International Diversification from a UK Perspective

Exploring the Risk-Reduction Effects of Diversification for UK Investors

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Executive Summary

The market turmoil of 2008 highlighted the importance of risk management to investors in the UK and worldwide. Realized risk levels and risk forecasts from the Barra Europe Equity Model (EUE2L) are both currently at the highest level for the last two decades.

According to portfolio theory, institutional investors can gain significant risk-reduction and return-enhancement benefits from venturing out of their domestic markets. These effects from international diversification are due to imperfect correlations among markets. In this paper, we explore the historical diversification effects of an international allocation for UK investors. We illustrate that investing only in the UK market can be considered an active deviation from a global benchmark. Although a domestic allocation to UK large-cap stocks has significant international exposure when revenue sources are taken into account, as an active deviation from a global benchmark a UK domestic strategy has high concentration, leading to high asset-specific risk, and significant style and industry tilts.

We show that an international allocation resulted in higher returns and lower risk for a UK investor in the last one, three, five, and ten years. In GBP terms, the MSCI All Country World Investable Market Index (ACWI IMI) — a global index that could be viewed as a proxy for a global portfolio — achieved higher return and lower risk compared to the MSCI UK Index during these periods. A developed market minimum-variance portfolio, represented by the MSCI World Minimum Volatility Index,[1] typically showed still better risk and return performance during these periods. The decreases in risk represented by allocations to MSCI ACWI IMI and the MSCI World Minimum Volatility Index were robust based on four different measures of portfolio risk.

We also consider a stepwise approach to international diversification, sequentially adding small cap and international assets to a large cap UK portfolio. We show that this approach also reduced risk during the observed period, but we did not find evidence that it was more efficient for risk reduction than a passive allocation to MSCI ACWI IMI.

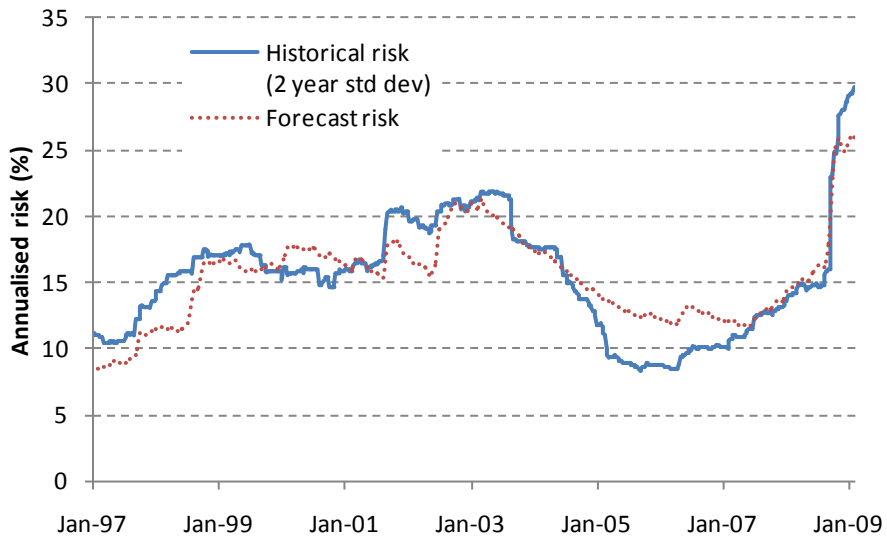
Introduction

The market turmoil of 2008 highlighted the importance of risk management to investors in the UK and worldwide. Figure 1 illustrates that the historical standard deviation of the MSCI UK Index is now near the highest level in recent history. The risk forecast for the index, obtained using the Barra Europe Equity Model,[2] (EUE2L) also shows historically high levels of expected risk. Given the current unprecedented levels of risk in UK equities, in this paper we examine the historical risk and return effects of international diversification.

The UK equity market has several characteristics that are worth highlighting. A UK large cap domestic strategy typically results in a very concentrated portfolio with significant asset-specific risk, compared to an international allocation. Table 1 compares some characteristics of the MSCI UK, MSCI Europe, MSCI World, and MSCI ACWI IMI Indices using the Barra Global Equity Model (GEM2L). It illustrates how the contribution of asset-specific risk to total portfolio risk changes when moving toward a more diversified portfolio. The MSCI UK Index—based on the MSCI Global Investable Market Indices methodology, which provides exhaustive coverage for the UK investable universe -- is representative of the UK large cap opportunity set. As of February 1, 2009, the MSCI UK Index had 113 constituents, or assets, with the largest five companies representing 35.3% of the weight of the index. As a consequence of this high concentration, asset-selection risk accounted for 4.1% of the total forecast risk for the index. By contrast, the MSCI ACWI IMI contained 8390 assets, with the largest five assets representing 5.3% of the index. Asset-selection risk contributed just 0.2% to the total risk for the index.

[1] See Appendix 1 for a detailed description of the MSCI World Minimum Volatility Index.
[2] This risk forecast is appropriate for an investor with a horizon in excess of 6 months. For details, refer to the EUE2S and EUE2L Research Notes, available at www.mscibarra.com

Figure 1: Historical and forecast risk for the MSCI UK Index (in GBP)



Source: MSCI Barra

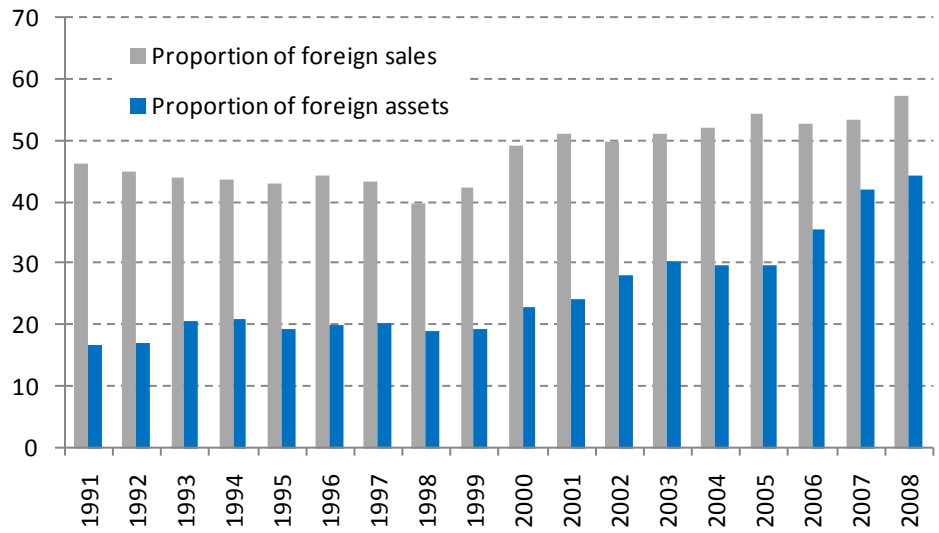
Table 1: Risk characteristics of indices using GEM2L (in GBP, as of February 1, 2009)

