Correlation between bond returns' in developed economies: Evidence from 6 developed countries.

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Abstract

This paper will compare the changing time-varying correlations of 6 developed countries' 10-year bond returns over two time periods. The changing levels of time-varying correlations between the 10-year bond yields of Australia, Canada, Korea, New Zealand, the UK and the US will be analysed and compared. The study looks at the period prior to the global financial crisis and the period post-crisis. The co-movement between the bond markets is of particular interest to investors who seek to diversify their portfolios. Whilst many multi-variate models are available, this paper applies the Dynamic Conditional Correlation (DCC) Multivariate Generalized Autoregressive Conditional Heteroskedasticity (MV-GARCH) modelling technique to estimate time varying conditional correlations. This will allow for the comparison of the returns of these bonds and how the correlation changed post global financial crisis. The paper finds high correlation between all the country pairs, in excess of 60 and 50 percent of the pre-crisis and post-crisis periods respectively. The only exception being Korea, whose correlation with all countries is low, but increases in the period after the global financial crisis. This portfolio offers little, if any diversification potential and is therefore not a good portfolio to hold in isolation.

Keywords: Multivariate GARCH, DCC, Bonds, Developed economies

JEL classification L250, L100

1. Introduction

The global financial markets are very turbulent even at the best of times. Bonds offer a safer alternative to stocks and equities, naturally, with a significantly lower return. Intuitively, the greater the correlation or co-movement between the returns of the bonds, the less diversification potential. Therefore, it is important to identify the correlation between the bonds returns, in order to generate a portfolio which could potentially provide good returns while minimising downside risk. Ideally, correlation between the assets should be relatively low. This enables spreading of risk of the portfolio. The main focus, however, is the correlation of the bond markets, particularly developed economies' bond returns. The correlation between developed economies' bond returns is expected to be high, given the global integration of the financial markets and similar financial market conditions (Nico Katzke 2013). The paper will investigate and add insights to correlation amongst developed economies' bond markets.

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This paper aims to study the correlation between the weekly returns of the 6 countries' 10-year bonds. Studying the periods before and after the global financial crisis will enable comparison across periods to identify effects and changes. This will also demonstrate the need for diversification in a portfolio, which can reduce the risk of losses. The paper will begin with a brief introduction to bonds and correlation in the bonds market in developed economies. This will be followed by a description of the data and the required transformations. The methodology section will provide insight to the approach taken to obtain the correlations. The results of the findings will then be reported and will be followed by concluding remarks.

2. Literature review and rationale

Bonds, in the simplest of terms, represents a debt obligation. Effectively, the money that is received by the person/entity that issues a bond, is a loan. Lenders require an incentive to provide their money as a source of financing. The incentive comes in the form of interest that is paid on these bonds, which ultimately attracts investors and is referred to as the yield. Bonds offer investors a safe alternative to stocks (equity), whose repayment is based on profitability (Fama and French 1989). Whilst potential returns are far greater than that of bonds, the potential losses in the case of stocks can be far more severe. Essentially, bonds provide a low risk alternative to investors who do not have an appetite for risk.

According to Cappiello, Engle, and Sheppard (2006), portfolio management requires two broad strategies. Firstly, to invest in different asset classes which have little to negative correlation. Secondly, investing in the same or similar asset markets, while diversifying through investing in multiple international markets. This paper only considers the second strategy and is secondary to the main objective of identifying correlation between the developed economies bond returns. Now that a brief understanding of what bonds are and the use of diversification, lets gain an understanding of the correlation between bond markets in developed economies.

Developed economies in general, do display relatively high correlation with other developed economies, due in part, according to Barr and Priestley (2004) to the growing integration of the global financial markets. Additionally, the ease of access to information in the 21st century, which means investors are able to make real-time decisions which results in partially coordinated actions (Kumar and Okimoto 2011). Barr and Priestley (2004) finds evidence of high correlation between the Canadian and US bond markets and also finds correlation (although to a lesser degree) between the US and UK bond markets. Moreover, Davies (2007) notes in a study including 6 bond markets, that the US, UK and Canadian bond markets share a common trend, subject to structural change. Davies (2007) also finds these results for some of the countries which are not included in this study and finds support for the growing integration of the international bond market. Lucey and Steeley (2006) notes that previous studies on the correlation of international bond markets are few but increasing. Not many studies have included countries selected in this study, as a result, this paper will add insights regarding the correlation amongst developed countries.

This study aims to provide additional insights to the literature regarding the correlation of the bond market, specifically that of developed economies. While methods such as ADCC, and EWMA to name just two of several models that can be used to model the conditional time-varying variance-covariance are available, this paper, due to time constraints will only discuss the DCC-GARCH methodology. This will be used to briefly note the need for diversification.

3. Data

The data used in the paper is obtained from the Bloomberg terminals, extracting the weekly returns of the 10-year bonds of 6 countries. The countries included in the study are Australia (AUS), Canada, Korea, United Kingdom (UK), New Zealand (NZ) and the United States of America (US). The data returns are calculated as follows:

$$r_{i,t} = \frac{B_{i,t}}{B_{i,t-1}} - 1 \tag{3.1}$$

The weekly returns as calculated according to equation 3.1 and are then log transformed, such that inferences regarding level changes over time can be made. To clean the data, the paper uses Boudt's technique. Additionally, the paper excludes the global financial crisis. This provides the benefit of the crisis not influencing the results dramatically and also allows for the evaluation of the impact of the crisis on volatility and co-movement in these bond markets. Tables 3.1 and 3.2 show the mean returns and the standard deviation of the returns. These appear to be the same for most countries, due to the rounding of the values, which tend to show the values are the same. However, it must be noted that this is an early sign that the correlation between these countries' bond returns may be high. The period prior to the crisis starts in the first week of February and ends in the final week of December 2009. The post-crisis period starts in the first week of October 2009 and ends in the final week of June 2018.[1]

	Country	mean_returns	std_dev_returns
1	AUS	0.0906	0.0206
2	Canada	0.0895	0.0188
3	Korea	0.0900	0.0229
4	NZ	0.0903	0.0162
5	UK	0.0900	0.0178
6	US	0.0896	0.0258

Table 3.1: Summary statistics: Bond Yields

[1]Tables 3.1 and 3.2 include 4 decimal places to illustrate that the means and standard deviations differ by country.

