Three Essays on International Financial and Monetary Interactions

Kemal Burak Bekircan

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THREE ESSAYS ON INTERNATIONAL FINANCIAL AND MONETARY INTERACTIONS

by

Kemal Burak Bekircan

A dissertation submitted to the Graduate College
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
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This dissertation develops three essays on safe haven currency behavior and international monetary interactions.

Essay one notes the dramatic appreciation of the U.S. dollar vis-à-vis all world currencies, along with its reversal after a year on the account of the Great Recession. This paper investigates bilateral U.S. dollar exchange rate movements during and in the aftermath of the Great Recession. I find that increasing global market uncertainty has a significant and consistent effect in strengthening of the U.S. dollar. This striking finding suggests flight-to-safety phenomenon of foreign investors, and repatriation of capital flows to the United States by the U.S. investors during and after the last financial crisis. This essay also demonstrates that global investors consider the 3-month and 1-year T-bill, the 5-year T-note, and the 20-year T-bond as the strongest safe haven instruments that can be bought and sold in U.S. dollars.

In essay two, it is noted that existing literature assumes that the euro is a safe haven currency but there is no evidence whether it actually behaves as a safe haven. This essay studies the validity of the safe haven hypothesis for the euro. A safe haven currency works as a hedge in the face of extreme market uncertainty. The results of this research imply that the euro is a safe haven currency if the market uncertainty originates in the
U.S. market. I show that there is no significant evidence to suggest that the euro serves as a safe haven currency if the uncertainty originates in the Euro-area. From the standpoint of world investors, however, this paper does not find any Euro-area safe haven asset (other than cash) using the EURO STOXX 50 Index as a measure of uncertainty.

Essay three studies whether the European Central Bank or the Federal Reserve have an influence on monetary policy implementations of each other and other major industrialized countries since the advent of the euro. I find that the Federal Reserve causes an endogenous monetary policy response in the Euro-area, and in other non-US G7 countries, with the exception of Japan, during the conventional monetary policy period of the post-euro era. I also show that exogenous Euro-area conventional monetary policy innovations cause foreign monetary policy endogeneity in Canada and the UK, but do not cause similar endogeneity in the US and Japan. I define foreign monetary policy endogeneity as the reaction of G7 monetary authorities (that persists for at least two time periods) following a monetary policy innovation of the other. The results of this chapter further reveal that, with respect to the G7 economies, U.S. unconventional monetary policy shocks induce endogenous policy reactions only in Japan during the Great Recession and its aftermath. Unconventional monetary policy innovations by the European Central Bank, instead, lead to a response by the monetary authorities of Japan, the UK, and the US.
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CHAPTER I

INTRODUCTION

The rapid appreciation of the U.S. dollar (USD) against all world currencies at the start of the Great Recession, together with its reversal after a year stands out as a remarkable event. This appreciation of the USD in 2007 was as sharp as any in the period since the floating exchange rate regime started in 1973. This appreciation was not expected given that the Great Recession originated in the United States (Fratzscher, 2009; McCauley & McGuire, 2009; Habib & Stracca, 2012). The appreciation stands out because it defied the consensus at the time, as Mozayani & Parvizi (2016) argue, that the USD would depreciate to improve U.S. competitiveness due to large global imbalances in U.S. current account positions. In the first chapter of this dissertation, I investigate whether safe haven behavior (the idea that the dollar and-dollar denominated “assets” were considered safe or safer “assets” in comparison to the available alternatives) is a possible explanation for the performance of the U.S. dollar since the Great Recession. The major indicator for market uncertainty is the volatility of the stock market, which I used to determine the instigator of safe haven flows on the USD exchange rate. Following the literature, I included the Chicago Board Options Exchange Volatility Index (VIX) as the main volatility indicator. I also used the EURO STOXX 50 Volatility Index (VSTOXX) as another measure of uncertainty to further examine the reaction of the USD to uncertainty during the Great Recession and in its aftermath. Using the VSTOXX as another measure of uncertainty is one of the more important contribution of this dissertation to the current literature.

VIX and the VSTOXX may contain different information, even though they appear to measure the same phenomena and employ similar calculation techniques. The VIX and the VSTOXX, as indicators of volatility, are also important variables incorporated in the main
hypotheses of interest for the first chapter, because a researcher can use them to determine the impact of safe haven flows on the USD. I explored whether they are correlated to the USD exchange rates to detect safe haven behavior. In the first chapter, I investigated the influence of safe haven behavior in the movements of the nominal USD exchange rate (against thirty-three currencies) by controlling for relevant macroeconomic fundamentals. I found that there is a positive and significant relationship between the VIX and USD at the time of Great Recession, and also during the post-crisis period. This result means that the USD appreciates when the U.S. market uncertainty increases. This positive and significant relationship between the value of the dollar and market uncertainty as reflected by the VIX implies flight-to-safety phenomenon of foreign investors, and repatriation of capital flows to the United States by U.S. investors. To the contrary, I demonstrated that the European stock market volatility does not have any impact on the value of the USD, because there is no significant relationship between the VSTOXX and the USD in the Great Recession and its aftermath. This finding serves as the motivation and starting point for my second chapter, because the Euro-area sovereign debt crisis kept uncertainty high while the US was trying to get back to normal terms.

I further explored the similarities and differences between the US and Euro-area (EA) for a couple of reasons. First, a motivating factor for construction of the common currency and joint monetary policy was to have the euro serve as a counterpart to the U.S. dollar (Krugman et al., 2012). To what extent has this taken place? Some completed research (Fatum & Yamamoto, 2016; Fatum et al., 2017) claim that the euro is a safe haven currency without any supporting empirical evidence. Studies like Ranaldo & Soderling (2010) argue that the euro, appear to have safe haven properties, but the results were weak for the euro providing motivation for further investigation of these properties. I, therefore, explored the safe haven behavior of euro since its
advent as the single European currency. I used the VSTOXX as the main indicator of market uncertainty, along with the VIX as another source of market volatility in the second chapter of this dissertation. I applied the same methodology used in the first chapter, and found that the euro is a safe haven as long as the source of uncertainty is not the EA, and is instead originating in the US. While I found that an increase in the U.S. sourced market uncertainty appreciated the euro during the Great Recession and its aftermath. I did not find similar result when the market uncertainty originated in the EA, rather demonstrated that world investors appear to move away from the euro while the EA sourced market uncertainty rises.

After finding evidence that the USD and euro serve as safe havens in the Great Recession and its aftermath, I studied safe haven instruments (that can be bought and sold in the USD and euro) to determine which of these instruments are chosen by world investors. Following the methodologies of Baur & Lucey (2010), Baur & McDermott (2016), and Hood & Malik (2013) in my first chapter, I found that VSTOXX futures, the one-year T-bill, five-year T-Note and twenty-year T-Bond are other safe haven possibilities for investors if the S&P 500 Index performs lower than the first-percentage-quantile of its return distribution. I also showed that the 3-months T-bill is chosen as another safe haven if the U.S. stock market return is lower than the five-percentage quantile of the return distribution of S&P 500 Index. However, the second chapter of this dissertation demonstrated that none of the EA government bonds are considered as a safe haven asset at periods of extreme negative returns of the EURO STOXX 50 Index.

Having compared the U.S. and EA currencies as being safe haven during the time of Great Recession and afterwards, I explore monetary policies of these economies to determine whether the European Central Bank (ECB) or the U.S. Federal Reserve (Fed) have an influence on monetary policy implementations of each other. Kim (2001) analyzed this relationship during
the pre-euro period and found that G6 monetary authorities did not respond to U.S. monetary policy shocks. Following Kim (2001) in the third chapter, I investigated the transmission of the U.S. and E.A. monetary policy decisions on each other’s, and on other major industrialized countries’ (Canada, Japan, and the UK) monetary policy implementations since the advent of the euro. I also studied the post-euro period and tested whether the ECB is more resilient to U.S. monetary policy shocks compared to the pre-euro period. The results of this chapter demonstrate that conventional contractionary monetary policy shocks of the Fed cause foreign policy endogeneity in the Euro-area and in other non-US G7 economies. However, conventional contractionary monetary policy innovations of the ECB only lead to an endogenous monetary policy implementation in Canada and the U.K. I also showed that U.S. unconventional monetary expansions only cause an endogenous monetary policy action on Japan.

The findings of my third chapter reveal that expansionary Euro-area unconventional monetary policy shocks lead to endogenous responses by the Federal Reserve, the Bank of England, and the Bank of Japan. Therefore, there is significant evidence to suggest that the EA becomes stronger during the Great Recession and its aftermath (2009-2015) in the third chapter of this dissertation. This result offers some evidence that the EA becomes successful in terms of becoming a counterpart to the US during the unconventional monetary policy period (2009-2015), while there is little evidence for the same claim before the Great Recession.
CHAPTER 2

BILATERAL U.S. DOLLAR EXCHANGE RATES AND SAFE HAVEN BEHAVIOR

My research analyzes U.S. dollar exchange movements against thirty-three currencies during and after the Great Recession.¹ Following Kaul & Sapp (2006) and Habib & Stracca (2012), my paper begins with traditional definition of safe haven currency as one that serves as a hedge with respect to market uncertainty. Investors from around the world buy assets denominated in currencies considered to be safe havens because they appear more attractive than others when uncertainty rises (Kohler, 2010). Investors appeared to consider the United States as a safe haven although the United States was at the core of the last financial crisis.

In this study, I demonstrate that safe haven behavior is a possible explanation for the performance of the U.S. dollar since the Great Recession. Such behavior appears to be an investment strategy in the face of global uncertainty. Safe haven flows are observed in the movements of the nominal U.S. dollar exchange rate when I also control for relevant macroeconomic fundamentals.

The striking appreciation of the U.S. dollar in 2007 was as sharp as any in the period since the floating exchange rate regime started in 1973. The U.S. dollar appreciation at the beginning of the last financial crisis becomes a distinctive feature of the Great Recession (Fratzscher, 2009; McCauley & McGuire, 2009; Habib & Stracca, 2012). This U.S. dollar strengthening surprised many observers because, as Mozayani & Parvizi (2016) state, before the

¹ These economies are Albania, Argentina, Australia, Brazil, Canada, Chile, Colombia, Czechia, Denmark, the Euro area, Hungary, Iceland, India, Indonesia, Israel, Japan, South Korea, Malaysia, Mexico, New Zealand, Norway, Peru, Philippines, Poland, Romania, Russia, Serbia, Singapore, South Africa, Sweden, Switzerland, Thailand, and the UK.
crisis, there was a consensus that the U.S. dollar (USD) would depreciate. The common belief was that a large depreciation was necessary to improve U.S. competitiveness due to large global imbalances in U.S. current account (CA) positions. The U.S. economy had been running current account deficits since the third quarter of 1991 (Federal Reserve Bank of St. Louis, 2017). However, the actual pattern of the U.S. dollar was very different from what was expected.

Following Habib & Stracca (2012) and Fatum & Yamamoto (2016), the Chicago Board Options Exchange Volatility Index (VIX) is the main indicator of volatility used to detect the effect of market uncertainty on the behavior of the U.S. dollar in this research. The Chicago Board Options Exchange (CBOE) (2015) defines the VIX as a forward-looking predictor for the variability of future market changes, because it measures expected volatility by averaging the weighted prices of the S&P 500 Index puts and calls over a wide range of strike prices. The VIX estimates 30-day expected volatility of the S&P 500 Index by calculating the midpoint of real-time S&P 500 Index option bid and ask quotes. The VIX aims to record an instantaneous measure of the level of implied volatility of the S&P 500 Index over the next 30 days. Therefore, the VIX is an up-to-the-minute estimate of market uncertainty, and the CBOE calculates it approximately every 15 seconds (CBOE, 2016).

Kohler (2010) states that the depreciation of many non-USD currencies, which are at the core of the crisis, differs from two previous financial crisis episodes, namely, the Asian crisis of 1997-98, and the Russian debt default of 1998 that followed it. Following his approach, in Figure 2, in the Appendix, I show the movement of some currencies that are included in this study. The depreciation of non-USD currencies contrasts with the previous episodes, because during the Asian crisis, Indonesia and South Korea (at the epicenter of the Asian crisis) experienced sharp depreciations while the others experienced small changes. Similarly, in the Russian debt default episode, South Africa and Chile (also at the epicenter of the Russian debt default due to their exposure) had reasonably large declines.

The strike of an option is the price at which a put (where the option can be bought) and a call (where the option can be sold) option can be applied. It is also called the exercise price. Whaley (1993) discusses the purpose and history of the VIX and states that the volatility index level equals the volatility futures price.

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4 Whaley (1993) discusses the purpose and history of the VIX and states that the volatility index level equals the volatility futures price.
To further explore the performance of the USD in this special era, I employ the EURO STOXX 50 Volatility Index (VSTOXX) as another measure of uncertainty. STOXX (2018) introduces the VSTOXX as the implied volatility across all EURO STOXX 50 options of a given time to expiration.\textsuperscript{5} STOXX (2018) describes the VSTOXX calculation as a direct replication of variance.\textsuperscript{6} The VSTOXX uses a similar averaging method for real-time bid and ask prices over a large EURO STOXX 50 portfolio with different exercise prices and weighting. Nonetheless, these volatility indices might contain different information, even though they appear to measure the same thing. Figure 1, in the Appendix, demonstrates that time plots of the two indices do not necessarily move in sync. Shore (2017) argues that global investors consider the VSTOXX/VIX spread as an additional information to hedge their portfolios.

The VIX and the VSTOXX, as indicators of volatility, are also important variables incorporated in the main hypotheses of interest for my paper, because a researcher can use them to detect safe haven behavior by observing whether they are correlated to exchange rates. In other words, a change in market uncertainty (measured by movements in the VIX and VSTOXX) may induce variation of investor’s preferences towards different currencies which are then reflected in exchange rate movements. For instance, if a rise in the VIX is related to appreciation of the U.S. dollar (USD), then this suggests that investors use the USD as a hedge against market uncertainty, and thus the USD is a safe haven currency. Considering the above, I explore the role

\textsuperscript{5} The purpose and calculation of the VSTOXX is similar to the VIX. The derivation of the VIX and the VSTOXX are further detailed in the Appendix.
\textsuperscript{6} The S&P 500 and EURO STOXX 50 indices represent the performance of the largest companies in terms of free-float market capitalization. The S&P 500 Index consists of stocks of 500 companies, whereas the EURO STOXX 50 Index includes largest 50 companies in 11 original members of the Euro-area. These countries are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. Both of these volatility indices use free-float market cap methodology in which large companies get higher weighting.
of global market uncertainty on the unusual pattern of the U.S. dollar exchange rate during and after the most recent financial crisis.

Literature Review

Standard models can be used to account for exchange rates during tranquil periods, but do not serve us well if there is a crisis. Fratzscher (2009) argues that determinants of exchange rates might be fundamentally different in crises periods compared to normal times. Other factors, such as global uncertainty, become very crucial for explaining currency movements. Fatum & Yamamoto (2016) discuss that market uncertainty is an important factor in understanding; and modeling exchange rate movements, because it can have an impact on currency behavior in a systematic fashion. Thus, explaining safe haven behavior becomes very crucial to analyze exchange rate movements.

The empirical literature on safe haven behavior can be divided into two parts. One uses low-frequency data and the other high-frequency data. Here, low-frequency data is defined as data that is at monthly or longer time intervals. High-frequency is data at shorter than monthly intervals (e.g. daily data). Fratzscher (2009), Habib & Stracca (2012), Kohler (2010) are the most striking examples in the sphere of low-frequency (monthly or quarterly) data. Fratzscher (2009) examines global foreign exchange (FX) movements in 2008 and 2009 by empirically investigating the determinants of bilateral exchange rate movements vis-à-vis the USD for 54 currencies. The author runs a cross-sectional regression in which all determinants of the exchange rate are measured prior to the financial crisis. Fratzscher (2009) finds that countries with large CA deficits, a low level of foreign currency assets, and higher financial liabilities vis-à-vis the United States have experienced significantly larger depreciations against the USD. Fratzscher (2009) also tests the transmission of U.S. shocks before and during the crisis. His
paper offers that negative news shocks during the crisis caused an appreciation of the USD, whereas before the Great Recession, negative US macroeconomic news led to a depreciation of the USD. Additionally, this research reports that a repatriation of capital to the US by domestic investors, flight-to-safety behavior by world investors, and unwinding carry trade flows may be reasons for the appreciation of the U.S. dollar in the second half of 2008, and early 2009. However, these hypotheses are not tested directly in his analysis, Fratzscher (2009) rather attempts to examine these effects on exchange rates by investigating countries’ macroeconomic fundamentals and financial exposure to the United States.

Habib & Stracca (2012) investigate the fundamental determinants of being a safe haven currency by examining 51 bilateral exchange rates against the US dollar from January 1986 to December 2009. The paper identifies a measure of global risk aversion shocks from applying sign restrictions to a bi-variate vector autoregressive model. The authors define this shock as a condition in which the VIX increases, and the return on a global unhedged stock market portfolio decreases. This study interacts this shock with relevant domestic variables while putting monthly USD-based excess returns as the dependent variable. The authors find that the net foreign asset position is the most consistent predictor of safe haven status, because it turns out to be positively and significantly related to the appreciation of the U.S. dollar in periods of global volatility (in all possible specifications of the paper). Nonetheless, they rely frequently on data interpolation techniques due to data unavailability at the monthly frequency. Hence, interpolation techniques are the major downside of this study, as Hossfeld & MacDonald (2015) emphasize.

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7 Habib & Stracca (2012) measure the return on a global unhedged stock market portfolio by the Modern Index Strategy (MSCI) world stock market index.
Kohler’s (2010) research takes a different approach and compares the last three major financial crises: the Asian crisis, the Russian debt default, and the Great Recession. The author maintains that the depreciation of some currencies against the USD quickly and strongly reversed within a year after the start of the last financial crisis. This aspect of the most recent crisis is more surprising than the appreciation of the USD, because similar reversals spread over years in the previous financial crises.

In addition, Kohler (2010) claims that there are two common elements across the crises, which can explain exchange rate movements. First, the author argues that the rise and the fall in uncertainty seems correlated to exchange rate changes. Her study shows that one-month implied volatility of currencies against the USD increased sharply as the latest crisis intensified. Second, this paper discusses that interest rate differentials have more explanatory power of the crisis-related exchange rate movements than in the past. The author plots crisis-related appreciations of 33 currencies vis-à-vis the Japanese yen over the two months following the particular crisis episode against the average short-term interest rates in the previous six months and the average contemporaneous short-term interest rates. Her findings support unwinding carry trade activities, and the currencies with the highest short-term interest rates depreciate the most in the period prior to the crisis. She also states that the channel between higher interest rates of currencies and exchange rate depreciations during the Great Recession is stronger than in previous crises incidents. Her research claims that the rise in carry trade activities over the past 15 years could be a reason for this finding.

Instead of using monthly, quarterly, or yearly (low-frequency) data, another set of researchers use data that is of higher frequency such as daily, minute-by-minute and even second-by-second. Examples include Ranaldo & Soderling, 2010; Hossfeld & MacDonald, 2015;
Faturn & Yamamoto, 2016. Having sorted the data according to the VIX levels, these high-frequency data articles use the Chicago Board Options Exchange Volatility Index (VIX) as the main indicator of market uncertainty in threshold regressions. This part of the safe haven literature tries to determine which conventionally assumed safe-haven currencies serve as a hedge on average or in times of stress.\(^8\) These articles determine the threshold values of the VIX as high and low regimes. After determining the threshold values, these studies argue that conventionally assumed safe-haven currencies are able to be compared with each other. Their purpose is specially to detect the market uncertainty threshold around which safe haven flows might change. In this way, these articles aim to test whether the relationship between the flight-to-safety behavior and market uncertainty depends on a particular level of uncertainty (Ranaldo & Soderling, 2010; Hossfeld & MacDonald, 2015; Faturn & Yamamoto, 2016).

For instance, Faturn & Yamamoto (2016) examine some currencies considered to be safe havens, and investigate safe haven currency behavior before, during, and after the Great Recession. The authors analyze the exchange rates of the USD vis-à-vis the Swiss franc, the Japanese yen, the Great Britain pound, the euro, the Canadian dollar and the Swedish krona. First, this study finds that the yen and franc experienced significant appreciation against the USD during the Great Recession. Second, Faturn & Yamamoto (2016) concentrate on a non-linear analysis with endogenously identified uncertainty thresholds separately for each bilateral USD exchange rate to determine whether safe haven behavior changes when the VIX rises above a certain level. The authors observe that increases in uncertainty (measured using increases in the VIX) do not seem to affect currency values unless those increases are above a certain level.

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\(^8\)These currencies are the U.S. dollar, the euro, the Swiss franc, the Japanese yen, the British pound, the Canadian dollar, the Swedish krona, the Australian dollar, the Norwegian krone.
Below that uncertainty level, the exchange rate does not respond to increased uncertainty. These findings hold for the pound, the euro, and the krona. Nevertheless, these currencies depreciate significantly against the USD when the VIX is higher than the currency specific threshold. In contrast, Fatum & Yamamoto (2016) demonstrate that the yen appreciates as the VIX increases regardless of whether the increase in uncertainty is small or large. The authors find no specific uncertainty threshold in the case of yen. Their findings also show that after the last financial crisis, the yen still strengthened against the USD, while other currencies depreciate vis-à-vis the USD. As a result, Fatum & Yamamoto (2016) suggest that the yen is better than the U.S. dollar in terms of being a safe haven currency.

Ranaldo & Soderling (2010) try to answer the same research question as Fatum & Yamamoto (2016). However, Ranaldo & Soderling (2010) include a carry trade channel, and employ different risk variables for a sample from January 1993 to December 2008.9 Ranaldo & Soderling’s (2010) results reveal that the franc, euro, yen have safe haven properties while the pound does not.

Hossfeld & MacDonald (2015) explore whether G10 currencies should be considered as safe haven currencies at the time of a crisis, because carry trade flows are less likely to happen. The authors use threshold regressions in which the VIX determines the high and low regimes for the period January 1986 to September 2012. However, their model includes the Modern Index Strategy (MSCI) world index as the stock return, and the old version VIX (the VXO) as the

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9 These risk variables are the VIX, the TED spread, foreign exchange volatility. The TED spread is the difference between the USD LIBOR rate and the T-bill rate. Their definition for the FX volatility is the first principal component of the realized volatilities of euro, yen, and pound vis-à-vis USD in logs. Ranaldo & Soderling (2010) find that the FX volatility and the VIX (for the yen only) are only significant risk variables.
market uncertainty threshold variable. Hossfeld & MacDonald (2015) show that the U.S. dollar and the Swiss franc are the only safe havens out of G10 exchange rates.

There are two important conclusions that emerge from the safe haven literature. The qualification of the USD as a safe haven currency regardless of the frequency data used is the primary conclusion. In addition, there is significant support for finding other currencies (such as the yen, the franc, and the euro) serve as safe havens. Lastly, the VIX, CA, FX reserves, the net foreign asset position (NFA) are the variables that are most commonly used to assign safe haven currency behavior. I chose not to incorporate NFA into my model, because a transformation of NFA might constitute current account balance.

My study adds important value to the current literature for many reasons. First, my article includes the volatility index for European stock prices (the VSTOXX) as another indicator for market uncertainty, because it might contain a different set of information. It is hard to examine the validity of safe haven behavior, because there are not individual volatility indices for every country’s stock market. Thus, employing the European volatility index to explain safe haven behavior is new approach in the existing literature. However, my article does not find any significant impact of the VSTOXX on the value of USD exchange rate.

10 Hossfeld & MacDonald (2015) identify high threshold uncertainty period as a crisis episode, which is defined according to a threshold value of the VXO (the old VIX that is based on the S&P 100 Index). Their threshold value of the VXO minimizes the sum of squared errors function.

11 The net international investment position (NIIP) is also called as net foreign assets (NFA). Tille (2003) argues that the U.S. net international investment position (which is also referred as the net foreign asset position) could change with only changes in their current stocks of U.S. assets and liabilities. The IMF (2014) defines NIIP as the subtraction of gold reserves and financial assets of a country’s residents in another economy from liabilities of those residents to non-residents. According to Lane & Shambaugh’s (2010) conceptual framework, the change in net foreign assets (also equals NIIP) can be modeled as \((NFA)_t - (NFA)_{t-1} = (\text{Current Account})_t + (\text{Valuation Effects})_t\). For this reason, my model only incorporates the current account balance as a regressor.
I further contribute to the existing literature by investigating the U.S. dollar exchange rate movements during the crisis period and its aftermath. I do not only focus on the period of the beginning of the Great Recession when a sharp appreciation of the U.S. dollar took place. The pattern of the U.S. dollar exchange rate would be better to explain if we include the crisis period and its aftermath. Following Baur & Lucey (2010), Baur & McDermott (2016), and Hood & Malik (2013), I use a large set of potential safe haven instruments and incorporated gold into my analysis to be able to judge the ultimate safe haven preference of world investors. My research differs from the current literature by also considering the VSTOXX futures as a potential safe haven instrument.¹²

Data & Model

My research uses quarterly data from January 2007 to December 2016. To construct my sample, I follow Fratzscher (2009) and consider all OECD countries along with some emerging market countries¹³ as candidates. The nineteen members of the Eurozone are included as a single entity, namely the Euro area. I exclude countries that maintain a hard peg exchange rate system, specifically exchange arrangements with no separate legal tender and currency boards according to the IMF’s (2017) de facto exchange rate classification.¹⁴ The final sample, therefore, covers

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¹² Hood & Malik (2013) is the only empirical study which evaluates the VIX futures as an investment vehicle. I explain their main results in detail on Page 25.

¹³ The emerging market countries that I consider for inclusion are Argentina, Brazil, Chile, China, Colombia, Costa Rica, Czechia, Egypt, Guyana, Hungary, India, Indonesia, Israel, Jamaica, South Korea, Lebanon, Malaysia, Mexico, Paraguay, Peru, Poland, Philippines, Qatar, Romania, Russia, Senegal, South Africa, Thailand, Trinidad & Tobago, Turkey. I excluded China, Costa Rica, Egypt, Guyana, Jamaica, Paraguay, Qatar, Senegal, and Trinidad & Tobago, Turkey because the required data is unavailable.

¹⁴ Following the previous literature, I include countries that have soft peg and floating exchange rate regimes. The IMF (2017) classifies that conventional pegs and exchange rate stabilized arrangements are some soft peg examples. The most common form of exchange rate stabilized arrangement is anchor currency. For instance, Czechia uses the U.S. dollar (USD) and Singapore anchors its exchange rate to a currency composite. IMF (2017) states that an exchange rate which uses stabilized arrangement could change within a margin of two-percent for at least six months or more. A two-percent window might be beneficial to explain safe haven behavior on the USD.
33 exchange rates, which are ultimately selected based on data availability. The complete list of countries used in this paper is presented in the Appendix under Table 1.

The quarterly data starts in the first quarter of 2007, because February 27, 2007 is recognized as the beginning of the financial crisis (The Federal Reserve Bank of St. Louis, 2017). My sample period allows us to focus on exchange rate changes at the start, during and in the aftermath of the Great Recession. My research estimates the recession and the post-recession period using different empirical models. The recession period is defined as January 2007 to March 2011, and the post-recession period runs from April 2011 to December 2016 (The Federal Reserve Bank of St. Louis, 2017).

