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Abstract

We study the correlation between pairs of bond and stock markets in Canada and the United States between January 1998 and December 2009 in the framework of diagonal-BEKK models. Our research question is whether monetary policy actions and communications by the Bank of Canada and the Federal Reserve significantly affect the conditional co-movement of financial markets (i) within Canada and (ii) between Canada and the United States. We find that central bank communication significantly increases the correlation of financial markets within and across the two countries and is particularly important for the correlation of Canadian and US long-term interest rates.

Keywords: Bank of Canada, Central Bank Communication, Diagonal-BEKK Models, Dynamic Correlations, Federal Reserve, Financial Markets

JEL: E52, F30, G12, G15

1. Introduction

Central bank communication has become a lively topic of research during the last decade (for a survey of the relevant literature, see Blinder et al. 2008). Many central banks communicate with the public as a way of providing information about the future course of monetary policy as well as their views of the economic outlook. This information helps guide the expectation formation process in the private sector and improves transparency of monetary policy decisions. A large part of the relevant literature focuses on how monetary policy actions, particularly interest rate changes, affect financial markets; relatively few studies investigate the impact of communication, either formal or informal, on financial markets.

Studies on the influence of central bank communication on financial markets can be broadly classified into four categories. (i) The impact of central bank communication on *financial market returns within one country*. For instance, Ehrmann and Fratzscher (2007), based on news wire communication, examine how markets in the euro area, the United Kingdom, and the United States react to domestic central bank communication. (ii) The effect of central bank communication on the *volatility of financial markets within one country*. Kohn and Sack (2004), for example, report that congressional hearings involving members of the US Federal Reserve (Fed) have a significantly positive effect on asset volatility in various financial markets. (iii) The *spillover effects* of communication by members of an important central bank on *financial market returns in other countries*. For instance, Hayo et al. (2010) show that US monetary communications have significant effects on European and Pacific equity market returns. (iv) The possible impact of *spillover effects* not only in the context of financial market returns but also with regard to *volatility*. As one part of their analysis, Hayo and Neuenkirch (2012) study the impact of US monetary policy communications on Canadian financial markets. They find that US interest rate changes increase volatility on 3-month treasury markets, but that US communication does not significantly affect volatility on Canadian financial markets.

An important issue not yet covered in the literature is whether central bank communication induces a higher degree of co-movement in financial markets. We address this gap in this literature by focussing on the impact of central bank communication on the correlation between different financial series. Financial market integration has increased over time, as has interdependence. Ayuso and Blanco (2001) provide evidence of this general trend, Bessler and Yang (2003) investigate world stock markets, Chen et al. (2002) focus on Latin America, and Kim et al. (2005) look at the euro area. Knowledge about the correlation of financial markets is important both from a monetary policy point of view, as it enhances the chance of increased co-movements in financial markets which possibly reduces the degrees of freedom for monetary policy based on domestic motives, and to individual investors trying to reduce the risk of their portfolio by diversification.

There are at least two ways of studying whether monetary policy communication affects financial market correlations: first, by comparing the correlation between different markets *within one country* and, second, by comparing the correlation of the same type of markets *across different countries*. We study this research question in the context of the United States and Canada. Since we allow for the impact of cross-country monetary policy communication spillovers in the sense of (iii) and (iv) above, we focus on Canada, as Canadian financial markets are affected by US macroeconomic shocks and Fed actions and communications (Hayo and Neuenkirch 2012). In terms of monetary policy communication, we rely on formal and informal communication by the Fed and the Bank of Canada (BoC). To provide empirical evidence, we study four combinations of potentially increasing financial market correlations in the aftermath of central bank communication: Canadian bonds markets with 6 and 10 years' maturity, equity and bonds markets in Canada, equity markets in the United States and Canada, and 10-year bonds in the United States and Canada.

The remainder of this paper is organised as follows. Section 2 describes the data and the econometric methodology. Section 3 presents the empirical results. Section 4 concludes.

2. Data and Empirical Methodology

Our financial market variables for the two countries comprise daily closing interest rates changes on 6-month treasury bills and 10-year government bonds, as well as daily rates of change of the Toronto Stock Exchange Index and the S&P 500 Index for the period 2 January 1998 to 31 December 2009.

We use data on Fed communications from Hayo et al. (2008). The dataset covers 837 speeches and 201 congressional hearings by Board of Governors members, as well as 94 post-meeting statements and 26 monetary policy reports (MPR).[1] In the case of the BoC, we rely on the dataset created by Hayo and Neuenkirch (2012) and extend it until the end of 2009. This dataset contains information from 142 speeches, 13 congressional hearings, 85 post-meeting statements, and 44 MPR. Our analysis incorporates a subset of these events: only those communications containing information on either the US and Canadian economic outlook or the Fed's and BoC's future monetary policy course are included. In total, we employ eight dummy variables for the occurrence of relevant (i) statements, (ii) MPR, (iii) testimony, and (iv) speeches for the Fed and the BoC, respectively.

Target rate changes by the BoC and the Fed are captured by including indicator variables. Target rate change surprises, which occur either after an unscheduled meeting or as an unexpected outcome of a meeting, are captured by separate indicators.[2] As control variables, we include several important US and Canadian macroeconomic variables that are regularly observed by financial market actors. In our analysis, these take the form of dummies for surprises, i.e., the actual release differs from the Bloomberg survey of financial market experts. In the case of the United States, we use 11 news items typically watched by financial market participants (Ielpo and Guégan 2009).[3] For Canada, we employ 12 macroeconomic announcements which are taken from the lists of Gravelle and Moessner (2001) and Doukas and Switzer (2004).[4] To conserve degrees of freedom for the regression analysis, we

[1] Note that our analysis employs a subset of the Hayo et al. (2008) dataset, as we exclude speeches by regional presidents. Previous studies show that speeches by regional presidents do not affect US (Hayo et al. 2008) or Canadian (Hayo and Neuenkirch 2012) financial markets to any substantial degree.

[2] Bloomberg surveys are used to identify surprises that occur during scheduled meetings. For instance, a 'surprise hike' can be (i) an unexpected rise in the target rate or (ii) an unchanged target rate when a rate cut was expected. Intermeeting moves are naturally classified as surprises.

[3] Advance gross domestic product, industrial production, and trade balance to capture the business cycle phase; the Institute for Supply Management manufacturing index and the Conference Board consumer confidence rating for producer and consumer confidence; housing starts for real estate effects; nonfarm payroll and the unemployment rate to proxy labour market conditions; retail sales for actual consumption; and the consumer price index and producer price index for inflation.

