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Long-Term Diversification Benefits Across Global Industries

An Empirical Analysis of International Return Correlations

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Abstract

This thesis contributes to the field of global capital allocations by examining the benefits of portfolio diversification across global equites, government bonds and industries for long-horizon investors over time. We use a vector autoregressive (VAR) model and a log-linear asset pricing framework to decompose global asset return correlations into cross-country correlation of cash flow shocks and discount rate shocks. Cash flow shocks are empirically shown to have persistent effects on prices, and therefore affect portfolio risk at all investment horizons. Conversely, discount rate shocks are shown to have only a transitory impact on valuations and portfolio risk, implying that it only affects short-horizon investors. We confirm the findings of Viceira and Wang (2018) that global equity portfolio diversification benefits have not declined for long-horizon investors, while investors in global bond markets have experienced a worsening of portfolio diversification benefits at all investment horizons. Our main contribution is to study the evolvement and implications of differences in asset return correlations across ten global equity industries. We find differences between the industries with respect to their impact on global portfolio diversification benefits over time. Consequently, investors may obtain substantial improvements in portfolio risk by investing in certain industries. Our findings thus expand on existing literature that primarily examines the diversification benefits across the market as a whole.

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Contents

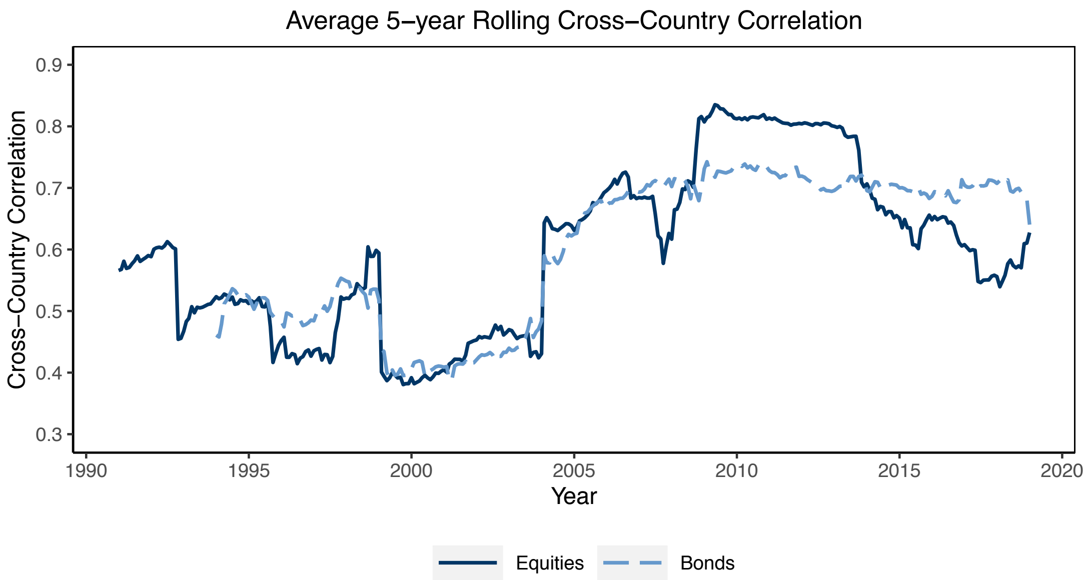
1 Introduction

Extant literature documents that considerable improvements in portfolio risk can be achieved by combining assets that are imperfectly correlated – a concept known as diversification (Markowitz, 1952). Investments dispersed across countries have traditionally provided investors with increased portfolio heterogeneity, reducing unsystematic risk (Grubel, 1968; Levy & Sarnat, 1970). This follows from low average levels of asset return correlations across countries historically.

However, over time, the world's economies have experienced a growing interdependence stemming from escalated cross-border trade, information sharing, the cohesiveness nature of new technologies, policy coordination and capital flows (IMF, 2008). Likewise, over the recent past, global equity and debt return correlations have increased considerably, leading economists and professional investors to question whether the gains from cross-border portfolio diversification benefits have declined (Goetzmann, Li & Rouwenhorst, 2005). We illustrate this phenomenon graphically in Figure 1. Here we plot the correlations of monthly stock and government bond returns across seven highly developed countries that account for approximately 65 percent of global stock market capitalisation (World Bank, 2018).

Figure 1: Average 5-year Rolling Cross-Country Return Correlation

The figure depicts the pairwise average 5-year rolling cross-country monthly USD-hedged return correlation for both equities and bonds across Australia, Canada, France, Germany, Japan, U.K. and the U.S. over the 1989-2018 period.



As shown in Figure 1, there has been a broad rising trend in global stock and government bond return correlations across time. Even though we observe an increase in global return correlations in stocks and bonds, this does not necessarily imply that global diversification benefits have declined for long-horizon investors. As we explain in the next paragraph, this depends on whether the cross-country return correlations have a transitory or persistent effect on asset prices, and hence, returns.

In the first part of this paper, for a confirmation of methodology, we follow Viceira and Wang (2018) and examine differences in cross-country asset return correlation on portfolio risk and global diversification benefits in equities and government bonds over the period 1989-2018. The methodology involves applying a VAR-model on the asset return decomposition framework of Campbell (1991). From this framework, asset prices may change either because of shocks to cash flows or shocks to discount rates. The former is commonly referred to as cash flow news, and the latter as discount rate news. By decomposing asset returns into these components, one may assess international return correlations in terms of correlated cash flow news, correlated discount rate news and the cross-correlation of cash flow news and discount rate news. Empirically, Campbell and Shiller (1988a) show that cash flow news has a persistent effect on valuations and portfolio risk, thus impacting the gains from portfolio diversification across the entire investment horizon. By contrast, the effect of discount rate news on portfolio risk is transitory as its impact on valuations is a declining function of the investment horizon. Yet, on short horizons, both effects should have the same impact on annualised portfolio risk. This highlights why it is important to consider the investors' investment horizon when assessing portfolio diversification benefits.

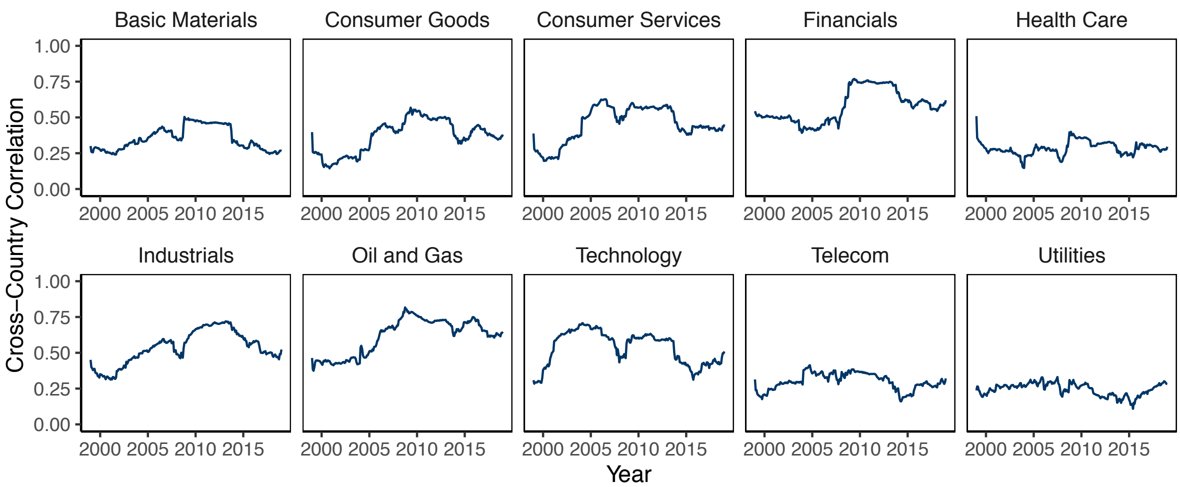
In brief, we obtain very similar results to those reported in Viceira and Wang (2018), with respect to both correlation estimates and statistical conclusions. Our results suggest an economically and statistically significant increase in average cross-country discount rate news correlation for equities over time. From this, we confirm the main finding of Viceira and Wang (2018) that global equity portfolio benefits have indeed declined in the short run. However, as discount rate shocks are shown to only have a transitory effect on valuations, it follows that the diversification benefits have not necessarily declined for long-term equity investors. Furthermore, as with Viceira and Wang (2018), we estimate a statistically significant increase in cross-country correlation of both cash flow news and discount rate news for bonds. Consequently, our results seem to suggest that diversification benefits for global government bond investors have declined independently of the investment horizon. Overall, our results suggest that we have been successful in replicating the work of Viceira and Wang (2018) in assessing the benefits of equity and bond portfolio diversification across countries. Having demonstrated that we are capable of applying the extensive methodology, we proceed to the main contribution of the thesis, which is to study diversification benefits across industries.

One prevailing investment strategy is to base global capital allocations on industries rather than countries. While earlier studies suggest that investors use country selection as a critical factor in decisions related to portfolio construction, other research documents that European asset managers also focus allocation strategies on industries in addition to countries (Isakov & Sonney, 2003). As of 2001, Galati and Tsatsaronis (2003) report that about 75 percent of European equity managers think that portfolio allocations based on industries are superior to those based on countries. Another interesting development is that banks and brokerage firms have reorganised their research departments to being industry-oriented as opposed to being country-oriented (Bolliger, 2004). Based on the above, it is evident that industry professionals assume that industry factors play an important role in strategic portfolio allocations.

Figure 2, which plots the average five-year rolling cross-country return correlations for ten global equity industries, may help to explain the presumption that there exist specific industry factors affecting portfolio characteristics. We observe that the return correlations have evolved rather differently between most of the industries, this may imply varying impacts on diversification benefits over time.

Figure 2: Industry-Specific Average 5-year Rolling Cross-Country Return Correlation

Figure 2 shows the pairwise average 5-year rolling cross-country USD-hedged return correlation within the industries included in our analysis over the period 1994-2018.



Our research question is motivated by this development. While most previous studies mainly focus on the broad equity markets, usually at short horizons, we expand on current literature by examining the case for diversifying across global industries for long-horizon investors. The basis for our research is a hypothesis that various global industries are subject to specific industry factors over time. This should suggest that a given industry's cross-country correlation and, hence, impact on global portfolio diversification benefits should vary over time, both relative to other industries, but also relative to the global equity market.

Motivated by the research question, we examine the cross-country asset return correlations for the ten equity industries defined by the FTSE Industry Classification Benchmark over time. These are Basic Materials, Consumer Goods, Consumer Services, Financials, Health Care, Industrials, Oil & Gas, Technology, Telecom and Utilities. From this, we study the implications for portfolio risk and the benefits from global portfolio diversification within each industry over the 1994-2018 period using the same methodology as before. To our knowledge, this is something that has never been done before.

Our empirical findings suggest that indeed differences exist between the various industries with respect to the development of cross-country cash flow news and discount rate news correlation across time. Moreover, we estimate that the various industries' impact on portfolio risk and global diversification benefits vary substantially.

For the Financials industry, we estimate an increase in average cross-country cash flow news correlation from 0.47 to 0.62, which is both economically and statistically significant. The same holds for the Industrials industry, which experiences an increase from 0.41 to 0.55. As cash flow news correlation has a persistent effect on valuations and portfolio risk, this development suggests that global diversification benefits have deteriorated across all investment horizons. Moreover, for these two industries, we also estimate a statistically significant increase in discount rate news correlation. With respect to the development of global diversification benefits, we obtain the same conclusion for the Oil and Gas industry. However, in contrast, we find that the only source of increased cross-country correlation is related to cash flow shocks.

On the other hand, the Technology industry is the only industry for which we estimate a statistically significant decline of cross-country cash flow news correlation from 0.50 to 0.37 across time. This implies that there has been an improvement in global diversification benefits within the Technology industry for long-horizons investors, which is interesting given the increase in economic integration that have occurred during the sample period.

Perhaps even more interestingly, for the Basic Materials, Consumer Goods, Consumer Services, Health Care, Telecom and Utilities industries, we find no evidence of either increased or decreased cross-country asset return news correlation between the two subperiods. In addition, these industries have, in general, relatively low average cross-country return correlations compared to the other industries in our sample and the global equity market. Thus, this finding suggests that there are distinctive effects among national industries within the same global industry. In other words, we argue that particular industries, to a certain degree, appear to be segmented across countries, which leads investors to obtain substantial diversification benefits from global portfolio diversification.

In summary, our findings show that differences exist across industries in relation to the development of global diversification benefits over time. Thus, in comparison to Viceira and Wang (2018), using the same methodology on the broad equity markets, our findings reveal that there is not a uniform trend among industries. The implications of our findings are that asset managers investing in certain global industries may obtain substantial improvements in portfolio risk, both relative to investing in certain other industries and the global equity market.

The rest of the paper is structured as follows. Chapter 2 contains a literature review. In Chapter 3, we provide a description of the data and its sources. Chapter 4 outlines the methodology and presents the results of the broad equity and bond markets in the period 1989-2018. Chapter 5 covers the development of industry-specific diversification benefits over time. Finally, Chapter 6 concludes the paper.

2 Literature Review

In this section, we present literature and concepts that are closely related to the empirical research conducted in this paper. As our research is focusing on a universe of developed countries, we primarily consider literature focusing on a comparable set of equity and bond markets. Thus, we do not consider any potential diversification benefits that may appear from investing into emerging or frontier markets. However, we recognise that studies have found significant benefits from diversifying into less-developed markets, see, e.g. Li, Sarkar and Wang (2001) for equities, and Fletcher, Paudyal and Santoso (2018) for bonds.

First, we present and discuss the findings of papers analysing the potential benefits from global portfolio diversification of equities and bonds. Second, we consider papers assessing the potential benefits from cross-country industry diversification.

2.1 Global Equity Portfolio Diversification

Although there are several dimensions related to portfolio diversification, a vast body of empirical research has assessed the benefits from global equity portfolio diversification. The early papers of Grubel (1968), using a sample of 11 major stock markets over the period 1959-1966, and Levy and Sarnat (1970) using a sample of 28 countries over the period 1951-1967, document significant benefits from internationally diversified equity portfolios. The benefits arise from the low average return correlations between the international equity markets assessed over time. Similarly, more recent papers of de Santis and Gerard (1997), and Bekaert, Hodrick and Zhang (2009) find that these benefits still exist, despite increased real and financial integration.

In contrast, Goetzmann, Li and Rouwenhorst (2005), using data from the last 150 years, find that global equity return correlations are currently near historical peaks. Thus, they suggest that the gains from international equity portfolio diversification have declined over time, given that the investment opportunity set is held constant. They also show that periods of increased global equity market correlations often appear in periods of increased trade and capital flow liberalisations. These results are also suggested by Quinn and Voth (2007), using a dataset accounting for capital market regulations in a sample of 16 countries over the period 1890-2001.

Despite the upward trend in global equity market correlations, Viceira and Wang (2018) show that the benefits from global equity portfolio diversification have not necessarily declined for long-term investors. As in the papers of Quinn and Voth (2007) and Goetxmann et al. (2005), they find an increase in global equity market correlations over time. However, they suggest that the nature of the increased correlation is transitory, as the correlation of global equity fundamentals driving long-run correlations of returns has remained steady over time. Consequently, the benefits from global equity portfolio diversification should not have declined for long-term investors.

As with the findings of Viceira and Wang (2018), the results of our empirical research suggest that there has not been any significant increase in the correlation of global equity fundamentals from the 1989-2003 period to the 2004-2018 period. Hence, from the perspective of long-horizon investors, we find no evidence of reduced benefits from global equity portfolio diversification. Yet we do find a significant increase in short-term global equity return correlations between the two subperiods. Our results thus seem to indicate that the benefits from internationally diversified equity portfolios have declined in a short-term perspective, confirming the findings of Goetzmann et al. (2005), Quinn and Voth (2007), and Viceira and Wang (2018).