	Number of assets	Weight of top 5 companies (%)	Asset selection Risk (% Std Dev)	Total Risk (% Std Dev)	Asset Selection Risk Contribution (% Total Risk)
MSCI UK	113	35.3	5.45	26.93	4.10
MSCI Europe	491	12.6	2.64	27.20	0.94
MSCI World	1685	6.6	1.54	25.68	0.36
MSCI ACWI IMI	8390	5.3	1.26	26.16	0.23

Source: MSCI Barra

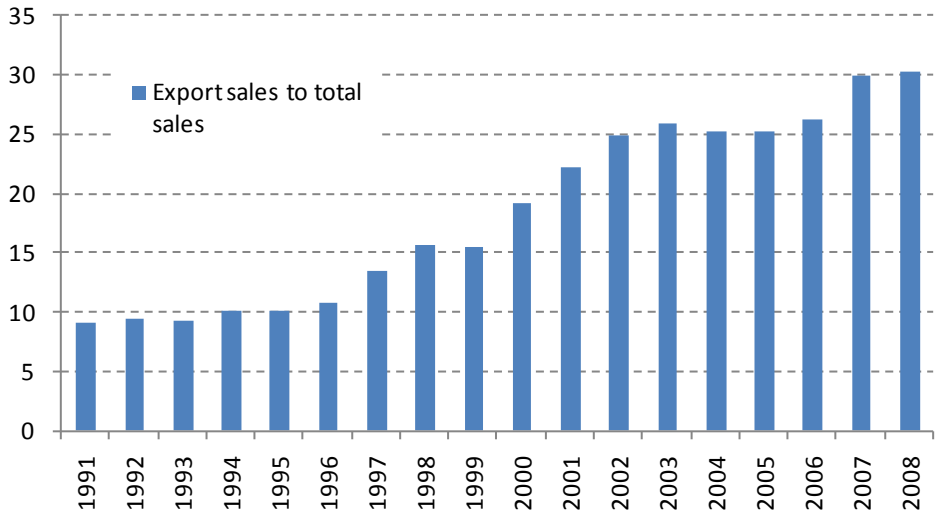
It is also interesting to consider how the international exposure of UK companies has changed through time. While companies traditionally derived most of their income from their home country, in an age of increasing globalization, domicile may no longer capture the true international exposure of a portfolio, as argued by Kottler and Hayes (2008). Instead, revenue and asset sources may provide a better proxy as to where a company operates in the world. The UK market has a special feature in this regard: due to the favorable regulatory environment, it consists of a number of international companies that have chosen to list in London, as well as companies that have traditionally been based in the UK. Using revenue and assets as a metric, a domestic UK equity allocation has taken on an increasingly international tilt in recent years. Figure 2 shows that the proportion of overseas sales, as well as the proportion of overseas assets, of the largest 150 UK companies from the estimation universe of the Barra EUE2 model, has grown considerably in recent decades. Therefore, taking revenues and assets into account, an investor in UK domestic equities takes on significant international exposure. This trend is apparent around the world—for example, in Japan, the proportion of exports to total sales has also grown considerably for the largest 350 companies, as shown in Figure 3. Japan provides an interesting comparison to the UK, as both UK and Japanese markets account for approximately 10% each of the developed market equity universe.

Figure 2: International exposure of UK companies (capitalization-weighted average)



Source: MSCI Barra

Figure 3: Proportion of export sales to total sales for Japanese companies (capitalization-weighted average)



Source: MSCI Barra

While a portfolio of large cap UK stocks takes on significant international exposure when revenue sources are taken into account, it does not do so in an efficient way. A straightforward way to see this is to examine the risk and return profile of the MSCI UK Index and compare it to an international allocation. Table 2 shows this comparison for the MSCI ACWI IMI and the MSCI World Minimum Volatility Index. The MSCI ACWI IMI provided higher return and lower risk compared to the MSCI UK Index in the last one, three, five, and ten years. The MSCI World

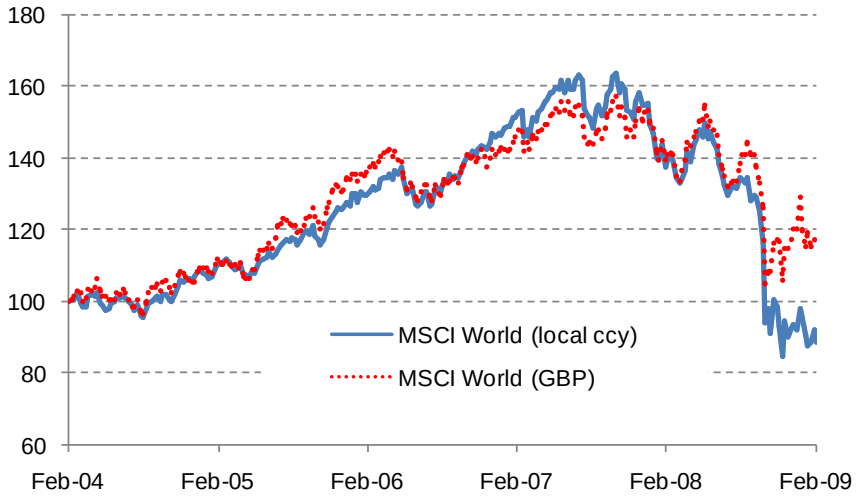
Minimum Volatility Index[3] also outperformed the MSCI UK Index in terms of both risk and return during all the trailing periods considered in the table.

Table 2: Recent performance of MSCI domestic and international indices (in GBP, as of January 9, 2009)

	1 year		3 years		5 years		10 years	
	Annualized return	Annualized risk	Annualized return	Annualized risk	Annualized return	Annualized risk	Annualized return	Annualized risk
UK	-28.78%	37.49%	-4.87%	24.27%	3.14%	19.65%	0.38%	18.85%
ACWI IMI	-24.29%	30.07%	-4.28%	20.16%	3.51%	17.20%	1.79%	18.19%
World Min Volatility	-10.53%	25.55%	-1.76%	16.83%	4.06%	14.37%	1.41%	13.76%

International investing may also seem particularly topical to UK asset owners in light of the currency movements of the last few months. The British Pound declined significantly since October, enhancing the sterling return to international investments (see Figure 4). While this episode is only an illustration, for investors concerned about possible depreciation of Pound, investing internationally and leaving currency exposure unhedged, expresses this view.[4]

Figure 4: Currency effect in the MSCI World Index



Source: MSCI Barra

The discussion above highlights several important issues that we will examine in this paper. We have seen that, taking revenue sources into account, a home-bias allocation to large cap UK stocks takes on significant international exposure. We have also demonstrated that such an allocation had higher and more concentrated risk relative to a true international allocation, such as the MSCI ACWI IMI. In Section I, we examine the characteristics of a UK domestic-bias allocation. Section II presents our main results regarding the risk and return effects of international diversification. Section III looks at the building blocks of international investment and Section IV provides a conclusion.

[3] See Appendix 1 for a description of the MSCI World Minimum Volatility Index
[4] Currency hedging is an important dimension of international investing. For a comprehensive review of currency hedging see Chang (2009).