[4] Real GDP, capacity utilisation rate, current account, and merchandise trade balance to control for business cycle; the Ivey Purchasing Managers Index for producer confidence; housing starts for real estate markets; net change in employment and the unemployment rate to proxy labour market conditions; retail sales for actual

create summary indicators for (i) US and (ii) Canadian price indicator surprises, as well as for (iii) US and (iv) Canadian announcements of other macroeconomic indicators.

We use MGARCH models to analyse the question of how target rate changes, central bank communication, and macroeconomic surprises affect the correlation of financial market returns in two markets. One reason this class of models is used rather sparingly in practical applications is their complexity, which often leads to severe convergence problems (for a survey, see Bauwens et al. 2006). This also explains why we concentrate on pairs of markets rather than the full possible system.

For our dataset, we find that bivariate diagonal-BEKK(1,1) models, proposed by Engle and Kroner (1995), provide a good compromise between conducting a multivariate analysis and still achieving robust convergence.[5] In addition to obtaining robust convergence, information criteria indicate the superiority of diagonal-BEKK models compared to other linear or non-linear combinations of univariate GARCH models, particularly O-GARCH, GO-GARCH (van der Weide 2002), CCC (Bollerslev 1990), DCC (Engle 2002), generalised DCC (Tse and Tsui 2002), and Scalar-BEKK.[6]

Diagonal-BEKK models simultaneously consider factors that have an influence on the variances of the time series as well as on their correlation. However, within our framework, these models are computationally still too demanding to allow including all variables, i.e., macroeconomic news, monetary policy actions, and central bank communications, at the same time in the mean equation *and* in the conditional variance equation. Therefore, in a conservative procedure, we first eliminate the influence of all variables on financial market returns and then study the impact of monetary policy communication on these filtered variables.[7] We estimate diagonal-BEKK models of the general form:

(1) $y_t = \mu + cH_t + \varepsilon_t$

(2) $H_t = C'C + \sum_{i=1}^{q} A'_{i\,t-i}{}'_{t-i} A_i + \sum_{j=1}^{p} B'_j H_{t-j} B_j$

y_t is a vector of N time series, μ is the mean of this process, ε is a white-noise error, H is the conditional variance covariance matrix of y, c is a parameter, and C is an NxN matrix, the elements of which are zero below the main diagonal. A_i and B_j are NxN matrices.

For bivariate diagonal-BEKK models, Equation (2) simplifies to:

(3) $$H_t = \begin{pmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{pmatrix}' \begin{pmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{pmatrix} + \begin{pmatrix} a_{11} & 0 \\ 0 & a_{22} \end{pmatrix}' \begin{pmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon_{2,t-1}^2 \end{pmatrix} \begin{pmatrix} a_{11} & 0 \\ 0 & a_{22} \end{pmatrix} + \begin{pmatrix} b_{11} & 0 \\ 0 & b_{22} \end{pmatrix}' H_{t-1} \begin{pmatrix} b_{11} & 0 \\ 0 & b_{22} \end{pmatrix}$$

The financial market correlations are then described by:

(4) $h_{12,t} = c_{11}c_{12} + a_{11}a_{22}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + b_{11}b_{22}h_{12,t-1}$

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consumption; and the consumer price index, industrial product price index, and raw materials price index for inflation.

[5] All our estimated models are stationary, as the following condition is always fulfilled: $a^2_{11} + b^2_{11} < 1$.

[6] The hypothesis of constant conditional correlations can be rejected (Engle and Sheppard 2001).

[7] To that end, we regress the univariate financial market returns on all variables of interest and use the residuals as filtered series.

Our communication indicators and target rate changes are then included as additional exogenous regressors in the volatility Equation (2) by adding:

$$F\ \mathrm{diag}(|Z_t|)F'$$

F is a 2xf matrix, where f is the number of explanatory variables and Z is the matrix itself (diag implies that there are non-zero elements only on the main diagonal).

As the impact of target rate changes and communication on mean and conditional variance is studied elsewhere (Hayo and Neuenkirch 2012), and to economise on space, we focus our attention on the effects relevant for the correlations between two filtered financial market series. If our explanatory variables have the same sign and are jointly significant across both volatility equations, monetary policy actions, central bank communications, and/or macroeconomic surprises increase or reduce the correlation between the time series.

We provide two sets of estimates for the MGARCH models. The first one covers the entire sample period 1998–2009; the second one focuses on the financial crisis subsample (August 2007–December 2009). Central bank communication plays an even more pronounced role during the recent financial crisis (for the United States, see Hayo et al. 2008), as central banks put a great deal of effort into preparing and explaining both their conventional and unconventional monetary policy actions. Thus, using this approach, we can address the question of whether financial market correlations react differently during 'crisis times' compared to during 'normal times.'[8] To explore anticipation effects and sticky information processing or rational inattention, we also estimate separate models including our variables of interest with one lead and one lag, respectively.[9]

3. Empirical Results

Tables 1–4 show the stylised outcome of estimating diagonal-BEKK(1,1) models for four pairs of financial markets.[10] Variables marked with * or ** are jointly significant at a 5% or 1% level *and* have the same sign in both conditional variance equations, respectively. Columns labelled 'Full' show the results for the full sample; the 'FC' columns contain the corresponding results for the financial crisis subsample.

Table 1 presents the estimates for 6-month and 10-year Canadian interest rates. The results indicate that correlations between Canadian short-term and long-term market interest rates are typically negatively affected by expected monetary policy decisions. This implies that interest rate changes at the very short end affect the whole term structure in an asymmetric way and cause a decline in the correlation between 6-month and 10-year rates. The reverse is found in the case of unexpected policy rate changes. Here, we observe a significantly more symmetric movement between these two interest rate series. Moreover, these effects are relevant for leads, contemporaneous, and lagged interest rate surprises. The influence of expected and unexpected interest rate decisions is slightly more significant over the whole sample compared to the financial crisis period. Possibly, this reflects

[8] Note that estimation of a model covering the whole sample period *and* including interaction terms for the financial crisis subsample is not feasible within our framework.

[9] Estimation of nested models including lead, contemporaneous, and lagged effects leads to severe convergence problems and is not feasible.

[10] Tables A1–A8 in the Appendix provide detailed regression estimates.

both central banks' reliance on unconventional monetary policy measures after hitting the zero-lower bound of interest rates during the financial crisis. BoC policy rate changes have a more significant effect on correlations when they hit the market as a surprise.