My objective is to understand USD behavior related to a rising uncertainty and the crisis situation. My main hypothesis is that the U.S. dollar reflects significant safe haven behavior. To empirically investigate bilateral U.S. dollar exchange rates and safe haven behavior, the baseline empirical model is formulated as

\[ s_{i,t} = \beta_0 + \beta_1 (s_{i,t-1}) + \beta_2 (VIX_t) + \beta_3 (VSTOXX_t) + \beta_4 (i^{us}_t - i^{other}_t) + \beta_5 (Z_{i,t}) + \alpha_i + u_{i,t} \ldots (1) \]

where least-square estimation is biased and inconsistent, because \( \alpha_i \) and \( s_{i,t-1} \) are not independent. The first-difference benchmark model is

\[ \Delta s_{i,t} = \beta_0 + \beta_1 (\Delta s_{i,t-1}) + \beta_2 (\Delta VIX_t) + \beta_3 (\Delta VSTOXX_t) + \beta_4 (\Delta(i^{us}_t - i^{other}_t)) + \beta_5 (\Delta Z_{i,t-1}) + \Delta \epsilon_{i,t} \ldots (2) \]

15 On 2/27/2007, the Federal Home Loan Mortgage Corporation (Freddie Mac) declared that it would not buy the riskiest subprime mortgages and mortgage-related securities henceforth. This announcement prompted panic behavior toward such assets, which eventually caused a series of bankruptcies, as well as the subsequent catastrophic and well-known events that marked the Great Recession (Batini & Dowling, 2011).
16 I reran all regressions without the first quarter of 2007. The results did not change.
17 The least-squares estimation fails due to \( E(\alpha_i | s_{i,t}) \neq 0 \).
where $\Delta s_{i,t}$ is the first-difference in the log of nominal bilateral exchange rate that is defined as foreign currency price of the USD. The notation, $\Delta VIX_t$, indicates the first-difference in the log of the Chicago Board Options Exchange Volatility Index whereas $\Delta VSTOXX_t$ shows the first-difference in the log of the EURO STOXX 50 Volatility Index. $\Delta(i_{us} - i_{other})$ denotes the short-term interest rate differential, $\Delta Z_{i,t}$ is a vector of country-specific macroeconomic fundamentals, and $\epsilon_{i,t}$ is the error term. All the model variables are first-difference in their logs while short-term interest rate differentials and the current account balance are first-differenced in levels.\(^\text{18}\)

Following the literature, the lagged dependent variable is included in the model specification, and the above equation (2) is estimated as a dynamic panel model. Since the lagged dependent variable is not strictly exogeneous, we need an instrumental variable (IV) for it. There are three main methodologies to deal with endogeneity: Anderson & Hsiao (1981), Arellano & Bond (1991), and Kiviet (1995). Anderson & Hsiao’s (1981) estimation technique is the oldest one, and it uses the method of moment (MOM) conditions with the IV solution. Anderson & Hsiao’s (1981) methodology limits researchers to using only as many IVs as the number of endogenous covariates. Anderson & Hsiao’s (1981) approach permits the twice lagged dependent variable ($s_{it-2}$) or twice lagged differences of the dependent variable ($\Delta s_{it-2}$) as valid instruments for the lagged difference of the dependent variable ($\Delta s_{it-1}$). The coefficient estimate of Anderson & Hsiao’s (1981) is inefficient, since their estimation technique does not

\(^{\text{18}}\) The current account balance of some economies in my data set indicates negative values in their datasets, and thus it was not possible to find their logarithmic values. Short-term interest differentials between countries is first-differenced in levels, because they are already rates.
utilize all the available moment conditions. Anderson & Hsiao (1981) does not take into
consider the autocorrelation in first differences of errors.

On the other hand, Arellano & Bond (1991) argue that their GMM estimation is more
efficient than Anderson & Hsiao’s (1981) methodology by incorporating the GMM technique to
similar panel datasets with small T (time dimension) and large N (individual/country dimension).
Arellano & Bond’s (1991) methodology allows researchers to use all lagged dependent variables
and exogenous covariates as IVs in addition to the exogenous covariates used in Anderson &
Hsiao’s (1981) estimation technique. The GMM estimation technique of Arellano & Bond
(1991) provides consistent and efficient coefficient estimates as it exploits all of the information
available in a sample. Kiviet (1995) also studies estimation of dynamic panel data and argues
that the least squares dummy variable (LSDV) estimation produces very efficient estimation
results when researchers remove the bias from the LSDV estimator.

Judson & Owen (1999) investigate the best methodology to estimate a dynamic panel
model for different macroeconomic datasets and develop a way to choose from these three
possibilities. Judson & Owen (1999) discuss that Kiviet’s (1995) LSDV is best if used on data
sets of small T and large N. In contrast, Judson & Owen (1999) suggest that the least squares
dummy variable estimation bias remains even if the time dimension equals thirty. Judson &
Owen (1999) determine that all estimation techniques yield better results with a larger N and T
(by using a root mean square error criterion). For this reason, I construct a large country sample

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19 If I apply Anderson & Hsiao’s (1981) methodology, I could only use 2 instrumental variables because my main
estimation model has 2 endogenous covariates. When I implement Arellano & Bond’s (1991) estimation technique, I
could employ 128 instrumental variables.
20 Judson & Owen (1999) maintain that microeconomic panel datasets have “far smaller T and far greater N than the
typical macroeconomic panel” (p. 9). Therefore, researchers might need different estimation techniques when
studying macroeconomic panel datasets.
21 Judson & Owen (1999) find “for a sufficiently large N and T, the differences in efficiency, bias, and RMSEs of
the different techniques become quite small.” (p. 13).
to include as many countries as possible. Judson & Owen (1999) find that the least squares dummy variable estimation only works similarly to other estimation alternatives when T equals thirty, and does not perform better than others when T is smaller than thirty. Arellano & Bond’s (1991) methodology (the GMM technique) is the best estimation technique when T equals twenty, because it generates the lowest root mean square error.22

In my paper, the spot exchange rate of a given country is defined as the period average national currency per USD, which is obtained from the IMF’s International Financial Statistics (IFS) database. The variable “s” is defined as national currency/USD rate. Accordingly, an increase in the dependent variable indicates an appreciation of the USD, while a decline reflects a depreciation of the USD.

The VIX is used as an indicator of stock market volatility to assess the impact of market uncertainty (US sourced) on the behavior of the U.S. dollar. World investors believe that putting their money into currencies such as the U.S. dollar is ideal when uncertainty rises, as Kaul & Sapp (2006) argue. The VIX measures volatility in percentage points and is calculated as 100 times the expected 30-day variance of the S&P 500 rate of return. The expected 30-day variance is a weighted average of the forward prices of two options strips with the two closest nearby expirations.23 These two option strips are used to calculate the VIX and contain out-of-the-money S&P puts and calls that are immediately below and immediately above the exercise price of the S&P 500 (CBOE, 2017). My study measures U.S. market uncertainty with this index, and the volatility of stock markets is a closely watched indicator for everyone who wants to assess

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22 The recession period has 16 quarters whereas the post-recession era includes 23 quarters to estimate equation (2).
23 Option strip is a trading strategy that is achieved by purchasing two at-the-money (ATM) puts and one ATM call of the same underlying stock, strike price and expiration date.
market uncertainty (Habib & Stracca, 2012; Fatum & Yamamoto, 2016). The data for the VIX is obtained from the Federal Reserve Bank of St. Louis.

The VSTOXX measures volatility in percentage points by calculating the 30-day implied variance, like the VIX, and is often called the European equivalent of the VIX (Rhoads, 2017). These two indices could contain different information. As Vause & von Peter (2011) state, there was still high pressure on the Euro-area sovereign bond yields due to weak European economic performance and policy uncertainty while the US was getting out of the last crisis throughout 2011. Figure 1, in the Appendix, reveals that the VIX and VSTOXX move differently from time to time. The VSTOXX/VIX spread indicates differences in the information sets of these volatility indices.

Shore (2017) maintains that investors can use the difference between the VSTOXX and the VIX as an indicator that shows how these volatility indices move in the near future. Therefore, market participants might buy VSTOXX futures and sell VIX futures when this spread is too high (Shore, 2017). However, investment strategies about these volatility indices are beyond the topic of my research, rather I incorporate the VIX and VSTOXX futures as other safe haven assets in the investors’ choice set toward the end of this chapter.

My article attempts to explain the sharp appreciation of the U.S. dollar at the beginning of the Great Recession, then strong reversal of the appreciation almost a year later, and after that phase of appreciation again. Hence, I include all potential variables, which could shed some light on these interesting exchange rate movements in this sample period.

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24 Futures are financial contracts giving both trading parties an obligation to exchange an asset at a predetermined date and price. VIX and VSTOXX futures provide investors a diversification opportunity to hedge their portfolio volatility risk by implementing volatility trading strategies.
Short-term interest rate differentials between countries are added to all of my estimations, because they are the channel for the effect of carry trade flows. Carry trade is an interest arbitrage opportunity where an investor borrows in the low interest rate currency (funding currency) and lends in the high interest rate currency (target currency). Gyntelberg & Remolona (2007) argue that carry trade is likely to take place if the short-term interest rate differential is sufficiently large to compensate for foreign exchange rate risk. OECD (2017) states that short-term interest rates are based on three-month money market rates, or equivalently are the rates of the government treasury bill of a country. The data of short-term interest rate differentials are sourced from the OECD’s database and the IMF’s IFS database.25

Fratzscher (2009) suggests that the last crisis underlines the importance of strong macroeconomic fundamentals of the countries. Similarly, De Bock & Carvalho Filho (2015) maintain that while the increased frequency of spikes in the VIX demonstrates that global factors have become more important, country-specific factors continue to be essential in identifying the impact of those global factors on specific currencies.

Considering the above, there are some country-specific macroeconomic fundamentals that we need to incorporate as control variables into the empirical model (equation 2). These macroeconomic fundamentals are foreign exchange (FX) reserves, inflation rate (CPI), exports to the United States (EXP), imports from the United States (IMP), GDP growth (GDPG), and CA net balance (CA).26

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25 The short-term interest rates of Argentina, Brazil, Japan, Romania, Paraguay, Philippines, Peru, Serbia, Singapore, and Thailand are downloaded from the IMF’s IFS database as money market rates. The rest of sample economies’ short-term interest rate data are downloaded from the OECD’s database as short-term interest rates.

26 FX, EXP, IMP are in U.S. dollars. CA of some economies have negative values, and thus is first-differenced in levels. Short-term interest differentials between countries is first-differenced in levels, because they are already rates. I do not need to take logs of short-term interest differentials since change in natural logs corresponds to percentage change. All the remaining model variables are first-differenced in logs.
FX reserves represent the foreign currency denominated assets that are readily available and controlled by the central bank of the particular country. These external assets include the U.S. dollar value of monetary gold, special drawing rights (SDRs), reserve position in the IMF (the IMF, 2013). FX reserves are obtained from the IMF’s International Reserves and Foreign Currency Liquidity database as foreign currency reserves (in convertible foreign currency).\textsuperscript{27} GDP growth is a measure for output and indicates the economic performance of the particular country. GDP growth data are found in the OECD database.\textsuperscript{28} In addition, log difference in CPI shows the inflation rate, and the data for CPI is sourced from the IMF’s IFS database.\textsuperscript{29}

Exports and imports used in my article indicate the value of goods exported to and imported from the given country into the United States. The main focus of my study is to explain bilateral U.S. dollar exchange rate behavior. For this reason, I only include exports to the U.S. and imports from the U.S. in my data sample.\textsuperscript{30} EXP and IMP data are found in the IMF’s Direction of Trade Statistics webpage. The current account balance measures the net acquisition of foreign assets so that the country is a net borrower when CA is negative. CA data are acquired from the IMF’s Balance of Payments and International Investment Position Statistics webpage.\textsuperscript{31} Table 2, in the Appendix, provides descriptive statistics for the variables that are included in this study.

\textsuperscript{27} FX data for India and Serbia are found in the IMF’s IFS database as official reserve assets (including gold deposits), because these countries do not have data in the IMF’s International Reserves and Foreign Currency Liquidity database.
\textsuperscript{28} Romania’s GDP growth data are downloaded from the Romania National Institute of Statistic’s webpage: http://www.insse.ro/cms/en/content/gross-domestic-product.
\textsuperscript{29} Argentina’s CPI is downloaded from Moody’s database as CPI (2015=100): https://www.economy.com/argentina/consumer-price-index-cpi.
\textsuperscript{30} Those export and import values are free-on-board (FOB) in the U.S. dollar.
\textsuperscript{31} I executed the R studio’s interface to X-13-ARIMA-SEATS software package of the U.S. Census Bureau to obtain final seasonally adjusted series.
Results

Benchmark Results

In this section, I estimate the benchmark equation (2) that I introduced earlier. The proper specification of this model requires that there be no autocorrelation in first-differenced errors. Arellano & Bond’s (1991) test for the serial correlation structure in the errors demonstrates that we reject the null hypothesis of no autocorrelation of order one and fail to reject no autocorrelation of order two. This means that the specified model is appropriate, and the instruments are valid for dynamic panel model regressions, because $E(\epsilon_{i,t}\epsilon_{i,t-1})$ does not need to be zero as the $\epsilon_{i,t}$ are first differences of serially uncorrelated errors. The GMM estimation procedure relies on the assumption that $E(\epsilon_{i,t}\epsilon_{i,t-2}) = 0$, namely the errors are not serially correlated of order two (Arellano & Bond, 1991). Results of auto-correlation tests are under Table 4 in the Appendix.

Table 3, in the Appendix, presents benchmark results of this study. The coefficient on the VIX is positive and significant for both the crisis and the post-crisis period. The positive coefficient on the VIX mean that the USD appreciates when U.S. market uncertainty rises. In other words, the depreciation of non-US currencies against the U.S. dollar are certainly influenced by safe haven behavior. This finding is striking since the US was at the epicenter of the last financial crisis. Consequently, the positive effect of U.S. market uncertainty on the change of the USD exchange rate suggests flight-to-safety phenomenon of foreign investors, and

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32 The recession model incorporates the second and third lagged dependent variables, while the post-recession model includes the second lagged dependent variable as additional regressors. Models that have only the first lagged dependent variable fail to reject no auto-correlation of order two.
repatriation of capital flows to the United States by the U.S. investors during and after the Great Recession.

On the other hand, the coefficient on the VSTOXX is insignificant in the Great Recession and its aftermath. The insignificant coefficient on the VSTOXX implies that the European stock market volatility does not affect the value of the USD. This result is important because, the Euro-area sovereign debt crisis kept uncertainty high while the US was trying to get back to normal terms.

The significant and positive impact of the VIX on the USD supports McCauley & McGuire (2009)’s claims. McCauley & McGuire (2009) argue that the recent financial crisis generated a safe haven demand for the U.S. Treasury bills (considered safe asset), because the U.S. investors and foreign investors wished to decrease risk in their portfolios. For that reason, foreign investors began to get rid of the U.S. corporate bonds while the U.S. investors started to sell foreign bonds and stocks, thus everyone went towards the U.S. T-bills and T-bonds.

The coefficient on non-US economies’ inflation rate is positive and significant for the crisis and post-crisis periods. The positive and significant relationship between the inflation rate and the USD emphasizes the importance of price stability. Therefore, this result suggests that stable exchange rates and price stability cannot be achieved separately.

There is a negative and significant relationship between the change in the spot bilateral exchange rate of the USD and the foreign currency denominated reserves (FX) of non-US countries at time of the Great Recession. The negative and significant coefficient on FX indeed implies that if a country has a high level of foreign reserves, it is more likely to protect its currency from huge depreciations against the USD. The negative and significant effect of FX on
the value of USD is an expected result, which is consistent with the findings of Fratzscher (2009). As Fratzscher (2009) maintains, extreme amounts of FX reserves could be helpful in reducing the pressure on the country’s currencies, since positive FX growth rate is significantly related to the appreciation of the currency vis-à-vis the U.S. dollar.\textsuperscript{33}

My research further shows that GDP growth and the CA of non-US economies play important roles on the behavior of the USD at the time of the Great Recession. The positive and significant impact of non-US GDP growth indicates that better economic performance of a country is related to the depreciation of its currency against the USD during the Great Recession. On the other hand, non-US CA significantly appreciates the U.S. dollar in the recession era. These findings amplify the demand of the USD during the Great Recession so that CA surplus and positive economic growth could not prevent depreciations of non-US currencies against the USD.

The coefficient on imports from the US (IMP) is negative and significant in the crisis era and becomes insignificant in the post-crisis period. To the best of my knowledge, my article is the only study that links the bilateral trade relationship to the USD in the Great Recession. The insignificant trade effect on the USD might be due to the fact that the majority of the current safe haven literature uses total trade balance of countries thereby potentially having the two variables offset each other.\textsuperscript{34}

\textsuperscript{33} Fratzscher (2009) defines extreme FX reserves that exceed what is needed for an economy.

\textsuperscript{34} Fratzscher (2009) incorporates exports to the US and imports from the US into his model, but obtains insignificant results on the coefficients of these trade variables. Following his article, my paper employs the value of exports to the US, and the value of imports from the US. Kohler (2010) reports that short-term interest rate differentials have more explanatory power on crisis-related exchange rate changes in the Great Recession than in the past. Kohler (2010) does not test whether the relationship between the short-term interest rate differential and exchange rate movements changed with the last financial crisis. To see whether a structural change takes place at the time of the Great Recession’s onset, I estimate a structural break model using an F-test (Chow, 1960) following the Hausman-test for fixed-effects vs. random-effects (Hausman, 1978). The results of the random-effect-model show that the
The coefficient on the short-term interest rate differential \((i_{us} - i_{other})\) is insignificant for the crisis period. In addition to the crisis period, carry trade flows do not affect the value of the USD significantly after the last financial crisis as well. I could argue that unwinding carry trade activities do not appear for the crisis period only, because world investors had continued to have some concerns to engage in risky arbitrage opportunities after the Great Recession.\(^{35}\)

Investors’ Choice as Safe Haven

After finding the evidence that the USD serves as a safe haven during the Great Recession and its aftermath, the next step is to consider safe haven instruments (that can be bought and sold in the USD) from the investors’ standpoint. To determine safe haven choice of world investors, the relationship between potential safe haven instruments and the U.S. stock market needs to be analyzed. These safe haven instruments include precious metals (such as gold and silver), and U.S. government treasury bills, notes, and bills. The VIX and VSTOXX futures are also other safe haven alternatives since the purpose of these volatility indices is to make volatility tradable (STOXX, 2018; Whaley, 2009).


\(^{35}\) The coefficient on exports to the US (EXP) is also not significant in both of the recession and post-recession era.

Following Baur & Lucey (2010), Baur & McDermott (2016), and Hood & Malik (2013), my research defines hedge and safe haven assets as follows: A safe haven asset is described as an asset that is negatively correlated with stock returns at the time of extreme stock market declines. By the same token, an asset is identified as a hedge if it is negatively correlated with the stock market return on average.36

To perform comparable analysis to this literature, I employ the following regression

\[ \Delta \text{asset}_{i,t} = \beta_0 + \beta_1 (\Delta S&P_t) + \beta_2 (\Delta Z_t) + \delta_1 * D_{q10} (\Delta S&P_t) + \delta_2 * D_{q5} (\Delta S&P_t) + \delta_3 * D_{q1} (\Delta S&P_t) + \epsilon_t \quad \ldots \quad (3) \]

where \( \Delta \text{asset}_{i,t} \) represents the return of potential safe haven asset, \( \Delta S&P_t \) indicates the U.S. stock market return, \( \Delta Z_t \) is the vector of other potential safe haven assets’ return. Following the literature, I multiply \( \Delta S&P_t \) with dummies which denote extreme negative downturns by

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36 Baur & Lucey (2010), Baur & McDermott (2016), and Hood & Malik (2013) consider their asset definitions as weak and strong alternatives. An asset is classified as a weak safe haven if its return is not affected by the stock returns during extreme stock market downturns. I do not mention about the weak safe haven and hedge potential of these assets and limit myself to strong ones, because I try to find assets that are negatively correlated with the stock market return.
calculating the first, five, and ten-percentage-quantiles of the S&P 500 Index’s return. For instance, $D_{q5}$ equals 1 if the U.S. stock market return is less than the five-percentage-quantile of the return distribution of the S&P 500.

The potential safe haven assets considered in this study are gold and silver as precious metals; VIX and VSTOXX futures; three-month and one-year U.S.\footnote{VIX and VSTOXX futures offer investors to be able to trade pure volatility by showing the stock market’s future estimated values of these volatility indices.} T-Bill; three-year, five-year, and ten-year U.S. T-Note; and twenty-year U.S. T-Bond. All Treasury bill, note, and bonds are the first-difference in levels.\footnote{I apply Breusch & Pagan’s (1979) heteroskedasticity test and estimate the above regression with robust standard errors if heteroskedasticity is present. I present heteroscedasticity test results under Table 7 in the Appendix. I find that I reject the null hypothesis of homoskedasticity for gold and silver. I show that there is homoskedasticity of all error variances for the VIX and VSTOXX futures; 3-month and 1-year T-Bill; 3-year, 5-year, and 10-year T-Note; 20-year T-Bond.} VIX, VSTOXX, gold and silver futures’ prices are first-differenced in logarithmic forms. As a consequence, significant and negative $\beta_1$ implies that the asset is a hedge, whereas an asset is safe haven if one or more deltas become negative and significant.\footnote{Gold price data is acquired from World Gold Council’s webpage: https://www.gold.org/data/gold-price. Silver price data is found at the Investing.com’s webpage: https://www.investing.com/commodities/silver. The data for U.S. government treasuries is sourced from the Federal Reserve Bank of St. Louis.}

I employ monthly data from March 2003 to December 2016 to estimate the above regression (3). Table 6, in the Appendix, presents the results of investors’ safe haven choices, and denotes that gold does not qualify as a safe haven, but instead becomes a hedge. The VSTOXX futures is a safe haven choice if the U.S. stock market return shows extreme negative returns less than the first-percentage-quantile of its return distribution. The VSTOXX futures are qualified as a hedge against the S&P 500 Index. On the contrary, the VIX futures are only a hedge against the U.S. stock market on average. The one-year T-bill, five-year T-Note and twenty-year T-Bond are other safe haven possibilities for investors if the S&P 500 Index...
performs lower return than the first-percentage-quantile of its return distribution. The 3-months T-bill is considered as another safe haven if the U.S. stock market return is lower than the five-percentage quantile of the return distribution of S&P 500 Index. Additionally, the twenty-year T-Bond is also a hedge against the U.S. stock market.

Conclusion

The Great Recession led to unexpected exchange rate fluctuations with the sharp appreciation of the U.S. dollar, and a reversal of that appreciation within a year. My research demonstrates that safe haven behavior is the most consistent and significant explanatory indicator for the USD before, during and after the Great Recession. The findings of my article are consistent with flight-to-safety behavior of world investors, because the U.S. stock market uncertainty has a significant and consistent role on the appreciation of the U.S. dollar (USD) since the start of the Great Recession. Furthermore, the Euro-area stock market uncertainty has no significant impact on the value of the USD although the Euro-area sovereign debt crisis was still the major source of uncertainty when the U.S. economy started to recover from the Great Recession. This result amplifies the safe haven currency status of the USD and denotes that the United States offers the best possible solution even though problems are U.S. sourced.

To determine the investors’ ultimate choice safe haven asset (spanning the period from March 2003 to the end of 2016), I examined the potential safe haven role of gold, silver, the US T-bill, T-note, and T-bond at different times to maturity. As a consequence, the 1-year T-bill, the 5-year T-note, the 20-year T-bond are considered to be as the strongest safe haven instruments when the S&P 500 Index’s return is below than the first-percentage-quantile of its return distribution. In addition, world investors considered the 3-months T-bill as yet another safe
haven asset when the U.S stock market performs lower than the five-percentage-quantile of the S&P 500 Index return distribution.

Yet, foreign assets of the non-US economies that are proxied by the growth in their foreign currency denominated exchange reserves is also an important shelter from the huge depreciations of a country’s currency vis-à-vis USD during the Great Recession. Having implied the interconnection between the price and exchange rate stability, my article further shows that increases in the inflation rate significantly appreciate the USD.
References


Appendix A. The VIX Calculation

The VIX calculation is as follows:

\[
\sigma^2 = \frac{2}{T} \sum i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T} \left[ \frac{F}{K_0} - 1 \right]^2
\]

where

- \(\sigma\) is VIX/100 so that VIX = \(\sigma \times 100\),
- \(T\) is the time to expiration and calculated as minutes remaining S&P 500 Index expirations divided to total minutes in a year,
- \(F\) is forward at-the-money price desired from the S&P 500 Index option prices,
- \(K_0\) is first strike below the forward index level (F), \(K_i\) is highest strike price of the \(i\)th out-the-money option from the S&P 500 puts and calls. A call if \(K_i > K_0\); and a put if \(K_i < K_0\); both put and call if \(K_i = K_0\). \(\Delta K_i = \frac{K_{i+1} - K_{i-1}}{2}\) in which \(\Delta K\) for the lowest strike is simply the difference between the lowest strike and the next higher strike.

Equivalently, \(\Delta K\) for the highest strike is the difference between the highest strike and the next lower strike. Thus, \(\Delta K\) is half the distance between the two strikes adjacent to \(K\).
- \(R\) is the risk-free interest rate to expiration (refinancing factor),
- \(Q(K_i)\) is the midpoint of the bid-ask spread for each option with strike \(K_i\).

Notes: Source is CBOE (2015) and CBOE (2017).
APPENDIX B
Appendix B. The VSTOXX Calculation

The VSTOXX calculation is as follows:

\[
\sigma_i^2 = \frac{2}{T} \sum_j \frac{\Delta K_{i,j}}{K_{i,j}^2} e^{R_i T} M_{K_{i,j}} - \frac{1}{T} \left[ \frac{F_i}{K_{i,0}} - 1 \right]^2
\]

where

- \( \sigma \) is VSTOXX/100 so that VSTOXX = \( \sigma \times 100 \),
- \( T \) is the time to expiration and equals to calculated as seconds remaining EURO STOXX 50 Index expirations divided to total seconds in a year,
- \( F_i \) is forward at-the-money price for the ith EURO STOXX 50 option’s expiration,
- \( K_0 \) is highest strike price below the forward index level (F), \( K_i \) is strike price of the ith out-the-money option from the S&P 500 puts and calls. A call if \( K_i > K_0 \); and a put if \( K_i < K_0 \); both put and call if \( K_i = K_0 \). \( \Delta K_i \) = \( \frac{K_{i+1} - K_{i-1}}{2} \) in which \( \Delta K \) for the lowest strike is simply the difference between the lowest strike and the next higher strike. Equivalently, \( \Delta K \) for the highest strike is the difference between the highest strike and the next lower strike. Thus, \( \Delta K \) is half the distance between the two strikes adjacent to \( K \).
- \( R \) is the risk-free interest rate to expiration (refinancing factor). \( M_{K_{i,j}} \) is the inclusion price with strike \( K_i \) whereas \( M_{K_{i,0}} \) indicates the midpoint of put and call prices of the option with strike \( K_i \).