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Table 3.2: Summary statistics post crisis: Bond Yields

4. Methodology

The concept of multivariate modelling involves mapping multiple univariate GARCH processes to the multivariate domain, whereby a series of n Univariate GARCH models are estimated. The paper will apply the Dynamic Conditional Correlation model, first proposed by R. Engle (2002). Essentially this is a two-step process. Firstly, generalising the univariate GARCH processes to the multivariate domain. Then using this to estimate the DCC model which will allow for the estimation of the dynamic correlation estimates for each series. This section will first explain how the univariate GARCH processes can be generalised to the multivariate domain, followed by a detailed description of the DCC methodology used to obtain the dynamic correlation estimates.

The generalization is as follows: Given the stochastic process, $x_t, t = 1, 2, ...T$ of financial returns with dimension $N \times 1$ and mean vector μ_t, given the information set I_{t-1}:

$$x_t \, | I_{t-1} = \mu_t + \varepsilon_t \tag{4.1}$$

where the residuals of the process are modelled as:

$$\varepsilon_t = H_t^{1/2} z_t, \tag{4.2}$$

$H_t^{1/2}$ above is a $N \times N$ positive definite matrix such that $\mathbf{H_t}$ is the conditional covariance matrix of $\mathbf{x_t}$.[2]

[2] $\mathbf{z_t}$ is a $N \times 1$ i.i.d. N(0,1) series

The DCC-GARCH methodology which follows, will explain how this can be used to map the H_t matrix into the multivariate plain.

4.1. DCC-GARCH methodology

DCC models offer a simple and more parsimonious means of doing MV-vol modelling N.F. Katzke (2017). In particular, it relaxes the constraint of a fixed correlation structure assumed by the constant conditional correlation (CCC) model to allow for estimates of time-varying correlation. The DCC model can be defined as:

$$H_t = D_t.R_t.D_t. \tag{4.3}$$

Equation 4.3, shows that H_t, which as mentioned above is the conditional covariance matrix of $\mathbf{x_t}$, this splits the variance-covariance matrix into identical diagonal matrices and an estimate of the time-varying correlation R_T. Estimating R_T requires it to be inverted at each estimated period, therefore, a proxy equation is used (R. Engle 2002):

$$\begin{aligned} Q_{ij,t} &= \bar{Q} + a\left(z_{t-1}z'_{t-1} - \bar{Q}\right) + b\left(Q_{ij,t-1} - \bar{Q}\right) \\ &= (1-a-b)\bar{Q} + az_{t-1}z'_{t-1} + b.Q_{ij,t-1} \end{aligned} \tag{4.4}$$

Note the above equation is similar in form to a GARCH(1,1) process, with non-negative scalars a and b, and with: $Q_{ij,t}$ the unconditional sample variance estimate between series i and j, and lastly $\bar{Q}$ the unconditional matrix of standardized residuals from each univariate pair estimate. Using this information, we can now to use equation 4.4 to estimate R_t as:

$$R_t = diag(Q_t)^{-1/2}Q_t.diag(Q_t)^{-1/2}. \tag{4.5}$$

Which contains the bivariate elements:

$$R_t = \rho_{ij,t} = \frac{q_{i,j,t}}{\sqrt{q_{ii,t}.q_{jj,t}}} \tag{4.6}$$

This process produces the DCC model used to obtain the correlation estimates and is formulated as:

$$\begin{aligned}
\varepsilon_t &\sim N(0, D_t.R_t.D_t) \\
D_t^2 &\sim \text{Univariate GARCH(1,1) processes } \forall \text{ (i,j), i} \neq \text{j} \\
z_t &= D_t^{-1}.\varepsilon_t \\
Q_t &= \bar{Q}(1-a-b) + a(z_t' z_t) + b(Q_{t-1}) \\
R_t &= Diag(Q_t^{-1}).Q_t.Diag({Q_t}^{-1})
\end{aligned} \tag{4.7}$$

5. Emperical results

The findings of the bivariate correlations between the 6 countries will be reported in this section. It is important to note that given the selection of 6 developed economies, the correlation is expected to be high as the financial conditions in the countries will be similar. Firstly, this section looks at the volatility plots of the 6 countries and how this changes between the period before the global financial crisis and the period post-crisis. This will be followed by studying selected bivariate correlation between the countries which display interesting findings, and will be compared between the two periods before and after the global financial crisis.

5.1. Volatility

The volatility of the bond market before the global financial crisis is significantly lower than after the crisis. The volatility of the returns in the US is the highest for a large portion of the period before the crisis, for as long as 2002-2005. Although it must be noted that this doesn't increase significantly post crisis. The UK and Canadian returns experience the greatest increase in volatility between the period before and the period after the crisis. The return on the UK bond, post-crisis, displays volatility of almost 6 times that of the volatility experienced before the crisis, peaking in the final quarter of 2016. While the volatility in the Canadian bond returns triples post-crisis compared to before the crisis. It is evident from these volatility plots that the correlation between the countries is high. According to Kumar and Okimoto (2011), there has been a significant amount of uncertainty in the economy after the global financial crisis. This adds to the explanation of the high and increased volatility compared to the period before the crisis.