I. International Investing for UK Asset Owners

According to portfolio theory, pure domestically invested asset portfolios are typically suboptimal. As international markets become more accessible, institutional investors may gain significant risk-reduction and return-enhancement benefits from venturing out of their domestic markets as a result of imperfect correlations among markets.

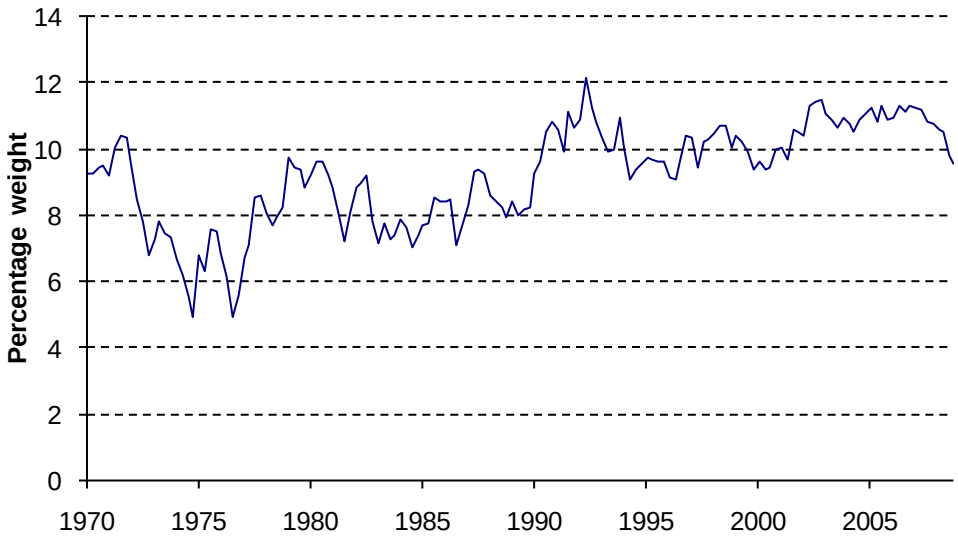
The risk-reduction and return-enhancement effects of international diversification have been well documented in the literature ever since the early studies of Grubel (1968) and Lessard (1973). Cavaglia, Melas, and Tsouderos (2000) show that institutional investors could substantially increase their return-to-risk tradeoffs by diversifying into foreign equity markets. Moreover, asset allocation across countries and across industries is shown to dominate the traditional country selection strategies. Fletcher and Marshall (2005) find significant diversification benefits from adding global industry or country equity portfolios to a UK domestic mean variance strategy.

Although the implications of international diversification are well known, it is also well established in academic studies that investors consistently fail to exploit these effects, preferring to concentrate their investments in the equities of their home country. For example, Cooper and Kaplanis (1994) report that UK investors place 78.5% of their equity portfolios in domestic equities, against a figure of 10.3% of the UK market as a proportion of the world equity market capitalization. While relative market capitalizations do not necessarily correspond to optimal portfolio weights, the wide disparity between domestic portfolio holdings and the weight of the domestic market in the world suggests a diversification inefficiency, which is known as the equity home-bias puzzle. The explanations for this bias typically focus on investor behavior or institutional factors. These include investor familiarity and optimism for the local market on the one hand, and liability driven investing considerations on the other, as local assets can be a better hedge against investor liabilities than foreign assets.

In recent years, the UK has seen a major shift towards global investing, either through separate UK and global ex UK mandates, or one mandate embracing both elements. There is evidence that many UK plan sponsors have reduced their domestic equity allocations to 50-60%, from a previous typical domestic allocation in excess of 70% (Motyl and Sweeting 2007). However, the weight of UK large-cap stocks in the developed market large-cap universe has remained at around 8-12% over the last two decades (see Figure 5), suggesting that a significant diversification inefficiency in asset allocation remains.

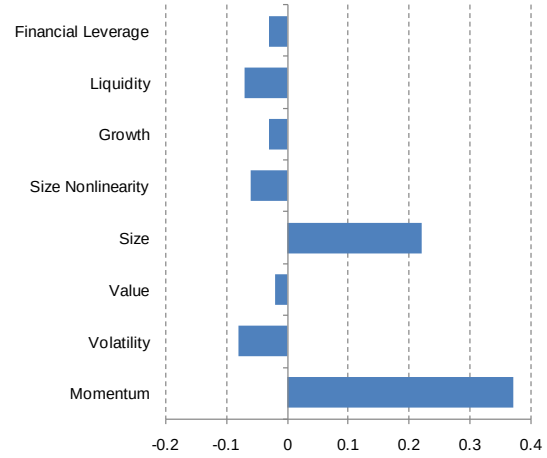
Doppel (2008) argued that in a global environment an investor should compare the risk and return of his portfolio with that of the average global investor. In recent decades, there has been significant progress in the removal of institutional barriers to international investing — more trade agreements, fewer currency controls and standardized accounting rules all make it easier to do business and invest globally. Allocating assets globally provides a wider opportunity set. The equity opportunity set of the average global investor can be approximated by the MSCI ACWI IMI, which is a market capitalization-weighted index portfolio spanning 23 Developed Markets and 23 Emerging Markets. The MSCI ACWI IMI comprises more than 8000 securities and is the most comprehensive index within the MSCI Global Investable Market Indices (GIMI). The MSCI Global Investable Market Indices combine the MSCI Standard Indices and MSCI Small Cap Indices for the Developed, Emerging and Frontier Markets, providing a passive representation of the large, mid and small cap global opportunity set. The MSCI ACWI IMI can serve as a benchmark for a global equity portfolio (see Kumar 2008). Any other domestic-international allocation, including a domestic-only allocation, would then be considered as an active deviation from the benchmark. A home-bias allocation, that constrains the portfolio's opportunity set to large-cap domestic equities, is one such active strategy.

Figure 5: Share of UK in MSCI World Index



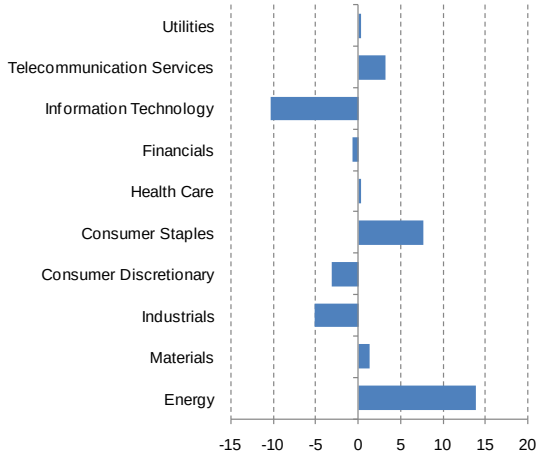
Source: MSCI Barra

Figure 6: Active style exposures of the MSCI UK Index (February 2009)



Source: MSCI Barra

Figure 7: Active GICS®[5] sector exposures of the MSCI UK Index (February 2009)