2.2 Global Bond Portfolio Diversification

While most studies which focus on global equity diversification generally document economically and statistically significant gains, there is a greater degree of disagreement as to whether this also applies to bonds.

Levy and Lerman (1988) show that low correlations across international bond markets in the period 1960-1980 allowed for significant gains from global bond portfolio diversification. Taking the standpoint of a U.S. investor, they document that a global bond portfolio, for the same level of risk, would more than double the mean rate of return compared to a U.S. bond portfolio. Moreover, they suggest that an internationally diversified bond portfolio would dominate an internationally diversified stock portfolio during the sample period. Yet, given the apparent benefits of holding a globally diversified bond portfolio, it may be surprising that U.S. investors on average were more likely to hold a diversified portfolio of stocks compared to bonds (Tesar & Werner, 1995).

Campbell, Serfaty-de-Medeiros and Viceria (2010) also seem to find benefits from global bond portfolio diversification in a sample of industrialised countries over the period 1975-2005. However, they find that the Euroland bond market is more highly correlated with both the Swiss bond market and the U.S. bond market. Euroland is here defined as a value-weighted average of the stock markets of Germany, France, Italy and the Netherlands. Also, the Canadian bond market is found to be more highly correlated with the U.S. bond market. These results add to the findings of Levy and Lerman (1988), who suggest that bond return correlations are higher between culturally and geographically connected countries. Consequently, international bond portfolio diversification benefits may vary, depending on the origin of the investor.

In contrast to the global diversification benefits reported in the papers presented above, other papers seem to offer a wider range of views on the existence of benefits from international bond diversification.

Using a mean-variance intersection and spanning test framework, Hansson, Liljeblom and Löflund (2009) find no significant gains from holding a diversified portfolio of government bonds. Their results are obtained using a sample of 11 developed markets over the period 1997-2006 and hold regardless of the investors' country of origin. Paudyal and Santoso (2018), on the other hand, find significant benefits from diversifying a portfolio of government bonds issued from the G7 countries over the 1986-2016 period. Contrary to Hansson et al. (2004), the results are obtained using a Bayesian approach, as suggested in Wang (1998).

Our results indicate an economically and statistically significant increase in international bond return correlations between the 1989-2003 period and the 2004-2018 period. This is also suggested in Viceira and Wang (2018), thus indicating that the benefits of holding a diversified bond portfolio have declined over time for both short and long-term investors. Nevertheless, our findings suggest that low improvements in portfolio risk are achieved by holding a globally diversified bond portfolio.

2.3 Cross-Country Industry Relationships in Equity Returns

Solnik (1974) suggests in his seminal paper on the gains from international diversification that cross-country diversification provides greater risk reduction than diversification across industries. This finding has traditionally led asset managers to base their allocation strategies on geographical areas rather than industries (Cavaglia, Brightman, & Aked, 2000). Moreover, Baca, Garbe and Weiss (2000) argue that industries are rarely viewed as a means of controlling risk in a global portfolio.

Since the discoveries of Solnik (1974), developed countries have experienced an accelerated increase in the cross-country integration of economic and monetary policy coordination. Consequently, the gains from diversifying across countries should have diminished, as increased cross-country integration are associated with a rise in cross-country return correlations (Beckers, Connor, & Curds, 1996). Despite the increased integration among developed countries, Cavaglia et al. (2000) document that industry return correlations across countries have remained stable. In their study of 21 developed equity markets over the period 1986-1999, they document that cross-country diversification benefits were superior to those from diversifying across industries during the period 1986-1994. However, during the period 1994-1999, international industry diversification provided greater reductions in risk than diversification across countries. Most benefits, however, stemmed from diversification across both industries and countries. This is also suggested by Baca, et al. (2000), using a sample of seven developed countries over the period 1979-1999. We find that that the evolvement of cross-country industry return correlations varies over time between industries, thereby contradicting the findings of Cavaglia et al. (2000) that industry return correlations across countries have remained stable.

Lessard (1974) suggests that industrial structures are non-homogenous across countries, which implies that diversification benefits should appear by investing across industries in different countries. This is also suggested by Varotto (2005), who argues that distinctive effects among national industries exist within the same global industry. Hence, there should be no reason why, for instance, systematic risk factors that apply to the U.S. Telecom industry should also apply to the Telecom industry in Canada, Japan or any other country. Therefore, despite increased economic and policy integration across developed countries, it is possible for industries, to a certain degree, to remain segmented across countries. Our results add to these suggestions. While we find increased short-term cross-country return correlation among some industries, this is indeed not the general trend. We further elaborate on these findings in Chapter 5.

In the next chapter, we present the data used in our analysis along with descriptive statistics that provide an overview of the data and further motivate the research topic.

3 Data

In this chapter, we present the data included in the VAR-model underlying our empirical research. Section 3.1 provides an extensive description of all data used in the paper. Section 3.2 describes the transformation techniques applied to the data in order to ensure compatibility with the estimation methods we utilise. Finally, we provide some descriptive statistics of the data sample. The data used in the global stock and bond analysis are obtained for the period Jan 1989 to Dec 2018. Further, for the industry estimations, we obtain data for the period Jan 1994 to Dec 2018. For the broad stock and debt markets, we define two subperiods. The first ranges from Jan 1989 to Dec 2003 and the second from Jan 2004 to Dec 2018. Similarly, for the industries, subperiod one ranges from Jan 1994 to Jun 2005, and subperiod two ranges from Jul 2005 to Dec 2018.

3.1 Data Description

3.1.1 Country-Specific Equity Returns, Bond Returns, Dividend Yields and Inflation

For all variables in our analysis, we obtain data for Australia, Canada, France, Germany, Japan, U.K. and the U.S. All data obtained on equity and bond returns, as well as dividend yields and inflation rates, are obtained from Datastream.

For equities, we measure monthly country level stock returns as the local currency returns on the MSCI total return index for each country in our sample. The total return index incorporates dividends, interest and other distributions to investors (Refinitiv, 2017). Monthly country level dividend yields are obtained from FTSE equity indices for each country. Ideally, we would have obtained total returns and dividend yields using the same equity index. However, we use the MSCI total return index, as opposed to the FTSE total return index, as it enables us to obtain four more years of monthly data for each country. Due to limitations in the availability of dividend yields for the various MSCI indices, we obtain dividend yields from FTSE equity indices for each country in our sample. This should, however, not cause any inconsistencies in the estimation results as the MSCI and FTSE equity indices are close to being perfectly correlated for each of the countries in our analysis.

For bonds, we obtain monthly country level returns as the local currency returns on a 10-year government bond index for each country. The bond indices we use are benchmark indices created and issued by Datastream.

Finally, we also obtain annualised monthly inflation rates for each country in our sample from Datastream.

Table 8 in Appendix section 8.1 summarises the Datastream tickers used to obtain country level data on the return indices, dividend yields and inflation rates.

3.1.2 Industry-Specific Returns and Dividend Yields

For the industry analysis, we use the FTSE Industry Classification Benchmark Index (FTSE Russel, 2019) to segregate various countries' equity markets into well-defined industries. The Industry Classification Benchmark is a globally utilised standard used to categorise companies into various industries and sectors. Thus, it allows investors to compare the performance of various industries across countries over time. The specific industries included in the analysis are Basic Materials, Consumer Goods, Consumer Services, Financials, Health Care, Industrials, Oil & Gas, Technology, Telecom and Utilities. For all industries, we collect data for the countries of Australia, Canada, France, Germany, Japan, U.K. and the U.S. We obtain monthly data on total returns and dividend yields for the various industries across the various countries in our sample from Datastream. Table 9 in Appendix section 8.1 summarises the various tickers used, and the Datastream fields.

3.1.3 Short-Term and Long-Term Nominal Interest Rates

We obtain monthly short-term nominal interest rates for the countries in our sample from OECD's database on Main Economic Indicators (OECD Short-term interest rates, 2019). This database includes a wide range of economic data for OECD countries, eurozone countries and a number of non-member economies (OECD Main Economic Indicators, 2019). The short rates are calculated as the daily average of three-month money market rates in the various countries. Based on this, we obtain the monthly averages. The rates thus reflect the rates at which short-term lending and borrowing are executed between financial institutions.

For Japan, we use the average three-month uncollateralised call rate as a measure of the short-term interest rate. From this, we obtain the monthly averages. This interest rate reflects the rate applied on uncollateralised transactions between financial institutions that borrow and lend short-term funds in the call markets (Bank of Japan, 2019). We obtain the data from publicly available statistics published on Bank of Japan's website (Statistics Bank of Japan, 2019).

We use 10-year government bond yields as a representation for long-term nominal interest rates for each country in our sample. Monthly rates are obtained from Datastream, and the various tickers used are listed in Table 10 in Appendix section 8.1.

3.2 Data Processing

In this section, we present all transformation methods applied to the data obtained in order to ensure that the data are compatible with the estimation method we apply. All data transformations applied are in accordance with the work of Viceira and Wang (2018).

First, we require logarithmic returns for equities and bonds in order to help stabilise the variance of the total return indices obtained from Datastream (Hyndman & Athanasopoulos, 2018). Whenever logarithmic returns are presented in the paper, we refer to the natural logarithm. At time *t*, the log-return of an equity and bond index is calculated as follows for country *i* in our sample:

$$r_{i,t} = log\left(\frac{P_{i,t}}{P_{i,t-1}}\right) \tag{1}$$

where $P_{i,t}$ denotes the value of the total return index for country *i* at time *t*. The exact same calculation is applied for the various industry indices.

Moreover, we compute the logarithm of the dividend yield series for all countries in our sample at all time periods. Log dividend yields are also calculated for the various industries in our sample.

Seasonality is documented to be present in time series consisting of inflation rates (Bryan & Cecchetti, 1995). As the data we have obtained on inflation rates are not seasonally adjusted, we calculate monthly differences in order to obtain stationarity in the data-series. Next, we compute the log of the monthly differences.

$$p_{i,t} = log\left((\pi_{i,t} - \pi_{i,t-1}) + 1\right) \quad (2)$$

where $\pi_{i,t}$ denotes the annualised inflation rate for country *i* at time *t*.

For short-term and long-term nominal interest rates, we also require logarithmic rates. In addition, as the data we have obtained on interest rates are annualised, we divide by 12 to ensure that the data are in the same format as the other variables in our research. Consequently, we calculate short and long-rates as:

$$r_{i,t} = \frac{log(1 + NR_{i,t})}{12} \quad (3)$$

where $NR_{i,t}$ denotes the annualised nominal interest rate for country *i* at time *t*.

We use yield spreads as a state variable in our VAR-specification. Following Campbell and Ammer (1991), we define the yield spread as the difference between long-term and short-term yields. Thus, we calculate log yield spreads for each country as the difference between the log of long-term interest rates and the log of short-term interest rates.

$$ys_{i,t} = r_{it}^{long} - r_{it}^{short} \quad (4)$$

where r_{it}^{long} and r_{it}^{short} denote the log of long-term and short-term interest rates for country *i* at time *t* respectively.

3.3 Descriptive Statistics

The purpose of the following section is to provide an overview of the data and give some reasoning as to why we would suspect changes in diversification benefits across time. In addition, we explore how various equity industries have evolved over time relative to the total equity market. Given that some industries have evolved differently from the overall market, it follows that diversification benefits could differ among the various industries.

First, it follows from Table 1 that there has been an increase in the cross-country return correlation for global equities and bonds over the sample period.

Table 1: Cross-Country Return Correlation Between Equities and Bonds

The table displays the average pairwise cross-country correlations between equity and 10-year government bond returns. The entire sample period ranges from 1989 to 2018. Furthermore, Subperiod 1 ranges from 1989 to 2003, and Subperiod 2 ranges from 2004 to 2018.

		Equities	Bonds
1989-2018	Equities	0.54	
	Bonds	-0.02	0.50
1989-2003	Equities	0.46	
	Bonds	0.11	0.40
2004-2018	Equities	0.72	
	Bonds	-0.23	0.70
Difference	Equities	0.26	
	Bonds	-0.34	0.30

As shown in Table 1, both bonds and equities experience large increases in cross-country correlations from subperiod 1 to subperiod 2. A natural conclusion would therefore be that diversification benefits have declined over the last 30 years, all other things being equal. However, our results seem to suggest that such conclusions depend on the investors' investment horizon, as we demonstrate in Chapter 4.

Furthermore, we find it interesting to study how the equity returns across global industries have evolved over time. We report the calculated correlations in Table 2 below.

Table 2: Cross-Country Return Correlation of Equity Industry Sectors

The table displays the average pairwise correlation of equity returns across countries by type of industry. The full sample period ranges from 1994 to 2018. Subperiod 1 ranges from January 1994 to June 2005, and Subperiod 2 ranges from July 2005 to December 2018.

	Basic Materials	Consumer Goods	Consumer Services	Financials	Health Care	Industrials	Oil and Gas	Technology	Telecom	Utilities
1994 - 2018	0.53	0.31	0.41	0.58	0.27	0.51	0.38	0.26	0.29	0.11
1994 - 2005	0.48	0.26	0.37	0.46	0.28	0.45	0.33	0.27	0.29	0.13
2005 - 2018	0.56	0.44	0.51	0.70	0.30	0.64	0.49	0.24	0.32	0.10
Difference	0.08	0.18	0.14	0.23	0.02	0.19	0.16	-0.03	0.03	-0.02

As shown above, approximately half of the industries included in our analysis have experienced a rather large increase in cross-country return correlation over time, which is similar to the global equity market in general. For the other half, on the other hand, the cross-country return correlation has more or less remained at the same level throughout the sample period. Consequently, the statistics seem to suggest that differences exist across industries with regard to how diversification benefits have evolved over time. We examine this question further in Chapter 5.

In our analyses, we mainly consider cross-country return correlations and portfolio risk. Although we do not explicitly examine risk-returns tradeoffs further in the thesis, these are important considerations in any capital allocation decision. Therefore, in order to obtain a more thorough understanding of especially the risk, but also the return properties, we present mean returns, volatilities and Sharpe ratios in Tables 3 and 4. The majority of the countries in our sample have experienced an increase in their respective Sharpe ratios, especially for equities, as shown in Table 3. Notably, the volatility in equity returns seems to have declined for all countries over time. The same appears to hold for most sovereign bond markets. This, in combination with a general increase in most countries' average annual return, implies that investors on average should have experienced higher profits and lower risk in the second half of the sample. Interestingly, both subperiods include periods of crisis, namely the dot-com crash in subperiod 1 and the subprime mortgage crisis in subperiod 2. Nevertheless, the statistics reported in Table 3 suggest that even though portfolio diversification benefits may have diminished over time as a result of increased cross-country return correlation, portfolio risk in total may have declined. We return to this question in Chapter 4 of the paper.

Table 3: Country-Specific Mean Return, Volatility and Sharpe Ratio

The table displays the mean return, volatility and Sharpe ratio annualised from monthly units for both equities and 10-year government bonds across the seven countries in our sample. The returns are USD-hedged by forward contracts, and in excess of the 3-month U.S. T-bill. Subperiod 1 ranges from 1989 to 2003 and Subperiod 2 ranges from 2004 to 2018.