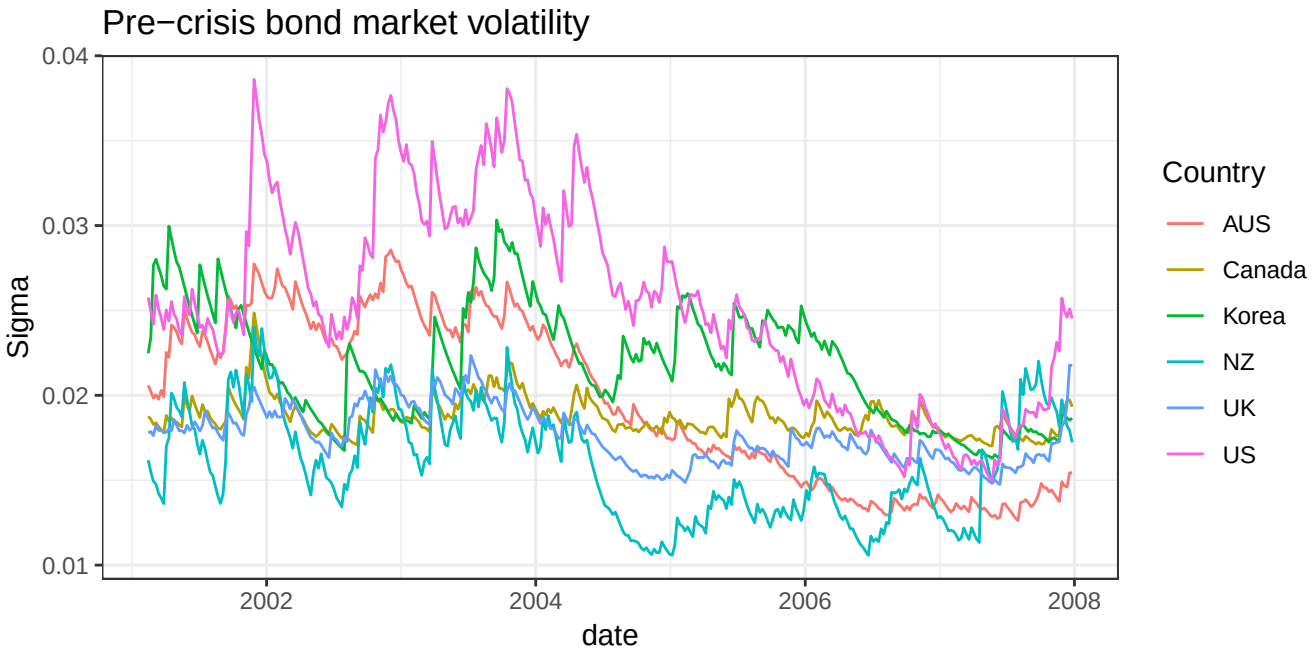

Figure 5.1: Volatility plot

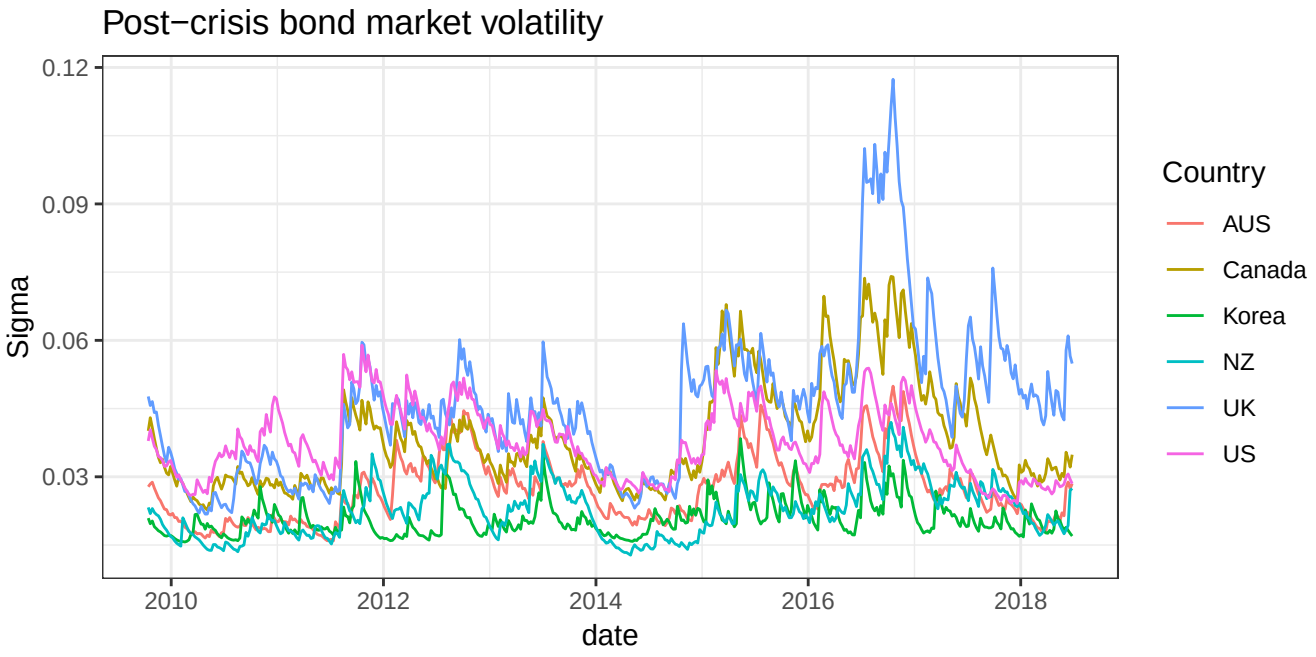

Figure 5.2: Volatility plot post-crisis

5.2. Dynamic correlation

The results of the Dynamic Conditional correlations show very high correlation in almost all cases with all pairs. Figures 7.1 to 7.6 show the correlation estimates for the period prior to the global financial crisis. All country pairs display correlation with each other of 60 percent or more, apart from with Korea. This low correlation of the Korean bond returns with every country is indicative in figure 7.4, which shows that correlation with any country pair, rarely goes beyond 30 percent. This provides for support for the argument that global financial markets are becoming more integrated. Additionally, the highest correlation, in excess of 80 percent, is between the Australian and New Zealand pair and the US and Canadian pair. This supports the evidence provided by Barr and Priestley (2004), who finds high correlation between the US and Canadian bond markets.

The Dynamic conditional correlation results do decrease by a significant amount in some country pairs in the period after the global financial crisis. However, the correlation is largely still above the 50 percent mark. Figures 7.7 to 7.12 show that almost all country pairs see a reduction in correlation in the post-crisis period. The exception is the Canada and US pair, which figure 7.8 shows increases to almost 90 percent which provides further evidence to the argument made by Barr and Priestley (2004) and illustrates the importance of diversification. Moreover, the correlation between Korea and all the countries in the sample increases substantially in the post-crisis period. This reaches as high as 60 percent between the Korean and Australian pair. In general, the correlation between all the developed countries is very high and demonstrates the need for diversification. This can come in the form of alternative assets or even the inclusion of developing economies to the portfolio.

