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Monetary Autonomy in times of Financial Integration

A VAR-study of the international transmission of monetary policies.

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Abstract

With the growing importance of financial stability as a policy goal, the effects of global financial cycles have increased as well. Due to these developments, monetary policy has seen significant convergence worldwide. Literature has argued that autonomous monetary policy-setting is no longer possible in conjuncture with integration into the world's financial system. The extent of policy dependence within OECD-countries is tested through Vector Auto-Regressions. In doing so we find that monetary sovereignty still exists, despite the increasing levels of financial integration. Nevertheless, moving forward, macroprudential policy should indeed receive increased attention to retain monetary sovereignty globally.

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1 Introduction

While thinking of financial integration one cannot help but notice that despite the increasing openness towards international capital flows, we have not conclusively seen the growth in prosperity which people often imagine to be associated with it (Edison et al., 2002). It has however led to increased macroeconomic stability, both in advanced and emerging economies alike (De Nicolò and Juvenal, 2014). Such stability could be recognized as a sign of economic integration, a product of the global financial assimilation happening at the moment. International harmonization could lead to transmission of foreign monetary policies on to domestic markets (Kim, 2001b). The increasing degree of international openness within financial markets is the likely driving force of such transmission effects, while these markets are in fact individually governed by their respective domestic monetary authority (Potjagailo, 2017). This raises some intriguing questions within the sphere of such policies. Among others, one might wonder how the transmission of monetary policy from one country to another affects the local policy-setting behavior as observed within central banks. Rey (2015) suggested that due to this integration-process one might be able to find a single policy-setting economy transmitting its stance to other economies which depend on it financially. The theoretical "irreconcilable trinity" has not been consistently proven by empirical literature as a result. Especially in the modern world of financial linkages, many wonder whether such independent policy-setting is still feasible.

According to Mundell (1963) and Fleming (1962), authorities can independently choose two out of three possible policy options. These consist of capital mobility, a fixed exchange rate and monetary sovereignty. Opting for any two of these renders the third option impossible according to their theory. For instance, when there exists free movement of capital and a fixed exchange rate, the central bank will find itself constantly following foreign monetary policies in a bid to keep the exchange rate stable. Similarly, monetary autonomy combined with capital mobility can by definition not allow for a fixed exchange rate. If this kind of an exchange rate would be part of this policy, the central bank in question would find itself, once again, following foreign policy and thus is forced to renege on its commitment to independence. Finally, monetary independence combined with a fixed exchange rate requires capital controls. Without it, a fixed exchange rate becomes impossible to uphold, as the rate becomes exposed to speculative attacks. This then explains why the trilemma is also known as the impossible trinity. Figure 1.1 depicts this trilemma, where only one side of the triangle can be followed according to Mundell and Fleming's theory.

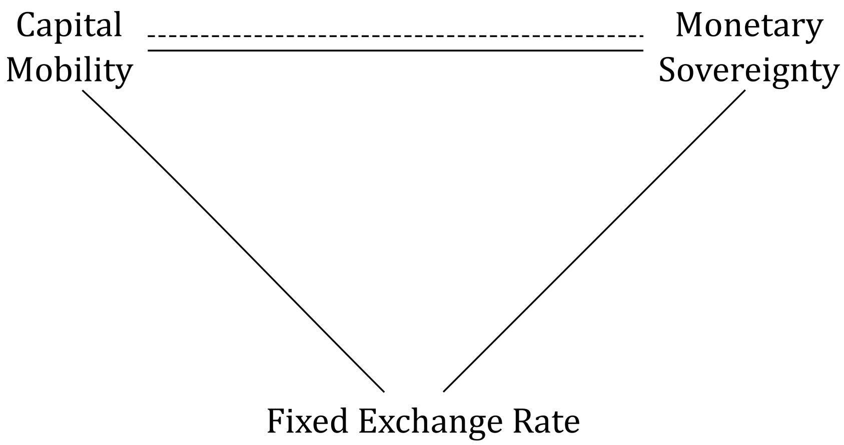

Figure 1.1: The Mundell-Fleming Trilemma

Although such a trilemma has generally been accepted within macroeconomic textbooks, it has been questioned by Rey (2015) and debated in empirical literature ever since. Rey provides strong evidence of monetary transmission channels having opened up through the process of worldwide financial integration. She argues that this leads to inconsistencies in the policy-trilemma provided by Mundell (1963) and Fleming (1962). Rey shows how the global financial cycle affects macroeconomic and macro-financial conditions across the globe due to the aforementioned financial integration of the major economies. Floating exchange rates can no longer guarantee the policy-pair of capital mobility and monetary sovereignty according to this argument. In the modern world, Rey argues, financial uncertainty and monetary fluctuations can be transmitted very efficiently across borders. This is due to the prevailing openness towards international capital flows, which was mentioned earlier.