Equities								
		AUS	CAN	FRA	GER	JPN	UK	USA
1989 - 2003	Mean	4.41 %	4.31 %	2.00 %	10.16 %	-9.39 %	4.31 %	6.78 %
	Volatility	13.63 %	15.61 %	23.60 %	31.79 %	20.31 %	15.37 %	14.97 %
	Sharpe Ratio	0.32	0.28	0.08	0.32	-0.46	0.28	0.45
2004 - 2018	Mean	6.31 %	4.88 %	4.87 %	4.30 %	2.57 %	4.67 %	5.93 %
	Volatility	13.06 %	12.70 %	12.71 %	15.48 %	18.15 %	12.78 %	13.77 %
	Sharpe Ratio	0.48	0.38	0.38	0.28	0.14	0.37	0.43

Bonds								
		AUS	CAN	FRA	GER	JPN	UK	USA
1989 - 2003	Mean	6.17 %	4.39 %	4.39 %	2.01 %	0.48 %	4.34 %	2.74 %
	Volatility	7.89 %	7.16 %	8.61 %	7.83 %	6.05 %	7.10 %	6.95 %
	Sharpe Ratio	0.78	0.61	0.51	0.26	0.08	0.61	0.39
2004 - 2018	Mean	4.40 %	3.31 %	3.30 %	3.77 %	0.96 %	4.13 %	2.49 %
	Volatility	6.23 %	5.45 %	5.47 %	5.47 %	3.19 %	6.17 %	7.09 %
	Sharpe Ratio	0.71	0.61	0.60	0.69	0.30	0.67	0.35

When we compare the risk-return figures for the global equity market to the various industry figures reported in Table 4, it becomes apparent that divergent trends exist. While some industries have experienced substantial increases in Sharpe ratios, others have suffered from adverse changes in volatility and mean returns. Yet, by taking into account the fact that there has been a financial shock in each subperiod, we should expect the risk-return ratios to behave differently among the industries. This is because each industry has been affected differently by each of the shocks. For instance, the run-up in returns during the dot-com bubble from 1994 to 2000 may potentially help explain the large increase in Sharpe ratios for the Technology and Telecom industries in subperiod 1. By contrast, the subprime mortgage crisis and the decline in the oil price in 2014, being included in subperiod 2, may help explain the decline in Sharpe ratios for the Financials and Oil and Gas industries respectively. In other words, the fact that industries are subject to specific shocks may suggest that there are differences in diversification benefits across industries over time. Also, it has been shown that correlation between markets increases in periods of distress (Longin & Solnik, 2001). Consequently, the global diversification benefits achieved by investing across industries may deteriorate in times of crisis.

Table 4: Industry-Specific Mean Return, Volatility and Sharpe Ratio

The table displays the mean return, volatility and Sharpe ratio annualised from monthly units for specific industries and averaged over the seven countries in our sample. The returns are USD-hedged by forward contracts, and in excess of the 3-month U.S. T-bill. Subperiod 1 ranges from January 1994 to June 2005 and Subperiod 2 ranges from July 2005 to December 2018.

		Basic Materials	Consumer Goods	Consumer Services	Financials	Health Care	Industrials	Oil and Gas	Technology	Telecom	Utilities
1994 - 2005	Mean	4.35 %	1.61 %	2.70 %	6.77 %	5.71 %	2.67 %	5.90 %	-7.62 %	3.47 %	5.42 %
	Volatility	15.87 %	17.17 %	13.24 %	14.63 %	10.88 %	18.05 %	18.41 %	35.08 %	13.93 %	9.67 %
	Sharpe Ratio	0.27	0.09	0.20	0.46	0.52	0.15	0.32	-0.22	0.25	0.56
2005 - 2018	Mean	1.53 %	7.01 %	5.39 %	0.89 %	5.44 %	5.86 %	-0.11 %	3.21 %	6.08 %	3.18 %
	Volatility	19.74 %	12.95 %	10.74 %	17.75 %	21.28 %	14.87 %	18.19 %	22.56 %	11.11 %	9.57 %
	Sharpe Ratio	0.08	0.54	0.50	0.05	0.26	0.39	-0.01	0.14	0.55	0.33

In summary, the descriptive statistics show a general increase in cross-country correlations of equity and bond returns. By contrast, we observe a more ambiguous pattern for the various industries. Furthermore, we find that the market in general has experienced an improvement in the risk-return tradeoff, while this has not necessarily been the case for all industries in the sample. In total, the descriptive properties of the data suggest that the portfolio diversification benefits across time would differ between specific industries and the broad market. This implies that a more rigorous analysis is necessary to fully understand the properties of changes in portfolio diversification, not only between the broad markets but also between specific industries across countries.

Having described the data, in the next chapter we present the methodology and apply it to the data covering global equities and government bonds.

4 Methodology and Portfolio Diversification Across Global Equity and Bond Markets

In this chapter, we present and discuss the methodology applied as well as the findings and implications of our empirical research conducted on the broad global equity and bond markets. As our empirical approach may be divided into several steps, for each step we first present the methodology and then immediately present our results and the implications as we proceed.

For the first part of our analysis, we follow the methodology of Viceira and Wang (2018) for measuring cross-country correlations of stock and bond returns. The primary objective of this exercise is to prove that we are capable of applying VAR-models on the asset return decomposition framework proposed by Campbell (1991). Nevertheless, the findings presented provide interesting evidence of the benefits from global diversification for long-horizon investors. Besides, the conclusions that we draw from this section create a sound basis for examining the results and implications when we later assess the diversification benefits across global industry sectors in Chapter 5.

The last part of this chapter is devoted to further assessing our estimates of cross-country correlations by forming portfolios and assessing the portfolio risk over time. Moreover, we decompose the portfolio risk into two components, that is, within-country variance and cross-country correlations, following Viceira and Wang (2018). The purpose of this decomposition is to examine the contributions of the two risk-components to total portfolio risk over time.

4.1 Asset Return Decomposition and Estimation of Return Correlations

First, we present the asset return decomposition of Campbell (1991), before we proceed to the model used in the empirical analysis.

In a context of present values, asset prices can be expressed as a function of the cash flows distributed to investors, and the discount rate used to discount the cash flows distributed. As a result, asset prices may change either because of changes to expected future cash flows, or changes to discount rates. Therefore, it follows that unexpected asset returns can be decomposed into changes in expectations of future cash flows, and changes in expectations of future discount rates, as suggested in Campbell and Shiller (1988a) and Campbell (1991). The former is commonly referred to as cash flow news, and the latter as discount rate news. Campbell and Shiller (1988a) show that a log-linearisation of the asset return may be expressed as in the following equation, where $r_{s,t+1}$ denotes the natural log of the gross total return, and Δd_{t+1} denotes the change in the asset's log dividend. Moreover, ρ_s is a log-linearisation parameter around the unconditional mean of the log dividend yield and is close to, but less than, unity.

$$r_{s,t+1} - \mathbb{E}[r_{s,t+1}] = (\mathbb{E}_{t+1} - \mathbb{E}_t) \sum_{j=1}^{\infty} \rho_s{}^j \Delta d_{t+1} - (\mathbb{E}_{t+1} - \mathbb{E}_t) \sum_{j=1}^{\infty} \rho_s{}^j r_{t+1} \qquad (5)$$

$$r_{s,t+1} - \mathbb{E}[r_{s,t+1}] = N_{CF,s,t+1} - N_{DR,S,t+1} \qquad (6)$$

Additionally, one may further decompose the $N_{DR,s,t+1}$ into news about risk premiums ($N_{RP,s,t+1}$) and news about the real rates ($N_{RR,s,t+1}$).

Following the return decomposition framework, international asset return correlations may arise from three different sources, that is, correlated cash flow news, correlated discount rate news, and the cross-correlation between cash flow news and discount rate news. One motivation for analysing global asset return correlations through these components, rather than simply calculating the cross-country return correlation, is that the extent to which the correlations persist may vary depending on the various sources.

As the components of asset return news cannot be observed directly, we apply an asset return generating model to estimate the news components, as proposed by Campbell (1991). This builds on the assumption that the return generating process may be explained by a first order VAR-model. From the residuals of the VAR system, we can estimate structural shocks to the return generating process which have economic interpretations. In other words, revisions to the estimated return forecasts function as proxies for changes in investors' expectations of discount rates and cash flows. We follow Viceira and Wang (2018) and estimate a homoscedastic panel VAR model with demeaned variables.

$$\tilde{z}_{t+1} = A\tilde{z}_t + u_{t+1} \qquad (7)$$

$$\tilde{z}_{t+1} = \left[xr_{s,t+1}, xr_{n,t+1}, d_{t+1} - p_{t+1}, \pi_{t+1}, y_{1,t+1}{}^N, y_{10,t+1}{}^N - y_{1,t+1}{}^N\right]'$$

Here, $\tilde{z}_{t+1}$, is a 6 x 1 state vector containing the variables excess equity return ($xr_{s,t+1}$), excess bond return ($xr_{n,t+1}$), dividend yield ($d_{t+1} - p_{t+1}$), inflation (π_{t+1}), short rates (${y_{1,t+1}}^N$) and yield spread (${y_{10,t+1}}^N - {y_{1,t+1}}^N$). A is a 6 x 6 matrix containing the estimated slope coefficients, and u_{t+1} is a 6 x 1 vector containing the residuals.

It is important to notice that there are a few general concerns when inferring the news components of asset returns through revisions of a return generating model. First, we are seeking to estimate expectations of variables that are realised over very long time periods. For instance, equity prices are the discounted sum of an infinite cash flow series. However, through VAR models, we impute the long-run behaviour of the variables in question from their short-run behaviour. This implies that we are reliant on the VAR model's ability to accurately describe the dynamics of the return process. Campbell (1991) suggests that this assumption seems to hold. Anyway, VAR models are in general considered better at capturing these dynamics than other long-horizon regression models (Hodrick, 1992). One should also note that the number of lags in the VAR model is not restrictive as the model is able to handle higher order of lags. Another potential issue with the estimation process is that there may be information possessed by investors which may affect the return process that is not included in the state vector. For instance, Engsted, Pedersen and Tanggaard (2012) show that the specification of the state vector has implications for the news decompositions. Consequently, in the specification of the state vector, we follow Viceira and Wang (2018) and include variables that are considered as good proxies for capturing the dynamics of the news components.

Following the asset return decomposition framework, we can infer cash flow news, real rate news and risk premium news for equities from the following equations in VAR notation:

$$(\mathbb{E}_{t+1} - \mathbb{E}_t)[xr_{s,t+1}] = e1' \, u_{t+1} \tag{8}$$

$$N_{CF,s,t+1} = (\mathbb{E}_{t+1} - \mathbb{E}_t)[xr_{s,t+1}] + N_{RR,s,t+1} + N_{RP,s,t+1} \tag{9}$$

$$N_{RR,s,t+1} = e5' \left(\sum_{j=1}^{\infty} {\rho_s}^j A^{j-1} \right) u_{t+1} - e4' \left(\sum_{j=0}^{\infty} {\rho_s}^j A^j \right) u_{t+1} \tag{10}$$

$$N_{RPs,t+1} = e1' \left(\sum_{j=1}^{\infty} {\rho_s}^j A^j \right) u_{t+1} \tag{11}$$

Where $e1$ to $e6$ is the column vectors of a 6 x 6 identity matrix which serves the purpose of extracting the i'th element of the state vector. It follows from this decomposition that the risk premium and real rate news are inferred directly from the residual terms, while the cash flow news are backed out as a residual. See section 8.2 in the Appendix for further description.

Similarly, for bonds, we infer the various news components from the following equations:

$$(r_{n,t+1} - \mathbb{E})[xr_{n,t+1}] = e2' \, u_{t+1} \tag{12}$$

$$N_{CF,n,t+1} = -e4' \left(\sum_{j=1}^{n-1} {\rho_b}^j A^j \right) u_{t+1} \tag{13}$$

$$N_{RR,n,t+1} = e5' \left(\sum_{j=1}^{n-1} {\rho_b}^j A^{j-1} \right) u_{t+1} - e4' \left(\sum_{j=1}^{n-1} {\rho_b}^j A^j \right) \tag{14}$$

$$N_{RP,n,t+1} = N_{CF,n,t+1} - N_{RR,n,t+1} - (r_{n,t+1} - \mathbb{E})[xr_{n,t+1}] \tag{15}$$

Contrary to equities, the cash flow news of bonds are estimated directly from the inflation equation of the VAR-system as bonds' real cash flows vary inversely with inflation. This is because we assume that a bond's cash flow is a fixed nominal coupon payment. Consequently, risk premium news are backed out as a residual in the bond news return decomposition.

In our empirical analysis, we start by estimating a homoscedastic panel VAR model with the state variables previously mentioned. We conduct the empirical analysis using the countries of Australia, Canada, France, Germany, Japan, U.K. and the U.S. as proxies for global asset return correlations. Ideally, we would include additional countries in order to make more accurate inference on global portfolio diversification benefits. However, it is worth mentioning that the countries included account for around 65 percent of global market capitalisation and around 45 percent of world GDP, implying that their respective markets should be able to capture the global movements in equity and bond correlations adequately (World Bank, 2018).

Furthermore, as with Viceira and Wang (2018), we apply a currency independent approach in the return specification of the VAR model. This is based on an assumption that covered interest rate parity holds (see section 8.5 in the Appendix). We recognise that this may have practical implications for the correlation estimates as empirical studies have documented deviations from covered interest rate parity after the global financial crisis of 2008 (Cerutti, Obstfeld, & Zhou, 2019). An alternative approach could therefore be to hedge the currency risk through forward contracts, however, this requires that we take the standpoint of a specific investor origin.

Furthermore, our specification of the VAR model implies that the slope coefficient matrix, A, is fixed across all countries. Ideally, we would have estimated a larger VAR model with individual country variables, in order to control for differences in the return generating process across countries. However, such a model would consist of 42 parameters (six state variables and seven countries), which would induce estimation problems due to overparameterisation. An alternative approach for conducting the analysis would be to estimate country-specific VAR models. Yet, this implies that we would have to average across various VAR models which may introduce additional estimation uncertainty. Therefore, we choose to stack the observations and estimate a pooled VAR model with demeaned variables. This allows us to use as much time-series and cross-country information as possible. Nevertheless, as a robustness check, we have also estimated country-specific VAR models which do not appear to cause any large differences in slope coefficients compared to the pooled specification of the model.[1]

Finally, we extract country-specific vectors of news components based on the vector of residuals estimated by the VAR model. Our full sample ranges from January 1989 to December 2018, which is the largest time interval for which we have data on all state variables for the various countries. We then split the vector of innovations in half and obtain two subperiods. The first subperiod ranges from 1st Jan 1989 to 31st Dec 2003 and the second from 1st Jan 2004 to 31st Dec 2018. As in Viceira and Wang (2018), we hold the slope coefficients fixed through the entire sample. This follows from the arguments that the state variables follow highly persistent processes and thus require long time series to be properly estimated.

[1] The results of the VAR-estimates are available on request.

Additionally, we do not have any particular hypothesis as to why the slope coefficients should have changed over the sample period.

We have now presented the methodology applied in the first part of our empirical research. In the next section, we present the findings obtained.

4.2 Cross-Country Correlations of Stock and Bond Returns

In this section, we present the findings of our research on the benefits from global portfolio diversification of equities and government bonds over the period 1989 to 2018, and the subperiods 1989 to 2003 and 2004 to 2018. Finally, we compare the results to the ones reported in Viceira & Wang (2018) using a sample over the period 1986 to 2016 with the two subperiods 1986 to 1999 and 2000 to 2016.

4.2.1 Findings

Table 5 reports our estimates of cross-country correlations for the various news components of stock and bond returns that have been extracted from the VAR estimates. For equities, our empirical research documents a statistically significant increase in the average correlation of discount rate news across the countries in our sample between the two subperiods. For the real rate news component, we estimate an increase in the average cross-country correlation from 0.21 to 0.52 between 1989 and 2003, and 2004 and 2018. This difference is both economically and statistically significant. Similarly, our estimates suggest that the risk premium news component has experienced a significant increase from 0.31 to 0.62 between the two subperiods. In addition, for bonds, we also estimate a statistically significant increase in average cross-country correlation of discount rates, both with respect to real rates and risk premiums.