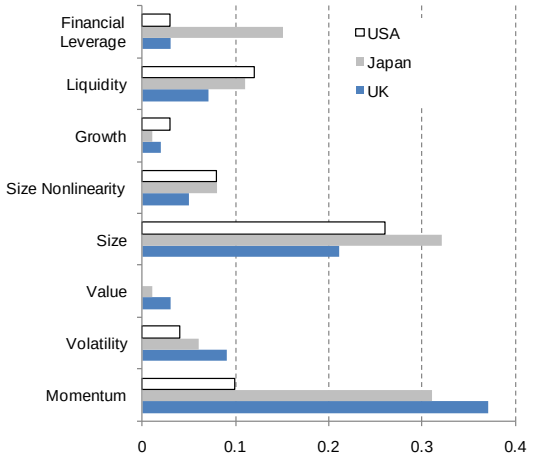
Source: MSCI Barra

Investors in the UK market have active exposures to several style and industry risks, as illustrated in Figures 6 and 7, when compared to a global benchmark. Taking the MSCI ACWI IMI as the global benchmark, the MSCI UK Index has a significant positive active exposure to the momentum and size style factors, meaning that the investor in the MSCI UK Index is overweight stocks that have outperformed in the last 12 months, as well as large cap stocks, compared to the investor in the MSCI ACWI IMI.[6] The MSCI UK Index also has positive sector tilts towards Energy and Consumer Staples sectors and a negative tilt towards the Information Technology sector.

[5] Global Industry Classification Standard (GICS®)
[6] It is worth noting that while the size exposure is a permanent effect, the momentum exposure will change through time.

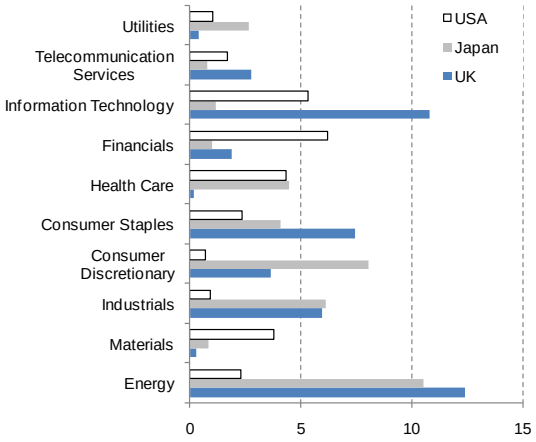
It is interesting to compare the magnitude of active style and sector tilts of the UK market with other domestic markets around the world. Figures 8 and 9 show the absolute values of style and sector tilts of the MSCI UK, MSCI Japan, and MSCI USA Indices. As mentioned earlier, the Japanese market provides an interesting comparison to the UK market, as both countries have an approximately equal weight in the developed market equity universe. We see that the UK and Japanese markets have a similar number of large style tilts, but the Japanese market appears more diversified across sectors. Unsurprisingly, the US market is more broadly diversified overall. This international comparison illustrates that domestic UK investors are likely to hold portfolios that are less diversified across risk factors compared to domestic Japan or US investors.

Figure 8: Absolute values of style exposures of domestic indices (February 2009)



Source: MSCI Barra

Figure 9: Absolute values of sector exposures of domestic indices (February 2009)



Source: MSCI Barra

Note: These charts illustrate the magnitude, but not the sign, of the exposures.

In this section we have demonstrated that a domestic allocation to UK equities still achieves some global exposure, but can be considered an active deviation from a global benchmark that results in a concentrated portfolio with significant asset specific risk. It also has important implicit style and sector bets if ACWI IMI is used as the benchmark.

II. Volatility and International Diversification

Table 4 compares the risk and return in recent times of the MSCI UK Index with international asset allocations. The top panel looks at the MSCI ACWI IMI and the MSCI World Minimum Volatility Index, while the bottom panel considers some individual components of the international investment universe. The MSCI World Minimum Volatility Index is based on the MSCI World Index security universe (see Nielsen and Aylursubramanian, 2008). It uses the global equity covariance matrix from the Barra Global Equity Model (GEM) to construct a minimum-variance portfolio for a specified set of constraints. Looking at the bottom panel of Table 4, we see significant differences between the different parts of the investable universe—for example, five-year annualized returns range from -0.2% for the MSCI US Small Cap Index to 10.5% for the MSCI Emerging Markets Index, while five-year annualized risk ranges from 16.9% for the MSCI World ex UK Index to 23.6% for the MSCI Emerging Markets Index. Japanese small cap stocks, as represented by the MSCI Japan Small Cap Index, are the least correlated with the MSCI UK Index (0.31-0.38), while the MSCI Europe ex UK Index is the most correlated (0.91-0.92). While correlations of Developed Markets and UK stocks are high in aggregate, there are still some

segments of the Developed Markets universe with low correlations, in particular Japan and Japan Small Caps. The MSCI World Minimum Volatility Index, which does not include small caps or Emerging Markets, was consistently less volatile than all of these segments as well as the other parts of the investable universe.[7]

Table 4: Recent performance and correlations of Developed, Emerging, and Frontier Markets (in GBP, as of January 9, 2009)

	1 year			3 years			5 years		
	Annualized return	Annualized risk	Corr. with MSCI UK	Annualized return	Annualized risk	Corr. with MSCI UK	Annualized return	Annualized risk	Corr. with MSCI UK
UK	-28.78%	37.49%	1.00	-4.87%	24.27%	1.00	3.14%	19.68%	1.00
ACWI IMI	-24.29%	30.07%	0.91	-4.28%	20.16%	0.90	3.51%	17.19%	0.88
World Min Volatility	-10.53%	25.55%	0.78	-1.76%	16.83%	0.78	4.06%	14.36%	0.77
UK Small Cap	-37.43%	33.37%	0.87	-12.24%	23.27%	0.85	0.70%	19.22%	0.83
Eur ex. UK	-30.88%	36.47%	0.92	-0.79%	24.24%	0.92	6.52%	20.15%	0.91
Eur ex. UK Small Cap	-38.97%	33.89%	0.83	-5.82%	23.59%	0.82	7.24%	19.77%	0.80
US	-17.61%	31.08%	0.78	-5.21%	20.92%	0.77	0.51%	18.19%	0.75
US Small Cap	-12.71%	35.14%	0.77	-8.34%	24.93%	0.75	-0.21%	22.38%	0.71
Japan	-4.22%	25.09%	0.46	-7.26%	19.36%	0.45	4.11%	18.69%	0.42
Japan Small Cap	5.01%	26.70%	0.38	-16.21%	22.57%	0.31	2.85%	21.16%	0.31
World ex. UK	-20.71%	29.60%	0.88	-4.01%	19.80%	0.87	2.93%	16.99%	0.85
World ex. UK Small Cap	-19.37%	30.68%	0.84	-8.75%	21.02%	0.83	2.65%	18.43%	0.80
EM	-47.40%	38.46%	0.83	-1.77%	27.34%	0.80	10.47%	23.56%	0.78
EM Small Cap	-59.09%	33.15%	0.71	-5.09%	24.58%	0.66	8.10%	21.34%	0.65

Volatility, or the standard deviation of return, is widely used as a measure of portfolio risk. If returns follow the normal distribution, then volatility is a complete measure of risk. Figure 10 shows how the realized volatility of the MSCI UK Index, the MSCI ACWI IMI, and the MSCI World Minimum Volatility Index changed through time. We see that the MSCI World Minimum Volatility Index typically had the lowest realized volatility of the three, while the MSCI ACWI IMI was consistently less volatile than the MSCI UK Index in the last two years.