On average, the bivariate correlation between the country pairs do not differ substantially between the pre-crisis and post-crisis periods. Whilst individual changes may have been large/small as mentioned above, the correlation in general, shows that these tend to balance one another out, such that the difference between the two periods, on average, is not substantial. The only exception is that of Korea. The bivariate correlation between Korea and the other 5 countries, prior to the crisis, increases by approximately 20-25 percent in the post-crisis period. However, these aggregate change interpretations are done merely by looking at the correlation before and after the crisis. Aggregating the data for the pre-crisis and post-crisis periods will yield more reliable interpretations but will not be done in this paper due to time constraints.

6. Conclusion

In recapitulating the findings of this paper, it is evident that correlation amongst the 6 developed economies is very high. This is explained in part by the growing integration of the global financial markets, but also by uncertainty and similar financial market conditions in the countries selected. The Korean bond returns display the lowest correlation with all the countries in the sample, while the pairs of Canada and the US and the pairs of Australia and New Zealand display the highest correlation. The high correlation in general, demonstrates the need for diversification. Including other countries with different financial market conditions and characteristics may yield the benefit of diversification. Additionally, inclusion of alternative assets in the portfolio, may yield diversification benefits as well.

It must be noted that this paper is limited in its evaluation of correlation amongst developed market economies, in that few countries are selected due to time constraints and data constraints. Future studies can improve on this study, by including more countries and applying less constraints to the DCC model.

