Impact of US Unconventional Monetary Policy on Dynamic Stock-Bond Correlations: Portfolio Rebalancing and Signaling Channel Effects

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ABSTRACT

This research examines the effects from unconventional monetary policy through, portfolio rebalancing and signaling channels, on the dynamic correlation between US stock and bond markets, as well as on the dynamic correlation between US stock (bond) and other advanced countries' bond (stock) markets. The research utilised daily data from 26 November 2008 to 30 November 2015, utilising the conditional nonlinear quantile regression approach. The empirical results reveal that the portfolio rebalancing channel exerts strong and predominantly negative effects on the dynamic correlation between US stock and bond markets, as well as between US bond and other advanced countries' stock markets. In contrast, the signaling channel exerts quite strong and weak positive effects on the dynamic correlation between US stock and bond markets, as well as between US bond and other advanced countries' stock markets, respectively. The results also provide evidence of asymmetric effects from portfolio rebalancing and signaling channels on the dynamic correlation between US stock and bond markets at lower quantiles, while only the portfolio rebalancing channel asymmetrically affects the dynamic correlation between US bond and other advanced countries' stock markets at lower quantiles. Thus, these findings provide valuable information for traders and portfolio managers who allocate capital with the US and across other developed countries' stock and bond markets.

Keywords: Dynamic stock-bond market correlations**,** portfolio rebalancing and signaling channels, quantile regression

ÖZ

Bu araştırma, geleneksel olmayan para polikasının, portföy yeniden dengeleme ve sinyal kanalları aracılığıyla, ABD hisse senedi ve tahvil piyasaları arasındaki dinamik korelasyonun yanı sıra ABD hisse senedi (tahvil) ve diğer gelişmiş ülkelerin tahvil (hisse senedi) piyasaları arasındaki dinamik korelasyon üzerindeki etkilerini incelemektedir. Araştırmada, 26 Kasım 2008 - 30 Kasım 2015 arasını kapsayan günlük veri seti koşullu doğrusal olmayan quantil regresyon yöntemi ile analiz edilmiştir. Elde edilen ampirik bulgular, portföy yeniden dengeleme kanalının ABD hisse senedi ve tahvil piyasaları ile ABD tahvil ve diğer gelişmiş ülkelerin hisse senedi piyasaları arasındaki dinamik korelasyon üzerinde ağırlıklı olarak güçlü bir negatif etkiye sahip olduğunu ortaya koymaktadır. Buna karşılık,sinyal kanalı sırasıyla ABD hisse senedi ve tahvil piyasaları arasındaki dinamik korelasyon üzerinde oldukça güçlü bir pozitif etki gösterirken, ABD tahvil ve diğer gelişmiş ülkelerin hisse senedi piyasaları arasındaki dinamik korelasyon üzerinde zayıf bir etkiye sahiptir. Aynı zamanda bulgular, belirtilen her iki kanalın da ABD hisse senedi ve tahvil piyasaları arasındaki dinamik korelasyonun düşük quantilleri üzerindeki asimetrik etkisini ortaya koyarken, ABD bono ve diğer gelişmiş ülkelerin hisse senedi piyasaları arasındaki korelasyonun düşük quantileları üzerinde sadece portföy yeniden dengeleme kanalının asimetrik etkisine işaret etmektedir. Elde edilen bulgular ABD ve diğer gelişmiş ülkelere yatırım yapan portföy yöneticileri için önemli bilgiler sağlamaktadır.

Anahtar Kelimeler: Dinamik hisse senedi-tahvil piyasası korelasyonları, portföy yeniden dengeleme ve sinyal kanalları, kuantil regresyon

DEDICATION

TO MY FAMILY

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVAIATIONS

ABD	Agency-Backed Debt
ADF	Augmented Dickey-Fuller
ARCH	Autoregressive Conditional Hteroskedasticity
BOE	Bank of England
DCC	Dynamic Conditional Correlation
ECB	European Central Bank
Fed	Federal Reserve
FOMC	Federal Open Market Committee
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
ILR	Interbank Lending Rate
LSAP	Large Scale Asset Purchases
MBS	Mortgage Backed-Securities
MPC	Monetary Policy Committee
PP	Phillips-Perron
QE	Quantitative Easing
UMP	Unconventional Monetary Policy
ZLB	Zero Lower Bound

Chapter 1

INTRODUCTION

1.1 Research background

Stocks and government bonds are considered key financial investment instruments, comprising a major portion of the market capitalisation of all securities traded in any international stock exchange and banks' balance sheets (Andersson, Krylova and Vähämaa, 2008). Government bonds are risk-free securities that deliver regular periodic incomes for investors, while stocks provide higher returns to compensate for risk-taking. Thus, constructing an investment portfolio comprising these two asset classes allows investors to diversify risk and, thus, increase portfolio immunisation by maintaining negative stock-bond market correlations (Marcello, 2018). The share of stocks and bonds to investors' total portfolio compositions cannot be held constant continually over time, as bond and stock markets are subject to developments and innovations in the economic and financial environment. These developments and innovations, in turn, influence stocks and bonds' payoffs and risks. Therefore, investors are advised to analyse and evaluate new economic and financial information frequently and make necessary adjustments to their portfolios (Chiang, Li and Yang, 2015). As a result, the correlation between stock and bond markets is subjected implicitly to developments and innovations occurring in the economic and financial environment. In light of the above realities, this research intends to explore unprecedented monetary policy measures that accompanied the 2008 financial crisis, namely the effect from the Federal Reserve's (Fed) unconventional monetary policy

(UNMP) on the stock and bond market dynamic correlations in the US and also between US stock (bond) and other advanced countries' bond (stock) markets.

International stocks and bonds, particularly in advanced countries, are the major asset classes because of their large market size, liquidity, and stability. Furthermore, bond and stock markets typically have different features related to risk-taking and reward compensation that help investors maintain efficient diversification while constructing portfolios (De Santis and Sarno, 2008). Also, international stock and bond markets are characterised by lower borrowing costs, giving investors and governments access to new sources of funds, as most domestic capital markets are smaller and more costly when borrowing (United Nations Conference on Trade and Development, 2018). Global investment portfolios' volatility is lower than that of domestic investment portfolios, as global investment portfolio asset combinations may have lower correlations compared with domestic ones. Therefore, global investment portfolios may provide an opportunity for further diversification, thereby reducing unsystematic risk (Bartram and Dufey, 2001). The reasons mentioned above are why international stocks and bonds comprise a major portion of international and local investment portfolios, making these instruments part of an investment strategy that affects both risk and return on the portfolios.

Understanding the dynamic movement of global stock and bond markets plays a vital role in optimal portfolio diversification and investment risk management strategies, as developments and innovations in the global financial environment do not affect all global stock and bond markets equally, making international diversification more essential and effective. Therefore, international investors often respond to shocks originating from global financial events by adjusting their investment portfolio compositions across multiple global financial markets (Kolluri, Wahab, and Wahab, 2015). For example, the decline in the US government's bond yields due to the Fed's implementation of UNMP during the 2008 financial crisis induced stock market participants to shift funds from US bond markets to global stock markets. This kind of adjustment by investors reflects global stock and bond markets' critical role in offering alternative investment opportunities and maximizes diversification benefits.

Governments' economic policy decisions – especially monetary policy decisions – elicit vital domestic and cross-border effects on financial market performance, particularly if decisions originate in developed economies such as the US because of its massive size and deep international connections. The US comprises one-fifth of global output and one-tenth of international trade streams. Specifically, the US accounts for almost 22% of global output, 30% of global stock market capitalisations and 20% of global investment in stocks, making the US a significant actor in international financial markets (Kose, Lakatos, Ohnsorge and Stocker, 2017). Also, the US dollar is used widely as the dominant currency in global financial transactions and is the world's reserve currency. About 80% of all issued bonds worldwide are denominated in this currency, and about 50% of bank-capital flows in Asian and European countries are denominated in US dollars. Furthermore, the US dollar is utilised largely to settle global trade dealings with about one-third and two-thirds of goods and services in Europe and Asia, respectively, priced in US dollars (Kose et al., 2017). Therefore, advanced countries are economically and financially linked to the US. As a result of such linkages, US financial markets are associated strongly with its international counterparts, especially developed European Union countries, Japan and Canada (Ehrmann, Fratzscher and Rigobon, 2011; Rose and Spiegel, 2011).

Based on the above realities, US monetary policy changes affect conditions within international financial environments (Ehrmann and Fratzscher, 2009; Bekaert, Hoerova and Duca, 2013; Rogers, Scotti and Wright, 2014; Bruno and Shin, 2015; Fratzscher, Lo Duca and Straub, 2018). These effects have been more critical since the 2008 global financial crisis, as countries became financially more integrated, and global stock markets turned out to be highly volatile (Joyce, Miles, Scott and Vayanos, 2012). Thus, US monetary policy changes drive international financial market conditions (Ehrmann and Fratzscher, 2009; Bekaert et al., 2013; Bruno and Shin, 2015; Rogers et al., 2014; Fratzscher et al., 2018).

US monetary policy's international impacts on global financial market conditions are clearly and mainly observed in countries with close economic ties to the US and whose monetary policies historically exhibit higher sensitivity to signals emanating from US monetary policy stance changes, e.g., Australia, Canada, and Germany (Bauer and Neely, 2014). Therefore, any shift in US monetary policy positions internationally will have consequences for these other advanced countries' financial markets. In practice, other advanced nations' central banks correlate their monetary policies with that of the Fed, as they react similarly to global crises such as the one in 2008. Also, for exchange rate stability, central banks in these advanced countries might be required to follow US monetary policy (Craine and Martin, 2008). In this regard, Hausman and Wongswan (2011) pointed out that advanced countries strongly react to surprise moves in US monetary policy in which yields on government bonds (long-term interest rates) in countries like Australia, Canada, and Germany respond substantially to US monetary policy announcements. Moreover, advanced countries' monetary policies are highly integrated and influenced by their US counterpart, in which innovations in both US long- and short-term interest rates explain 15% and 10% of Euro area bond yield variance, respectively (Ehrmann et al., 2011).

Before the 2008 financial crisis, key advanced countries' central banks particularly that of the US, were conducting conventional monetary policy, i.e., employing conventional methods, namely adjusting official short-term interest rates to keep inflation rates below a certain threshold and employment at maximum levels (Glick and Leduc, 2013). In other words, in normal situations, central banks adjust the Federal funds rate to affect credit requirements for banks and other credit institutions, as well as influence longer-term interest rates, thereby achieving the aforementioned desired goals (Blinder, Ehrmann, Fratzscher, De Haan and Jansen, 2008; Boivin, Kiley and Mishkin, 2010). However, with the first sign of the financial crisis in 2007, the Fed started to reduce the Federal funds rate's target rate to increase the liquidity level in the financial spectrum system and, thus, boost aggregate demand and catalyse economic activities. At the beginning of 2007, in an unprecedented move, the Federal funds rate was reduced by 5%, but with worsening economic conditions, the first cut was not enough to stimulate the economy, so an additional 7% needed to be cut. These unprecedented reductions in the Federal funds rate's target rate continued, particularly after the downfall of Bear Stearns and Lehman Brothers in September 2008, eventually falling to the near-zero target range between 0% and 0.25% in December 2008 – the so-called Zero lower bound (ZLB) (Rudebusch, 2011).

After hitting ZLB, an additional reduction in the Federal funds rate's target rate to provide further credit easing and boost the economy could not be achieved through traditional monetary policy by depressing the Federal funds rate's target rate.

Therefore, the central bank needed to use unconventional monetary policy tools to tackle liquidity and credit issues that emerged from the financial crisis to achieve financial stability (Joyce et al., 2012). Accordingly, the Fed began to employ UNMP by using a forward communication tool (signaling channel) to offer guidance about the prospective path of monetary policy by signaling to market participants that the Federal funds rate's target rate would remain between 0% and 0.25% until mid-2015 in an attempt to reduce long-term government bond yields to encourage aggregate demand and enhance economic growth (Gagnona, Raskinb, Remacheb and Sack, 2011). To achieve an additional reduction in long-term interest rates, the Fed had to implement quantitative easing (QE) programs that entail purchasing large amounts of financial assets comprising long-term government bonds and mortgage-backed securities to reduce the risk premium of these long-term interest rates and, thus, their yields (Eksi and Tas, 2017; Neely, 2015). In other words, the Fed had to use another channel besides the signaling channel to diminish long-term interest rates, namely the portfolio rebalancing channel (D'Amico and Farka, 2011; Christensena and Rudebuscha, 2012; Bauer and Rudebusch, 2014).

The Fed's efforts to use signaling and portfolio rebalancing channels to reduce yields on government bonds coincided with changes in domestic and foreign financial asset prices, particularly government bond and stock prices. First, the signaling channel can affect domestic stock and bond prices through its effects on investors' expectations on the prospective path of short-term interest rates (Neely, 2015; Hughes and Rogers, 2016). Lower levels of expected future short-term interest rates decrease discount rates by which bonds and stocks' future cash flows are discounted, thereby increasing stock and bond prices and influencing the dynamic correlation between US stock and bond markets (Ilmanen, 2003). Moreover, due to higher monetary interconnections and economic ties between the US and foreign countries, the Fed's signaling channel is more likely to exercise decreasing effects on foreign short-term interest rates abroad, specifically in advanced countries (Bauer and Rudebusch, 2014; Bauer and Neely, 2014). As a result, foreign bond and stock prices tend to increase, thereby affecting the dynamic correlations between US stock (bond) and other advanced countries' bond (stock) market correlations in response to the Fed's signaling channel.

Second, the portfolio rebalancing channel also can affect bond and stock prices domestically and internationally by pushing the risk premium of longer-term US government bonds downward, thereby reducing yields on these government bonds. On the one hand, the reduction in yields on US government bonds convinces institutional investors, such as mutual fund and life insurance firms who prefer specific maturity for matching their liabilities, to shift their portfolios toward more risky assets.[1] This behaviour corresponds with the preferred-habit theory by Modigliani and Sutch (1966) and Tobin (1958, 1969). Also, the decline in US government bond yields encourages investors with less risk aversion[2] to investing in risky assets such as stocks. This shift in inventors' portfolio compositions will lead to an increase in US and foreign stock prices (Gagnon et al., 2011; Hamilton and Wu, 2012; Wright, 2012; Thornton, 2013; Rogers et al., 2014; Tillmann, 2016; Bernhard and Ebner, 2017; Fratzscher et al., 2018). Therefore, the dynamic correlations between US stock and bond markets, as affected by Fed's UNMP through portfolio-

[1] Boubaker, Gounopoulos, Nguyen and Paltalidis (2017) found that unconventional US monetary policy induces US institutional investors, such as pension funds, to increase and allocate more capital toward equity rapidly. Moreover, Eksi and Tas (2017) indicated that US investors rebalance their portfolios toward US stocks after the Fed conducts large-scale asset purchases (LSAP).

[2] Fassas and Papadamou, (2018) pointed out that UNMP announcements significantly reduce investors' risk aversion, thereby encouraging them to invest in higher-risk investments due to higher liquidity levels and extremely low short-term interest rates during the UNMP period.

rebalancing channel. On the other hand, the decrease in the yields of US long-term government bonds is accompanied by a parallel lower decline in government bond yields in foreign countries in response to US UNMP Under this condition, risk-averse investors may look for other international government bonds that carry similar features relative to the US by re-balancing their portfolios to such international government bonds (Greenwood and Vayanos, 2010; Vayanos and Vila, 2009), especially those in advanced countries whose excess bond returns' covariance and correlation are high, along with their counterparts in the US, such as Australia, Canada, Japan and Germany (Bauer and Neely, 2014). This indicates that any change in US government bond yields due to UNMP via the portfolio balance channel will exert strong portfolio balance effects in these countries' bonds, which would increase these bonds' prices in advanced countries.[3] Given that US stock prices tend to increase as a result of less risk-averse investors' actions, the dynamic correlation between US stock prices and other advanced countries' bond prices tends to be affected by the Fed's UNMP via the portfolio rebalancing channel.[4]

This thesis contains six chapters. Chapter 2 presents literature conducted on UNMP effects on stock and bond markets, as well as literature was done on the determinants of stock-bond market correlations. Chapter 3 provides a theoretical background on UNMP and its transmission mechanism channels. Chapter 3 also theoretically analyses how UNMP channels influence dynamic stock-bond market correlations. Chapter 4 describes and presents both data and econometric models used to examine

[3] Bubeck, Habib and Manganelli (2018) indicated that European and emerging-market funds' bond prices increased by 0.5% and 0.2%, respectively, in response to unconventional European monetary policy.

[4] Hughes and Rogers (2016) found that unconditional correlations between the US stock market and other advanced countries' bond market indices were highly negative during (ZLB) comparatively prior (ZLB).

UNMP's effects on dynamic stock-bond market correlations. Chapter 5 demonstrates and discusses the estimated empirical results. Finally, Chapter 6 summarises the research's results and provides monetary policy makers and the financial community with related implications.

1.2 Research's objective

This thesis intends, first, to gauge the dynamic correlation between US stock and bond markets, and the dynamic correlations between the US bond (stock) and other advanced countries' stock (bond) markets. The dynamic correlations are computed during the US UNMP period, which ran from 26 November 2008 to 30 November 2015, utilising the dynamic conditional correlations approach of Engle (2002). The second objective is to explore to what degree the US UNMP drives the dynamic correlations between the US stock and bond markets, as well as the dynamic correlation between US bond (stock) and other advanced countries' stock (bond) markets through signaling and portfolio rebalancing channels using the quantile regression approach. Accordingly, this research mainly aims to answer the following research questions:

Does US UNMP through signaling and portfolio rebalance channels significantly influence the dynamic correlation between US stock and bond markets?

Does US UNMP through signaling and portfolio rebalance channels significantly influence the dynamic correlation between US bond and other advanced countries' stock markets?

Does US UNMP through signaling and portfolio rebalance channels significantly influence the dynamic correlation between the US stock and other advanced countries' bond markets?

1.3 Research's importance

Understanding that stock-bond market correlations are dynamic and vary from time to time implies that bond and stock markets within a country or across countries are not independent of each other, but are interrelated. Therefore, identifying the direction and strength of the dynamic correlation between US stock and bond markets and between US stock (bond) and other advanced countries' bond (stock) markets elicits direct impacts on the distribution of investors' capital in their portfolios to build risk-reduction strategies as bond-stock market correlations play an essential role in affecting investment portfolios' risk. Moreover, investment portfolio strategies that deem stock-bond market correlations as constants may be improved by considering that stock-bond market correlations are dynamic and impacted by changes in the economic and financial environment. Therefore, it is essential for investors and portfolio managers to identify whether dynamic stock-bond market correlations are negative, as lower dynamic stock-bond market correlations provide an opportunity for investors to reduce their portfolio risk by including US bonds or bonds from other advanced countries' markets in their stock portfolios. Moreover, UNMP's role through signaling and portfolio rebalancing channels in determining dynamic stock-bond market correlations becomes relevant for finance community particularity, investors, and portfolio managers. They will have useful guidance for portfolio asset allocation and for building risk-reduction strategies by identifying the direction and strength of the comparative effects from signaling and portfolio rebalancing channels on dynamic stock-bond market correlations. Also, this research offers valuable information for traders, enabling them to establish their arbitrage strategies so they can make a profit through the dynamic association between stock and bond markets and its determinants.

1.4 Research's contribution

To the best of my knowledge, this research is the first to explore US UNMP effects by investigating them through signaling and portfolio rebalancing channels and the dynamic correlation between US stock markets and bond markets, as well as dynamic correlations between US stock (bond) and other advanced countries' bond (stock) markets. Therefore, this thesis contributes to the extant literature in three ways. First, it addresses and highlights the relative influence of US UNMP, conducted by the Fed, by investigating the effect of portfolio rebalancing and signaling channels on dynamic stock-bond market correlations. Thus, this thesis offers new empirical results on UNMP's effects on the dynamic correlation between stock and bond markets. Related studies primarily have concentrated on conventional monetary policy's role on dynamic stock-bond market correlations (Ilmanen, 2003; Yang, Zhou and Wang, 2009; Aslanidis and Christiansen, 2012; Dimic, Kiviaho, Piljak and Äijö, 2016; Flageollet and Bahaji 2016; Skintzi, 2019). Second, it also addresses US UNMP channels' spillover effects on the dynamic stock-bond market associations across countries – and across asset levels – while previous empirical literature primarily concentrated on dynamic stock-bond market correlations at the national level (Aslanidis and Christiansen, 2010; Aslanidis and Christiansen, 2014; Chiang et al., 2015; Asgharian, Christiansen and Hou, 2016; Dimic et al., 2016). Therefore, this thesis will provide new evidence on how US UNMP channels influenced dynamic correlations between US stock (bond) and other advanced countries' bond (stock) markets. Third, this research offers new insight into the effect of the Fed's QE announcements on the dynamic correlation between asset markets. Previous literature has concentrated on the response from dynamic correlations between the stock, bond and currency markets and the Fed's QE announcements

(Kryzanowski, Imus and Srinivasan, 2017). Therefore, this research adds to extant literature on QE and the impact from QE phases Q1, Q2 and Q3 on the dynamic correlations between US stock and bond markets, as well as between US stocks (bond) and other advanced countries' bond (stock) markets.

Chapter 2

LITERATURE REVIEW

2.1 UNMP's effect on bond markets

Extant literature substantially has examined UNMP's effects on domestic and international government bonds. The vast majority of empirical research has concluded that UNMP, through investigating the effects of signaling and portfolio rebalancing channels, as well as the announcement of large-scale asset purchases (LSAP), remarkably and substantially reduces the US and foreign long-term government bond yields (e.g., Gagnon, Raskin, Remache and Sack, 2010; Gagnon et al., 2011; Krishnamurthy and Vissing-Jorgensen, 2011; Christensen and Rudebusch, 2012; Joyce and Tonks, 2012; Wright, 2012; Bauer and Neely, 2014; Alpanda and Kabaca, 2015; Neel, 2015; Altavilla, Carboni and Motto, 2015; D'Amico and King, 2015; Andrade, Breckenfelder, Fiore, Karadi and Tristani, 2016; Eser and Schwaab, 2016; Haldane, Roberts-Sklar, Young and Wieladek, 2016).

In this respect, several studies (e.g., Gagnon et al., 2011; Christensen and Rudebusch, 2012; Joyce et al., 2012) have emphasized that LSAP announcements by the Fed and Bank of England (BOE) exert significant negative effects on government bond yields in the US and UK, respectively. Bauer and Neely (2014) pointed out that UNMP has exerted domestic and international effects on government bond yields. They indicated that signaling and portfolio rebalancing channels from US UNMP asymmetrically reduced yields on government bonds in the US and other advanced countries, including Australia, Canada, France, Germany, and the UK. For the US and Canada, yields substantially were reduced in response to signaling and portfolio rebalancing channels with a relatively larger effect from the signaling channel. For Australian and German yields, the portfolio rebalancing channel exerted a dominant effect in lowering their yields compared with the signaling channel. The exception is Japan, where both channels are irrelevant to Japanese yields. Also, Neely (2015) found that LSAP announcements by the Fed largely reduced yields on government bonds, particularly in the US and also in other advanced countries such as Australia, Canada, Germany, Japan, and the UK.

2.2 UNMP's effect on the stock markets

Extant literature has attempted to investigate, domestically and internationally, UNMP's effect on stock market prices (e.g., Gagnon et al., 2011; Joyce et al., 2011; Rogers et al., 2014; Kiley, 2014; Moessner, 2015; Swanson, 2015; Neely, 2015; Boubaker et al., 2017; Fratzscher et al., 2018; Shaha, Schmidt-Fischera, Malkib and Hatfield, 2019). This literature mainly concluded that UNMP positively affects domestic and international stock market prices. Joyce et al. (2011) argued that QE conducted by the Bank of England (BOE) generates an incentive for investors to rebalance their portfolios toward domestic stocks in place of government bonds. This, in turn, leads to decreases in additional compensation that investor's demand holding stocks (stock-risk premium), thereby increasing stock prices. Also, Moessner (2015) pointed out that US UNMP has exerted positive spillover effects on stock market prices in developed and emerging-market countries. He argued that the Fed's signals to maintain the Federal funds rate's target rate between 0% and 0.25% give rise to reduced yields on long-term US government bonds and follow-offs to reduce yields on long-term foreign bonds. The decline in these foreign yields leads to increased foreign stock prices, as future cash flows of foreign stocks are discounted to lower rates. Moreover, Boubaker et al. (2017) pointed out that the reduction in long-term US government bonds due to QE done by the Fed induces investors with partiality for specific maturities like mutual funds to seek yields and rebalance their portfolios toward another risky domestic asset such as stocks, leading to price increases for those stocks.

A few studies have considered UNMP's effects on stock market returns and have come up with different results. For example, Eksi and Tas (2017) found that US stock market returns profoundly and negatively reacted to the Fed's UNMP. In contrast, Fausch and Sigonius (2018) and Chebbi (2019) concluded that European stock market index returns in Germany, Italy, and Spain positively reacted to the announcement of UNMP implementation by the European Central Bank (ECB). In another research, Chortareas, Karanasos, and Noikokyris (2019) found that UK stock market returns' response to asset-purchase announcements by the BOE's monetary policy committee (MPC) depends on previous MPC meetings' information statements on inflation and unanimity. Stock returns' response appears to be positive to MPC announcements, but after inflation and unanimous decisions were reported, stock returns' responses turned out to be negative.

Some studies have paid attention to UNMP's impact through QE announcements on stock market volatility. In this respect, studies have found that QE announcements exerted mixed effects on stock market volatility (e.g., Joyce et al., 2011; Tan and Kohli, 2011; Shogbuyi and Steeley, 2017; Lyócsa, Molnár and Plíhal, 2019). Tan and Kohli (2011) indicated that stock market volatility temporarily declines in response to QE announcements. They found that out of the QE phases (Q1, Q2 and Q3), the

Fed reduces US stock index volatility by significant levels, then reverts it to prior levels at the end of each QE phase. Also, Joyce et al. (2011) indicated that stock index volatility on the FTSE100 significantly and temporarily declines after the Q1 announcement by BOE, then returns to its preceding level at the end of Q1. Moreover, Shogbuyi and Steeley (2017) confirmed that QE exerts a temporary effect in lowering stock index volatility, as they indicated that QE conducted by the Fed and BOE reduces S&P 500 and FTSE100 returns' volatility, respectively, after the end of the QE phase, then reverts to previous levels. However, they pointed out that QE conducted by the Fed and BOE caused an increase in stock index volatility in Germany, France, and Japan. They concluded that the Fed and BOE's UNMP effect through portfolio rebalancing could induce investors to seek higher-yield assets such as stocks (in Germany, France, and Japan), thereby leading to higher stock index volatility in these countries. Conversely, Lyócsa, Molnár, and Plíhal (2019) found that stock market volatility in Canada, Japan, the US, and the UK did not respond significantly to QE announcements. In another research, Chortareas, Karanasos, and Noikokyris (2019) attempted to examine UNMP's effects through MPC declarations on stock market volatility in the UK. They referred to FTSE100 return volatility positively reacting to the BOE's MPC announcement. This reaction turned out to be negative after the BOE's inflation, and unanimous-decision report was released.

2.3 Dynamic stock-bond market correlation determinants

Extant literature has been given considerable attention to research macroeconomic factor expectation effects, particularly inflation expectations, on dynamic stock-bond market correlations (Ilmanen, 2003; Li, 2004; Andersson et al., 2008; Baele, Bekaert and Inghelbrecht, 2010; David and Veronesi, 2013). However, the controversy over the influence of expected inflation on dynamic stock-bond market correlation continues. Ilmanen (2003) points out that the dynamic correlations between US stock and bond markets are positively influenced by expected inflation rates. Ilmanen explained this result through the dividend discount model framework[5], arguing that if expected inflation rates rise more than the expected growth rate of stocks' future dividends, stock market prices and returns tend to decrease. Bond market prices are inevitably and negatively affected by higher expected inflation rates, resulting in declines in bond market returns. Therefore, returns on stock and bond markets go in the same direction, so the dynamic correlation between the two markets tends to be positive over periods of higher expected inflation. Also, Li (2004) found that expected inflation has a large positive effect on the dynamic correlation between stock and bond markets in G7 countries. Andersson et al. (2008) also indicated that as the anticipated growth rate of inflation increases, the dynamic correlation between stock and bond markets tends to increase in countries like Germany and the US. However, Baele et al. (2010) demonstrated that expected inflation is not as crucial as microfinance factors, especially bond-market liquidity variables, in deriving dynamic movement between stock and bond returns in the US market. David and Veronesi (2013) provided evidence that the co-movement between US stock and bond markets is non-linearly influenced by expected inflation in the US. They discovered that the covariance between stock and bond markets positively and significantly responded to higher expected inflation periods, as greater expectations on inflation (positive inflation shocks) signal longer probability of the inflation stage and bad news for both stock and bond markets. Therefore, the stock market returns move in directions similar to bond market returns. However, lower expected inflation periods signal good news for stock markets, but still signal bad news for bond markets, leading to

[5] See Chapter (3) Equation (4) page (49). Note that in Equation (4), the stock-risk premium includes the expected inflation rate.

increasing stock returns, decreasing bond returns and, thus, negative co-movement between stock and bond markets.

Another area of extant literature addressed the influence of other macroeconomic-factor expectations, such as real interest rates and economic growth on dynamic correlations between stock and bond markets. A few empirical studies were conducted on real interest rate expectation effects on dynamic correlations between stock and bond markets. For example, Li (2004) found that expectations on real interest rates positively affect the dynamic correlation between the two markets, and expectations on real interest rates are a driving force in forecasting the dynamic correlation between stock and bond markets in G7 countries. Also, d'Addona and Kind (2006) examined how expected real interest rates derive the dynamic correlation between stock and bond markets in G7 countries. Results showed that increasing real interest rates' expectations positively derives dynamic stock-bond market correlations. They argued that the decline (rise) in expectations on real interest rates implies that stocks and bonds' future returns are discounted at higher (lower) rates. Therefore, higher (lower) expected real interest rates are linked to lower (higher) stock and bond prices, making stock and bond returns move together, thereby positively deriving stock-bond market correlations.

Also, few studies have addressed expectations' effect on economic growth concerning the dynamic correlation between stock and bond markets. None of these studies found that expectations on economic growth exert a significant influence on the dynamic correlation between the two markets. For example, d'Addona and Kind (2006) found that the dynamic correlation between stock and bond market expectations in Germany, the UK, and the US seems irrelevant to economic growth in these countries. Also, Andersson et al. (2008) indicated that expectations on GDP exert no significant impact on the dynamic correlation between stock and bond markets in Germany, the UK, and the US. In the same way, Baele et al. (2010) indicated that the correlation between stock and bond returns in the US could not be explained by expected GDP. Moreover, David and Veronesi (2013) found that expectations on US real economic growth insignificantly influence co-movement between US stock and bond markets.