With regard to cash flow news, we find no evidence of increased average cross-country correlation for equities between the two subperiods. In contrast, we estimate a statistically significant increase in cross-country cash flow correlations from 0.46 to 0.65 for nominal government bonds.

Table 5: Cross-Country Correlations of Stock and Bond Return News Components

Table 5 shows our estimates of average cross-country cash flow (CF)-, Real Rate (RR)-, and Risk Premium (RP) news correlations of excess stock and government bond returns for the periods 1989-2003 and 2004-2018. Additionally, the table displays Viceira and Wang's (2018) obtained estimates for the 1986-2016 period. We also report the differences between the two subperiods, and the corresponding p-values. The p-values are calculated from the Fisher r-to-z Transformation method. See section 8.4 in the Appendix for calculation of p-values.

Our Estimates (1989 - 2018)								Viceira and Wang (2018) (1986 - 2016)							
		Equities			Bonds					Equities			Bonds		
		CF	RR	RP	CF	RR	RP			CF	RR	RP	CF	RR	RP
	CF	0.55			0.46				CF	0.41			0.34		
1989-2003	RR	0.12	0.21		-0.21	0.35		1986-1999	RR	0.03	0.39		-0.34	0.35	
	RP	-0.37	-0.18	0.31	0.21	-0.13	0.41		RP	-0.30	-0.33	0.49	0.02	-0.01	0.20
	CF	0.64			0.65				CF	0.47			0.64		
2004-2018	RR	0.40	0.52		-0.57	0.68		2000-2016	RR	0.28	0.63		-0.63	0.63	
	RP	-0.54	-0.44	0.62	0.37	-0.44	0.60		RP	-0.39	-0.59	0.63	0.10	-0.08	0.42
	CF	0.09			0.19				CF	0.06			0.30		
Difference	RR	0.27	0.31		-0.36	0.33		Difference	RR	0.25	0.25		-0.28	0.28	
	RP	-0.17	-0.26	0.31	0.16	-0.32	0.19		RP	-0.09	-0.26	0.14	0.08	-0.07	0.22
	CF	0.12			0.00				CF	0.25			0.00		
p-values	RR	0.00	0.00		0.00	0.00		p-values	RR	0.00	0.00		0.00	0.00	
	RP	0.02	0.00	0.00	0.05	0.00	0.01		RP	0.18	0.00	0.03	0.22	0.25	0.01

As shown above, our results are very similar to those reported in Viceira and Wang (2018). Most importantly, for equities, we estimate an economically and statistically significant increase in cross-country discount rate news correlation between the two subperiods, while we find no significant increase in cross-country cash flow news correlation. Furthermore, we estimate a statistically significant increase in cross-country cash flow news and discount rate news correlation for bonds between the subperiods. Thus, we obtain the same conclusions with regard to statistical significance as Viceira and Wang (2018). Overall, we are satisfied with our results compared to those reported in Viceira and Wang (2018). Yet we observe that some correlation estimates experience small deviations. However, we did not expect to obtain exactly the same results as the datasets differ with regard to some important metrics which we discuss in the paragraph below.

First, the start date of our dataset is constrained by the data availability on the state variables for the various countries. Hence, our empirical analysis is conducted on a dataset from 1989 to 2018, with the two subperiods 1989-2003 and 2004-2018. Viceira and Wang (2018) have a dataset from 1986 to 2016, with the subperiods 1986-1999 and 2000-2016. Moreover, as described in the data description section, we have obtained dividend yields from country-specific FTSE-equity indices while Viceira and Wang (2018) have obtained dividend yields from MSCI-indices. However, as the two indices have evolved very similarly over time, we do not expect much deviation to occur here. With regard to bonds, the datasets differ somewhat more. First, we have used 10-year government bond indices for each country while Viceira and Wang (2018) have used 7-10-year sovereign bond indices. Furthermore, for short-term interest rates, we have used monthly averages of the three-month money market rate for the various countries, in contrast to Viceira and Wang (2018) who have used one-month rates.

To sum up, our estimated correlation coefficients are relatively similar to those reported in Viceira and Wang (2018), and all have the same signs. Additionally, we have obtained the same conclusions with regard to statistical significance for both equities and bonds. Nonetheless, as the datasets are not entirely similar with respect to both time-horizon and some variables, particularly affecting bonds, we would naturally obtain some small deviations. Thus, the results from our empirical analysis suggest that we have been successful in applying the VAR-model on the asset return decomposition framework proposed by Campbell (1991).

Before we examine the implications of the findings reported in this section, following Viceira and Wang (2018), we find it necessary to present a framework that allows us to study the behaviour of the various news component correlations across the investment horizon.

4.3 Portfolio Risk for Long-Horizon Investors

In order to understand how the correlation between news to asset returns impact global diversification benefits, we need a portfolio risk framework that considers the investors' investment horizon. Viceira and Wang (2018) show that for an equally weighted portfolio of N markets, the portfolio risk, normalised by the investment horizon K, is given by:

$$\frac{1}{K}\mathbb{V}_t\left[r_{p,t+k}^{(k)}\right] = \frac{1}{N}\frac{1}{K}\mathbb{V}_t\left[r_{i,t+k}^{(k)}\right] + \left(1-\frac{1}{N}\right)\frac{1}{K}\mathbb{C}_t\left[r_{i,t+k}^{(k)}, r_{j,t+k}^{(k)}\right] \tag{16}$$

Here, it follows that the portfolio variance is given by two components. That is, a within-country variance component, $\mathbb{V}_t\left[r_{i,t+k}^{(k)}\right]$, and a cross-country covariance component, $\mathbb{C}_t\left[r_{i,t+k}^{(k)}, r_{j,t+k}^{(k)}\right]$. Furthermore, by using a forward recursion of the VAR (1) model, it follows that future one-period realised returns may be expressed as:

$$r_{n,t+l} - \mathbb{E}\left[r_{i,t+1}\right] = N_{CF,i,t+l} - N_{DR,i,t+l} + \frac{\beta}{\lambda}\sum_{m=1}^{l-1}\phi^{m-1}N_{DR,i,t+l-m} \qquad (17)$$

Through this equation, the transitory nature of discount rates news becomes apparent. The realised return l periods ahead depends on the full shock to cash flows, while the impact of discount rate shocks experiences a reverting process over time. This is clearly shown in the last term of the equation. Moreover, this presentation of the realised returns can be used to demonstrate that the covariance component in the equation of total portfolio risk is given by:

$$\frac{1}{K}\mathbb{C}_t\left[r_{i,t+k}^{(k)}, r_{j,t+k}^{(k)}\right] = \sigma_{CF,CF}^{xc} + [a(k)^2 + b(k)\,] * \sigma_{DR,DR}^{xc} - 2 * a(k) * \sigma_{CF,DR}^{xc} \qquad (18)$$

Here, $\sigma_{CF,CF}^{xc}$ denotes the cross-country covariance between cash flow news, $\sigma_{DR,DR}^{xc}$ denotes the cross-country covariance between discount rate news, and lastly, $\sigma_{CF,DR}^{xc}$ denotes the cross-country covariance between cash flow and discount rate news. The coefficients $a(k)$ and $b(k)$ are given in section 8.3 in the Appendix. However, note that when $k = 1$, then $a(1) = 1$ and $b(1) = 0$, and that the coefficients experience an exponential decay towards zero as K increases. This implies that cross-country discount rate news covariances are subject to a diminishing effect for longer investment horizons. Consequently, cross-country cash flow news covariances will move towards being the only contributor to the covariance component of total portfolio risk.

From this, it naturally follows that the within-country variance component in (16) is equal to:

$$\frac{1}{K}\mathbb{V}_t\left[r_{i,t+k}^{(k)}\right] = \sigma_{CF,CF}^{wc} + [a(k)^2 + b(k)\,] * \sigma_{DR,DR}^{wc} - 2 * a(k) * \sigma_{CF,DR}^{wc} \qquad (19)$$

Thus, the variance component of portfolio risk is given by within-country cash flow news variance, within-country discount rate news variance, and within-country cash flow and discount rate news covariance. In addition, note that the variance component follows the same path as the covariance term in the sense that the cash flow news component will move towards being the only contributor as the investment horizon increases.

From this framework, it is straightforward to examine why the implications of increased correlation of the various news components vary with regard to portfolio risk. The cash flow news component is the only component that has a persistent impact on portfolio risk, independently of the investment horizon. The discount rate news component, on the other hand, has a diminishing effect on portfolio risk as the investment horizon increases. Hence, with regard to global portfolios, increased global correlation of cash flow news will lead to a reduction in global portfolio diversification benefits at all horizons. In contrast, the impact of increased cross-country correlation of discount rate news is a decreasing function of time. This highlights the importance of understanding the sources of asset return correlation before examining how globalisation affects portfolio diversification benefits.

Having described this framework, in the following section we discuss the implications of our findings that were presented in section 4.2.1.

4.3.1 Implications

The following discussion is based on the findings presented in the previous section and is thus based on the original work of Viceira and Wang (2018). We include this section in order to both present and apply the framework. In addition, it enables us to examine the evolvement of the global equity and debt markets which we later compare to the evolvement of the various industries.

For equities, our results seem to suggest that the rise in global stock excess return correlation is primarily driven by an economically and statistically significant increase in cross-country correlation of discount rate news. However, as presented above, shocks to discount rate news correlation are shown to be transitory. Thus, the impact of cross-country discount rate news correlation on portfolio risk is decreasing over time. Hence, we argue that the benefits from global equity portfolio diversification have not necessarily declined for long-horizon investors. That being said, for short-horizon investors, the benefits from global equity portfolio diversification have deteriorated during the last 15 years. This is also suggested by Viceira and Wang (2018).

According to Ammer and Mei (1996), increased cross-country correlation of discount rate news may be viewed as a measure of increased financial or capital markets integration. Consequently, the results seem to suggest that increased financial and capital markets integration has been the main contributor to the recent substantial increase in global stock excess return correlation over time. This estimated increase of financial markets integration in the late subperiod could partly be a result of the responses that were put into action in the aftermath of the global financial crisis. At the 2008 Washington Summit on Financial Markets and The World Economy, G-20 leaders agreed on the objective of promoting integrity in global financial markets. In this case, development of transparent financial systems, regulations and governance may have been important factors contributing to enhanced integrity in financial markets in recent years (Mohan & Kapur, 2014).

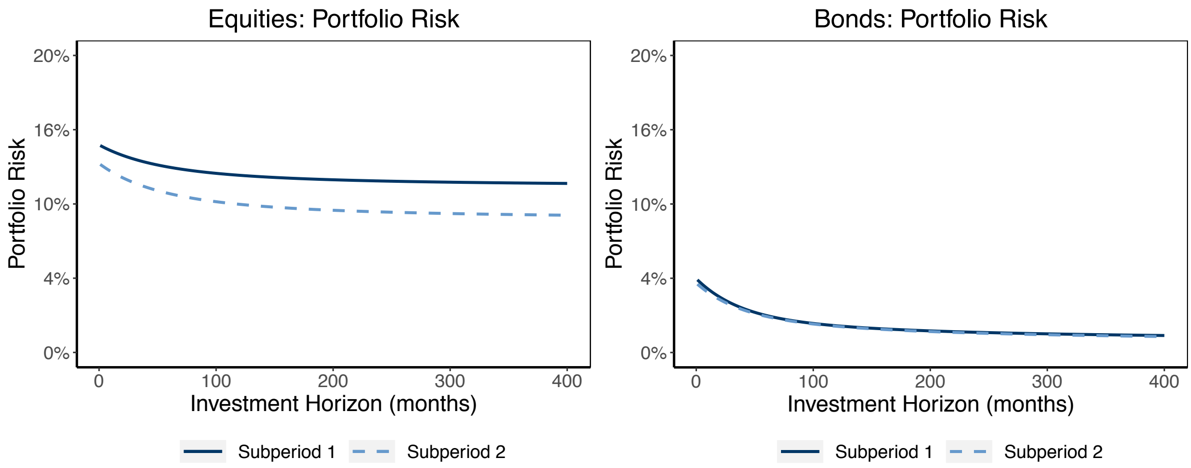
For bonds, we document an economically and statistically significant increase in both the cross-country cash flow news and discount rate news components between the two subperiods. As we have demonstrated above, cash flow shocks are shown to have a persistent impact on prices and returns, thus their impact on portfolio risk is independent of time. As with Viceira and Wang (2018), our results thus imply that the benefits from holding a globally diversified portfolio of government bonds have declined for all horizons.

As inflation is used as a proxy for bond cash flows in the VAR model, we may infer that the increased global correlation of bond excess returns is primarily driven by a rise in cross-country correlation of inflation news. This may be explained by the gradual adoption of flexible inflation targeting policies across developed countries towards the late 1990s-early 2000s (Taylor, 2013). Successful inflation targeting among advanced economies could therefore help explain the estimated increase in average cross-country correlation of inflation rates between the two subperiods.

In order to investigate our findings even further, we follow Viceira and Wang (2018) in constructing equal-weighted portfolios for both global stocks and bonds in each subperiod. The portfolios are equally weighted across the countries in our sample. The reasoning for using equal-weighted portfolios, as opposed to value-weighted, is that we realise that the U.S. would be assigned a disproportionately large weight, which could skew our analysis. From the equal-weighted portfolios, we examine how the total portfolio risk has evolved and, perhaps more interestingly, the forces driving the change over time. We compute the portfolio variance from equation (16), and annualise the standard deviation.

Figure 3: Global Portfolio Risk for Equities and Government Bonds Across Investment Horizon

The figure shows the estimated annualised standard deviation of excess returns for equal-weighted portfolios of global equities and global government bonds across the investment horizon for each subperiod.



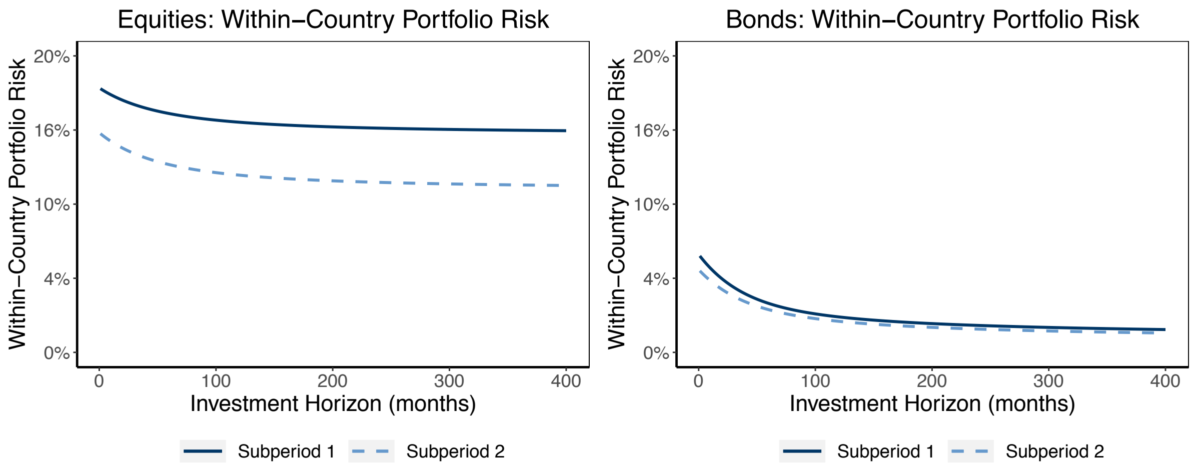
As shown in the left diagram above, for equities, we estimate that the total portfolio risk is a declining function of the investment horizon in both subperiods. For short and long-term investors, the difference in annualised portfolio risk in subperiod 2 is approximately three percent, which highlights the importance of considering the investors' investment horizon. In addition, we find that portfolio risk in subperiod two is less than in subperiod one across all investment horizons and that the difference is increasing over time. To highlight the important implications of this finding, we consider an example. For instance, at the 400-month horizon, the equity portfolio risk in the first and second subperiod is close to 12 percent and 10 percent respectively. For a long-horizon investor, this difference would imply an economically significant risk reduction at long investment horizons, especially when we consider the compounding effect over more than 30 years. For bonds, on the other hand, our estimates seem to suggest that the portfolio risk is very similar across the investment horizon for each subperiod. Nevertheless, as with equities, we estimate that the total portfolio risk is declining across the investment horizon. This is also in accordance with the findings of Viceira and Wang (2018).