7. Appendix

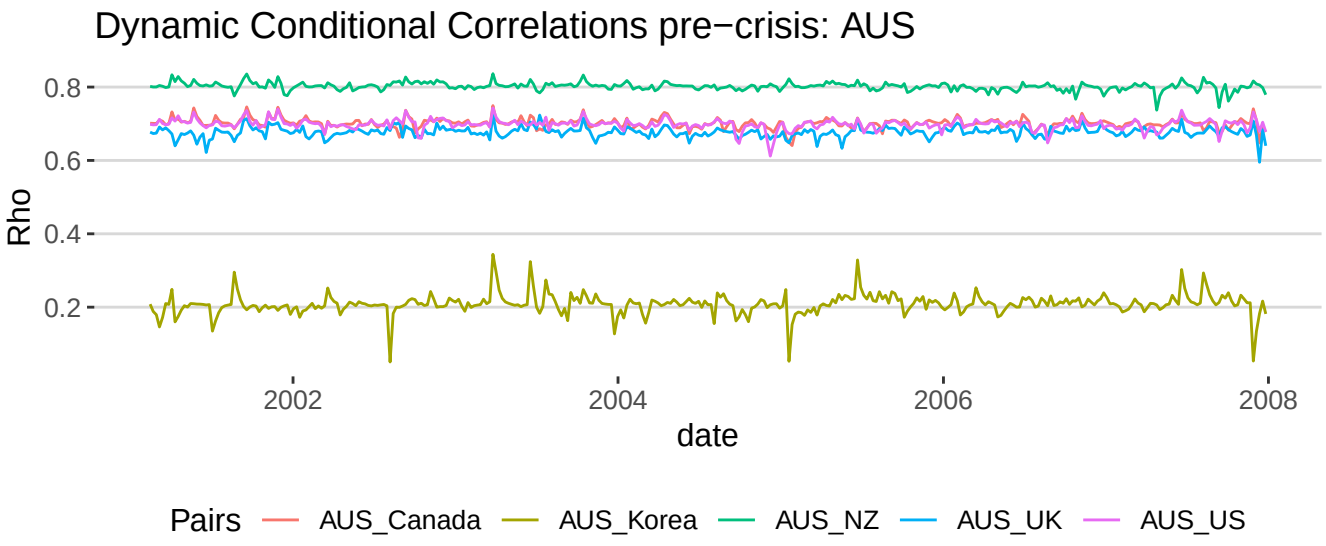

Figure 7.1: Dynanmic correlation

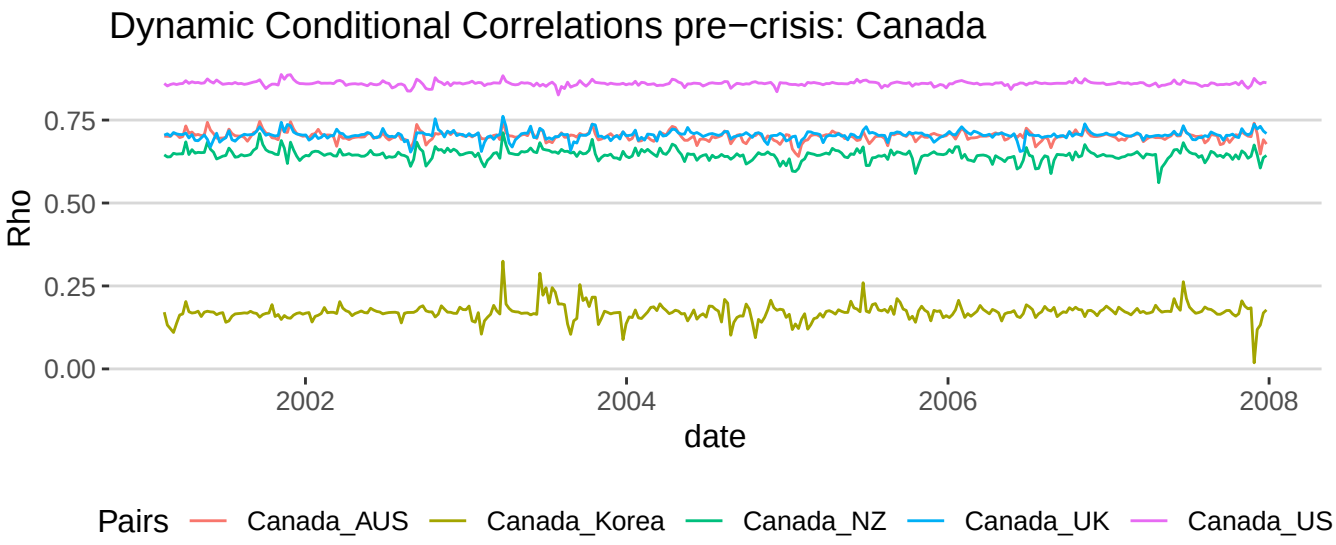

Figure 7.2: Dynanmic correlation

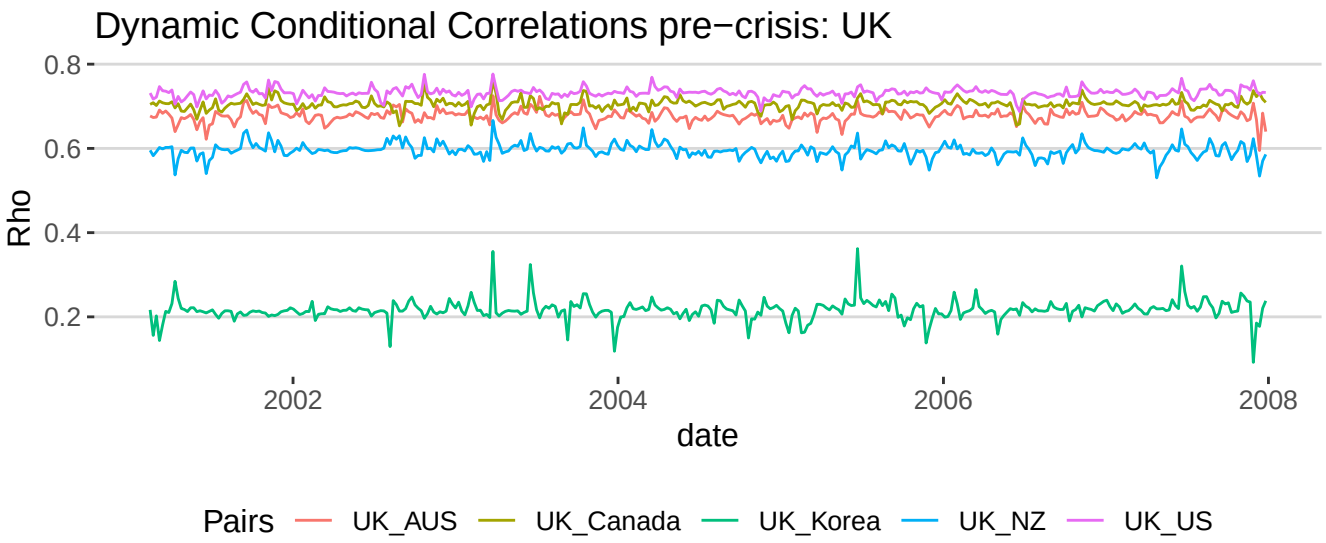

Figure 7.3: Dynanmic correlation