Notes: Source is STOXX (2018).
Appendix C. Plots and Main Results

Figure 1. Plot of the VIX & VSTOXX

Notes: The mean spread of the VSTOXX and the VIX is 2.51 volatility points. This spread is the subtraction of the VSTOXX from the VIX in logarithmic forms.
Figure 2. Plot for exchange rate of Canada and Sweden

Notes: The left-axis represents the country’s home currency price per the U.S. dollar (national currency/USD rate) ($s_i$).
Figure 3. Plot for exchange rate of Indonesia and South Korea

Notes: The left-axis represents the country’s home currency price per the U.S. dollar (national currency/USD rate) ($s_i$).
Figure 4. Plot for exchange rate of South Africa and Chile

Notes: The left-axis represents the country’s home currency price per the U.S. dollar (national currency/USD rate) \( (s) \).
<table>
<thead>
<tr>
<th>Country Sample of Essay One</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albania *</td>
</tr>
<tr>
<td>Argentina</td>
</tr>
<tr>
<td>Australia</td>
</tr>
<tr>
<td>Brazil</td>
</tr>
<tr>
<td>Canada</td>
</tr>
<tr>
<td>Chile</td>
</tr>
<tr>
<td>Colombia *</td>
</tr>
<tr>
<td>Czechia</td>
</tr>
<tr>
<td>Denmark</td>
</tr>
<tr>
<td>the Euro-area</td>
</tr>
<tr>
<td>Hungary *</td>
</tr>
<tr>
<td>Iceland</td>
</tr>
<tr>
<td>India *</td>
</tr>
<tr>
<td>Indonesia *</td>
</tr>
<tr>
<td>Israel</td>
</tr>
<tr>
<td>Japan</td>
</tr>
<tr>
<td>South Korea *</td>
</tr>
<tr>
<td>Malaysia *</td>
</tr>
<tr>
<td>Mexico</td>
</tr>
<tr>
<td>New Zealand</td>
</tr>
<tr>
<td>Norway</td>
</tr>
<tr>
<td>Peru *</td>
</tr>
<tr>
<td>Philippines</td>
</tr>
<tr>
<td>Poland</td>
</tr>
<tr>
<td>Romania *</td>
</tr>
<tr>
<td>Russia *</td>
</tr>
<tr>
<td>Serbia *</td>
</tr>
<tr>
<td>Singapore</td>
</tr>
<tr>
<td>South Africa</td>
</tr>
<tr>
<td>Sweden</td>
</tr>
<tr>
<td>Switzerland</td>
</tr>
<tr>
<td>Thailand</td>
</tr>
<tr>
<td>the United Kingdom</td>
</tr>
</tbody>
</table>

Notes: * countries are excluded from the structural break analysis due to data availability before 2007.
Table 2. Summary Statistics of Essay One

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD exchange rate</td>
<td>1.284</td>
<td>1.113</td>
<td>-0.031</td>
<td>4.141</td>
</tr>
<tr>
<td>CBOE’s Volatility Index</td>
<td>1.292</td>
<td>0.149</td>
<td>1.097</td>
<td>1.753</td>
</tr>
<tr>
<td>EURO STOXX Volatility Index</td>
<td>1.388</td>
<td>0.122</td>
<td>1.204</td>
<td>1.75</td>
</tr>
<tr>
<td>Interest rate differentials</td>
<td>-3.557</td>
<td>4.175</td>
<td>-34.877</td>
<td>4.932</td>
</tr>
<tr>
<td>CA Balance</td>
<td>2,126,944</td>
<td>15,543,349</td>
<td>-45,909,406</td>
<td>112,903,615</td>
</tr>
<tr>
<td>Foreign exchange reserves</td>
<td>4.525</td>
<td>1.08</td>
<td>-3.087</td>
<td>6.087</td>
</tr>
<tr>
<td>Inflation Rate</td>
<td>0.004</td>
<td>0.005</td>
<td>-0.014</td>
<td>0.059</td>
</tr>
<tr>
<td>Exports to the US</td>
<td>3.327</td>
<td>0.905</td>
<td>0.021</td>
<td>4.988</td>
</tr>
<tr>
<td>Imports from the US</td>
<td>3.233</td>
<td>0.835</td>
<td>0.766</td>
<td>4.899</td>
</tr>
<tr>
<td>GDP Growth</td>
<td>0.738</td>
<td>1.246</td>
<td>-7.55</td>
<td>8.828</td>
</tr>
</tbody>
</table>

Notes: All my model variables are in logs except short-term interest rate differentials and current account balance of sample economies. Foreign exchange reserves and current account balance are in thousands of U.S. dollars.
Table 3. Benchmark Results of the Essay One’s Dynamic Panel Model

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Lagged dependent variable</td>
<td>0.607 (0.001) *</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Lagged dependent variable</td>
<td>-0.346 (0.001) *</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Lagged dependent variable</td>
<td>0.13 (0.002) *</td>
</tr>
<tr>
<td>VIX</td>
<td>0.096 (0.004) *</td>
</tr>
<tr>
<td>VSTOXX</td>
<td>0.52 (0.154)</td>
</tr>
<tr>
<td>FX</td>
<td>-0.065 (0.044) *</td>
</tr>
<tr>
<td>Interest rate differentials</td>
<td>0.001 (0.998)</td>
</tr>
<tr>
<td>CPI</td>
<td>0.806 (0.001) *</td>
</tr>
<tr>
<td>GDPG</td>
<td>0.002 (0.021) *</td>
</tr>
<tr>
<td>EXP</td>
<td>-0.003 (0.912)</td>
</tr>
<tr>
<td>IMP</td>
<td>-0.063 (0.005) *</td>
</tr>
<tr>
<td>CA</td>
<td>0.001 (0.028) *</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.577 (0.061) *</td>
</tr>
</tbody>
</table>

Notes: The table shows the coefficient estimates and the p-values in the parenthesis. * indicates statistical significance at the 5% level.
Table 4. Auto-correlation Test Results for Benchmark Model of Essay One (Equation 2)

<table>
<thead>
<tr>
<th>Autocorrelation Test Order</th>
<th>p-value for the recession era</th>
<th>p-value for the post-recession era</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Order 1</td>
<td>&lt;0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Test Order 2</td>
<td>0.755</td>
<td>0.152</td>
</tr>
<tr>
<td>Test Order 3</td>
<td>0.968</td>
<td>0.153</td>
</tr>
<tr>
<td>Test Order 4</td>
<td>0.194</td>
<td>0.312</td>
</tr>
</tbody>
</table>

Notes: Due to the inclusion of the second and third lagged dependent variables, we have to test the hypothesis of no auto-correlation of order 3 and 4 (addition to order 2)
Table 5. Results for the Structural Break Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIX</td>
<td>0.01</td>
<td>(0.424)</td>
</tr>
<tr>
<td>FX</td>
<td>-0.057 *</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>Interest Rate Differentials</td>
<td>-0.001</td>
<td>(0.542)</td>
</tr>
<tr>
<td>CPI</td>
<td>1.417 *</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>GDPG</td>
<td>-0.003 *</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>EXP</td>
<td>-0.054 *</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>IMP</td>
<td>-0.034 *</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>CA</td>
<td>0.001</td>
<td>(0.111)</td>
</tr>
<tr>
<td>Break Dummy</td>
<td>0.003 *</td>
<td>(0.005)</td>
</tr>
<tr>
<td>Break Dummy*VIX</td>
<td>0.087 *</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>Break Dummy*Interest Rate Differentials</td>
<td>-0.001</td>
<td>(0.972)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.741 *</td>
<td>(0.005)</td>
</tr>
</tbody>
</table>

F-test for Break Dummies: \( H_0 : \delta_1 = \delta_2 = \delta_3 = 0 \)
\[ H_1 : \text{at least one of them not zero} \]

Results for F-test: \( F(3, 58) = 13.11 \) \( (F_{critical} = 2.79) \) \( p\text{-value} = <0.001 \)

Notes: This table presents the results of the regression of model variables and structural break dummies on bilateral USD exchange rate return (national currency/USD rate). I define structural break dummies as taking value of one after the Great Recession (zero otherwise). * indicates statistical significance at the 5% level. Economies included in this model are Argentina, Australia, Brazil, Canada, Chile, Czechia, Denmark, the Euro area, Iceland, Israel, Japan, Mexico, New Zealand, Norway, Philippines, Singapore, South Africa, Sweden, Switzerland, Thailand and the UK.
Table 6. Results for the Investors’ Choice as Safe Haven Analysis of Essay One (Equation 3)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hedge</th>
<th>Safe haven at the 1% quantile</th>
<th>Safe haven at the 5% quantile</th>
<th>Safe haven at the 10% quantile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Safe Haven Asset</td>
<td>S&amp;P 500 Coefficient Estimate (p-value) – β₁</td>
<td>Stock Return * Dummy Quantile at the 1% - δ₁</td>
<td>Stock Return * Dummy Quantile at the 5% - δ₂</td>
<td>Stock Return * Dummy Quantile at the 10% - δ₃</td>
</tr>
<tr>
<td>Gold</td>
<td>-0.003 (0.981)</td>
<td>-0.025 (0.06)</td>
<td>-0.001 (0.903)</td>
<td>0.011 (0.07)</td>
</tr>
<tr>
<td>Silver</td>
<td>0.264 (0.256)</td>
<td>0.029 (0.239)</td>
<td>-0.002 (0.886)</td>
<td>-0.008 (0.514)</td>
</tr>
<tr>
<td>VIX Futures</td>
<td>-1.515 * (&lt;0.001)</td>
<td>-0.03 (0.533)</td>
<td>-0.03 (0.262)</td>
<td>0.015 (0.525)</td>
</tr>
<tr>
<td>VSTOXX Futures</td>
<td>-2.749 * (0.004)</td>
<td>-0.135 * (0.01)</td>
<td>0.002 (0.945)</td>
<td>-0.033 (0.204)</td>
</tr>
<tr>
<td>3-months T-Bill</td>
<td>-0.035 (0.959)</td>
<td>0.18 * (0.012)</td>
<td>-0.099 * (0.018)</td>
<td>0.031 (0.374)</td>
</tr>
<tr>
<td>1-year T-Bill</td>
<td>0.301 (0.505)</td>
<td>-0.098* (0.04)</td>
<td>0.052 (0.06)</td>
<td>-0.02 (0.399)</td>
</tr>
<tr>
<td>3-year T-Note</td>
<td>-0.16 (0.547)</td>
<td>0.018 (0.524)</td>
<td>0.007 (0.66)</td>
<td>-0.013 (0.35)</td>
</tr>
<tr>
<td>5-year T-Note</td>
<td>-0.121 (0.503)</td>
<td>-0.04 * (0.032)</td>
<td>-0.005 (0.593)</td>
<td>0.009 (0.341)</td>
</tr>
<tr>
<td>10-year T-Note</td>
<td>0.384 * (0.02)</td>
<td>0.06 ** (&lt;0.001)</td>
<td>0.006 (0.562)</td>
<td>-0.005 (0.519)</td>
</tr>
<tr>
<td>20-year T-Bond</td>
<td>-0.79 * (0.006)</td>
<td>-0.084* (0.005)</td>
<td>-0.013 (0.461)</td>
<td>0.004 (0.790)</td>
</tr>
</tbody>
</table>

Notes: This table shows the results for regression of particular potential safe haven assets on the return on S&P 500 Index, safe haven dummies, and other potential safe haven assets. These safe haven dummies represent extreme negative stock market returns less than 1.5, and 10-percent-quantile of the S&P 500 Index’s return distribution. ** denotes that the safe haven instrument is a diversifier asset.
Table 7. Breusch & Pagan’s (1979) Heteroskedasticity Test Results of Essay One (Equation 3)

<table>
<thead>
<tr>
<th>Dependent Variable – Potential Safe Haven Asset ($\Delta asset_{i,t}$)</th>
<th>p-value for the Heteroskedasticity Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>0.25</td>
</tr>
<tr>
<td>Silver</td>
<td>0.281</td>
</tr>
<tr>
<td>VIX Futures</td>
<td>0.003</td>
</tr>
<tr>
<td>VSTOXX Futures</td>
<td>0.05</td>
</tr>
<tr>
<td>3-Month Bond</td>
<td>0.002</td>
</tr>
<tr>
<td>1-Year Bond</td>
<td>0.021</td>
</tr>
<tr>
<td>3-Year Bond</td>
<td>0.007</td>
</tr>
<tr>
<td>5-Year Bond</td>
<td>0.008</td>
</tr>
<tr>
<td>10-Year Bond</td>
<td>0.001</td>
</tr>
<tr>
<td>20-Year Bond</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Test Hypothesis: $H_0$ : The error variances are all equal (homoscedasticity)

$H_1$ : The error variances are not equal (heteroscedasticity)
CHAPTER III

IS THE EURO A SAFE HAVEN CURRENCY?

This research analyzes euro exchange movements against thirty-three currencies during and after the Great Recession. In particular, I study the performance of the euro regarding its potential safe haven status against thirty-three currencies at the time of the last financial crisis and its aftermath.\(^{40}\) In the spirit of Kaul & Sapp (2006) and Habib & Stracca (2012), my paper describes the euro as a safe haven currency when it serves as a hedge with respect to market uncertainty. World investors seek to buy potential safe haven assets because their attractiveness relative to other assets increases while market uncertainty climbs (Kohler, 2010). My study reveals that the euro qualifies as a safe haven currency after the Great Recession, when uncertainty originates in the United States (and is not sourced from the Euro area). However, if uncertainty originates in the Euro area, global investors do not opt for the euro as a safe haven.

The EURO STOXX 50 Volatility Index (VSTOXX) and the Chicago Board Options Exchange Volatility Index (VIX) are market uncertainty variables for my study. The VSTOXX reveals market expectations of future fluctuations in the European stock market because this index is constructed as a futures instrument for the Euro-area stock market volatility (STOXX, 2018; Whaley, 2009).\(^{41}\) The Stoxx Strategy Index Guide (Stoxx, 2018) states, “This is not achieved through direct replication of volatility, but rather of variance” (p.26). The VSTOXX

\(^{40}\) These are the currencies of Albania, Argentina, Australia, Brazil, Canada, Chile, Colombia, Czechia, Denmark, Hungary, Iceland, India, Indonesia, Israel, Japan, South Korea, Malaysia, Mexico, New Zealand, Norway, Peru, Philippines, Poland, Romania, Russia, Serbia, Singapore, South Africa, Sweden, Switzerland, Thailand, the UK, and the US.

\(^{41}\) Whaley (1993) examines the purpose and history of the VIX and states that the volatility index level equals the volatility futures price.
reflects the implied volatility\textsuperscript{42} of the EURO STOXX 50 Index by replicating the variance of all eligible EURO STOXX 50 options over a future time horizon (Stoxx, 2018).\textsuperscript{43}

Following Habib & Stracca (2012) and Fatum & Yamamoto (2016), I also use the VIX as an indicator of market uncertainty. The current literature (e.g. Fratzscher 2009; Habib & Stracca 2012; Fatum & Yamamoto 2016) only incorporate the VIX in their models. However, the researcher needs to incorporate the VSTOXX and VIX in the same model to more completely assess whether the euro is a safe haven currency. The Chicago Board Options (CBOE) (2015) states that the VIX calculates the implied volatility of the S&P 500 Index. The VIX and VSTOXX are calculated in comparable ways, one simply referring to the U.S. stock market and the other referring to the European stock market.\textsuperscript{44} Nevertheless, the VIX and VSTOXX might contain different information, because these volatility indicators are not reflective of the same markets. This is borne out by the plots of the two indexes over the same period in Figure 5 (in the Appendix). Figure 5 suggests the existence of different information sets using the VSTOXX/VIX spread, which is computed by subtracting the VSTOXX from the VIX in logs. The mean spread of the VIX and VSTOXX is 2.51 volatility points. Figure 5 further demonstrates different sources of market uncertainty as the VSTOXX/VIX spread seems to reflect. Different information contained in these volatility indices, in turn, may be useful to explain exchange rate behavior.

\textsuperscript{42}Implied volatility denotes expected volatility return in a stock that is obtained from an option-pricing model by using time to expiration, the difference between actual price and strike price of a stock, and a risk-free interest rate. Implied volatility is an important indicator by which global investors could forecast future fluctuations of the price of a security.

\textsuperscript{43}The S&P 500 and EURO STOXX 50 indices show the performance of the largest corporations in terms of free-float market capitalization. The S&P 500 Index includes stocks of 500 companies, whereas the EURO STOXX 50 Index contains the largest 50 companies in 11 original members of the Euro-area. These countries are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. Both of these volatility indices use free-float market cap methodology in which large corporations get higher weighting.

\textsuperscript{44}I further explore the detailed calculation of these volatility indices in the Appendix (Appendix A & B).
Hence, the VIX and VSTOXX, as volatility indices, are crucial variables embodied in the main hypotheses of interest for my research, since researchers might utilize them to identify safe haven behavior. The VIX and VSTOXX provide us with the ability to detect safe haven flows by allowing how the exchange rates respond to these indicators of future volatility. For instance, if an increase in the VSTOXX (or in the VIX) is associated with an appreciation of the euro, then this implies that the euro is a safe haven currency.

To counter the dominant power of United States and become a world economic contender, countries in Europe strove to come together and produce a common currency that could compete with the U.S. dollar (Krugman et al., 2012). In 1999, this currency was born—the Euro.\(^{45}\) Does the euro behave like the U.S. dollar in terms of offering a safe haven option? In the first essay of this dissertation, I studied the U.S. dollar and found that global investors choose the U.S. dollar as a safe haven currency even though volatility from the Great Recession originated in the US. The existing literature specifies that the euro, the U.S. dollar, the Japanese yen, the Great Britain pound, and the Swiss franc are possible safe-haven currency candidates (Fatum et al., 2017). However, this safe haven literature misses testing the safe haven status of the euro. To determine whether the euro is a safe haven, I use the Great Recession and European sovereign debt crisis as important time periods when there was extreme market uncertainty.\(^{46}\) Therefore, my study tests the safe haven hypothesis for the euro during these highly uncertain time periods.

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\(^{45}\) Having specified conditions to join the Euro area (five convergence criteria) in 1992, the Maastricht Treaty imposed the attainment of stable national nominal exchange rate within the European Monetary System as one of these convergence criteria. In 1999, the euro was officially in the financial market as the common Euro-area currency.

\(^{46}\) Vause & von Peter (2011) argue that Euro-area was facing high pressure on the Euro-area sovereign bond yields with high debt burdens because of weak European economic performance and policy uncertainty. At the same time throughout 2011, the US was exiting from the Great Recession. The European sovereign debt crisis is another time episode that gives us an opportunity to test for safe haven flows.
Literature Review

The existing safe haven literature can be separated into two types of studies. One group of studies use high-frequency data and the other uses low-frequency data. High-frequency data is defined as data at shorter than monthly time intervals (such as daily data). Low-frequency data is defined as data at monthly or longer than monthly time intervals (e.g. quarterly data). Fatum & Yamamoto (2016), Hossfeld & MacDonald (2015), and Ranaldo & Soderling (2010) are important examples of studies that use high-frequency data. They use the Chicago Board Options Exchange Volatility Index (VIX) as the major indicator of market uncertainty. The authors using high-frequency data compare the performance of conventionally assumed safe-haven currencies against one another to be able to decide which of these currencies serve as a hedge during times of crisis. If a currency is a safe haven, we would expect to see that its value appreciates vis-à-vis the others as investors move from assets that are riskier into less risky ones (the safe havens). These articles explore different threshold values to distinguish periods of high versus low uncertainty. The purpose of these researchers is to analyze the relationship between the VIX and the exchange rate (a reflection of safe haven flows into a currency) and in particular whether those presumed flows hinge upon a specific level of market uncertainty.

Fatum & Yamamoto (2016) analyze safe haven flows between the US, Euro area, the UK, Japan, Switzerland, Canada, and Sweden before, during, and after the Great Recession. These authors examine the exchange rate of these economies against the U.S. dollar (USD) and show that the Swiss franc and yen significantly appreciate vis-à-vis the USD at the time of the Great Recession. Having endogenously specified market uncertainty thresholds, their non-linear analysis reveals that the yen appreciates as market uncertainty rises regardless of the VIX threshold, while the relationship between VIX and other bilateral USD rates seems to be non-
linear. For this reason, Fatum & Yamamoto (2016) conclude that the yen is the best safe haven currency out of these conventionally-assumed safe havens. Fatum et al. (2017) apply the same methodology to investigate the relationship between market uncertainty and the relative value of the Chinese renminbi against the U.S. dollar, the yen, the euro, the pound, and the Swiss franc from February 28, 2011 to April 30, 2016. Fatum et al. (2017) maintain that the Chinese renminbi depreciates against the U.S. dollar (USD) as uncertainty rises. This implies that the Chinese currency is not safer than the USD and the yen, because Fatum et al. (2017) show that the Chinese renminbi depreciates against the USD and the yen when uncertainty rises. Fatum et al. (2017) also find that the renminbi appreciates against the euro and the pound while uncertainty increases. The authors, thus, conclude that the USD and the yen are the safest currencies and the renminbi comes next. According to Fatum et al.’s (2017) results, the euro and the pound are the least safe currencies in their dataset.

Ranaldo & Soderling (2010) use the same approach as Fatum & Yamamoto (2016) and investigate the euro, yen, and pound against the USD from January 1993 to December 2008. However, this study incorporates more determinants of exchange rates like a carry trade channel47 and different risk variables.48 The authors argue that the euro, Swiss franc, and yen appear to have safe haven properties while the pound does not.

Hossfeld & MacDonald (2015) investigate which G10 currencies might be evaluated as safe havens. This article uses the Modern Index Strategy (MSCI) world index as the stock market

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47 Carry trade refers to an interest arbitrage opportunity for investors on account of opportunity to borrow in the low interest rate currency and lend in the high interest rate currency.
48 Ranaldo & Soderling (2010) employ the VIX, the TED spread, and foreign exchange volatility as their risk variables. The TED spread is the difference between the USD LIBOR rate and the T-bill rate. Foreign exchange volatility is the first principal component of the realized volatilities of bilateral USD exchange rates in their logarithmic forms. The authors conclude that foreign exchange volatility and the VIX (for the yen only) are significant risk variables in their analysis.
return for the period of January 1986 to September 2012. Hossfeld & MacDonald (2015) determine market uncertainty thresholds from the old version VIX (the VXO)\textsuperscript{49} and also employ carry trade as another regressor as Ranaldo & Soderling (2010) did.\textsuperscript{50} Hossfeld & MacDonald’s findings (2015) are that the USD and the Swiss franc are the only currencies to qualify as safe havens when all of the G10 currencies are considered.

In the literature that studies safe haven behavior and employs low-frequency data, a monthly or quarterly market uncertainty indicator along with macroeconomic fundamentals are used to explain safe haven behavior. Fatum et al. (2017) claim that there is no consensus as to what variables can be used to identify a safe haven currency. Nonetheless, the current safe haven literature analyzes a wide range of macroeconomic indicators to explain safe haven currency behavior but mainly investigates whether the USD is a safe haven. Fratzscher (2009), Kohler (2010), and Habib & Stracca (2012) are important examples in the safe haven literature that uses low-frequency data.

Fratzscher (2009) analyzes the USD vis-à-vis 54 currencies during 2008 and 2009 in a cross-sectional regression model. Having measured all model variables prior to the Great Recession, Fratzscher (2009) demonstrates that the USD significantly appreciates against the currencies of countries which have higher financial liabilities to the US, larger current account (CA) deficits, and fewer foreign currency denominated assets.

Habib & Stracca (2012) explore the fundamental determinants of being a safe haven currency by including the MSCI world stock market index like Hossfeld & MacDonald (2015)

\textsuperscript{49} The VIX data is available after January 1990, whereas the VXO data starts at January 1986. The VXO is based on the S&P 100 Index.

\textsuperscript{50} Carry trade is an arbitrage opportunity in which a global investor borrows in the low interest rate currency (funding currency) and lends in the high interest rate currency (target currency).
do. These authors study 51 bilateral exchange rates against the USD from January 1986 to December 2009. As Hossfeld & MacDonald (2015) point out, a drawback to Habib & Stracca’s (2012) analysis is dependent on data interpolation methods due to the unavailability of their model variables at the monthly frequency. Habib & Stracca’s (2012) findings reveal that the net foreign asset position is the most consistent predictor of safe haven status, due to the positive and significant coefficient on the bilateral USD exchange rate in periods of high global uncertainty (in all their model specifications).

Kohler (2010), instead, researches the last major financial crises, namely the Asian crisis, the Russian debt default, and the Great Recession. This paper presents exchange rate returns of 33 currencies against the Japanese yen during the two-month period after the start of a given crisis period. Kohler (2010) compares exchange rate correlation to the average short-term contemporaneous interest rate and the average short-term interest rates in the previous six months. This article concludes that short-term interest rate differentials have more impact on exchange rate behavior at the time of the Great Recession than during the other previous three crises.

There are two important conclusions from the safe haven literature. First, the current literature concludes that the USD is a safe haven currency regardless of the frequency of the data. Some of the studies evaluating whether the euro, the yen, and the Swiss franc serve as safe havens find that these currencies might serve as safe haven currencies. However, the results are weak for the euro providing motivation for further exploration of the safe haven properties of the euro. A second conclusion follows from this literature review. The VIX, CA, foreign exchange reserves, the net foreign asset position (NFA) are the most commonly employed variables used to test safe haven hypothesis for currencies.
My research contributes to the safe haven literature in a couple of ways. To the best of my knowledge, there is no research that has explored the euro safe haven hypothesis during the Great Recession and its aftermath. The Great Recession and the European sovereign debt crisis are both important and alternative sources of uncertainty to judge the safe haven status of the euro given the greater number of sources of uncertainty. My research further includes the volatility index for the European stock prices (VSTOXX) as a market uncertainty indicator for the Euro-area. It serves as an additional source of information. Using the VSTOXX and VIX in the same model has not been employed to date in the safe haven literature. I also investigate the ultimate safe haven preference of global investors by using a large set of potential safe haven instruments including gold. I follow Baur & Lucey (2010), Baur & McDermott (2016), and Hood & Malik (2013) to determine the safe haven instrument choices of world investors, but I also incorporate the VSTOXX futures as another potential safe haven instrument.