It follows from the framework we have applied that total global portfolio risk consists of a correlation effect and a volatility effect. Thus, by decomposing the portfolio risk into these two components, we should be able to explain the effects we observe in the graphs above more precisely. Therefore, in the following, we present this decomposition as suggested in Viceira and Wang (2018) and display the results graphically in Figure 4 and Figure 5.

Based on the split in equation (16), it follows that portfolio risk is dependent on a within-country variance component, and a cross-country covariance component. We plot the former term given by equation (19) in Figure 4 below. This allows us to assess the contribution of the within-country variance component to total global portfolio risk in each subperiod across the investment horizon.

Figure 4: Within-Country Portfolio Risk for Equities and Government Bonds Across Investment Horizon

The figure shows the estimated annualised within-country portfolio risks for equal-weighted portfolios of global equites and government bonds across the investment horizon for each subperiod.



For equities, we estimate that the within-country portfolio risk is declining over the investment horizon, with the late subperiod having less risk than the early subperiod at all horizons. We may infer the volatility effect to be a measure of return predictability. Hence, our results seem to suggest that stock returns have been more predictable in the late subperiod, which should reduce the portfolio risk, all other things being equal. The findings make sense given the deteriorated evidence of return predictability in the late 1990s, caused by extraordinary stock returns relative to fundamentals (Lettau & Nieuwerburgh, 2007; Campbell & Yogo, 2006). In addition, the descriptive statistics reported in Table 3 also suggest lower equity return volatility in subperiod 2. Consequently, lower within-country excess return volatility in the second subperiod helps to explain the estimated decline in global equity portfolio risk during the second subperiod relative to the first, as displayed in Figure 3.

We also estimate that the within-country portfolio risk for bonds is declining over time in both subperiods. Moreover, the estimated portfolio risk in subperiod two is less than in subperiod one. However, as can be seen from the graph, the difference in within-country portfolio risk between the two subperiods appears to be neither economically nor statistically significant. For both equities and bonds, Viceira and Wang (2018) report similar results.

Some interesting results are found when we compare the estimated within-country portfolio risk to the estimated global portfolio risk shown in Figure 3. For equities, the within-country portfolio risk is substantially higher than the global equity portfolio risk across all horizons for both subperiods, and especially during the first. With regard to risk reduction, this finding clearly demonstrates the benefits from diversifying equity portfolios globally. It follows from the framework we have applied that the reduction in global equity portfolio risk must stem from imperfectly correlated equity returns across countries over time. For government bonds, on the other hand, our estimates seem to suggest that the risk reduction has only been improved marginally by investing globally. Next, we examine the other component affecting global portfolio risk, that is, the cross-country correlation.

With regard to the cross-country covariance term (18), Viceira and Wang (2018) specify that it is affected by the within-country variances. However, in an attempt to exclude all other potential variations between the two subperiods, the within-country standard deviations from subperiod one can be held fixed through subperiod two. This implies that the only source of variation is stemming from the cross-country correlation components of asset return news. This follows from the equation below.

$$\frac{1}{K} corr\left[xr_{i,t+1}^{(k)}, xr_{j,t+1}^{(k)}\right] = \frac{\rho_{CF,CF,i,j}^{xc}\sigma_{CF,i}^{wc}\sigma_{CF,j}^{wc}}{\sigma_{xr,i}\sigma_{xr,j}} + [a(k)^2 + b(k)\,] * \frac{\rho_{DR,DR,i,j}^{xc}\sigma_{DR,i}^{wc}\sigma_{DR,j}^{wc}}{\sigma_{xr,i}\sigma_{xr,j}} - 2 * a(k) * \frac{\rho_{CF,DR,i,j}^{xc}\sigma_{CF,i}^{wc}\sigma_{DR,j}^{wc}}{\sigma_{xr,i}\sigma_{xr,j}} \qquad (20)$$

Here, $\rho_{CF,CF,i,j}^{xc}$ denotes the cross-country correlation between cash flow news, and $\sigma_{CF,j}^{wc}$ denotes the within-country standard deviation of cash flow news. The same holds for the other asset return news components denoted in the equation above. $\sigma_{xr,i}$ denotes the within-country standard deviation of total asset return news. Note that equation (20) is derived from (18), which implies that the cross-country correlation follows the same trend as the cross-country covariance across the investment horizon. In Figure 5, we plot the weighted average of pairwise cross-country correlations of excess asset returns.

Figure 5: Cross-Country Correlations of Equities and Government Bonds

The figure plots, for each subperiod, the average pairwise cross-country correlations for equal-weighted global equity and government bond portfolios across the investment horizon.

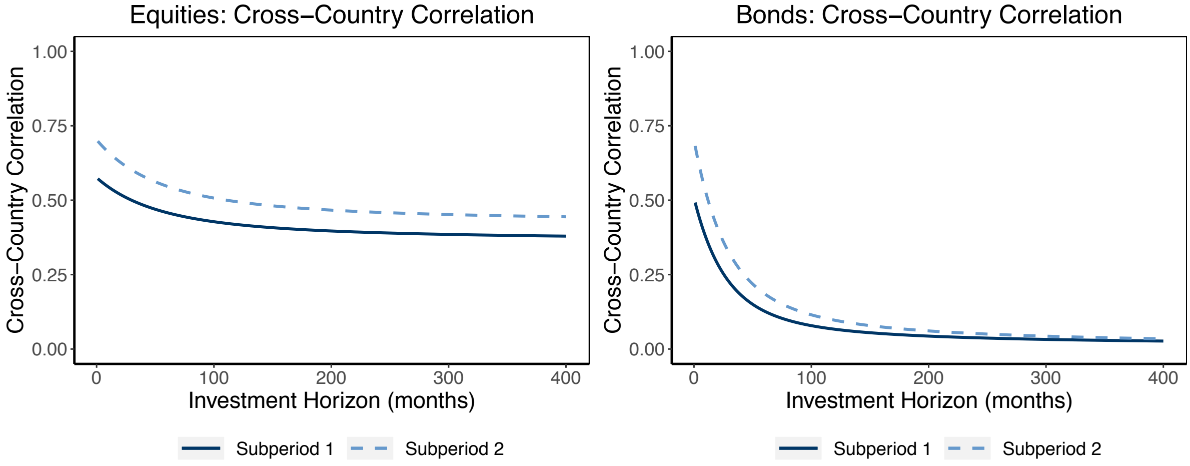


Figure 5 shows an upward shift in monthly excess return correlations across countries in the late subperiod relative to the early subperiod for both global equities and government bonds. This is consistent with our empirical findings reported in Table 5, and is also suggested by Viceira and Wang (2018).

Our estimates suggest that global equity return correlations are higher in the 2004-2018 period relative to the 1989-2003 period. Hence, given that all other factors affecting global portfolio risk are held constant, the benefits from holding a globally diversified equity portfolio should have declined. However, as we demonstrate in Table 5, the increased cross-country excess return correlation is driven by a statistically significant increase in discount rate news. As equation (20) explains, correlated discount rate shocks do only have a transitory effect on global portfolio risk, as their effect on long-term return correlations is minimal. Therefore, we argue that the estimated upward shift in global equity return correlations has only increased the short-run risk of investing across global equity markets, while the long-run risk is not necessarily affected. In other words, the difference between the cross-country correlations between the two subperiods is not statistically significant at long investment horizons.

For bonds, we also estimate a significant increase in global return correlations in the second subperiod relative to the first. In contrast to equities, as shown in Table 5, we estimate that the increase in cross-country bond return correlations is driven by both a statistically significant increase in correlated cash flow news and discount rate news. We have previously demonstrated that cash flow news have a persistent effect on return correlations.

Consequently, the diversification benefits for a long-horizon international bond investor have declined across all investment horizons. However, this effect does not seem to have large economic implications, as the cash flow news contribution to total cross-country asset return news correlation appears to be rather limited. This may be a result of our return generating model being better at predicting cash flow news contrary to discount rate news. In other words, the variation of inflation rate news is less, and hence more predictable, than discount rate news.

In this chapter, we have presented the methodology used in our empirical research and further applied it to the financial and macroeconomic data obtained. From this, we have examined the gains from global portfolio diversification of equities and government bonds in the period 1989-2018, as well as in the subperiods 1989-2003 and 2004-2018. To a large extent, the results and subsequent discussion are based on the work of Viceira and Wang (2018). This is both to prove that we are capable of applying the comprehensive methodology presented, and to form a sound basis for examining the gains from global industry diversification which is the main contribution of our research. In the coming chapter, we present and discuss the findings and implication from our analysis on global equity industries.

5 Diversification Benefits Across Global Industry Sectors

This chapter is devoted to the main contribution of our empirical research, which is the assessment of the gains from portfolio diversification across global industry sectors over time. Because we generally apply the same methodology in the following analyses as was outlined in the previous chapter, we do not give a detailed presentation of the methodology again, but rather refer to the presentation given in Chapter 4.

Note that the start date of our analysis is constrained by the data availability of the various equity industry indices across the seven countries in our sample. Consequently, we conduct the analysis over the period 1994-2018, as well as for two subperiods starting 1st Jan 1994 to 30th Jun 2005 and 1st Jul 2005 to 31st Dec 2018. This differs from the previous analysis that is conducted on data from 1989 to 2018.

We will, in the following section, present the findings of our research, before we discuss the implications in section 5.2.

5.1 Findings

Before we present the findings of the industry analysis, we find it necessary to briefly present our estimates of average cross-country correlations of the asset return news components for the global equity market using the sample period 1994-2018. The purpose of this exercise is to examine whether our previous results are sensitive with respect to the time horizon, and thus also whether the results obtained from the industry sector analysis are comparable to the development of the global equity market. We report the estimated cross-country news component correlations from the 1994-2018 sample period in Table 6 on the next page.

Table 6: Cross-Country Correlations of Equity Return News Components (1994-2018)

The following table shows the estimated average cross-country news component correlations of excess stock returns for the periods 1994-June 2005 and July 2005-2018. We also report the differences between the two subperiods, and the corresponding p-values. The p-values are calculated from the Fisher r-to-z Transformation method.

		Equities		
		CF	RR	RP
1994 - 2005	CF	0.60		
	RR	0.16	0.34	
	RP	-0.37	-0.19	0.35
2005 - 2018	CF	0.66		
	RR	0.38	0.51	
	RP	-0.51	-0.39	0.60
Difference	CF	0.06		
	RR	0.21	0.17	
	RP	-0.14	-0.20	0.25
p-values	CF	0.17		
	RR	0.01	0.02	
	RP	0.05	0.02	0.00

As shown above, from the 1994-2018 sample period, we estimate an economically and statistically significant increase in average cross-country discount rate news correlation between the two subperiods. Furthermore, we find no evidence of increased average cross-country cash flow news correlation. The results are thus similar to those obtained using data from 1989-2018. Based on this, we proceed to examine how the cross-country asset return news correlation has evolved over time for 10 different global industry sectors. We also compare the results to the development of the global equity market in the same period.

On the following page, we present the estimated average cross-country asset return news correlation across the 10 global industries defined by the Industry Classification Benchmark. The results are obtained by using the same methodology as we presented in section 4.1.

Table 7: Asset Return News Component Correlations Across Global Industry Sectors

The table shows our estimates of average cross-country cash flow (CF)-, Real Rate (RR)-, and Risk Premium (RP) news correlations across 10 global industry sectors for the countries of Australia, Canada, France, Germany, Japan, U.K. and the U.S. The estimates are obtained for the subperiods 1994-June 2005 and July 2005-2018. We also report the differences between the two subperiods, and the corresponding p-values. The p-values are calculated from the Fisher r-to-z Transformation method (see section 8.4 in the Appendix).

		Basic Materials			Consumer Goods			Consumer Services			Financials			Health Care			Industrials			Oil and Gas			Technology			Telecom			Utilities		
		CF	RR	RP	CF	RR	RP	CF	RR	RP	CF	RR	RP	CF	RR	RP	CF	RR	RP	CF	RR	RP	CF	RR	RP	CF	RR	RP	CF	RR	RP
	CF	0.46			0.32			0.41			0.47			0.34			0.41			0.52			0.50			0.37			0.21		
1994 - 2005	RR	0.05	0.33		0.04	0.33		0.07	0.33		0.09	0.28		0.06	0.36		0.08	0.35		-0.01	0.28		-0.03	0.35		0.03	0.27		-0.01	0.28	
	RP	-0.24	-0.23	0.27	-0.04	-0.40	0.37	-0.11	-0.32	0.26	-0.12	-0.07	0.28	-0.11	-0.01	0.15	-0.18	-0.37	0.36	-0.41	0.11	0.40	-0.05	-0.29	0.32	0.00	-0.14	0.14	-0.17	0.07	0.28
	CF	0.52			0.31			0.45			0.62			0.30			0.55			0.64			0.37			0.30			0.26		
2005 - 2018	RR	0.21	0.45		0.15	0.43		0.16	0.43		0.32	0.43		0.12	0.45		0.20	0.48		0.23	0.38		-0.10	0.47		0.12	0.36		0.07	0.30	
	RP	-0.32	-0.27	0.37	-0.14	-0.48	0.50	-0.15	-0.38	0.36	-0.29	-0.22	0.40	-0.14	-0.16	0.24	-0.33	-0.46	0.56	-0.46	-0.10	0.38	0.04	-0.41	0.47	-0.13	-0.18	0.26	-0.11	0.03	0.23
	CF	0.06			-0.01			0.04			0.16			-0.04			0.14			0.12			-0.12			-0.07			0.05		
Difference	RR	0.16	0.11		0.11	0.10		0.08	0.10		0.23	0.15		0.06	0.09		0.12	0.13		0.24	0.10		-0.07	0.11		0.10	0.10		0.07	0.02	
	RP	-0.09	-0.05	0.10	-0.09	-0.08	0.13	-0.04	-0.05	0.11	-0.18	-0.15	0.12	-0.03	-0.15	0.09	-0.15	-0.09	0.20	-0.04	-0.21	-0.03	0.09	-0.11	0.15	-0.13	-0.04	0.12	0.05	-0.05	-0.05
	CF	0.24			0.47			0.31			0.02			0.35			0.04			0.04			0.08			0.23			0.33		
p-values	RR	0.07	0.10		0.14	0.13		0.22	0.13		0.01	0.05		0.28	0.16		0.12	0.07		0.01	0.15		0.26	0.10		0.18	0.16		0.25	0.43	
	RP	0.19	0.32	0.16	0.19	0.19	0.07	0.36	0.29	0.13	0.04	0.07	0.10	0.38	0.08	0.19	0.07	0.16	0.01	0.30	0.02	0.39	0.21	0.11	0.04	0.11	0.37	0.11	0.30	0.33	0.32

While we estimate a statistically significant increase in discount rate news correlation over time for the global equity market, this is not the general trend for the various industries. At a 10 percent significance level, we estimate a statistically significant increase of average cross-country discount rate news correlation for only the Financials, Industrials and Technology industries. That is, both the real rate news and the risk premium news have experienced a significant increase between the two subperiods.