Also, another area of extant literature specifically has investigated the monetary policy's effect on the correlation between stock and bond markets. Monetary policy's effect varies depending on time horizons, stock-bond market correlations' regime and across countries. Dimic et al. (2016) provided evidence on how dynamic stock-bond market correlations in emerging markets are being impacted by monetary policy at different time horizons. Results indicated that over the short term, monetary policy is the dominant force that drives stock-bond market correlations with different signs across emerging economies. However, for some countries, it positively impacts these dynamic correlations, while for others, a negative impact was observed, indicating that effects from monetary policy on dynamic stock-bond market correlations are not consistent in all countries. However, over the long term, monetary policy is not the leading force in correlations between stock and bond markets in all countries. Flageollet and Bahaji (2016) explored how the stock-bond market correlations regime responds to different proxies for US monetary policy. They found that for lower stock-bond market correlation regimes, unemployment rate and Taylor rule gap are positively linked to stock-bond market correlations, while the real monetary base is related negatively to correlations. However, in higher stock-bond market correlation regimes, only unemployment rate is positively and significantly associated with stock-bond market correlations. Also, they indicate that UNMP implemented by the Fed caused instability in stock-bond market correlations, and they called for research that empirically would examine UNMP's influence on the dynamic correlation between stock and bond markets. More recently, Skintzi, (2019) examined monetary policy's influence on the dynamic correlation between stock and bond markets in Eurozone countries. Results revealed that the dynamic correlation between the two markets in peripheral Eurozone countries is affected positively by monetary policy, while monetary policy exerts no significant effect on dynamic correlations in advanced Eurozone countries.

Macroeconomic factors indicate the state of a macroeconomic variable in different periods. Several studies have provided empirical results on the macroeconomic stance's impact on dynamic stock-bond market correlations. Since a macroeconomic variable may have a different state at a particular time, its effect on the other variables will be different according to the state at a specific time compared with its effect on the whole period. Therefore, studies have paid attention to macroeconomic factors' stance influences on dynamic stock-bond correlations, such as general economic stance. Yang et al. (2009) found a significant effect from an economic stance in the US and UK on the dynamic correlation between stock and bond markets in these two countries. They emphasised that the dynamic correlation between the two markets within the US tends to be lower during recessions compared with those during expansion times. In contrast, this dynamic correlation in the UK is likely to be higher during recession periods relative to expansion times. Also, Aslanidis and Christiansen (2012) found that macro-finance factors' stance, including short-term interest rates, and yield spread are significantly and positively more important than the effect of economic stance in shifting stock-bond correlation regimes in the US.

Ohm and Okimoto, (2016) argued that adding trend effect AR (1) into the model would alter macro-finance stances' influence on the stock-bond correlation regime. Stances on the economy, short-term interest rates, and yield spread are not as significant as before adding the trend effect. Moreover, Asgharian, Christiansen, and Hou (2016) pointed out that these long-term stock-bond market correlations are significantly and positively driven by the general state of the economy. They argued that when the economic stance is a boom, long-term stock-bond correlations tend to be a positive, advocating a flight-to-safe-haven-assets hypothesis, while this correlation becomes negative during weak economic periods. When the economic stance is a boom, prices of both stock and bond markets move together in one direction, leading to a positive correlation between the two markets, while during weaker economic periods, investors prefer to invest in bond markets, signifying a flight to safe-haven bond markets. Therefore, the correlation between the two markets tends to be negative.

Another segment of literature has provided evidence on macro-finance factors' stance effects on dynamic stock-bond market correlations. In this regard, Yang et al. (2009) emphasised that such dynamic correlations between the US and UK markets proportionally follow short-term interest rates' directions in both countries. They found that greater (lower) correlations between stock and bond markets are likely to be followed by greater (lower) short-term interest rate periods. Besides, they found the same pattern in inflation rates, but with lesser effects relative to short-term interest rates. Also, Aslanidis and Christiansen (2012) found that during times of higher short-term US interest rates, stock-bond market correlations tend to fall in the positive regime. More so, periods of higher yield spread are associated with higher stock-bond market correlation regimes. However, periods of higher inflation are not associated with the correlations regime. Asgharian et al. (2016) investigated other macro-finance factors' stances, such as inflation and bond market liquidity in the US, on long-term stock-bond market correlations. They indicated that neither inflation nor bond market liquidity helps explain such a long-term correlation. Finally, Song (2017) attempted to explain the correlation between US stock and bond markets through monetary policy stance changes. He documented how an aggressive monetary policy (active monetary policy when the Fed raises interest rates more than the inflation rate) makes stock-bond market correlations within the US negative. He argued that in an environment in which the inflation-risk premium is negative and the yield curve is downward sloping, bond markets are safer markets, providing a hedge opportunity for investors by shifting part of their portfolio capital from stock markets to bond markets. Thus, the dynamic correlation between the two markets tends to be negative.

Extant literature also has paid attention to uncertainty factors' effects, including macroeconomic uncertainty, stock market uncertainty, bond market uncertainty, and economic policy uncertainty on dynamic stock-bond market correlations. Increasing the level of these uncertainties may alter investors' portfolio asset compositions that, in turn, influence portfolio asset correlations and, thus, the portfolios' risk. Extant literature has investigated these factors' role in deriving stock-bond market correlation directions. Regarding macroeconomic factors, one research has been done by Asgharian, Christiansen, and Hou (2015), who addressed macroeconomic uncertainty's effect on the dynamic correlation between US stock and bond markets. They discovered that US macroeconomic uncertainty negatively derives the dynamic correlation between the two US markets, arguing that as US macroeconomic uncertainty rises, investors move funds from the stock market into safer markets, such as the bond market, causing a flight-to-quality phenomenon. As a result, returns on stock and bond markets go in opposite directions, leading to negative stock-bond market correlations.

Furthermore, extant literature has considered domestic and global stock markets' uncertainty. Most extant literature indicated that both global and domestic uncertainties negatively drive dynamic stock-bond correlations. They argued that during periods of higher stock market uncertainty, risk-averse investors switch capital from the stock market to safer-haven markets such as bond markets, leading to negative stock-bond market correlations (Cappiello, Engle and Sheppard, 2006; Kim, Moshirian and Wu, 2006; Connolly, Stivers and Sun, 2007; Andersson et al., 2008; Baur and Lucey, 2009; Aslanidis and Christiansen, 2012; Chiang et al., 2015; Dimic et al., 2016; Skintz, 2019). Studies have come up with different conclusions on uncertainty in global stock market effects as gauged by VIX[6] on the dynamic correlation between stock and bond markets. Andersson et al. (2008) indicated that the dynamic correlation between the two markets in Germany and the UK was influenced negatively by VIX. Also, Chiang et al. (2015) studied the dynamic correlation between stock and bond markets in Canada, France, Germany, Italy, and the UK, confirming that VIX negatively derives the dynamic correlation in these countries. However, Dimic et al. (2016) found that uncertainty in the US stock market differently impacts stock-bond market correlations within emerging markets, according to time horizons. In the long term, uncertainty in the US stock market exerts positive effects on the dynamic correlation between stocks and bonds in countries such as Argentina, Brazil, Bulgaria, Colombia, Peru, Russia, and

[6] VIX represents the US stock market uncertainty and measured as the stock market's expectation of volatility implied by S&P 500 index options calculated by the Chicago Board Options Exchange (CBOE).

Venezuela, while it negatively influences dynamic stock-bond correlations only in Mexico. This positive effect indicates that stock and bond market prices fall in response to US stock market uncertainty, making returns on stock and bond markets move in the same direction, leading to the positive dynamic correlation between them. Also in the short term, uncertainty in the US stock market exerts different effects on dynamic stock-bond correlations. A negative effect was found in Bulgaria and the Philippines, while a positive effect was found in Argentina and Peru.

Other studies examined how dynamic stock-bond correlations are affected by uncertainty in the domestic stock market. In this respect, most empirical studies have arrived at different conclusions. For example, Connolly, Stivers, and Sun (2005) argued that when the VIX level exceeds 25%, a 36.5% chance exists that future stock-bond market correlations in the US will be negative. However, only a 6.1% chance exists that the correlation will be negative if VIX is less than 20%. Also, Cappiello et al. (2006) found that the stock-bond market correlation in several advanced countries exhibits negative patterns during higher levels of stock market uncertainty in each country. Conversely, Baele et al. (2010) found that stock-bond market correlations in the US do not respond significantly to VIX after adding a variance premium, calculated as the difference between squared VIX and stock market variance. Chiang et al. (2015) used conditional variance of the stock market to examine stock market uncertainty's effect in Canada, France, Germany, Italy, and the UK on the dynamic stock-bond correlations in these countries. They indicated that stock market uncertainty negatively derives the dynamic correlation in these countries. More recently, Skintz (2019) pointed out that domestic stock market uncertainty impacts dynamic movement between stock and bond market correlations differently across eurozone countries. In core countries, the dynamic movement between the two markets is influenced negatively by the domestic stock market's uncertainty, while in peripheral countries, it positively influences the correlation. The negative response to dynamic movement between stock and bond markets toward domestic uncertainty because of higher levels of stock market uncertainty convinces investors in core eurozone countries to move part of their funds from local stock markets to local bond markets, thereby leading to negative dynamic correlations between the two markets. However, investors in peripheral countries remove funds from both domestic stock and bond markets, giving priority to investing their funds in foreign bond markets. Thus, stock and bond market prices move together, leading to a positive correlation between stock and bond markets in peripheral eurozone countries.

A few empirical studies have taken into account how uncertainty in bond markets can derive the dynamic correlation between stock and bond markets. In this respect, Chiang et al. (2015) indicated that the dynamic correlation between the two markets is strongly and positively associated with uncertainty in the bond market as calculated by the conditional variance of the bond market in six core financial markets: Canada, France, Germany, Italy, the UK, and the US. They argued that by keeping stock-risk premiums stable, the rise in such uncertainty increases the rate at which future returns on both stocks and bonds are discounted to their present value. Therefore, prices in both markets tend to go in similar directions, leading the dynamic correlation to a positive one between the two markets. However, dynamic stock-bond market correlations tend to weaken during periods of higher term spread and default-risk spread (the latter is another channel of bond market uncertainty). As term spread and default-risk spread widen, economic conditions deteriorate, thereby inducing investors to allocate more capital to the bond market and leading to a flight-to-quality phenomenon in which the dynamic relationship between stock and bond market correlations turns out to be negative. However, Dimic et al. (2016) pointed out that US bond market uncertainty exerts negative and positive effects on dynamic correlations between US stock and bond markets in both the short and long terms, while it positively impacts the dynamic stock-bond market correlation within emerging markets such as Mexico, the Philippines, and Turkey for both short- and long-term horizons. More recently, Skintz (2019) found that the dynamic correlation between the stock and bond markets positively responds to the domestic bond market in both core and peripheral Eurozone countries.

Stock-bond market correlations also can be influenced by economic policy uncertainty. In this regard, there is little number of studies that have taken into account the effect of economic policy uncertainty on the dynamic stock-bond market correlations. Li, Zhang, and Gao, (2015) were the first who sheds light on this issue done by who identified the effect of US economic policy uncertainty shocks on the dynamic correlation between US stock and US bond market correlations. Results indicated that such dynamic correlation is asymmetrically influenced by economic policy uncertainty in that, positive shocks of economic policy uncertainty cause flight to quality phenomena and thus resulting in negative dynamic stock-bond market correlations. While negative shocks do not lead to a flight to quality phenomena. They explained these effects as follows: positive shocks of economic policy uncertainty signals positive news to market making the demand for both assets; namely, stocks and bonds to be higher and thus that both assets' prices move in similar way leading to the correlation between stock and bond market to be positive. Whereas, negative shocks indicates bad news for stocks, which in turn induces investors to shift funds to bond market, leading to a negative correlation between the two markets. Finally, Fang, Yu, and Li, (2017) explored how long-term stock-bond market correlations within US react to economic policy uncertainty in the US. They pointed out that the long-term stock-bond market correlations negatively responded to economic policy uncertainty arguing that when uncertainty of economic policy rises, more risk-averse investors seek for the safer market such as bond market which in turn, induces those investors to allocate more capital of their portfolio on stock markets. Therefore, causing a flight to quality phenomena is likely to take place, leading to negative stock-bond market correlations.

Although much extant literature on stock-bond market correlations exists, many of these studies mainly focus on particular variables' effects on conditional means of dynamic stock-bond market correlations. However, this approach may not provide the complete picture on the topic under investigation because of the characteristics of stock and bond data distributions. To fill the aforementioned gap, some studies have attempted to explore several variables' impact on the tail distribution of the dynamic correlation between stock and bond markets. The reason is that some factors strongly or weakly may influence the dynamic correlation between bond and stock market correlations at the left or right tail, eliciting different consequences for investment portfolios' diversification strategy. Therefore, these studies were conducted to provide a comprehensive picture of how aspects such as macroeconomic factors influence stock-bond market correlations in different scenarios with stock-bond market correlations, including scenarios with weaker correlations, as well as scenarios with stronger correlations. In this regard, Aslanidis and Christiansen (2010) used the quantile regression approach to examine to what extent microfinance and macroeconomic variables influence the dynamic stock-bond market correlations within the US. They discovered that in the lower quantile of stock-bond correlations (highly negative stock-bond correlations), only volatility in industrial production and the bond market could derive the dynamic correlation between the two markets positively and significantly. However, at higher quantiles (highly positive stock-bond correlations),dynamic stock-market correlations are negatively influenced by inflation uncertainty, bond market liquidity and stock market volatility, but bond market volatility still exerts a significant positive effect, even in high quantile scenarios. Aslanidis and Christiansen (2014) utilised a large number of microfinance factors to research their effects on the realised correlation between stock and bond markets in the US. They used factor analysis to select the most important factors among all microfinance factors. Also, they used the quantile regression approach to investigate selected microfinance factors' influence on realised stock-bond market correlations. Their findings indicated that microfinance factors exert significant effects on the realised correlation between stock and bond markets only during highly negative, realised stock-bond market correlation scenarios (at lower quantiles), while during highly positive stock-bond market correlation scenarios (at higher quantiles), they are irrelevant, with the findings attributed to bonds being vulnerable to macro-finance factors at all times, while stocks are exposed to such factors only in intensely volatile times.

Based on the above realities, a substantial body of literature that addresses UNMP's impact on financial markets primarily has focussed on the response from stock prices, stock returns, stock volatility, and government bond yields to UNMP. Thus, extant literature has ignored UNMP's effect on the dynamic correlation between financial markets. Moreover, the vast majority of extant literature that investigated the determinants of the dynamic correlation between the stock and bond markets primarily has concentrated on the impacts of macroeconomic factors and conventional monetary policy. Therefore, this thesis aims to extend existing literature on monetary policy by shedding light on how UNMP, through signaling and portfolio rebalancing channels, derives the dynamic correlation between US stock and bond markets, as well as the dynamic correlation between these markets and other advanced countries' bond (stock) markets. Moreover, this thesis also takes into account the importance of the distributions' tails. To do so, I investigated the role of US UNMP portfolio rebalancing channels in explaining changes in the dynamic correlation between stock and bond markets under two correlation scenarios, including highly positive stock-bond correlation scenarios (higher quantiles) and highly negative stock-bond correlation scenarios (lower quantiles).

Chapter 3

BACKGROUND ON UNCONVENTIONAL MONETARY POLICY

3.1 Transition from conventional monetary policy to unconventional monetary policy

Before the 2008 financial crises key central banks in developed countries, particularly the US, were conducting monetary policy by controlling and altering conventional tools, namely official short-term interest rates, to keep inflation rates below a certain threshold and employment at a maximum level (dual mandate)[7] (Glick and Leduc, 2013). For example, the US, UK, and the eurozone would accomplish this by adjusting the Federal funds rate's target rate, policy rate and marginal lending rate, respectively (Philip and Alexis, 2015). In other words, in normal situations, central banks can maintain this goal by altering official short-term interest rates that, in turn, affect long-term interest rates and, thus, conditions and terms in credit markets, including banks and financial markets (Blinder et al., 2008; Boivin et al., 2010).

At the first sign of the 2008 financial crises, the Fed began to reduce the Federal funds rate's target rate to inject money into the financial sector, particularly banks, to boost aggregate demand and stimulate the economy. At the beginning of 2007, the

[7] A dual mandate is the Fed's monetary goal to obtain both inflation stability and maximum employment levels, while in the UK and Europe, monetary policy aims to achieve the target rate of inflation.

Federal funds rate unprecedentedly was reduced by 5%, but as economic conditions worsened, the first cut was not enough to stimulate the economy. Thus, an additional 7% cut was made. The unprecedented reductions in the Federal funds rate's target rate continued, especially after Bear Stearns and Lehman Brothers' bankruptcy in September 2008, until the Federal Open Market Committee (FOMC) cut it nearly to zero, leaving it between 0% and 0.25% in December 2008 – the so-called ZLB (Rudebusch, 2011).

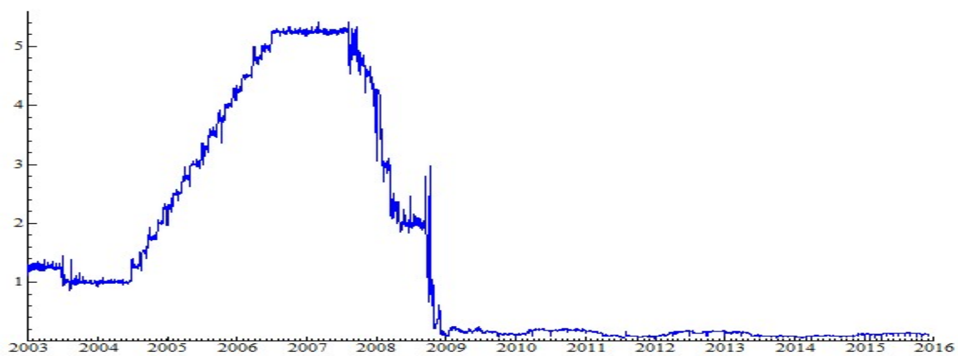

Figure 1: Daily Federal fund target rate during the period of January 2003 to 30 November 2015.

After hitting ZLB, an additional reduction in the Federal funds rate's target rate was no longer practical,[8] in that any further credit easing could not be achieved by depressing the Federal funds rate's target rate (following a traditional monetary policy) with a view toward rejuvenating the economy (Chung, Laforte, Reifschneider and Williams, 2012). This implies that as disturbances in the financial sector severely intensified because of financial crisis shocks, the transmission mechanism of

[8] The Fed's decision to engage in the purchase of large-scale of long-term assets was because optimal short-term interest rates predicted by the Taylor rule theoretically would have been less than zero due to the existence of cash (Philip and Alexis, 2015).

conventional monetary policy through the Federal funds rate into aggregate demand became an ineffective tool and a much more complex operation (Cecioni, Ferrero and Secchi, 2011).First reason for this is that as the financial crisis intensified, liquidity was low, and demand for reserves by depository and non-depository institutions rose sharply (Janus (2016). As a result, the interbank lending rate (ILR) among depository institutions dramatically increased, leading to an increase in the additional compensation that banks demand in the money markets, even though the Fed had not made any announcement on increasing short-term interest rates. Therefore, the relationship between the interbank lending rate and the official short-term interest rate was broken, which eventually limits central banks' ability to control market interest rates, thereby hindering monetary policy's ability to stimulate the economy by altering short-term interest rates (Yao, 2015). The second reason, as a result of the worsening financial crisis, credit banks became more worried about their liquidity levels, which were needed to meet their liquidity demands emerging from mortgage-backed securities activities, inducing banks not to lend to other banks to restore cash reserves (Heider, Hoerova and Holthausen, 2009). Therefore, uncertainty about liquidity spread widely and rapidly among banks and other segments of the money market, impeding conventional monetary policy's efficacy across the entire financial market (Yao, 2015). Last reason, as the financial crisis led to substantial distortions in the money market, heavily affecting the real economy, economic agents were more likely to respond weakly to more cuts in the Federal funds rate's target rate (Janus, 2016). As a result, rejuvenating the economy was unattainable through conventional monetary policy, which had become unable to accomplish the desired objectives for which this policy had been implemented. In the light of the above realities, a central bank may require adherence to unconventional monetary policy tools to tackle liquidity and credit issues emerging from financial crises to achieve financial stability, along with inflation targets (Joyce et al., 2012).

3.2 UMMP and its transmission channels in theory

3.2.1 The concept of UNMP

The difference between conventional and UNMP policies lies in the tools that each uses. Conventional monetary policy mainly is accomplished by altering official short-term interest rates, while UNMP is associated with other policy instruments, such as QE. UNMP aims to boost economic growth and attain required inflation rates when conventional monetary policy fails to attain these desired objectives. In other words, UNMP implies that a central bank employs a non-priced approach and manipulates its balance-sheet size to reinstate and stimulate aggregate demand so that conventional monetary policy can be restored (Joyce et al., 2012; Sharpe and Watts, 2013).

UNMP can be implemented through credit easing (qualitative easing) and QE. Qualitative easing is related to the central bank's purchase of less-liquid securities, such as commercial paper and asset-backed securities, with a view toward extending credit and injecting liquidity into the credit market[9] (Klyuev, de Imus and Srinivasan, 2009). Conversely, QE involves a central bank purchasing liquid assets, such as long-term government bonds, to influence long-term interest rates for further increases in liquidity levels in money markets to boost future economic growth (Neely, 2015). Gagnon et al. (2011) pointed out that UNMP involves the use of QE, as well as providing signals about the prospective direction of short-term interest

[9] Before BOE's QE entered into force, the BOE purchased less liquid assets in return for Treasury bills (more liquid assets) to generate liquidity in the banking system. This kind of credit easing (qualitative easing) does not expand the BOE's balance sheet (John, Roberts-Sklar and Weeken, 2012).

rates to further reduce long-term interest rates, as the latter is the average weighted measure of short-term rates. Thus, any changes in short-term interest rates carry implications for long-term interest rates. Thus, central bank signaling to maintain short-term interest rates at lower levels and continuing QE for a longer period can reduce long-term interest rates, thereby leading to more liquidity in the money market and eventually boosting the economy (Woodford, 2012). What distinguishes between qualitative easing and QE is that the latter increases the central bank's balance sheet and alters the structure of central bank assets, increasing the money supply and, thus, liquidity in credit markets. While qualitative easing implies changing the central bank's balance-sheet structure, it does not result in an increase in the central bank's balance sheet (Borio and Disyatat, 2010).

3.2.2 UNMP transmission channels

UNMP's key objective is to restore financial market stability and the activation of aggregate demand to stimulate economic activity. This objective is achieved by affecting long-term interest rates through signaling and portfolio rebalancing channels (Lloyd, 2017; Cenedese and Elard, 2018). Thus, these two channels[10] are the primary channels by which UNMP is transmitted into the economy, as these channels comprise the decomposition of long-term interest rates. This decomposition is classified into two components: the risk-neutral component, which equals expected future short-term interest rates and represents the signaling channel, and the term-premium component, which represents the portfolio rebalancing channel and is the additional compensation that investors demand for risk-taking associated with long-term government bonds, as well as the risk from investors' preferences for specific

[10] Former Fed chief Ben Bernanke (2010) accentuated that portfolio balance is the most important channel through which the Fed's QE can influence the economy. For more information, see www. Federalreserve.gov/newsevents/other/o_bernanke20101105a.htm.

assets' maturity (Neely, 2015). The decomposition of long-term government bond yields is demonstrated as follows:

$$y_t^n = n^{-1} \sum_{i=0}^{n-1} E_t r_{t+i} + YTP_t^n \tag{1}$$

$$y_t^n = n^{-1} \sum_{i=0}^{n-1} E_t r_{t+i} + YTP_{risk,t}^n + YTP_{insturment,t}^n \tag{2}$$

Where: y_t^n is the yield on an n-period bond (in this research, 10-year government bonds are used) at time t, $E_t r_{t+i}$ is the expected short-term interest rates over the succeeding n periods (risk-neutral) and YTP_t^n is the term premium on an n-period bond at time t (risk premium on a 10-year government bond). The term premium in Equation (2) can be classified further into two elements: The first, $YTP_{risk,t}^n$, is the macroeconomic risk premium on an n-bond at time t at a particular interest rate and inflation risk, and the second, $YTP_{insturment,t}^n$, is the instrument risk premium on an n-period bond at time t, representing the bond issuer's risk premium. The scale of risk premium depends on the risk default related to the bond issuer, liquidity risk associated with the bond issuer, risk aversion, demand and supply changes for a bond that has been issued (10-year government bond) and investors' preferred habitats (Buer and Neely, 2014; Kettemann and Krogstrup, 2014).

3.2.2.1 Signaling channel

Signaling is one of the major channels through which UNMP is transmitted into the economy (Bauer & Rudebusch, 2014). It also is denoted in the extant literature as the channel of inflation risk (Krishnamurty and Vissing-Jorgensen, 2011). A central bank's asset-purchase announcement generally implies conducting a more expansionary monetary policy by providing indications that signify lower levels of future short-term interest rates. Therefore, the signaling channel comprises the effect of the central bank's QE announcements on long-term interest rates by signaling to market participants that future short-term interest rates will be lower for a longer period (Gagnon et al., 2011; Woodford, 2012). In other words, the signaling channel can be defined as any effect that UNMP, through its QE announcements, could have on long-term interest rates (e.g., the yield on a 10-year government bond) by depressing investors' expectations on future short-term interest rates (risk-natural component). This description considers that the signaling channel aims to provide forward direction communications to reduce the level of long-term interest rates on government bonds (Akkaya, 2014), but it excludes the notion that UNMP, through the announcement of QE, may lead to changes to investors' portfolios. The signaling channel can be activated not only by providing information to market participants, but also through other types of communication, such as the purchase of securities or taking other actions that intend to correct market dysfunctions (Cecioni et al., 2011). Not all types of communication through which the signaling channel can be activated are considered unconventional monetary policy tools. Signaling macroeconomic factors' stance has appeared increasingly since the 1990s. Thus, in some cases, central banks' use of signals to provide information on short-term interest rates can be deemed one of the conventional monetary policy tools (Ferrero and Secchi, 2009, 2010). Accordingly, the signaling channel is assumed to be a UNMP tool only in cases of delivering information to the market on the prospective direction of short-term interest rates during financial crises.

The notion through which a signaling channel is transmitting messages into the economy is called a neutrality proposition. Introduced by Wallace (1981), the so-called Wallace hypothesis postulates that under the assumptions of economic agents' full rationality and capital markets' higher efficiency, purchasing government bonds through central bank markets exerts no influence on key macroeconomic variable conditions. In this regard, Curdia and Woodford (2010) claimed that neutrality proposition should be framed by taking into account the following major assumptions: An investor's limitations in buying assets are only their budget restrictions, and that all investors can purchase amounts of assets at the same prices equally. Therefore, Wallace's hypothesis assumes that the central bank conducting UNMP through QE does not affect the economy's general equilibrium. The reason behind this is that the implementation of UNMP through QE implies that the central bank is holding more assets and that households are holding on to cash; thus, UNMP can cause shifts only in the distribution of assets between the central bank and households. However, QE does not result in changing financial assets' availability (mainly stocks and bonds) for future consumption making pricing of those assets by discounting their future cash flows as well as the amount of stock unchanged (Eggertsson and Woodford, 2003). In addition, implementing UNMP by purchasing long-term assets from households indicates that risk will be transferred from the central bank and government (public sector) to households (private sector). Therefore, conducting QE will be irrelevant in stimulating the economy unless it is accompanied by a credible central bank commitment to keep short-term interest rates lower for longer periods and prevent the central bank from incurring any capital losses emanating from its balance sheet (Eggertsson and Woodford, 2003; Bhattarai, Eggertsson and Gafarov, 2015).

Regardless of theoretical criticism related to the signaling channel over its efficacy in affecting the real economy, this channel's practical exercise has demonstrated its relevant efficiency to the real economy. Rudebusch (2011) argued that as the Fed is not a profitable institution, the Fed's QE exercises would not lead to significant losses in the central bank's balance sheet when interest rates rise, and these losses also only would be recognised on the portion of long-term security portfolios that is not kept until their maturity. Thus, the signaling channel can be effective, and its theoretical assumption can be validated. In addition, Gagnon et al. (2011) indicated that the existence of non-financial variables, such as economic agent sentiment, can boost the demand for safer assets (bonds) during financial crises and raise these assets' future cash flows, leading to changes in their prices and, thus, their returns. Therefore, the existence of such non-financial factors can validate the signaling channel's theoretical assumption, thereby indicating such a channel's practical effect. To conclude, the signaling channel is designed to escape ZLB, and it is associated with the following phenomena: raised expectations on inflation rates; declines in real interest rates; changes in market interest rate composition, particularly long-term interest rates (government bonds and other fixed-income securities); and rises in levels of consumption, investments and overall demand (Lenza, Pill and Reichlin, 2010; Bauer and Rudebusch, 2014).

3.2.2.2 Portfolio rebalancing channel

Monetary policymakers in major economies have indicated that the UNMP transmission mechanism used most often to generate economic activity has been the portfolio rebalancing channel (see, e.g., Bean, 2011; Yellen, 2011; Praet, 2015). This indicates the channel's crucial role compared with other UNMP channels. This channel's essence is formed by altering the total size and structure of the central bank's asset side due to QE and its influence on the private sector's portfolio-composition changes. As a result, this channel has been termed in the extant literature as the portfolio rebalancing channel (Cecioni et al., 2011; Gagon et al., 2011; Bowdler and Radia, 2012), or portfolio substitution channel (Joyce and Tong, 2012). Theoretically, the portfolio rebalancing channel can be used interchangeably with wealth effects, acting as a balance channel and risk-taking channel for UNMP.

A central bank can use the portfolio rebalancing channel as an unconventional tool of monetary policy through operations that result in expanding and changing the structure of both the private sector and central bank's balance sheets – operations that include the purchase of government securities and asset swaps (Cecioni et al., 2011; Chodorow-Reich, 2014). The objective of the central bank's operations through purchasing government securities is to exert a kind of effect to reduce yields extensively on long-term government bonds by depressing their risk premiums (Gertler and Karadi, 2011). Thus, the portfolio rebalancing channel stands for government bonds' term-premium movements.