Table 1: Estimating Bivariate Financial Market Correlations: 6-Month vs. 10-Year Canadian Yields

	US Lead		**US Cont.**		**US Lag**		**CAN Lead**		**CAN Cont.**		**CAN Lag**	
	Full	FC	Full	FC	Full	FC	Full	FC	Full	FC	Full	FC
IR	–**		–**	–*			–*			–*		
IR Surprise	+*	+**			+**		+**	+*	+**	+**	–**	
Statement									–**		–*	
MPR												
Testimony			–*									
Speech	–**	+*			–*							
Macro: Price					+*		+**		–**			
Macro: Other		–*	–**	–**				–*				+**

Note: * and ** indicates same sign and joint significance across both volatility equations at a 5% and 1% level, respectively. + and – represents whether the effect on the volatility equation is positive or negative, respectively. Columns labelled 'Full' show the results for the full sample; columns labelled 'FC' contain the corresponding results for the financial crisis subsample. Table A1 and A2 in the Appendix provide the full set of regression estimates.

Regarding monetary policy communication, we find that Canadian communication is relevant only in the form of post-meeting statements and only over the full sample. Contemporaneous and lagged values of this type of news have a significantly negative impact on the correlation of short- and long-run bond markets in Canada. Thus, they resemble the effects of expected target rate changes. US communication is important for these Canadian markets if delivered in the form of a speech or as testimony. Speeches appear to affect financial market correlations when entering as leads, contemporaneous, and lagged values; testimony is significant only when considered contemporaneously. Similar to the case of Canadian communication, the correlation between the two Canadian interest rates is declining after an announcement by the Fed. There is one exception, namely, speeches in the financial crisis period, which increase the correlation of the two series.

Macroeconomic surprises from both countries significantly affect correlations. Price news tends to increase the correlation between Canadian interest rates, whereas real news has more of a negative effect.

Interestingly, although we examine correlations between two Canadian interest rate series, the influence of US variables is roughly the same in terms of significance and direction of effect for both.

Table 2 reports the estimation results for Canadian long-term interest rates and the TSX stock index. In contrast to the pair of Canadian interest rates, here we find only few significant effects. Thus, the correlation between these series is barely affected by our explanatory variables. Perhaps surprisingly, interest rate decisions do not matter at all.

Table 2: Estimating Bivariate Financial Market Correlations: 10-Year Canadian Yields vs. TSX

	US Lead		**US Cont.**		**US Lag**		**CAN Lead**		**CAN Cont.**		**CAN Lag**	
	Full	FC	Full	FC	Full	FC	Full	FC	Full	FC	Full	FC
IR												
IR Surprise												
Statement								+**				
MPR		–*										+**
Testimony		+*		+*								
Speech												
Macro: Price	+*		–*									
Macro: Other												

Note: * and ** indicates same sign and joint significance across both volatility equations at a 5% and 1% level, respectively. + and – represents whether the effect on the volatility equation is positive or negative, respectively. Columns labelled 'Full' show the results for the full sample; columns labelled 'FC' contain the corresponding results for the financial crisis subsample. Table A3 and A4 in the Appendix provide the full set of regression estimates.

Monetary policy communication is relevant only during the financial crisis period, with anticipatory effects taking place before BoC statements and lagged effects kicking in after BoC MPR. MPR and testimony by the Fed also are significant when entering as lead or contemporaneous values. Generally, central bank communication from both the Fed and the BoC increases the correlation between these two Canadian markets.

US price shocks, as the sole macroeconomic indicator, have a significant effect when entering as the lead or contemporaneous variable over the full sample period but their effect varies depending on the specification.

Table 3: Estimating Bivariate Financial Market Correlations: TSX vs. S&P 500

	US Lead		**US Cont.**		**US Lag**		**CAN Lead**		**CAN Cont.**		**CAN Lag**	
	Full	FC	Full	FC	Full	FC	Full	FC	Full	FC	Full	FC
IR										+*		
IR Surprise	+**		+**	+*		+*						
Statement								+*				
MPR				+*	+*							
Testimony				+*		+*						
Speech							+*			+*		+**
Macro: Price			+**									+**
Macro: Other		+**										+**

Note: * and ** indicates same sign and joint significance across both volatility equations at a 5% and 1% level, respectively. + and – represents whether the effect on the volatility equation is positive or negative, respectively. Columns labelled 'Full' show the results for the full sample; columns labelled 'FC' contain the corresponding results for the financial crisis subsample. Table A5 and A6 in the Appendix provide the full set of regression estimates.

Table 3 reveals the impact of our explanatory variables on the correlation of US and Canadian equity returns. We find that Fed target rate change surprises play an important role, irrespective of whether included as lead, contemporaneous, or lagged variables, whereas BoC rate changes are influential only during the financial crisis.

Several types of communication by both central banks affect the conditional correlations between equity returns. BoC speeches are significant over the full sample period and especially during the financial crisis. In the case of the Fed, we discover that MPRs and testimony play a significant role. US price shocks drive correlations over the full sample.

Other US macroeconomic shocks, as well as Canadian price and other shocks (with a lag), are significant only during the financial crisis period.

Finally, it is remarkable that all the news we consider here leads to an increase in the correlation between stock markets in the two countries.

Table 4: Estimating Bivariate Financial Market Correlations: 10-Year Yields Canada vs. US

	US Lead		**US Cont.**		**US Lag**		**CAN Lead**		**CAN Cont.**		**CAN Lag**	
	Full	FC	Full	FC	Full	FC	Full	FC	Full	FC	Full	FC
IR								–*			–**	
IR Surprise	+**	+**	+**	+**		–**						
Statement					+**		–*		+**		–*	
MPR		+**		+**		–*		+**				
Testimony		+**		+**		+**	–**	+**		+**		
Speech	–**	+*					–*				+*	
Macro: Price								+**		+*	–*	–**
Macro: Other	+**	–**	–**	–**				–*				

Note: * and ** indicates same sign and joint significance across both volatility equations at a 5% and 1% level, respectively. + and – represents whether the effect on the volatility equation is positive or negative, respectively. Columns labelled 'Full' show the results for the full sample; columns labelled 'FC' contain the corresponding results for the financial crisis subsample. Table A7 and A8 in the Appendix provide the full set of regression estimates.

Results for US and Canadian long-term interest rates are reported in Table 4. Similar to the results in Table 3, US interest rate surprises have a broad impact on correlations, regardless of whether included as lead, contemporaneous, or lagged variable. Expected BoC changes also influence correlations but only with a lag (full sample) and a lead (financial crisis). Again, we find that expected target rate changes tend to lower financial market correlation, whereas unexpected changes increase it.

