	0.019
2015	0.061	0.050	0.022	0.022	0.022
2016	0.031	0.017	0.028	0.028	0.028
2017	0.215	0.212	0.006	0.006	0.006
2018	-0.031	-0.036	0.010	0.010	0.010
2019	0.182	0.177	0.009	0.009	0.009
2020	-0.018	-0.051	0.064	0.065	0.065
2021	0.381	0.374	0.012	0.012	0.013
2022	-0.076	-0.095	0.039	0.039	0.039
2023	0.254	0.248	0.012	0.012	0.012
2024	0.326	0.323	0.007	0.007	0.008

Appendix B

Correlation tables

Table B.1: Correlation Matrices for Denominated Returns

	Period 1		
Asset	SPX	$STOXX$	PX
SPXCZK	1.00	0.52	0.23
STOXXCZK	0.52	1.00	0.64
PX	0.23	0.64	1.00

	Period 2		
Asset	SPX	$STOXX$	PX
SPXCZK	1.00	0.59	0.30
STOXXCZK	0.59	1.00	0.59
PX	0.30	0.59	1.00

	Period 3		
Asset	SPX	$STOXX$	PX
SPXCZK	1.00	0.54	0.29
STOXXCZK	0.54	1.00	0.57
PX	0.29	0.57	1.00

Table B.2: Correlation Matrices for Index Currency Returns

2006-2012			
Asset	SPX	$STOXX$	PX
SPX	1.00	0.63	0.37
STOXX	0.63	1.00	0.67
PX	0.37	0.67	1.00

2012-2018			
Asset	SPX	$STOXX$	PX
SPX	1.00	0.56	0.33
STOXX	0	1.00	0.60
PX	0	0	1.00

2018-2024			
Asset	SPX	$STOXX$	PX
SPX	1.00	0.61	0.40
STOXX	0	1.00	0.62
PX	0	0	1.00