The portfolio rebalancing channel's ability and efficiency in achieving its desired goals depend on the imperfect substitutability within the private sector's balance sheet, and to what extent private-sector decisions are affected by changes in the size of the private sector's assets and liabilities (Tobin, 1958, 1969)[11]. The imperfect substitutability, which occurs on the asset side of the private sector's balance sheet, has been addressed through the preferred-habitat theory by Modigliani and Sutch (1966). This theory has been investigated empirically in more formal models in several leading studies (e.g., Vayanos and Vila, 2009; Gertler and Karadi, 2011; Chen, Filardo, He and Zhu, 2013; He and Krishnamurthy, 2013; Ellison and Tischbirek, 2014). According to the preferred-habitat theory, yields on an asset at a specific maturity (typically long-term maturity) are determined by the relative market supply of the asset at that specific maturity. Consequently, whenever a segment of investors in particular pension funds and life insurance firms has a preference (the so-called preferred habitat) for a particular asset at a specific maturity to match their

[11] Harrison (2011) and Chen et al. (2013) showed that the US UNMP portfolio rebalancing channel can stimulate the economy within the theoretical conditions proposed by Tobin (1958, 1969).

long-term liabilities, the central bank's action (open market operations), through which the available supply of purchased assets at a given maturity gets altered, may affect yields on these assets (Vayanos and Vila, 2009). Furthermore, when investors have different characteristics, as they have different degrees regarding their sensitivity to risks, or they have preferences for a particular maturity of assets, central bank management of QE will exert a potential effect on real activity and inflation rates (Ashcraft, Garleanu and Pedersen, 2010; Curdia and Woodford, 2010). To conclude, the preferred-habitat theory assumes that market assets are imperfectly substituted not due to the income they generate, but to causes related to their maturity (market segmentation).

The assumption of the imperfect substitutability of assets and market segmentation play an essential role in determining to what extent purchases of long-term assets by the central bank (government bonds) can affect private-sector portfolios. The central bank's purchase of long-term assets from the private sector implies decreasing those assets' market availability because of the local supply effect and increasing the private sector's short-term reserve holdings (broad money holdings) (Bowdler and Radia, 2012; Joyce, Liu and Tonks, 2014). Therefore, if money being held by the private sector is considered an imperfect alternative to long-term assets being purchased by the central bank, investors (private sector) will be induced into rebalancing their portfolios to remain within a specific segment of the market by purchasing other assets with characteristics that are comparable to those that they sold (Boubaker et al., 2017; Goldstein, Witmer and Yang, 2018). Thus, the process through which the central bank purchases long-term assets under QE will result in bringing up the prices of the assets purchased and those substituted for them, but it also results in reducing term premiums and, thus, yields on long-term assets purchased (Krishnamurthy and Vissing-Jorgensen, 2011; Alpanda and Kabaca, 2015; D'Amico and King, 2015; Haldane et al., 2016).

The adjustment in private-sector portfolios and changes in the price of long-term assets purchased depend on to what extent the size of those assets purchased under QE could cause a decline in their yields by depressing their term premium ($YTP^{n}_{insturment,t}$) (Joyce et al., 2011)[12]. Lower long-term asset yields generate incentives for investors to seek higher-asset yields by purchasing other long-term assets that may be riskier, such as domestic or foreign stocks, or safer, such as foreign bonds (Tillmann, 2016; Rogers et al., 2014; Bernhard and Ebner, 2017, Fratzscher et al., 2018; Greenwood and Vayanos, 2010; Vayanos and Vila, 2009). This version of portfolio rebalancing channels is called the local supply channel because the decline in government bond yields emerged from the adjustments in the net stock of long-term assets in response to QE. Also, the purchase of long-term securities under QE decreases duration risk (risk pricing) in the market and, thus, the term premium on duration risk ($YTP^{n}_{risk,t}$). Therefore, through the portfolio rebalancing channel's duration channel, purchases of long-term assets by the central bank, even just small amounts, can influence the duration risk and term premium of all fixed-income assets (D'Amico and King, 2013). If a central bank intended to purchase 10-year government bonds from the market to get rid of a certain amount of duration risk, the central bank would achieve the same goal by purchasing, for instance, 30-year government bonds. Based on the above realities, UNMP's portfolio rebalancing channel, through the purchase of long-term government bonds, directly

[12] Joyce et al. (2011) found that QE conducted by the BOE exerts a large positive effect on yields from long-term assets (10-year government bonds) purchased by the BOE, while the yields on swap contracts indicate slight effects from QE and significant market segmentation.

can influence the term premium of long-term government bond yields in two ways: First, if markets for long-term government bonds and other fixed-income securities with dissimilar maturities are segmented, long-term government bonds' term premium can be reduced (local supply channel). Second, purchasing long-term assets leads to declines in duration risk and, thus, in the term premium on all fixed-yield securities (duration channel).

According to aspects mentioned above, the portfolio rebalancing channel can transfer and, thus, influence the economy by lowering the term premium on long-term assets, such as government bonds, thereby resulting in reduced borrowing costs and generating increases in private asset holders' wealth. This leads to activation of aggregate demand and, thus, economic stimulation (Bauer and Rudebusch, 2011; Christensena and Rudebusch, 2012). The strength of portfolio rebalancing in stimulating the economy depends on the number of assets being purchased and its effect on the term premium of those assets. As the decline in term premium is attributed not only to diminishing the yield from long-term assets, but also because of investors' compensation for interest rate risk ($YTP^{n}_{risk,t}$), the signaling channel also may affect the term premium. If the central bank's commitment to maintaining short-term interest rates fails, investors' uncertainty on the prospective direction of short-term interest rates, inflation rate, and growth rate would rise and, thus, affect the duration-risk premium, indicating that the signaling channel could participate lower the term premium ($YTP^{n}_{risk,t}$) (Lloyd, 2017). Moreover, increasing investors' uncertainty on macroeconomic outlook could increase market-risk aversion, which, in turn, affects bond term premium ($YTP^{n}_{insturment,t}$) (Kettemann and Krogstrup, 2014).

3.3 Fed's UNMP in practice

After the 2008 financial crises struck, and particularly following the collapse of Lehman Brothers and Bear steams in September 2008, the Fed decided to conduct UNMP by purchasing a large number of long-term securities under QE from secondary markets. These purchases have been made under three different phases of QE (Q1, Q2, and Q3), which gave rise to expanding the Fed's balance sheet by over 600% (Lloyd, 2017). Figure 2 shows the dramatic increase in the Fed's total assets, particularly at the end of 2008, when the Fed started to conduct UNMP through QE. The Fed's total assets rapidly rose from about $900 billion at the beginning of September 2008 to $2.2 trillion by the end of 2008. As it continued to purchase assets from the market, total Fed assets exploded, eventually reaching about $4.5 trillion by October 2015.

The first QE phase (Q1) was announced on 18 March, 2009, as the Fed committed to purchasing a large number of long-term securities worth more than $1 trillion. Under Q1, different long-term assets were purchased, including the purchase of $750 billion in mortgage-backed securities (MBS), $100 billion in agency-backed debt (ABD) to help finance the real estate sector and housing markets, and $300 billion in long-term bond securities to ameliorate credit market situations. The purchases of MBS and ABD continued until 16 March, 2010, reaching $1.25 trillion and $175 billion, respectively.

According to the FOMC statement on 18 March, 2009, all purchases of different long-term assets under Q1[13] were insufficient to stimulate the economy and maintain

[13] See the FOMC's statement from 18 March, 2009, at www.federalreserve.gov/newsevents/pressrelease/monetary20090318a.htm

price stability. Consequently, Fed Chairman Ben Bernanke, in statements on 27 August, 2010, and 15 October, 2010, decided to implement another QE phase (Q2), entailing the purchase of more long-term assets on 3 November, 2010. The Q2 committed to purchasing, in monthly phases $75 billion in long-term US Treasuries over eight months, and then in June 2011[14], it added $600 billion more. However, the Fed's implementation of another round of large-scale purchases of long-term assets under Q2 did not spark an economic recovery, with employment still sluggish and inflation rate below the target level of 2%, according to an FOMC statement on 18 October, 2011 Consequently, the Fed, on 12 December 2012,[15] declared Q3, its third phase of large-scale asset purchases, entailing a Fed commitment to buy $45 billion in long-term US bonds and $40 billion in MBS. In May 2013, the Fed started to talk about the possibility of tapering asset purchases under Q3 if the economy were to recover. In response to that, the Fed announced that between 18 December, 2013, and 17 September, 2014, assets purchased under Q3 ($40 billion in MBS and $45 billion in US Treasuries) would be reduced each month by $10 billion. As mentioned earlier, when QE ended in October 2014, the Fed was holding $4.5 trillion in securities[16].

[14] See the FOMC's statement from 18 October, 2010, at www.federalreserve.gov/newsevents/pressrelease/monetary20101103a.htm.

[15] Between Q2 and Q3, the Fed also conducted a maturity extension program (MEP) that involved Fed action to sell $667 billion in short-term Treasury securities and use the proceeds to buy long-term Treasuries.

[16] Fed statistical release: www.federalreserve.gov/releases/h41.

During the UNMP period, the Fed used different forms of forward-guidance language to signal the prospective direction of its monetary policy stance to market participants (Geraats, 2014). The first forward-guidance language was qualitative (end date not specified) and announced by the FOMC on 16 December, 2008, signaling to market participants that economic conditions necessitated lowering the federal funds rate's target rate to between 0% and 0.25% for an extended period. The second forward-guidance language was quantitative and involved in providing specific data. Under this type of forward guidance, the FOMC provided important guidance on the prospective direction of the Fed's monetary policy: On 9 August, 2011, the FOMC clearly and precisely presented its forward-guidance language by signaling to market participants that economic conditions require adopting exceptionally lower interest rates at least until mid-2013[17]. On 12 December, 2012, the FOMC introduced another important form of forward-guidance language on short-term interest rates' prospective path, namely threshold-based forward guidance, which indicated that the federal funds rate would be bounded between 0% and 0.25% as long as the unemployment rate is greater than 6.5% and the expected inflation rate two years from then is not more than 0.5% above the FOMC's 2% target inflation rate[18]. On 19 March, 2014, the threshold-based forward guidance had been adjusted in a way that kept the federal funds rate's target rate between 0% and 0.25% long after QE ends, particularly if the inflation rate continues to be less than the FOMC's 2% target inflation rate[19]. Moreover, on 28 October, 2015, the FOMC declared its intention to raise the policy rate at its next meeting. Then, on 16 December, 2015, the

[17] See the Fed's timelines on policy actions and communications: www.federalreserve.gov/monetarypolicy/timeline-forward-guidance-about-the-federal-funds-rate.htm.
[18] For more details, go to www.federalreserve.gov/monetarypolicy/files/FOMC20130422memo02.pdf.
[19]www.federalreserve.gov/monetarypolicy/timeline-forward-guidance-about-the-federal-funds-rate.htm.

FOMC decided to raise the federal funds rate's target rate above the upper limit of ZLB (0.25%) for the first time since the 2008 financial crisis[20].

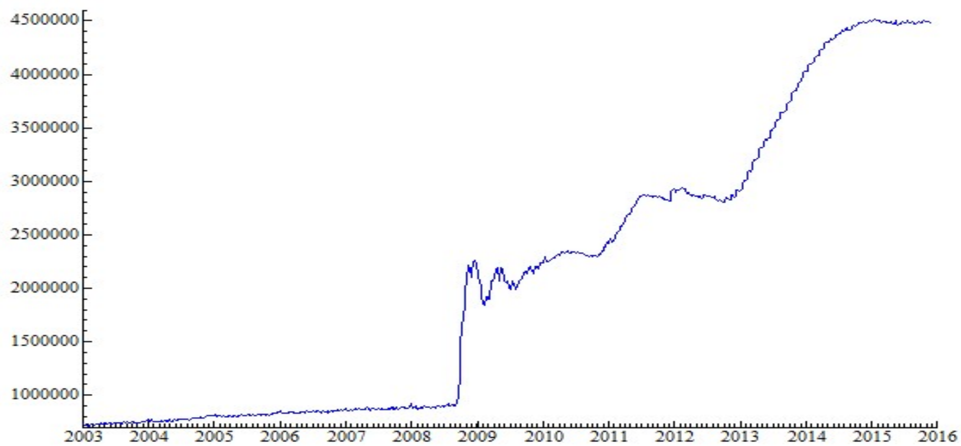

Figure 2: Weakly Fed's total assets during the period of January 2003 to 30 November 2015.

3.4 Effect of signaling and portfolio rebalancing channels on the dynamic correlation between stock and bond markets

3.4.1 Effect of signaling channel on the dynamic correlation between stock and bond markets

The signaling channel is related to any influence that UNMP announcements could have on market participants, particularly on investors' expectations on short-term interest rates' prospective path. In other words, the signaling channel operates by signaling to investors that short-term interest rates will be maintained at ZLB for longer period, which, in turn, alter investors' perspectives on expectations on short-term interest rates' prospective path (Bauer and Rudebusch, 2014; Bauer and Neely, 2014). In this regard, the Fed directly provided signals in the form of forward-

[20]www.federalreserve.gov/econresdata/notes/feds-notes/2016/the-federal-reserves-new-approach-to-raising-interest-rates-accessible-20160212.html.

guidance language through FOMC statements[21] that committed to keeping short-term interest rates lower for a longer period, with a view toward reducing long-term interest rates (yield on government bonds) (Gagnon et al., 2011; Woodford, 2012). So, how can we understand the signaling channel's effect on the dynamic correlation between US stock and bond markets in the context of long-term government bond yield decomposition in Equation (1)? To do so, we need to comprehend how the signaling channel influences both government bond market prices and stock market prices.

UNMP through signaling channel significantly affects both bond and stock market prices in the US. On one hand, Fed's signals to maintain the future short-term interest rates at lower levels for longer time leads to significantly diminish longer-term government bond yields in US (Joyce et al. 2011; Krishnamurthy and Vissing-Jorgensen, 2011; Swanson, 2011; Woodford, 2012; D'Amico and King, 2013; Bauer and Rudebusch, 2014). Theoretically, bond prices move in inverse direction with bond yields. In the sense that when bond yield declines, investors will demand compensation for declines in yields to sell their bonds, leading to higher bond prices (Cox, Ingersoll, and Ross, 2005). Thus, the decline in the US government bond yields as response to signaling channel is more likely to increase the US government bond prices. On the other hand, Fed's signaling to keep the level of expected short term interest rate lower for longer time of periods may significantly influence the US stock market prices since such signals change the economic agents' expectations on the prospective direction of short-term interest rates by expanding the anticipated period of ZLB (Bauer and Rudebusch, 2014). This implies that signaling channel

[21] Gurkaynak, Sack and Swanson (2004) indicated that FOMC statements in times of conventional monetary policy exert significant effects on US government bond yields and stock prices.

enables economic agents to get fund at lower cost leading to activate the aggregate demand and stimulate the US economy (Lloyd, 2017) which in turn increase the level of US stock market prices.[22] Therefore, stock and bond prices move in the same direction, and hence, the dynamic correlation between US stock and US bond markets tends to be positively reacted to the signaling channel of UNMP.

Also, the dividend discount model framework can be used to establish the relationship between government bond prices, stock market prices, and expected short-term interest rates. This model states that an asset's price is the present value of that asset's generated future yields (Ilmanen, 2003; Andersson et al., 2008). According to Equation (3), the Fed's signals to keep expected short-term interest rates low for a long time indicate that future cash flows generated from government bonds (C_t) are being discounted at a lower rate. As a result, US government bond prices are more likely to increase as long as market expectations call for a lower inflation rate[23]. In the same way, according to Equation (4), US stock market prices are likely to increase in response to the US UNMP's signaling channel, as stocks' future cash flows (G_t) are discounted at a lower rate, and the inflation rate is expected to be lower[24]. Based on aforementioned aspects, US stock and bond market prices are likely to move together, as will their returns, in response to lower short-term interest rates. As a result, the dynamic correlation between US stock and bond markets tends to be positively linked to the UNMP's signaling channel. The

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[22] Rogers et al., (2014) found out that the decline in government bond yield resulted from UNMP significantly leads to increase the US stock market prices.

[23] Expectations on inflation rate may influence the positive link between expected short-term interest rates and government bond prices, as higher levels of expected inflation positively influence bond yields and, thus, lower bond prices (Andersson et al., 2008).

[24] In case of higher expectations on inflation rate, the discount rate effect may overwhelm changes in expected future dividends, with higher expectations on inflation likely to affect stock prices negatively (Ilmanen, 2003).

following is how bond and stock prices are formulated according to the dividend discount model framework:

$$B_t = E_t \left[\sum_{t=1}^{T} \frac{C_t}{(1+ Er_t + BRP_t)^t} + \frac{F_v}{(1+Y_T)^T} \right] \quad (3)$$

Where: B_t is a government bond price at time t, C_t represents coupon payment (future cash flows), Er_t is the anticipated short-term interest rate, BRP_t is the government bond risk premium, F_v is the bond's face value, Y_T stands for government bond yield to maturity, t is time till the bond's sale and T denotes time until maturity.

$$S_t = E_t \left[\sum_{t=1}^{T} \left(\frac{1+G_t}{1+E\ _t + BRP_t + SRP_t}\right)^t * D \right] \quad (4)$$

Where: S_t is the stock price; G_t is the anticipated dividend rate of stocks; D represent stock dividends; Er_t denotes the anticipated short-term interest rate; BRP_t and SRP_t are the risk premium on government bonds and stocks, respectively; $and\ t$ represents time investment in stocks.

The US UNMP's signaling channel may have an international spillover effect on the dynamic correlation between other advanced countries' bond markets and the US stock market. This spillover effect from the signaling channel on such dynamic correlations is attributed first: to the signaling channel's significant and negative effect on foreign government bond yields, particularly for those countries with close economic ties to the US and whose monetary policies exhibit higher sensitivity to signals from US monetary policy, such as Australia, Canada and Germany (Bauer and Neely, 2014). This suggests that the Fed's signaling channel has changed the expected perspective on short-term interest rates abroad, thereby indicating that advanced countries' bond cash flows are discounted at a lower rate, leading to price hikes, according to Equation (2). In practice, advanced central banks' monetary policy is correlated, i.e., they react similarly to global crises, such as the 2008 financial crisis. Also, for exchange-rate stability, central banks in those advanced countries might be required to follow other nations' monetary policy, particularly that of the US. Second, lower short-term interest rates resulted in increasing US stock prices, as mentioned earlier, according to Equation (4). Accordingly, the dynamic movement between advanced countries' bond markets and US stock markets is expected to react positively to US UNMP via the signaling channel since the US stock and advanced countries' bond market move together.

Moreover, UNMP via the signaling channel could exert a positive effect on foreign stock market prices. In this regard, Moessner (2015) indicated that the FOMC's forward-guidance announcements on the future path of US short-term interest rates will exert positive international spillover effects on foreign stock market prices, particularly advanced countries' prices. Moessner argues that the Fed's signals on maintaining the federal funds rate at the ZLB leads to reductions in advanced countries' long-term bond yields and, in turn, reduces the discount rate at which advanced countries' stock cash flows are discounted. As a result, advanced countries' stock prices are more likely a response to the Fed's signaling channel. Therefore, the Fed UNMP's signaling channel could exert a positive effect on the dynamic correlations between the US bond market and advanced countries' stock markets.

The signaling channel's efficacy in affecting the dynamic correlation between US stock and bond markets, or between US bond (stock) and advanced countries' stock (bond) markets, depends on how market participants react to the FED's signals on future policy rates. In other words, it depends on how market participants react to optimistic (positive signaling shocks) or pessimistic (negative signaling shocks) interpretations of forward-guidance policy announcements on the prospective direction of short-term interest rates (Bernhard and Ebner, 2017). Since financial domestic or foreign asset prices, particularly stock prices, may react differently to market participants' interpretation of Fed signals on prospective directions for short-term interest rates, the dynamic correlation between US stock and bond markets, within advanced countries, as well as between US bond (stock) and advanced countries' stock (bond) markets, is likely to be affected by such a reaction. For example, when the Fed provides signals indicating that future short-term interest rates will be set at lower levels, economic agents read such signals as worsening economic global conditions. As a result, domestic and foreign stock prices tend to decrease. However, stock prices may react positively to the Fed's signals when the negative signaling effect on stock prices is being compensated by a lower discount rate. Regarding government bond prices, indications of a deteriorated economic outlook are likely to depress bond term premiums, and the Fed's signals of a lowering policy mainly lead to a reduced discount rate, both of which positively influence bond prices. Thus, the signaling channel is expected to increase government bond prices.

3.4.2 Effect of portfolio rebalancing channel on the dynamic correlation between stock and bond markets

The portfolio rebalancing channel operates based on the notion that investors such as pension funds and life insurance companies have preferences for specific types of assets with specific maturities (market segmentation) due to the nature of their long-term liabilities on the balance sheet (Vayanos and Vila, 2009; Greenwood and Vayanos, 2010). The portfolio balance model postulates that investors have elastic demand for specific types of assets; thus, a reduction in the supply of long-term government bonds due to EQ should reduce their term premium and, thus, depress their required expected return (yields) (Bauer and Neely, 2014). Therefore, the drop in US long-term government bond yields induces institutional investors, such as pension funds and life insurance companies, to build a clientele with a preference for specific maturities. Therefore, these institutional investors will be induced to take risks and rebalance their portfolios by looking domestically or internationally for risky assets, such as stocks, with a view toward matching their long-term liabilities (Joyce et al., 2014; Boubaker et al., 2017). Also, investors who are less risk-averse may be convinced to allocate part of their portfolio holdings to riskier assets, such as domestic or foreign stocks, in response to the drop in US government bond yields (Krishnamurthy and Vissing-Jorgensen, 2011, Gagnon et al., 2011). In both cases, the portfolio rebalancing channel influences the domestic and foreign financial market (bonds and stocks) prices.

Domestically, US bond and stock prices tend to increase, so their returns indicate that both assets' returns move together in response to the portfolio rebalancing channel, which tends to impact the dynamic correlation between stock and bond markets positively within the US. However, this dynamic correlation would turn out to be negative if bond and stock risk premiums are affected by other factors as follows: (i) If a drop in long-term government bond yields coincides with a flattening yield curve,[25] in which the latter indicates greater short-term bond market risks (Viceira, 2012), risk premiums on long-term government bonds are more likely to increase, resulting in lower bond prices. (ii) If stock risk premiums fall[26] in response to the

[25] Gilchrist, Yue and Egon (2018) found that US UNMP and conventional monetary policy made the yield curve flat and steeper in the US and foreign markets, respectively.

[26] Cenedese and Elard ,(2018) found that QE, through the portfolio rebalancing channel, exerts a significant effect on reductions in US stock market risk premiums, thereby causing US stock market prices to increase by 9.6%, which is considered proof of an active portfolio rebalancing toward risky assets.

portfolio rebalancing channel, stock prices are likely to increase. Therefore, stock and bond market prices move in opposite directions, indicating that the portfolio rebalancing channel negatively affects the dynamic correlation between US stock and bond markets. Moreover, if stock market premiums negatively respond to the portfolio rebalancing channel, stock market prices are likely to decline, implying that government bond market prices move inversely concerning stock market prices. In this case, the portfolio rebalancing channel could derive a dynamic correlation between US stock and bond markets.

Internationally, the portfolio rebalancing channel has spillover effects in that investors may rebalance long-term government bonds purchased by the Fed with other foreign financial assets. On the one hand, less risk-averse investors may rebalance their profile internationally toward advanced countries' stock markets[27]. This would reflect on increasing advanced countries' stock weights in investors' portfolio compositions, thereby increasing these advanced countries' stock prices and, thus, stock returns. Holding that US government bond and foreign stock market risk premiums were not affected by Fed QE (in the way mentioned in the previous paragraph), the dynamic correlation between advanced countries' stock markets and the US bond market is likely to be positively affected by the portfolio rebalancing channel, as both US bond market prices and advanced countries' stock prices move in the same direction in response to the portfolio rebalancing channel. On the other hand, the decline in US government bond yields will generate an incentive for investors who are more risk-averse to rebalance their portfolios internationally toward bonds with the same features as those in advanced countries (Bauer and

[27] Cenedese and Elard (2018) indicated that international equity funds increase their portfolio weight toward advanced countries' equity funds as a response to Fed UNPM via the international portfolio rebalancing channel.

Neely, 2014, and Bernhard and Ebner, 2017). In this case, the dynamic correlation between the US stock market and advanced countries' bond markets is more likely to respond negatively to the portfolio rebalancing channel. This negative correlation is due to the flight-to-quality phenomenon, which results in rising bond prices in advanced countries and a decline in US stock prices

Chapter 4

DATA AND METHODOLOGY

4.1 Data and variable descriptions

This research aims to examine US UNMP effects through signaling and portfolio rebalancing channels on the dynamic correlation between US stock-bond market, and between US stock (bond) and other advanced countries' bond (stock) markets over the period 26 November 2008 to 30 November 2015. The analysis is conducting using daily data on stock and bond market returns for the US and seven advanced countries, Australia, Canada, France, Germany, Italy, Japan, and the UK. I selected these counties as a sample because of their broad stock markets, and highly integrated financial market with the US market. In this regard, Hausman and Wongswan, (2011) pointed out that historically; the advanced countries strongly reacted to the US monetary policy surprise. They indicated that long-term interest rates in countries like Australia, Canada, and Germany were substantially responded to the US monetary announcements indicating that those advanced countries' long-term interest rates are highly linked to monetary condition changes in the US. Moreover, Ehrmann et al.,(2011) emphasized the existence of monetary interrelations between the US and advanced countries. They indicated that innovations in US bond yields and short- term interest rates explain 15% and 10% of Euro area bond yield variance respectively, while shocks to Euro area bond yields and short- term interest rates account for 12% and 3% of the US bond yields variance respectively indicating substantial linking between these two markets[28]. Therefore, US short-term interest rate signals are likely to affect bond and stock market prices in particular developed countries, which in turn, influence the cross stock-bond market correlations between the US and those advanced countries. In addition, any change in the US government bond yields will have a strong portfolio balance effects towards advanced countries' markets since the correlation between advanced countries' government bond yields and their counterparts in the US are highly positive (Bauer and Neely,2014). Therefore, US UNMP likely has a strong effect on the cross stock-bond market correlations between the US and other advanced countries, through portfolio rebalancing channel.

4.2 Generating the dynamic correlation between stock and bond markets

4.2.1 Computing stock and bond market returns

To generate the daily stock-bond market correlations which stand for the independent variable in this research, I first calculated the daily stock and bond market returns as $Ln\ (P_t/\ P_{t-1})\ \times 100$ where P_t is the price index for stock and bond markets. The stock market price indices were used: S&P 500 (US), DAX 30 (Germany), CAC 40 (France), TSX (Canada), ASX 300 (Australia), NIKKEI 225 (Japan), FTSE MIB (Italy) and FTSE100 (the UK). The bond market price indices were represented by the 10-year benchmark government bond price index for each of the countries being considered. Substantial body of literature (e.g. Andersson et al., 2008; Baele et al., 2010; Aslanidis and Christiansen, 2012; Chiang et.al, 2015; Jammazi, Tiwarid, Ferrere, and Moyaf, 2015; Dimic et al., 2016; Skintzi, 2019) have been increasingly

[28] Also, they pointed out that the Euro area bond yields, short-term interest rates and Euro exchange rate against the US dollar are significantly influenced by the US short-term rates, US bond yields and US stock market returns. However, the US bond yields and the US dollar exchange rate against Euro are significantly affected by the Euro bond yield and short-term rates.

used the 10-year maturity of government bond price index to addressed the effect of economic and financial factors on the dynamic stock-bond market correlations. Jammazi et al. (2015) attributed the usage of 10-year government bond price index to the following reasons: First, 10-year government bond yields reflect market participant's expectations on the future prospects of the economy and primarily used in determining the cost of borrowing. Therefore, investment decisions are likely to be affected by 10-year government bond yield changes, which, in turn, would have an important influence on firms' profitability and, hence, their stock returns. Second, the long-term government bonds in particular 10-year maturities are deemed to be as closer maturity substitutes to stocks, which in turn, influence the correlation between stock and bond markets. Third, monetary policy measures are more likely to have a confusing effect on shorter-term securities, other words short term securities are less likely to get affected by monetary policy procedures, which justifies the use of long-term securities.

Data on stock and bond indices were collected from Thomson Reuters DataStream. The sample period ranged from 26 November 2008 to 30 November 2015. The starting point for our sample corresponds to the day after the first QE announcement. Following this date, the Fed made a number of extraordinary decisions, for example, (i) the reduction of short-term interest rates on 16 December 2008 so that they were bounded between 0% and 0.25%, that is, the so-called zero lower bound (ZLB) policy, and (ii) the use of forward-guidance language on September 2012 that implies keeping the future path of short-term interest rates at lower levels. Moreover, following September 2012, dramatic negative levels of expected short-term interest rates and term premium on the 10-years government bond were observed, along with a remarkable decline in the 10-year government bond yields. The sample finishes at the end of November 2015 since it was at that point when Fed started to raise short-term interest rates and to move away from the ZLB policy and UNMP.

Table 1 displays descriptive statistics of stock and bond markets in Australia, Canada, France, Germany, Italy, Japan, the UK, and the US. According to table 1, the standard deviations of 10-year bond market returns are lesser than its counterparts in stock market returns for all countries. Therefore, all bond markets exhibit lower volatility than stock markets in line with the fact of safe-haven characteristic of government bond markets. Moreover, most of the advanced countries' bond markets volatility showed closer level to its counterpart in the US except for Japan while stock market volatility in particular in Italy is greater than its counterparts in the US. The skewness is negative for almost all stock market returns and some of bond market returns, indicating that these return series are skewed to the left and negatively biased in the sense that these returns' distribution is extending toward more negative values. Therefore, the probability of negative and extreme values in these returns distribution is higher justifying the usage of quantile regression approach. Kurtosis exceeds the reference value of 3 for all stock and bond return series.