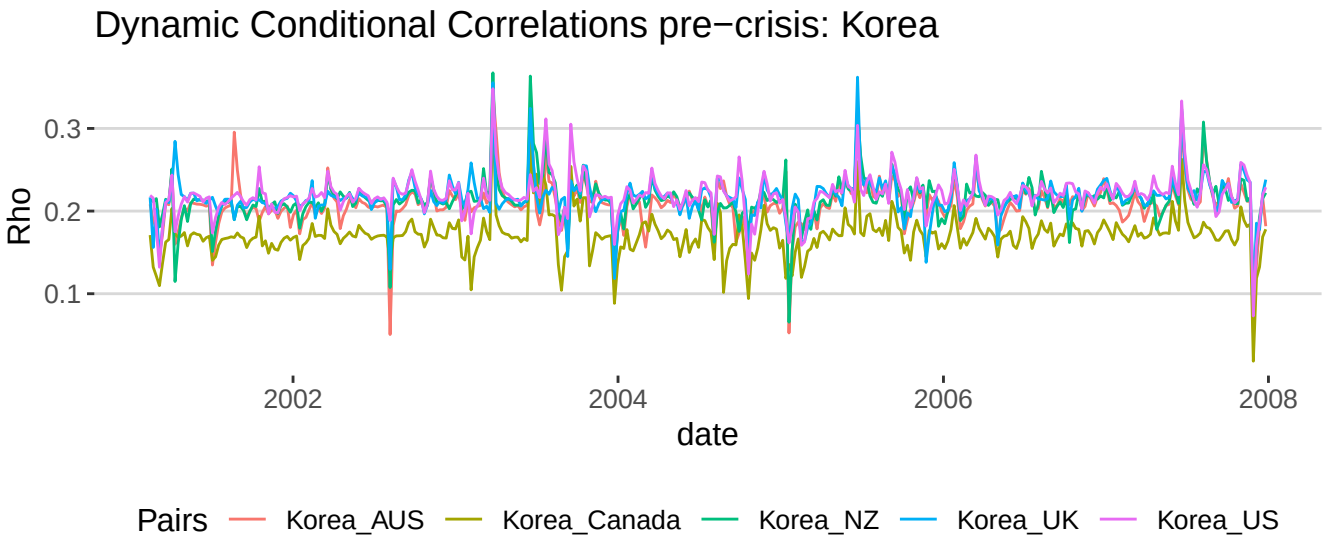

Figure 7.4: Dynanmic correlation

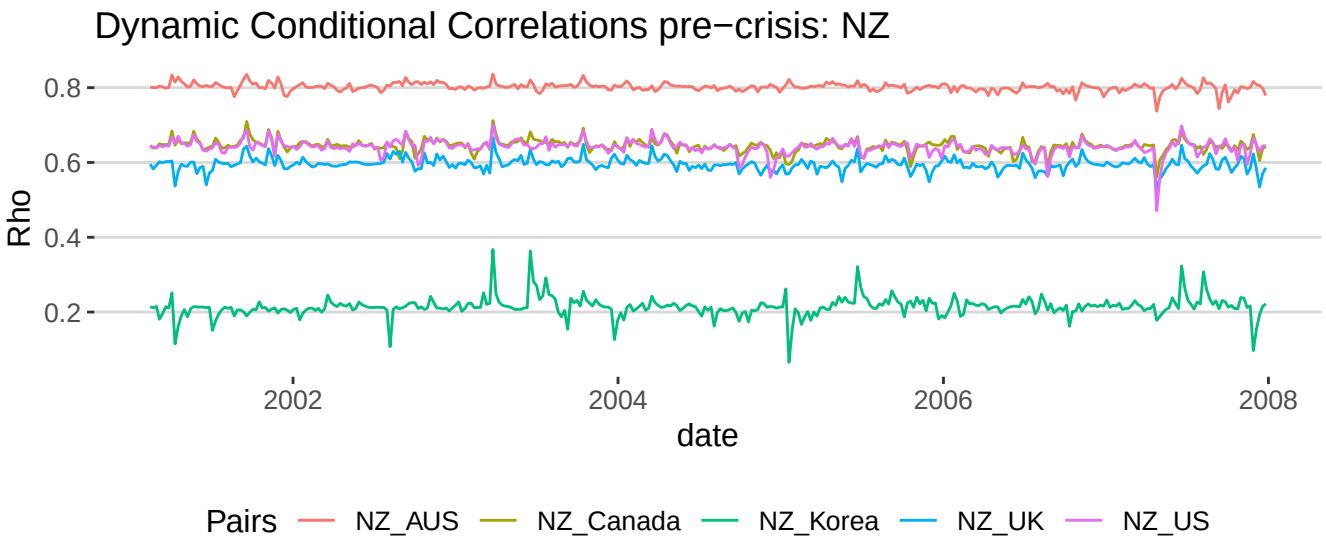

Figure 7.5: Dynanmic correlation

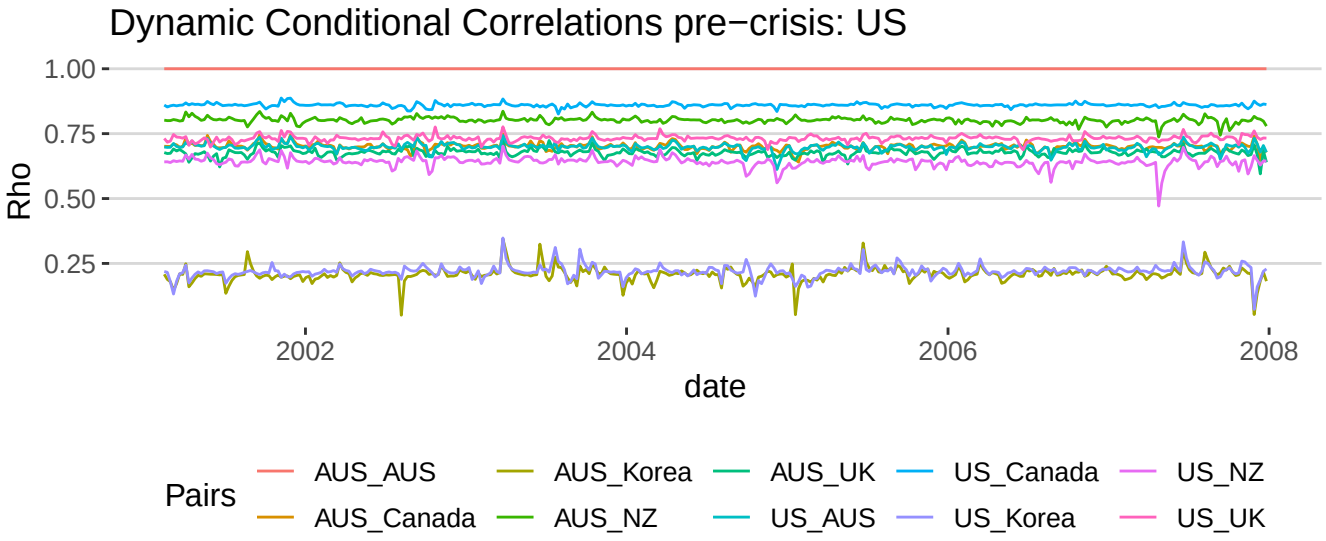

Figure 7.6: Dynanmic correlation

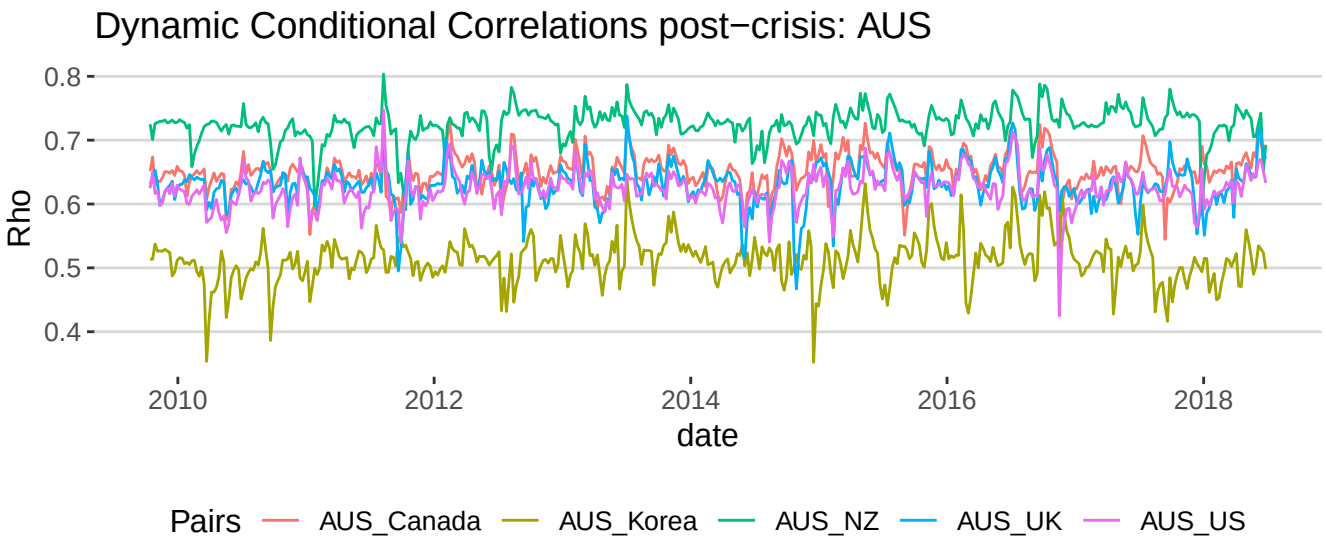