The argument further implies that there must actually exist a dichotomous choice between monetary independence and integration within the global financial system. Subsequently, the type of exchange rate regime is entirely sidelined in this setting. Floating regimes that opt for capital mobility will still face financial pressures due to foreign policies, thereby limiting the autonomy of their own monetary policy. In Figure 1.1 this dichotomy, as suggested by Rey, is therefore highlighted by the horizontal dashed link between capital mobility and monetary policy, leaving the fixed exchange rate option out of the dilemma. Subsequently, an economy can merely choose to either allow for international financial integration, foregoing any capital controls, or to subject itself to internationally leading monetary policy, which leads to a cyclical movement within global financial markets according to Rey (2015).

In the original trilemma setting, the exchange rate regime acted as a focal point for monetary policy. Given there exists capital mobility and a fixed exchange rate, monetary policy has to ensure currency stability. As a result, such a policy would be bound to the movements of policies abroad. Moreover, in case of a fixed exchange rate without free flow of capital, monetary policy would be autonomous as there can be no speculative attacks on the currency. This is the key point of the trilemma. However, as noted by Rey (2015), in the current policy-environment a new aim has emerged. Financial stability has become as much of a goal for policymakers as price and output stability, two of the primary policy goals often found as officially stated mandates. This implies that a new policy-transmission mechanism can be identified regardless of the exchange rate regime. Capital mobility allows the cyclical movements of the global financial cycle to be transmitted across borders. This results in similar monetary issues within different countries, due to the emerging financial stability goals. Therefore policy independence can be lost through the financial cycles (Rey, 2015). Subsequently, Rey suggests reducing the original trilemma to a dilemma, by eliminating the fixed exchange rate option. As a result there merely exists a dichotomous choice between capital mobility and monetary sovereignty. A further implication, therefore, is that within any monetary jurisdiction which allows for free flows of capital, no monetary autonomy would be able to exist. Conversely, capital controls assure monetary independence, immunizing a given economy to the global financial cycle as a whole.

This paper aims to contribute to the growing body of literature regarding the validity of the classical Mundell-Fleming policy trilemma, through the particular case of the OECD member-states. These nations have a unique position within both the trilemma as well as the dilemma. They indeed find themselves within the floating exchange rate combined with free capital flows position, which according to the trilemma should allow them to set their own independent monetary policies. However, if the "irreconcilable duo" described by Rey (2015) proves correct, monetary autonomy should not be available to these countries. This will be tested by means of a Vector Autoregression (VAR) approach, using a sample period between 2002 and 2020. In doing so we attempt to uncover the relation between monetary policies in center- and periphery-countries. We hypothesize that there still exists monetary autonomy to a certain extent, even within the periphery. This entails that center-countries' monetary policies do not in fact dictate the policies of countries in the periphery. The rest of this paper will be structured as follows. In section 2 the literature concerning this interesting question of monetary autonomy will be discussed. This will be followed by a discussion of the methodology in section 3 and a brief overview of the data used in section 4. The empirical analysis will then be performed and discussed in section 5. The results and implications will be discussed in sections 6 and 7.

2 Literature

2.1 Policy coordination and convergence

Conventional wisdom says monetary policies should keep prices stable within some bandwidth. This aim is separate from serving other mandates which have been put on to monetary authorities. However, as central banks often find their primary task to be the controlling of inflation, other tasks often fall into the background. One could subsequently wonder whether policies aimed at financial stability within domestic markets can be effective. Additional concerns can be raised given the high levels of international assimilation between markets. Regardless of such questionable efficiency, this type of mandate is becoming more prevalent among the worlds' central banks. We should consider whether international policy-coordination would be feasible as a means to control the stability of financial markets from a central vantage point. This could be of great importance to the goal of financial market stability in the global sense (Rey, 2015). Coordination of policies was the de facto goal behind the creation of the European Monetary System in 1979, given the already existing dependence of countries like France, Belgium, and the Netherlands on West-German monetary policy (von Hagen and Fratianni, 1990). Indeed, countries do converge their policies, as has been observed through historical examples.

A noteworthy example is that of the Dutch Guilder and West-German Mark, as the economies to which these currencies belonged appeared to be closely linked due to institutional similarities and trade-linkages (Delsen and de Jong, 2012). As a result of the inter-connectivity of these economies, a convergence of monetary policies was indeed observed, as the Guilder was fixed tightly to the Mark since the 1970s, albeit unofficially (Bredin and Fountas, 1998; De Haan et al., 1991). The Dutch central bank (*De Nederlandsche Bank*) seemed to follow the West-German central bank (*Deutsche Bundesbank*) in each policy decision, as trade relations between the two nations was of such importance to the Netherlands so as to warrant the potential costs of these actions. The very fact Dutch policies closely followed West-German policies exemplifies the possibility of center-periphery relations existing in the monetary sphere. Although the convergence of policies might have been deliberate, it does show the possibility for advantageous effects coming from such convergence. As such, convergence might in some cases be beneficial for the economies in the periphery, even if it comes at the cost of monetary autonomy.