Table 1: Descriptive statistics for stock and bond market returns

	Mean	Median	Max	Min	S.td	Skewness	Kurtosis	Obs.
Panel A: stock returns								
Australia	0.000	0.000	0.055	-0.043	0.010	-0.193	4.841	1754
Canada	0.000	0.000	0.070	-0.097	0.010	-0.496	10.66	1754
France	0.000	0.000	0.092	-0.057	0.015	0.015	6.044	1754
Germany	0.000	0.000	0.073	-0.060	0.014	-0.118	5.341	1754
Italy	0.004	0.010	10.68	-7.044	1.703	-0.161	5.382	1754
Japan	0.000	0.000	0.074	-0.111	0.014	-0.468	7.115	1754
UK	0.000	0.000	0.060	-0.054	0.011	-0.161	5.964	1754
US	0.000	0.000	0.068	-0.093	0.012	-0.443	9.081	1754
Panel B: bond returns								
Australia	0.000	0.000	0.037	-0.031	0.005	0.031	5.542	1754
Canada	0.000	0.000	0.017	-0.014	0.003	-0.075	3.755	1754
France	0.000	0.000	0.023	-0.020	0.003	-0.165	5.646	1754
Germany	0.000	0.000	0.012	-0.026	0.004	-0.165	4.891	1754
Italy	0.000	0.000	0.059	-0.036	0.006	0.584	16.253	1754
Japan	0.000	0.000	0.010	-0.009	0.001	-0.142	6.525	1754
UK	0.000	0.000	0.024	-0.022	0.004	0.019	4.887	1754
US	0.000	0.000	0.040	-0.020	0.005	0.139	5.826	1754

I also, examined whether time series of stock and bond returns are stationary or not using Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) unit root tests. According to appendix 1, table 6 results suggest that all the returns series are stationary. Besides, the unconditional correlations between stock and bond market returns were tested. Results reported in Table 2 shows that most of the advanced countries bond market returns exhibit negative and statistically significant correlations with the US stock markets with an exception for Italy and Japan where the correlations are significantly positive and insignificantly negative respectively. This reflects that most of the advanced countries' bond markets may be considered a safe-haven asset for US stock markets. Notably, correlations between most of the advanced countries' bonds and US stock markets are lesser negative than the correlation between stock and bond markets within the US except for Canada where the correlation is very closer to its counterpart in the US. Also, the correlations between advanced countries' stock markets and US bond markets are negative and statistically significant; indicating that US bond markets can be considered as a hedged asset for advanced countries stock markets. All advanced countries, including Canada, France, Germany, Italy, and the UK stock markets have strong negative correlations with US bond markets comparatively to Australia and Japan stock markets.

Table 2: Unconditional correlations between stock and bond markets

	Bond markets	Correlation
Panel A: Correlation with US stock markets	Australia	-0.117***
	Canada	-0.413***
	France	-0.182***
	Germany	-0.312***
	Italy	0.128***
	Japan	-0.034
	UK	-0.289***
	US	-0.424***
	Stock markets	Correlation
Panel A: Correlation with US bond markets	Australia	-0.092***
	Canada	-0.325***
	France	-0.410***
	Germany	-0.398***
	Italy	-0.379***
	Japan	-0.098***
	UK	-0.384***

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively.

4.2.2 Test for autoregressive conditional heteroskedasticity (ARCH) and generalized autoregressive conditional heteroskedasticity (GARCH) effects

The second step in generating the dynamic stock-bond market correlations is to test for the existence of ARCH and GARCH effects in all stock and bond market return series before running the multivariate GARCH models in the next step. To do so, standard Lagrange Multiplier (LM) test (Engle, 1982) is applied to identify the presence of the ARCH effect. Table 3 displays strong support for ARCH effects in all stock and bond market returns. To test GARCH effects, we estimated the Ljung-Box Q-statistics for serial correlation using both returns and squared returns for stock and bond markets. The serial correlation exists in all series, indicating the existence of GARCH effects in all stock and bond market returns.

Table 3: ARCH and GARCH effect tests for bond and stock markets

	LM test		Q test on row data		Q test on squared data	
Panel A: stock returns	F(5,1743)	F(10,1733)	Q (5)	Q (10)	Q (5)	Q (10)
Australia	27.738***	79.524***	13.514**	16.033**	215.510***	377.290***
Canada	19.302***	344.760***	13.308**	15.953**	336.640***	355.940***
Franc	29.533***	15.389***	8.750	14.436**	203.510***	280.040***
Germany	39.678***	24.270***	16.069**	18.309**	282.980***	448.450***
Italy	27.187***	15.855***	5.607	17.526**	179.240***	281.450***
Japan	25.646***	13.875***	10.715 *	15.676**	162.500***	210.470***
UK	39.759***	23.342***	13.019**	19.713**	293.980***	461.920***
US	62.523***	43.278***	23.176***	29.553***	379.220***	609.390***
Panel A: bond returns						
Australia	26.751***	13.985***	30.054***	32.41***	156.990***	168.050***
Canada	17.498***	9.938***	12.744**	13.904	115.110***	165.740***
France	35.214***	19.452***	30.946***	42.808***	252.480***	379.310***
Germany	14.324***	9.315***	36.128***	45.131***	88.891***	146.010***
Italy	17.210***	10.437***	39.268***	49.96***	108.100***	165.270***
Japan	30.428***	16.618***	15.615***	24.802***	211.870***	304.390***
UK	15.953***	10.203***	15.371***	32.239***	90.756***	122.050***
US	8.803***	7.662***	14.072**	20.283**	52.732***	108.52***

Note: *, ** and *** denote the rejection of the null hypothesis that series has no ARCH or GARCH effect at the 1%, 5%, and 10% levels. The F-statistics (k, n) related to the Lagrange Multiplier (LM) test, where k is the lag length and n is the sample size. The Q test represents Ljung-Box statistical for serial correlation up to the 5th and 10th lag.

4.2.3 Multivariate dynamic conditional correlation

Since all stock and bond market returns have ARCH and GARCH effects, I employed the dynamic conditional correlation (DCC) model (Engle, 2002) to construct the dynamic correlation between stock and bond markets which require two steps following (Anderss et al., 2008; Chiang et al., 2015). The first step is to estimate conditional variances for stock and bond market by using a univariate ARMA (2, 1)-GARCH (1, 1) model, the ARMA (2, 1) process is included in the mean equation to capture the effect of serial correlation. The second step is to estimate the parameters used to compute time series of the dynamic correlation coefficients between stock and bond markets. The usage of DCC method is to overcome the heteroskedasticity problem since the residuals of the stock and bond market returns are standardized by the conditional standard deviation constructed from ARMA (2,1)-GARCH (1,1) process. The DCC model is estimated through two steps: the first step is to estimate the conditional variances of stock and bond markets as follows:

Mean equation:

$$R_{it} = \chi_i + \psi_i R_{i,t-1} + \gamma_i R_{i,t-2} + \omega_i M_{i,t-1} + \varepsilon_{i,t} \quad (5)$$

$$\varepsilon_{i,t} = \eta_t \sqrt{h_{i,t}} \quad \eta_{i,t} \sim iid\ (0,1)$$

Variance equation:

$$h_{i,t} = \phi_i + \alpha_i \varepsilon_{i,t-1}^2 + B_i h_{i,t-1}^2 \quad (6)$$

Where: R_{it} refers to returns on assets i, χ_i is the constant term, ψ_i *and* γ_i refer to the coefficients of the first and second lagged returns of asset i respectively, ω_i is the coefficient of lagged residual return of asset i, $\varepsilon_{i,t}$ is the error term following independently and identically normal distribution, $h_{i,t}$ is the conditional variance of assets i, α_i and B_i are the ARCH and GARCH coefficients, and subscript i stands for stocks and bonds respectively. In the second step, I modeled the dynamic stock-bond market correlations coefficients based on the residuals of stock and bond market returns that have been normalized from the first step as follows:

$$z_{i,t} = \frac{\varepsilon_{i,t}}{\sqrt{h_{i,t}}} \quad (7)$$

$$z_{i,t} \sim N(0, q_{i,t})$$

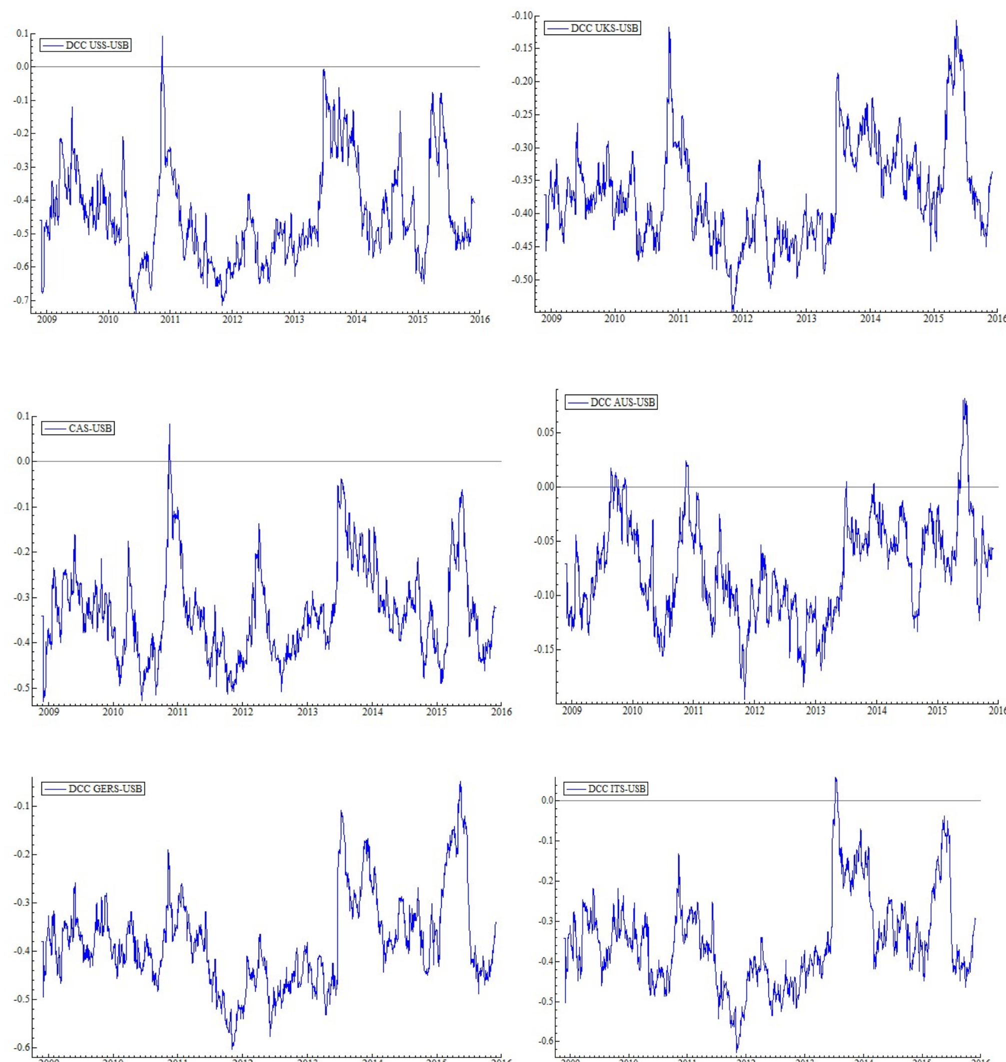
$$q_{SB,t} = \overline{\rho}_{SB}(1 - a - b) + b q_{SB,t-1} + a z_{S,t-1} z_{B,t-1} \quad (8)$$

$$\rho_{SB,t} = \frac{q_{SB,t}}{\sqrt{h_{S,t}}\sqrt{h_{B,t}}} \quad (9)$$

Where: $z_{i,t}$ is the normalized residual of asset i at time t, $h_{i,t}$ is the conditional variance of asset i at time t, z_S and z_B are the normalized residual of stocks and bonds respectively, $q_{SB,t}$, $\overline{\rho}_{S,B}$ refer to the dynamic conditional covariance and the unconditional correlation between stock and bond normalized residuals, respectively. a and b are non-negative parameters associated with the exponential smoothing process that employed to create the dynamic conditional correlation between stock and bond markets, and the sum of those parameters must be less and close to one to ensure that this dynamic correlation exhibits mean-reverting process, $h_{S,t}$ and $h_{B,t}$ denote the conditional variances of the stock and bond markets respectively. $\rho_{SB,t}$ represents the dynamic correlation between the stock and bond markets.

Appendix B displays results of the estimated DCC–GARCH models between US bond markets, advanced countries bond markets, and US stock markets. Also, the results of the estimated DCC–GARCH models between US stock markets and advanced countries bond markets are shown in appendix C. According to appendix B and C, the sum of all univariate GARCH (1, 1) α and B coefficients are less and close to one indicating that volatility in the US and advanced countries stock market, as well as volatility in the US and advanced countries bond markets, revert slowly to their mean values. Also, the DCC coefficients (ρ) are statistically significant and negative in most countries except for Italy and Japan. The ρs' coefficients between Japan (stock) markets and US stock (bond) markets were insignificantly negative and significantly (positive) respectively. See appendix B, table 11, and appendix C, table 20. Also, the parameters a and b for most of DCC models are statistically significant, and they are less and close to 1 indicating that DCC the models are exhibiting mean-reverting process. The exception is Japan where DCC between Japan stock (bond) and the US bond (stock) markets were not mean-reverting process yet exploding process as a and b were not statistically significant as revealed in appendix B, table

12 and appendix C, table 20. Thus, Japan will be not included for analyzing the impact of signaling and portfolio rebalancing channels on dynamic stock-bond market correlations. Finally, all univariate ARMA- GARCH (1, 1) models, and the multivariate DCC- GARCH (1.1) models have no serial correlation, since the Ljung-Box statistics (Q-statistics) and Hosking multivariate portmanteau on residual and squared residuals of stock and bond returns up to 5th and 10th lags are not statistically significant respectively.



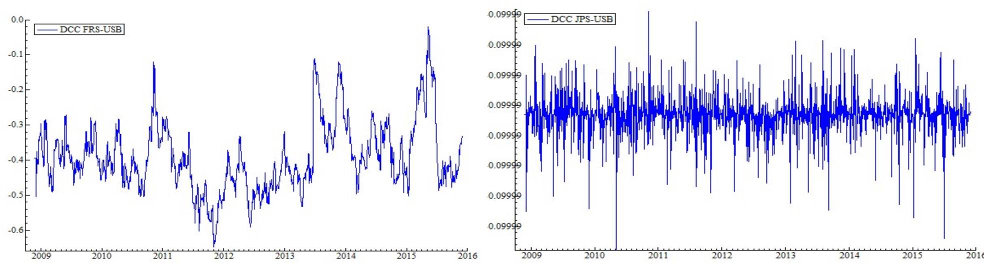
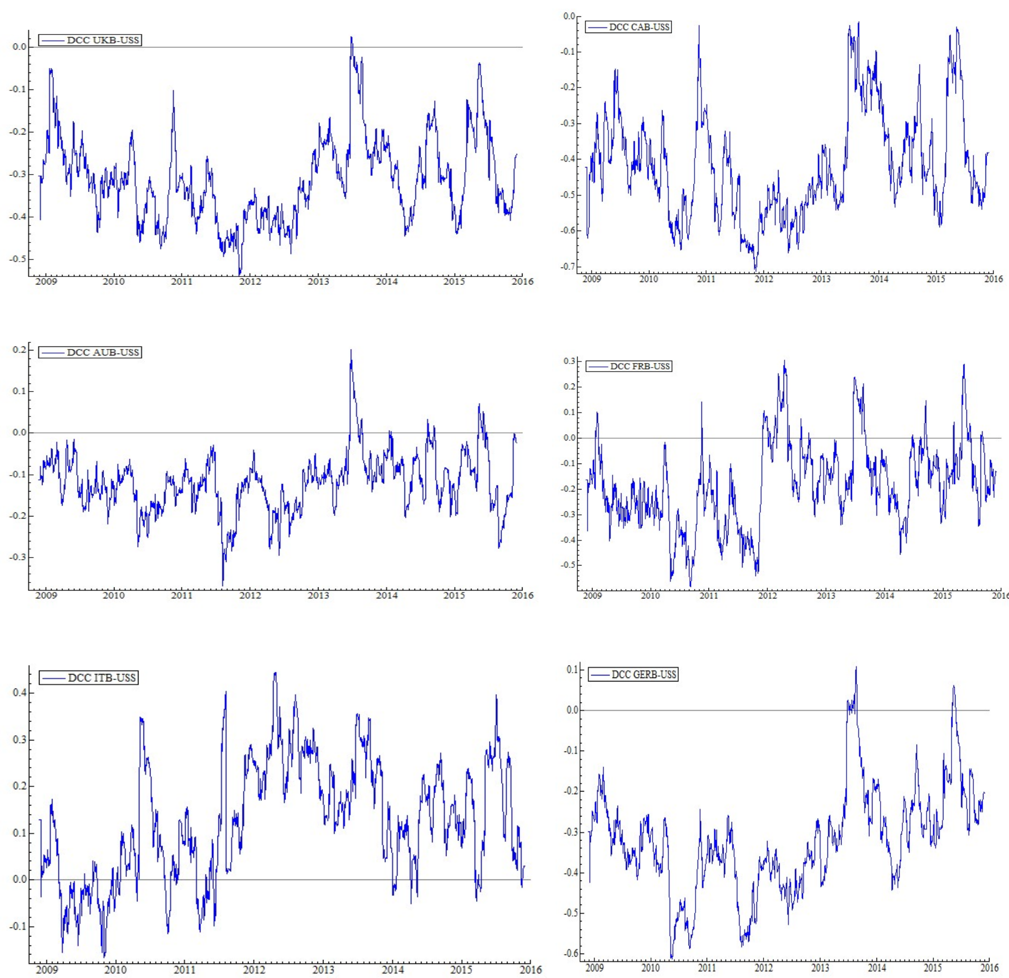


Figure 3: Daily dynamic correlations between advanced countries' stock and US bond markets.
Note: USS = US stock market returns, USB = US bond market returns, FRS = France stock market returns, ITS = Italy stock market returns, AUS = Australia stock market returns, JPS = Japan stock market returns, GERS = Germany stock market returns.



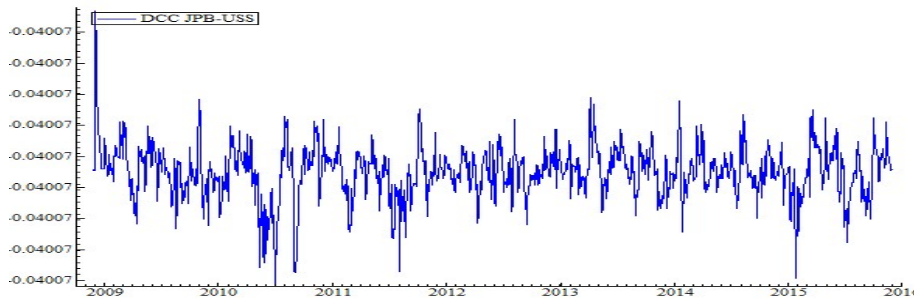


Figure 4: Daily dynamic correlations between advanced countries' bond and US stock markets.
Note: USS = US stock market returns, UKB = UK bond market returns, FRB = France bond market returns, ITB = Italy bond market returns, AUB = Australia bond market returns, JPB = Japan bond market returns, GERB = Germany bond market returns.

4.3 Explanatory variables

To investigate the impact of the effect of US UNMP via signaling and portfolio rebalance channels on the dynamic stock-bond market correlations. I employed the decompositions of the 10-year government bond yield calculated by Kim and Wright (2005). Following (e.g.Gagnon et al., 2011; Bauer and Rudebusch, 2014; Neely, 2015; Lloyd, 2017). This decomposition is formed by two components; risk-neutral yield component (expectations of future short-term interest rates) and term premium component. The risk-neutral component represents the expected path of future short-term interest rates, and the term premium is the additional compensation for the interest rate risk related to long-term government bond, as well as other risks, originated from market segmentation (Bauer and Neely, 2014). Therefore, the risk-neutral and term premium components of 10-year government bond yield to stand for signaling channel effect (EIB) and portfolio rebalance channel effect (POR) of UNMP respectively. I added control variables into the econometric model including; the conditional variance of stock and bond markets generated by ARMA (1, 1)

GARCH (1, 1)[29] model to stand for stock market volatility (CVS) and bond market volatility (CVB) respectively following (Chiang et al., 2015), $\rho_{SB,t-1}$ is the one-lagged period of the dependent variable to mitigate the serial correlation problem in line with (Andersson et al., 2008; Kim, et al., 2006), and a dummy variable (TAP) to capture the effect of FED's talk about the possibility of cutting off QE (tapering QE talk effect) that takes value of one during the period 22 May 2013 to 31 August 2013, and otherwise zero. Since the effectiveness of the portfolio rebalancing channel in stimulating economic activity depends on the magnitude of QE (Lloyd, 2017), I also placed three dummy variables (QE1, QE2, and QE3) into the econometric model following Jawadi, Sousa, and Traverso (2017) to capture the effect of the three different phases of QE; by taking the value of one over the periods (i) 26 November 2008 to 02 November 2010 (ii) 03 November 2010 to 13 September 2012, (iii) 14 September 2012 to 12 December 2013, for $QE1, QE2, QE3$ respectively, and otherwise zero.

4.4 Econometric model

This research explores the effects from unconventional monetary policy channels, namely portfolio rebalancing and signaling channels, on the dynamic correlation between US stock and bond markets, as well as on the dynamic correlation between US stock (bond) and other advanced countries' bond (stock) markets. To do so, I applied the conditional nonlinear quantile regression developed by Koenker and Bassett (1978) in line with previous studies (Aslanidis and Christiansen, 2014; Lee and Cho, 2017). Quantile regression enables us to investigate that dependence under different stock-bond market correlation scenarios including scenarios of highly negative correlation (lower quantile) and highly positive correlation (upper quantile)

[29] For more details, see appendix (D).

(Aslanidis and Christiansen, 2014). However, ordinary least square (OLS) shows the same effect of explanatory variables despite the existence of various levels of the dependent variables; hence, explanatory variables influence the correlation in precisely the same way. Therefore, quantile regression provides a comprehensive view of different effects of a set of regressors across various quantiles of the conditional distribution of the regressand variable (Zhu, Guo, You, and Xua, 2016). This property of quantile regression then gives robust and informative results even for data on response variable with large extreme outliers and non-normally distributed (Koenker and Hallock, 2001; Fattouh, Scaramozzino, and Harris, 2005; Aslanidis and Christiansen, 2014). More specifically, outliers and non-normality may largely influence the mean of distribution than on the median hence, the application of (OLS) might produce biased estimates, while quantile regression reveals more robust outcomes even in the presence of outliers and non-normality (Fattouh et al., 2005). The quantile regression takes the following form:

$$Q_{yi}(\tau|x_i) = \alpha_i\,(\tau) + x_i'\,B_i(\tau) + (\varepsilon_i|x_i) \qquad (10)$$

Where:

$Q_{yi}(\tau|x_i)$ is the τ^{th} conditional quantile of y_i given x_i ,$0 < \tau < 1$, α presents the intercept, β is the vector of unknown parameters to be estimated at different quantile, x_i are independent variables, and $(\varepsilon_i|x_i)$ signifies the value of the error term (ε_i) conditional on the regressors (x_i) which assumed to be equal to zero. Estimating the coefficient B_i at various level of τ allows us to trace the whole distribution of y_i given x_i. Thus, the conditional quantile regression estimator for $\beta(\tau)$ is estimated as:

$$'B(\tau) = \arg\min \textstyle\sum_{i=1}^{n} \rho_\tau(y_i \text{-} x_i'\,B(\tau) - \,\alpha(\tau) \qquad (11)$$

Where:

$\rho_\tau(u) = u(\tau - I(u<0))$ is the check function, and $I(.)$ is an indicator function equal to $(u = y_i - x_i' B(\tau) - \alpha(\tau))$. The estimation method is robust since it divides the residuals into positives and negatives and gives weights of τ and $1-\tau$.

First, I examined the impact of US UNMP through signaling and portfolio rebalancing channels on the dynamic correlation between US stock and bond markets using the following model:

$$Q\left(\rho_{SB,t} \middle| \rho_{SB,t-1}, POR_{i,t}, EIR_{i,t}, \text{CVS}_{i,t}, CVB_{i,t}, QE1, QE2, QE3, TAP\right) = \alpha_i B_0(\tau) + B_1(\tau)\rho_{SB,t-1} + B_2 POR_{i,t} + B_3(\tau) EIR_{i,t} + B_4(\tau)\text{CVS}_{i,t} + B_5(\tau) CVB_{i,t} + B_6(\tau) QE1 + B_7(\tau) QE2 + B_8(\tau) QE3 + B_9(\tau) TAP \quad (12)$$

Where:

$Q\left(\rho_{SB,t} \middle| \rho_{SB,t-1}, POR_{i,t}, EIR_{i,t}, \text{CVS}_{i,t}, CVB_{i,t}, QE1, QE2, QE3, TAP\right)$ represents the τ^{th} quantile of the dynamic correlation between US stock and US bond markets at month i conditional on the vector of independent variables[30], α_i is the intercept, $\rho_{SB,t-1}$ $POR_{i,t}, EIR_{i,t}$, $\text{CVS}_{i,t}$, $CVB_{i,t}$, QE1, $QE2, QE3$, and TAP, represent independent variables selected to account for the dynamic correlation between US stock and bond markets.

Second, I examined the spillover effects of US UNMP channels on the dynamic stock-bond market correlations by investigating the effects of signaling and portfolio rebalancing channels on the dynamic correlation between US stock (bond) and other advanced countries' bond (stock) markets. To do so, I added into the model (12)'s

[30] Since the dynamic correlation coefficient is limited value between (-1, +1) while the other variables do not have such limit, we use a Fisher-Z transformation as $Ln\ (\frac{1+\rho_{SB,t}}{1-\rho_{SB,t}})$ to make the dependent variable unrestricted to the range (-1, +1) in model (12) mode (13) and model (14) before running the quntile regression (Andersson et al., 2008; Aslanidis and Christiansen 2014; Skintzi, 2019).

explanatory variables, the conditional variances of stock ($CVS_{j,t}$) and bond markets ($CVB_{j,t}$) in each advanced country to account for the level of stock and bond markets volatility in those advanced countries. Moreover, as the exchange rate is an international component of signaling and portfolio balance channel effects on foreign financial markets Bauer, and Neely (2014), I have taken into account the possible effect of the exchange rate (by adding each country exchange rate against the US dollar ($EXR_{j,t}$) into model (12). Therefore, models (13) and (14) have been estimated: model (13) estimated to examine the effects of signaling and portfolio rebalancing channel effects on the dynamic correlation between US bond and other advanced countries' stock markets as follows:

$$Q(\rho_{BiSj,t}|\rho_{SiBj,t-1}, POR_{i,t}, EIR_{i,t}, \text{CVS}_{i,t}, CVB_{i,t}, \text{CVS}_{j,t}, CVB_{j,t}, QE1, QE2, QE3, TAP)$$
$$= \alpha_i B_0(\tau) + B_1(\tau)\rho_{SiBj,t-1} + B_2 POR_{i,t} + B_3(\tau)EIR_{i,t} + B_4(\tau)\text{CVS}_{i,t} +$$
$$B_5(\tau)CVB_{i,t} + B_6(\tau)\text{CVS}_{j,t} + B_7(\tau)CVB_{j,t} + B_8(\tau)QE1 + B_9(\tau)QE2 +$$
$$B_{10}(\tau)QE3 + B_{11}(\tau)TAP + B_{12}(\tau)EXR_{j,t} \tag{13}$$

Where:

$Q\left(\rho_{BiSj,t} \mid \rho_{BiSj,t-1}, POR_{i,t}, EIR_{i,t}, \text{CVS}_{i,t}, CVB_{i,t}, \text{CVS}_{j,t}, CVB_{j,t}, QE1, QE2, QE3, TAP\right)$ represents the τ^{th} quantile of the dynamic correlation between US bond and other advanced county stock markets at month i conditional on the vector of independent variables selected to account for the dynamic correlations between US bond markets advanced countries' stock markets. $\text{CVS}_{j,t}$, $CVB_{j,t}$ are the conditional variance of stock and bond markets in an advanced county respectively, i and j stand for the US and advanced country respectively, S, and B account for stock and bond markets. Besides, model (14) estimated to examine the effects of signaling and portfolio rebalancing channel effects on the dynamic correlation between US stock and other advanced countries' bond markets as follows:

$$Q(\rho_{SiBj,t}|\rho_{SiBj,t-1}, POR_{i,t}, EIR_{i,t}, \mathrm{CVS}_{i,t}, CVB_{i,t}, \mathrm{CVS}_{j,t}, CVB_{j,t}, QE1, QE2, QE3, TAP)$$

$$= \alpha_i B_0(\tau) + B_1(\tau)\rho_{BiSj,t-1} + B_2 POR_{i,t} + B_3(\tau)EIR_{i,t} + B_4(\tau)\mathrm{CVS}_{i,t} +$$

$$B_5(\tau)CVB_{i,t} + B_6(\tau)\mathrm{CVS}_{j,t} + B_7(\tau)CVB_{j,t} + B_8(\tau)QE1 + B_9(\tau)QE2 +$$

$$B_{10}(\tau)QE3 + +B_{11}(\tau)TAP + B_{12}(\tau)EXR_{j,t} \quad (14)$$

Where:

$Q(\rho_{BiSj,t} \mid \rho_{BiSj,t-1},\ POR_{i,t},\ EIR_{i,t},\ \mathrm{CVS}_{i,t},\ CVB_{i,t},\ \mathrm{CVS}_{j,t},\ CVB_{j,t},\ QE1, QE2,\ QE3,\ TAP)$ represents the τ^{th} quantile of the dynamic correlations between US stock and other advanced countries' bond markets at month i conditional on the vector of independent variables, i and j stand for the US and advanced country respectively, S, and B account for stock and bond markets respectively.

The models are estimated at nine quantiles τ = (0.10, 0.2, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80 and 0.90).These quantiles can be classified into lower quantiles (0.10, 0.2, 0.30, and 0.40) which represent negative dynamic stock-bond market correlations (left tail of stock-bond market correlation distributions), a medium quantile (0.50), and higher quantiles (0.60, 0.70, 0.80, and 90) that express positive dynamic stock-bond market correlations (right tail of stock-bond market correlation distributions). The effect of a given explanatory variable varies according to the two tails due to the distinctive characteristics of the dependent variable (the dynamic stock-bond market correlation).In other words; at lower and higher quantiles, the explanatory variables have different effects on the dynamic stock-bond market correlations according to their signs respectively. At the lower quantiles, a negative sign coefficient of an explanatory variable ($B^{0.1,0.2,0.3,0.4} < 0$) implies that the greater the explanatory's variable effect is, the stronger the dynamic correlation between stock and bond markets (a negative correlation becomes closer to -1). However, at the upper quantiles, a negative sign of an explanatory variable's coefficient($B^{0.6,0.7,0.8,0.9} < 0$), indicates that the dynamic correlation is increasing in the positive direction, as the explanatory variable coefficients become larger. Similarly, at the lower quantiles, a positive explanatory variable' coefficient ($B^{0.1,0.2,0.3,0.4} > 0$), implies weaker dynamic stock-bond market correlations (closer to zero) as this coefficient increases, while at the upper quantile, the dynamic correlation get stronger (closer to +1) when the explanatory variable coefficient turns out to be larger ($B^{0.6,0.7,0.8,0.9} > 0$).