Data & Model

My research employs quarterly and seasonally adjusted data from January 2007 to December 2016. To obtain my sample of countries, I consider including all OECD countries and some emerging market countries. I incorporate the nineteen members of the Euro area as a single entity. I then exclude several countries from the original set of OECD plus emerging market countries depending on number of criteria. My first criteria for keeping an economy in

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51 The current account balance and GDP growth data are available at quarterly basis and not at monthly frequency.
52 The data I obtain is not seasonally adjusted with the exception of the GDP growth and short-term interest rate differentials. The data for GDP growth is available as seasonally adjusted at the OECD’s database. I used the R studio’s interface of X-13-ARIMA-SEATS software package of the U.S. Census Bureau to seasonally adjust the data requiring seasonal adjustment.
53 The emerging market economies that I consider for inclusion are Argentina, Brazil, Chile, China, Colombia, Costa Rica, Czechia, Egypt, Guyana, Hungary, India, Indonesia, Israel, Jamaica, South Korea, Lebanon, Malaysia, Mexico, Paraguay, Peru, Poland, Philippines, Qatar, Romania, Russia, Senegal, South Africa, Thailand, Trinidad & Tobago, Turkey. I excluded China, Costa Rica, Egypt, Guyana, Jamaica, Paraguay, Qatar, Senegal, and Trinidad & Tobago, Turkey because the required data is not available.
the sample is determining that it maintains a floating exchange rate regime. I used the IMF’s
(2017) de facto exchange rate classification to ascertain the exchange rate system in place. I
eliminated countries which maintain a hard peg exchange rate, exchange arrangement with no
separate legal tender (e.g. countries that are dollarized) and currency boards. I keep in the sample
economies that have a soft peg exchange rate regime. My final sample contains thirty-three
countries that satisfy the conditions described above and for which data are available. The
complete list of country/country areas in my sample is listed in the Appendix in Table 8.

According to the Federal Reserve Bank of St. Louis’ financial crisis timeline, I classify
the period from January 2007 to the end of March 2011 as the recession period, and from April
2011 to December 2016 as the post-recession period.\textsuperscript{54} I estimate exchange rate behavior during
the recession and the post-recession periods separately.

To test the hypothesis that the euro is a safe haven, I formulate the baseline empirical
model as

\[ s_{i,t} = \beta_0 + \beta_1 (s_{i,t-1}) + \beta_2 (VSTOXX_t) + \beta_3 (VIX_t) + \beta_4 (i^{\text{euro}}_t - i^{\text{other}}_t) + \beta_5 (Z_{i,t}) + \alpha_i + u_{i,t} \ldots (1) \]

where \( \alpha_i \) represents individual (country panel) heterogeneity and \( s_{i,t-1} \) is the lagged dependent
variable. This model is inappropriate because \( \alpha_i \) and \( s_{i,t-1} \) are not independent which leads to
biased and inefficient least-squares estimation results.\textsuperscript{55} I, then, use a first-difference model and
estimate the following first-difference benchmark model as

\[ \Delta s_{i,t} = \beta_0 + \beta_1 (\Delta s_{i,t-1}) + \beta_2 (\Delta VSTOXX_t) + \beta_3 (\Delta VIX_t) + \beta_4 \Delta (i^{\text{euro}}_t - i^{\text{other}}_t) + \beta_5 (\Delta Z_{i,t-1}) + \epsilon_{i,t} \ldots (2) \]

\textsuperscript{54} https://www.stlouisfed.org/financial-crisis.
\textsuperscript{55} The least-square estimation technique is not suitable because \( E(\alpha_i | s_{i,t-1}) \neq 0. \)
where $\Delta$ represents the first difference ($\Delta s_{i,t-1} = s_{i,t-1} - s_{i,t-2}$), and thus $\Delta s_{i,t-1}$ is the first-difference in the log of nominal bilateral exchange rate, where the exchange rate is defined as the foreign currency price of the euro. The notation, $\Delta VSTOXX_t$, is the first-difference in the log of the EURO STOXX 50 Volatility Index. $\Delta VIX_t$ is computed as the first-difference in the log of the Chicago Board Options Exchange Volatility Index. $\Delta (i^{\text{euro}}_t - i^{\text{other}}_t)$ measures the short-term interest rate differential for the euro and the foreign currency, $\Delta Z_{i,t}$ represents a vector of macroeconomic fundamentals, and $\epsilon_{i,t}$ is the error term. All of the data in this model are first-differenced in logs except the short-term interest rate differentials and current account balance of the countries, which are first-differenced in levels.\(^{56}\)

Following the literature, I include the lagged dependent variable as another regressor and estimate equation (2) as a dynamic panel model. To estimate equation (2), a valid instrumental variable (IV) is needed for the lagged dependent variable because the lagged dependent variable is not strictly exogenous. The existing literature provides three main methodologies to tackle this endogeneity: Anderson & Hsiao (1981), Arellano & Bond (1991), and Kiviet (1995). Anderson & Hsiao’s (1981) employ the method of moment (MOM) conditions with the IV solution, but their MOM technique constrains the researcher to incorporate only as many IVs as the number of endogenous covariates. Anderson & Hsiao’s (1981) model allows us to use the twice lagged dependent variable ($s_{it-2}$) or twice lagged differences of the dependent variable ($\Delta s_{it-2}$) as valid instruments for the lagged difference of the dependent variable ($\Delta s_{it-1}$). Anderson & Hsiao’s (1981) estimation technique produces inefficient coefficient estimates, because this technique does not utilize all the available moment conditions.

\(^{56}\) The current account balance of some sample countries is negative, so their logarithmic values do not exist. Short-term interest rate differentials between economies are first-differenced in levels because they are already in rate form.
Arellano & Bond (1991) study similar datasets with small T (time dimension) and large N (individual/country dimension), but instead use the GMM technique. These authors claim that their model is more efficient than Anderson & Hsiao (1981) since their methodology allows researchers to employ all lagged dependent variables and exogenous covariates as IVs. Arellano & Bond’s (1991) methodology gives us consistent and efficient coefficient estimates as it makes use of all available information in a sample. Kiviet (1995), further, investigates dynamic panel data estimation and maintains that the least squares dummy variable (LSDV) estimation yields efficient coefficient estimates if researchers remove the bias from the LSDV estimator.

Judson & Owen (1999) investigate the best methodology to estimate a dynamic panel model for different macroeconomic datasets and develop a way to choose from these three possibilities. Judson & Owen (1999) discuss that Kiviet’s (1995) LSDV is best if used on data sets of small T and large N. In contrast, Judson & Owen (1999) suggest that the least squares dummy variable estimation bias remains even if the time dimension equals thirty. Judson & Owen (1999) determine that all estimation techniques yield better results with a larger N and T (by using a root mean square error criterion). For this reason, I construct a large country sample to include as many countries as possible. Judson & Owen (1999) find that the least squares dummy variable estimation only works similarly to other estimation alternatives when T equals thirty, and does not perform better than others when T is smaller than thirty. Arellano & Bond’s...

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57 Judson & Owen (1999) maintain that microeconomic panel datasets have “far smaller T and far greater N than the typical macroeconomic panel” (p. 9). Therefore, researchers might need different estimation techniques when studying macroeconomic panel datasets.

58 Judson & Owen (1999) find “for a sufficiently large N and T, the differences in efficiency, bias, and RMSEs of the different techniques become quite small.” (p. 13).
methodology (the GMM technique) is the best estimation technique when $T$ equals twenty, because it generates the lowest root mean square error.\textsuperscript{59}

In my research, the spot exchange rate of a sample economy reflects a currency’s price per euro over the period and is obtained from the IMF’s International Financial Statistics (IFS) database. The dependent variable “$s$” is defined as the national currency/euro rate. For this reason, a rise in the dependent variable reflects an appreciation of the euro and a fall denotes the euro’s depreciation.

The EURO STOXX 50 index incorporates the performance of the 50 largest companies from the original eleven members of the Eurozone.\textsuperscript{60} The VSTOXX uses the option contracts of the EURO STOXX 50 index to measure the volatility of the EURO STOXX 50 Index over a future time horizon (STOXX, 2018). Similarly, the VIX reflects the volatility of the S&P 500 Index in percentage points, as the VSTOXX does.

Both of these volatility indices calculate the implied volatility across all eligible stock options from the weighted average of forward prices of out-of-the-money S&P 500 and EURO STOXX 50 puts and calls. CBOE (2017) and STOXX (2018) measure volatility by multiplying the expected 30-day variance of their particular stock market return by 100.\textsuperscript{61} Figure 5, in the Appendix, shows that the VIX is historically lower than the VSTOXX, even though they remain at their peak values during the Great Recession period. However, the VSTOXX and VIX series hint at different sets of information perhaps due to how the European sovereign debt crisis (a

\textsuperscript{59} My recession estimation period contains 16 quarters whereas my post-recession model spans 23 quarters to estimate equation (2).

\textsuperscript{60} These countries are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain.

\textsuperscript{61} The purpose and calculation of the VSTOXX and VIX are similar to each other. The derivation of these volatility indices are further detailed in the Appendix A and Appendix B.
spillover of the Great Recession) is reflected in the VSTOXX and the VIX. The VSTOXX data was obtained from Stoxx’s and investing.com webpage, whereas the VIX data is available at the Federal Reserve Bank of St. Louis database.  

The variable, $\Delta(i_{\text{euro}_t} - i_{\text{other}_t})$ measures short-term interest rate differentials of non-euro countries. In this way, I am able to see the impact of carry trades on bilateral euro exchange rates. I download this data from the OECD database and IMF’s IFS database.

The vector, $Z_{i,t-1}$ includes some non-euro-country-specific macroeconomic indicators. These are foreign exchange reserves (FX), the inflation rate (CPI), exports to the Euro area (EXP), imports from the Euro area (IMP), GDP growth (GDPG), and the current account balance (CA). The foreign exchange reserves (FX) of non-euro economies denote available foreign currency denominated assets (including the euro value of special drawing rights but excluding gold) controlled by the country’s monetary authority. FX reserves data is found at the IMF’s International Reserves and Foreign Currency Liquidity database and is referred to foreign currency reserves (in convertible foreign currency). The log differences of non-euro countries’ CPI gives us the inflation rate. The data for CPI and FX is acquired through the IMF’s IFS database.

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63 Money market rates for Argentina, Brazil, Japan, Romania, Paraguay, Philippines, Peru, Serbia, Singapore, and Thailand from the IMF’s IFS database are used to represent short-term interest rates. For the remaining economies, the short-term interest rate in the OECD’s database is used.  
64 I download the FX data for India and Serbia in the IMF’s IFS database as official reserve assets (including gold deposits), because these countries do not have data in the IMF’s International Reserves and Foreign Currency Liquidity database. Russian FX data is found at the IMF’s International Liquidity and Foreign Reserves database as official reserve assets and other foreign currency assets.  
I do not to include the net foreign asset position (NFA) as another macroeconomic indicator, even though the NFA is commonly used when testing for safe haven flows. I exclude the NFA from my dataset, because its transformation is already included in the form of the current account balance.\textsuperscript{66}

Non-euro GDP growth measures output and is obtained from the OECD database.\textsuperscript{67} CA of non-euro countries measures whether the particular country is a net borrower or net lender with respect to the rest of world.\textsuperscript{68} CA data is obtained from the IMF’s Balance of Payments and International Investment Position Statistics database. EXP and IMP only consider the free-on-board value of total amount of goods exported to and imported from a country into the Euro area. This trade data is acquired from the IMF’s Direction of Trade Statistics webpage.\textsuperscript{69} Table 9, in the Appendix, presents descriptive statistics for my sample variables.

Results

Baseline Results

The proper specification of my estimation model (equation 2) requires that there be no autocorrelation in first-differenced errors. Arellano & Bond’s (1991) test for the serial correlation structure in the errors demonstrates that we reject the null hypothesis of no

\begin{footnotesize}
\begin{enumerate}
\item NFA is also referred as the net international investment position (NIIP). Tille (2003) maintains that the U.S. net international investment position (or the net foreign asset position) could only change with variations in the dollar value of current stocks of U.S. assets and liabilities (because some of these may be in foreign currencies). The IMF (2014) describes NIIP as the subtraction of gold reserves and financial assets of a country’s residents in another economy from liabilities of those residents to non-residents. Lane & Shambaugh’s (2010) conceptual framework states that we can model the change in net foreign assets as \((\text{NFA})_t - (\text{NFA})_{t-1} = (\text{Current Account})_t + (\text{Valuation Effects})\). Therefore, in this study, I only use the current account balance as a regressor.
\item I found Romania’s GDP growth data at the Romania National Institute of Statistic’s webpage: http://www.insse.ro/cms/en/content/gross-domestic-product.
\item Having denoted the net acquisition of foreign assets, negative CA balance shows that a country is a net borrower (a net lender when it is positive). CA of some economies indicate negative values in their datasets, and therefore it is not possible to find their logarithmic values.
\item The imports of Serbia from the Euro area data is discontinued and does not have any observation after the first quarter of 2015.
\end{enumerate}
\end{footnotesize}
autocorrelation of order one and fail to reject no autocorrelation of order two. This means that
the specified model is appropriate, and the instruments are valid for dynamic panel model
regressions, because $E (\varepsilon_{i,t} \varepsilon_{i,t-1})$ does not need to be zero as the $\varepsilon_{i,t}$ are first differences of serially
uncorrelated errors. The GMM estimation procedure relies on the assumption that $E (\varepsilon_{i,t} \varepsilon_{i,t-2}) = 0$, namely the errors are not serially correlated of order two (Arellano & Bond, 1991).

Table 10 reports benchmark results for the Great Recession and its aftermath. During
the last financial crisis and after the recession, the euro appears to be a safe haven only if the
source of uncertainty is not the Euro area (is the other area which in this model is the US). An
increase in the VIX reflects an increase in the volatility of the S&P 500 Index. This finding
implies that the euro appreciates while the U.S. sourced market uncertainty rises during and in
the aftermath of last Great Recession. On the other hand, if the Euro-area sourced uncertainty
increases, the euro depreciates during and after the Great Recession. The negative and significant
coefficient on the VSTOXX might suggest that investors move out from the euro when the
market uncertainty originates in the Euro area.

My chapter further shows that non-euro economies’ inflation rate (CPI) has a positive
and significant impact on the behavior of the euro after the Great Recession. This result
unsurprisingly indicates a significant relationship between the inflation rate and depreciation of a
national currency against the euro. This positive and significant coefficient on CPI underlines the
importance of interconnected stable exchange rates and price stability targets of a monetary

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70 I show the auto-correlation test results under Table 11 in the Appendix.
71 In order to be a valid regression pertaining to the Great Recession period, I need to incorporate second, third,
fourth, and fifth lags of the dependent variable to account for first-order autocorrelation in first-differenced errors.
The post-recession model contains the second lagged dependent variable as an additional regressor. Models that
have only the first lagged dependent variable fail to reject no auto-correlation of order two.
authority to tackle huge currency fluctuations at uncertain times (such as the European sovereign debt crisis).

I also find significant results for the control variables of equation (2) that influence exchange rate behavior. During the Great Recession, the euro significantly depreciates if non-euro foreign exchange reserves (FX) increase. The negative and significant impact of FX on the euro is consistent with Fratzscher’s (2009) results on the U.S. dollar. I further find that the coefficient on the imports from the Euro area (IMP) is negative and significant for the recession period. This finding indicates that if a country increases its total value of imports from the Euro area (i.e., if the Euro-area’s exports to the individual countries in my sample increase), this country’s currency appreciates vis-à-vis the euro at the time of the Great Recession and may serve as a reflection of the ability of these countries to buy from the Euro area in those hard times. However, my study does not find any potential impact of other conditioning factors that influence exchange rates, namely the non-euro CA balance, the non-euro GDP growth, and exports to the Euro area on the bilateral exchange rate of the euro.

The insignificant coefficient on short-term interest rate differentials might imply that carry trade activities play no role in the behavior of the euro. On the other hand, valuation effects (that could emerge from changes in asset prices or exchange rates) arising from the existing holdings of foreign assets and liabilities may be the reason for this insignificant effect of CA on the euro (Tille, 2003; Lane & Shambaugh, 2010). If a national currency depreciates against the euro, then this would improve the CA balance of this economy as its assets denominated in the euro would gain value in accordance to valuation effects.
Investor’s Choice as Safe Haven

Having determined that the euro is a safe haven when the uncertainty does not originate in the Euro area (when originates in the US), we need to figure out which potential safe haven assets (that can be bought and sold in euros) are really chosen by world investors. I investigate the relationship between potential safe haven instruments and the European stock market behavior in an attempt to detect investors’ safe haven choices. The safe haven assets considered in this section are precious metals (such as gold and silver) and, the Euro-area government bonds at different terms to maturity. Having constructed instruments to make volatility tradable, the VSTOXX and VIX futures options could be additional safe haven alternatives.\textsuperscript{72}

Some studies examine the safe haven status of gold by comparing its returns to returns of other precious metals and the VIX futures. Baur & Lucey (2010) and Baur & McDermott (2010) are the first to define and demonstrate how to test for gold’s potential to serve as a safe haven and hedge. Hood & Malik (2013), Baur & McDermott (2016) followed up on that methodology and confirm the safe haven status of gold against the U.S stock market. Baur & McDermott (2016) is the only study that considers and confirms gold’s safe haven option for the Euro area by studying the G7 economies. Baur & McDermott (2016) more extensively study the safe haven status of gold and consider government bonds as possible safe haven instruments. Baur & McDermott (2016) find that the three-month U.S. T-bill, and the ten-year U.S. T-bond are other safe haven options if the S&P 500 has a worse return than the one percent quantile of the stock return distribution.\textsuperscript{73}

\textsuperscript{72} Stoxx (2018) and Whaley (2009) explain how the VSTOXX and the VIX reflect the future volatility of European and U.S. stock markets.

I follow the safe haven and hedge asset definitions by Baur & Lucey (2010), Baur & McDermott (2016), and Hood & Malik (2013). According to their definitions, I classify the asset as a safe haven if its returns are negatively correlated with stock returns at the time of extreme stock market declines. Additionally, these articles state that if the correlation of the return on an asset and the stock market return is negative and significant, on average, this implies that the asset is a hedge. To conduct a similar analysis in the spirit of these papers, I estimate the following regression:

$$\Delta \text{asset}_{i,t} = \beta_0 + \beta_1 (\Delta \text{EUROSTOXX50}_t) + \beta_2 (\Delta Z_t) + \delta_1 D_{q10} * (\Delta \text{EUROSTOXX50}_t) + \delta_2 D_{q5} * (\Delta \text{EUROSTOXX50}_t) + \delta_3 D_{q1} * (\Delta \text{EUROSTOXX50}_t) + \epsilon_t \ldots (3)$$

where $\text{asset}_{i,t}$ represents the return on a potential safe haven asset, $\Delta \text{EUROSTOXX50}_t$ is the Euro-area stock market return, $\Delta Z_t$ denotes the vector of other potential safe haven assets’ return. Following the literature, I interact the EURO STOXX 50 return with the three-dummies that indicate extreme negative stock market downturns by calculating the first, five, and ten-percentage-quantiles of the European stock market return. As an example, $D_{q1}$ equals 1 if the Euro-area stock market return is below the first-percentage-quantile of the return distribution of the EURO STOXX 50.

In the spirit of Baur & McDermott (2016), I chose the following assets to include; gold and silver as precious metals; VIX and VSTOXX futures; the three-month, the one-year, the two-

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74 There are alternative definitions of safe haven and hedge assets in the current literature (see Baur & Lucey (2010), Baur & McDermott (2016), and Hood & Malik (2013) for these alternative definitions). These articles define their assets as weak and strong alternatives. An asset is classified as a weak safe haven if its return is not affected by the stock returns during extreme stock market downturns. My paper is simply limited to strong safe haven assets. We are not concerned of weak safe haven and hedge potential of these assets.

75 I estimate the equation (3) separately for each potential safe haven asset with robust standard errors if heteroskedasticity is present using the Breusch & Pagan’s (1979) test. My results under Table 13 in the Appendix reflect that I reject the null hypothesis of homoskedasticity for gold, silver, 7-year and 10-year bond. I find homoskedasticity of all error variances for the VIX and VSTOXX futures; 3-month, 1-year, 2-year, 5-year bonds.
year, the five-year, the seven-year, and the ten-year Euro-area government bonds.\textsuperscript{76} The return on potential safe haven assets other than the Euro-area government bond returns are first-differenced in their logs. By contrast, yield curves of the Euro-area government bond returns are first-differenced in levels.\textsuperscript{77} The important coefficients for us to consider are $\beta_1$ and deltas. A negative and significant $\beta_1$ indicates that the corresponding asset is a hedge while the asset becomes a safe haven if one or more deltas turn out to be negative and significant.

I use monthly data from September 2004 to December 2016 as this is the data that is available. Table 12, in the Appendix, presents the findings concerning which assets are safe havens.\textsuperscript{78} According to these results, none of these potential safe haven instruments turn out to be a significant safe haven asset from the perspective of world investors. Specifically, the Euro-area government bonds are not chosen as a safe haven asset at periods of extreme negative returns of the EURO STOXX 50 Index. This result suggests that investors use the euro as a safe haven only in cash (as the positive and significant coefficient on the VIX suggests from Table 10), because I could not show any significant impact that implies a safe haven behavior of these Euro-area assets (all of my deltas are insignificant except 7-year bond which is positive and significant).\textsuperscript{79}

\textsuperscript{76} These Euro-area government bonds show the yield curve spot rates at different terms to its maturity. The source of this data is the European Central Bank Statistical Data Warehouse. Gold prices data is acquired from World Gold Council’s webpage (https://www.gold.org/data/gold-price). The source webpage of investment.com for the silver prices is https://www.investing.com/commodities/silver.

\textsuperscript{77} These Euro-area government bonds have AAA ratings.

\textsuperscript{78} Table 12, in the Appendix, shows the results for regression of particular potential safe haven assets on the return on EURO STOXX 50 Index, safe haven dummies, and other potential safe haven assets. These safe haven dummies denote extreme negative stock market returns below the 1, 5, and 10-percent-quantile of the EURO STOXX 50 Index’s return distribution. These bonds are all AAA rating Euro-area central government bonds at different terms to maturity.

\textsuperscript{79} According to the previous literature, the positive and significant delta implies that the asset is a diversifier asset.
Conclusion

My paper empirically analyzes the safe haven status of the euro exchange rate against thirty-three currencies. Several different time periods were chosen using different methodologies. During the Great Recession and in its aftermath, my paper demonstrates that the euro qualifies as a safe haven if the source of market uncertainty is not the Euro area. The European single currency becomes a safe haven when the United States is the origin of market uncertainty.

I derived this conclusion from testing the euro relative to thirty-three currencies to see whether it is a safe haven or not from 2007 to the end of 2016. I found that the euro is a safe haven during this time period as long as uncertainty does not originate in the Euro area (originates in the US). Because I found that the euro is a safe haven currency, I continued to investigate potential safe haven assets of the Euro-area (other than cash) using the Euro STOXX 50 Index from September 2004 to the end of 2016 as a measure of uncertainty. According to this analysis, I cannot describe any of the potential Euro-area assets as safe havens. I, thus, show some significant evidence that the euro is a safe haven currency against thirty three currencies during and after the Great Recession, with global investors staying in the euro as a safe haven in cash only (given the positive and significant coefficient on the VIX embodies in the main regression equation (2)).
References


APPENDIX A
Appendix A. The VSTOXX Calculation

The VSTOXX calculation is as follows:

\[ \sigma_i^2 = \frac{2}{T} \sum_j \frac{\Delta K_{i,j}}{K_{i,j}^2} e^{R_i T} M_{K_{i,j}} - \frac{1}{T} \left[ \frac{F_i}{K_{i,0}} - 1 \right]^2 \]

where

- \( \sigma \) is VSTOXX/100 so that VSTOXX = \( \sigma \times 100 \),
- \( T \) is the time to expiration and equals to calculated as seconds remaining EURO STOXX 50 Index expirations divided to total seconds in a year,
- \( F_i \) is forward at-the-money price for the \( i \)th EURO STOXX 50 option’s expiration,
- \( K_0 \) is highest strike price below the forward index level (F), \( K_i \) is strike price of the \( i \)th out-the-money option from the S&P 500 puts and calls. A call if \( K_i > K_0 \); and a put if \( K_i < K_0 \); both put and call if \( K_i = K_0 \). \( \Delta K_i = \frac{K_{i+1} - K_{i-1}}{2} \) in which \( \Delta K \) for the lowest strike is simply the difference between the lowest strike and the next higher strike.
- Equivalently, \( \Delta K \) for the highest strike is the difference between the highest strike and the next lower strike. Thus, \( \Delta K \) is half the distance between the two strikes adjacent to \( K \).
- \( R \) is the risk-free interest rate to expiration (refinancing factor). \( M_{K_{i,j}} \) is the inclusion price with strike \( K_i \) whereas \( M_{K_{i,0}} \) indicates the midpoint of put and call prices of the option with strike \( K_i \).

Notes: Source is STOXX (2018).
The VIX calculation is as follows:

\[ \sigma^2 = \frac{2}{T} \sum_i \frac{\Delta K_i}{K_i^2} e^{RT} \left[ Q(K_i) - \frac{1}{T} \left( \frac{F}{K_0} - 1 \right)^2 \right] \]

where

- \( \sigma \) is VIX/100 so that VIX = \( \sigma \times 100 \),
- \( T \) is the time to expiration and calculated as minutes remaining S&P 500 Index expirations divided to total minutes in a year,
- \( F \) is forward at-the-money price desired from the S&P 500 Index option prices,
- \( K_0 \) is first strike below the forward index level (F), \( K_i \) is highest strike price of the ith out-the-money option from the S&P 500 puts and calls. A call if \( K_i > K_0 \); and a put if \( K_i < K_0 \); both put and call if \( K_i = K_0 \). \( \Delta K_i = \frac{K_{i+1} - K_{i-1}}{2} \) in which \( \Delta K \) for the lowest strike is simply the difference between the lowest strike and the next higher strike.
- Equivalently, \( \Delta K \) for the highest strike is the difference between the highest strike and the next lower strike. Thus, \( \Delta K \) is half the distance between the two strikes adjacent to K.
- \( R \) is the risk-free interest rate to expiration (refinancing factor),
- \( Q(K_i) \) is the midpoint of the bid-ask spread for each option with strike \( K_i \).