Figure 7.7: Dynanmic correlation

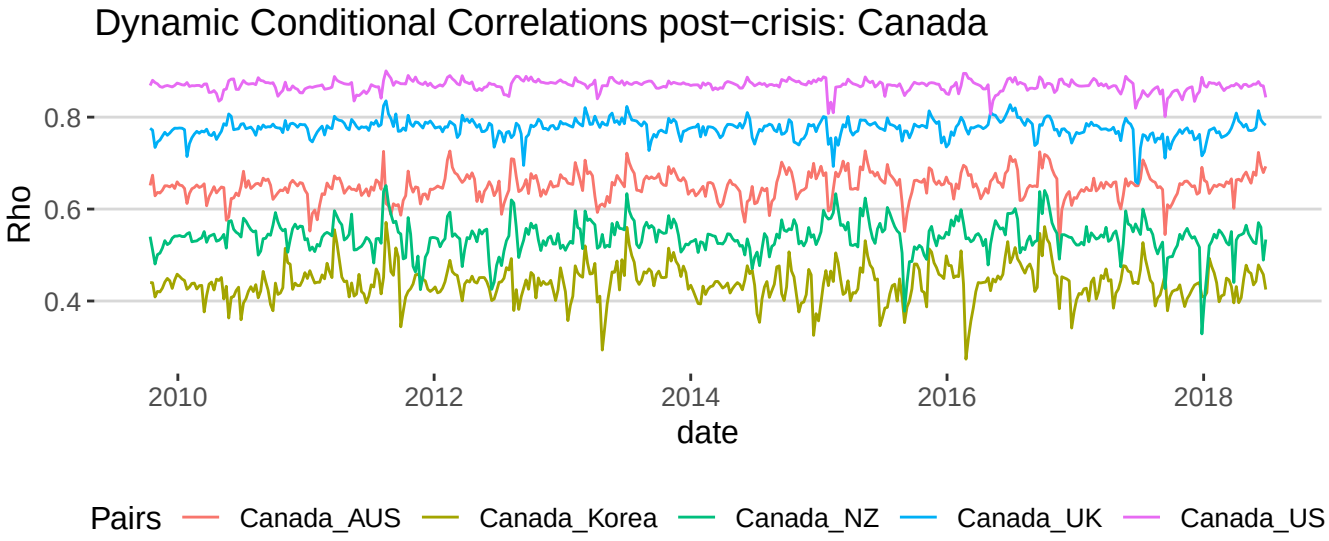

Figure 7.8: Dynanmic correlation

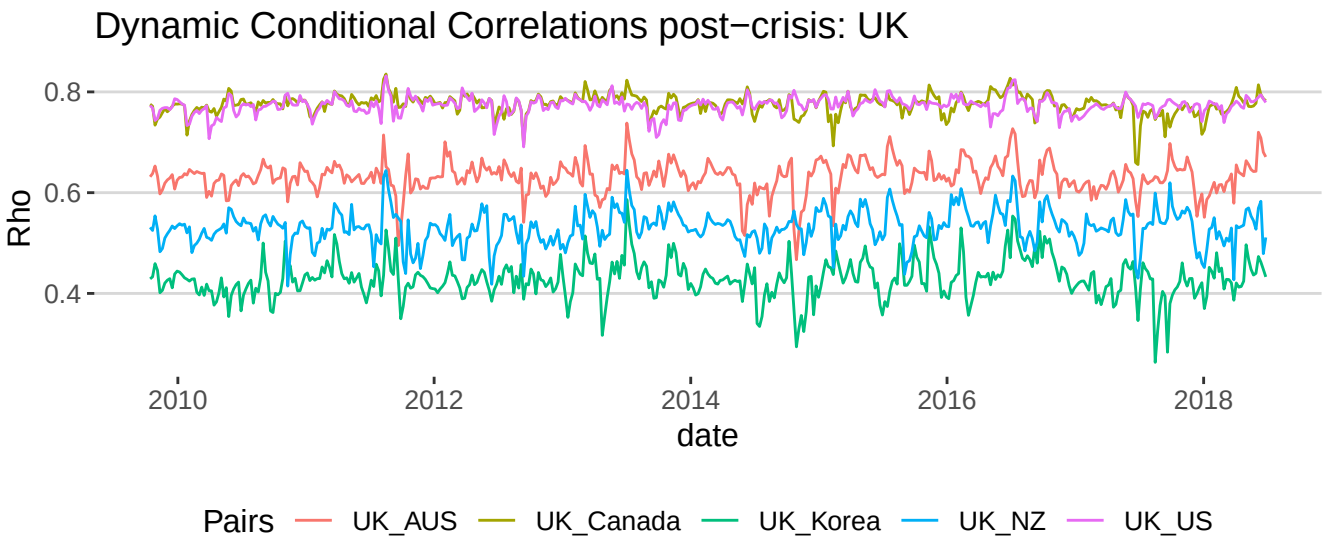

Figure 7.9: Dynanmic correlation

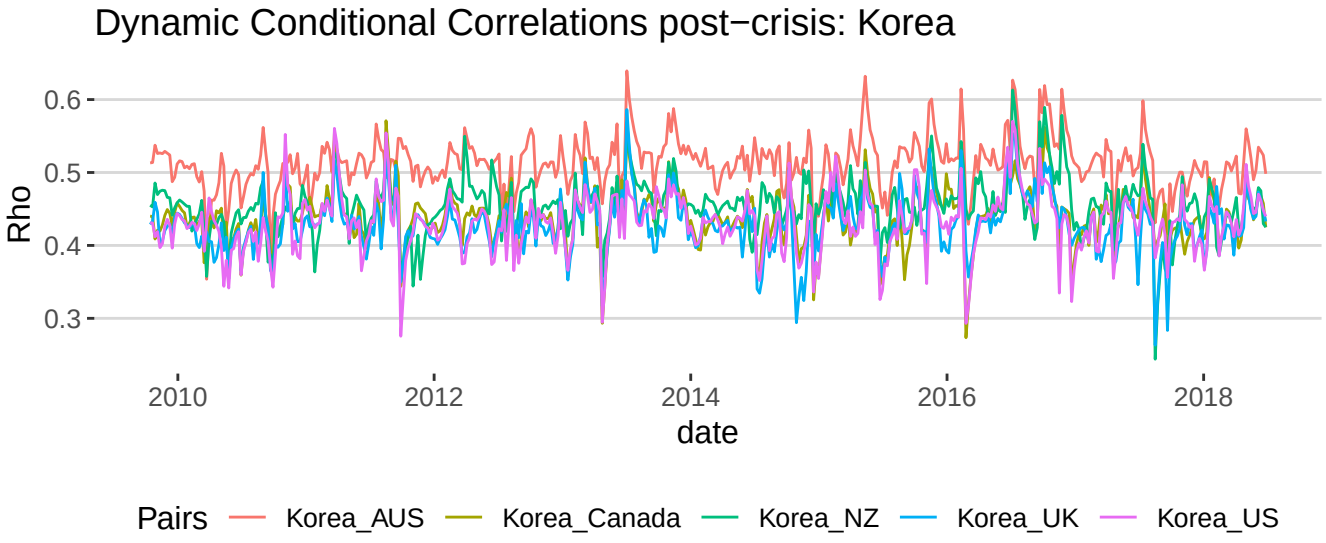