Chapter 5

EMPIRICAL RESULTS AND DISCUSSION

First, I estimated the econometric model (12) at the quantiles τ = (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 and 0.9) to investigate US UNMP effects through signaling and portfolio rebalancing channels on dynamic correlation between US stock and bond markets. Table 4 presents the empirical results of the quantile regression model of equation 12. The POR has a (diminishing) predominantly negative effect on the dynamic correlation between US stock and bond markets. The magnitude of the estimated coefficient confirms that the portfolio rebalancing is the main channel through which UNMP operates. The POR is related to changes in long-term government bond term premiums. By expanding the size of its balance sheet via QE, the Fed decreases the long-term bond yield and increases investors' holding of cash. If investors consider cash to be an imperfect substitute for long-term government bonds, then they constitute a clientele with a preference for specific maturities, such as mutual funds and insurance companies, and so will have an incentive to take a risk and rebalance their portfolios so as to meet their long-term liabilities in line with the preferred habit theory introduced by Modigliani and Sutch (1966). Therefore, investors will seek higher returns by purchasing other risky assets, such as stocks, which results in higher stock prices. In this regards, Boubaker et al., (2017) found that US unconventional monetary policy induces US institutional investors such as pension fund to rapidly increase and allocate more capital towards equity. Moreover, Eksi and Tas, (2017) indicated that the US investors rebalance their portfolio towards

US stocks after conducting large scale asset purchases (LSAP) by the Fed. However, a decline in long-term bond yields is accompanied by a flattening yield curve and, therefore, increasing short-term bond market risks (Viceira, 2012). Accordingly, long-term government bond risk premiums tend to increase, which results in lower bond prices. Hence, the stock and bond prices move in opposite directions, thereby resulting in negative dynamic stock-bond correlations. The quantile regression reveals decreasingly significant and negative coefficients of the POR at quantiles 0.1 to 0.6, indicating the asymmetric effect of this variable on the dynamic stock-bond correlations. The POR coefficients are not significant at the higher quantiles (0.7 to 0.9), indicating the lack of a relationship between the POR and the dynamic stock-bond market correlations during periods of highly positive correlations.

The EIR has a positive impact on the dynamic correlation between US stock and bond markets. As expectations regarding short-term interest rates remain lower, the correlation tends to be positive or, at least, less negative. This result theoretically is not in line with Wallace (1981) hypothesis that assumes conducting UNMP by the central bank through QE does not affect the general equilibrium of an economy therefore, signaling channel should have no effects on stock and bond prices and thereby the dynamic correlation between them. However, in practice this hypothesis can be validated. Gagnon et al. (2011) indicated that the existence of non-financial variables such as economy agent sentiment which can boost the demand for safer assets (bonds) during financial crises raising the future cash flows of those assets leading to increase in their prices and thus their returns. Therefore, the existence of such non-financial factors can validate the theoretical assumption of non-signaling channel effect on the dynamic correlation between stock and bond markets and thus indicating the practical effect of such a channel. Accordingly, Lower short-term interest rates imply lower credit market constraints and higher investor sentiment, which in turn decreases investors' risk aversion, thereby leading to higher stock prices (Kurov, 2010; Lutz, 2015). Also, lower short-term interest rates are associated with lower bond yields and, therefore, with higher bond prices. This finding is consistent with the intuitive explanations offered by Ilmanen (2003), who indicated that lower future short-term interest rates imply lower discount rates at which future bond and stock cash flows are discounted. Accordingly, lower discount rates imply higher bond and stock prices, which indicates that the stock and bond prices move together during periods of lower short-term interest rate expectations, thereby causing positive or, at least, less negative dynamic stock-bond market correlations. Also, this finding is in line with d'Addona and Kind (2006) who showed that increasing real interest rates expectations positively derives the dynamic stock-bond market correlations in G7 countries. Moreover, our findings are in line with those of Yang et al., (2009), who documented how stock-bond market correlations in the US are lower during periods of lower short-term interest rates. I also find that, at quantiles 0.1 to 0.6, the estimated coefficients of the EIR significantly and consistently decrease in magnitude, which provides evidence of an asymmetric effect. However, the estimated coefficients of the EIR are statistically insignificant at the upper quantiles (0.7, 0.8 and 0.9), which indicates the lack of a relationship between the signaling channel and the dynamic stock-bond market correlations during periods of highly positive correlations.

Table 4: Quantile regression results for signaling and portfolio rebalancing channel effects on the dynamic correlation between US stock and bond markets

Quantiles	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
α	-1.484***	-0.999***	-0.729***	-0.502***	-0.180***	-0.190***	-0.236*	-0.083	-0.263
$\rho_{SB,t-1}$	0.873***	0.964***	0.937***	0.953***	0.965***	0.969***	0.977***	0.977***	0.997***
POR	-1.405**	-0.917***	-0.719***	-0.504***	-0.209*	-0.225**	-0.297	-0.138	-0.364
EIR	0.611***	0.398***	0.309***	0.217***	0.091*	0.098**	0.127	0.062	0.159
CVS	-0.079***	-0.040***	-0.021**	-0.011***	-0.006***	-0.005***	0.005**	-0.005**	-0.003
CVB	0.030**	0.018***	0.008**	0.005***	0.005***	0.006***	0.005*	0.005*	0.002
$QE1$	-0.053**	-0.033***	-0.022***	-0.015**	-0.006	-0.010	-0.019*	-0.020	-0.028
$QE2$	-0.035***	-0.027***	-0.018**	-0.015***	-0.007	-0.009*	-0.016***	-0.023**	-0.022
$QE3$	0.009	0.005	-0.003	-0.004	0.002	0.006	-0.002	-0.002	-0.016
TAP	-0.005	0.033**	0.032***	0.026***	0.018	0.021	0.030	0.125	0.256

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

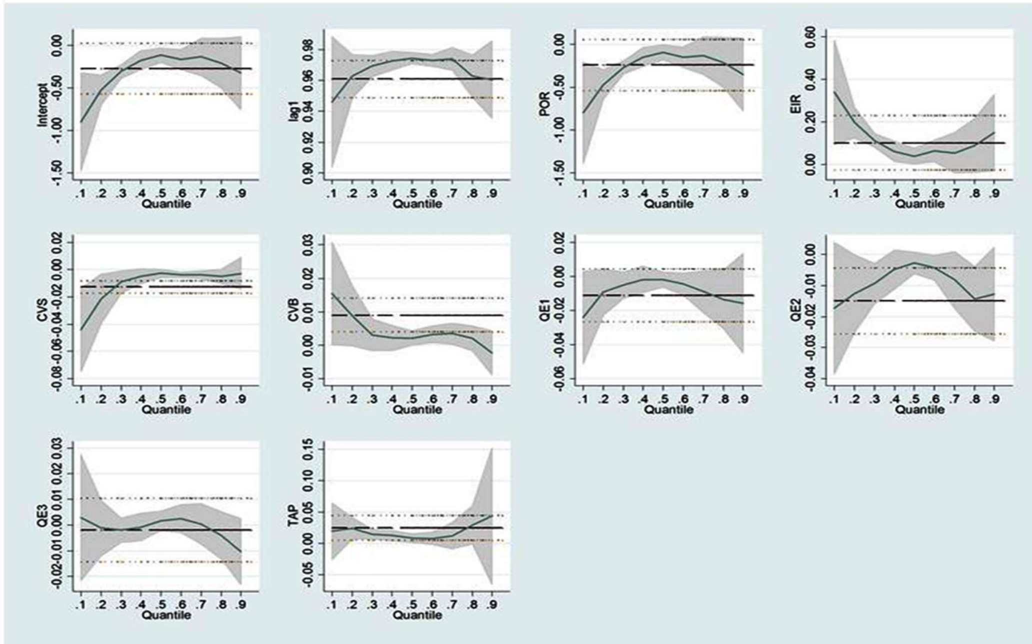


Figure 5: Quantile regression processes of independent variables on the dynamic correlation between US stock and bond markets.

To check the robustness of the empirical results, I run Wald tests of the equality of the slopes, as proposed by Koenker and Bassett (1982). The null hypothesis of the test is $B_{0.1} = B_{0.2},\ B_{0.2} = B_{0.3}, B_{0.3} = B_{0.4}, B_{0.4} = B_{0.5}, B_{0.5} = B_{0.6}, B_{0.6} = B_{0.7}, B_{0.7} = B_{0.8},\ B_{0.8} = B_{0.9}, B_{0.1} = B_{0.5}, B_{0.5} = B_{0.9},\ B_{0.1} = B_{0.9}$. The results presented in Table 4 indicate the rejection of the null hypothesis for the lower quantiles, thereby implying that the coefficients are significantly different from each other, while at the higher quantile, the coefficients do not differ from each other significantly. Furthermore, the coefficients of the lowest (0.1) and the highest (0.9) quantiles, as well as of the median (0.5) and the highest (0.9) quantiles, are significantly different from each other. These findings confirm that the impacts of the explanatory variables differ across these three quantiles of the stock-bond market correlations, which indicates the importance of using the quantile regression model rather than relying on a standard regression model.

Table 5: Wald test results for regressing signaling and portfolio rebalancing channels on the dynamic between US stock and US bond markets

Quantiles	F(10,1744)
0.1 ; 0.2	4.65***
0.2 ; 0.3	6.63***
0.3 ; 0.4	17.10***
0.4 ; 0.5	4.43***
0.5 ; 0.6	6.35**
0.6 ; 0.7	1.39
0.7 ; 0.8	1.02
0.8 ; 0.9	1.62
0.1 ; 0.5	17.67***
0.5 ; 0.9	4.16***
0.1 ; 0.9	17.25***

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k is the independent variable's' number, and n is the sample size.

Second, to examine the spillover effect of US UNMP through signaling and portfolio rebalancing channels on dynamic correlations between US stock (bond) and other advanced countries' bond (stock) markets, the econometric models in equation 13 and 14[31] respectively have been estimated at the quantiles τ = (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 and 0.9). To investigate the effects of signaling and portfolio rebalancing channels on the dynamic correlations between US bond and other advanced countries' stock markets, the econometric model (13) was estimated. Results are shown in appendix 6, tables (18, 19, 20, 21, 22, and 23).

According to the obtained results, POR has a strong negative effect on the dynamic correlations between Australia, Canada, France, Germany, UK stock markets, and US bond markets. This finding implies that as QE pushes down the US government bond yields, investors with less risk-averse internationally rebalance their portfolio

[31] I also, examined the effect of exchange rate on the dynamic correlation between US stock and US bond markets by adding the average exchange rate of the US dollar against 60 countries. Results indicated that exchange rate has no significant effect on the dynamic correlation between US stock and bond markets. See appendix E table 22, p 128.

seeking for yields by shifting their funds into advanced countries' stock markets in line with Krishnamurthy and Vissing-Jorgensen (2011), and Gagnon et al., (2011). This finding is in accordance with the preferred habit theory introduced by Modigliani and Sutch (1966). The Fed's balance sheet massive expanding due to the purchases of the US longer-term government under QE leads to decreases the long-term government bond yields and increases investors' holding of cash. Therefore, If investors consider cash to be an imperfect substitute for long-term government bonds, then investors like mutual funds and insurance companies constitute a clientele with a preference for specific maturities with a view much their long-term liabilities. As a result, they will be induced to take a risk and internationally rebalance their portfolios to foreign stocks. The negative effect of POR on the dynamic correlations between Australia, Canada, France, Germany, UK bond markets, and US stock markets can be attributed to flight from the quality phenomenon. This phenomenon implies that less risk-averse investors search for yields by rebalancing their portfolio internationally towards risky assets such as stocks of advanced countries leading to increase their prices and hence their returns. This finding is in line with Cenedese and Elard (2018) who indicated that international equity funds increase their portfolio weight towards advanced countries' equity fund as a response to Fed UNMP via international portfolio rebalancing channel. As mentioned earlier, the decline in long-term bond yields is accompanied by a flattening yield curve, which, in turn, increases the short-term bond market risks. As a result, long-term government bond risk premiums tend to increase, which leads to lower these bond prices. Therefore, advanced countries' stock market prices and US bond prices move in the opposite directions indicating that the dynamic correlation between those advanced countries' stock markets and

US bond markets negatively response to POR. The magnitude of the estimated coefficients of POR in Australia, Canada, France, Germany, UK notably varies across quantiles with decreasingly significant and negative coefficients at lower quantiles 0.1 to 0.4, indicating the asymmetric effect of POR on the dynamic correlation between those countries stock markets and US bond markets. However, the POR coefficients are not significant at the higher quantiles 0.6 to 0.9, indicating the lack of a relationship between the POR and the dynamic correlations during periods of highly positive correlations.

The EIR has weak positive spillover effects on the dynamic correlation between Australia, Canada, France, Germany, UK stock, and between US bond markets. This finding indicated that as expectations regarding the US short-term interest rates remain low, the dynamic correlations between those countries' stock markets and US bond markets tend to be positive or, at least, less negative. These negative correlations imply that during periods of lower short-term interest rate expectations, the US bond market and advanced countries stock market prices move in the same direction. On the one hand, US UNMP through signaling channel has significant negative spillover effects on foreign short-term interest rates in particular, for those countries which are close economic ties to US and their monetary policy exhibits higher sensitivity to signals from US monetary policy such as Australia, Canada, Germany (Bauer and Neely, 2014). This suggests that the Fed signaling channel has lowered the future expectations of short-term interest rates in those advanced countries. As a result, the future cash flows of advanced countries' stocks are discounted at lower rates, thereby those stock prices and hence returns tend to increase. This is in line with Moessner, (2015) who found that FOMC frowned guidance announcements on the future path of US short-term have positively international spillover effects on foreign stock market prices in particular advanced countries.

On the other hand, US bond market prices tend to rise as a response to US UNMP signaling channel, since the lower level of short-term interest rates decrease yields on long-term govern bond, investors demand higher compensation to sell their bond holdings and thus leads to increase those bond prices. Therefore, advanced countries stock market and US bond market prices tend to move together during periods of lower short-term interest rates indicating that the dynamic correlations between US bond market and advanced countries' stock markets positively response to signaling channel of US UNMP. This result is in line with studies which documented that expectations on short-term interest rates positively influences the dynamic correlation between US stock and bond markets (e.g. Ilmanen 2003; d'Addona and Kind 2006; Yang et al., 2009). The quantile regression results indicate that EIR has almost equally significant on the dynamic between Australia, Canada, France, Germany, UK advanced countries stock and between US bond markets at lower quantile (0.1 to 0.4), indicating the lack of asymmetric effect of EIR on the dynamic correlations. Whereas, the EIR coefficients are not significant at the higher quantiles (0.7 to 0.9) indicating that during periods of highly positive dynamic correlations, the EIR has no significant impact on this dynamic correlations.

To investigate the effects of US UNMP via signaling and portfolio rebalancing channels on dynamic correlations between US stock and other advanced countries' bond markets , the econometric model (14) was estimated Results in appendix 7, table (24, 25, 26, 27, 28, and 29) indicated that POR and EIR have no impacts on those dynamic correlations. This may suggest that investors did not rebalance their portfolio internationally towards advanced countries bond markets as their yields also declined in response to US UNMP. To check the robustness of the empirical results, I run Wald tests of the equality of the coefficients estimated in equations (13) and (14). The null hypothesis of the test is $B_{0.1} = B_{0.2}$, $B_{0.2} = B_{0.3}$, $B_{0.3} = B_{0.4}$, $B_{0.4} = B_{0.5}$, $B_{0.5} = B_{0.6}$, $B_{0.6} = B_{0.7}$, $B_{0.7} = B_{0.8}$, $B_{0.8} = B_{0.9}$, $B_{0.9} = B_{0.10}$, $B_{0.10} = B_{0.11}$, $B_{0.1} = B_{0.5}$, $B_{0.5} = B_{0.9}$, $B_{0.1} = B_{0.9}$. The results presented in appendix 8, tables (30, 31, 32, 33, 34 and 35) and appendix 9, tables (36, 37, 38, 39,40 and 41) indicate the rejection of the null hypothesis for all quantiles, thereby implying that the coefficients are significantly different from each other in models (13) and (14).

Chapter 6

CONCLUSION

This research investigated the effects of unconventional monetary policy through portfolio rebalancing and signaling channels, on the dynamic correlation between US stock and bond markets, as well as on the dynamic correlation between US stock (bond) and other advanced countries' bond (stock) markets over the period 26 November 2008 to 30 November 2015. To do this end, I utilized the conditional quantile regression approach to capture the nonlinear effect of independent variables on the dynamic correlations between stock and bond markets. The main finding of the quantile regression analysis was that the portfolio rebalancing channel is a major force that negatively, strongly, and asymmetrically influences the dynamic correlation between US stock and bond markets. However, the signaling channel positively and asymmetrically affects the dynamic correlation between US stock and bond markets. Also, results revealed that the portfolio rebalancing and signaling channels have significant spillover effects on the dynamic correlations between Australia, Canada, France, Germany, UK stock markets and US bond markets with expectation for Italy. In this regard, the portfolio rebalancing channel is the leading driver that negatively and asymmetrically drives those dynamic correlations between the mentioned countries stock and US bond markets. Also, results disclose that signaling channel positively and weakly affect the dynamic correlations between Australia, Canada, France, Germany, UK stock markets, and US bond markets. In contrast, portfolio rebalancing and signaling channels have no significant effects on the dynamic correlations between Australia, Canada, France, Germany, UK bond markets, and US stock markets. Based on the above, investors rebalance their portfolio domestically and internationally towards US and advanced countries' stock markets respectively, while they did not do so towards advanced countries' bond markets when the Fed implemented UNMP.

These results have important implications for the finance community, such as portfolio managers and traders, also for monetary policymakers and academics. First of all, the dynamic correlation between international stock and bond markets is one of the primary interests of portfolio managers. Referring to this research, portfolio managers and investors who internationally diversify their investment can reassess portfolio construction, given that the changes in the dynamic correlation between US stock and bond markets as well as between US bond and other advanced countries' stock market correlations are significantly associated with the US UNMP channels. The portfolio rebalancing channel effect is the most effective channel by which US UNMP negatively affects the dynamic correlation between US stock and US bond market as well as the dynamic correlation between US bond and other advanced countries' stock market during periods of extremely negative correlation. This finding indicates that investors can take advantage of diversification by allocating more capital to the stock markets and less to the bond markets within the US when the government bond yields reduced as a consequence of implementing UNMP. Also, investors can take benefits from international diversification by allocating less capital to the US bond markets and more to advanced bond stocks in Australia, Canada, France, Germany, Italy, and the UK. Our findings can serve as guidelines for traders as well.

Second, a trader could make a profit by buying the US bonds and keep holding US and other advanced countries' stocks when the correlation is highly negative (at the lower quantiles) due to the portfolio rebalancing effect and then sell bonds before the correlation reverts to the mean (-0.45), since the signaling effect is the driving force by which the correlation becomes less negative (towards the mean). This trading strategy could not be applied to Japan since the dynamic correlation between the Japanese bond markets, and US stock markets were not exhibiting mean revert process. This strategy suggests the benefits of buying bonds when the expected short-term interest rate is lower than the current short-term interest rate and selling them when the expected short-term interest rate is higher than the current short-term interest. That is, buying bonds during the Fed's forward guidance period (characterized by an exceptional decrease of the short-term interest rates) and selling bonds prior to the Fed's announcement of tapering QE (signaling the increase of short-term interest rates).

For monetary policymakers, the obtained findings are useful as well. The information that priced into stocks and bonds are increasingly used by the monetary authority to measure, for example, market investor's growth and inflation expectations. Therefore, stock-bond return correlations may provide useful information to policymakers to determine whether investors are changing their views on inflation or monetary prospects. Finally, for academics, this research can provide a more in-depth understanding about transmission mechanism of the effect of the US UNMP through signaling and portfolio rebalancing channels on stock-bond markets interdependence within the US as well as on US stock (bond) and other advanced countries' bond (stock) markets. While, our research provides evidence on the impact of US UNMP channels on the dynamic correlation between US stock and US bond markets as well as on US stock (bond) and advanced countries' bond (stock) markets, as future research it would be interesting to examine these effects considering emerging countries; bond markets. This kind of research will enable us to compare the importance of these effects at advanced and emerging countries level. Limitation of this research is the lack of adding other control variables into the econometric models used, since this research used daily based data. More specifically, this research has been done during a particular period namely UNMP periods; thus daily data has been used to capture and meet the criteria of ARCH and GARCH effects since using monthly based data in such short period may make meeting those criteria unattainable.

REFERENCES

Alpanda, S. & S. Kabaca (2015). International spillovers of large-scale asset purchases. *Working paper* No.2015- 2, Ottawa, Canada, Bank of Canada. Available: https://www.econstor.eu/bitstream/10419/123751/1/81618349X.pdf

Altavilla, C., Carboni, G., & Motto, R. (2015). Asset purchase programmes and financial markets: Lessons from the Euro area. *Working paper* No.1864, Frankfurt, Germany, European Central Bank. Available at: https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp1864.en.pdf

Akkaya, Y. (2014). Uncertainty of interest rate path as a monetary policy instrument. *Job Market Paper*. Available at: https://editorialexpress.com/cgi-bin/conference/download.cgi?db_name=EEAMannheim2015&paper_id=149

Andersson, M., Krylova, E., & Vähämaa, S. (2008). Why does the correlation between stock and bond returns vary over time? *Applied Financial Economics*, 18(2), 139-151.

Andrade, P., Breckenfelder, J. H., De Fiore, F., Karadi, P., & Tristani, O. (2016). The ECB's asset purchase programs: an early assessment. *Working paper* No.1956, Frankfurt, Germany, European Central Bank. Available at: http://www.ecb.europa.eu/home/html/index.en.html

Asgharian, H., Christiansen, C., & Hou, A. J. (2016). Macro-finance determinants of the long-run stock-bond correlation: The DCC-MIDAS specification. *Journal of Financial Econometrics*, 14(3), 617-642.

Asgharian, H., Christiansen, C., & Hou, A. J. (2015). Effects of macroeconomic uncertainty on the stock and bond markets. *Finance Research Letters*, 13, 10-16.

Ashcraft, A., Gârleanu, N. & Pedersen, L.H. (2010), Two monetary tools: interest rates and haircuts, *Working Papers* No. 16337, National Bureau of Economic Research, Massachusetts, U.S.A.
Available: https://www.nber.org/papers/w16337

Aslanidis, N., & Christiansen, C. (2014). Quantiles of the realized stock-bond correlation and links to the macroeconomy. *Journal of Empirical Finance*, 28, 321-331.

Aslanidis, N., & Christiansen, C. (2012). Smooth transition patterns in the realized stock-bond correlation. *Journal of Empirical Finance*, 19(4), 454-464.

Aslanidis, N., & Christiansen, C. (2010). Sign and quantiles of the realized stock-bond correlation. *Department of Economics and Business Economics*, Aarhus University. Available at: https://pure.au.dk/portal/files/21775917/rp10_55.pdf

Baele, L., Bekaert, G., & Inghelbrecht, K. (2010). The determinants of stock and bond return comovements. *The Review of Financial Studies*, 23(6), 2374-2428.

Bhattarai, S., Eggertsson, G. B., & Gafarov, B. (2015). Time consistency and the duration of government debt: A signaling theory of quantitative easing. *Working paper* No. 21336. National Bureau of Economic Research, Massasjutee, U.S.A. Available at: https://www.nber.org/papers/w21336

Bartram, S. M., & Dufey, G. (2001). International portfolio investment: Theory, evidence, and institutional framework. *Financial Markets*, Institutions & Instruments, 10(3), 85-155.

Baur, D. G., & Lucey, B. M. (2009). Flights and contagion - An empirical analysis of stock-bond correlations. *Journal of Financial Stability*, 5(4), 339-352.

Bauer, M. D., & Neely, C. J. (2014). International channels of the Fed's unconventional monetary policy. *Journal of International Money and Finance*, 44, 24-46.

Bauer, M., & Rudebusch, G. (2011). Signals from unconventional monetary policy. Federal Reserve Bank of San Francisco *Economic Letter* No 2011- 36. Available at: https://www.frbsf.org/economic-research/files/el2011-36.pdf

Bauer, M. D. & Rudebusch, G. D. (2014). The signaling channel for Federal Reserve bond purchases. *International Journal of Central Banking*, 10(3), 233-289.

Bernanke, B. S. (2010). Opening remarks: the economic outlook and monetary policy. In Proceedings - *Economic Policy Symposium-Jackson* Hole (pp. 1-16). Federal Reserve Bank of Kansas City. Available at: https://www.federalreserve.gov/newsevents/speech/bernank2010827a.htm.

Bean, C. (2011). Lessons on unconventional monetary policy from the United Kingdom. Speech to the U.S. *Monetary Policy Forum*, New York, 25 February.Retrivedfrom:https://www.bankofengland.co.uk/speech/2011/lessons-on-unconventional-monetary-policy-from-the-uk-speech-by-charles-bean

Bernhard, S., & Ebner, T. (2017). Cross-border spillover effects of unconventional monetary policies on Swiss asset prices. *Journal of International Money and Finance*, 75, 109-127.

Bekaert, G., Hoerova, M., & Duca, M. L. (2013). Risk, uncertainty and monetary policy. *Journal of Monetary Economics*, 60(7), 771-788.

Bhattarai, S., Eggertsson, G. B., & Gafarov, B. (2015). Time consistency and the duration of government debt: A signaling theory of quantitative easing. *working paper* No. 21336, National Bureau of Economic Research, Massachusetts, U.S.A. Available at: https://www.nber.org/papers/w21336.

Boivin, J., Kiley, M. T., & Mishkin, F. S. (2010). How has the monetary transmission mechanism evolved over time? In *Handbook of monetary economics* (Vol. 3, pp. 369-422), Elsevier.

Borio, C., & Disyatat, P. (2010). Unconventional monetary policies: an appraisal. *The Manchester School*, 78, 53-89.

Boubaker, S., Gounopoulos, D., Nguyen, D. K., & Paltalidis, N. (2017). Assessing the effects of unconventional monetary policy and low-interest rates on pension fund risk incentives. *Journal of Banking & Finance*, 77, 35-52.

Bowdler, C., & Radia, A. (2012). Unconventional monetary policy: the assessment. *Oxford Review of Economic Policy*, 28(4), 603-621.

Bruno, V., & Shin, H. S. (2015). Capital flows and the risk-taking channel of monetary policy. *Journal of Monetary Economics*, 71, 119-132.

Blinder, A. S., Ehrmann, M., Fratzscher, M., De Haan, J., & Jansen, D. J. (2008). Central bank communication and monetary policy: A survey of theory and evidence. *Journal of Economic Literature*, 46(4), 910-45.

Bubeck, J., Habib, M. M., & Manganelli, S. (2018). The portfolio of Euro area fund investors and ECB monetary policy announcements. *Journal of International Money and Finance*, 89, 103-126.

Campbell, J. Y., & Ammer, J. (1993). What moves the stock and bond markets? A variance decomposition for long-term asset returns. *The journal of finance*, 48(1), 3-37.

Cappiello, L., Engle, R.F., & Sheppard, K. (2006). Asymmetric dynamics in the correlations of global equity and bond returns. *Journal of Financial Econometrics,* 4(4), 537-572.

Cecioni, M., Ferrero, G., & Secchi, A. (2011). Unconventional monetary policy in theory and in practice. Occasional paper No. 102, *Economic Research and International Relations* Area ,Bank of Italy, Rome, Italy. Available at:https://www.bancaditalia.it/pubblicazioni/ qef/20110102/index.html?com.dotmarketing.htmlpage.language=1.

Cenedese, G., & Elard, I. (2018). Unconventional monetary policy and the portfolio choice of international mutual funds. *Workin Paper* No. 705, Bank of England, London, UK. Available https://www.bankofengland.co.uk/working-paper/2018/unconventional-monetary-policy-and-the-portfolio-choice-of-international-mutual-funds.

Chebbi, T. (2019). What does unconventional monetary policy do to stock markets in the Euro area? International *Journal of Finance & Economics*, 24(1), 391-411.

Chen, Q., Filardo, A. J., He, D., & Zhu, F. (2013). International spillovers of central bank balance sheet policies. Working Paper No.66, Basel, Switzerland, Bank for International Settlements. https://www.bis.org/publ/bppdf/bispap66p.pdf.

Chiang, T. C., Li, J., & Yang, S. Y. (2015). Dynamic stock-bond return correlations and financial market uncertainty. *Review of Quantitative Finance and Accounting,* 45(1), 59-88.

Chodorow-Reich, G.(2014). Effects of unconventional monetary policy on financial institutions., *Working paper* No.2023.National Bureau of Economic Research, Massachusetts, U.S.A Available at: https://www.nber.org/papers/w20230.

Chortareas, G., Karanasos, M., & Noikokyris, E. (2019). Quantitative easing and the UK stock market: does the Bank of England information dissemination strategy matter? *Economic Inquiry,* 57(1), 569-583.

Christensen, J. H., & Rudebusch, G. D. (2012). The response of interest rates to US and UK quantitative easing. *The Economic Journal*, 122(564), 385-414.

Chung, H., Laforte, J. P., Reifschneider, D., & Williams, J. C. (2012). Have we underestimated the probability of hitting the zero lower bound? *Journal of Money, Credit and Banking*, 44(2), 47-48.

Connolly, R., Stivers, C., & Sun, L. (2005). Stock market uncertainty and the stock-bond return relation. *Journal of Financial and Quantitative Analysis*, 40(1), 161-194.

Connolly, R. A., Stivers, C., & Sun, L. (2007). The commonality in the time-variation of stock–stock and stock-bond return comovements. *Journal of Financial Markets*, 10(2), 192-218.

Cúrdia, V. & Woodford, M., (2010).Conventional and unconventional monetary policy. *Federal Reserve Bank of St. Louis Review*, 92(4), 229-264.

Cox, J. C., Ingersoll Jr, J. E., & Ross, S. A. (2005). A theory of the term structure of interest rates. *In Theory of Valuation*, 129-164.

Craine, R., & Martin, V. L. (2008). International monetary policy surprise spillovers. *Journal of International Economics* 75, 180-196.

d'Addona, S., & Kind, A. H. (2006). International stock-bond correlations in a simple affine asset pricing model. *Journal of Banking & Finance*, 30(10), 2747-2765.

D’Amico, S., & Farka, M. (2011). The Fed and the stock market: An identification based on intraday futures data. *Journal of Business & Economic Statistics*, 29(1), 126-137.