Different forms of communication by both central banks affect the correlation between Canadian and US long-term interest rates. Congressional hearings are the most important driver of correlations. Whereas the effect of US communications shows significant effects irrespective of whether included as lag, lead, or current variable, anticipatory effects dominate in the case of the BoC. The direction of change in the correlation is somewhat ambiguous. However, the general tendency is that central bank communication increases the correlation between long-run interest rates in both countries.

Other US macroeconomic announcements affect correlations on the actual day of their announcement and on the day prior thereto. Canadian price indicator shocks are particularly relevant during the financial crisis. The direction of change is ambiguous, with real macro news showing a tendency to decrease the correlation.

In general, the correlations of 10-year government yields in both countries show the most pronounced reaction to interest rate decisions, central bank communications, and macroeconomic announcements. News from the United States is slightly more important in general, but clearly dominates when it involves interest rate surprises.

Comparison of all estimations reveals some interesting facts. First, although Tables 1 and 2 present the effects on correlations between Canadian financial markets, we find US variables to be an equally important driver of these correlations. This indicates that Canadian financial markets are influenced to a large degree by economic events in the United States, its most important partner with regard to trade and capital flows. Second, correlations between Canadian short-term and long-term interest rates are more affected by interest rate surprises than by expected changes. Thus, expected interest rate changes do not lead to a change in the conditional yield curve correlations, suggesting that financial market actors have already incorporated their impact into their trading. In the case of equity markets, US interest rate surprises are the most significant factor influencing the strength of the correlation. Finally, central bank communication affects all markets considered, but is particularly important for the correlation of 10-year Canadian and US interest rates. Communication significantly affects correlations, no matter whether entered as current, lead, or lagged. Generally, communication tends to increase the correlation of long-run interest rates in the two countries.

To understand the quantitative importance of considering the impact of the various types of news, we also estimated small diagonal-BEKK models without the explanatory variables. Figures A1–A4 in the Appendix plot the difference in conditional correlations between models employing (i) the full sample period and contemporaneous explanatory variables and (ii) models without any explanatory variables. The graphs show that our variables of interest have a substantial influence on the estimated conditional correlations.

4. Conclusion

The extant literature shows that central bank communication can affect financial market returns and volatility within one country and cause spillover effects on financial market returns and volatility in other countries. In this paper, we study the correlation between pairs of bond and stock markets (i) within Canada and (ii) between Canada and the United States for the period January 1998 to December 2009 in the framework of diagonal-BEKK models. Our research question is whether monetary policy actions and communications by the BoC and the Fed significantly affect the conditional co-movement of financial markets.

Our results show that central bank communications affect the dynamic correlations between two financial markets, both within and across countries. First, even for correlations between Canadian markets only, we find US variables to be an important influence. This indicates that Canada as a small open economy is strongly affected by its most important economic partner, the United States. Second, correlations between Canadian short-term and long-term interest rates are significantly affected by interest rate surprises. Expected interest rate changes and central bank communications cause very little change in the conditional yield curve correlations. In the case of equity markets, US interest rate surprises significantly change the correlation between the S&P 500 and the TSX Index. Third, central bank communication is particularly important for the correlation of 10-year Canadian and US interest rates. The communications significantly affect correlations irrespective of whether included as lag, lead, or current variable. Finally, we find that different types of news can increase or decrease the correlation of financial markets, within and across countries. Expected target rate changes tend to decrease the correlation; surprises have a positive effect. Central bank communication tends to have a positive effect as well, but our estimation outcome is somewhat ambiguous. Macro news can have positive or negative effects on the correlations, with price news showing a tendency to increase correlations and real news having the opposite effect. In addition to the evidence based on statistical testing, we graphically show that the inclusion of our variables of interest influences estimated conditional correlations in an economically relevant way.

Our results have important implications. Monetary policy communication can increase co-movements across financial markets, in particular, between long-term interest rates in Canada and the United States. Thus, in addition to spillover effects on returns and volatility of other countries' financial markets, we detect a third channel which a central bank should take into account before communicating with the public. Central bank communications by a foreign central bank might reduce the degrees of freedom of domestic monetary policy. As we find communications by both the Fed and the BoC to significantly affect correlations between financial markets across the two countries, this finding is relevant not only for a relatively small economy such as Canada but also for the United States. Our findings are relevant to individual investors, too, as central bank communication has the potential to limit diversification opportunities as it leads to an increase in correlations.

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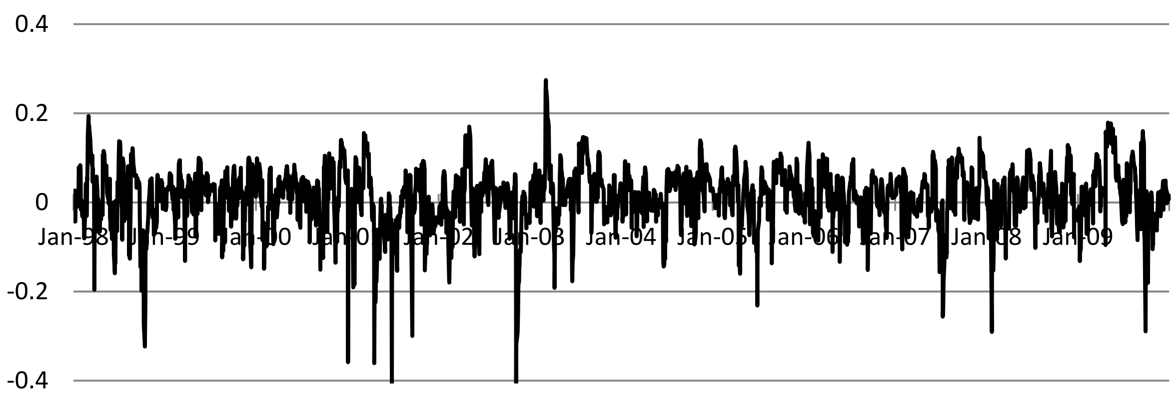
Appendix

Table A1: Estimating Bivariate Financial Market Correlations: 6-Month vs. 10-Year Canadian Yields