Notes: Source is CBOE (2015) and CBOE (2017).
APPENDIX C
Notes: The VIX is the CBOE’s volatility index, a U.S. market uncertainty variable, and the VSTOXX represents EURO STOXX 50’s volatility index for the Euro-area market uncertainty indicator. These volatility indexes are in volatility points. See Appendix A and Appendix B for details on how these indices are computed.
Table 8. Country Sample of Essay Two

<table>
<thead>
<tr>
<th>Country</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albania</td>
<td>Mexico</td>
</tr>
<tr>
<td>Argentina</td>
<td>New Zealand</td>
</tr>
<tr>
<td>Australia</td>
<td>Norway</td>
</tr>
<tr>
<td>Brazil</td>
<td>Peru</td>
</tr>
<tr>
<td>Canada</td>
<td>Philippines</td>
</tr>
<tr>
<td>Chile</td>
<td>Poland</td>
</tr>
<tr>
<td>Colombia</td>
<td>Romania</td>
</tr>
<tr>
<td>Czechia</td>
<td>Russia</td>
</tr>
<tr>
<td>Denmark</td>
<td>Serbia</td>
</tr>
<tr>
<td>Hungary</td>
<td>Singapore</td>
</tr>
<tr>
<td>Iceland</td>
<td>South Africa</td>
</tr>
<tr>
<td>India</td>
<td>Sweden</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Switzerland</td>
</tr>
<tr>
<td>Israel</td>
<td>Thailand</td>
</tr>
<tr>
<td>Japan</td>
<td>the United Kingdom</td>
</tr>
<tr>
<td>South Korea</td>
<td>the United States</td>
</tr>
<tr>
<td>Malaysia</td>
<td></td>
</tr>
</tbody>
</table>

Notes: I exclude China, Costa Rica, Egypt, Guyana, Jamaica, Lebanon, Paraguay, Qatar, Senegal and Trinidad & Tobago due to data availability. Following the literature, I incorporate countries that maintain soft peg and floating exchange rate regimes. IMF (2017) categorizes conventional pegs and exchange rate stabilized arrangements as some soft peg examples. Anchor currency is the most commonly used type of exchange rate stabilized arrangement. IMF (2017) defines an exchange rate stabilized arrangement as an exchange rate that could change within a margin of two percent for at least six months or more. A two-percent alteration could be helpful to demonstrate safe haven status of the euro.
Table 9. Summary Statistics of Essay Two

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euro exchange rate</td>
<td>1.31</td>
<td>1.052</td>
<td>-0.174</td>
<td>4.21</td>
</tr>
<tr>
<td>CBOE’s Volatility Index</td>
<td>1.292</td>
<td>0.149</td>
<td>1.097</td>
<td>1.753</td>
</tr>
<tr>
<td>EURO STOXX Volatility Index</td>
<td>1.388</td>
<td>0.122</td>
<td>1.204</td>
<td>1.75</td>
</tr>
<tr>
<td>Interest rate differentials</td>
<td>-3.114</td>
<td>4.067</td>
<td>-35.616</td>
<td>4.481</td>
</tr>
<tr>
<td>CA Balance</td>
<td>2,126,944</td>
<td>15,543,349</td>
<td>-45,909,406</td>
<td>112,903,615</td>
</tr>
<tr>
<td>Foreign exchange reserves</td>
<td>4.525</td>
<td>1.08</td>
<td>-3.087</td>
<td>6.087</td>
</tr>
<tr>
<td>Inflation Rate</td>
<td>0.004</td>
<td>0.005</td>
<td>-0.014</td>
<td>0.059</td>
</tr>
<tr>
<td>Exports to the Euro area</td>
<td>3.685</td>
<td>0.608</td>
<td>1.661</td>
<td>4.805</td>
</tr>
<tr>
<td>Imports from the Euro area</td>
<td>3.712</td>
<td>0.632</td>
<td>1.719</td>
<td>4.954</td>
</tr>
<tr>
<td>GDP Growth</td>
<td>0.738</td>
<td>1.246</td>
<td>-7.55</td>
<td>8.828</td>
</tr>
</tbody>
</table>

Notes: All model variables are in logs except short-term interest rate differentials and CA balance of sample economies.
Table 10. Benchmark Results of the Essay Two’s Dynamic Panel Model

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1st lagged dependent variable</td>
<td>1st lagged dependent variable</td>
</tr>
<tr>
<td>0.843 (&lt;0.001) *</td>
<td>0.832 (&lt;0.001) *</td>
</tr>
<tr>
<td>2nd lagged dependent variable</td>
<td>2nd lagged dependent variable</td>
</tr>
<tr>
<td>-0.43 (0.001) *</td>
<td>-0.201 (&lt;0.001) *</td>
</tr>
<tr>
<td>3rd lagged dependent variable</td>
<td>3rd lagged dependent variable</td>
</tr>
<tr>
<td>0.159 (0.151) *</td>
<td>N/A</td>
</tr>
<tr>
<td>4th lagged dependent variable</td>
<td>4th lagged dependent variable</td>
</tr>
<tr>
<td>-0.07 (0.349)</td>
<td>N/A</td>
</tr>
<tr>
<td>5th lagged dependent variable</td>
<td>5th lagged dependent variable</td>
</tr>
<tr>
<td>-0.06 (0.884)</td>
<td>N/A</td>
</tr>
<tr>
<td>VIX</td>
<td>VIX</td>
</tr>
<tr>
<td>0.096 (0.004) *</td>
<td>0.143 (&lt;0.001) *</td>
</tr>
<tr>
<td>VSTOXX</td>
<td>VSTOXX</td>
</tr>
<tr>
<td>-0.095 (0.032) *</td>
<td>-0.119 (&lt;0.001) *</td>
</tr>
<tr>
<td>FX</td>
<td>FX</td>
</tr>
<tr>
<td>-0.071 (0.044) *</td>
<td>-0.052 (0.093)</td>
</tr>
<tr>
<td>Interest rate differentials</td>
<td>Interest rate differentials</td>
</tr>
<tr>
<td>0.001 (0.844)</td>
<td>-0.002 (0.231)</td>
</tr>
<tr>
<td>CPI</td>
<td>CPI</td>
</tr>
<tr>
<td>0.147 (0.256)</td>
<td>0.381 (&lt;0.001) *</td>
</tr>
<tr>
<td>GDPG</td>
<td>GDPG</td>
</tr>
<tr>
<td>0.001 (0.613)</td>
<td>0.001 (0.219)</td>
</tr>
<tr>
<td>EXP</td>
<td>EXP</td>
</tr>
<tr>
<td>-0.008 (0.709)</td>
<td>-0.03 (0.168)</td>
</tr>
<tr>
<td>IMP</td>
<td>IMP</td>
</tr>
<tr>
<td>-0.083 (0.008) *</td>
<td>-0.018 (0.675)</td>
</tr>
<tr>
<td>CA</td>
<td>CA</td>
</tr>
<tr>
<td>0.001 (0.579)</td>
<td>-0.002 (0.105)</td>
</tr>
<tr>
<td>Constant</td>
<td>Constant</td>
</tr>
<tr>
<td>1.044 (0.001) *</td>
<td>0.109 (0.709)</td>
</tr>
</tbody>
</table>

Notes: The table shows the coefficient estimates and the p-values in the parenthesis. * indicates statistical significance at the 5% level.
Table 11. Auto-correlation Test Results for Benchmark Model of Essay Two (Equation 2)

<table>
<thead>
<tr>
<th>Autocorrelation Test Order</th>
<th>p-value for the recession era</th>
<th>p-value for the post-recession era</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Order 1</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Test Order 2</td>
<td>0.395</td>
<td>0.115</td>
</tr>
<tr>
<td>Test Order 3</td>
<td>0.112</td>
<td>0.15</td>
</tr>
<tr>
<td>Test Order 4</td>
<td>0.137</td>
<td>0.212</td>
</tr>
<tr>
<td>Test Order 5</td>
<td>0.665</td>
<td>0.565</td>
</tr>
</tbody>
</table>

Notes: Due to the inclusion of the second, third, fourth and fifth lagged dependent variables, we have to test the hypothesis of no auto-correlation of order 3, 4, and 5 (addition to order 2).
Table 12. Results for the Investors’ Choice as Safe Haven Analysis of Essay Two (Equation 3)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hedge</th>
<th>Safe haven at the 1% quantile</th>
<th>Safe haven at the 5% quantile</th>
<th>Safe haven at the 10% quantile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Safe Haven Asset</td>
<td>EURO STOXX 50 Coefficient Estimate (p-value) - $\beta_1$</td>
<td>Stock Return Dummy Quantile at the 1% - $\delta_1$</td>
<td>Stock Return Dummy Quantile at the 5% - $\delta_2$</td>
<td>Stock Return Dummy Quantile at the 10% - $\delta_3$</td>
</tr>
<tr>
<td>Gold</td>
<td>-0.034 (0.726)</td>
<td>-0.012 (0.395)</td>
<td>0.023 ** (0.019)</td>
<td>-0.01 (0.188)</td>
</tr>
<tr>
<td>Silver</td>
<td>-0.167 (0.447)</td>
<td>0.01 (0.745)</td>
<td>-0.035 (0.115)</td>
<td>-0.003 (0.863)</td>
</tr>
<tr>
<td>VIX Futures</td>
<td>-0.407 (0.737)</td>
<td>-0.014 (0.999)</td>
<td>-0.49 (0.28)</td>
<td>-0.414 (0.748)</td>
</tr>
<tr>
<td>VSTOXX Futures</td>
<td>0.01 (0.978)</td>
<td>0.005 (0.338)</td>
<td>-0.005 (0.89)</td>
<td>-0.002 (0.951)</td>
</tr>
<tr>
<td>3-month bond</td>
<td>-0.287 (0.489)</td>
<td>-0.055 (0.366)</td>
<td>-0.015 (0.717)</td>
<td>-0.024 (0.458)</td>
</tr>
<tr>
<td>1-year bond</td>
<td>-0.296 (0.255)</td>
<td>-0.004 (0.904)</td>
<td>-0.001 (0.971)</td>
<td>-0.015 (0.454)</td>
</tr>
<tr>
<td>2-year bond</td>
<td>0.306 ** (0.023)</td>
<td>0.023 (0.262)</td>
<td>-0.005 (0.735)</td>
<td>0.014 (0.183)</td>
</tr>
<tr>
<td>5-year bond</td>
<td>-0.926 (0.122)</td>
<td>-0.481 (0.119)</td>
<td>0.155 (0.466)</td>
<td>0.108 (0.51)</td>
</tr>
<tr>
<td>7-year bond</td>
<td>0.046 (0.168)</td>
<td>0.008** (0.008)</td>
<td>-0.002 (0.482)</td>
<td>-0.001 (0.782)</td>
</tr>
<tr>
<td>10-year bond</td>
<td>-0.119 (0.161)</td>
<td>-0.022 (0.085)</td>
<td>0.005 (0.588)</td>
<td>-0.001 (0.917)</td>
</tr>
</tbody>
</table>

Notes: ** indicates that the instrument is a diversifier asset.
Table 13. Breusch & Pagan’s (1979) Heteroskedasticity Test Results of Essay Two (Equation 3)

<table>
<thead>
<tr>
<th>Dependent Variable – Potential Safe Haven Asset (Δasset_t)</th>
<th>p-value for the Heteroskedasticity Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>0.856</td>
</tr>
<tr>
<td>Silver</td>
<td>0.33</td>
</tr>
<tr>
<td>VIX Futures</td>
<td>0.04</td>
</tr>
<tr>
<td>VSTOXX Futures</td>
<td>0.001</td>
</tr>
<tr>
<td>3-Month Bond</td>
<td>0.001</td>
</tr>
<tr>
<td>1-Year Bond</td>
<td>0.004</td>
</tr>
<tr>
<td>2-Year Bond</td>
<td>0.006</td>
</tr>
<tr>
<td>5-Year Bond</td>
<td>0.03</td>
</tr>
<tr>
<td>7-Year Bond</td>
<td>0.123</td>
</tr>
<tr>
<td>10-Year Bond</td>
<td>0.271</td>
</tr>
</tbody>
</table>

Test Hypothesis: $H_0$: The error variances are all equal (homoscedasticity)

$H_1$: The error variances are not equal (heteroscedasticity)
CHAPTER IV

INTERNATIONAL MONETARY INTERACTIONS AFTER THE IMPLEMENTATION OF THE EURO

The purpose of my study is to investigate international monetary policy interactions since the advent of the euro. My research tries to explain whether monetary authority actions of the U.S. and the Euro area (E.A.) generate foreign monetary policy endogeneity in G7 economies after the introduction of the euro. In addition, this chapter considers spillover effects of the Federal Reserve’s (Fed) and the European Central Bank’s (ECB) monetary policies from one economy to macroeconomic fundamentals of each other and other G7 countries. Following Kim (2001), policy endogeneity refers to the systematic monetary authority reaction of one economy (that persists for at least two time periods) following a monetary policy innovation of the other. To further analyze the international monetary policy transmission mechanism of the largest central banks, I investigate the influence of a monetary policy change on output, the trade balance, and the exchange rate of these major industrialized economies. I refer to these detailed transmission channels as spillover effects of monetary policy innovations.80

The findings of my paper denote that the E.A. becomes more influential during the unconventional monetary policies era, because expansionary innovations in the ECB’s assets create an endogenous policy reaction on the monetary policy authorities of the US, Japan, and the U.K.81 However, exogenous E.A. conventional monetary policy shocks do not cause an endogenous reaction in the US, Canada, and Japan, but only lead to foreign monetary policy

80 I do not require two months persistence to define spillover effects on output, trade balance, and exchange rate of G7 economies following monetary policy shocks of the Federal Reserve and ECB.
81 The Federal Reserve, the Bank of Japan, and the Bank of England give an endogenous reaction after two months, following the ECB’s unconventional expansionary shock. The response of the Canadian monetary authority does not show any significant impact after a similar shock.
endogeneity in the U.K. Exogenous U.S. conventional contractionary monetary policy innovations, instead, significantly cause an endogenous reaction to the all non-US G7 monetary authorities.\footnote{The endogenous reactions of monetary policy authorities in the EA and Canada have one month lag, whereas the U.K and Japanese response have 10 months lag following U.S. conventional contractionary innovations.} However, U.S. unconventional expansionary monetary shocks only lead to an endogenous monetary policy reaction in Japan. My paper is important, because its empirical results imply that the EA has been successful in terms of becoming a counterpart to the US during unconventional monetary policies period (2009-2015), a motivating factor for the construction of the monetary union and common currency. However, the results of my chapter suggest that the EA has been unsuccessful in becoming a counterpart to the US during conventional monetary policy era (1999-2008), since the non-US G7 economies pursue an endogenous monetary policy response following a U.S. conventional monetary policy shock before the Great Recession. This finding implies that US is still the origin of monetary policy shocks during the current conventional monetary policy period (2015-2020). Krugman et al. (2012) state that the EA expected to secure its own economic benefits by establishing a joint monetary system, because the US, as a world banker, was more interested in solving its own problems after the collapse of the Bretton Woods system. This result suggests that this did not happen before the Great Recession.

Central banks influence each other, and sometimes this interaction leads to similar policy implementation from the different monetary authorities. For instance, the ECB may implement monetary expansion following U.S. monetary expansion, or vice versa. Coeuré (2016) argues that the new level of economic and financial integration might modify effects and spillovers from monetary policies, because, ceteris paribus, more policy coordination is required for a higher
level of globalization. Nevertheless, Engel (2016) discusses that the goal of policy coordination is not to get rid of spillovers and emphasizes that policy cooperation is not necessarily inevitable despite the existence of spillovers. Thus, foreign monetary policy endogeneity is a testable hypothesis for the U.S. and the E.A. monetary authorities.

My research studies the transmission of the U.S. and the E.A. monetary policy decisions on each other’s policy implementations by analyzing both conventional and unconventional actions of the largest central banks. Kim (2001) examined this link during the pre-euro period and found that G6 monetary authorities did not respond to U.S. monetary policy shocks. My study takes into account the post-euro period and inspects whether the ECB is more resilient to U.S. monetary policy shocks compared to the pre-euro period. This chapter also explores whether, in the post-euro period, the ECB impacts the behavior of the remaining three non-euro G7 countries’ monetary policy decisions (Canada, Japan, and the UK). I define conventional monetary policy shocks as either the U.S. or the E.A. monetary contraction, specifically increasing the Fed Funds Rate or the Euro-area short-term policy rate. Unconventional monetary policy shocks, instead, are defined as the U.S. or the E.A. monetary expansion, namely increasing the amount of their central bank assets. I define conventional monetary policy shocks as contractionary and unconventional monetary policy shocks as expansionary only due to the needs at the time. Following Kim (2001), I apply the marginal method employing a vector autoregressive (VAR) model in which every international and/or foreign variable is included one by one to the benchmark VAR model. Table 14, Table 15, and Table 16 provide a summary of the results of my study.

Table 14 summarizes my finding concerning how monetary policy shocks of the Fed and the ECB spill over to each other and to the remaining G7 economies. The columns of Table 14 refer to the type and source of monetary policy change, so that we can compare spillovers’ origin and kind. For example, the first row shows the impact of monetary policy innovations on the Chicago Board Options Exchange Volatility Index (VIX), which is the main variable of volatility in my research. Specifically, the third and fourth column of the first row tell us that U.S. and E.A. conventional monetary contractions have insignificant outcomes on market uncertainty.

Table 15 summarizes my findings investigating whether U.S. and E.A. conventional monetary policy innovations result in an endogenous policy reaction in G7 economies. In this table, the third and fourth columns allow us to analyze the similarities and differences between the impacts of conventional monetary policy shocks. For instance, the third row shows that E.A. conventional monetary innovations result in an endogenous response to the monetary authority of Canada.

Table 16 summarizes my results concerning the impact of unconventional U.S. and E.A. monetary shocks in G7 economies. We could compare the effects of the Fed and the ECB by looking at the third and fourth columns of Table 16. The fourth row, for example, clarifies that Japanese monetary policy-makers follow the Fed and the ECB.

Engel (2016) states that the Federal Reserve’s expansionary policy during the Great Recession and its aftermath assisted to reduce the liquidity crunch and provided safe conditions for world investors to seek for profitable opportunities. A U.S. monetary expansion might lead to negative results in other economies due to the depreciation of the U.S. dollar. Specifically, such expansionary monetary policy raises domestic inflation making the U.S. dollar depreciate. A dollar depreciation promotes U.S. exports by making U.S. goods cheaper and reduces U.S.
imports. Additionally, a U.S. expansionary monetary policy decreases domestic short-term interest rates causing capital outflows from the United States and capital inflows elsewhere. These capital inflows positively influence the output level of other countries, where short-term interest rates are higher than the US.\textsuperscript{84} Even though, the direction of spillovers (positive or negative correlation) from expansionary monetary policy is not clear, one still needs to determine if there are any spillover effects on economies (Engel, 2016). Therefore, do conventional and unconventional monetary policies of the largest central banks have an impact on the other bank, and do those actions create spillovers on other large advanced economies?

**Literature Review**


\textsuperscript{84} The short-term policy interest rates of non-Euro G7 economies were higher than the US, except Japan, during conventional monetary policy period (1999-2008). The E.A. short-term policy rate was higher than the Federal Funds Rate in 2001 (from June to December), 2002, 2003 (January to October), 2004 and 2008. The Federal Funds Rate was higher than the E.A. short-term policy rate in 1999, 2000, 2001 (from January to June), 2003 (November & December), 2005, 2006, and 2007.
U.S. contractionary monetary shocks cause contemporaneous increases in Latin American short-term interest rates.

Kucharcukova et al. (2016) examine the influence of conventional and unconventional European Central Bank (ECB) policy changes on six European Union (E.U.) countries outside the Euro area. The novelty of Kucharcukova et al. (2016) is in introducing the method of principal factor analysis in which they calculate an indicator for the monetary policy stance from information based on interest rates, monetary aggregates, selected ECB balance sheet items, and exchange rates. These authors find that an ECB monetary tightening reduces the industrial production of six non-Euro-area countries. The article also demonstrates that the response of national short-term interest rates to a conventional monetary policy shock is significant for all six of these E.U. economies. On the other hand, Kucharcukova et al. (2016) do not find any significant evidence of the impact of an unconventional monetary policy shock on national short-term interest rates, and thus maintain that there is no endogenous monetary policy response of ECB unconventional monetary shocks in the neighboring countries.

Similarly, Jannsen & Klein (2011) analyze how Euro-area monetary policy innovations impact non-Euro-area economies from western Europe. However, Jannsen & Klein (2011) show that non-Euro-area short-term interest rates rise after a contractionary ECB monetary policy shock. Jannsen & Klein’s (2011) results also reveal that there is more noticeable spillover of ECB monetary policy shocks on non-Euro-area output after the introduction of the euro.

Vespignani (2015) observes the effects of monetary shocks in the US, China, and Japan on the Euro area for the period 1999 – 2012 in a structural VAR (SVAR) analysis. The article

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85 These economies are Czechia (Czech Republic), Denmark, Hungary, Poland, Sweden, and the United Kingdom.
86 These western European countries are Denmark, Norway, Sweden, Switzerland, and the United Kingdom.
displays that Euro-area industrial production decreases with positive shocks of the U.S. M2 and Japan’s M2, but a positive innovation in China’s M2 creates a positive impact on the Euro-area output. Vespignani (2015) does not present any significant results for the effects of monetary innovations of these countries on the Euro-area short-term interest rate. Likewise, Sousa & Zaghini (2008) study the international spillover effects of foreign monetary innovations on the Euro-area economy in a SVAR framework. Sousa & Zaghini (2008) calculate a measure of liquidity outside the Euro area by considering the US, Japan, the UK, and Canada as foreign economies. A global liquidity variable is computed by subtracting the logarithm of real GDP of these non-Euro-area G7 economies from their logarithm of the weighted sum of monetary aggregates. Sousa & Zaghini (2008) find that Euro-area output increases in the period following innovations in global liquidity. Sousa & Zaghini (2008) further show that a positive shock to global liquidity causes a significant and permanent rise in the Euro-area M3.

Neri & Nobili (2010) investigate the impact of changes in the U.S. monetary policy stance on the Euro area employing a SVAR model from 1982 to 2007. Neri & Nobili’s (2010) results demonstrate that the euro depreciates due to a U.S. contractionary monetary policy shock. Moreover, these authors maintain that the trade balance is not a key factor in the transmission of U.S. monetary policy changes to the euro area, which is in line with Kim’s (2001) findings. In Neri & Nobili’s (2010) research, there is limited evidence of foreign monetary policy endogeneity, because a positive innovation in the Federal Funds Rate leads to an increase in the Euro-area short-term interest rate in the next period.

Maćkowiak (2007) also discusses the effects of U.S. monetary policy shocks, but studies how these shocks affect emerging markets by incorporating a SVAR analysis. Maćkowiak (2007) tries to determine the role of U.S. monetary policy shocks relative to some other external
shocks jointly on eight emerging countries. Maćkowiak (2007) demonstrates that innovations of U.S. monetary policy are less influential on emerging markets relative to other kinds of external shocks.

Gambacorta et al. (2014) take a different approach and examine the influence of unconventional monetary policies in a panel VAR framework. The estimations of Gambacorta et al. (2014) are from January 2008 to June 2011 and include Canada, the Euro area, Japan, Norway, Sweden, Switzerland, the U.K., and the US. This article reports that an exogenous shock to the unconventional monetary policy tool leads to a rise in output in the following period. Additionally, Gambacorta et al. (2014)’s findings indicate that innovations to central bank assets explain a small portion of output and price variability.

My study follows Kim’s (2001) marginal method, because I argue that it is a better approach than including all international variables into the benchmark model at the same time. Doing so would result in a dimensionality problem. In all empirical analyses of my chapter, using small VAR models is a better approach as it allows for the preservation of degrees of freedom.

My research adds substantial value to the current literature. First, my project tries to explain international monetary interactions with the onset of the euro as a single currency. This period has not been examined before. Second, my paper expands beyond focusing on the period

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87 These economies are Chile, Hong Kong, South Korea, Malaysia, Mexico, Philippines, Singapore, and Thailand.
88 Gambacorta et al. (2014) use monthly data.
89 If I include all variables (9 variables for a VAR model) at the same time, the degrees of freedom would decrease to 30 with one lag, which prevents obtaining reliable results. However, the marginal method has 90 degrees of freedom with one lag, and 65 degrees of freedom with 2 lags.
of the Great Recession when unconventional monetary policy actions took place. I further compare conventional and unconventional monetary policies in the post-euro era.

Data & Model

I use monthly data from January 1999 to December 2015. My sample economies are Canada, the Euro area, Japan, the United Kingdom, and the United States. The nineteen members of the Eurozone are included as a single entity. I apply a different analysis according to monetary policy developments. The post-euro period consists of two different monetary policy behaviors of central banks, namely conventional and unconventional monetary policies. Conventional monetary policy becomes useless after short-term nominal interest rates get stuck at their effective lower bounds (or the zero-lower bound), and central bank balance sheets take the place of the traditional monetary policy instrument. Monetary authorities in advanced economies have implemented accommodative monetary actions such as quantitative easing (Gambacorta et al., 2014; Coeuré, 2016). Hence, conventional monetary policy period covers from January 1999 to December 2008, while unconventional monetary policy era spans from the first month of 2009 to December 2015. After December 2015, the Federal Reserve (Fed) started to raise short-term interest rates again, so that we are faced with conventional monetary policies until recently. However, the European Central Bank (ECB) still uses its unconventional monetary policy tools (such as the asset purchasing program) and keeps its short-term interest rate at the zero-lower bound as of March 2020.

Canada is the only sample country that did not adopt unconventional monetary policy tools during the Great Recession. Gordon (2017) states that lower debt-to-equity ratios of the Canadian banks relative to their counterparts helped them to defend against insolvency in the crisis. The Bank of Canada decreased its short-term policy rate from 3 to 2.5 percent and then
kept reducing the rate until reaching the zero-lower bound in April 2009. The Canadian monetary authority preserved a conditional commitment to remain at the zero-lower bound until the middle of 2010 and did not need to implement unconventional monetary measures (Gordon, 2017).

I use a VAR model to analyze international monetary interactions and make separate VAR analyses for the effects of the U.S. and the E.A. monetary policies in different sections. Following Kim (2001), I assume that the economy is described in a way that each model variable depends on the lag of its own and all other macroeconomic variables in the model

\[ S_t = B(L) S_{t-1} + U_t \quad \ldots (1) \]

where \( B(L) \) is a matrix polynomial in the lag operator \( L \), \( S_t \) is an \((n*1)\) data vector, and \( U_t \) is an \((n*1)\) structural disturbance vector. The vector, \( U_t \), is serially uncorrelated and \( \text{var}(U_t) = \Omega \) (symmetric positive definite matrix) which is a diagonal matrix with the variances of structural disturbances along its diagonal.\(^90\) I estimate the following reduced form VAR equation

\[ S_t = G(L) S_{t-1} + e_t \quad \ldots (2) \]

where \( G(L) \) is a matrix polynomial in the lag operator \( L \) and \( \text{var}(e_t) = \Sigma \) (symmetric positive definite matrix). The vector, \( S_t \), contains short-term policy interest rate (INTRATE)\(^91\) or central

\(^{90}\) Any positive definite symmetric matrix can be decomposed into \( A' A \) where \( A \) is upper triangle matrix and \( A' \) is the transpose of this matrix. \( A \) has 1s along its main diagonal. \( D \), as being unique diagonal matrix with positive diagonal element, can be written such that \( \Omega = A' D A \). Then we can write \( \text{var}(U_t) = A' D^{1/2} D^{1/2} A \). This is the Choleski decomposition where \( \text{var}(U_t) \) = \( \Omega \) = \( \Sigma \). I need to find the pure impact of the true innovations of exogenous U.S. and E.A. monetary changes on each endogenous variable. I, thus, must have uncorrelated monetary shocks implying a pure orthogonalized innovation. A pure orthogonalized innovation shows a completely unpredictable effect from past observations and totally uncorrelated with any indicator that affects the economy. I need to orthogonalize \( U_t \)s to find the impulse response functions of pure shocks in U.S. and E.A. monetary policy tools. I define \( V_t = P^{-1} U_t \) where \( V_t \) is the orthogonalized innovation because \( E(V_t) = 0 \) and \( \text{var}(V_t) = I \).