D’Amico, S., & King, T. B. (2013). Flow and stock effects of large-scale treasury purchases: Evidence on the importance of local supply. *Journal of Financial Economics*, 108(2), 425-448.

D'Amico, S., & King, T. B. (2015). What does anticipated monetary policy do? *Working paper* No. 2015-10, Federal Reserve Bank of Chicago, Chicago, U.S.A. Available at: https://www.chicagofed.org/publications/working-papers/2015/wp2015-10

David, A., & Veronesi, P. (2013). What ties return volatilities to price valuations and fundamentals? *Journal of Political Economy*, 121(4), 682-746.

De Santis, R. A., & Sarno, L. (2008). Assessing the benefits of international portfolio diversification in bonds and stocks. *Working Paper*, No. 883, European Central Bank (ECB), Frankfurt, Germany. Available at: https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp883

Dimic, N., Kiviaho, J., Piljak, V., & Äijö, J. (2016). Impact of financial market uncertainty and macroeconomic factors on stock-bond correlation in emerging markets. *Research in International Business and Finance,* 36, 41-51.

Eggertsson, G. & Woodford,M (2003) "Zero bound on interest rates and optimal monetary policy." *Brookings Papers on Economic Activity*, vol. 2003 no. 1, 2003, pp. 139-233. Project MUSE, doi:10.1353/eca.2003.0010

Ehrmann, M., Fratzscher, M., & Rigobon, R. (2011). Stocks, bonds, money markets and exchange rates: Measuring international financial transmission. Journal of Applied Econometrics, 26(6), 948-974.

Ehrmann, M., & Fratzscher, M. (2009). Global financial transmission of monetary policy shocks. *Oxford Bulletin of Economics and Statistics*, 71(6), 739-759.

Ellison, M., & Tischbirek, A. (2014). Unconventional government debt purchases as a supplement to conventional monetary policy. *Journal of Economic Dynamics and Control,* 43, 199-217.

Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. Econometrica: *Journal of the Econometric* Society, 987-1007.

Engle, R. (2002). Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics,* 20(3), 339-350.

Eksi, O., & Tas, B. K. O. (2017). Unconventional monetary policy and the stock market's reaction to Federal Reserve policy actions. *The North American Journal of Economics and Finance,* 40, 136-147.

Eser, F., & Schwaab, B. (2016). Evaluating the impact of unconventional monetary policy measures: Empirical evidence from the ECB′s securities markets programme. *Journal of Financial Economics*, 119(1), 147-167.

Fassas, A. P., & Papadamou, S. (2018). Unconventional monetary policy announcements and risk aversion: evidence from the US and European equity markets. *The European Journal of Finance,* 24(18), 1885-1901.

Fattouh, B., Scaramozzino, P., & Harris, L. (2005). Capital structure in South Korea: A quantile regression approach. *Journal of Development Economics*, 76(1), 231-250.

Fang, L., Yu, H., & Li, L. (2017). The effect of economic policy uncertainty on the long-term correlation between US stock and bond markets. *Economic Modelling*, 66, 139-145.

Fausch, J., & Sigonius, M. (2018). The impact of ECB monetary policy surprises on the German stock market. *Journal of Macroeconomics*, 55, 46-63.

Ferrero, G., & Secchi, A. (2009). The announcement of monetary policy intentions. Working Paper No. 720, *Economic Research and International Relations* Area, Bank of Italy, Rome, Italy. https://www.bancaditalia.it/pubblicazioni/temi-discussione/2009/2009-0720/en_tema_720.pdf

Ferrero, G., & Secchi, A. (2010). Central bank's macroeconomic projections and learning. Working paper No.782, *Economic Research and International*

Relations Area, Bank of Italy, Rome, Italy .https://www.bancaditalia.it/pubblicazioni/temi-discussione/2010/2010-

Flageollet, A., Bahaji, H. (2016). Monetary policy and risk-based asset allocation. Open *Economies Review*, 27(5), 851-870.

Fratzscher, M., Lo Duca, M., & Straub, R. (2018). On the international spillovers of US quantitative easing. *The Economic Journal*, 128(608), 330-377.

Gagnon, J., Raskin, M., Remache, J., & Sack, B. (2011). The financial market effects of the Federal Reserve's large-scale asset purchases. *International Journal of Central Banking*, 7(1), 3-43.

Gagnon, J., Raskin, M., Remache, J., & Sack, B. P. (2010). Large-scale asset purchases by the Federal Reserve: Did they work? *Working paper* No.441, Federal Reserve Bank of New York, New York, U.S.A. Available at: https://www.newyorkfed.org/research/staff_reports/sr441.html

Geraats, P. M. (2014). Monetary Policy Transparency. The Oxford Handbook of Economic and Institutional Transparency, ed. by J. Forssbck and L. Oxelheim, Oxford University Press, chap. 3.

Gertler, M., & Karadi, P. (2011). A model of unconventional monetary policy. Journal of monetary Economics, 58(1), 17-34.

Glick, R., & Leduc, S. (2013). The effects of unconventional and conventional US monetary policy on the dollar. Federal Reserve Bank of San Francisco, working paper No.2013-11, San Francisco, U.S.A. https://www.frbsf.org/economic-research/files/wp2013-11.pdf

Gilchrist, S., Yue, V. Z., & Zakrajsek, E. (2018). US monetary policy and international bond. *Working paper* No.2018-014, Board of Governors of the Federal Reserve System, Washington, U.S.A. Available at: https://www.federalreserve.gov/econres/feds/files/2018014pap.pdf.

Goldstein, I., Witmer, J., & Yang, J. (2018). Following the Money: Evidence for the portfolio balance channel of quantitative easing. *Working paper* No.18-33, Bank of Canada, Ottawa, Canada. https://www.bankofcanada.ca/wp-content/uploads/2018/07/swp2018-33.pdf

Greenwood, R., & Vayanos, D. (2010). Price pressure in the government bond market. *American Economic Review,* 100(2), 585-90.

Gurkaynak, R. S., Sack, B. P., & Swanson, E. T. (2005). Do actions speak louder than words? The response of asset prices to monetary policy actions and statements. *International Journal of Central Banking,* 1(1), 55-93.

Haldane, A., Roberts-Sklar, M., Young, C., & Wieladek, T. (2016). QE: the story so far. *Working paper* No.426, Bank of England, London, UK. Available at: https://www.bankofengland.co.uk/working-paper/2016/qe-the-story-so-far.

Harrison, R. (2011). Asset purchase policies and portfolio balance effects: A DSGE analysis, in Interest Rates, Prices and Liquidity: Lessons from the Financial Crisis, ed. by J. S. Chadha and S. Holly, *Cambridge University Press, Macroeconomic Policy Making, chap*.5, 177-143.

Ohmi, H., & Okimoto, T. (2016). Trends in stock-bond correlations. *Applied Economics*, 48(6), 536-552.

Hamilton, J. D., & Wu, J. C. (2012). The effectiveness of alternative monetary policy tools in a zero lower bound environment. *Journal of Money, Credit and Banking*, 44, 3-46.

Hausman, J., & Wongswan, J. (2011). Global asset prices and FOMC announcements. *Journal of International Money and Finance,* 30(3), 547-571.

He, Z., & Krishnamurthy, A. (2013). Intermediary asset pricing. *American Economic Review,* 103(2), 732-70.

Heider, F., Hoerova, M., & Holthausen, C. (2009). Liquidity hoarding and interbank market spreads: The role of counterparty risk. Working paper No.1126, *European central Bank*, Frankfort, Germany, Available at: https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp1126.pdf

Hughes, M. P., & Rogers, K. (2016). Zero lower bound monetary policy's effect on financial asset's correlations. *International Advances in Economic Research*, 22(2), 151-170.

Ilmanen, A. (2003). Stock-bond correlations. *The Journal of Fixed Income*, 13(2), 55-66.

Jammazi, R., Tiwari, A. K., Ferrer, R., & Moya, P. (2015). Time-varying dependence between stock and government bond returns: International evidence with dynamic copulas. *The North American Journal of Economics and Finance,* 33, 74-93.

Janus, J. (2016). The transmission mechanism of unconventional monetary policy. *Oeconomia Copernicana,* 7(1), 7-21.

Jawadi, F., Sousa, R. M., & Traverso, R. (2017). On the macroeconomic and wealth effects of unconventional monetary policy. *Macroeconomic Dynamics*, 21(5), 1189-1204.

John, S., Roberts-Sklar, M., & Weeken, O. (2012). The Bank of England's special liquidity scheme. *Bank of England Quarterly Bulletin*, 25(1), 57-66.

Joyce, M., Lasaosa, A., Stevens, I., & Tong, M. (2011). The financial market impact of quantitative easing in the United Kingdom. *International Journal of Central Banking,* 7(3), 113-161.

Joyce, M., Liu, Z., & Tonks, I. (2014). Institutional investor portfolio allocation, quantitative easing and the global financial crisis. *Working paper* No.501, Bank of England, London, UK. https://www.bankofengland.co.uk/working-paper/2014/institutional-investor-portfolio-allocation-quantitative-easing-and-the-global-financial-crisis

Joyce, M. A., & Tong, M. (2012). QE and the gilt market: A disaggregated analysis. *The Economic Journal*, 122(564), 348-384.

Joyce, M., Miles, D., Scott, A., & Vayanos, D. (2012). Quantitative easing and unconventional monetary policy–an introduction. *The Economic Journal*, 122(564), 271-288.

Kettemann, A., & Krogstrup, S. (2014). Portfolio balance effects of the Swiss National Bank's bond purchase program. *Journal of Macroeconomics*, 40, 132-149.

Kiley, Michael T. (2014). The response of equity prices to movements in longterm interest rates associated with monetary policy statements: Before and after the zero lower bound. *Journal of Money, Credit and Banking* 46 (5): 1057-1071.

Kim, D. H., & Wright, J. H. (2005). An arbitrage-free three-factor term structure model and the recent behaviour of long-term yields and distant-horizon forward rates. *Finance and Economics Discussion Series* 2005-33, Board of Governors of the Federal Reserve System. Available at: https://www.federalreserve.gov/pubs/feds/2005/200533/200533abs.html

Kim, S. J., Moshirian, F., & Wu, E. (2006). Evolution of international stock and bond market integration: Influence of the European Monetary Union. *Journal of Banking & Finance*, 30(5), 1507-1534.

Koenker, R., & Bassett, G., Jr. (1978). Regression quantiles. Econometrica, 46(1), 33-50.

Koenker, R., & Bassett Jr, G. (1982). Robust tests for heteroscedasticity based on regression quantiles. Econometrica: *Journal of the Econometric Society*, 43-61.

Koenker, R., & Hallock, K. F. (2001). Quantile regression. *Journal of Economic Perspectives*, 15(4), 143–156.

Kolluri, B., Wahab, S., & Wahab, M. (2015). An examination of co-movements of India's stock and government bond markets. *Journal of Asian Economics*, 41, 39-56.

Kose, A., Lakatos, C., Ohnsorge, F. L., & Stocker, M. (2017). The global role of the US economy: Linkages, policies, and spillovers. *Working Paper* No. 7962, World Bank, Washington, U.S.A. Available at: https://openknowledge.worldbank.org/handle/10986/26021

Krishnamurthy, A., & Vissing-Jorgensen, A.(2011). The effects of quantitative easing on interest rates: Channels and implications for policy, *working paper* No. 17555, National Bureau of Economic Research, Massachusetts, U.S.A. Available at: https://www.nber.org/papers/w17555.

Kryzanowski, L., Zhang, J., & Zhong, R. (2017). Cross-financial-market correlations and quantitative easing. *Finance Research Letters*, 20, 13-21.

Klyuev, M. V., De Imus, P., & Srinivasan, M. K. (2009). Unconventional choices for unconventional times credit and quantitative easing in advanced economies (No. 2009-2027). *International Monetary Fund*.

Kurov, A. (2010). Investor sentiment and the stock market's reaction to monetary policy. *Journal of Banking & Finance,* 34(1), 139-149.

Lee, H., & Cho, S. M. (2017). What drives dynamic co-movements of stock markets in the Pacific Basin region?: A quantile regression approach. *International Review of Economics & Finance*, 51, 314-327.

Lenza, M., Pill, H., & Reichlin, L. (2010). Monetary policy in exceptional times. *Economic Policy,* 25(62), 295-339.

Lloyd, S. P. (2017). Unconventional monetary policy and the interest rate channel: Signaling and portfolio rebalancing. *Working Papers* in Economics No.1735, Faculty of Economics, University of Cambridge Cambridge,UK., Available at: https://www.inet.econ.cam.ac.uk/working-paper-pdfs/wp1715.pdf

Li, L. (2004). Macroeconomic factors and the correlation of stock and bond returns, in Proceeding of the 2004 *American Finance Association Meeting*.

Li, X. M., Zhang, B., & Gao, R. (2015). Economic policy uncertainty shocks and stock-bond correlations: Evidence from the US market. *Economics Letters*, 132, 91-96.

Lutz, C. (2015). The impact of conventional and unconventional monetary policy on investor sentiment. *Journal of Banking & Finance*, 61, 89-105.

Lyócsa, Š., Molnár, P., & Plíhal, T. (2019). Central bank announcements and realized volatility of stock markets in G7 countries. *Journal of International Financial Markets, Institutions and Money*, 58, 117-135.

Marcello, P. (2018). Macroeconomics determinants of the correlation between stocks and bonds. Working papers No. 1198., *Economic Research and International Relations* Area, Bank of Italy, Rome, Italy. Available at: https://www.bancaditalia.it/pubblicazioni/temi-discussione/2018/2018-1198/index.html?com.dotmarketing.htmlpage.language=1.

Modigliani, F., & Sutch, R. (1966). Innovations in interest rate policy. *The American Economic Review,* 56(1/2), 178-197.

Moessner, R. (2015). International spillovers from US forward guidance to equity markets. *Applied Economics*, 47(42), 4549-4560.

Neely, C. J. (2015). The unconventional monetary policy had large international effects. *Journal of Banking & Finance*, 52, 101-111.

Philip, J., & Alexis, J. (2015). The impact of unconventional monetary policy on uncertainty: Evidence from the U.S. and the EMU (*Master thesis, Copenhagen University*). Copenhagen, Denmark. Retrieved from: https://studenttheses.cbs.dk/handle/10417/5745.

Praet, P. (2015). The transmission of recent non-standard measures. Speech at the Joint BoE, ECB, CEPR and CFM *Conference on credit dynamics and the macroeconomy*; London, 11 December 2015. Retrieved from:

https://www.ecb.europa.eu/press/key/date/2015/html/sp151211.en.html

Rogers, J. H., Scotti, C., & Wright, J. H. (2014). Evaluating asset-market effects of unconventional monetary policy: A multi-country review. *Economic Policy*, 29(80), 749-799.

Rose, A. K., & Spiegel, M. M. (2011). Cross-country causes and consequences of the crisis: An update. *European Economic Review*, 55(3), 309-324.

Rudebusch, G. D. (2011). The Fed’s interest rate risk. Federal Reserve Bank of San Francisco, *Economic Letter* No. 2011- 11. Available at: https://www.frbsf.org/economic-research/publications/economic-letter/2011/april/fed-interest-rate-risk/

Shah, I. H., Schmidt-Fischer, F., Malki, I., & Hatfield, R. (2019). A structural break approach to analysing the impact of the QE portfolio balance channel on the US stock market. *International Review of Financial Analysis*.64, 204-220.

Sharpe, T. P., & Watts, M. J. (2013). Unconventional monetary policy in the UK: a modern money critique. *Economic Issues*, 18(2), 41-64.

Shogbuyi, A., & Steeley, J. M. (2017). The effect of quantitative easing on the variance and covariance of the UK and US equity markets. *International Review of Financial Analysis*, 52, 281-291.

Song, D. (2017). Bond market exposures to macroeconomic and monetary policy risks. *Review of Financial Studies,* 30(8), 2761-2817.

Skintzi, V.D. (2019). Determinants of stock-bond market comovement in the Eurozone under model uncertainty. *International Review of Financial Analysis*, 61, 20-28.

Swanson, E. T. (2015). Measuring the effects of unconventional monetary policy on asset prices (No. w21816). *National Bureau of Economic Research*, Massachusetts, U.S.A. Available at: https://www.nber.org/papers/w21816

Tan, J., & Kohli, V. (2011). The effect of Fed's quantitative easing on stock volatility. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2215423

Thornton, D. L. (2013). An evaluation of event-research evidence on the effectiveness of the FOMC's LSAP program: Are the announcement effects identified? *Working paper* No.2013-033B, Federal Reserve Bank of St. Louis, Louis ,U.S.A. Available at: https://research.stlouisfed.org/wp/more/2013-033

Tobin, J. (1958). Liquidity preference as behavior towards risk. *The review of economic studies*, 25(2), 65-86.

Tobin, J. (1969). A general equilibrium approach to monetary theory. *Journal of money, credit and banking*, 1(1), 15-29.

Tillmann, P. (2016). Unconventional monetary policy and the spillovers to emerging markets. *Journal of International Money and Finance*, 66, 136-156.

Vayanos, D., & Vila, J. L. (2009). A preferred-habitat model of the term structure of interest rates.*Working paper* No.15487. National Bureau of Economic Research. Massachusetts, U.S.A. https://www.nber.org/papers/w15487

Viceira, L. M. (2012). Bond risk, bond return volatility, and the term structure of interest rates. *International Journal of Forecasting*, 28(1), 97-117.

United nations conference on trade and development. (2018).Trade and development report. New York and Geneva, United nations. Retrieved from: https://unctad.org/en/PublicationsLibrary/tdr2018_en.pdf

Wallace, N. (1981). A Modigliani-Miller theorem for open market operations. *American Economic Review*, 71(3), 276-274.

Woodford, M. (2012). Methods of policy accommodation at the interest-rate lower bound. *Federal Reserve Bank of Kansas*. Retrieved from: https://www.Kansacityfed.org/publicat/sympos/2012/Woodford_final.pdf

Wright, J. H. (2012). What does monetary policy do at the zero lower bound. *Economic Journal*, 122, 447-466.

Yao, W. (2015). The effectiveness of unconventional monetary policy on risk premium in the interbank market: Evidence from the UK, the US and the EMU (*Doctoral dissertation, University of the West of England*) Bristol, UK.

Yang, J., Zhou, Y., & Wang, Z. (2009). The stock-bond correlation and macroeconomic conditions: One and a half centuries of evidence. *Journal of Banking & Finance*, 33(4), 670-680.

APPENDICES

Appendix A: Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests

Table 6: Unit root test results for stock and bond market returns

	τ_μ (ADF)	τ_T(ADF)	τ(ADF)	$\tau\mu$ (PP)	τ_T (PP)	τ (PP)
Panel A stock returns						
Australia	-43.378***	-43.383***	-43.371***	-43.452***	-43.460***	-43.432***
Canada	-42.060***	-42.081***	-42.047***	-43.455***	-43.728***	-47.303***
France	-42.825***	-42.814***	-42.823***	-43.311***	-43.300***	-43.270***
Germany	-41.271***	-41.259***	-41.227***	-41.300***	-41.287***	-41.244***
Italy	-42.657***	-42.648***	-42.669***	-42.723***	-42.714***	-42.735***
Japan	-44.559***	-44.553***	-44.515***	-44.554***	-44.549***	-44.502***
UK	-41.941***	-41.950***	-41.933***	-42.187***	-42.242***	-42.161***
US	-45.580***	-45.569***	-45.508***	-46.236***	-46.229***	-45.937***
Panel B bond returns						
Australia	-47.121***	-47.115***	-47.123***	-47.688***	-47.678***	-47.654***
Canada	-42.481***	-42.469***	-42.460***	-42.604***	-42.591***	-42.565***
France	-37.048***	-37.148***	-36.973***	-36.807***	-36.803***	-36.75***
Germany	-30.445***	-30.437***	-30.363***	-37.434***	-37.422***	-37.301***
Italy	-29.915***	-29.934***	-37.384***	-37.206***	-37.235***	-37.156***
Japan	-42.063***	-42.051***	-41.963***	-42.094***	-42.082***	-41.982***
UK	-30.900***	-30.892***	-30.866***	-39.918***	-39.907***	-39.843***
US	-43.003***	-42.990***	-43.008***	-43.153***	-43.140***	-43.156***

***, ** and * denote the rejection of the null hypothesis that the series has a unit root at the 1%, 5%, and 10% levels respectively for ADF and PP tests. τ_μ is to tests equation with a drift and without trend; τ_T is with drift and trend; τ is without drift and trend.

Appendix B: DCC-GARCH model results between US stock markets and other advanced countries bond markets

Table 7: Estimation results from the DCC-GARCH between Australia bond and US stock markets

	Stock	bond
Mean equation		
χ	0.000***	0.000
ψ	-0.987***	0.757***
γ	-0.053	0.072*
w	0.932***	-0.862***
Variance equation		
ϕ	0.026***	0.377
α	0.105***	0.053***
B	0.870***	0.934***
Univariate diagnostic on standardized residuals		
Q-statistics (5)	2.218	4.442
Q-statistics (10)	6.738	5.849
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	8.002	15.913
Q-statistics (10)	10.332	16.458
Multivariate diagnostics on standardized residuals		
Hosking (5)	124.307	
Hosking (10)	136.332	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	59.991	
Hosking (10)	71.468	
DCC parameters		
ρ	-0.113***	
a	0.017***	
b	0.944***	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 8: Estimation results from the DCC-GARCH between Canada bond and US stock markets

	Stock	bond
Mean equation		
χ	0.000***	0.000
ψ	-0.987***	0.946***
γ	-0.053	0.005
w	0.932***	-0.951***
Variance equation		
ϕ	0.026***	0.607
α	0.105***	0.065***
B	0.870***	0.893***
Univariate diagnostic on standardized residuals		
Q-statistics (5)	2.218	4.023
Q-statistics (10)	6.738	7.747
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	8.002	0.968
Q-statistics (10)	10.332	7.169
Multivariate diagnostics on standardized residuals		
Hosking (5)	19.379	
Hosking (10)	38.586	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	16.271	
Hosking (10)	32.466	
DCC parameters		
ρ	-0.421***	
a	0.030***	
b	0.952***	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 9: Estimation results from the DCC-GARCH between France bond and US stock markets

	Stock	bond
Mean equation		
χ	0.000***	0.000***
ψ	-0.987***	-0.863***
γ	-0.053	0.108***
w	0.932***	0.980***
Variance equation		
ϕ	0.026***	0.364**
α	0.105***	0.062***
B	0.870***	0.909***
Univariate diagnostic on standardized residuals		
Q-statistics (5)	2.218	8.897
Q-statistics (10)	6.738	13.609
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	8.002	3.595
Q-statistics (10)	10.332	7.344
Multivariate diagnostics on standardized residuals		
Hosking (5)	20.345	
Hosking (10)	40.534	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	39.481	
Hosking (10)	49.870	
DCC parameters		
ρ	-0.163***	
a	0.041***	
b	0.933***	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 10: Estimation results from the DCC-GARCH between Germany bond and US stock markets

	Stock	bond
Mean equation		
χ	0.000***	0.020***
ψ	-0.987***	0.213
γ	-0.053	-0.083**
w	0.932***	-0.110
Variance equation		
ϕ	0.026***	0.002*
α	0.105***	0.047***
B	0.870***	0.936***
Univariate diagnostic on standardized residuals		
Q-statistics (5)	2.218	0.896
Q-statistics (10)	6.738	5.744
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	8.002	3.525
Q-statistics (10)	10.332	4.911
Multivariate diagnostics on standardized residuals		
Hosking (5)	19.997	
Hosking (10)	39.704	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	32.923	
Hosking (10)	39.704	
DCC parameters		
ρ	-0.300***	
a	0.022***	
b	0.957***	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 11: Estimation results from the DCC-GARCH between Italy bond and US stock markets

	Stock	bond
Mean equation		
χ	0.000***	0.000***
ψ	-0.987***	0.128
γ	-0.053	-0.112***
w	0.932***	-0.022
Variance equation		
ϕ	0.026***	0.285**
α	0.105***	0.110***
B	0.870***	0.886***
Univariate diagnostic on standardized residuals		
Q-statistics (5)	2.218	4.116
Q-statistics (10)	6.738	11.944
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	8.002	2.191
Q-statistics (10)	10.332	7.844
Multivariate diagnostics on standardized residuals		
Hosking (5)	27.719	
Hosking (10)	51.121	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	64.517	
Hosking (10)	129.118	
DCC parameters		
ρ	0.128***	
a	0.024***	
b	0.961***	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 12: Estimation results from the DCC-GARCH between Japan bond and US stock markets

	Stock	bond
Mean equation		
χ	0.000^{***}	0.000^{***}
ψ	-0.987^{***}	-0.884^{***}
γ	-0.053	0.009
w	0.932^{***}	0.882
Variance equation		
ϕ	0.026^{***}	0.027^{***}
α	0.105^{***}	0.077^{***}
B	0.870^{***}	0.919^{***}
Univariate diagnostic on standardized residuals		
Q-statistics (5)	2.218	4.577
Q-statistics (10)	6.738	7.569
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	8.002	6.336
Q-statistics (10)	10.332	8.898
Multivariate diagnostics on standardized residuals		
Hosking (5)	81.216	
Hosking (10)	99.736	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	43.647	
Hosking (10)	56.209	
DCC parameters		
ρ	-0.040	
a	0.000	
b	0.846	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 13: Estimation results from the DCC-GARCH between UK bond and US stock markets

	Stock	bond
Mean equation		
χ	0.000***	0.000
ψ	-0.987***	0.719**
γ	-0.053	-0.065**
w	0.932***	-0.683*
Variance equation		
ϕ	0.026***	0.286**
α	0.105***	0.030***
B	0.870***	0.954***
Univariate diagnostic on standardized residuals		
Q-statistics (5)	2.218	11.562
Q-statistics (10)	6.738	26.791
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	8.002	3.902
Q-statistics (10)	10.332	8.226
Multivariate diagnostics on standardized residuals		
Hosking (5)	34.092	
Hosking (10)	70.072	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	93.399	
Hosking (10)	69.014	
DCC parameters		
ρ	-0.303***	
a	0.020	
b	0.958	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 14: Estimation results from the DCC-GARCH between US bond and US stock markets

	Stock	bond
Mean equation		
χ	0.000	0.000
ψ	-0.860***	0.909***
γ	-0.023	-0.005
w	0.861***	-0.922***
Variance equation		
ϕ	0.023**	0.201*
α	0.100***	0.043***
B	0.880***	0.944***
Univariate diagnostic on standardized residuals		
Q-statistics (5)	5.779	4.725
Q-statistics (10)	10.519	9.422
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	4.660	2.275
Q-statistics (10)	5.026	2.967
Multivariate diagnostics on standardized residuals		
Hosking (5)	17.863	
Hosking (10)	35.120	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	15.790	
Hosking (10)	24.752	
DCC parameters		
ρ	-0.459***	
a	0.031***	
b	0.948***	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Appendix C: DCC-GARCH model results between US stock markets and other advanced countries bond markets.

Table 15: Estimation results from the DCC-GARCH between Australia stock and US bond markets

	Stock	bond
Mean equation		
χ	0.000	0.000
ψ	0.010**	0.909***
γ	0.027	-0.005
w	0.028	-0.922***
Variance equation		
ϕ	0.013	0.201*
α	0.070***	0.043***
B	0.916***	0.944***
Univariate diagnostic on standardized residuals		
Q-statistics (5)	4.185	4.725
Q-statistics (10)	8.672	9.422
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	5.518	2.275
Q-statistics (10)	11.623	2.967
Multivariate diagnostics on standardized residuals		
Hosking (5)	86.631	
Hosking (10)	99.614	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	53.191	
Hosking (10)	70.307	
DCC parameters		
ρ	-0.070***	
a	0.009***	
b	0.973***	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 16: Estimation results from DCC-GARCH between Canada stock and US bond markets

	Stock	bond
Mean equation		
χ	0.000*	0.000
ψ	-0.743***	0.909***
γ	0.037	-0.005
w	0.778***	-0.922***
Variance equation		
ϕ	0.009**	0.201*
α	0.082***	0.043***
B	0.907***	0.944***
Univariate diagnostic on standardized residuals		
Q-statistics (5)	8.110	4.725
Q-statistics (10)	10.236	9.422
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	4.220	2.275
Q-statistics (10)	9.673	2.967
Multivariate diagnostics on standardized residuals		
Hosking (5)	29.889	
Hosking (10)	40.983	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	16.262	
Hosking (10)	30.896	
DCC parameters		
ρ	-0.340***	
a	0.022***	
b	0.952***	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 17: Estimation results from DCC-GARCH between France stock and US bond markets

	Stock	bond
Mean equation		
χ	0.000**	0.000
ψ	-0.928***	0.909***
γ	-0.037	-0.005
w	-0.893***	-0.922***
Variance equation		
ϕ	0.043**	0.201*
α	0.087***	0.043***
B	0.891***	0.944***
Univariate diagnostic on standardized residuals		
Q-statistics (5)	4.630	4.725
Q-statistics (10)	11.116	9.422
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	1.101	2.275
Q-statistics (10)	3.396	2.967
Multivariate diagnostics on standardized residuals		
Hosking (5)	20.435	
Hosking (10)	63.973	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	34.216	
Hosking (10)	57.814	
DCC parameters		
ρ	-0.394***	
a	0.024***	
b	0.926***	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 18: Estimation results from DCC-GARCH between Germany stock and US bond markets

	Stock	bond
Mean equation		
χ	0.000^{**}	0.000
ψ	-0.904^{***}	0.909^{***}
γ	-0.007	-0.005
w	-0.910^{***}	-0.922^{***}
Variance equation		
ϕ	0.026^{**}	0.201^{*}
α	0.075^{***}	0.043^{***}
B	0.910^{***}	0.944^{***}
Univariate diagnostic on standardized residuals		
Q-statistics (5)	3.918	4.725
Q-statistics (10)	8.803	9.422
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	2.281	2.275
Q-statistics (10)	4.247	2.967
Multivariate diagnostics on standardized residuals		
Hosking (5)	82.226	
Hosking (10)	219.129	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	91.617	
Hosking (10)	209.950	
DCC parameters		
ρ	-0.379^{***}	
a	0.019^{***}	
b	0.965^{***}	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 19: Estimation results from DCC-GARCH between Italy stock and US bond markets

	Stock	bond
Mean equation		
χ	0.045	0.000
ψ	0.736^{***}	0.909^{***}
γ	0.011	-0.005
w	-0.733^{***}	-0.922^{***}
Variance equation		
ϕ	0.066^{***}	0.201^{*}
α	0.075^{***}	0.043^{***}
B	0.900^{***}	0.944^{***}
Univariate diagnostic on standardized residuals		
Q-statistics (5)	2.218	4.725
Q-statistics (10)	6.738	9.422
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	8.002	2.275
Q-statistics (10)	10.332	2.967
Multivariate diagnostics on standardized residuals		
Hosking (5)	86.084	
Hosking (10)	231.683	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	94.022	
Hosking (10)	200.475	
DCC parameters		
ρ	-0.343^{***}	
a	0.022^{***}	
b	0.962^{***}	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 20: Estimation results from DCC-GARCH between Japan stock and US bond markets

	Stock	bond
Mean equation		
χ	0.000	0.000
ψ	0.174	0.909***
γ	0.028	-0.005
w	-0.206	-0.922***
Variance equation		
ϕ	0.074***	0.201*
α	0.108***	0.043***
B	0.857***	0.944***
Univariate diagnostic on standardized residuals		
Q-statistics (5)	1.171	4.725
Q-statistics (10)	3.797	9.422
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	5.817	2.275
Q-statistics (10)	7.318	2.967
Multivariate diagnostics on standardized residuals		
Hosking (5)	200.114***	
Hosking (10)	216.339***	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	47.796***	
Hosking (10)	61.608***	
DCC parameters		
ρ	-0.099***	
a	0.000	
b	0.045	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively

Table 21: Estimation results from DCC-GARCH between UK stock and US bond markets

	Stock	bond
Mean equation		
χ	0.000	0.000
ψ	-0.860***	0.909***
γ	-0.023	-0.005
w	0.861***	-0.922***
Variance equation		
ϕ	0.023**	0.201*
α	0.100***	0.043***
B	0.880***	0.944***
Univariate diagnostic on standardized residuals		
Q-statistics (5)	0.920	4.725
Q-statistics (10)	0.609	9.422
Univariate diagnostic on squared standardized residuals		
Q-statistics (5)	3.983	2.275
Q-statistics (10)	5.319	2.967
Multivariate diagnostics on standardized residuals		
Hosking (5)	28.087	
Hosking (10)	55.851	
Multivariate diagnostics on squared standardized residuals		
Hosking (5)	20.396	
Hosking (10)	59.783	
DCC parameters		
ρ	-0.371***	
a	0.051***	
b	0.946***	

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% levels, respectively.