Perhaps even more interestingly, we estimate a statistically significant increase in average cross-country cash flow news correlation for the Financials, Industrials, and Oil and Gas industries at a five percent level. On the other hand, for the Technology industry, we estimate a weak statistically significant decline in the cash flow news correlation. These results are rather contrary to our estimates for the global equity market, where we found no evidence of changed cross-country cash flow news correlation between the two subperiods. Our results thus have important implications for the global portfolio diversification benefits of investing into these industries for long-term investors. We examine this question further in the next section.

Finally, for the Basic Materials, Consumer Goods, Consumer Services, Health Care, Telecom and Utilities industries, our estimates suggest that there has been no significant change in the correlation of either cash flow or discount rates news. From Figure 2 which plots the 5-year rolling cross-country USD-hedged return correlation, we visually verify that the global return correlation for these industries has been stable over time.

In the following section, we discuss the implications of these findings and examine how the portfolio risk of equal weighted portfolios across countries has evolved over the investment horizon within the various industries.

5.2 Implications

In this section, we analyse the implications of our findings presented in the previous section. Additionally, we form equal-weighted portfolios within each of the global industries across countries, and assess how the portfolio risk has evolved over the investment horizon.

5.2.1 Financials and Industrials

For the Financials and Industrials industries, we estimate a statistically significant increase in cross-country correlation of both discount rate news and cash flow news between the two subperiods. Interestingly, the global equity market has, in contrast, only experienced a statistically significant increase in discount rate news correlation over the same period. From Figure 2 showing the return correlations, we may visually observe that the cross-country return correlations have increased for these industries over time. However, this graph is not able to indicate whether this increased correlation primarily stems from correlated cash flow news or discount rate news. Thus, we are not able to make an inference of diversification benefits for long horizons.

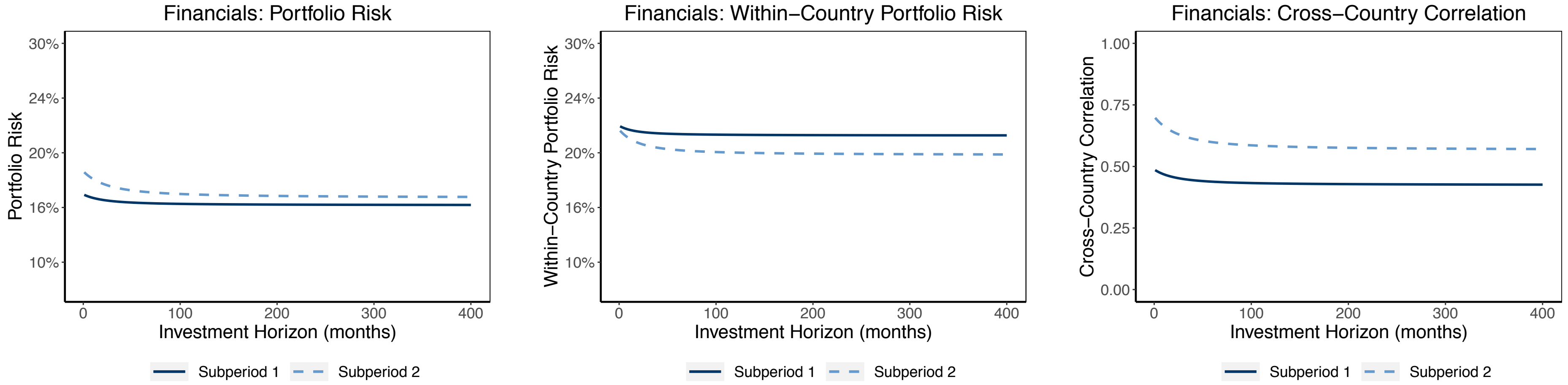
As discussed in Chapter 4, discount rate news are shown to only have a transitory effect on prices and hence returns, while cash flow news are shown to have a persistent effect independently of the investment horizon. Consequently, our results seem to suggest that indeed the portfolio risk has increased at short horizons in the second subperiod relative to the first, given that the within-country variances are held constant. Given that we also estimate a significant increase in cross-country cash flow news correlations, the question is how much of the estimated increase in cross-country return correlation that persists at long horizons.

In Figure 6, we present the estimated portfolio risk across the investment horizon for these two industries. Moreover, we also examine how the within-country variance and the correlation components have evolved, and thus affected, the portfolio risk over time.

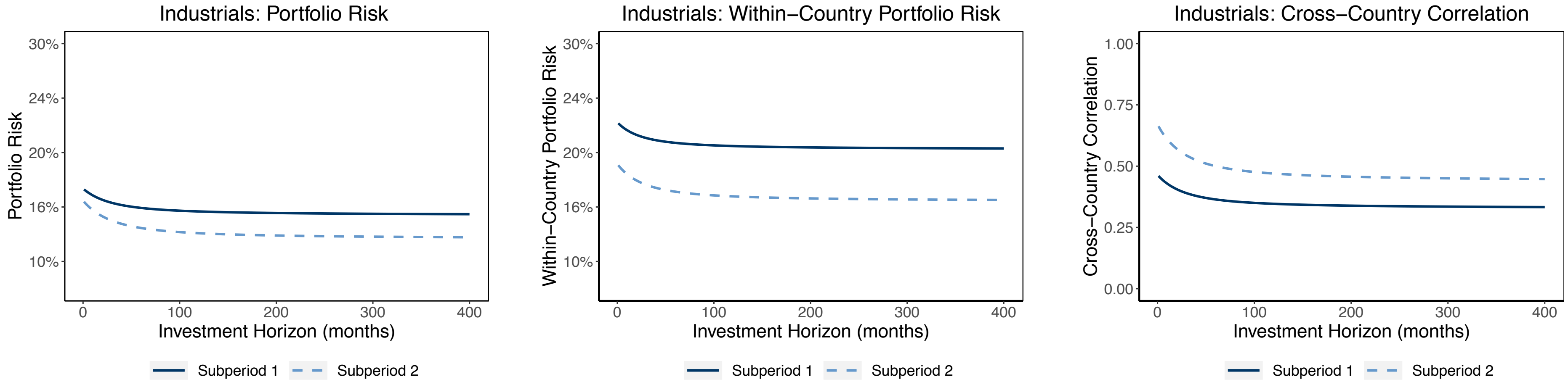
Figure 6: Financials and Industrials

The figure shows the global portfolio risk within the Financials and Industrial industries across investment horizons. In addition, it plots the within-country portfolio risk and the cross-country return correlations. All the plots are for equal-weighted portfolios that have been formed within each industry, across the countries in our sample

Panel A: Financials



Panel B: Industrials



As shown in Panel A of Figure 6, the estimated global portfolio risk for the Financials industry is declining across the investment horizon. More interestingly, we find that the portfolio risk is higher at all investment horizons during the second subperiod relative to the first. It follows that the increased portfolio risk during the second subperiod stems from either increased within-country variance or increased cross-country correlation.

We estimate that the within-country portfolio risk for the Financials industry is higher during the early subperiod compared to the last. Thus, we know that the estimated increase in global portfolio risk between the two subperiods must stem from an increase in cross-country return correlation. In Table 7, we report a statistically significant increase in cross-country correlations of both discount rate news and cash flow news over time. This is also shown graphically in Figure 6. Moreover, from the plot, we see that the cross-country correlation in subperiod 2 is high initially, but that it declines over the investment horizon, thus reflecting the temporary effect of discount rate news on prices and returns. However, the decline in cross-country correlation across time eventually ceases to exist and converges towards the cross-country correlation of cash flow news. This clearly demonstrates the persistent nature of cash flow news correlation.

The estimated increase in cross-country correlation within the Financials industry in the second subperiod may partly be a result of the subprime mortgage crisis, where banks and insurance companies were affected substantially. This follows from the often-observed phenomenon of increased asset return correlations in periods of distress (Longin & Solnik, 2001).

In conclusion, for the Financials industry, we demonstrate that increased cross-country return correlation has contributed to increased portfolio risk over time, even though the within-country variance has declined in the same period. Although increased global return correlation has reduced the global diversification benefits within the Financials industry over time, investors would on average still obtain lower portfolio risk by investing globally. This is due to the global portfolio risk being lower than the within-country portfolio risk in subperiod 2 across the investment horizon. Thus, diversification benefits appear to still exist, but to a lesser extent than in the subperiod before.

In contrast, for the Industrials industry, we estimate that the global portfolio risk has declined in the second subperiod relative to the first at all horizons, despite of an estimated statistically significant increase in average cross-country correlation in discount rate news and cash flow rate news between the two subperiods.

Because we estimate an improvement in global portfolio risk in the second subperiod and an increase in cross-country correlations, it must be the case that the within-country portfolio risk has declined in the second subperiod. We observe this graphically in Figure 6. Also, we find that the global portfolio risk is considerably lower than the within-country portfolio risk, thus suggesting that there are indeed benefits from holding a globally diversified portfolio within the Industrials industry. However, our estimates suggest that the diversification benefits have declined for all investment horizons due to a persistent increase of cross-country return correlation. As with the Financials industry, it follows that the Industrials industry was largely impacted by the financial crisis of 2008 (Alcorta & Nixson, 2011). This may have had a joint effect on earnings in the industry and thereby leading to an increase in cash flow correlations.

Finally, among the industries in our sample, the results seem to indicate that the Financials and Industrials industries have experienced the highest degree of capital market integration between the two subperiods. This is due to the estimated significant increase in discount rate news correlation. The same holds for the Technology industry, which we examine in the following subsection.

5.2.2 Oil & Gas and Technology

The Oil and Gas industry is the only industry in our sample for which we exclusively estimate a statistically significant increase in cash flow news correlation, without an associated increase in discount rate news correlation. This is indeed interesting, as the global equity market in contrast only experiences an increase of discount rate news correlation in the same period.

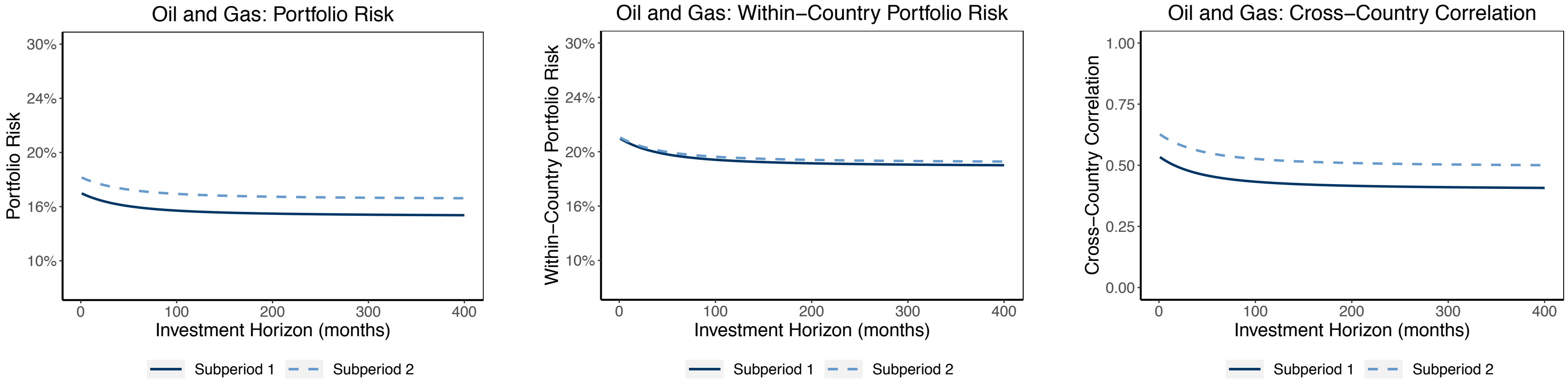
Perhaps even more interestingly, for the Technology industry, we estimate a statistically significant decline in cross-country correlation of cash flow news between the two subperiods at a 10 percent significance level. In addition, we estimate a significant increase of cross-country discount rate news correlation.

In Figure 7 on the following page, we study how these findings have affected the global portfolio risk within these industries across time, and further examine whether investors still benefit from global diversification gains.

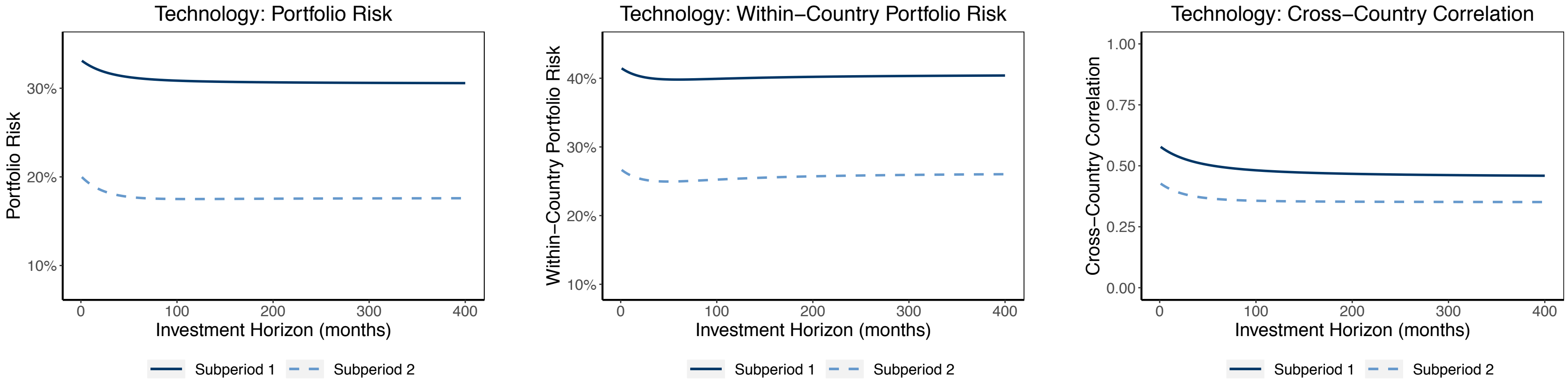
Figure 7: Oil & Gas and Technology

Figure 7 shows the global portfolio risk within the Oil & Gas and the Technology industries across investment horizons. In addition, it plots the within-country portfolio risk and the cross-country return correlations. All the plots are for equal-weighted portfolios that have been formed within each industry, across the countries in our sample.

Panel A: Oil and Gas



Panel B: Technology



For the Oil and Gas industry, we estimate an increase in global portfolio risk between the two subperiods. Moreover, we find that the within-country portfolio risk is relatively similar between the two subperiods, which is also confirmed in the descriptive statistics. Our results suggest that the increase in global portfolio risk is driven by a statistically significant increase in cross-country cash flow news correlation. This can further be observed from Panel A in Figure 7. Thus, our results seem to suggest that the benefits from global portfolio diversification within the Oil and Gas industry have declined independent of the investors' investment horizon. This may partly be a result of the large fluctuations in the oil price which have occurred during subperiod 2. Naturally, the oil price is fundamentally important for oil companies' earnings (Shaeri & Katircioğlu, 2018). This implies that variability in the oil price, to a certain extent, will affect all companies similarly, and hence, perhaps increase cross-country cash flow news correlation.

The Technology industry has experienced a substantial decline in global portfolio risk between the two subperiods. From Panel B of Figure 7, we observe that this decline is a result of both reduced within-country portfolio risk and reduced cross-country correlation between the early and the late subperiods.

With regard to the within-country portfolio risk, we estimate a large decline from the early to the last subperiod. Given this, our estimates seem to suggest that the return predictability has been substantially improved over time. By considering that the tech bubble occurred during the first period, our results seem reasonable. During this period, technology stocks experienced rapid growth and high valuations relative to fundamentals which weakened the evidence of return predictability (Cogman & Lau, 2016).