\(^{91}\) I define conventional monetary policy tool as short-term policy interest rates. Short-term policy interest rate is the Federal Funds Rate for the US. The Euro-area short-term interest rate is the E.A. monetary policy rate. I define the
bank assets (CBA), industrial production (IP), consumer price index (CPI), global price index (GPI). I use X-13-ARIMA-SEATS software package of the U.S. Census Bureau to eliminate seasonality from my data sample (except short-term interest rates).

The Choleski decomposition is used to orthogonalize residuals from the VAR models to compute impulse response functions (IRF). I estimate a separate VAR model for Japan, Canada, and the UK. The identification of the U.S. and the E.A. monetary policy shocks follows Kim (2001) and Kucharcukova et al. (2016), who use recursive restrictions on the contemporaneous impact of monetary policy shocks on other model variables. The Choleski ordering for the benchmark model is as follows: IP, CPI, GPI, INTRATE (or CBA). Thus, the U.S. and the E.A. monetary policy shocks come last in the ordering of my benchmark model. This ordering suggests that IP has a contemporaneous impact on all system variables, but CPI, GPI, INTRATE can affect IP only through a lag. Following Kim (2001) and Kucharcukova et al. (2016), I assume that these domestic macroeconomic fundamentals are contemporaneously exogenous to the monetary policy instrument of the US and the EU. Kucharcukova et al. (2016) state, “The identification of the spillover effect of monetary policy shocks from the large economy on the small open economy comes from the restriction of the impact of domestic shocks on the foreign economy” (p.210). Following Kim’s (2001) marginal method, I add each international variable to the above benchmark model one by one. Every international variable, which I try to investigate the impact of U.S. and E.A. monetary policy shocks on, comes last in the ordering. I,

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92 Unconventional monetary policy tool is defined as central bank assets of the sample G7 economies in this paper.
93 The Federal Funds Rate (FFR) shows the interest rate at which banks lend Federal Reserve funds to each other on an overnight basis. The Euro-area short-term policy rate depends on three main key interest rates that are the main refinancing operations, the deposit facility, and marginal lending facility rates.
94 I used the R studio’s interface to X-13-ARIMA-SEATS to acquire final seasonally adjusted series.
95 Kucharcukova et al. (2016) define the domestic economy as small open economy in their article.
therefore, put the restriction of other G7 shocks on U.S. and E.A. economies, because their economies are larger than other G7 countries. G7 domestic shocks have no contemporaneous effect on U.S. and E.A. economies in my estimations.

I estimate different VAR models to investigate exogenous shocks to the monetary policy tools of the Fed and ECB. My benchmark VAR model for the impact of U.S. monetary policy shocks includes USIP, USCPI, GPI, and FFR (or USCBA). I estimate another benchmark VAR model that includes EURIP, EURCPI, GPI, EURINTRATE (or EURCBA) to see the effect of Euro-area monetary policy shocks. In my estimations, IP serves as an indicator for output. INTRATE represents the conventional monetary policy tool, whereas CBA is the unconventional monetary policy instrument. CPI is the average change in the prices of U.S. or E.A. market basket of consumer goods purchased by their urban consumers. I include GPI to guard against the price puzzle. The nominal exchange rate (EXCHRATE), trade balance (TBAL), and the Chicago Board of Exchange Volatility Index (VIX) are the international variables that I add to my benchmark models one at a time. All the sample variables are logged other than short-term interest rates, which is in levels.

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96 IMF (2018) defines IP as an index that contains manufacturing & electricity, mining & quarrying, and gas & water according to the UN International Standard Industrial Classification.
97 GPI is the IMF’s All Commodity Price Index (2005 = 100).
98 The price puzzle refers to the positive response of the price level to a rise in short-term interest rates. This relationship is puzzling, because one would expect that an increase in short-term interest rates would reduce aggregate demand, which would decrease inflation. To eliminate the price puzzle, the previous literature such as Sims (1992), Kim (2001), and McMillin (2001) opted to include another measure of price level.
99 The S&P 500 Index shows the performance of the 500 largest corporations in terms of free-float market capitalization. The VIX aims to record an instantaneous measure of the level of implied volatility of the S&P 500 Index over the next 30 days. Therefore, VIX is an international variable in this chapter as it reflects the performance of the largest U.S. and non-US G7 corporations.
100 The trade balance of Japan is expressed in levels in unconventional monetary policy analyses spanning from 2009 to 2015 because it was negative in June 2013.
The VIX indicates the volatility of the S&P 500 index to detect the influence of monetary policy shocks on market uncertainty. EXCHRATE and TBAL would help us to be able to examine the international transmission of the largest monetary policy authorities through bilateral finance and trade channels. In analyses of the effect from U.S. monetary policy changes, the nominal exchange rate of a country represents the national currency price per the U.S. dollar (national currency/dollar), whereas in analyses for the impact of the ECB’s policy shocks the exchange rate corresponds to the value of the national currency in terms of the euro (national currency/euro).

I obtain GPI, FFR, CBA, and the U.S. dollar exchange rates against other G7 economies data from the Federal Reserve Bank of St. Louis. Euro exchange rates vis-à-vis the U.S., Canada, and Japan are downloaded from the Eurostat’s webpage, whereas the euro exchange rate against the U.K. pound is found at the Bank of England’s database. IP, TBAL, CPI are acquired from the International Monetary Fund’s International Financial Statistics (IFS) database. I download the Euro-area short-term policy rate from the Eurostat’s webpage. Short-term interest rate of non-EU G7 data is available at the OECD database. I download the VIX data from the Yahoo Finance’s webpage.

Kilian & Lutkepohl (2017) maintain that there are two main problems that cause augmented Dickey-Fuller (ADF) to be misleading. These authors state that ADF tests have low

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102 https://www.bankofengland.co.uk/boeapps/database/FromShowColumns.asp?Travel=NlxAZxI3x&FromCategoryList=Yes&New MeaningId=REURO&CategId=6&HighlightCatValueDisplay=Exchange%20rate%20(spot)%20Euro%20into%20sterling.
103 I obtain the Euro-area output from the Eurostat’s database.
105 https://finance.yahoo.com/quote/%5EVIX/history?period1=915148800&period2=1485820800&interval=1mo&filter=history&frequency=1mo.
power for rejecting the null hypothesis of non-stationarity, which in turn could lead to over-differencing data. Kilian & Lutkepohl (2017) argue that researchers cannot use the ADF results to confirm model properties identified under the null hypothesis of non-stationarity. Sims et al. (1990) also demonstrate that the common transformation of models to stationary form by differencing data is unnecessary in many cases.

Kilian & Lutkepohl (2017) maintain that a VAR model in levels is the best approach for near-unit root processes, and the estimator of this model continues asymptotically valid in the existence of possible unit roots and cointegration. Gospodinov et al. (2013) demonstrate that estimates based on the VAR specification in levels perform better than the VAR model in first differences, except for the root equal to one (unit-root). I use VAR models in log-levels (except short-term interest rates) to estimate IRFs, because Gospodinov et al. (2013) emphasize using the importance of VAR specification in levels as it produces valid inferences on IRFs when the researcher is uncertain about the integration and cointegration properties of his/her data.

I estimate a standard VAR model using OLS. In addition, the Schwarz information criterion (SIC) is used to determine the lag length. The SIC advocates having one, two, and three lags depending on VAR models. Moreover, Box & Pierce’s (1970) multivariate portmanteau test is conducted to check the serial correlation in the residuals of each VAR estimation. The serial correlation test results reveal that the residuals are independent. I show the test results for lag selection and autocorrelation between errors in Table 17, 18, 19, and 20 under the Appendix A.

I report the empirical results of my research using IRFs in the Appendix B. Two standard error confidence bands (95%) of IRF’s are constructed from the one thousand bootstrap runs. I estimate my VAR model and save estimation (fitted) residuals as my first step. Second, I draw uniformly from the series of fitted residuals and set this bootstrap residual equal to the first
selected realization of the fitted residual. I, thereafter, take a second draw by replacing the fitted residual with the bootstrap residual again. I repeat this process one-thousand times and collect one-thousand realizations to construct bootstrap time series recursively. I use this sample to construct my bootstrap confidence bands at the 5th and 95th percentile of its distribution. All of the IRFs indicate no reaction after the second year. Thus, I present all the IRFs of this study up to the thirtieth month for visual ease.

Results


This model uses monthly data from January 1999 to December 2008. The benchmark VAR model in this section contains U.S. output, U.S. consumer price index, a global price index, and the Federal Funds Rate (FFR). The FFR is the conventional monetary policy tool of the Federal Reserve. As I mentioned above, the benchmark model has a Choleski ordering of {USIP, USCPI, GPI, FFR}. After identifying the U.S. monetary policy shock, each international variable is added to this benchmark model one at a time. In the VAR models of this section, the nominal exchange rate is defined as domestic currency per U.S. dollar (i.e., yen/U.S. dollar). Figure 6 shows that contractionary shocks to U.S. conventional monetary policy appreciate the U.S. dollar against the euro in between the twentieth and twenty-fifth month. USIP significantly

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106 Policy endogeneity refers to the systematic monetary authority reaction of a non-US G7 economy (that persists for at least two time periods) following a U.S. conventional contractionary shock. I do not require at least two months reaction to define spillover effects on output, trade balance, and exchange rate of non-US G7 economies following similar shocks.

107 I show the lag selection and portmanteau test results for this section in Table 21 under Appendix A.
increases from the fifth month up to the twelfth month, and USCPI has significant increase in between the eleventh and the eighteenth month.\footnote{108 GPI has significant increase in between the eleventh and the seventeenth month following a U.S. conventional contractionary monetary policy shock.}

Figure 7 displays the response of the VIX and the Euro-area macroeconomic fundamentals to a contractionary U.S. monetary policy innovation. The short-term policy rate of the Euro area shows some significant response in the second and third month following a contractionary U.S. conventional monetary policy innovation. This finding indicates that the Euro-area short-term policy rate response is not significantly different from 0 with 95% probability in the first month, but gives a significant reaction in the following two months after U.S. conventional contractionary monetary policy shocks. Therefore, there is enough evidence to suggest foreign monetary policy endogeneity with one month lag, because the European Central Bank increases short-term policy rate in the following second and third months due to a U.S. conventional contractionary shock. On the other hand, the Euro-area IP significantly increases in between the sixth and twelfth months due to a positive shock in the FFR, and does not show any significant response before these periods. However, the Euro-area trade balance does not indicate any significant reaction after a U.S. conventional contractionary monetary policy shock. Additionally, Figure 7 reflects that a contractionary innovation in the FFR does not lead to any significant response in the VIX.

Figure 8 (for Canada), Figure 9 (for Japan), and Figure 10 (for the UK) show the IRFs of other G7 countries. These figures denote some evidence of foreign monetary policy endogeneity for Canada with one month lag, but for Japan and the UK with ten months lag. Figure 8 shows that the short-term interest of Canada increases in the following eighteenth months due to a U.S.
conventional monetary contraction. According to Figure 9 and Figure 10, the response of Japanese and U.K. short-term interest rate are insignificant until the eleventh month following a U.S. conventional contractionary monetary policy shock, but they have significant increases in between the eleventh and eighteenth periods.

Figure 9 indicates that the IP of Japan increases due to a U.S. monetary contraction shock in following the ninth month, but does not show any significant response before this period. U.K. output increases significantly after the sixth month following a U.S. conventional contractionary monetary policy shock, and does not have significant reaction before this month. The output of Canada does not have any significant response following a contractionary shock to the FFR.

According to Figure 8, the trade balance of Canada improves significantly at the end of first year following a U.S. conventional monetary policy shock, and does not show any significant response before the eleventh month. The Japanese trade balance has a significant improvement in between following the tenth and fourteenth months. The U.K. trade balance significantly worsens in the third month, and improves in the fourth month due to a U.S. conventional contractionary shock. Exogenous contractionary shocks in the FFR in addition cause significant depreciation in the yen, but leads to a significant appreciation in the Canadian dollar against the U.S. dollar in between following the eleventh and fourteenth months. Similar U.S. contractionary monetary policy shocks do not lead to any significant impact on the exchange rate of pound vis-à-vis the U.S. dollar in the following twenty-first month.

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109 The Canadian dollar and yen against the U.S. dollar do not show any significant response until the eleventh month following a U.S. conventional contractionary shock.

This analysis has the same time period and sample of the countries as the previous one, but I intend to see the influence of the European Central Bank’s (ECB) conventional monetary policies. Hence, the benchmark VAR model includes the Euro-area output, the Euro-area consumer price index, the global price index, the Euro-area short-term policy rate, and is assumed to have a Choleski ordering of \{EURIP, EURCPI, GPI, EURINTRATE\}.\(^{110}\) I included every international variable one by one to the above benchmark model after identifying the Euro-area monetary policy shock as was the case for the US in the last section.\(^{111}\) In this analysis, the nominal exchange rate represents national currency units per euro (i.e. yen/euro). Figure 11 reports the results for this benchmark model, which only show a significant effect of the European Central Bank’s conventional monetary policies on the U.S. dollar/euro exchange rate because the other Euro-area domestic variables do not show any significant response following a contractionary E.A. conventional monetary policy shock.\(^{112}\)

Figure 12 presents the IRFs for the US and the VIX. According to these IRFs, an exogenous contractionary shock to the Euro-area short-term policy rate produces an initial rise in the FFR, but becomes insignificant in the second period. Therefore, the response of FFR does not imply an endogenous reaction of the Federal Reserve (Fed) to E.A. conventional monetary policies in the post-euro era following the first period. USIP decreases in between the third and fifteenth months, but turns to positive after the second year due to a contractionary innovation to

\(^{110}\) Policy endogeneity refers to the systematic monetary authority reaction of a non-euro G7 economy (that persists for at least two time periods) following an E.A. conventional contractionary shock. I do not require at least two months reaction to define spillover effects on output, trade balance, and exchange rate of non-EA G7 economies following similar shocks.

\(^{111}\) I present the lag selection and portmanteau test results for this section in Table 22 under Appendix A.

\(^{112}\) The euro appreciates in the sixth month, but depreciates from the seventh to ninth month following a Euro-area conventional monetary policy shock, and does not show any significant reaction other than these periods.
the Euro-area short-term policy rate.\textsuperscript{113} In addition, E.A. conventional contractionary shocks do not lead to any significant response in the U.S. trade balance and VIX.

Figure 13 (for Canada), Figure 14 (for Japan), and Figure 15 (for the UK) show the IRFs for other G7 economies following a contractionary innovation in the Euro-area short-term policy rate. Figure 13 shows that the Canadian short-term interest rate significantly increases in the first three months due to a Euro-area conventional contractionary monetary policy shock.\textsuperscript{114} Figure 14 reveals that E.A. conventional contractionary monetary policy innovations do not lead to any significant impact in the Japanese short-term interest rate. According to Figure 15, the reaction of monetary authority in the UK does not reflect any significant response until the eleventh month, but becomes negative and significant in between the eleventh and eighteenth months following a Euro-area conventional monetary policy shock. Thus, there is some evidence for an endogenous policy reaction of Canada and the UK (except Japan) to the Euro-area.

Moreover, the contractionary shock to the ECB’s conventional monetary policy tool does not induce a significant response in the output of non-US G7 economies other than the UK. The U.K. output significantly decreases after the first month due to an E.A. conventional contractionary shock. The spillover effect of E.A. contractionary conventional monetary innovations is more evident on the trade balances of these non-US G7 economies (except Japan).\textsuperscript{115} The trade balance of Canada improves in the third month, whereas the U.K. trade balance worsens in the same month following a contractionary shock to the Euro-area short-term

\textsuperscript{113} The U.S. output does not show any significant reaction due to an E.A. conventional contractionary monetary policy shock in the first two months.
\textsuperscript{114} The Canadian short-term interest rate decreases in the fourth and fifth months, but turns to insignificant in the sixth month.
\textsuperscript{115} The Japanese trade balance does not show any significant response following E.A. conventional monetary policy shocks.
policy rate. The currencies of these G7 economies (except Canada) reflect some significant reaction against the euro after Euro-area conventional monetary policy innovations. The pound significantly depreciates against the euro in between the eighth and eighteenth months following E.A. conventional monetary contractions. The Japanese yen is also insignificant in the following eighteenth month, but depreciates after this period due to a similar E.A. contractionary shock.


This section analyzes effects of changes in U.S. unconventional monetary policies using monthly data from 2009 to 2015, because unconventional monetary policies have taken into action with the Federal Reserve’s large-scale asset purchases (The Federal Reserve Bank of St. Louis, 2017). The benchmark VAR model employs U.S. output, U.S. consumer price index, a global price index, and the Federal Reserve (Fed)’s assets by initiating a Choleski ordering of \{USIP, USCPI, GPI, USCBA\}. As was the case for the previous sections, I include every international variable one at a time to the benchmark VAR model. Figure 16 denotes that U.S. unconventional monetary policy innovations do not create any significant influence on the domestic economy. However, the U.S. dollar depreciates (the euro appreciates) in the month following an expansionary shock in U.S. central bank assets, but becomes insignificant in the second month.

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116 Trade balances of Canada and the UK do not show any significant response in the first two months after E.A. conventional monetary contractions.

117 The response of Canadian dollar does not turn significant in any time period.

118 Policy endogeneity refers to the systematic monetary authority reaction of a non-US G7 economy (that persists for at least two time periods) following a U.S. unconventional expansionary shock. I do not require at least two months reaction to define spillover effects on output, trade balance, and exchange rate of non-US G7 economies following similar shocks.

119 I show the lag selection and portmanteau test results for this section in Table 23 under Appendix A.

120 The nominal exchange is defined as the value of national currency in terms of the U.S. dollar, i.e. yen/U.S. dollar, in this section.
Figure 17 gives us the IRFs for the VIX and Euro-area macroeconomic fundamentals to an expansionary shock in the Fed assets. The European Central Bank assets do not show any significant response following a U.S. unconventional expansionary monetary policy shock. Figure 17 also indicates that an U.S. unconventional expansionary monetary policy shock does not generate any significant impact in the output and trade balance of the Euro-area. Moreover, I do not find any significant reaction in the VIX after a U.S. unconventional expansionary monetary policy innovation during the Great Recession and its aftermath.

Figure 18 (for Canada), Figure 19 (for Japan), and Figure 20 (for the UK) show effects of changes in U.S. unconventional monetary policies on other G7 countries. The evidence of foreign monetary policy endogeneity is only significant for Japan out of non-US G7 economies. The central bank assets of Japan have significant increases in the first three months following a U.S. unconventional expansionary monetary policy shock. U.S. unconventional expansionary monetary policy innovations do not lead to any significant response to the U.K. and Canadian monetary authorities. In addition, U.S. unconventional monetary shocks do not cause spillovers on these non-euro G7 countries, since I do not find any significant reaction in the exchange rate against the euro, output, and trade balances of these economies.


In this section, the benchmark VAR model includes the Euro-area macroeconomic fundamentals to see the influence of the European Central Bank’s (ECB) unconventional monetary policies. I include the Euro-area output, the Euro-area consumer price index, a global

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121 The U.K. central bank assets data are limited and contain only observations up to September 2014.
122 The response of Japanese central bank assets stay stable in the fourth and fifth months, and turn to insignificant after this period.
price index, and the ECB’s assets in this benchmark model. The Choleski ordering is as follows:
{EURIP, EURCPI, GPI, EURCBA}. I applied the same methodology as in the earlier analyses by employing the marginal method. Figure 21 reports that shocks in the Euro-area central bank assets do not have any significant impact on the domestic economy. However, the euro depreciates (the U.S. dollar appreciates) in the following month due to an exogenous change in the ECB’s assets, but appreciates in the second, third, and fourth months.

Figure 22 demonstrates a set of IRFs for the VIX and the US. I find that U.S. central bank assets have significant decreases starting from the third month up to the ninth month following an exogenous E.A. unconventional monetary policy shock, but this response does not show any significant response other than this time interval. Thus, there is some evidence to imply an endogenous reaction of the Federal Reserve (with two months lag) to an exogenous unconventional expansionary monetary shock from the ECB. Unconventional Euro-area monetary expansions, instead, do not generate spillovers in the US, because I show no significant response in the U.S. output and trade balance.

Figure 23, Figure 24, and Figure 25 show the IRFs for Canada, Japan and the UK to an exogenous Euro-area unconventional expansionary policy shock. An expansionary innovation to the ECB’s assets induces an endogenous policy reaction (with two months lag) in the monetary authority of Japan and the UK, but does not have any significant impact in Canada. For this

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123 Policy endogeneity refers to the systematic monetary authority reaction of a non-euro G7 economy (that persists for at least two time periods) following an E.A. unconventional expansionary shock. I do not require at least two months reaction to define spillover effects on output, trade balance, and exchange rate of non-EA G7 economies following similar shocks.

124 I present the lag selection and portmanteau test results for this section in Table 24 under Appendix A.

125 U.S. central bank assets do not have any significant reaction in the first two months due to a Euro-area unconventional expansionary monetary policy shock.

126 I do not find any significant impact of E.A. unconventional expansionary monetary shocks on the VIX.

127 The central bank assets of Japan and the UK do not show any significant response after a Euro-area unconventional expansionary monetary policy shock in the first two months. The Japanese central bank assets
reason, Euro-area conventional monetary policy changes are more powerful than E.A. unconventional policy innovations in terms of generating foreign monetary policy endogeneity in non-US G7 economies.

Figure 25 shows that the U.K. output has some significant decreases in between the eleventh and eighteenth months following a Euro-area unconventional monetary policy expansion. In addition to the U.K. output, a Euro-area unconventional expansionary monetary policy shock only spills over to the exchange rates of non-US G7 economies, because I find no significant response in the output (except UK) and trade balance of these economies. However, innovations to the ECB’s assets appreciate the Canadian dollar, and the pound against the euro starting from the first month, but significantly appreciate the yen in the second month following an exogenous Euro-area unconventional expansionary monetary policy innovation.128

Robustness Checks

Following Vespignani (2015), I replace the global price index (GPI) with a global crude oil price, which was obtained from the IMF’s primary commodity prices data.129 In this way, I investigate the robustness of earlier results by replacing the GPI with a comparable supply index that I represent with the global crude oil price (Vespignani, 2015). Overall, the results seem robust (from Figure 26 to Figure 93 in the Appendix C) other than seven cases (from Figure 94 to Figure 100 in the Appendix C).

decrease in the following three months, whereas U.K. central bank assets increase in the following three months due to E.A. unconventional monetary expansions.

128 The Japanese yen does not show any significant response in the first period following E.A. unconventional monetary policy expansions.

Four cases are related to the existence of autocorrelation between errors. I find that the VAR models investigating the impact of E.A. conventional monetary contractions on the FFR, Japanese trade balance, and short-term interest rate estimated with the oil price instead of GPI fail from autocorrelation tests when the lag length is same as the marginal method estimation.\textsuperscript{130} I, therefore, increase the lag length, but find different results to the IRFs of marginal method estimations. I include the industrial inputs price index (IPI) and substitute it with the oil price in these three experiments. I show that the VAR models with the IPI in the place of oil price do not have any serial correlation between errors (when the lag length is the same as the marginal method) and produce similar responses to their marginal method estimation.\textsuperscript{131} I also find different result for the impact of E.A. unconventional monetary policy shocks on the U.S. output if I include the price of oil rather than GPI into my estimation model. The U.S. output does not show any positive response after the second period when I estimate it with the price of oil instead of GPI. Similarly, I estimate the U.S. output by replacing the oil price with IPI, but this VAR model fails from autocorrelation test when the lag equals to the marginal method estimation. I, thus, increase the lag length and present very similar response to the marginal method estimation.\textsuperscript{132}

The other three cases that show different results with the price of oil instead of the GPI further amplify the importance of using the IPI rather than the oil price as a substitute to the GPI. The IRF of Canadian trade balance demonstrates different response in the first month following a

\textsuperscript{130} I use the same lag length of marginal method estimation in these robustness checks to compare substitutability of GPI and the oil price. 
\textsuperscript{131} Figure 94 for the FFR, Figure 95 for the Japanese trade balance, and Figure 96 for the short-term interest rate of Japan show the IRFs of these VAR models in the Appendix C. 
\textsuperscript{132} Figure 97 shows that the VAR model estimated the U.S. output with IPI gives us a similar IRF to the marginal method estimation even though the lag length are not the same. The VAR model of marginal method estimation has one lag whereas the model with IPI contains two lags.
Euro-area conventional monetary policy shock when I estimate it with the oil price in the place of GPI. However, this response becomes very similar to the IRF of marginal method estimation when I substitute the oil price with the IPI.\(^{133}\) The influence of U.S. unconventional monetary expansions on the Euro-area output is different when I introduce the price of oil instead of GPI. An exogenous unconventional U.S. monetary expansion produces no response on the Euro-area output when I use the price of oil instead of GPI.\(^{134}\)

I further find that the effect of U.S. unconventional monetary policy shocks on the output of Canada indicates different results when I estimate the Canadian output with the oil price rather than the GPI. The small negative impact on the Canadian output in the next period due to an exogenous U.S. monetary expansion vanishes when it is included with the price of oil instead of the GPI. I, thus, replace the oil price with IPI (as was the case in the above experiments), and find that the IRF of Canadian output estimated with the IPI gives us similar results to the marginal method estimation.\(^{135}\) One explanation could be the behavior of the price of oil during 2009 and 2010, which was less stable than GPI. The standard deviation of the price of oil is 0.304 that is higher than GPI’s standard deviation (0.222) during the same period. For this reason, I add the industrial inputs price index (IPI) to replace GPI in the above estimations, because its movement is closer to GPI than the price of oil.\(^{136}\) Therefore, unlike Vespignani’s (2015) proposal, these robustness checks suggest that the industrial inputs price index is a better substitute for the GPI than the price of oil for the post-euro era.

\(^{133}\) Figure 98 presents the results of these IRFs under the Appendix C.
\(^{134}\) Figure 99 shows the IRFs of these VAR models in the Appendix C.
\(^{135}\) I present the IRFs of these estimations in Figure 100 under the Appendix C.
\(^{136}\) The standard deviation of the industrial inputs price index is 0.19 for this period.
Following Kim (2001), I added every international variable to the benchmark VAR model one by one. I further investigate the robustness of earlier findings by including two and three international variables at the same time to consider some interactions between these variables. I present all robustness check results in the Appendix C. The results denote similar responses to the previous impulse response functions (IRF) when I estimate two international variables in the same VAR model (from Figure 26 to Figure 93 in the Appendix C), except one case. The IRF of the trade balance of Japan is different when this trade balance interacts with the central bank assets of Japan as an additional international variable than only including the Japanese trade balance following a U.S. conventional monetary policy shock. The trade balance of Japan improves more than the IRF of marginal method estimation when I estimate it with the central bank assets of Japan. I believe that we observe more positive response on the Japanese trade balance due to the increase in the central bank assets of Japan following a U.S. unconventional monetary policy shock. I believe that the IRF estimated the trade balance of Japan as only international variable is more realistic scenario than adding the Japanese central bank assets as another international variable, because I expect a significant worsening of Japanese trade balance after a U.S unconventional monetary innovation.

IRFs of including three international variables together in the same model are not robust in 4 cases. The effect of E.A. conventional monetary contractions on the exchange rate of the Canadian dollar against the euro imply different reaction when it is included with the Canadian dollar.