	CAN 6M		CAN 10Y			CAN 6M		CAN 10Y			CAN 6M		CAN 10Y		
c_{11}	0.0037					0.0000					0.0044				
c_{12}	0.0038	*				0.0000					0.0046	**			
c_{22}	0.0000					0.0000	*				0.0000				
a_1	0.3837	**	0.1707	**		0.4370	**	0.1788	**		0.4039	**	0.1344	**	
b_1	0.9015	**	0.9746	**		0.8645	**	0.9716	**		0.9148	**	0.9811	**	
	United States Lead					**United States Contemp.**					**United States Lag**				
IR	-0.0206	**	-0.0079		xx	-0.0256	**	-0.0130	**	xx	0.0000		0.0000		
IR Surprise	0.0829	**	0.0154		x	0.0770	*	-0.0038			0.0135		0.0318	**	xx
Statement	0.0041		0.0126			0.0000		0.0000			-0.0007		-0.0034		
MPR	-0.0147		0.0007			-0.0181		-0.0031			-0.0012		-0.0001		
Testimony	0.0019		0.0121			-0.0047		-0.0145		x	-0.0036		-0.0087		
Speech	-0.0089	*	-0.0072		xx	0.0064		0.0058			-0.0099		-0.0057		x
Macro: Price	0.0000		0.0000			0.0075		0.0022			0.0148		0.0057		x
Macro: Other	0.0000		0.0000			-0.0134	*	-0.0105	**	xx	0.0000		0.0000		
	Canada Lead					**Canada Contemp.**					**Canada Lag**				
IR	-0.0339	**	-0.0077		x	0.0211		-0.0054			0.0000		0.0000		
IR Surprise	0.0818	**	0.0186		xx	0.0909	**	0.0178		xx	-0.0155		-0.0269	*	xx
Statement	-0.0134		0.0060			-0.0274	**	-0.0141	**	xx	-0.0040		-0.0164	*	x
MPR	0.0000	*	0.0000			0.0000		0.0000			0.0000		0.0000		
Testimony	0.0001		0.0173			0.0009		0.0160			0.0001		0.0082		
Speech	-0.0069		0.0121	*		-0.0080		0.0109			-0.0034		0.0043		
Macro: Price	0.0151	**	0.0142	**	xx	-0.0145	**	-0.0100	**	xx	0.0093		0.0092		
Macro: Other	0.0000		0.0000			0.0000		0.0000			0.0000		0.0000		
Observations	2900					2900					2900				
Parameters	41					41					41				
Log-likelihood	10717					10700					10482				

Note: * and ** indicate significance at a 5% and 1% level, respectively. x and xx indicates same sign and joint significance across both volatility equations at a 5% and 1% level, respectively. Standard errors are robust.

Figure A1: Change in Conditional Correlation: 6 Month vs. 10 Year Canadian Yields



Note: Figure plots the difference in conditional correlations between a model employing (i) the full sample period and contemporaneous explanatory variables and (ii) a model without any explanatory variables.

Table A2: 6-Month vs. 10-Year Canadian Yields: Financial Crisis

	CAN 6M		CAN 10Y			CAN 6M		CAN 10Y			CAN 6M		CAN 10Y		
c_{11}	0.0013					0.0000					0.0000				
c_{12}	0.0006					0.0000					0.0000				
c_{22}	0.0000					0.0000					0.0000				
a_1	0.4926	**	0.2018	**		0.5021	**	0.2218	**		0.5598	**	0.2115	**	
b_1	0.8580	**	0.9449	**		0.8217	**	0.9523	**		0.8286	**	0.9582	**	
	United States Lead					**United States Contemp.**					**United States Lag**				
IR	-0.0251	*	-0.0059			-0.0193		-0.0203		x	0.0000		0.0000		
IR Surprise	0.0957	**	0.0696	**	xx	0.1146		-0.0239			0.0354		-0.0465	**	
Statement	0.0000		0.0000			0.0000		0.0000			0.0000		0.0000		
MPR	-0.0327		0.0048			-0.0454		-0.0089			0.0230		-0.0204		
Testimony	-0.0105		-0.0252			0.0103		0.0226			0.0289		0.0211		
Speech	0.0098		0.0158		x	0.0061		0.0067			0.0234		0.0018		
Macro: Price	-0.0025		-0.0127			-0.0024		-0.0072			-0.0264		-0.0123		
Macro: Other	-0.0036		-0.0144		x	-0.0197	*	-0.0135	**	xx	0.0000		0.0000		
	Canada Lead					**Canada Contemp.**					**Canada Lag**				
IR	-0.0359		-0.0075			-0.0368	*	-0.0032		x	0.0000		0.0000		
IR Surprise	0.0884	**	0.0085		x	0.0891	**	0.0147		xx	0.0246		-0.0021		
Statement	-0.0112		-0.0010			-0.0125		-0.0013			0.0000		0.0000		
MPR	0.0000		0.0000			0.0000		0.0000			0.0039		-0.0073		
Testimony	-0.0030		0.0244			-0.0001		0.0299			0.0007		0.0252		
Speech	-0.0013		-0.0197			-0.0038		-0.0223			0.0000		0.0217	*	
Macro: Price	-0.0033		0.0215			-0.0034		0.0186	*		-0.0162	*	-0.0047		
Macro: Other	-0.0078	*	-0.0079		x	0.0000		0.0000			0.0099		0.0142	**	xx
Observations	588					588					588				
Parameters	41					41					41				
Log-likelihood	2034					2006					1962				

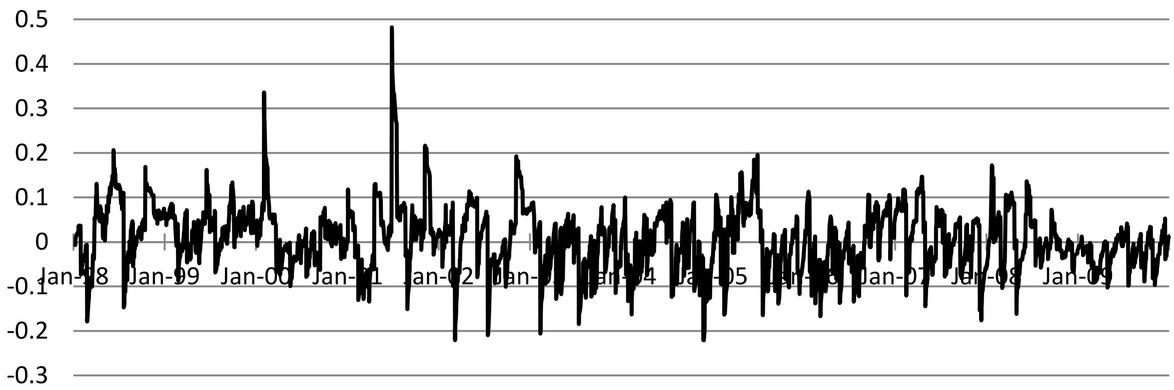
Note: * and ** indicate significance at a 5% and 1% level, respectively. x and xx indicates same sign and joint significance across both volatility equations at a 5% and 1% level, respectively. Standard errors are robust.