Recently, we have seen increasing interest in risk measures that go beyond the normal distribution. These measures complement volatility by quantifying the risk of extreme events. Table 5 examines some of these risk measures for the MSCI UK, MSCI ACWI IMI, and MSCI World Minimum Volatility Indices for one-, three- and five-year horizons. We consider Value at Risk (VAR), Expected Shortfall, and Maximum Drawdown. VAR is defined as the minimum loss experienced by a portfolio at a given probability over a given investment horizon. For example, using data from the last 100 trading days, we can estimate 1-day 95% VAR as the fifth largest daily loss experienced by the portfolio in the last 100 trading days. Expected Shortfall, on the other hand, is defined as the average loss experienced by a portfolio when the VAR level is breached. For example, using data from the last 100 trading days, we could compute 1-day 95% Expected Shortfall as the average of the four largest 1-day losses in the last 100 trading days. In layman terms, VAR is how much money you could lose on your “best” bad day, while Expected Shortfall is how much money you could lose on your “average” bad day. Maximum Drawdown is the maximum cumulative loss from a market peak to the following trough. It is a measure of how sustained one’s losses can be. Large drawdowns can lead to fund redemptions, and therefore drawdown can be a valuable indicator to money management professionals. The MSCI ACWI IMI consistently outperformed the MSCI UK Index across all risk measures and all trailing horizons during the observed period. The MSCI World Minimum Volatility Index, however, performed even better, offering approximately a two-fold reduction in Expected Shortfall and Maximum Drawdown compared to the MSCI UK Index. Figure 11 illustrates the drawdowns through the observed period.

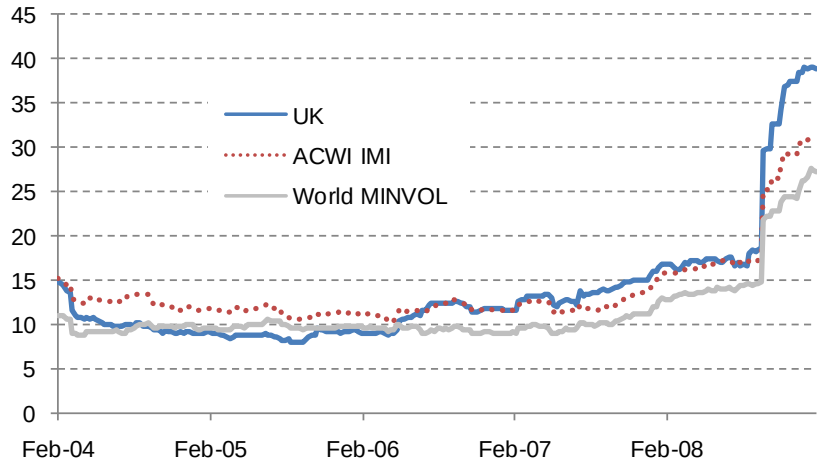
[7] One exception is the MSCI Japan Index, which was slightly less volatile than the MSCI World Minimum Volatility Index over the last year.

Table 5: Alternative risk measures (in GBP, as of January 9, 2009)

	1 year			3 years			5 years		
	VAR	Expected shortfall	Maximum drawdown	VAR	Expected shortfall	Maximum drawdown	VAR	Expected shortfall	Maximum drawdown
UK	-2.50%	-4.07%	39.43%	-2.58%	-4.14%	41.56%	-1.87%	-3.19%	41.56%
ACWI IMI	-2.05%	-3.35%	36.14%	-2.08%	-3.36%	36.74%	-1.58%	-2.61%	36.74%
World Min Volatility	-1.65%	-2.69%	21.97%	-1.65%	-2.70%	24.55%	-1.30%	-2.08%	24.55%

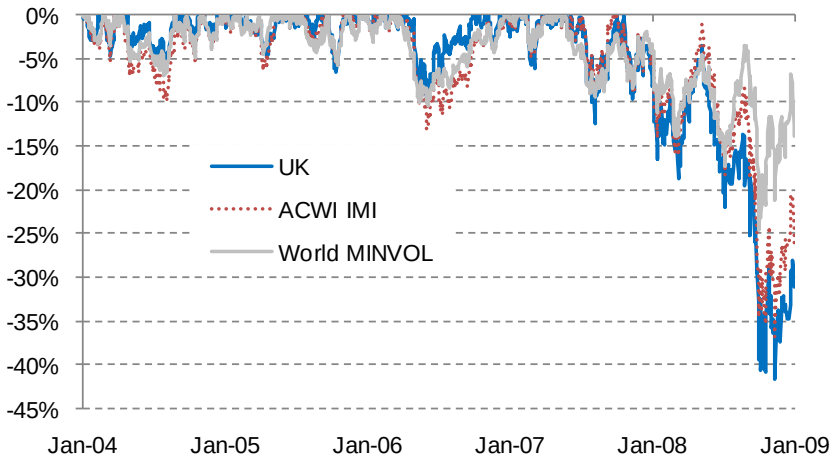
Source: MSCI Barra

Figure 10: Historical volatility of MSCI UK and international portfolios (1-year standard deviation)



Source: MSCI Barra

Figure 11: Drawdowns of MSCI UK and international portfolios



Source: MSCI Barra

In this section, we have illustrated that a domestic-only allocation to UK equities has been suboptimal in terms of both return and several risk measures compared to a global allocation over the last one-, three- and five-year horizons. Even greater risk-reduction benefits were achieved by a minimum-variance portfolio of Developed Market equities, represented by the MSCI World Minimum Volatility Index, during this period.

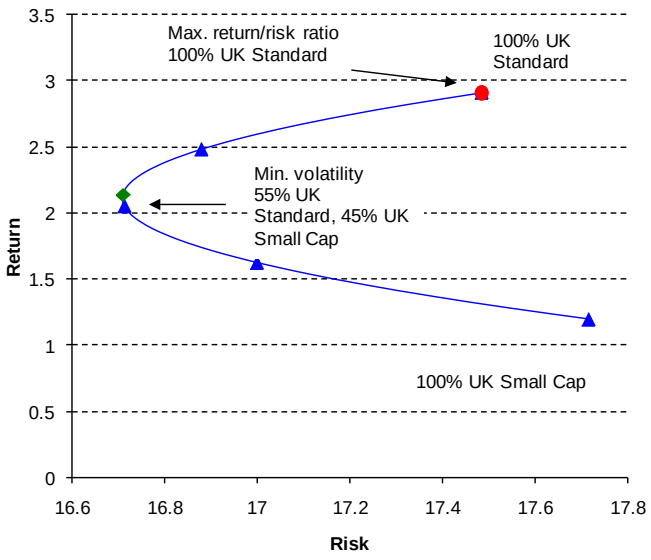
III. A Stepwise Approach to International Diversification

Some investors looking for potential diversification benefits from adopting an international portfolio prefer to take a stepwise approach to international diversification. While we show that this approach is often suboptimal from a diversification perspective compared to a truly global portfolio, some of the risk-reduction effects of international diversification can still be realized in this way.