Appendix D: Generating the conditional variances of stock and bond markets

I used the ARMA (1,1) GARCH(1,1) model to generate the conditional variances of stock and bond markets which used as a proxy for stock and bond markets volatility following Chiang, Li, and Yung Yang,(2015).The model is estimated as follows:

Mean equation:

$$R_{it} = \chi_{i,t} + \psi_i R_{i,t-1} + \omega_i M_{i,t-1} + \varepsilon_{i,t}$$

$$\varepsilon_{i,t} = \eta_t \sqrt{h_{i,t}} \quad \eta_{i,t} \sim iid\ (0,1)$$

Where: R_{it} is the return on asset i at time t, $\chi_{i,t}$ is the intercept for asset i at time t $R_{i,t-1}$ is one lagged period of returns on asset i, $M_{i,t-1}$ is one lagged period of return residual on asset i, $\varepsilon_{i,t}$ is the error term of asset i at time t, and i stands for stock and bond returns.

Variance equation:

$$h_{i,t} = \phi_{i,t} + \alpha_i \varepsilon^2_{i,t-1} + B_i h^2_{i,t-1}$$

Where: $h_{i,t}$ is the conditional variance of asset i at time t, $\phi_{i,t}$ is the intercept for asset i at time t, $\varepsilon^2_{i,t-1}$ is the one lagged period of squared residual of asset i that represents, $h^2_{i,t-1}$ is the one lagged period of conditional variance of asset$i$.

Appendix E: Quantile regression results for the effect of exchange rate on the dynamic correlation between US stock and bond markets

Table 22: Quantile regression results for the effect of exchange rate on the dynamic correlation between US stock and bond markets

Quantile	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
A	-1.493**	-0.993**	-0.783**	-0.448**	-0.205*	-0.223*	-0.270*	-0.167	-0.310
$\rho_{SB,t-1}$	0.870***	0.908***	0.936***	0.953***	0.960***	0.970***	0.978***	0.982***	1.000***
POR	-1.358***	-1.111***	-0.865***	-0.497***	-0.224*	-0.262*	-0.291*	-0.247	-0.395
EIB	0.593***	0.482***	0.371***	0.213**	0.097**	0.114**	0.126*	0.105	0.169
CVS	-0.073***	-0.038***	-0.020***	-0.011***	-0.006**	-0.006**	-0.005*	-0.005	-0.004
CVB	0.027***	0.020***	0.010**	0.006**	0.005**	0.007**	0.006*	0.003	0.000
$Q1$	-0.049**	-0.054**	-0.033**	-0.017**	-0.007**	-0.012*	-0.016	-0.019	-0.025
$Q2$	-0.030***	-0.049***	-0.033***	-0.020**	-0.008**	-0.012**	-0.012	-0.023	-0.014
$Q3$	0.016	0.013	-0.013**	-0.008	-0.000	-0.003	-0.001	-0.009	-0.017
TPR	0.001	0.038	0.034**	0.028**	0.016	0.021**	0.028**	0.012	0.217*
EXR	0.000	-0.005	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

Appendix F: Quantile regression model results for signaling and portfolio rebalancing channel effects the dynamic correlations between on US bond and other advanced countries' stock markets

Table 23: Quantile regression results for signaling and portfolio rebalancing channel effects on the dynamic correlations between on US bond and Australia stock markets

Quantiles	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
A	-0.190	-0.176	-0.109	-0.071	-0.003	0.037	0.025	0.074	0.209
$Lag1$	0.944***	0.985***	0.955***	0.957***	0.960***	0.951***	0.965***	0.950***	0.942***
POR	-0.020***	-0.019***	-0.021***	-0.022**	-0.001	0.037	0.026	0.070	0.181
EIR	0.084***	0.074***	0.042**	0.027***	0.000	-0.015	-0.009	-0.027	-0.071
$USCVS$	-0.015***	-0.017***	-0.013***	-0.001**	-0.000	0.000	0.003	-0.006**	-0.011**
$USCVB$	0.002	-0.003	0.000	-0.000	-0.000	-0.000	0.000	-0.001	-0.003*
$AUCVS$	-0.021***	-0.022**	-0.025**	-0.023**	-0.000	-0.000	-0.001	-0.003**	-0.005
$AUCVB$	-0.001	-0.000	0.000	0.000	0.000	-0.000	0.000	0.000	0.001
TAP	0.015***	0.007**	0.003**	0.002*	0.002	0.001*	0.002	0.005	0.035*
$Q1$	-0.090**	-0.009**	-0.050***	-0.001	0.000	0.000	-0.003	-0.005	-0.007
$Q2$	-0.011**	-0.014**	-0.012**	-0.080**	0.001	0.001	-0.001	-0.004	-0.001
$Q3$	0.009	0.002	0.001	0.000	0.001	0.001	0.001	-0.006	0.002
EXR	-0.070**	-0.031**	-0.005**	-0.003	-0.003	-0.008	-0.002	0.000	-0.017

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

Table 24: Quantile regression results for signaling and portfolio rebalancing channel effects the dynamic correlations between on US bond and Canada stock markets

Quantiles	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
α	-0.449	-0.490	0.342***	-0.153	-0.091*	-0.102	0.027	0.024	-0.360
$Lag1$	0.965***	0.966***	0.967***	0.976***	0.979***	0.979***	0.974***	0.967***	0.981***
POR	-1.210**	-0.991***	-0.712***	-0.126**	-0.074	-0.078	0.038	-0.034	-0.361
EIR	0.025***	0.023***	0.024***	0.026**	0.031	0.033	-0.013	0.021	0.160
$USCVS$	-0.021***	-0.022***	-0.019**	-0.026**	-0.023	-0.013**	-0.002	-0.003	-0.001
$USCVB$	0.007***	0.008***	0.004**	0.000	0.000	0.000	0.000	0.000	-0.012**
$CACVS$	-0.060**	-0.057***	-0.052**	-0.022**	0.001	0.002	0.000	0.000	0.001
$CACVB$	-0.006**	-0.007***	-0.002**	0.000	0.000	0.000	0.001	0.004	0.015***
TAP	0.017**	0.021**	0.015**	0.009	0.005	0.008	0.019**	0.014	0.045
$Q1$	-0.015***	-0.016**	-0.015***	-0.002	-0.001	-0.004	-0.001	-0.007	-0.018
$Q2$	-0.014**	-0.014**	-0.019***	-0.003	-0.002	-0.006	-0.003	-0.009	-0.016
$Q3$	-0.002	-0.004	-0.003	0.000	0.000	0.000	0.001	0.003	-0.02
EXR	-0.001**	-0.002**	-0.038**	0.002	0.000	0.013	0.000	-0.014	0.052

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

Table 25: Quantile regression results for signaling and portfolio rebalancing channel effects the dynamic correlations between on US bond and France stock markets

Quantiles	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
α	-0.380	-0.377	-0.208	-0.208	-0.074	-0.087	-0.075	-0.065	-0.062
$Lag1$	0.968***	0.972***	0.972***	0.932***	0.969***	0.955***	0.976***	0.966***	0.942***
POR	-0.530***	-0.308***	-0.164**	-0.142**	-0.120*	-0.085	0.076	-0.09	-0.096
EIR	0.013**	0.012***	0.016**	0.015**	0.014**	0.031	0.033	0.041	0.032
$USCVS$	-0.010***	-0.011**	-0.012**	-0.096**	-0.019	-0.012	0.005	0.010	0.0125
$USCVB$	-0.002**	-0.001**	-0.003**	-0.003**	0.002	-0.002*	-0.001**	-0.007	-0.013
$FRCVS$	-0.002***	-0.005***	-0.004**	-0.002**	-0.001**	-0.002**	-0.005**	-0.009**	0.012
FRCVB	0.004	0.005	0.005	0.005	0.004	0.004	0.004	0.006	0.011
TAP	0.017	0.008	0.015	0.016	0.014	0.015	0.012	0.015	0.031
$Q1$	-0.003***	-0.002***	-0.008**	-0.007**	-0.009**	-0.006	-0.005	-0.007	0.000
$Q2$	-0.003***	-0.004***	-0.002**	-0.005**	-0.006**	-0.006*	0.001	0.001	0.001
$Q3$	-0.009	-0.005	-0.006	-0.007	-0.008	-0.009	-0.003	-0.005	-0.007
EXR	-0.024	-0.022	-0.020	-0.018	-0.021	-0.021	0.018	0.014	-0.022

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

Table 26: Quantile regression results for signaling and portfolio rebalancing channel effects the dynamic correlations between on US bond and Germany stock markets

Quantiles	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
A	-1.491	-0.364**	-0.148	-0.108**	-0.026	0.031	-0.004	-0.076	-0.005
$Lag1$	0.863***	0.986***	0.979***	0.982***	0.987***	0.982***	0.984***	0.977***	0.970***
POR	-1.245***	-0.936**	-0.811**	-0.452**	-0.025**	0.027	-0.011	-0.075	-0.013
EIR	0.052***	0.050***	0.054**	0.051***	0.011	-0.010	0.006	0.036	0.013
$USCVS$	-0.089***	-0.088**	-0.076**	-0.064**	0.001	-0.003**	-0.004**	-0.007**	-0.007**
$USCVB$	-0.017***	-0.015**	-0.011**	-0.011**	0.000	-0.001*	-0.002**	-0.003**	-0.007**
$GERCVS$	-0.040***	-0.015**	-0.012**	-0.001	-0.001	-0.002**	-0.003**	-0.005**	-0.001
$GERCVB$	-0.009	-0.001	0.000	0.000	0.000	0.001	0.002*	0.004**	0.005
TAP	0.056**	0.054**	0.053**	0.044**	0.003**	0.005*	0.009**	0.007	0.024
$Q1$	-0.065**	-0.018**	-0.016**	-0.015**	0.000	0.000	0.000	-0.008*	-0.016
$Q2$	-0.086***	-0.019***	-0.007**	-0.004**	0.000	0.001	0.001	-0.002	-0.005
$Q3$	0.004	0.001	-0.001	0.000	0.000	0.001	0.000	0.002	0.003
EXR	0.046	-0.001	-0.008	-0.012*	-0.005	-0.01	-0.006	0.000	0.006

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

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Table 27: Quantile regression results for signaling and portfolio rebalancing channel effects the dynamic correlations between on US bond and Italy stock markets

Quantiles	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
A	-0.246	-0.101	-0.029	-0.021	-0.020	-0.021	-0.021	-0.019	-0.019
$Lag1$	0.965^{***}	0.971^{***}	0.973^{***}	0.977^{***}	0.987^{***}	0.977^{***}	0.985^{***}	0.952^{***}	0.910^{***}
POR	-0.981^{***}	-0.810^{**}	-0.700^{**}	-0.520^{**}	-0.192^{**}	-0.001	-0.001	0.001	0.001
EIR	0.045^{***}	0.041^{**}	0.045^{**}	0.040^{***}	0.039^{***}	0.015	0.014	0.010	0.010
$USCVS$	-0.059^{***}	-0.055^{**}	-0.045^{**}	-0.043^{**}	-0.041^{**}	-0.020	-0.015	-0.015	-0.012
$USCVB$	-0.012^{***}	-0.015^{**}	-0.015^{***}	-0.014^{**}	0.012	0.010	0.008	0.008	0.008
$ITCVS$	-0.019^{***}	-0.014^{***}	-0.012^{***}	-0.011^{**}	-0.004^{*}	0.002	0.001	0.001	0.000
$ITCVB$	0.002^{**}	0.001^{**}	0.001	0.001	0.001	0.002	0.002	0.00.	0.000
TAP	0.009^{**}	0.006^{**}	0.005^{**}	0.001	0.001	0.000	0.000	0.000	0.000
$Q1$	-0.051^{**}	-0.051^{**}	-0.050^{***}	-0.044^{**}	-0.039^{**}	0.030	0.030	0.031	0.031
$Q2$	-0.081^{**}	-0.080^{***}	-0.081^{***}	-0.075^{**}	-0.070^{**}	0.020	0.020	0.025	0.012
$Q3$	0.005	0.005	0.006	0.006	0.007	0.005	0.005	0.004	0.004
EXR	0.023	0.003	-0.005	0.000	0.000	0.000	0.000	0.000	0.000

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

Table 28: Quantile regression results for signaling and portfolio rebalancing channel effects on the dynamic between US bond and UK stock markets

Quantile	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
A	-0.095**	-0.244	-0.142*	-0.099*	-0.082*	-0.090*	-0.088	-0.032	0.126
$Lag1$	0.933***	0.975***	0.977***	0.976***	0.973***	0.973***	0.969***	0.968***	0.957***
POR	-0.960***	-0.753***	-0.500**	-0.220**	-0.080**	-0.092*	-0.095	-0.025	0.109
EIR	0.071***	0.070***	0.072**	0.073**	0.071**	0.030*	0.042	0.015	-0.039
$USCVS$	-0.022	-0.006	-0.001	0.000	0.001	-0.003***	-0.003**	-0.010**	-0.012**
$USCVB$	0.004	-0.002	-0.001	-0.001	-0.001*	-0.002**	-0.002**	-0.004**	-0.012**
$UKCVS$	-0.003	0.002	-0.003	-0.002	-0.002	-0.004***	-0.004**	-0.008**	-0.012**
$UKCVB$	0.007	0.004*	0.002	0.001	0.002	0.002***	0.003***	0.006***	0.014***
TAP	0.013	0.010	0.006	0.004*	0.005**	0.007*	0.015***	0.014	0.039**
$Q1$	-0.012***	-0.015**	-0.042**	-0.053**	-0.022**	-0.013**	0.000	-0.001	-0.001
$Q2$	-0.015***	-0.016***	-0.022**	-0.031**	-0.001	-0.001	-0.001	0.000	-0.004
$Q3$	0.007	-0.005	-0.002	0.000	0.000	-0.001	0.000	0.000	-0.004
EXR	-0.059**	-0.024**	-0.009*	-0.011	-0.008	-0.009	-0.011	0.000	-0.009

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model

Appendix G: Quantile regression model results for signaling and portfolio rebalancing channel effects the dynamic correlations between on US stock and other advanced countries bond markets

Table 29: Quantile regression results for signaling and portfolio rebalancing channel effects on the dynamic between US stock and Australia bond markets

Quantile	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
A	-0.014	0.05	0.041	0.026	0.024	0.055^{**}	0.082	0.104	0.111
$Lag1$	0.921^{***}	0.954^{***}	0.970^{***}	0.977^{***}	0.978^{***}	0.052^{***}	0.977^{***}	0.981^{***}	0.985^{***}
POR	-0.026	0.045	0.036	0.025	0.024	-0.022	0.079	0.103	0.093
EIR	0.012	-0.018	-0.014	-0.010	-0.01	0.000	-0.033	-0.045	-0.038
$USCVS$	-0.009^{***}	-0.003^{***}	0.001^{**}	0.002^{**}	0.000	0.000	-0.000	0.000	0.001
$USCVB$	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.001	0.000
$AUCVS$	-0.002	-0.003^{**}	-0.002^{**}	-0.003^{**}	0.000^{*}	0.000	-0.000	0.000	0.001
$AUCVB$	0.002^{***}	0.000^{**}	0.001^{***}	-0.001	0.000	0.000	0.000	0.000	-0.001
TAP	0.004^{***}	-0.001	0.001	0.001	0.000	0.000	0.000	0.007	0.012
$Q1$	-0.021^{**}	-0.003^{***}	-0.002^{**}	0.001	0.000	0.000	0.002	0.003	0.000
$Q2$	-0.002^{***}	-0.004^{**}	-0.002^{**}	0.001	0.000	0.000	0.000	-0.004	0.000
$Q3$	0.000	0.002	-0.001	0.000	0.000	0.000	0.000	-0.003	0.002
EXR	-0.047^{**}	-0.035^{***}	-0.0165^{*}	-0.026^{**}	-0.004^{**}	-0.005	-0.004	0.008	-0.003

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

Table 30: Quantile regression results for signaling and portfolio rebalancing channel effects on the dynamic between US stock and Canada bond markets

Quantile	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
A	-0.521*	-0.318**	-0.200**	-0.094*	-0.052	-0.051	-0.124	-0.168	-0.144
$Lag1$	0.934***	0.961***	0.965***	0.967***	0.971***	0.970***	0.963***	0.957***	0.960***
POR	-0.499	-0.267	-0.152	-0.065	-0.029	-0.086	-0.114	-0.131	-0.103
EIR	0.209	0.113	0.063	0.027	0.012	0.036	0.049	0.058	0.045
$USCVS$	-0.035***	-0.033***	-0.037**	-0.035**	-0.002	-0.002	-0.002	-0.001	0.007*
$USCVB$	0.010**	0.004**	0.002**	0.001*	0.000	0.000	0.005	0.002	0.001
$CACVS$	-0.018***	-0.020**	-0.021**	-0.019**	-0.019**	0.000	-0.001	-0.001	-0.012
$CACVB$	-0.004	-0.003	0.000	0.000	0.000	0.000	0.001	0.000	0.006
TAP	0.018**	0.012**	0.008**	0.004**	0.003	0.005	0.01	0.025*	0.023
$Q1$	-0.011**	-0.012**	-0.014**	-0.014**	0.000	-0.003	-0.005	-0.012	-0.004
$Q2$	-0.016**	-0.012*	-0.009**	-0.002	0.000	-0.002	-0.004	-0.012	-0.021
$Q3$	0.004	-0.003	-0.004	0.000	0.000	0.000	-0.002	-0.006	-0.016
EXR	-0.057	0.008	0.019	0.002	0.002	0.008	-0.003	0.034	-0.069

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

Table 31: Quantile regression results for signaling and portfolio rebalancing channel effects on the dynamic between US stock and France bond markets

Quantile	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
α	-0.559	-0.283	-0.057	0.000	-0.007	0.068	0.141	0.125	0.247
$Lag1$	0.943***	0.946***	0.960***	0.965***	0.970***	0.968***	0.964***	0.965***	0.954***
POR	-0.468	-0.233	-0.019	0.016	0.005	-0.024	0.131	0.122	0.201
EIR	0.204	0.098	0.006	-0.007	-0.001	0.001	-0.054	-0.051	-0.087
$USCVS$	-0.014**	-0.013**	-0.012**	-0.000	-0.001	-0.001	-0.001	-0.003	-0.010
$USCVB$	0.003***	0.004***	0.002	0.001	0.000	0.000	0.001	0.000	0.000
FRCVS	-0.010**	-0.013***	-0.009***	-0.006***	0.002	-0.004**	-0.005**	-0.006**	-0.009
FRCVB	0.008**	0.004***	0.001	0.001**	0.000	0.001	0.002	0.001	-0.001
TAP	0.006***	0.009**	0.008**	0.005**	0.005**	0.008	0.008	0.009	0.019
$Q1$	-0.018**	-0.006**	-0.003**	-0.005**	0.003	0.006	0.006	0.001	0.008
$Q2$	-0.020**	-0.013**	-0.003**	0.000	0.000	0.002	0.000	-0.005	-0.003
$Q3$	0.001	-0.004	-0.002	0.001	0.001	0.002	0.002	-0.002	-0.002
EXR	0.000	-0.009	-0.002	-0.011	-0.009	-0.024**	-0.025**	-0.007	-0.023

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

Table 32: Quantile regression results for signaling and portfolio rebalancing channel effects on the dynamic between US stock and Germany bond markets

Quantile	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
α	-0.585**	-0.011	-0.018	0.015	0.013	0.001	0.023	0.135	0.243
$Lag1$	0.968***	0.956***	0.963***	0.972***	0.976***	0.977***	0.975***	0.974***	0.967***
POR	-0.516	0.018	0.008	0.029	0.022	0.008	0.016	0.125	0.190
EIR	0.219	-0.009	-0.004	-0.012	-0.008	-0.003	-0.006	-0.51	-0.076
$USCVS$	-0.027**	-0.025***	-0.020**	-0.015**	-0.001**	0.000	0.000	0.002	0.004
$USCVB$	0.007***	0.006**	0.004**	0.002***	0.001	0.001*	0.002	0.002	-0.003
$GERCVS$	-0.004**	-0.006**	-0.005**	-0.004**	-0.003**	-0.002*	-0.002	-0.004	-0.004
$GERCVB$	-0.002	0.001	0.000	0.000	0.000	0.000	-0.001	-0.001	0.002
TAP	0.002	0.000	0.002	0.004	0.002	0.003	0.008	0.011	0.023
$Q1$	-0.013**	-0.015**	-0.013**	-0.010**	0.000	-0.001	0.000	0.000	0.000
$Q2$	-0.017**	-0.008	-0.005**	-0.002**	-0.001	-0.003	-0.003	-0.003	-0.001
$Q3$	-0.002	-0.002	-0.002	-0.002	0.000	-0.002	-0.002	-0.004	-0.002
EXR	-0.010**	-0.011**	-0.095**	-0.087**	-0.007**	0.001	-0.013	-0.012	-0.038

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

Table 33: Quantile regression results for signaling and portfolio rebalancing channel effects on the dynamic between US stock and Italy bond markets

Quantile	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
A	0.231	-0.319	-0.154	-0.142	-0.005	-0.001	-0.235	-0.214	-0.012
$Lag1$	0.965***	0.952***	0.971***	0.975***	0.979***	0.950***	0.977***	0.970***	0.966***
POR	-0.156	0.117	-0.131	-0.041	0.020	0.011	-0.006	0.002	0.002
EIR	0.067	-0.004	0.054	0.032	0.024	0.015	0.004	0.000	0.000
$USCVS$	-0.006**	-0.003***	-0.004***	-0.005***	0.005	0.003	0.004	0.000	0.005
$USCVB$	-0.027***	-0.025**	-0.026***	-0.023**	0.021	0.010	0.012	0.015	0.020
$ITCVS$	-0.094***	-0.092**	-0.087***	-0.085**	-0.073**	-0.010	-0.009	-0.009	0.008
$ITCVB$	0.006	0.003	0.001	0.002	0.001	-0.001	-0.001	-0.010	0.020
TAP	0.008***	0.009**	0.008**	0.007**	0.002	0.000	0.000	0.000	0.000
$Q1$	-0.016**	-0.013***	-0.013**	-0.012**	-0.012**	-0.004	-0.001	-0.001	-0.002
$Q2$	-0.018***	0.016***	-0.013**	-0.010**	-0.008	-0.007	-0.004	-0.002	0.000
$Q3$	0.001	-0.007	0.004	0.002	0.000	0.002	0.001	0.002	0.000
EXR	0.006	0.002	-0.002	-0.001	-0.006	0.000	0.000	0.000	0.000

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

Table 34: Quantile regression results for signaling and portfolio rebalancing channel effects on the dynamic between US stock and UK bond markets

Quantile	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
A	0.876	-0.356	-0.342	-0.321	-0.008	-0.009	-0.342	-0.287	-0.098
$Lag1$	-0.208	-0.108	-0.032	-0.015	0.026	0.015	0.024	0.079	0.029
POR	0.962***	0.966***	0.972***	0.977***	0.978***	0.977***	0.974***	0.973***	0.972***
EIR	-0.218	-0.085	0.029	-0.013	0.018	0.013	0.015	0.065	0.007
$USCVS$	0.094	0.037	-0.012	0.006	-0.007	-0.005	-0.005	-0.020	-0.002
$USCVB$	-0.012	-0.001	0.000	0.001	0.001	0.001	0.002	0.002	0.007
$UKCVS$	-0.009**	-0.009**	-0.007***	-0.003***	-0.002**	-0.002**	-0.003**	-0.004**	-0.005*
$UKCVB$	0.013**	0.007***	0.003***	0.001**	0.000	0.000	0.000	0.000	-0.005
TAP	0.013	0.009**	0.007**	0.004	0.003	0.006***	0.011*	0.016**	0.019**
$Q1$	-0.003**	-0.003**	0.000	0.000	0.000	0.000	0.000	0.002	0.003
$Q2$	-0.006**	-0.007**	-0.004	0.002	-0.008	-0.001	-0.002	-0.002	-0.006
$Q3$	-0.008	-0.005**	-0.004**	-0.002*	-0.001	-0.001	-0.002	-0.003	-0.008
EXR	-0.042	-0.010	-0.020**	-0.011*	-0.015**	-0.012	-0.014	-0.013	-0.008

Note: ***, ** and * denote that the coefficient is statistically significant at the 1%, 5%, and 10% level, respectively, (based on the bootstrapped standard errors) when using the simultaneous regression model.

Appendix H: Wald test results for regressing signaling and portfolio rebalancing channels on the dynamic correlations between US bond and other advanced countries' stock markets

Table 35: Wald test result for regressing signaling and portfolio rebalancing channels on the dynamic between the US bond and Australia stock markets

Quantile	F(12,1742)
0.10;0.20	4.80***
0.20;0.30	5.96***
0.30;0.40	4.77***
0.40;0.50	2.82***
0.50;0.60	1.39
0.60;0.70	2.60***
0.70;0.80	1.99***
0.80;0.90	5.99***
0.10;0.50	6.78***
0.50;0.90	3.36***
0.10;0.90	7.50***

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k: is the number of independent variables, n: is the sample size.

Table 36: Wald test result for regressing signaling and portfolio rebalancing channels on the dynamic between the US bond and Canada stock markets

Quantile	F(12,1742)
0.10;0.20	2.68***
0.20;0.30	2.56**
0.30;0.40	2.04***
0.40;0.50	2.91***
0.50;0.60	1.96**
0.60;0.70	3.36***
0.70;0.80	1.84**
0.80;0.90	3.66***
0.10;0.50	7.82**
0.50;0.90	26.32***
0.10;0.90	2.30***

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k: is the number of independent variables, n: is the sample size.

Table 37: Wald test result for regressing signaling and portfolio rebalancing channels on the dynamic between the US bond and France stock markets

Quantile	F(12,1742)
0.10;0.20	8.24***
0.20;0.30	11.16***
0.30;0.40	2.01**
0.40;0.50	3.30***
0.50;0.60	2.98***
0.60;0.70	3.34***
0.70;0.80	2.54***
0.80;0.90	1.21*
0.10;0.50	13.60**
0.50;0.90	2.74***
0.10;0.90	2.36***

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k: is the number of independent variables, n: is the sample size

Table 38: Wald test result for regressing signaling and portfolio rebalancing channels on the dynamic between the US bond and Germany stock markets

Quantile	F(12,1742)
0.10;0.20	7.70***
0.20;0.30	24.88***
0.30;0.40	5.86***
0.40;0.50	10.94***
0.50;0.60	5.12***
0.60;0.70	3.62***
0.70;0.80	6.62***
0.80;0.90	7.40***
0.10;0.50	51.50**
0.50;0.90	83.87***
0.10;0.90	8.68***

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k: is the number of independent variables, n: is the sample size

Table 39: Wald test result for regressing signaling and portfolio rebalancing channels on the dynamic between the US bond and Italy stock markets

Quantile	F(12,1742)
0.10;0.20	2.02**
0.20;0.30	11.12***
0.30;0.40	4.91***
0.40;0.50	3.69***
0.50;0.60	3.47***
0.60;0.70	3.33***
0.70;0.80	1.05
0.80;0.90	1.26
0.10;0.50	3.65***
0.50;0.90	2.72***
0.10;0.90	2.62***

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k: is the number of independent variables, n: is the sample size

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Table 40: Wald test result for regressing signaling and portfolio rebalancing channels on the dynamic between the US bond and UK stock markets

Quantile	F(12,1742)
0.10;0.20	4.86***
0.20;0.30	5.20***
0.30;0.40	3.12***
0.40;0.50	3.17***
0.50;0.60	1.96**
0.60;0.70	1.35
0.70;0.80	1.29
0.80;0.90	4.25**
0.10;0.50	17.64***
0.50;0.90	18.83**
0.10;0.90	4.91***

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k: is the number of independent variables, n: is the sample size.

Appendix I: Wald test results for regressing signaling and portfolio rebalancing channels on the dynamic correlations between US stock and other advanced countries bond markets.

Table 41: Wald tests for regressing signaling and portfolio rebalancing channels on the dynamic between the US stock and Australia bond markets

Quantile	F(12,1742)
0.10;0.20	1.68*
0.20;0.30	10.26***
0.30;0.40	4.64***
0.40;0.50	4.86***
0.50;0.60	1.07
0.60;0.70	4.57***
0.70;0.80	9.64***
0.80;0.90	2.29***
0.10;0.50	4.60***
0.50;0.90	8.76***
0.10;0.90	4.74***

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k: is the number of independent variables, n: is the sample size.