Table A3: Estimating Bivariate Financial Market Correlations: 10-Year Canadian Yields vs. TSX

	CAN 10Y		**TSX**			**CAN 10Y**		**TSX**			**CAN 10Y**		**TSX**	
c_{11}	0.0011					0.0007					0.0054	**		
c_{12}	0.0060					-0.0099					-0.0035			
c_{22}	0.0000					0.0000	**				0.0350			
a_1	0.1956	**	0.2487	**		0.2061	**	0.2550	**		0.1995	**	0.2426	**
b_1	0.9664	**	0.9641	**		0.9625	**	0.9622	**		0.9673	**	0.9665	**
	United States Lead					**United States Contemp.**					**United States Lag**			
IR	0.0000		0.0000			0.0000		0.0000			0.0000		0.0000	
IR Surprise	0.0474	**	0.7600			0.0396	*	0.8286			0.0378	**	0.3084	
Statement	-0.0086		0.2367			0.0129	*	-0.2565	*		-0.0078		0.2089	
MPR	-0.0126		0.4035	*		0.0133		-0.4275	*		-0.0032		0.4373	**
Testimony	0.0091		0.1800			0.0091		0.2400			0.0000		0.0000	
Speech	0.0112	*	-0.0067			0.0090		-0.0050			0.0076		-0.0110	
Macro: Price	0.0018		0.2265	*	**x**	-0.0011		-0.2230	*	**x**	-0.0048		-0.1982	
Macro: Other	-0.0087	*	-0.0698			-0.0126	*	-0.0746			0.0000		0.0000	
	Canada Lead					**Canada Contemp.**					**Canada Lag**			
IR	0.0163		-0.1737			-0.0121		0.2079			-0.0020		-0.3319	
IR Surprise	0.0268	*	0.1672			0.0265		0.1773			0.0270	*	0.2196	
Statement	-0.0061		0.2306			0.0132		-0.1526			-0.0078		0.0686	
MPR	0.0000		0.0000			0.0000		0.0000			0.0001		0.0016	
Testimony	0.0265	*	-0.1073			0.0247	*	-0.2013			0.0225	*	-0.2682	
Speech	-0.0108		-0.1407			0.0093		0.1465			0.0099		0.1102	
Macro: Price	-0.0136	*	-0.0038			0.0069		0.0067			0.0126		0.0861	
Macro: Other	0.0000		0.0000			0.0000		0.0000			0.0000		0.0000	
Observations	2900					2900					2900			
Parameters	41					41					41			
Log-likelihood	532					527					508			

Note: * and ** indicate significance at a 5% and 1% level, respectively. x and xx indicates same sign and joint significance across both volatility equations at a 5% and 1% level, respectively. Standard errors are robust.

Figure A2: Change in Conditional Correlation: 10-Year Canadian Yields vs. TSX



Note: Figure plots the difference in conditional correlations between a model employing (i) the full sample period and contemporaneous explanatory variables and (ii) a model without any explanatory variables.

Table A4: 10-Year Canadian Yields vs. TSX: Financial Crisis

	CAN 10Y		TSX			CAN 10Y		TSX			CAN 10Y		TSX		
c_{11}	0.0000					0.0082					0.0044				
c_{12}	0.0000					0.0691					-0.0234				
c_{22}	0.0000	**				0.0000					0.0000				
a_1	0.1552		0.2971	**		0.2318		0.3085	**		0.1534		0.3195	**	
b_1	0.9406	**	0.9377	**		0.8853	**	0.9391	**		0.9354	**	0.9364	**	
	United States Lead					**United States Contemp.**					**United States Lag**				
IR	-0.0106		0.1089			0.0296		-0.1200			-0.0264		0.2423		
IR Surprise	0.0715	**	0.9805			0.0653	*	0.7236			-0.0570	*	-1.0872		
Statement	-0.0008		-0.1150			0.0052		-0.2373			0.0000		0.0000		
MPR	-0.0172		-0.9756	*	**x**	-0.0368		-0.8873			0.0431		0.9027		
Testimony	0.0308	*	0.6987	*	**x**	0.0413	**	0.5933	*	**x**	0.0474	**	0.3095		
Speech	-0.0165		-0.1117			0.0218		0.1362			0.0000		0.0000		
Macro: Price	0.0105		-0.4403	*		0.0226		-0.2942			0.0118		-0.2898		
Macro: Other	0.0170		0.1547			0.0205		0.1343			0.0000		0.0000		
	Canada Lead					**Canada Contemp.**					**Canada Lag**				
IR	0.0000		0.0000			0.0000		0.0000			-0.0174		0.0863		
IR Surprise	0.0288		-0.6734			-0.0164		0.7643			0.0000		0.0000		
Statement	0.0064		1.0402	**	**xx**	-0.0024		0.4546			-0.0006		0.2577		
MPR	0.0000		0.0000			0.0121		0.7402			0.0072		0.8759	**	**xx**
Testimony	-0.0185		0.3675			0.0173		0.3555			0.0000		0.0000		
Speech	0.0181		0.0802			0.0146		0.3197			0.0227		0.4031		
Macro: Price	0.0308	*	0.2148			-0.0283		-0.1128			0.0268	*	0.4373		
Macro: Other	-0.0077		-0.0248			-0.0185		-0.0701			0.0210	*	0.0587		
Observations	588					588					588				
Parameters	41					41					41				
Log-likelihood	-179					-183					-188				

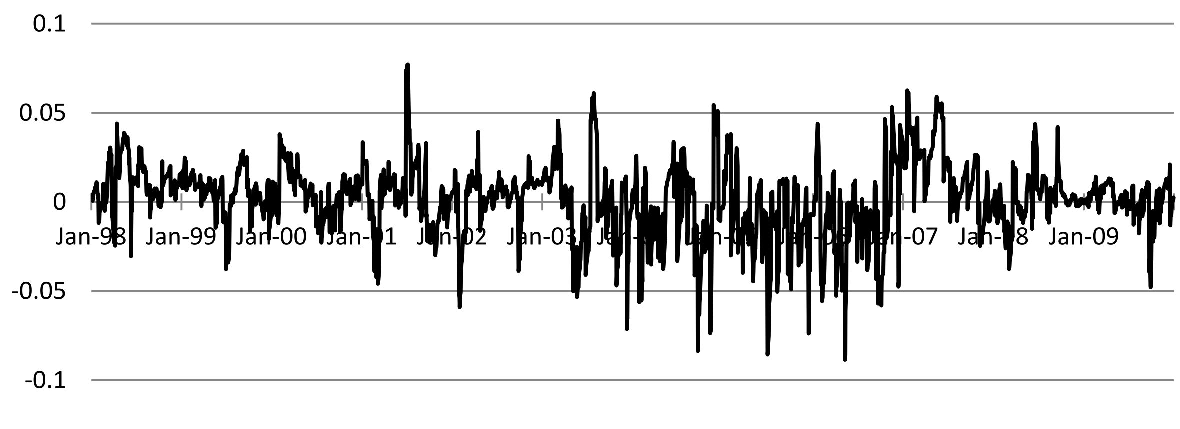
Note: * and ** indicate significance at a 5% and 1% level, respectively. x and xx indicates same sign and joint significance across both volatility equations at a 5% and 1% level, respectively. Standard errors are robust.