Figure 7.10: Dynanmic correlation

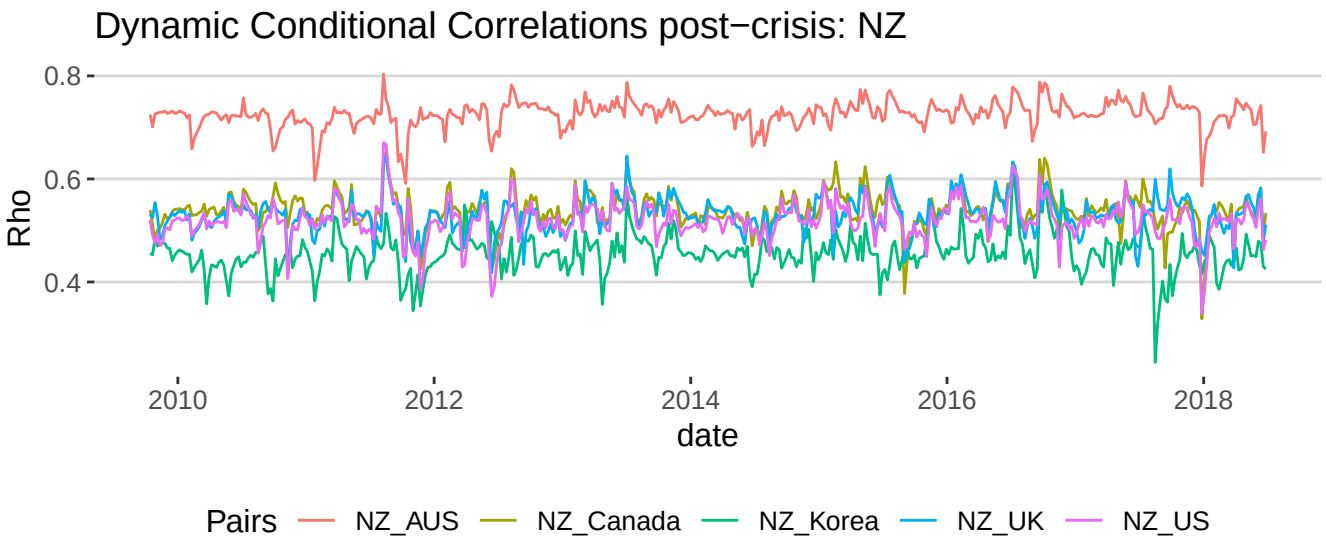

Figure 7.11: Dynanmic correlation

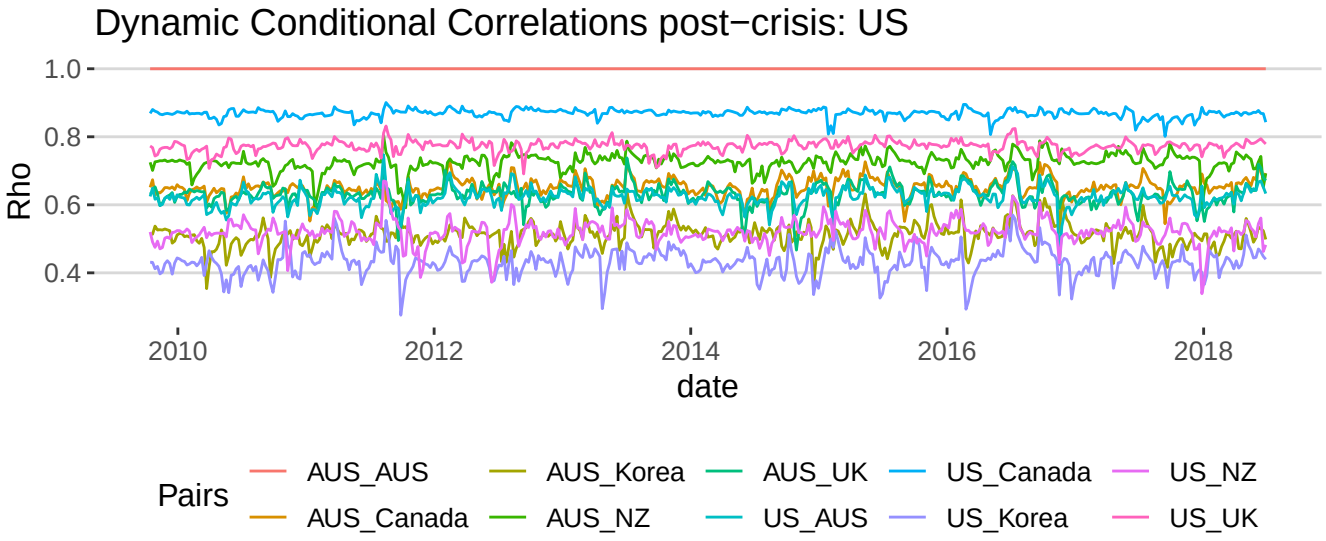

Figure 7.12: Dynanmic correlation

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