Table 42: Wald tests for regressing signaling and portfolio rebalancing channels on the dynamic between the US stock and Canada bond markets

Quantile	F(12,1742)
0.10;0.20	3.96***
0.20;0.30	4.67**
0.30;0.40	6.39***
0.40;0.50	2.85***
0.50;0.60	0.57
0.60;0.70	1.61***
0.70;0.80	3.21***
0.80;0.90	1.47***
0.10;0.50	6.91**
0.50;0.90	4.90***
0.10;0.90	3.82***

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k: is the number of independent variables, n: is the sample size.

Table 43: Wald tests for regressing signaling and portfolio rebalancing channels on the dynamic between the US stock and France bond markets

Quantile	F(12,1742)
0.10;0.20	2.60***
0.20;0.30	1.03
0.30;0.40	4.84***
0.40;0.50	1.89**
0.50;0.60	5.54***
0.60;0.70	2.09***
0.70;0.80	2.85***
0.80;0.90	3.09***
0.10;0.50	2.12**
0.50;0.90	3.10***
0.10;0.90	3.30***

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k: is the number of independent variables, n: is the sample size

Table 44: Wald tests for regressing signaling and portfolio rebalancing channels on the dynamic between the US stock and Germany bond markets

Quantile	F(12,1742)
0.10;0.20	1.77***
0.20;0.30	0.66
0.30;0.40	2.01**
0.40;0.50	5.85***
0.50;0.60	1.45*
0.60;0.70	1.68***
0.70;0.80	1.55
0.80;0.90	1.44*
0.10;0.50	7.37**
0.50;0.90	1.78**
0.10;0.90	0.95

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k: is the number of independent variables, n: is the sample size.

Table 45: Wald tests for regressing signaling and portfolio rebalancing channels on the dynamic between the US stock and Italy bond markets

Quantile	F(12,1742)
0.10;0.20	4.21***
0.20;0.30	13.14***
0.30;0.40	4.30***
0.40;0.50	2.42***
0.50;0.60	2.47***
0.60;0.70	17.56***
0.70;0.80	5.70***
0.80;0.90	1.82***
0.10;0.50	5.01***
0.50;0.90	5.24***
0.10;0.90	5.09***

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k: is the number of independent variables, n: is the sample size.

Table 46: Wald tests for regressing signaling and portfolio rebalancing channels on the dynamic between the US stock and UK bond markets

Quantile	F(12,1742)
0.10;0.20	3.36***
0.20;0.30	1.12***
0.30;0.40	4.50***
0.40;0.50	1.53***
0.50;0.60	4.10***
0.60;0.70	3.59***
0.70;0.80	6.87***
0.80;0.90	2.76***
0.10;0.50	3.87***
0.50;0.90	7.11***
0.10;0.90	2.56***

Note: ***, ** and * indicate that the coefficient is significant at the 1%, 5%, and 10% level, respectively. The F-statistics (k, n) are related to the Wald test, where k: is the number of independent variables, n: is the sample size.

Appendix J: Quantile process for independent variables effects on the dynamic correlation between US bond and advanced countries' stock markets

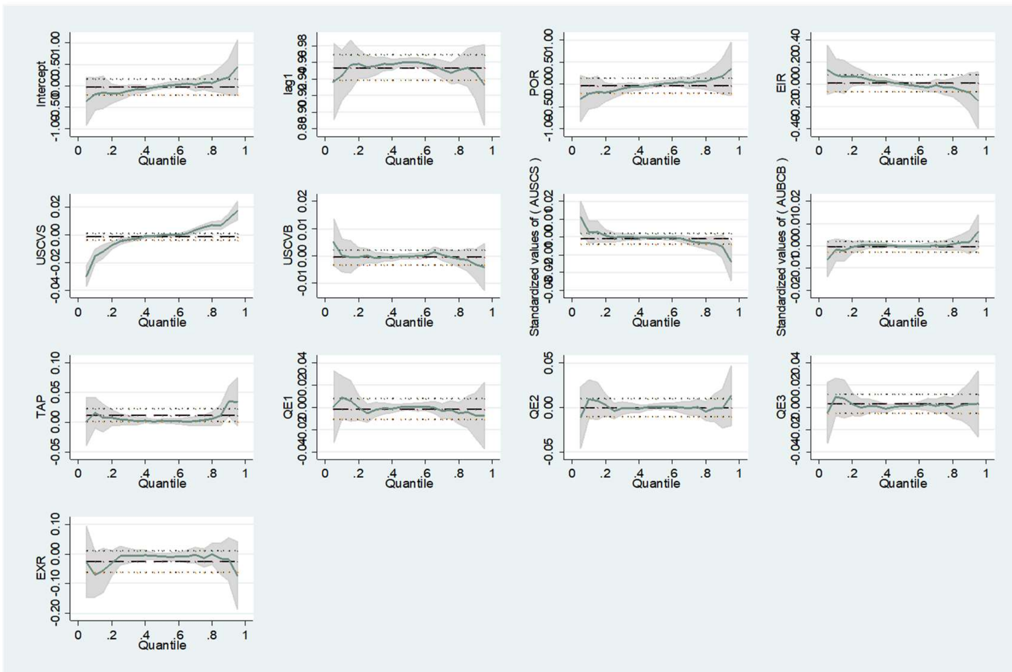

Figure 6: Quantile regression process of independent variable effects on the dynamic correlation between the US bond and Australia stock markets.

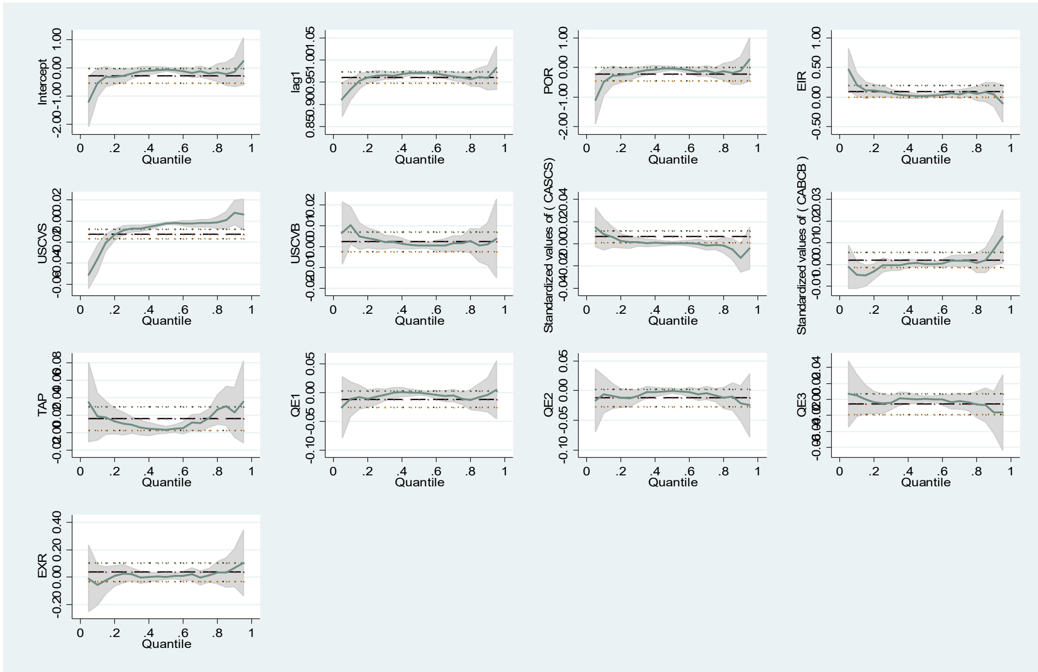

Figure 7: Quantile regression process of independent variables effects on the dynamic correlation between the US bond and Canada stock markets.

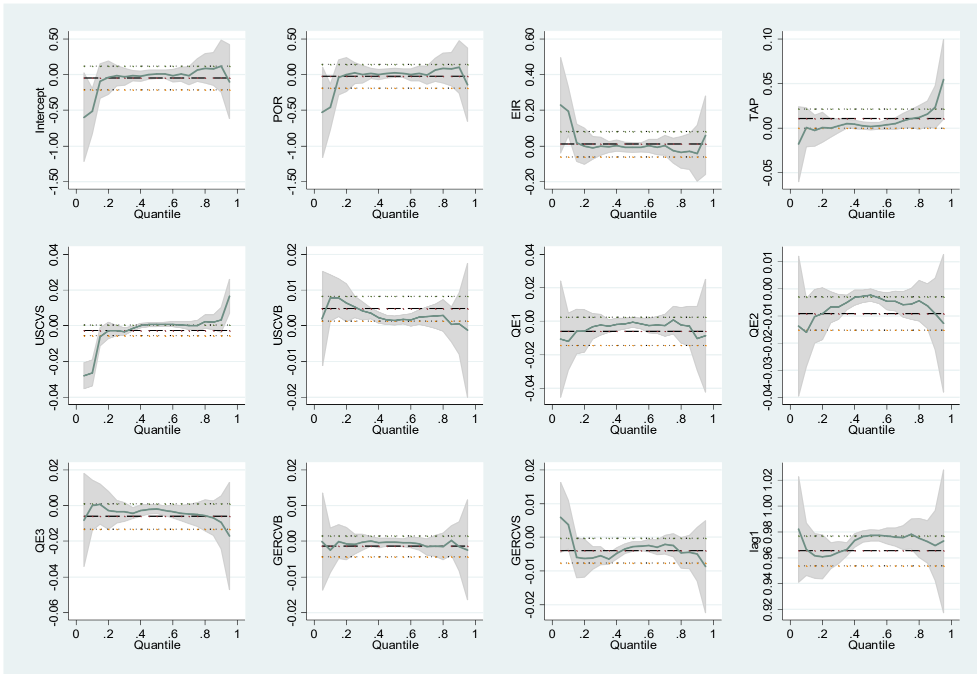

Figure 8: Quantile regression process of independent variables effects on the dynamic correlation between the US bond and Germany stock markets.

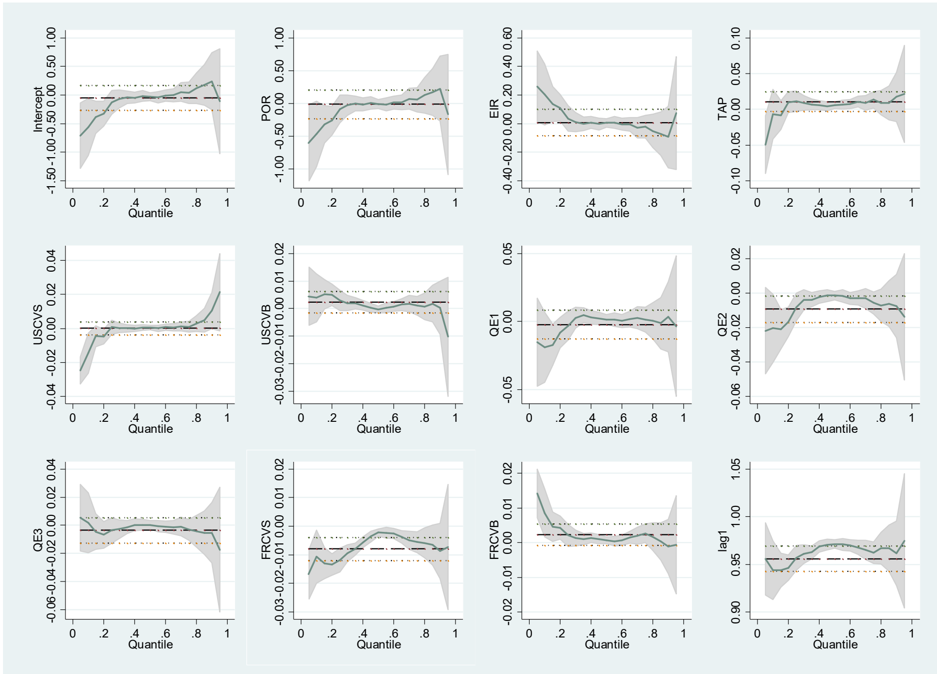

Figure 9: Quantile regression process of independent variables effects on the dynamic correlation between the US bond and France stock markets.

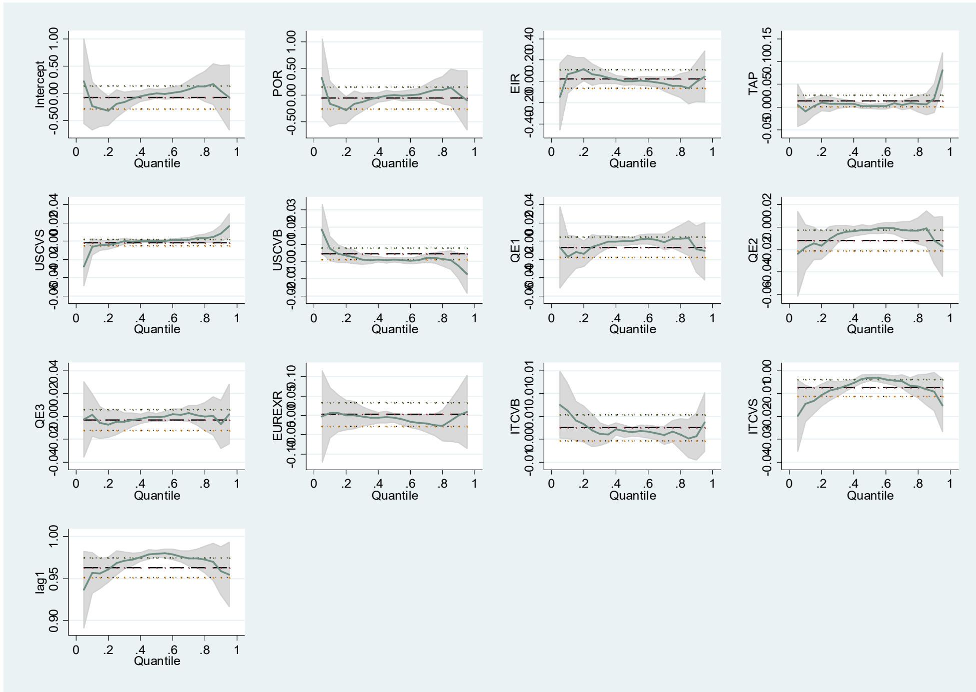

Figure 10: Quantile regression process of independent variables effects on the dynamic correlation between the US bond and Italy stock markets.

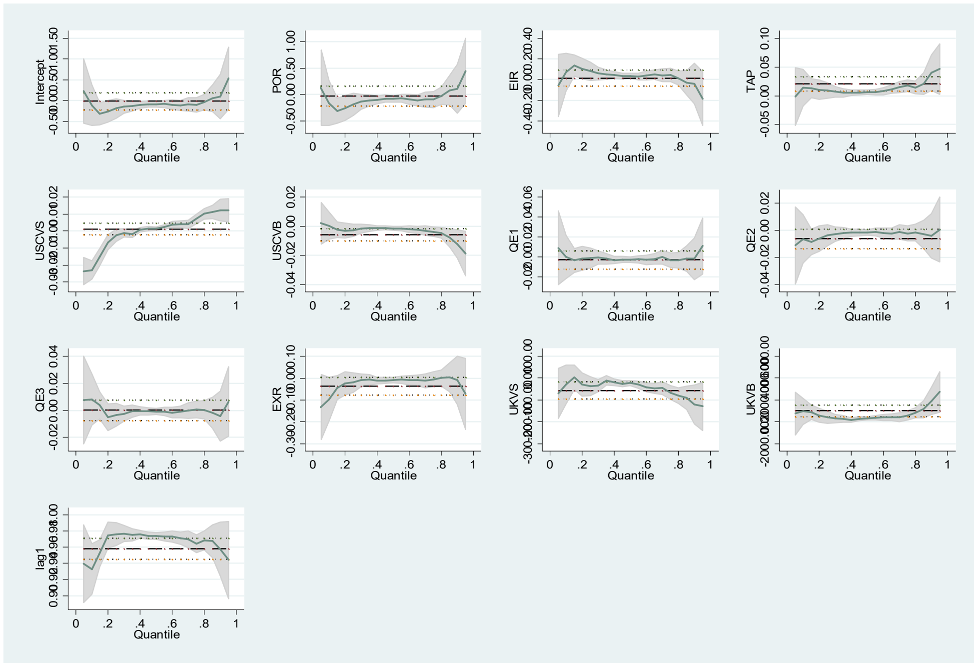

Figure 11: Quantile regression process of independent variables effects on the dynamic correlation between the US bond and UK stock markets.

Appendix K: Quantile process for independent variables effects on the dynamic correlation between US stock and advanced countries' bond markets

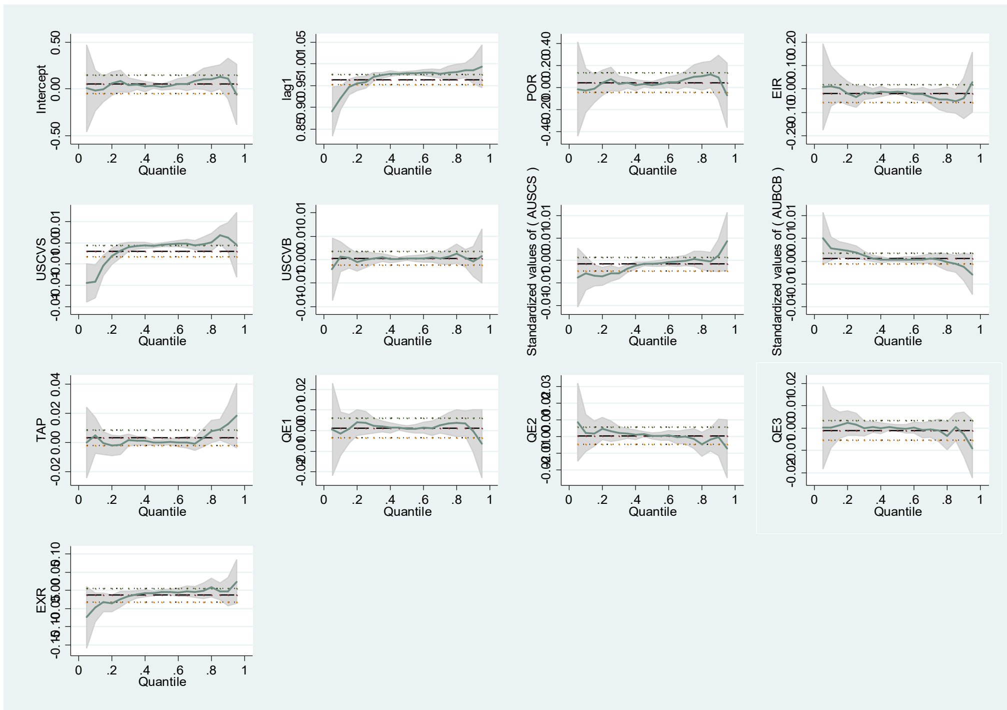

Figure 12: Quantile regression process for independent variables effects on the dynamic correlation between the US stock and Australia bond markets.

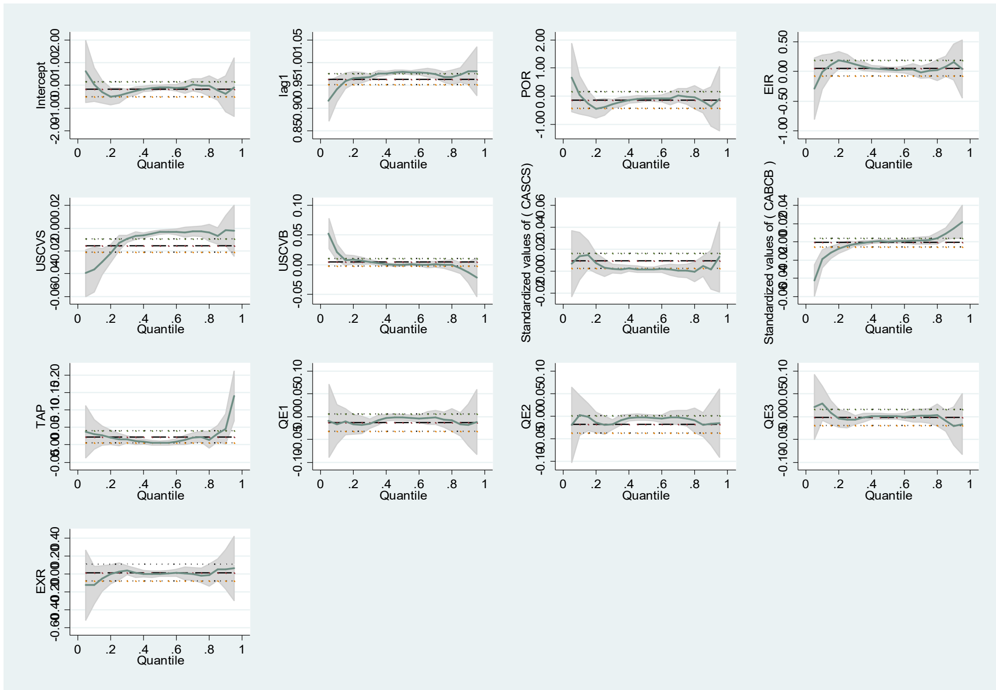

Figure 13: Quantile regression process for independent variables effects on the dynamic correlation between the US stock and Canada bond markets.

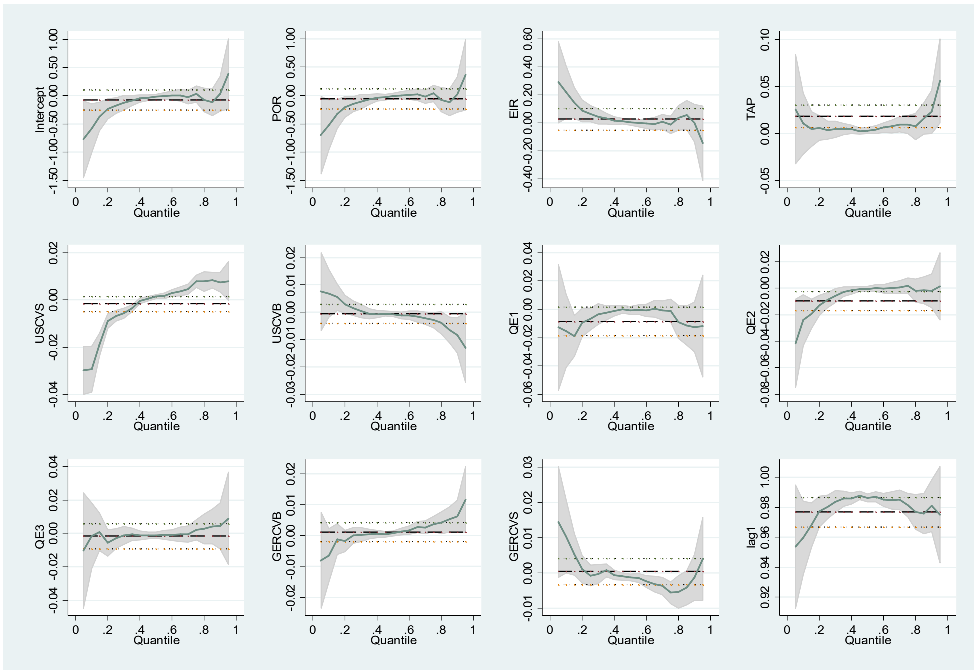

Figure 14: Quantile regression process for independent variables effects on the dynamic correlation between the US stock and Germany bond markets.

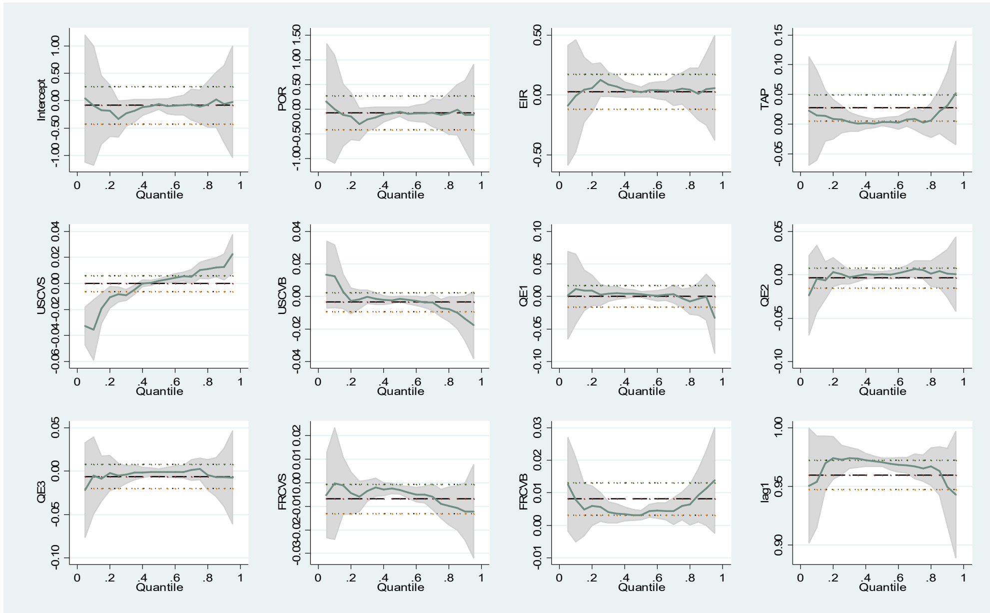

Figure 15: Quantile regression process for independent variables effects on the dynamic correlation between the US stock and France bond markets.

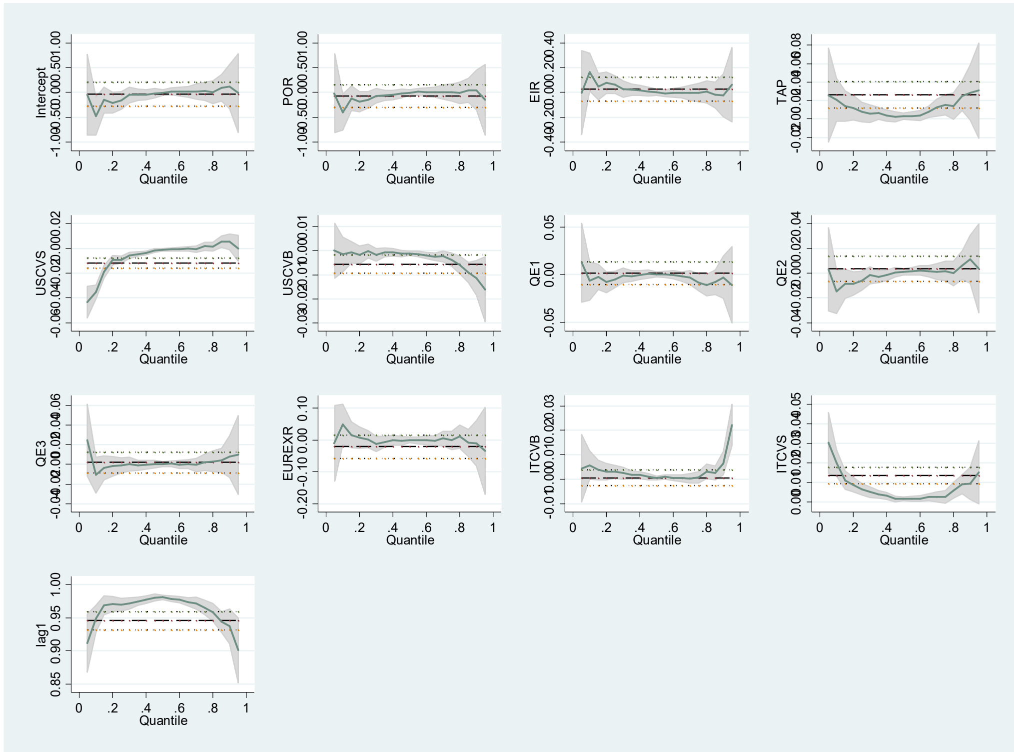

Figure 16: Quantile regression process for independent variables effects on the dynamic correlation between the US stock and Italy bond markets.

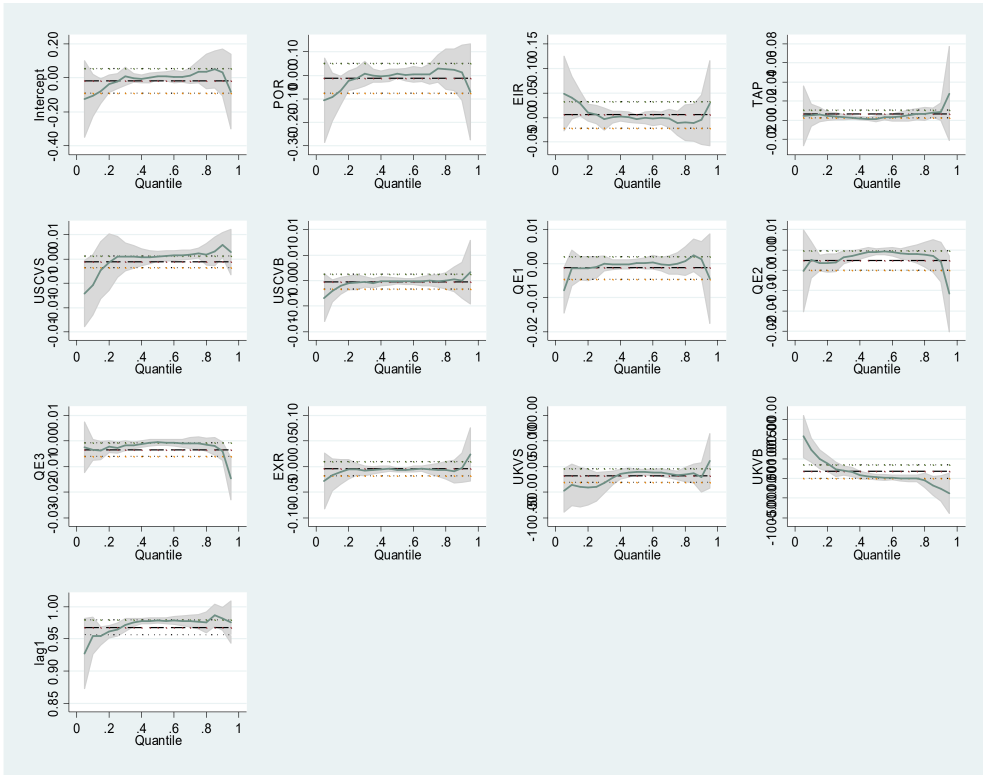

Figure 17: Quantile regression process for independent variables effects on the dynamic correlation between the US stock and UK bond markets.