Table A5: Estimating Bivariate Financial Market Correlations: TSX vs. S&P 500

	TSX		S&P 500			TSX		S&P 500			TSX		S&P 500		
c_{11}	0.0504					0.0458					0.0421				
c_{12}	0.0829	**				0.0653					0.0809	**			
c_{22}	0.0000					0.0280					0.0000				
a_1	0.2275	**	0.2463	**		0.2279	**	0.2490	**		0.2191	**	0.2436	**	
b_1	0.9692	**	0.9644	**		0.9693	**	0.9639	**		0.9727	**	0.9658	**	
	United States Lead					**United States Contemp.**					**United States Lag**				
IR	0.0000		0.0000			0.0000		0.0000			0.0000		0.0000		
IR Surprise	0.8627	**	0.6843		xx	0.8441	**	0.5815		xx	0.0000		0.0000		
Statement	0.0667		-0.1089			0.0883		-0.1752			0.1540		0.0113		
MPR	-0.1423		-0.5024			0.1697		0.5588	*		0.3235		0.5727	**	x
Testimony	-0.1269		0.1160			0.2068		-0.0262			0.1483		-0.0591		
Speech	0.0000		0.0000			0.0000		0.0000			0.0000		0.0000		
Macro: Price	0.2315	**	0.1238			0.2561	**	0.1491		xx	-0.1803		-0.0877		
Macro: Other	0.0000		0.0000			-0.0487		-0.0252			0.0724		0.0015		
	Canada Lead					**Canada Contemp.**					**Canada Lag**				
IR	-0.0116		-0.2777			0.0660		0.3368	*		0.0047		-0.3072		
IR Surprise	0.2303		0.5319			0.2430		0.5367			0.2096		0.5016		
Statement	0.1898		0.1375			0.0000		0.0000			0.1049		0.1119		
MPR	0.0000		0.0000			0.0000		0.0000			0.0000		0.0000		
Testimony	0.1827		0.1804			0.1934		0.3294			0.2776		0.3625		
Speech	0.0130		0.2596	*	x	0.0156		0.2542	*		0.0153		0.2069		
Macro: Price	0.1271		-0.0142			-0.0491		-0.0064			0.0000		0.0000		
Macro: Other	0.0000		0.0000			0.0000		0.0000			0.0000		0.0000		
Observations	2900					2900					2900				
Parameters	41					41					41				
Log-likelihood	-7734					-7732					-7749				

Note: * and ** indicate significance at a 5% and 1% level, respectively. x and xx indicates same sign and joint significance across both volatility equations at a 5% and 1% level, respectively. Standard errors are robust.

Figure A3: Change in Conditional Correlation: TSX vs. S&P 500



Note: Figure plots the difference in conditional correlations between a model employing (i) the full sample period and contemporaneous explanatory variables and (ii) a model without any explanatory variables.

Table A6: TSX vs. S&P 500: Financial Crisis

	TSX		S&P 500			TSX		S&P 500			TSX		S&P 500		
c_{11}	1.6022	**				1.7970	**				1.7130	**			
c_{12}	1.2598					1.4826	**				1.3784	**			
c_{22}	0.0000					0.0000	*				0.0001				
a_1	0.2202		0.4977	**		0.2191	**	0.4962	**		0.1923		0.4713	**	
b_1	0.0000		-0.4625			0.0000		-0.4480			0.0000		-0.4556	**	
	United States Lead					**United States Contemp.**					**United States Lag**				
IR	1.3629		2.1337			-1.0687		-0.4632			0.0000		0.0000		
IR Surprise	3.0590		3.9785			0.8005		3.2633	**	x	2.2131		3.8835		x
Statement	1.1664		1.6095			-0.4209		0.8791	*		0.1126		0.4718		
MPR	-0.0001		-0.0001			1.5176		1.3709		x	0.2030		1.3692		
Testimony	1.2370		1.4357			1.7755		2.0555		x	0.9766		1.9035	*	x
Speech	0.0000		0.0000			0.0000		0.0000			0.0000		0.0000		
Macro: Price	-0.2201		0.1047			0.0000		0.0000			-0.0663		0.3186		
Macro: Other	1.2378	*	1.0636	*	xx	0.0421		0.3357			0.6734		0.6060		
	Canada Lead					**Canada Contemp.**					**Canada Lag**				
IR	1.0519		0.9048			1.1735		1.3274		x	0.5812		0.2191		
IR Surprise	2.6481		2.5248			1.1844		0.8810			1.0253		1.2450		
Statement	1.2063	*	0.3534		x	0.0000		0.0000			0.0000		0.0000		
MPR	0.0000		0.0000			0.0000		0.0000			0.3557		-0.0203		
Testimony	0.4542		0.4438			0.0215		0.5794			0.0736		0.4735		
Speech	0.0000		0.0000			1.8420		0.9679		x	2.0262		1.8780		xx
Macro: Price	1.2051		1.4310			0.2641		-0.2026			1.3678	*	0.8995		xx
Macro: Other	0.2406		-0.0234			0.0000		0.0000			0.5330		0.8272	*	xx
Observations	588					588					588				
Parameters	41					41					41				
Log-likelihood	-2087					-2100					-2100				