Diversification with UK small-cap stocks

As a first step, let us evaluate the diversification effects of adding a small cap allocation to the MSCI UK Index. Numerous studies have shown that the return-generating mechanisms for large and small cap stocks are quite different — for example Nielsen (2007) finds that not only are small cap returns more dispersed cross-sectionally, they also depend much less on common-factor sources of return than large caps. This suggests that small cap stocks can be an effective vehicle for diversification, however adding a UK small cap allocation to a UK large cap portfolio still retains the home bias. From Table 4, we see that UK small caps have underperformed UK large caps during recent times, but have been less volatile. The correlations between small and large caps have been high recently, above 0.8. Figure 12 illustrates the ex post efficient frontier over the last 5 years achieved by adding a UK small cap allocation to a UK large cap portfolio. Adding small caps to the portfolio decreased portfolio volatility—the minimum-volatility portfolio is achieved with 55% UK and 45% UK small cap allocation. However, a 100% allocation to the MSCI UK Index achieved the highest return-to-risk ratio.

Figure 12: Ex post efficient frontier with MSCI UK and MSCI UK Small Cap Indices (2003-2008, weekly rebalancing, in GBP)



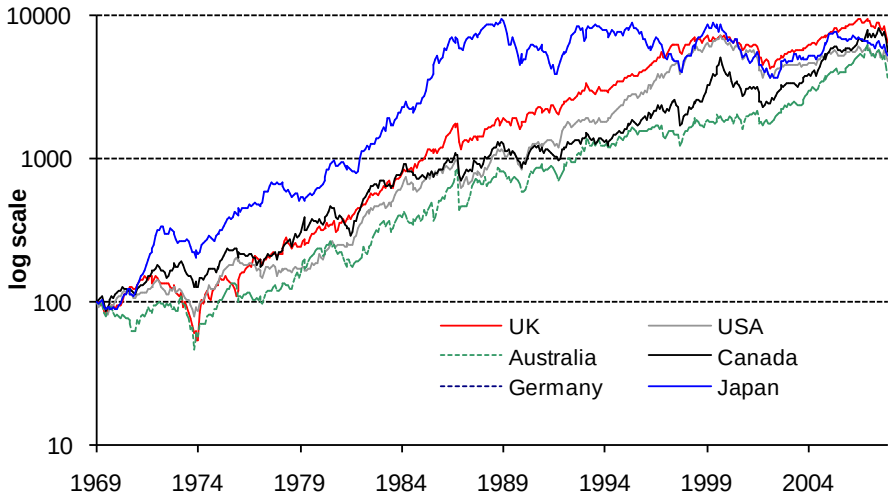
Source: MSCI Barra

Examining Links Between World Markets

Traditionally, international diversification commonly involved investing only in Developed Markets and only in larger capitalization stocks. The diversification effects of such strategies depend on whether the performance of large cap stocks in different countries is sufficiently distinct. In this section, by analyzing monthly returns of MSCI Country Indices for the UK, USA, Australia, Canada, Germany, and Japan, we briefly examine how the linkages between developed market large-cap equity indices have changed since the 1970s. Figure 13 shows the cumulative performance of the equity markets of these six countries. We can see that major equity markets have not always performed similarly—the 1980s saw a bubble specific to Japan, while Australia did not participate in the technology bull market of the late 1990s. Figure 14 shows the correlations of the UK with other equity markets, estimated from a Dynamic Conditional Correlation (DCC)-GARCH model.[8] This estimate is a more structured way to examine correlations in comparison to the rolling-window estimation, where excess noise is created as observations drop out of the estimation window. It is clear that correlations of the UK with other equity markets have differed through time: in general, they remained stable until the mid 1980s and grew since then. We also found that intertemporal links between markets have evolved consistently with the trends in correlations (see Appendix 2).

The analysis of correlations implies that potential risk-reduction effects from international diversification using large-cap stocks have diminished through the recent decades, and consideration of other asset classes for international diversification may be appropriate. Nevertheless, although correlations between Developed Markets have grown over the years, international diversification benefits still exist, as correlations remain below 1.

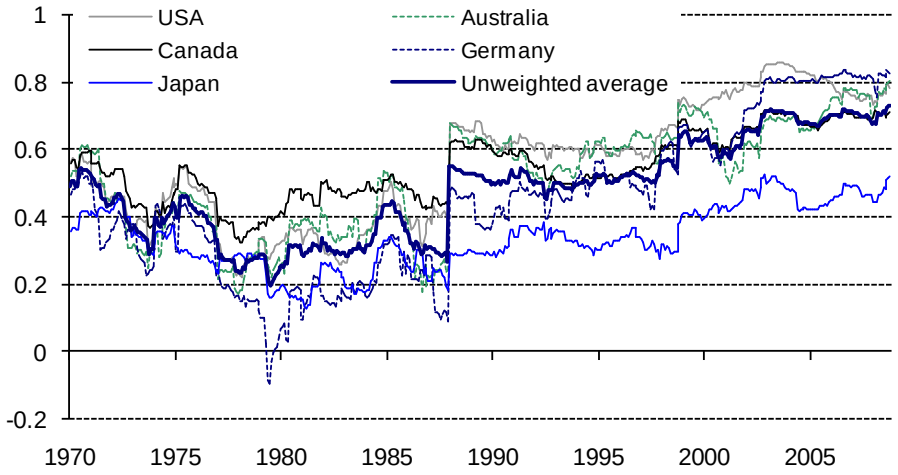
Figure 13: MSCI Country Index performance (in GBP)



Source: MSCI Barra

[8] See Engle (2002) and Appendix 2.