Furthermore, the Technology industry is the only industry for which we find a weak statistically significant decline in cross-country cash flow news correlation between the two subperiods. Yet we estimate a significant increase of cross-country discount rate news correlations. In other words, the capital market integration within the Technology industry seems to have increased, while the cross-country correlations of equity fundamentals have declined during the same period. Nevertheless, as shown in Panel B of Figure 7, we find that the cross-country correlation during the second subperiod is lower than in the first, across all horizons. Therefore, our results seem to suggest that global diversification benefits have improved over time within the Technology industry, implying that the reduced cross-country return correlation from equity fundamentals outweighs the increased correlation stemming from amplified capital market integration. However, when interpreting these results, one should remember that the tech bubble and the subsequent crash occurred during the first subperiod. As previously mentioned, international asset return correlations often appear to increase during "down" markets or periods of increased volatility (Longin & Solnik, 2001). Thus, the estimated decline in cross-country cash flow correlation during the late subperiod may partly be a consequence of an extraordinary high cross-country correlation during the early subperiod.

5.2.3 Basic Materials, Consumer Goods, Consumer Services, Health Care, Telecom and Utilities

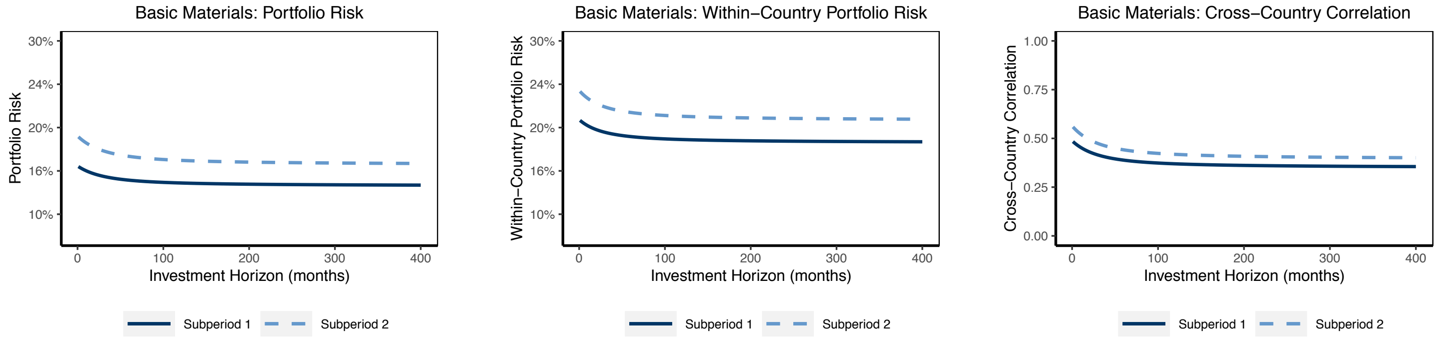
In this subsection, we examine the industries for which we find no evidence of increased cross-country asset return news correlation between the two subperiods. For each of the industries plotted in Figure 8, we observe that the cross-country correlations between the two subperiods are relatively similar across the entire investment horizon. This is also suggested in Table 7, where we find no statistical evidence of significant differences in any of the asset return news correlation coefficients. Hence, it follows that the variations in global portfolio risk for each of the industries are primarily due to differences in within-country portfolio risk between the two subperiods.

On the following two pages, we present the plots for portfolio risk, within-country portfolio risk and cross-country correlation. These are given in Figure 8.

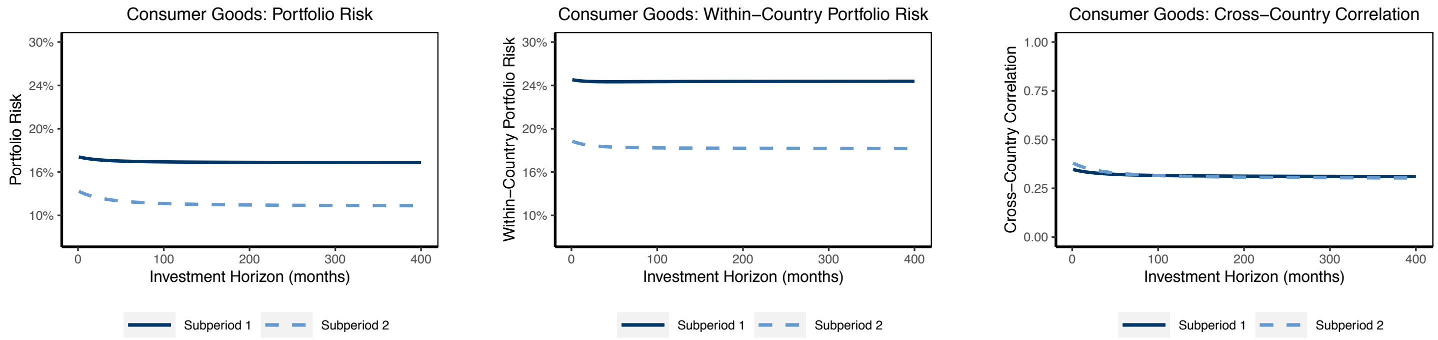
Figure 8: Basic Materials, Consumer Goods, Consumer Services, Health Care, Telecom and Utilities

Figure 8 shows the global portfolio risk for the Basic Materials, Consumer Goods, Consumer Services, Health Care, Telecom and Utilities industries across investment horizons. In addition, it plots the within-country portfolio risk and the cross-country return correlations. All the plots are for equal-weighted portfolios that have been formed within each industry, across the countries in our sample.

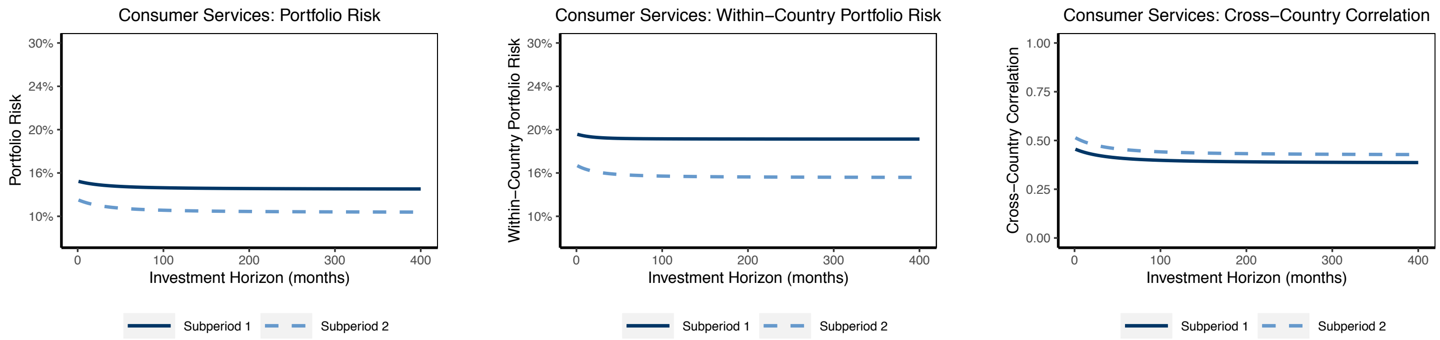
Panel A: Basic Materials



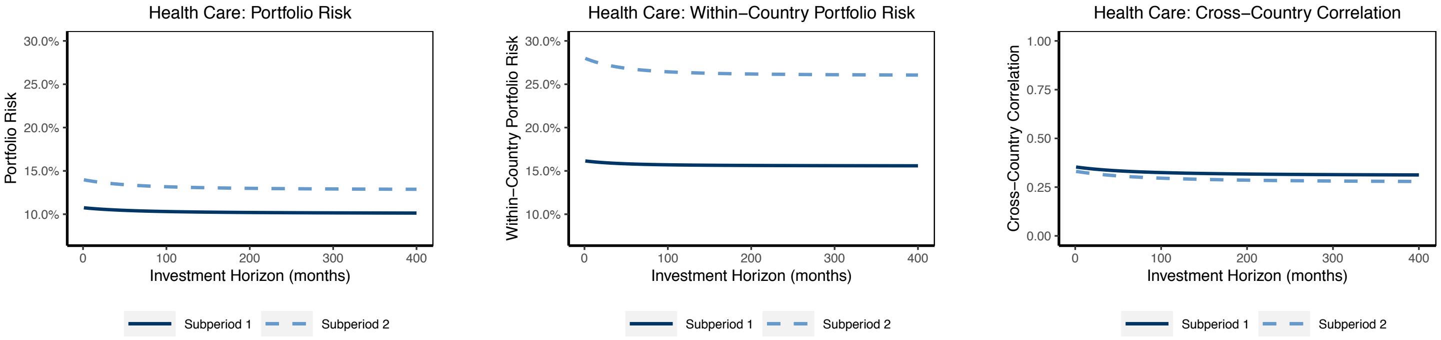
Panel B: Consumer Goods



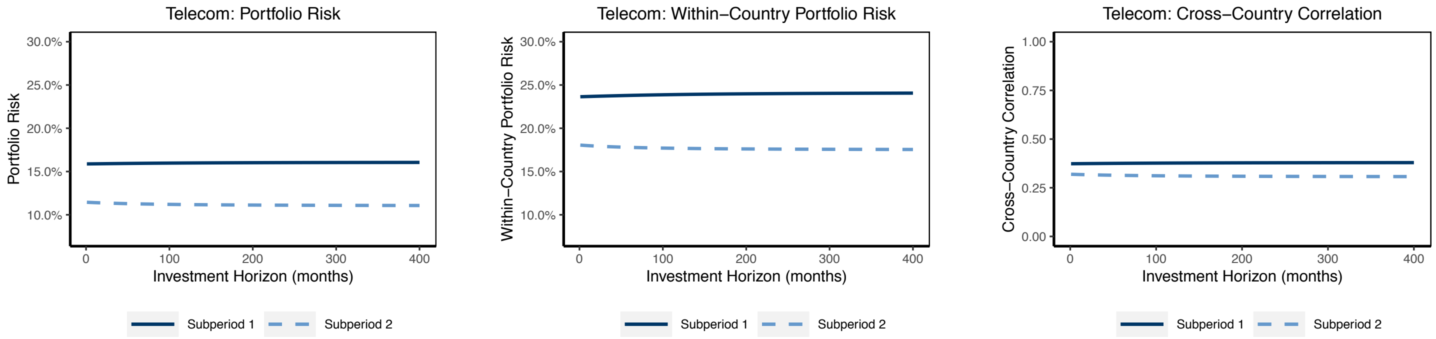
Panel C: Consumer Services



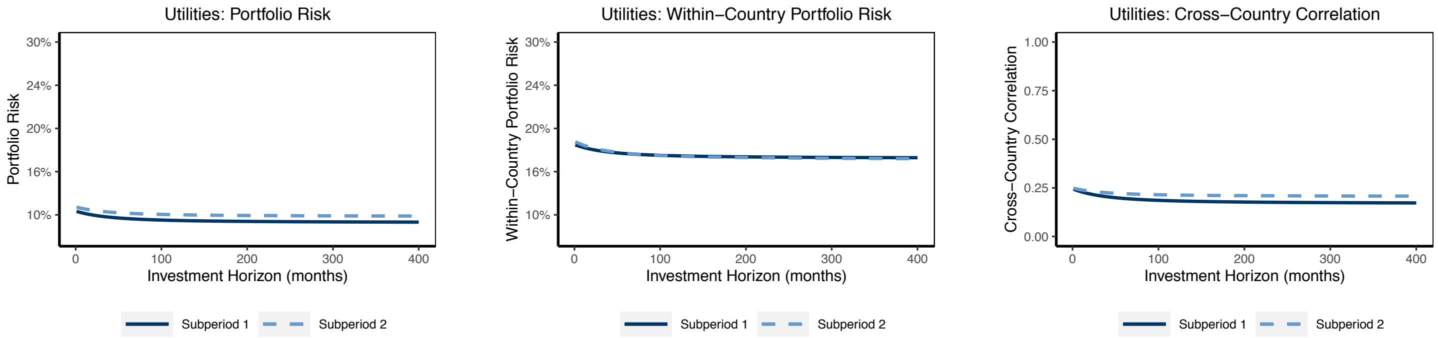
Panel D: Health Care



Panel E: Telecom



Panel F: Utilities



For each of the industries in Figure 8, we see that the global portfolio risk is considerably less than the within-country portfolio risk across the investment horizon, thus suggesting that there are benefits of holding a globally diversified portfolio within the various industries. Moreover, we observe that for lower levels of cross-country correlation, the lower is the global portfolio risk for a given level of within-country portfolio risk. For instance, the Health Care, Telecom and Utilities industries have some of the lowest cross-country correlation estimates among the industries in our sample. Here, we observe that the global portfolio risk is substantially less than the within-country portfolio risk. More specifically, for the Health Care industry, the within-country portfolio risk is close to 25 percent at the 400-month horizon. Yet, at the same horizon, the global portfolio risk is approximately 12 percent, thus suggesting that investors would have achieved considerable improvements in portfolio risk through a global allocation of funds.

Moreover, our findings suggest that industrial structures within the six industries reported in this subsection appear to be non-homogenous across the seven countries in our sample. This follows from the estimates of low cross-country correlations. Hence, we advocate that there are distinctive effects among national industries within the same global industry. Consequently, the industries covered in this subsection appear, to a certain degree, to be segmented across countries. This finding is interesting considering the increased real and financial integration that has occurred during the sample period. Also, our results demonstrate that even though the global equity market has experienced a significant increase in discount rate news correlations between the two subperiods, this is indeed not the situation for all of the various equity industries.

6 Conclusion

In this thesis, we examine the implications of cross-country asset return correlation on portfolio risk and the benefits stemming from global portfolio diversification as a function of the investment horizon. First, we follow the methodology of Viceira and Wang (2018) in applying VAR-models on the asset return decomposition framework of Campbell (1991). This allows us to study the sources of cross-country asset return correlations of stocks and bonds across seven advanced economies that account for the vast majority of global stock and bond market capitalisation. From this framework, it follows that asset returns may be correlated across countries either because of correlated discount rate news or correlated cash flow news.

Using an extensive dataset over the sample period 1989-2018 and the two subperiods 1989-2003 and 2004-2018, for equities, we document a statistically significant increase of cross-country discount rate news correlation between the two subperiods. Moreover, we find no evidence of increased cross-country cash flow news correlation. On the other hand, for bonds, we estimate a statistically significant increase in average cross-country correlation of both discount rate news and cash flow news. These findings are consistent with the findings of Viceira and Wang (2018). As discount rate news correlations are empirically shown to only have a transitory effect on prices and hence returns, we conclude that global portfolio benefits have not necessarily declined for long-term equity investors. Yet, our findings suggest that the benefits have declined in the short run. Conversely, cash flow news correlations are demonstrated to have persistent effects on prices and returns independently of the investment horizon. As a result, for bonds, our analysis seems to suggest that the benefits stemming from global portfolio diversification of government bonds have declined independently of the investors' investment horizon. Nonetheless, our findings suggest that there are small improvements to portfolio risk by diversifying government bonds across countries.

Our main contribution in this thesis has been to examine the cross-country asset return correlations for the ten equity industries defined by the FTSE Industry Classification Benchmark. From this, we study the implications for portfolio risk and the benefits of global portfolio diversification within each of these industries across countries over time. Due to limitations in the data availability, our analysis is conducted over the sample period 1994-2018, and the subperiods 1994-June 2005, and July 2005-2018.