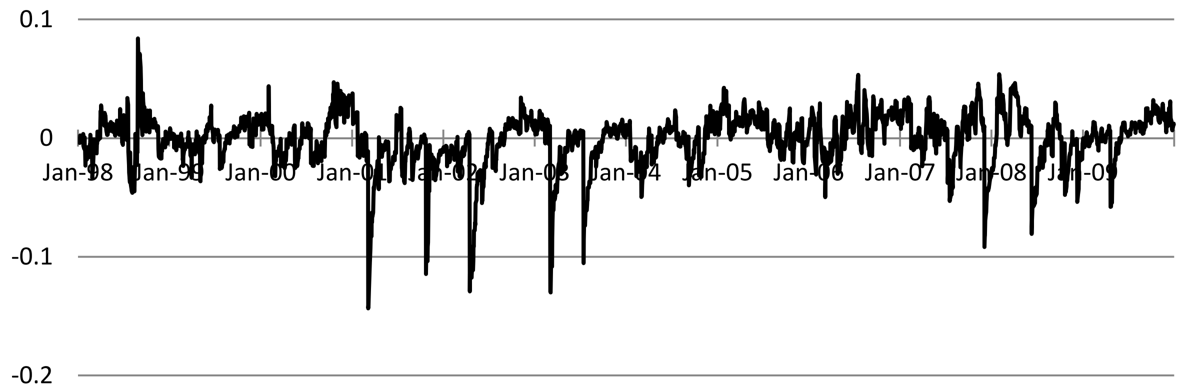
Note: * and ** indicate significance at a 5% and 1% level, respectively. x and xx indicates same sign and joint significance across both volatility equations at a 5% and 1% level, respectively. Standard errors are robust.

Table A7: Estimating Bivariate Financial Market Correlations: 10-Year Yields Canada vs. US

	CAN 10Y	US 10Y		CAN 10Y	US 10Y		CAN 10Y	US 10Y	
c_{11}	0.0006			0.0005			0.0041 *		
c_{12}	0.0036			-0.0022			0.0041 *		
c_{22}	0.0000 **			0.0000			0.0029 **		
a_1	0.2065 **	0.1909 **		0.2069 **	0.1938 **		0.2096 **	0.1939 **	
b_1	0.9670 **	0.9723 **		0.9676 **	0.9713 **		0.9686 **	0.9737 **	
	United States Lead			**United States Contemp.**			**United States Lag**		
IR	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	
IR Surprise	0.0398 **	0.0574 **	xx	0.0245	0.0454 **	xx	0.0090	0.0289	
Statement	-0.0072	-0.0051		0.0104	0.0081		0.0139 *	0.0109	xx
MPR	0.0110	0.0197		0.0027	0.0175		-0.0072	0.0093	
Testimony	-0.0086	-0.0031		0.0060	0.0153		-0.0055	-0.0124	
Speech	-0.0102 *	-0.0120 *	xx	-0.0076	-0.0087		0.0000	0.0000	
Macro: Price	0.0000	0.0000		0.0000	0.0000		0.0044	0.0011	
Macro: Other	0.0075 *	0.0078	xx	-0.0104 **	-0.0114 **	xx	0.0000	0.0000 *	
	Canada Lead			**Canada Contemp.**			**Canada Lag**		
IR	-0.0134	0.0023		-0.0152	-0.0009		-0.0203 **	-0.0147	xx
IR Surprise	0.0093	-0.0194		-0.0110	0.0168		-0.0015	-0.0267	
Statement	-0.0080	-0.0172 *	x	0.0120	0.0225 **	xx	-0.0113	-0.0173	x
MPR	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	
Testimony	-0.0256	-0.0362 *	xx	0.0128	0.0312		0.0013	0.0202	
Speech	-0.0123	-0.0144	x	-0.0086	-0.0092		0.0126	0.0122	x
Macro: Price	-0.0139 *	-0.0076		-0.0077	-0.0012		-0.0111	-0.0104	x
Macro: Other	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	
Observations	2900			2900			2900		
Parameters	41			41			41		
Log-likelihood	10316			10311			10299		

Note: * and ** indicate significance at a 5% and 1% level, respectively. x and xx indicates same sign and joint significance across both volatility equations at a 5% and 1% level, respectively. Standard errors are robust.

Figure A4: Change in Conditional Correlation: 10-Year Yields Canada vs. US



Note: Figure plots the difference in conditional correlations between a model employing (i) the full sample period and contemporaneous explanatory variables and (ii) a model without any explanatory variables.

Table A8: 10-Year Yields Canada vs. US: Financial Crisis

	CAN 10Y		US 10Y			CAN 10Y		US 10Y			CAN 10Y		US 10Y		
c_{11}	0.0000					0.0082					0.0052				
c_{12}	0.0000					0.0054					0.0022				
c_{22}	0.0000					0.0000	**				0.0000				
a_1	0.1147		-0.0238			0.1711		0.0148			0.0883		-0.0479		
b_1	0.9408	**	0.9624	**		0.8983	**	0.9403	**		0.9549	**	0.9652	**	
	United States Lead					**United States Contemp.**					**United States Lag**				
IR	0.0286		-0.0043			0.0391	*	-0.0021			0.0235		-0.0046		
IR Surprise	0.0729	**	0.0864	**	xx	0.0660		0.0739	**	xx	-0.0581	**	-0.0622	*	xx
Statement	-0.0023		-0.0120			0.0047		0.0171			0.0014		-0.0122		
MPR	0.0340	*	0.0592	**	xx	0.0399	*	0.0695	**	xx	-0.0316		-0.0562		x
Testimony	0.0455	**	0.0772	**	xx	0.0555	**	0.0943	**	xx	0.0470	**	0.0844	**	xx
Speech	0.0209		0.0211		x	-0.0277		-0.0264			0.0000		0.0000		
Macro: Price	0.0000		0.0000			-0.0162		-0.0267			-0.0042		-0.0076		
Macro: Other	-0.0156	*	-0.0209	*	xx	-0.0215	**	-0.0329	**	xx	0.0033		0.0092		
	Canada Lead					**Canada Contemp.**					**Canada Lag**				
IR	-0.0128		-0.0349		x	-0.0097		-0.0298			-0.0047		-0.0290		
IR Surprise	0.0224		-0.0051			-0.0060		0.0297			0.0034		-0.0120		
Statement	0.0000		0.0000			0.0000		0.0000			-0.0257		-0.0435		
MPR	0.0118		0.0318	*	xx	0.0000		0.0000			0.0000		0.0000		
Testimony	0.0260		0.0481		xx	0.0278		0.0476	*	xx	0.0079		0.0182		
Speech	0.0000		0.0000			0.0000		0.0000			0.0167		0.0167		
Macro: Price	0.0249		0.0296	*	xx	0.0273		0.0210		x	-0.0287	**	-0.0329	**	xx
Macro: Other	-0.0150		-0.0070		x	-0.0153	*	-0.0054			-0.0126		-0.0139		
Observations	588					588					588				
Parameters	41					41					41				
Log-likelihood	1820					1822					1814				

Note: * and ** indicate significance at a 5% and 1% level, respectively. x and xx indicates same sign and joint significance across both volatility equations at a 5% and 1% level, respectively. Standard errors are robust.