Figure 14: Correlations between MSCI Country Indices estimated from a DCC model

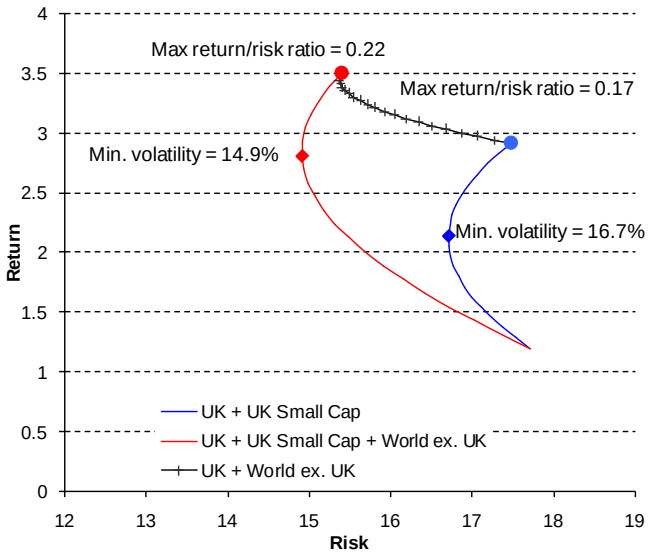


Source: MSCI Barra

Diversification with Developed Market Large- and Small-Cap Stocks

A UK institutional investor seeking broad exposure to international equities might consider adding a World ex UK allocation to the portfolio. Figure 15 shows the efficient frontier obtained in this case. The minimum attainable volatility is reduced to 14.9%, which is a significant reduction from a UK-only volatility of 16.7%. The minimum-volatility portfolio has no UK large cap allocation, 30% UK small cap allocation, and 70% World ex UK allocation. An interesting finding is that adding a World ex UK small cap allocation to the portfolio does not change the frontier. Once UK small cap stocks are included in the portfolio, then including small cap stocks from other regions did not appear to give noteworthy risk-reduction or return-enhancement benefits during the observed period.

Figure 15: Adding a World allocation to a UK portfolio (2003-2008, weekly rebalancing, in GBP)



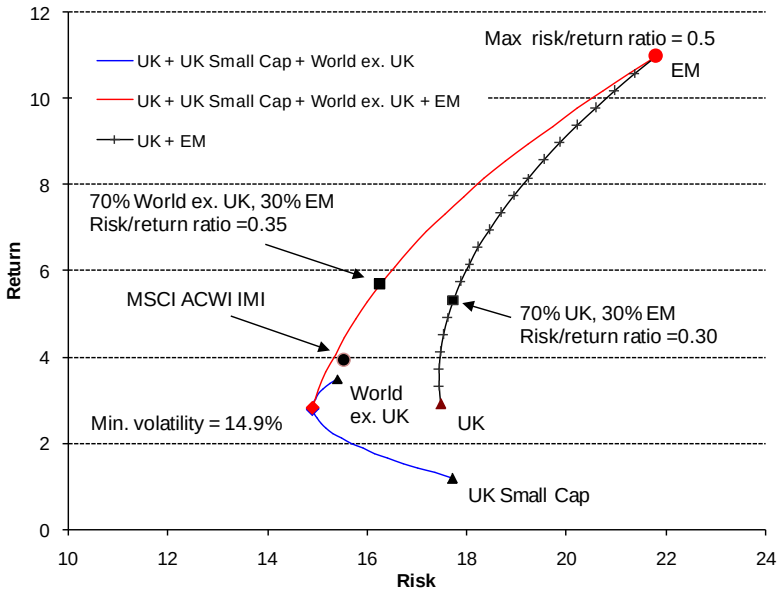
Source: MSCI Barra

Adding Emerging Markets

We have shown that adding international Developed Market allocations to a UK large and small cap portfolio can yield diversification benefits. Historically, the high rates of return and low correlation to Developed Markets have made passive allocations to Emerging Markets attractive from a diversification perspective. In recent years, however, correlations between Emerging Markets and the UK have been high, at approximately 0.8. The performance of Emerging Markets as a group has varied—from Table 4, we see that they outperformed all other segments considered on 3- and 5-year horizons, but underperformed in the last year. Figure 16 illustrates how the efficient frontier changes during the observed period with the addition of the MSCI Emerging Markets Index to a UK portfolio. The minimum-volatility portfolio remains the same, although adding an Emerging Markets allocation would have increased portfolio returns, and the maximum attainable return-to-risk ratio rises to 0.5. Even an allocation of 30% to Emerging Markets showed a significant impact on the return-to-risk ratio.

An important observation is that the MSCI ACWI IMI lies very close to the efficient frontier that combines Developed and Emerging Markets. The MSCI ACWI IMI is a passive representation of investment in both Developed and Emerging Markets, requiring no inputs in terms of selection or allocations, such as having to choose geography or size within that opportunity set.

Figure 16: Adding Emerging Markets (2003-2008, weekly rebalancing, in GBP)



Source: MSCI Barra

IV. Conclusion

In this paper, we show certain historical diversification effects of an international allocation for UK investors. The links between developed equity markets increased over the last 30 years, leading to higher correlations and necessitating the expansion of the potential investment universe to achieve the greatest diversification effects. However, despite this general increase in correlations, substantial diversification effects from international investing were possible even within the developed market universe.

We first illustrated that the MSCI UK Index can be considered an active deviation from a global benchmark. We demonstrated during the observed period how this active strategy was inefficient from a diversification perspective in several ways: it had high concentration, leading to high asset-specific risk, and significant style and industry tilts. In GBP terms, the MSCI ACWI IMI achieved higher return and lower risk in the last one, three and five years compared to the MSCI UK Index, illustrating the diversification effects to UK institutional investors from broadening the opportunity set to include international large and small cap assets. A Developed Market minimum-variance portfolio, represented by the MSCI World Minimum Volatility Index, showed still better risk and return performance. The decreases in risk represented by allocations to MSCI ACWI IMI and the MSCI World Minimum Volatility Index were robust whether measured by volatility, VAR, expected shortfall or maximum drawdown during the observed period.

Further, we showed how the diversification effects gradually increased for a UK investor, starting with a UK large cap allocation, and then adding UK small caps, Developed Market equities, Emerging Market equities, and Frontier Market equities. Once UK small caps were included in the portfolio, however, we did not find any substantial diversification benefits of including European, World, or Emerging Market small cap stocks during the observed period.

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Appendix 1: A Primer on the MSCI World Minimum Volatility Index[9]

The theoretical minimum-variance (MV) portfolio has been widely known since Markowitz's seminal paper in 1952.[10] The MV portfolio is positioned at the very tip of a mean-variance efficient frontier and describes an equity portfolio with the lowest return variance for a given covariance matrix of stock returns. While all other portfolios on the efficient frontier minimize risk for a given expected return, the MV portfolio minimizes risk without an expected return input.

The MSCI Minimum Volatility World Index is a global minimum-volatility index based on the MSCI World Index security universe. The critical input in a MV Index is the risk estimate, the covariance matrix of equity returns. While return history can be used to create the sample covariance matrix, a more robust covariance matrix would take into account errors in estimation that arise from using purely historical returns. Hence, the global equity covariance matrix from the Barra Global Equity Model (GEM) is used as the risk estimate input to construct the index.

The index is rebalanced semi-annually, and a number of constraints are applied to ensure investability and replicability under realistic assumptions:

- The index is unhedged and constructed from a US dollar perspective.
- The maximum weight of an index constituent is constrained to 1.5%.
- The minimum weight of an index constituent is constrained to 0.05%.
- The GICS® sector weights of the MV index are constrained to ± 5% around the GICS® sector weights of the MSCI World Index.
- The country weights of the MV index are constrained to ± 5% around the country weights of the MSCI World Index.
- The country weights of the MV index are constrained to ± 0.25 standard deviations around the Barra risk index exposures of the MSCI World Index.
- The one-way index turnover is constrained to a maximum of 10% per semi-annual rebalancing.