The basis for our analysis is a suspicion that various industries are subject to specific factors which induce variations in cross-cross country return correlation over time. As a result, we should expect specific industries to have different impacts on global portfolio risk, and hence diversification benefits. Our results seem indeed to suggest that the various industries in our sample have evolved differently over time with respect to diversification benefits. While for the global equity market we estimate a statistically significant increase of discount rate news correlation, the same has not been the general trend for the various industries over the same period.

For the Financials and Industrials industries, we find statistical evidence of increased cross-country discount rate news and cash flow news correlation. Also, for the Oil and Gas industry, we estimate a statistically significant increase in cross-country cash flow news correlation. These findings thus suggest that the benefits stemming from global portfolio diversification have declined over time for both long-term and short-term investors. From our analysis, the Technology industry is the only industry for which we find a statistically significant decline of cross-country correlation across time. Still, we find a statistically significant increase of discount rate news correlation. However, interestingly, on a net basis, we find that the global diversification benefits have been improved over time for all investment horizons.

Finally, for the Basic Materials, Consumer Goods, Consumer Services, Health Care, Telecom and Utilities industries, we find no evidence of either increased or decreased cross-country asset return news correlation between the two subperiods. At the same time, these industries have relatively low average cross-country correlations compared to both the other industries and the global equity market. Therefore, we argue that non-homogeneous effects appear to exist among national industries within the same global industry. Hence, certain industries seem to be more or less segmented across countries, which leads investors to obtain substantial diversification benefits from global portfolio diversification.

We emphasise that our results are descriptive, in the sense that we cannot infer causal relationships explaining why industries have evolved in their respective manner. Consequently, a highly relevant topic for further research is to explore why some industries experience large variations with regard to diversification benefits, and what has caused these differences in correlation components over time.

In conclusion, our findings highlight that when considering the development of diversification benefits over time, one has to consider the investors' investment horizon. Furthermore, our findings suggest that the impact of strengthened international economic and financial integration varies greatly across industries. From this, it follows that there are differences between the industries with respect to their impact on global portfolio diversification over time. Hence, a final and important practical implication is that asset managers investing in certain global industries may obtain substantial improvements in portfolio risk. This is both relative to investors invested in other industries and the broad equity market. Our findings thus expand on existing literature that primarily examines the diversification benefits across the market as a whole.

7 References

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8 Appendix

8.1 Datastream Tickers

Table 8: Datastream Tickers of Equity Indices, Dividend Yields, Bond Indices and Inflation

Country	*MSCI Equity Index* *Field: RI*	*FTSE Dividend Yield* *Field: DY*	*Gov Bond Index* *Field: RI*	*Inflation*
Australia	MSAUSTL	WIAUSTL	BMAU10Y	AUCPANNL
Canada	MSCNDAL	WICNDAL	BMCN10Y	CNCPANNL
France	MSFRNCL	WIFRNCL	BMFR10Y	FRCPANNL
Germany	MSGERML	WIWGRML	BMBD10Y	BDCPANNL
Japan	MSJPANL	WIJPANL	BMJP10Y	JPCPANNL
United Kingdom	MSUTDKL	WIUTDKL	BMUK10Y	UKCPANNL
United States	MSUSAML	WIUSAML	BMUS10Y	USCPANNL

Table 9: Datastream Tickers of Industry Sectors per Country

Country	*Basic Materials* *Field: RI, DY*	*Consumer Goods* *Field: RI, DY*	*Consumer Services* *Field: RI, DY*	*Financials* *Field: RI, DY*	*Health Care* *Field: RI, DY*
Australia	F1AUBML	F1AUCGL	F1AUCSL	F1AUCGL	F1AUH1L
Canada	F1CNBML	F1CNCGL	F1CNCSL	F1CNCGL	F1CNH1L
France	F1FRBML	F1FRCGL	F1FRCSL	F1FRCGL	F1FRH1L
Germany	F1BDBML	F1BDCGL	F1BDCSL	F1BDCGL	F1BDH1L
Japan	F1JPBML	F1JPCGL	F1JPCSL	F1JPCGL	F1JPH1L
United Kingdom	F1UKBML	F1UKCGL	F1UKCSL	F1UKCGL	F1UKH1L
United States	F1USBML	F1USCGL	F1USCSL	F1USCGL	F1USH1L

Country	*Industrials* *Field: RI, DY*	*Oil & Gas* *Field: RI, DY*	*Technology* *Field: RI, DY*	*Telecom* *Field: RI, DY*	*Utilities* *Field: RI, DY*
Australia	F1AUIDL	F1AUO1L	F1AUG1L	F1AUT1L	F1AUU1L
Canada	F1CNIDL	F1CNO1L	F1CNG1L	F1CNT1L	F1CNU1L
France	F1FRIDL	F1FRO1L	F1FRG1L	F1FRT1L	F1FRU1L
Germany	F1BDIDL	F1BDO1L	F1BDG1L	F1BDT1L	F1BDU1L
Japan	F1JPIDL	F1JPO1L	F1JPG1L	F1JPT1L	F1JPU1L
United Kingdom	F1UKIDL	F1UKO1L	F1UKG1L	F1UKT1L	F1UKU1L
United States	F1USIDL	F1USO1L	F1USG1L	F1UST1L	F1USU1L

Table 10: Datastream Tickers of 10-Year Government Bond Yields

Country	*10-year Government Bond Yields*
Australia	AUOIR080R
Canada	CNOIR080R
France	FROIR080R
Germany	BDMIR080R
Japan	JPOIR080R
United Kingdom	UKOIR080R
United States	USOIR080R

8.2 Decomposition of Structural Shocks

8.2.1 Equities

From the asset return decomposition, it follows that the structural shocks are given by the following equations:

$$N_{CF,s,t+1} = (\mathbb{E}_{t+1} - \mathbb{E}_{t+1}) \left[\sum_{j=0}^{\infty} \rho_s{}^j \Delta d_{t+1+j} \right]$$

$$N_{RR,s,t+1} = (\mathbb{E}_{t+1} - \mathbb{E}_{t+1}) \left[\sum_{j=0}^{\infty} \rho_s{}^j r_{f,t+1+j} \right]$$

$$N_{RP,s,t+1} = (\mathbb{E}_{t+1} - \mathbb{E}_{t+1}) \left[\sum_{j=0}^{\infty} \rho_s{}^j xr_{s,t+1+j} \right]$$

When fitting these equations into the VAR framework, the following notation is obtained:

$$(\mathbb{E}_{t+1} - \mathbb{E}_t)[xr_{s,t+1}] = e1' \, u_{t+1}$$

$$N_{CF,s,t+1} = (\mathbb{E}_{t+1} - \mathbb{E}_t)[xr_{s,t+1}] + N_{RR,s,t+1} + N_{RP,s,t+1}$$

$$N_{RR,s,t+1} = e5' \left(\sum_{j=1}^{\infty} \rho_s{}^j A^{j-1} \right) u_{t+1} - e4' \left(\sum_{j=0}^{\infty} \rho_s{}^j A^j \right) u_{t+1}$$

$$N_{RPs,t+1} = e1' \left(\sum_{j=1}^{\infty} {\rho_s}^j A^j \right) u_{t+1}$$

Here $e1$ to $e6$ is the column vectors of a 6 x 6 identity matrix, ρ_s is the log-linearisation parameter, A is the 6 x 6 slope coefficient matrix and u_{t+1} is the 6 x 1 residual vector. We may further take advantage of the properties of an infinite series and write the equations in the following form:

$$N_{CF,s,t+1} = e1' \, u_{t+1} + N_{RR,s,t+1} + N_{RP,s,t+1}$$

$$N_{RP,s,t+1} = e1' \, \rho_s A \, (I - \rho_s A)^{-1} \, u_{t+1}$$

$$N_{RR,s,t+1} = e5' \, \rho_s \, (I - \rho_s A)^{-1} \, u_{t+1} - e4' \, (I - \rho_s A)^{-1}$$

Here, I denotes the identity matrix.

8.2.2 Bonds

For bonds, it follows from the asset return decomposition that the structural shocks are given by the following equations:

$$N_{CF,n,t+1} = -N_{INFL,n,t+1} = -(\mathbb{E}_{t+1} - \mathbb{E}_{t+1}) \left[\sum_{j=1}^{n-1} {\rho_b}^j \pi_{t+1+j} \right]$$

$$N_{RR,n,t+1} = (\mathbb{E}_{t+1} - \mathbb{E}_{t+1}) \left[\sum_{j=1}^{n-1} {\rho_b}^j r_{f,t+1+j} \right]$$

$$N_{RP,n,t+1} = (\mathbb{E}_{t+1} - \mathbb{E}_{t+1}) \left[\sum_{j=1}^{n-1} {\rho_b}^j xr_{n-j,t+1+j} \right]$$

As with equities, we can fit these into the VAR framework and obtain the following notation:

$$(r_{n,t+1} - \mathbb{E})[xr_{n,t+1}] = e2' \, u_{t+1}$$

$$N_{CF,n,t+1} = -e4' \left(\sum_{j=1}^{n-1} \rho_b{}^j A^j \right) u_{t+1}$$

$$N_{RR,n,t+1} = e5' \left(\sum_{j=1}^{n-1} \rho_b{}^j A^{j-1} \right) u_{t+1} - e4' \left(\sum_{j=1}^{n-1} \rho_b{}^j A^j \right)$$

$$N_{RP,n,t+1} = N_{CF,n,t+1} - N_{RR,n,t+1} - (r_{n,t+1} - \mathbb{E})[xr_{n,t+1}]$$

Finally, from the properties of a geometric series, we show that these equations can also be expressed as:

$$N_{CF,n,t+1} = -e4' \, (I - \rho_b A)^{-1} \, (\rho_b A - \rho_b^n A^n) \, u_{t+1}$$

$$N_{RR,n,t+1} = e5' \, (I - \rho_b A)^{-1} \, (\rho_b - \rho_b^n A^{n-1}) \, u_{t+1} - e4' \, (I - \rho_b A)^{-1} \, (\rho_b A - \rho_b^n A^n) \, u_{t+1}$$

$$N_{RP,n,t+1} = N_{CF,n,t+1} - N_{RR,n,t+1} - e2' \, u_{t+1}$$

8.3 Coefficients Used for Calculating Portfolio Risk Across Investment Horizon

For an equally weighted portfolio of N markets, the portfolio risk, normalised by the investment horizon, K, is given by:

$$\frac{1}{K} \mathbb{V}_t\left[r_{p,t+k}^{(k)}\right] = \frac{1}{N} \frac{1}{K} \mathbb{V}_t\left[r_{i,t+k}^{(k)}\right] + (1 - \frac{1}{N}) \frac{1}{K} \mathbb{C}_t\left[r_{i,t+k}^{(k)}, r_{j,t+k}^{(k)}\right]$$

Where the variance and covariance terms are expressed as:

$$\frac{1}{K} \mathbb{V}_t\left[r_{i,t+k}^{(k)}\right] = \sigma_{CF,CF}^{wc} + [a(k)^2 + b(k)\,] * \sigma_{DR,DR}^{wc} - 2 * a(k) * \sigma_{CF,DR}^{wc}$$

$$\frac{1}{K} \mathbb{C}_t\left[r_{i,t+k}^{(k)}, r_{j,t+k}^{(k)}\right] = \sigma_{CF,CF}^{xc} + [a(k)^2 + b(k)\,] * \sigma_{DR,DR}^{xc} - 2 * a(k) * \sigma_{CF,DR}^{xc}$$

Here, the coefficients are given by:

$$a(k; \beta, \phi, \lambda) = \left(\frac{\beta}{\lambda * (1 - \phi)} \right) \left(\frac{k-1}{k} - \phi \frac{1 - \phi^{k-1}}{k(1 - \phi)} \right)$$

$$b(k;\beta,\phi,\lambda) = \left(\frac{\beta}{\lambda * (1-\phi)}\right)^2 \left(\frac{1-\phi}{1+\phi} - \frac{1-(\phi^2)^k}{(k(1+\phi)(1+\phi)} + 2\frac{\phi}{(1+\phi)}\left(\frac{k-1}{k} + \frac{(\phi^{k-1}-1)*(\phi-\phi^{k-1})}{\left(k(1-\phi)\right)} - \frac{1-(\phi^2)^{k-1}}{k(1-\phi)(1+\phi)}\right) - \left(\frac{k-1}{k} - \phi\frac{1-\phi^{k-1}}{k(1-\phi)}\right)^2\right)$$

Where k denotes the investment horizon, β is the slope coefficient given by the position [1,3] in the slope coefficient matrix, ϕ is the slope coefficient given by the position [3,3] in the slope coefficient matrix, and $\lambda = \frac{\rho_s * \beta}{1-\rho_s * \phi}$. Recall that ρ_s is a log-linearisation parameter, given by $\frac{1}{1+\exp(\overline{d-p})}$. Here, $(\overline{d-p})$ denotes the unconditional mean around the dividend yield. For bonds, the log-linearisation parameter, ρ_b, is given by $\frac{1}{1+\exp(\overline{c-p})}$, where $(\overline{c-p})$ is the unconditional mean around the yield to maturity.

8.4 Fisher r-to-z Transformation

We apply the Fisher transformation method to calculate whether there have been any significant changes in correlation between the two subperiods.

The formula is given by: $z_1 - z_2 \sim \mathcal{N}\left(\frac{1}{2}\ln\left(\frac{1+\rho_1}{1-\rho_1}\right) - \frac{1}{2}\ln\left(\frac{1+\rho_2}{1-\rho_2}\right), \frac{1}{N_1-3} + \frac{1}{N_2-3}\right)$. Here, ρ_t, denotes correlation in subperiod t, and N_t denotes number of observations in subperiod t.

8.5 Currency Hedging Properties Applied in the VAR-Estimations

For an investor investing into an asset denoted in a foreign currency, his one-period unhedged return denominated in home currency follows from the equation:

$$1 + R_{t+1}^h = \left(1 + R_{t+1}^f\right)\frac{S_{t+1}}{S_t}$$

Here, R^f denotes the one-period return on the foreign asset denominated in foreign currency, and R^h denotes the one-period return in home currency. S denotes the spot foreign exchange rate, which implies that an increase in S reflects that the foreign currency is strengthening relative to the home currency. It should here be noted that the investor's one-period return is uncertain as the future spot exchange rate, S_{t+1} is not known at time t.

Therefore, if the investor at time t would like to lock in the one-period return, he could apply a forward contract. Thus, the investor's one-period hedged return follows from:

$$1 + R_{t+1}^{h} = \left(1 + R_{t+1}^{f}\right)\frac{F_{t+1}}{S_t}$$

Here, F, denotes the forward rate.

From covered interest rate parity, it follows that the relationship between the nominal interest rates and the spot and forward exchange rates in the two countries should be given by:

$$1 + i_{t+1}^{h} = \left(1 + i_{t+1}^{f}\right)\frac{F_{t+1}}{S_t}$$

This theoretical condition follows from a no-arbitrage argument. It states that it does not matter in which currency you invest in, given that you hedge the currency risk. A forward hedged investment in any currency will have the same return denominated in the home currency. This is because the forward premiums or discounts will exactly outweigh the interest rate differentials (Bekaert & Hodrick, 2011).

From this relationship, it follows by combining the equations above that the hedged excess returns denominated in home currency is given by:

$$\frac{1 + R_{t+1}^{h}}{1 + i_{t+1}^{h}} = \frac{1 + R_{t+1}^{f}}{1 + i_{t+1}^{f}}$$

Or in log terms:

$$r_{t+1}^{h} - r_{f,t+1}^{h} = r_{t+1}^{f} - r_{f,t+1}^{f}$$

This implies that an investor would obtain the same excess currency-hedged return denominated in home currency from investing into a foreign asset denominated in foreign currency that a foreign investor would obtain by investing into the same asset in his home currency. In other words, from the covered interest rate parity, it follows that home excess currency-hedged returns should equal local excess returns.