Both of the aforementioned nations would later join the Economic and Monetary Union (EMU). Under the EMU, policy coordination became specified, as convergence of policies is an integral part of the program's aims across the member-states. Indeed stable exchange rates to the European Currency Unit were required under the European Exchange Rate Mechanism (ERM), both introduced in 1979. Subsequently, policies converged in most cases through a smooth process. Some EMU/ERM member-states however may not have had a natural tendency for such convergence (Grauwe and Schnabl, 2005). Therefore one should be careful when estimating the true force behind policy convergence in the setting of monetary unity, as exhibited by the EMU/ERM. None the less, history has shown policy convergence is not only feasible in the current economic environment, but sometimes actively encouraged.

Equally well established is the fact that in times of financial disruption, monetary policies should respond to any foreign policy transmission onto domestic markets (Mishkin, 2010). As a result, these policies could converge down to a single strategy as was seen during the aftermath of the global financial crisis (Fawley and Neely, 2013). Such an episode of unconventional monetary policies could serve as an example for the similar approaches taken by various central banks around the world, as a potential result of policy transmission. However other episodes in which deviations from normal monetary operations have led to an array of similar policy changes have been recorded in the past as well (Taylor, 2013). Policy spillovers as described by Taylor (2013) are now seen as common and even the real economy is shown to be affected by these policy spillovers (Potjagailo, 2017).

Evidence for this was provided by Kim (2001b), who suggested that the macroeconomic responses to monetary policy transmission within the G-7 countries might not support the Mundell-Fleming argument for a policy trilemma, as traditionally used within the prevailing literature (Obstfeld, 2000). This follows from the previously discussed setup of the trilemma. If evidence of monetary dependence can indeed be found in conjecture with floating exchange rates and free movement of capital, the trilemma cannot hold. Kim (2001a) provides suggestive evidence for this but does not definitively prove or disprove this kind of relation. Hence policy convergence should be studied in greater detail. Obstfeld et al. (2005) have however revived this discussion in favor of the trilemma through empirical research. It is therefore worth noting that the debate on this issue is still ongoing. Moreover, a recent paper by Aizenman (2019) attempts to reformulate this trilemma to fit the empirics. Such a reformulation will be discussed later in this paper as it is worth noting possible flexibility in the interpretation of this trilemma.

2.2 The Global Financial Cycle

Some argue that due to the increasing international integration of financial markets, the transmission of monetary policies occurs at a global scale and converges policies of all countries that allow free movements of capital across their borders (Rey, 2016). In her influential paper, Rey (2015) discusses the cyclical movements of global capital flows as a transmitter of monetary conditions from a center-economy to countries in the periphery[1]. Financial openness enables these cycles to affect the macroeconomic variables which happen to be crucial to policy-setting, thereby forcing various economies to counteract these effects.

This global financial cycle, a term also used by Rey (2015), can in fact be broken down into two distinct parts according to Habib and Venditti (2018). Habib and Venditti argue that such cyclical movements are on the one hand affected by U.S. monetary policy, often seen as being at the center of global financial markets. On the other hand it is also affected by risk aversion at a global scale. Although the U.S.' importance to global financial markets is rarely questioned, it can only partly explain the current financial cycle (Miranda-Agrippino and Rey, 2015a). Nonetheless, Miranda and Rey indeed provide evidence of the importance of U.S. monetary policy to global asset pricing, and by extension therefore of the U.S.'s role in the global financial cycle. In doing so they show high degrees of comovements between financial market indicators, such as leverage, the flow of capital, bond spreads and global credit, and the U.S. monetary stance.

It is also clear is that risk aversion can equally drive the global financial cycle, thereby also driving the quantity of capital flows (Habib and Venditti, 2018). In various papers, this risk aspect of the global financial cycle is approximated through the Chicago Board Options Exchange's Volatility Index (Cerutti et al., 2019). This measure of risk has indeed been shown to be a good approximation of the global financial cycle (Cerutti et al., 2019; Rey, 2015). However this risk-perception can also be driven by monetary stances through risk-aversion (Bekaert et al., 2013). Risk-aversion could in fact be a feature of U.S. policy changes, as described by Miranda-Agrippino and Rey (2015a). Hence there is indeed a strong possibility for monetary policy of a center-market affecting asset prices, and thus financial stability, globally through the risk-attitude it introduces (Miranda-Agrippino and Rey, 2015a).