Given these constraints, the MSCI World Minimum Volatility Index is constructed using the Barra Aegis Optimizer.[11]

[9] For a detailed discussion of the MSCI World Minimum Volatility Index, see Nielsen and Aylursubramanian (2008).
[10] See Markowitz, H. (1952), Portfolio Selection, *Journal of Finance*, 7 (1), pp. 77-91.
[11] A detailed methodology guide for the construction and maintenance of the MSCI Global Minimum Volatility Index is available on request.

Appendix 2: A Description of Statistical Techniques Used in this Study

In this study, we calculate correlations between equity markets using a DCC model, as well as employing principal component analysis and Granger causality tests. This appendix provides a short description of these tools.

Dynamic conditional correlation model

The DCC model extends the GARCH framework to the multivariate case. Let us assume that we have a vector of returns to *n* assets $r_t = (r_{1,t}, r_{2,t}..., r_{n,t})$. Further, assume that the conditional returns are normally distributed with zero mean and conditional covariance matrix H_t. In the DCC model, the covariance matrix is decomposed into

$$H_t = D_t R_t D_t,$$

where D_t is the $n \times n$ diagonal matrix of time-varying standard deviations from univariate GARCH models

$$D_t = \begin{bmatrix} \sqrt{h_{1,t}} & 0 & \dots & 0 \\ 0 & \sqrt{h_{2,t}} & \dots & \vdots \\ \vdots & \vdots & \ddots & 0 \\ 0 & \dots & 0 & \sqrt{h_{n,t}} \end{bmatrix},$$

and R_t is the time-varying correlation matrix. A DCC(1,1) model has the following structure

$$Q_t = (1-\alpha-\beta)\overline{Q} + \alpha\varepsilon_{t-1}\varepsilon'_{t-1} + \beta Q_{t-1}$$

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1},$$

where $\varepsilon_t = D_t^{-1} r_t \sim N(0, R_t)$, $\overline{Q}$ is the unconditional covariance of the standardized residuals ($\overline{Q} = Cov(\varepsilon_t \varepsilon'_t)$), α and β are scalars and

$$Q_t^* = \begin{bmatrix} \sqrt{q_{11,t}} & 0 & \cdots & 0 \\ 0 & \sqrt{q_{22,t}} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sqrt{q_{nn,t}} \end{bmatrix},$$

that is, Q_t^* is a diagonal matrix composed of the square root of the diagonal elements of Q_t. A typical element of R_t will be of the form $\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t} q_{jj,t}}}$. The conditions of parameters α and β mirror those of the univariate GARCH model, that is, $\alpha \geq 0$, $\beta \geq 0$, and $\alpha + \beta < 1$.

Granger Causality Tests

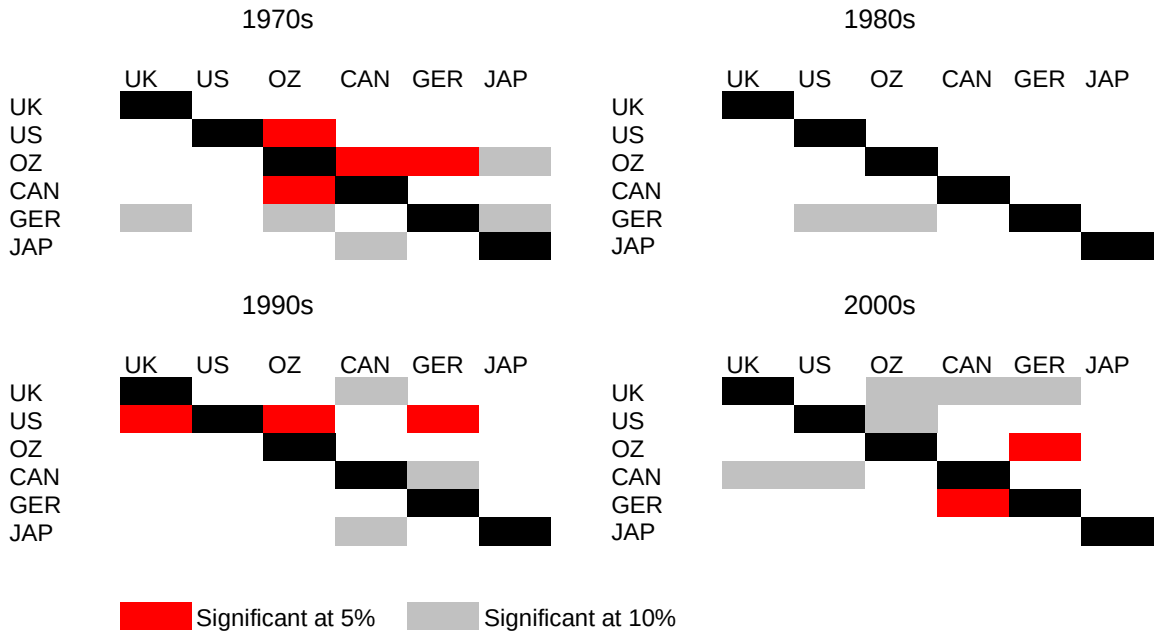
Granger causality tests for statistical feedback between two variables by examining whether the lags of one variable x help to determine another variable y once the lags of y itself are

accounted for. More formally, assume that the information set $\Im_t$ has the form $(x_t, x_{t-1},..., x_1, y_t, y_{t-1},..., y_1)$. In this case, x_t is Granger causal for y_t if the variance of the optimal linear predictor of y_{t+h}, based on $\Im_t$, is smaller than the variance of the optimal linear predictor of y_{t+h}, based on $y_t, y_{t-1},..., y_1$, for any h. In other words, x_t is Granger causal for y_t if x_t helps to predict y_t at some time in the future. It is straightforward to test for Granger causality in a vector autoregression.[12] Causality in the Granger sense does not necessarily imply a cause and effect relationship, but one of predictability.

Using Granger Causality Tests to Analyze Intertemporal Links Between Markets

Granger causality tests can be used to investigate the lead-lag linkages between markets. An independent variable *X* Granger causes changes in dependent variable *Y* if *Y* can be better forecast with past values of *X* and *Y* than just with past values of *Y* alone. Figure A1 shows the results of pairwise tests between developed equity markets for different decades.[13] The results indicate that, while in the 1970s there were numerous lead-lag relationships between markets, these relationships have all but disappeared in the 1980s, only to re-emerge in the recent decade, which is consistent with the trends we observe in correlations. It should be noted that these relationships are only a test of predictability, rather than an indication of any structural link between markets. Therefore, while we believe that at the aggregate level they provide a good overview of the number of statistical connections between markets in different decades, we would interpret any individual relationship between pairs with great caution.

Figure A1: Granger causality test results



Note: Causality runs from rows to columns: in the 1970s, US Granger causes Australia at 5% significance, but no country Granger causes US

[12] See, for example, Enders (2004, p. 283).
[13] A lag of two months was used in the tests.

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