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1. My benchmark VAR model for the impact of U.S. monetary policy shocks includes USIP, USCPI, GPI, and FFR (or USCBA). I estimate another benchmark VAR model that includes EURIP, EURCPI, GPI, EURINTRATE (or EURCBA) to see the effect of Euro-area monetary policy shocks.
2. Figure 101 shows the results of these IRFs in the Appendix C. I also present that the VAR models which replace the central bank assets of Japan with the Japanese output and yen/U.S. dollar exchange rate demonstrate different responses than the marginal method estimation.
output and trade balance.\textsuperscript{139} The appreciation of the Canadian dollar against the euro in the next month following a Euro-area conventional monetary policy shock almost disappears when I estimate it with the Canadian output and trade balance. I believe that the IRF estimated the Canadian dollar exchange rate against the euro as only international variable is more realistic case, because I expect an appreciation of the Canadian dollar against the euro in the following month due to a Euro-area conventional monetary contraction.

The IRF of trade balance of Canada is different following an exogenous E.A. conventional monetary policy shock if I include it with the Canadian dollar vs euro exchange rate and short-term interest rate of Canada into the same VAR model. The trade balance of Canada increases after the first period due to a Euro-area conventional monetary shock when I estimate it with the euro exchange rate of the Canadian dollar and short-term interest rate of Canada. I believe that the Canadian trade balance would worsen in the first two periods due to capital outflows from Canada to the Euro-area (as the IRF only included Canadian trade balance shows in Figure 3.8). The IRF of three Canadian international variables together shows that the trade balance of Canada improves after the first period because of the appreciation of the Canadian dollar against the euro and increase in the short-term interest rate of Canada.\textsuperscript{140}

The impact of an exogenous U.S. unconventional monetary policy shock on the trade balance of Japan suggests different findings when I estimate this trade balance with the yen vs U.S. dollar (USD) exchange rate and central bank assets of Japan than its marginal method.

\textsuperscript{139} I also find different results when I estimate the exchange rate of Canadian dollar vs. euro with the Canadian output and short-term interest rate of Canada. I present these IRFs in the Figure 102 under the Appendix C.

\textsuperscript{140} I show different findings when I estimate this exchange rate with the Canadian output and short-term interest rate of Canada. I present the IRFs of these VAR models in Figure 103 under the Appendix C.
estimation.\textsuperscript{141} I believe that the trade balance of Japan improves (instead of worsening) in the first period, because of the appreciation of yen against the USD and increase in central bank assets of Japan.\textsuperscript{142} I believe that the IRF included the Japanese trade balance as only international variable is more realistic scenario because I expect the Japanese trade balance to worsen in the first period and to improve after this period due to the endogenous reaction of the Bank of Japan to the Federal Reserve. Similarly, U.S. unconventional monetary policy shocks create different impact on the exchange rate of yen against the USD in the first period when I include it with the trade balance and output of Japan in the same model. I believe that the IRF included the yen against USD exchange rate as only international variable is more realistic scenario, because the small initial appreciation of the yen against USD disappears when it is estimated with two other Japanese variables.\textsuperscript{143} I expect an appreciation of the USD against yen in the first month following a U.S. expansionary unconventional monetary innovation (as Figure 3.14 shows).

Conclusion

The aim of my research is to explore interactions of the largest central banks’ actions in the post-euro era. This paper analyzes the influence of the monetary policy behavior of the US and the Euro area (EA) on their monetary policy actions since the advent of the euro as the single currency. I further examine whether the monetary stance of the US and the Euro area create endogenous monetary responses and/or spillovers for other G7 countries. The results of my study reveal that conventional contractionary monetary policy shocks of the Federal Reserve (Fed)

\textsuperscript{141} The IRF is also different than the marginal method estimation when I estimate the trade balance of Japan with the yen/USD exchange rate and output of Japan. I present these findings in Figure 104 under the Appendix C.
\textsuperscript{142} The marginal method estimation of the Japanese trade balance (without other Japanese international variables in this model) demonstrates that it worsens in the first period following a U.S. unconventional monetary policy shock as Figure 19 shows in the Appendix B.
\textsuperscript{143} I find the same result when I estimate the yen vs. USD exchange rate with the trade balance and central bank assets of Japan. I show these IRFs in Figure 3.105 under the Appendix C.
cause foreign policy endogeneity in the Euro-area and in other non-US G7 economies. The Canadian monetary authority significantly responds to the Fed’s contractionary shock with one month lag, whereas the U.K. and Japanese monetary policy significantly reacts to the similar shock after the tenth month. However, the European Central Bank (ECB)’s conventional contractionary monetary policy innovations only cause an endogenous monetary policy implementation in Canada at the first time period, and in the U.K. with ten months lag.

On the other hand, the exogenous U.S. unconventional monetary expansions only cause an endogenous monetary policy action on Japan. However, expansionary Euro-area unconventional monetary policy shocks lead to endogenous responses by the Federal Reserve, the Bank of England, and the Bank of Japan with two months lag. According to the findings of my paper, the Fed significantly causes a foreign monetary policy endogeneity in the ECB (starting from the second month) due to a U.S. conventional contractionary monetary policy shock, but not due to a U.S. unconventional one. The ECB leads to an endogenous response on the Fed with two months lag following a Euro-area unconventional expansionary monetary policy innovation. Thus, I have sufficient evidence to imply that the Euro area becomes stronger during the Great Recession and its aftermath (2009-2015). The results of my research also suggest that there is some evidence regarding the European target of being a counterpart to the US during unconventional monetary policy period (2009-2015).

My chapter suggests that there is an endogenous reaction of G7 monetary authorities to the ECB’s unconventional actions, although the design of unconventional monetary policies differ across these economies as Gambacorta et al. (2012) state. My findings of unconventional

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144 Expansionary Euro-area unconventional monetary policy innovations do not create any significant impact on the monetary policy of Canada.

145 I don’t have enough evidence to claim that E.A. was a counterpart to the US before the Great Recession.
monetary policy period imply that the EU has achieved the target of becoming a counterpart to the US, which was one of the main reasons for the common European monetary union and currency. Consequently, the results of my study empirically demonstrate the real influence of accommodative monetary policies of advanced economies during and in the aftermath of the Great Recession.
References


International Monetary Fund, IMF Primary Commodity Prices (2017). *Crude Oil (Petroleum), Price index, 2005 = 100, simple average of three spot prices; Dated Brent, West Texas*


Table 14. Some Spillover Effects of Monetary Policy Changes in the Post-Euro Era

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<td>Insignificant at the beginning, significant in between the 3rd and 16th periods</td>
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<td>Insignificant at the beginning, significant in between the 6th and 9th periods</td>
<td>U.S. dollar depreciates in the 1st month, but insignificant in the 2nd period</td>
<td>Euro depreciates in the 1st month, but appreciates in the 2nd, 3rd, &amp; 4th periods</td>
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<td>The Effect of E.A. Conventional Monetary Policy Shocks (Monetary Contraction)</td>
<td>Conclusion</td>
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<td>Euro Area</td>
<td>Short-term interest rate</td>
<td>Insignificant in the 1st month, ↑ in the 2nd and 3rd periods</td>
<td>↑ (because this is its own shock)</td>
<td>Endogenous policy reaction to the Federal Reserve</td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>The Federal Funds Rate</td>
<td>↑ (because this is its own shock)</td>
<td>↑ in the 1st month, but insignificant in the 2nd period</td>
<td>Not enough evidence for foreign policy endogeneity</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>Short-term interest rate</td>
<td>Insignificant in the 1st month, ↑ in the 2nd and 3rd periods</td>
<td>↑ in the 1st, 2nd, &amp; 3rd months, but ↓ after the 3rd period</td>
<td>Endogenous policy reaction to the Federal Reserve and to the European Central Bank</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>Short-term interest rate</td>
<td>Insignificant in the first 10 months, ↑ in between the 11th and 18th periods</td>
<td>Insignificant</td>
<td>Endogenous policy reaction to the Federal Reserve</td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>Short-term interest rate</td>
<td>Insignificant in the first 10 months, but ↑ in between the 11th and 18th periods</td>
<td>Insignificant in the first 10 months, but ↓ in between the 11th and 18th periods</td>
<td>Endogenous policy reaction to the Federal Reserve and to the European Central Bank</td>
<td></td>
</tr>
<tr>
<td>Economy</td>
<td>Response Variable of the Impacted Economy</td>
<td>The Effect of U.S. Unconventional Monetary Policy Shocks (Monetary Expansion)</td>
<td>The Effect of E.A. Unconventional Monetary Policy Shocks (Monetary Expansion)</td>
<td>Conclusion</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Euro Area</td>
<td>Central bank assets</td>
<td>Insignificant</td>
<td>↑ (because this is its own shock)</td>
<td>Not enough evidence for foreign policy endogeneity</td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>Central bank assets</td>
<td>↑ (because this is its own shock)</td>
<td>Insignificant in the two months, ↓ after the 2nd period</td>
<td>Endogenous policy reaction to the European Central Bank</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>Short-term interest rate</td>
<td>Insignificant</td>
<td>Insignificant</td>
<td>Not enough evidence for foreign policy endogeneity</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>Central bank assets</td>
<td>↑ in the 1st &amp; 2nd months, but insignificant in the 3rd period</td>
<td>Insignificant in the two months, ↓ after the 2nd period</td>
<td>Endogenous policy reaction to the Federal Reserve &amp; European Central Bank</td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>Central bank assets</td>
<td>Insignificant</td>
<td>Insignificant in the two months, ↑ after the 2nd period</td>
<td>Endogenous policy reaction to the European Central Bank</td>
<td></td>
</tr>
</tbody>
</table>
Table 17. Lag Selection and Portmanteau Test Results for the Impact of U.S. Conventional Monetary Shocks

<table>
<thead>
<tr>
<th>VAR Model</th>
<th>AIC Lag Test</th>
<th>SIC Lag Test</th>
<th>Portmanteau Test p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(USIP, USCPI, GPI, FFR) *</td>
<td>6</td>
<td>2</td>
<td>0.36</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, EUREXCHRATE)</td>
<td>2</td>
<td>2</td>
<td>0.776</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, EURTBALANCE)</td>
<td>8</td>
<td>2</td>
<td>0.241</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, EURIP)</td>
<td>8</td>
<td>2</td>
<td>0.08</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, EURINTRATE)</td>
<td>2</td>
<td>1</td>
<td>0.008 **</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, VIX)</td>
<td>4</td>
<td>2</td>
<td>0.683</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, CANEXCHRATE)</td>
<td>2</td>
<td>2</td>
<td>0.773</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, CANTBALANCE)</td>
<td>4</td>
<td>2</td>
<td>0.712</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, CANIP)</td>
<td>6</td>
<td>2</td>
<td>0.158</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, CANINTRATE)</td>
<td>6</td>
<td>2</td>
<td>0.592</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, JPNECHRATE)</td>
<td>2</td>
<td>2</td>
<td>0.744</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, JPNTBALANCE)</td>
<td>6</td>
<td>2</td>
<td>0.277</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, JPNIP)</td>
<td>2</td>
<td>2</td>
<td>0.844</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, JPNNTRATE)</td>
<td>6</td>
<td>2</td>
<td>0.352</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, UKEXCHRATE)</td>
<td>2</td>
<td>2</td>
<td>0.501</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, UKTBALANCE)</td>
<td>2</td>
<td>2</td>
<td>0.304</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, UKIP)</td>
<td>2</td>
<td>2</td>
<td>0.709</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, UKINTRATE)</td>
<td>8</td>
<td>2</td>
<td>0.241</td>
</tr>
</tbody>
</table>

Notes: AIC refers to the Akaike information criterion whereas SIC the Schwarz information criterion. The second and third column give us the recommended lag selection according to these information criterion. * VAR model is the benchmark VAR model for this section.

The null hypothesis for portmanteau test us no serial correlation between errors so that if p-value exceeds 0.05 then we cannot reject the null hypothesis of no autocorrelation. ** represents the VAR model that fails from autocorrelation test when the lag length equals 1. I increase the lag length for ** VAR model, and estimate it again. I find that I cannot reject the null hypothesis of no autocorrelation when the lag length equals 2. I show the IRFs for ** VAR model with 2 lags.
Table 18. Lag Selection and Portmanteau Test Results for the Impact of E.A. Conventional Monetary Shocks

<table>
<thead>
<tr>
<th>VAR Model</th>
<th>AIC Lag Test</th>
<th>SIC Lag Test</th>
<th>Portmanteau Test p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE) *</td>
<td>3</td>
<td>2</td>
<td>0.144</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, EURUSEXCHRATE)</td>
<td>3</td>
<td>1</td>
<td>0.064</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, USTBALANCE)</td>
<td>3</td>
<td>1</td>
<td>0.003 ***</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, USIP)</td>
<td>2</td>
<td>1</td>
<td>0.134</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, FFR)</td>
<td>2</td>
<td>1</td>
<td>0.002 **</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, VIX)</td>
<td>3</td>
<td>1</td>
<td>0.009 **</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, CANEXCHRATE)</td>
<td>3</td>
<td>1</td>
<td>0.09</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, CANTBALANCE)</td>
<td>3</td>
<td>1</td>
<td>0.352</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, CANIP)</td>
<td>3</td>
<td>1</td>
<td>0.019 **</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, CANINTRATE)</td>
<td>3</td>
<td>2</td>
<td>0.324</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, JPNEXCHRATE)</td>
<td>3</td>
<td>1</td>
<td>0.118</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, JPNTBALANCE)</td>
<td>2</td>
<td>1</td>
<td>0.075</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, JPNIP)</td>
<td>3</td>
<td>1</td>
<td>0.04 **</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, JPNINTRATE)</td>
<td>3</td>
<td>1</td>
<td>0.001 **</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, UKEXCHRATE)</td>
<td>2</td>
<td>1</td>
<td>0.098</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, UKTBALANCE)</td>
<td>2</td>
<td>1</td>
<td>0.293</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, UKIP)</td>
<td>2</td>
<td>1</td>
<td>0.123</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURINTRATE, UKINTRATE)</td>
<td>7</td>
<td>1</td>
<td>0.017 **</td>
</tr>
</tbody>
</table>

Notes: AIC refers to the Akaike information criterion whereas SIC the Schwarz information criterion. The second and third column give us the recommended lag selection according to these information criterion. * VAR model is the benchmark VAR model for this section.

The null hypothesis for portmanteau test us no serial correlation between errors so that if p-value exceeds 0.05 then we cannot reject the null hypothesis of no autocorrelation. ** represents the VAR models that fail from autocorrelation test when the lag length equals 1. I increase the lag length for ** VAR models, and estimate it again. I find that I cannot reject the null hypothesis of no autocorrelation when the lag length increases to 2. I show the IRFs for ** VAR model with 2 lags. *** represents the VAR model that fails from autocorrelation test when the lag length equals one, and also equals two. I increase the lag length to 3 for *** VAR model, and estimate it again. I find that I cannot reject the null hypothesis of no autocorrelation when the lag length equals 3.
Table 19. Lag Selection and Portmanteau Test Results for the Impact of U.S. Unconventional Monetary Shocks

<table>
<thead>
<tr>
<th>VAR Model</th>
<th>AIC Lag Test</th>
<th>SIC Lag Test</th>
<th>Portmanteau Test p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(USIP, USCPI, GPI, USCBA) *</td>
<td>2</td>
<td>1</td>
<td>0.707</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, EUREXCHRATE)</td>
<td>8</td>
<td>1</td>
<td>0.801</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, EURTBALANCE)</td>
<td>8</td>
<td>1</td>
<td>0.296</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, EURIP)</td>
<td>2</td>
<td>1</td>
<td>0.615</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, EURCBA)</td>
<td>8</td>
<td>1</td>
<td>0.419</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, VIX)</td>
<td>2</td>
<td>1</td>
<td>0.899</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, CANEXCHRATE)</td>
<td>8</td>
<td>2</td>
<td>0.931</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, CANTBALANCE)</td>
<td>8</td>
<td>1</td>
<td>0.633</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, CANIP)</td>
<td>8</td>
<td>1</td>
<td>0.487</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, CANINTRATE)</td>
<td>8</td>
<td>1</td>
<td>0.867</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, JPNEXCHRATE)</td>
<td>8</td>
<td>1</td>
<td>0.694</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, JPNTBALANCE)</td>
<td>8</td>
<td>1</td>
<td>0.977</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, JPNPIC)</td>
<td>8</td>
<td>1</td>
<td>0.963</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, JPNPCBA)</td>
<td>8</td>
<td>1</td>
<td>0.672</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, UKEXCHRATE)</td>
<td>8</td>
<td>1</td>
<td>0.505</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, UKTBALANCE)</td>
<td>2</td>
<td>1</td>
<td>0.965</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, UKIP)</td>
<td>2</td>
<td>1</td>
<td>0.822</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, USCBA, UKCBA)</td>
<td>8</td>
<td></td>
<td>0.695</td>
</tr>
</tbody>
</table>

Notes: AIC refers to the Akaike information criterion whereas SIC the Schwarz information criterion. The second and third column give us the recommended lag selection according to these information criterion. * VAR model is the benchmark VAR model for this section.

The null hypothesis for portmanteau test us no serial correlation between errors so that if p-value exceeds 0.05 then we cannot reject the null hypothesis of no autocorrelation.
Table 20. Lag Selection and Portmanteau Test Results for the Impact of E.A. Unconventional Monetary Shocks

<table>
<thead>
<tr>
<th>VAR Model</th>
<th>AIC Lag Test</th>
<th>SIC Lag Test</th>
<th>Portmanteau Test p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA) *</td>
<td>2</td>
<td>1</td>
<td>0.415</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, EURUSEXCHRATE)</td>
<td>8</td>
<td>1</td>
<td>0.523</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, USTBALANCE)</td>
<td>8</td>
<td>1</td>
<td>0.003 ***</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, USIP)</td>
<td>8</td>
<td>1</td>
<td>0.105</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, USCBA)</td>
<td>8</td>
<td>1</td>
<td>0.829</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, VIX)</td>
<td>1</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, CANEXCHRATE)</td>
<td>8</td>
<td>1</td>
<td>0.631</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, CANTBALANCE)</td>
<td>2</td>
<td>1</td>
<td>0.459</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, CANIP)</td>
<td>8</td>
<td>1</td>
<td>0.139</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, CANINTRATE)</td>
<td>8</td>
<td>1</td>
<td>0.049</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, JPNEXCHRATE)</td>
<td>7</td>
<td>1</td>
<td>0.131</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, JPNTBALANCE)</td>
<td>2</td>
<td>1</td>
<td>0.294</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, JPNI)</td>
<td>8</td>
<td>1</td>
<td>0.52</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, JPNLBALANCE)</td>
<td>8</td>
<td>1</td>
<td>0.39</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, UKEXCHRATE)</td>
<td>8</td>
<td>1</td>
<td>0.507</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, UKTBALANCE)</td>
<td>2</td>
<td>1</td>
<td>0.686</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, UKIP)</td>
<td>8</td>
<td>1</td>
<td>0.576</td>
</tr>
<tr>
<td>(EURIP, EURCPI, GPI, EURCBA, UKCBA)</td>
<td>8</td>
<td>1</td>
<td>0.939</td>
</tr>
</tbody>
</table>

Notes: AIC refers to the Akaike information criterion whereas SIC the Schwarz information criterion. The second and third column give us the recommended lag selection according to these information criterion. * VAR model is the benchmark VAR model for this section.

The null hypothesis for portmanteau test us no serial correlation between errors so that if p-value exceeds 0.05 then we cannot reject the null hypothesis of no autocorrelation. *** represents the VAR model that fails from autocorrelation test when the lag length equals one, and also equals two. I increase the lag length to 3 for *** VAR model, and estimate it again. I find that I cannot reject the null hypothesis of no autocorrelation when the lag length equals 3.
Table 21. Portmanteau Test Results of Robustness Checks for the Impact of U.S. Conventional Monetary Shocks

<table>
<thead>
<tr>
<th>VAR Model</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(USIP, USCPI, OIL, FFR, EUREXCHRATE)</td>
<td>0.681</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, EURTBALANCE)</td>
<td>0.398</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, EURIP)</td>
<td>0.109</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, EURINTRATE)</td>
<td>0.203</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, VIX)</td>
<td>0.629</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, CANEXCHRATE)</td>
<td>0.49</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, CANTBALANCE)</td>
<td>0.241</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, CANIP)</td>
<td>0.806</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, CANINTRATE)</td>
<td>0.592</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, JPNEXCHRATE)</td>
<td>0.69</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, JPNTBALANCE)</td>
<td>0.124</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, JPNIP)</td>
<td>0.745</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, JPNINTRATE)</td>
<td>0.522</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, UKEXCHRATE)</td>
<td>0.271</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, UKTBALANCE)</td>
<td>0.411</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, UKIP)</td>
<td>0.596</td>
</tr>
<tr>
<td>(USIP, USCPI, OIL, FFR, UKINTRATE)</td>
<td>0.443</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, EURIP, EUREXCHRATE)</td>
<td>0.477</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, EURTBALANCE, EURINTRATE)</td>
<td>0.248</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, EURTBALANCE, VIX)</td>
<td>0.251</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, EURIP, EURTBALANCE, EURINTRATE)</td>
<td>0.32</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, EUREXCHRATE, EURTBALANCE, VIX)</td>
<td>0.252</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, CANEXCHRATE, CANTBALANCE)</td>
<td>0.938</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, CANIP, CANINTRATE)</td>
<td>0.27</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, CANEXCHRATE, CANTBALANCE, CANINTRATE)</td>
<td>0.964</td>
</tr>
<tr>
<td>(USIP, USCPI, GPI, FFR, CANIP, CANEXCHRATE, CANTBALANCE)</td>
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Notes: I use the same lag length of marginal method estimations in these robustness checks.
Table 22. Portmanteau Test Results of Robustness Checks for the Impact of E.A. Conventional Monetary Shocks

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<th>VAR Model</th>
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Notes: I use the same lag length of marginal method estimations in these robustness checks. Therefore, some above models have different lag length although contain same model variables to compare their IRFs to marginal method estimations.
Table 23. Portmanteau Test Results of Robustness Checks for the Impact of U.S. Unconventional Monetary Shocks

<table>
<thead>
<tr>
<th>VAR Model</th>
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<td>(USIP, USCPI, OIL, USCBA, EUREXCHRATE)</td>
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<tr>
<td>(USIP, USCPI, OIL, USCBA, EURTBALANCE)</td>
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<tr>
<td>(USIP, USCPI, OIL, USCBA, VIX)</td>
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<tr>
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Notes: I use the same lag length of marginal method estimations in these robustness checks.
Table 24. Portmanteau Test Results of Robustness Checks for the Impact of E.A.
Unconventional Monetary Shocks

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<tr>
<th>VAR Model</th>
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<td>(EURIP, EURCPI, OIL, EURCBA, EUREXCHRATE)</td>
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Notes: I use the same lag length of marginal method estimations in these robustness checks.
APPENDIX B
Figure 6. The Effect of U.S. Conventional Monetary Shocks on the Domestic Economy, and the Global Price Index

Notes: These IRFs show the impact of a positive shock to the FFR on the exchange rate of the U.S. dollar against the euro (euro/U.S. dollar), U.S. output, U.S. CPI, and the global price index (from 1999 to the 30th month).
Figure 7. The Effect of U.S. Conventional Monetary Shocks on the Euro-area, and the VIX

Notes: These IRFs show the impact of a positive shock to the FFR on the short-term policy rate, output, the trade balance of the Euro area, and on the VIX (from 1999 up to the 30th month).
Figure 8. The Effect of U.S. Conventional Monetary Shocks on Canada

Notes: These IRFs show the impact of a positive shock to the FFR on the exchange rate of the U.S. dollar against the Canadian dollar (Canadian dollar/U.S. dollar), short-term policy rate, output, and trade balance of Canada (from 1999 up to the 30th month).
Figure 9. The Effect of U.S. Conventional Monetary Shocks on Japan

Notes: These IRFs show the impact of a positive shock to the FFR on the exchange rate of the U.S. dollar against the Japanese yen (yen/U.S. dollar), short-term policy rate, output, and trade balance of Japan (from 1999 up to the 30th month).
Figure 10. The Effect of U.S. Conventional Monetary Shocks on the UK

Notes: These IRFs show the impact of a positive shock to the FFR on the exchange rate of the U.S. dollar against the British pound (pound/U.S. dollar), short-term policy rate, output, and trade balance of the UK (from 1999 up to the 30th month).
Figure 11. The Effect of E.A. Conventional Monetary Shocks on the Domestic Economy, and on the Global Price Index

Notes: These IRFs show the impact of a positive shock to the Euro-area short-term policy rate on the exchange rate of the euro against the U.S. dollar (U.S. dollar/euro), the global price index, output and CPI of the Euro-area (from 1999 up to the 30th month).
Figure 12. The Effect of E.A. Conventional Monetary Shocks on the US and the VIX

Notes: These IRFs show the impact of a positive shock to the Euro-area short-term policy rate on the VIX, FFR, the U.S. output and trade balance (from 1999 up to the 30th month).
Figure 13. The Effect of E.A. Conventional Monetary Shocks on Canada

Notes: These IRFs show the impact of a positive shock to the Euro-area short-term policy rate on the exchange rate of the Canadian dollar against the euro (Canadian dollar/euro), short-term interest rate, output, and trade balance of Canada (from 1999 up to the 30th month).
Figure 14. The Effect of E.A. Conventional Monetary Shocks on Japan

Notes: These IRFs show the impact of a positive shock to the Euro-area short-term policy rate on the exchange rate of the Japanese yen against the euro (yen/euro), short-term interest rate, output, and trade balance of Japan (from 1999 up to the 30th month).
Figure 15. The Effect of E.A. Conventional Monetary Shocks on the UK

Notes: These IRFs show the impact of a positive shock to the Euro-area short-term policy rate on the nominal exchange of the British pound against the euro (pound/euro), short-term interest rate, output, and trade balance of the UK (from 1999 up to the 30th month).
Figure 16. The Effect of the U.S. Unconventional Monetary Shocks on the Domestic Economy, and the Global Price Index

Notes: These IRFs show the impact of a positive shock to the Federal Reserve’s assets on the exchange rate of the U.S. dollar against the euro (euro/U.S. dollar), the global price index, the U.S. output and CPI (from 2009 up to the 30th month).
Figure 17. The Effect of the U.S. Unconventional Monetary Shocks on the Euro-area, and the VIX

Notes: These IRFs show the impact of a positive shock to the Federal Reserve’s assets on the VIX, central bank assets, output, and trade balance of the Euro area (from 2009 up to the 30th month).
Figure 18. The Effect of U.S. Unconventional Monetary Shocks on Canada

Notes: These IRFs show the impact of a positive shock to the Federal Reserve’s assets on the exchange rate of the U.S. dollar against the Canadian dollar (Canadian dollar/U.S. dollar), short-term interest rate, output, and trade balance of Canada, and (from 2009 up to the 30th month).
Figure 19. The Effect of U.S. Unconventional Monetary Shocks on Japan

Notes: These IRFs show the impact of a positive shock to the Federal Reserve’s assets on the exchange of the U.S. dollar against the Japanese yen (yen/U.S. dollar), short-term interest rate, output, and trade balance of Japan (from 2009 up to the 30\textsuperscript{th} month).
Figure 20. The Effect of U.S. Unconventional Monetary Shocks on the UK

Notes: These IRFs show the impact of a positive shock to the Federal Reserve’s assets on the exchange of the U.S. dollar against the British pound (pound/U.S. dollar), short-term interest rate, output, and trade balance of the UK (up to the 30th month). The U.K. central bank assets data are limited and contain only observations up to September 2014.
Figure 21. The Effect of E.A. Unconventional Monetary Shocks on the Domestic Economy, and on the Global Price Index

Notes: These IRFs show the impact of a positive shock to the European Central Bank’s assets on the exchange rate of the euro against the U.S. dollar (U.S. dollar/euro), the global price index, output and CPI of the Euro-area (from 2009 up to the 30th month).
Figure 22. The Effect of E.A. Unconventional Monetary Shocks on the US and the VIX

Notes: These IRFs show the impact of a positive shock to the European Central Bank’s assets on the VIX, the Federal Reserve’s assets, U.S. output and trade balance (from 2009 up to the 30th month).
Figure 23. The Effect of E.A. Unconventional Monetary Shocks on Canada

Notes: These IRFs show the impact of a positive shock to the European Central Bank’s assets on the exchange rate of the Canadian dollar against the euro (Canadian dollar/euro), short-term interest rate, output, and trade balance of Canada (from 2009 up to the 30th month).
Figure 24. The Effect of E.A. Unconventional Monetary Shocks on Japan

Notes: These IRFs show the impact of a positive shock to the European Central Bank’s assets on the exchange rate of the Japanese yen against the euro (yen/euro), central bank assets, output, and trade balance of Japan (from 2009 up to the 30th month).
Figure 25. The Effect of E.A. Unconventional Monetary Shocks on the UK

Notes: These IRFs show the impact of a positive shock to the European Central Bank’s assets on the exchange rate of the British pound against the euro (pound/euro), central bank assets, output, and trade balance of the UK (from 2009 up to the 30th month).
Figure 26. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Exchange Rate of the U.S. Dollar against the Euro

Notes: The first IRF estimates nominal exchange rate of the U.S. dollar against the euro (euro/U.S. dollar) with the price oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the Euro-area output, and the right bottom one uses the Euro-area trade balance and VIX with the euro/USD rate as robustness checks.
Figure 27. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Euro-area Policy Rate

Notes: The first IRF estimates the Euro-area short-term policy rate with the price oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the Euro-area trade balance, and the right bottom one uses the Euro-area output and trade balance with the Euro-area policy rate as robustness checks.
Figure 28. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Euro-area Output

Notes: The first IRF estimates the Euro-area output with the price oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the euro/USD exchange rate, and the right bottom one uses the Euro-area short-term policy rate and the trade balance with the Euro-area output as robustness checks.
Figure 29. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Euro-area Trade Balance

Notes: The first IRF estimates the Euro-area trade balance with the price oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the short-term policy rate, and the right bottom one uses the euro/USD exchange rate and the VIX with the Euro-area trade balance as robustness checks.
Figure 30. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the VIX

Notes: The first IRF estimates the VIX with the price oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the Euro-area trade balance, and the right bottom one uses the euro/USD exchange rate and the Euro-area trade balance with the VIX as robustness checks.
Figure 31. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Short-Term Interest Rate of Canada

Notes: The first IRF estimates the short-term interest rate of Canada with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the Canadian output, and the right bottom one uses the Canadian dollar/USD exchange rate and the trade balance of Canada with the short-term interest rate of Canada as robustness checks.
Figure 32. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Output of Canada

Notes: The first IRF estimates the output of Canada with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30\textsuperscript{th} month). The left bottom IRF includes the short-term interest rate of Canada, and the right bottom one uses the Canadian dollar/USD exchange rate and the trade balance of Canada with the Canadian output as robustness checks.
Figure 33. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Exchange Rate of Canadian Dollar against the U.S. Dollar

Notes: The first IRF estimates the Canadian dollar/USD rate with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the trade balance of Canada, and the right bottom one uses the trade balance and short-term interest rate of Canada with the Canadian dollar/USD rate as robustness checks.
Figure 34. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Trade Balance of Canada

Notes: The first IRF estimates the trade balance of Canada with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the Canadian dollar/USD rate, and the right bottom one uses the Canadian dollar/USD exchange rate and the short-term interest rate of Canada with the trade balance of Canada as robustness checks.
Figure 35. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Short-term Interest Rate of Japan

Notes: The first IRF estimates the short-term interest rate of Japan with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the Japanese output, and the right bottom one uses the yen/USD exchange rate and the Japanese output with the short-term interest rate of Japan as robustness checks.
Figure 36. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Output of Japan

Notes: The first IRF estimates the output of Japan with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the short-term interest rate of Japan, and the right bottom one uses the yen/USD exchange rate and the short-term interest rate of Japan with the Japanese output as robustness checks.
Figure 37. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Exchange Rate of Yen against the U.S. Dollar

Notes: The first IRF estimates the yen/USD exchange rate with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the trade balance of Japan, and the right bottom one uses the trade balance and the short-term interest rate of Japan with the yen/USD rate as robustness checks.
Figure 38. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Trade Balance of Japan

Notes: The first IRF estimates the trade balance of Japan with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the yen/USD rate, and the right bottom one uses the yen/USD exchange rate and the output of Japan with the short-term interest rate of Japan as robustness checks.
Figure 39. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the U.K. Short-term Interest Rate

Notes: The first IRF estimates the U.K. short-term interest rate with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the U.K. output, and the right bottom one uses the U.K. trade balance and U.K. output with the U.K. short-term interest rate as robustness checks.
Figure 40. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the U.K. Output

Notes: The first IRF estimates the U.K. output with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the U.K. short-term interest rate, and the right bottom one uses the pound/USD exchange rate and the U.K. trade balance with the U.K. output as robustness checks.
Figure 41. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the Exchange Rate of Pound against the U.S. Dollar

Notes: The first IRF estimates the pound/USD exchange rate with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the U.K. trade balance the right bottom one uses and the U.K. output and U.K. trade balance with the pound/USD rate as robustness checks.
Figure 42. The Robustness Checks for the Effect of U.S. Conventional Monetary Shocks on the U.K. Trade Balance

Notes: The first IRF estimates the U.K. trade balance with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the pound/USD exchange rate, and the right bottom one uses the pound/USD exchange rate and the U.K. output with the U.K. trade balance as robustness checks.
Figure 43. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Exchange Rate of the U.S. Dollar against the Euro

Notes: The first IRF estimates the USD/euro exchange rate with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the U.S. output, and the right bottom one uses the U.S. output and U.S. trade balance with the USD/euro exchange rate as robustness checks.
Figure 44. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Federal Funds Rate (FFR)

Notes: The first IRF estimates the FFR with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the VIX, and the right bottom one uses the VIX and USD/euro exchange rate with the FFR as robustness checks.
Figure 45. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the U.S. Output

Notes: The first IRF estimates the U.S. output with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the USD/euro exchange rate, and the right bottom one uses the USD/euro exchange rate and U.S. trade balance with the U.S. output as robustness checks.
Figure 46. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the U.S. Trade Balance

Notes: The first IRF estimates the U.S. trade balance with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the $30^{th}$ month). The left bottom IRF includes the U.S. output, and the right bottom one uses the U.S. output and the USD/euro exchange rate with the U.S. trade balance as robustness checks.
Figure 47. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the VIX

Notes: The first IRF estimates the VIX with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the FFR, and the right bottom one uses the FFR and USD/euro exchange rate with the VIX as robustness checks.
Figure 48. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Short-term Interest Rate of Canada

Notes: The first IRF estimates the short-term interest rate of Canada with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the Canadian output, and the right bottom one uses the output of Canada and Canadian dollar/euro exchange rate with the short-term interest rate of Canada as robustness checks.
Figure 49. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Output of Canada

Notes: The first IRF estimates the output of Canada with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the short-term interest rate of Canada, and the right bottom one uses the short-term interest rate of Canada and Canadian dollar/euro exchange rate with the output of Canada as robustness checks.
Figure 50. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Exchange Rate of Canadian Dollar against the Euro

Notes: The first IRF estimates the Canadian dollar/euro exchange rate with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the trade balance of Canada, and the right bottom one uses the output and trade balance of Canada with the Canadian dollar/euro exchange rate as robustness checks.
Figure 51. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Trade Balance of Canada

Notes: The first IRF estimates the trade balance of Canada with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the Canadian dollar/euro exchange rate, and the right bottom one uses the output of Canada and Canadian dollar/euro exchange rate with the trade balance of Canada as robustness checks.
Figure 52. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Short-term Interest Rate of Japan

Notes: The first IRF estimates the short-term interest rate of Japan with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the output of Japan, and the right bottom one uses the yen/euro exchange rate and output of Japan with the short-term interest rate of Japan as robustness checks.
Figure 53. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Output of Japan

Notes: The first IRF estimates the output of Japan with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30\textsuperscript{th} month). The left bottom IRF includes the short-term interest rate of Japan, and the right bottom one uses the short-term interest rate of Japan and yen/euro exchange rate with the output of Japan as robustness checks.
Notes: The first IRF estimates the yen/euro exchange rate with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30\textsuperscript{th} month). The left bottom IRF includes the trade balance of Japan, and the right bottom one uses the output and trade balance of Japan with the yen/euro exchange rate as robustness checks.
Figure 55. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Trade Balance of Japan

Notes: The first IRF estimates the trade balance of Japan with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30\textsuperscript{th} month). The left bottom IRF includes the yen/euro exchange rate, and the right bottom one uses the output of Japan and yen/euro exchange rate with the trade balance of Japan as robustness checks.
Figure 56. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the U.K. Short-term Interest Rate

Notes: The first IRF estimates the U.K. short-term interest rate with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the U.K. output, and the right bottom one uses the pound/euro exchange rate and U.K. output with the U.K. short-term interest rate as robustness checks.
Figure 57. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the U.K. Output

Notes: The first IRF estimates the U.K. output with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the U.K. short-term interest rate, and the right bottom one uses the U.K. trade balance and pound/euro exchange rate with the U.K. output as robustness checks.
Figure 58. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Exchange Rate of Pound against the Euro

Notes: The first IRF estimates the pound/euro exchange rate with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the U.K. trade balance, and the right bottom one uses the U.K. output and trade balance with the pound/euro exchange rate as robustness checks.
Figure 59. The Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the U.K. Trade Balance

Notes: The first IRF estimates the U.K. trade balance rate with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month). The left bottom IRF includes the pound/euro exchange rate, and the right bottom one uses the pound/euro exchange rate and U.K. output with the U.K. trade balance as robustness checks.
Figure 60. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Exchange Rate of the Euro against the U.S. Dollar

Notes: The first IRF estimates the euro/USD exchange rate with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the Euro-area trade balance, and the right bottom one uses the output and trade balance of Euro-area with the euro/USD exchange rate as robustness checks.
Figure 61. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Euro-Area Central Bank Assets

Notes: The first IRF estimates the Euro-area central bank assets with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the VIX, and the right bottom one uses the VIX and euro/USD exchange rate with the Euro-area central bank assets as robustness checks.
Figure 62. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Euro-Area Output

Notes: The first IRF estimates the Euro-area output with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the Euro-area trade balance, and the right bottom one uses the euro/USD exchange rate, and trade balance of Euro-area with the Euro-area output as robustness checks.
Figure 63. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Euro-Area Trade Balance

Notes: The first IRF estimates the Euro-area trade balance with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the euro/USD exchange rate, and the right bottom one uses the euro/USD exchange rate and Euro-area output with the Euro-area trade balance as robustness checks.
Figure 64. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the VIX

Notes: The first IRF estimates the VIX with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the Euro-area central bank assets, and the right bottom one uses the Euro-area central bank assets and the euro/USD exchange rate with the VIX as robustness checks.
Figure 65. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Short-term Interest Rate of Canada

Notes: The first IRF estimates the short-term interest rate of Canada with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the trade balance of Canada, and the right bottom one uses the trade balance and output of Canada with the short-term interest rate of Canada as robustness checks.
Figure 66. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Output of Canada

Notes: The first IRF estimates the output of Canada with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the Canadian dollar/euro exchange rate, and the right bottom one uses the Canadian dollar/USD exchange rate and trade balance of Canada with the Canadian output as robustness checks.
Figure 67. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Exchange Rate of Canadian dollar against the U.S. Dollar

Notes: The first IRF estimates the Canadian dollar/USD exchange rate with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the Canadian output, and the right bottom one uses the output and trade balance of Canada with the Canadian dollar/USD exchange rate as robustness checks.
Figure 68. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Trade Balance of Canada

Notes: The first IRF estimates the trade balance of Canada with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the short-term interest rate of Canada, and the right bottom one uses the Canadian output of Canada and the short-term interest rate of Canada with the Canadian trade balance as robustness checks.
Figure 69. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Central Bank Assets of Japan

Notes: The first IRF estimates the central bank assets of Japan with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the trade balance of Japan, and the right bottom one uses the yen/USD exchange rate and trade balance of Japan with central bank assets of Japan as robustness checks.
Figure 70. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Output of Japan

Notes: The first IRF estimates the output of Japan with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the yen/USD exchange rate, and the right bottom one uses the yen/USD exchange rate and trade balance of Japan with the output of Japan as robustness checks.
Figure 71. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Exchange Rate of Yen against the U.S. Dollar

Notes: The first IRF estimates the yen/USD exchange rate with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the Japanese trade balance, and the right bottom one uses the output and trade balance of Japan with the yen/USD exchange rate as robustness checks.
Figure 72. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Trade Balance of Japan

Notes: The first IRF estimates the trade balance of Japan with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes central bank assets of Japan, and the right bottom one uses the yen/USD exchange rate and central bank assets of Japan with the trade balance of Japan as robustness checks.
Figure 73. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on U.K. Central Bank Assets

Notes: The first IRF estimates U.K. central bank assets with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the U.K. trade balance, and the right bottom one uses the U.K. trade balance and U.K. output with U.K. central bank assets as robustness checks.
Figure 74. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the U.K. Output

Notes: The first IRF estimates the U.K. output with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the pound/USD exchange rate, and the right bottom one uses the pound/USD exchange rate and U.K. trade balance with the U.K. output as robustness checks.
Figure 75. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Exchange Rate of Pound against the U.S. Dollar

Notes: The first IRF estimates the pound/USD exchange rate with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the U.K. output, and the right bottom one uses the U.K. output and trade balance with the pound/USD exchange rate as robustness checks.
Figure 76. The Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the U.K. Trade Balance

Notes: The first IRF estimates the U.K. trade balance with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes U.K. central bank assets, and the right bottom one uses the pound/USD exchange rate and U.K. output with the U.K. trade balance as robustness checks.
Figure 77. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the Exchange Rate of U.S. Dollar against the Euro

Notes: The first IRF estimates the USD/euro exchange rate with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the VIX, and the right bottom one uses the U.S. output and VIX with the USD/euro exchange rate as robustness checks.
Figure 78. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on U.S. Central Bank Assets

Notes: The first IRF estimates U.S. central bank assets with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the U.S. output, and the right bottom one uses the U.S. output and VIX with U.S. central bank assets as robustness checks.
Figure 79. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the U.S. Output

Notes: The first IRF estimates U.S. central bank assets with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the U.S. central bank assets, and the right bottom one uses the USD/euro exchange rate and VIX with the U.S. output as robustness checks.
Figure 80. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the U.S. Trade Balance

Notes: The first IRF estimates the U.S. trade balance with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the USD/euro exchange rate, and the right bottom one uses the USD/euro exchange rate and U.S. output with U.S. central bank assets as robustness checks.
Figure 81. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the VIX

Notes: The first IRF estimates the VIX with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the USD/euro exchange rate, and the right bottom one uses the USD/euro exchange rate and U.S. output with the VIX as robustness checks.
Figure 82. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the Short-term Interest Rate of Canada

Notes: The first IRF estimates the short-term interest rate of Canada with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the output of Canada, and the right bottom one uses the Canadian dollar/euro exchange rate and output of Canada with the short-term interest rate of Canada as robustness checks.
Figure 83. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the Output of Canada

Notes: The first IRF estimates the output of Canada with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the short-term interest rate of Canada, and the right bottom one uses the Canadian dollar/euro exchange rate and trade balance of Canada with the output of Canada as robustness checks.
Figure 84. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the Exchange Rate of Canadian Dollar against the Euro

Notes: The first IRF estimates the Canadian dollar/euro exchange rate with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the trade balance of Canada, and the right bottom one uses the output and trade balance of Canada with the Canadian dollar/euro exchange rate as robustness checks.
Figure 85. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the Trade Balance of Canada

Notes: The first IRF estimates the trade balance of Canada with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the Canadian dollar/euro exchange rate, and the right bottom one uses the output of Canada and Canadian dollar/euro exchange rate with trade balance of Canada as robustness checks.
Figure 86. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the Central Bank Assets of Japan

Notes: The first IRF estimates the central bank assets of Japan with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the output of Japan, and the right bottom one uses the Japanese trade balance and output of Japan with the central bank assets of Japan as robustness checks.
Figure 87. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the Output of Japan

Notes: The first IRF estimates the output of Japan with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the central bank assets of Japan, and the right bottom one uses the yen/euro exchange rate and central bank assets of Japan with the output of Japan as robustness checks.
Figure 88. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the Exchange Rate of Yen against the Euro

Notes: The first IRF estimates the yen/euro exchange rate with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the trade balance of Japan, and the right bottom one uses the output and trade balance of Japan with the yen/euro exchange rate as robustness checks.
Figure 89. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the Trade Balance of Japan

Notes: The first IRF estimates the trade balance of Japan with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the yen/euro exchange rate, and the right bottom one uses the yen/euro exchange rate and output of Japan with the trade balance of Japan as robustness checks.
Figure 90. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on U.K. Central Bank Assets

Notes: The first IRF estimates U.K. central bank assets with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30\textsuperscript{th} month). The left bottom IRF includes the U.K. trade balance, and the right bottom one uses the pound/euro exchange rate and U.K. trade balance with U.K. central bank assets as robustness checks.
Figure 91. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the U.K. Output

Notes: The first IRF estimates the U.K. output with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the pound/euro exchange rate, and the right bottom one uses the pound/euro exchange rate and U.K. trade balance with the U.K. output as robustness checks.
Figure 92. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the Exchange Rate of Pound against the Euro

Notes: The first IRF estimates the pound/euro exchange rate with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes the U.K. output, and the right bottom one uses the U.K. output and U.K. trade balance with the pound/euro exchange rate as robustness checks.
Figure 93. The Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the U.K. Trade Balance

Notes: The first IRF estimates the U.K. trade balance with the price of oil (instead of GPI) in the unconventional monetary policy period (from 2009 up to the 30th month). The left bottom IRF includes U.K. central bank assets, and the right bottom one uses the pound/euro exchange rate and U.K. output with the U.K. trade balance as robustness checks.
Figure 94. The Main Results and Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the FFR

Notes: The first IRF shows the results of marginal method (with 2 lags) in which the FFR was estimated with the GPI. The left bottom IRF estimates the FFR with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month), but fails from the autocorrelation test when the lag length equals 2 (so lag length equals 3). The right bottom IRF includes the Industrial Inputs Price Index (instead of GPI) with the FFR (lag length equals 2) as robustness checks.
Figure 95. The Main Results and Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Trade Balance of Japan

Notes: The first IRF shows the results of marginal method (with 1 lag) in which the Japanese trade balance was estimated with the GPI. The left bottom IRF estimates the Japanese trade balance with the price of oil (instead of GPI) in the conventional monetary policy period (from 1999 up to the 30th month), but fails from the autocorrelation test when the lag length equals 1 (so lag length equals 2). The right bottom IRF includes the Industrial Inputs Price Index (instead of GPI) with the trade balance of Japan (lag length equals 1) as robustness checks.
Figure 96. The Main Results and Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Short-term Interest Rate of Japan

Notes: The first IRF shows the results of marginal method (with 2 lags) in which the short-term interest rate of Japan as the only international variable was estimated with the GPI. The left bottom IRF estimates the short-term interest rate of Japan with the price of oil in the conventional monetary policy period (from 1999 up to the 30th month), but fails from the autocorrelation test when the lag length equals 2 (so lag length equals 3). The right bottom IRF includes the Industrial Inputs Price Index (instead of GPI) with the short-term interest rate of Japan (lag length equals 2) as robustness checks.
Figure 97. The Main Results and Robustness Checks for the Effect of E.A. Unconventional Monetary Shocks on the U.S. Output

Notes: The first IRF shows the results of marginal method (with 1 lag) in which the U.S. output as the only international variable was estimated with the GPI. The left bottom IRF estimates the U.S. output with the price of oil (lag length equals to 1) in the unconventional monetary policy period (from 2009 up to the 30th month). The right bottom IRF includes the Industrial Inputs Price Index (instead of GPI) with the U.S. output, but fails from the autocorrelation test when the lag length equals 1 (so lag length equals 2).
Figure 98. The Main Results and Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Trade Balance of Canada

Notes: The first IRF shows the results of marginal method in which the Canadian trade balance as the only international variable was estimated with the GPI. The left bottom IRF estimates the Canadian trade balance with the price of oil in the conventional monetary policy period (from 1999 up to the 30th month). The right bottom IRF includes the Industrial Inputs Price Index (instead of GPI) with the Canadian trade balance as robustness checks.
Figure 99. The Main Results and Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Euro-area Output

Notes: The first IRF shows the results of marginal method in which the Euro-area output as the only international variable was estimated with the GPI. The left bottom IRF estimates the Euro-area output with the price of oil in the unconventional monetary policy period (from 2009 up to the 30th month). The right bottom IRF includes the Industrial Inputs Price Index (instead of GPI) with the Euro-area output as robustness checks.
Figure 100. The Main Results and Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Output of Canada

Notes: The first IRF shows the results of marginal method in which the Canadian output as the only international variable was estimated with the GPI. The left bottom IRF estimates the Canadian output with the price of oil in the unconventional monetary policy period (from 2009 up to the 30th month). The right bottom IRF includes the Industrial Inputs Price Index (instead of GPI) with the Canadian output as robustness checks.
Figure 101. The Main Results and Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Trade Balance of Japan

Notes: The first IRF shows the results of marginal method in which the trade balance of Japan as the only international variable was estimated with the GPI. The above right bottom IRF estimates the Japanese trade balance with central bank assets of Japan in the unconventional monetary policy period (from 2009 up to the 30th month). The bottom left bottom IRF includes the Japanese output, and the right bottom IRF estimates the yen/USD exchange rate with the trade balance of Japan as robustness checks.
Figure 102. The Main Results and Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Exchange Rate of Canadian Dollar against Euro

Notes: The first IRF shows the results of marginal method in which the Canadian dollar/euro exchange rate as the only international variable was estimated with the GPI. The left bottom IRF estimates the Canadian dollar/euro exchange rate with the Canadian output and trade balance in the conventional monetary policy period (from 1999 up to the 30th month). The right bottom IRF includes the Canadian output and short-term interest rate of Canada with the Canadian dollar/euro exchange rate as robustness checks.
Figure 103. The Main Results and Robustness Checks for the Effect of E.A. Conventional Monetary Shocks on the Trade Balance of Canada

Notes: The first IRF shows the results of marginal method in which the Canadian trade balance as the only international variable was estimated with the GPI. The left bottom IRF estimates the trade balance of Canada with the Canadian dollar/euro exchange rate and Canadian output in the conventional monetary policy period (from 1999 up to the 30th month). The right bottom IRF includes the output of Canada and short-term interest rate of Canada with the Canadian trade balance as robustness checks.
Notes: The first IRF shows the results of marginal method in which the trade balance of Japan as the only international variable was estimated with the GPI. The left bottom IRF estimates the trade balance of Japan with the yen/euro exchange rate and central bank assets of Japan in the unconventional monetary policy period (from 2009 up to the 30th month). The right bottom IRF includes the yen/euro exchange rate and output of Japan with the trade balance of Japan as robustness checks.
Figure 105. The Main Results and Robustness Checks for the Effect of U.S. Unconventional Monetary Shocks on the Exchange Rate of Yen against the U.S. Dollar

Notes: The first IRF shows the results of marginal method in which the yen/USD exchange rate as the only international variable was estimated with the GPI. The left bottom IRF estimates the euro/USD exchange rate with the output and trade balance of Japan in the unconventional monetary policy period (from 2009 up to the 30th month). The right bottom IRF includes the trade balance of and central bank assets of Japan with the yen/USD exchange rate as robustness checks.
CHAPTER V

CONCLUSION

In the first two chapters of this dissertation, I showed that safe haven behavior is an important explanation for the performance of USD and euro. Safe haven behavior appears to be an investment strategy in the face of global uncertainty. The Great Recession serves as a perfect candidate to test safe haven behavior. I observed significant impact of safe haven flows in the movements of the nominal U.S. dollar and euro exchange rates when I also control for relevant macroeconomic fundamentals. I found that the USD and euro qualify as safe haven currencies when the market uncertainty originates in the U.S, because as revealed in the first two chapters, the VIX has a positive and significant impact on the values of USD and euro. I showed that the VSTOXX, however, does not have any significant impact on the value of USD during the Great Recession and afterwards in the first chapter of this dissertation. In the second chapter, my results implied that global investors move away from the euro when the European market uncertainty is high, because there is a negative and significant relationship between the euro and VSTOXX. I also showed that world investors use the euro as a safe haven only in cash (as the positive and significant coefficient on the VIX suggests from Table 2.3), because there was no significant impact of the European stock market on the euro-denominated possible safe haven assets (Table 2.6). On the other hand, the findings of my first chapter suggested that VSTOXX futures, the one-year T-bill, five-year T-Note and twenty-year T-Bond are other safe haven possibilities for investors if the S&P 500 Index performs lower return than the first-percentage-quantile of its return distribution. The results of first two chapters imply that the USD was stronger in terms of being safe haven currency, because investors used the euro only in cash.
In the last chapter of this dissertation, I investigated the influence of the monetary policy behavior of the US and the Euro area (EA) on their monetary policy actions since the advent of the euro as the single currency. Following Kim’s (2001) methodology, I explored the transmission of largest central banks’ monetary policy decisions on each other, and other G7 economies (Canada, Japan, and the UK). The results of this chapter show that US was the origin of conventional monetary policy shocks (1999-2008), because the non-US G7 economies pursue an endogenous monetary policy response following a U.S. conventional monetary policy shock before the Great Recession. This finding implies that US is still the origin of monetary policy shocks during the current conventional monetary policy period (2015-2020).

I also demonstrated that Euro-area unconventional monetary policy shocks cause an endogenous reaction in the monetary authorities of US, UK, and Japan. My dissertation, thus, provides some significant evidence to suggest that the Euro area has been successful in terms of becoming a counterpart to the US during unconventional monetary policies period (2009-2015), a motivating factor for the construction of the monetary union and common currency. The findings of this third chapter demonstrate that being the European counterpart to the US was not existed before the Great Recession.