[1] Rey (2015) uses this term to describe any market that influenced by the center's monetary policy. As such the same term will be used in this paper and applies to all countries under the effect of a foreign monetary authorities' policies.

Rey (2015) shows that various types of capital flows correlate strongly with the Volatility Index (VIX), in most parts of the world. Moreover, she shows how the VIX is greatly affected by the Federal Reserve's policy rate. This adds to the idea of the global financial cycle being subjected to monetary policies of center-economies. Indeed Miranda-Agrippino and Rey (2015a) confirmed this through decreasing credit flows following U.S. monetary tightening.

Borio (2014) points out that both monetary and macroprudential policy should respond to the booms and busts of the financial cycle. In times of a boom, monetary authorities should implement tightening policies, whilst during a bust expansionary policy is recommended (Borio, 2014). Hence any nation affected by this cycle should condition its policies to the booms and busts it induces within its domestic markets, and subsequently the global markets through the financial cycle, making convergence seemingly more likely to occur. This is especially true given the current financial openness, in which most countries do indeed connect to the large network of global financial linkages, subjecting them to this possible policy convergence.

Milesi-Ferretti and Tille (2011) showed that most nations in the world have seen a dramatic increase with regard to their financial integration in recent decades. This certainly increases the importance of macroprudential policy as a support to the goal of financial stability in the process of monetary policy-making. If macroprudential policy indeed could substitute the monetary goal of financial stability, this would likely prove vital to retaining monetary autonomy. A convergence of monetary policies becomes far less likely if not driven by the need to interact with financial markets which are subjected to the global financial cycle. This means such policies should perhaps not be focused on financial stability if one is to maintain monetary autonomy. Such a separation between monetary and macroprudential goals was, in fact, one of the policy suggestions concluded by Rey (2015).

Usage of macroprudential policy gained greater attention following the Great Financial Crisis (Galati and Moessner, 2013), as financial stability gained importance. Smets (2014) subsequently shows macroprudential policy should be considered when financial stability becomes too large a goal to keep within an inflation-targeting framework. However, at the same time Smets (2014) concludes that monetary policy is still very much intertwined with financial stability at the moment. As such, the global financial cycle is potentially still of great importance to monetary authorities, and to monetary sovereignty by extension.

2.3 OECD position

OECD member-states seem particularly well integrated into the global financial system (Inklaar et al., 2008). As a result, OECD-members find themselves in a situation where the cyclicity of global finances, as described by Rey (2015), becomes detrimental to the conditions in the domestic financial markets. In terms of the infamous Mundell-Fleming trilemma, these countries are subjected to both free capital flows[2] and floating exchange rates.

The original model proposed by the works of Mundell (1963) and Fleming (1962), suggests that these countries should, therefore, be able to independently set their respective monetary policies, given their floating exchange rates. However, in the dilemma proposed by Rey (2015), a binary option between monetary independence and capital mobility, regardless of the exchange rate regime being followed, would force these countries into a consolidation of policies. Rey continues by suggesting the significance of monetary policy in the United States could force countries to follow its example by principle, as the global financial cycle in open-market economies drives the need for monetary conformity. This makes the OECD-economies particularly interesting as a means of testing such a notion, as they conform to the floating exchange rate and capital mobility options within the trilemma framework. This subsequently suggests that these countries are free to set their monetary policies autonomously. In Rey's dilemma however, these economies should be subject to monetary dependence on some central-economy.

The classical version of the Mundell-Fleming model as first suggested in the 1960s has been reconsidered a number of times throughout its existence. A recent example by Aizenman (2019) is particularly interesting as it examined the model within the context of the twenty-first century. Here the argument for policy goal changes has been examined in more detail, specifically the change to financial stability. Of course, Mundell (1963) could merely consider the policy goals available at the time, which most certainly did not include financial stability. Aizenman subsequently suggests extending the trilemma, rather than reducing it to a dilemma as brought forward by Rey (2015), with the inclusion of the various channels through which financial stability is controlled in the modern era. However, by imposing financial restrictions for the sake of financial stability, one could argue the sphere of macroprudential regulation is being entered. This kind of policy should be distinct from monetary policy by design. It should be noted that new institutions for these macroprudential regulations are indeed in the process of being created.

[2] Iceland exempted. Although it is an OECD member-state it implemented some capital controls following the global financial crisis.

In this paper the original Mundell-Fleming trilemma will subsequently be re-examined, taking the conditions of the OECD member-countries as a platform for testing its predictions. Using vector autoregressions, monetary policies of countries in the periphery will be tested for responsiveness to monetary policy changes in global financial center-economies. Moreover, this paper aims to further uncover the mechanisms through which monetary policy is transmitted between centers and their periphery. This will be done by investigating the responsiveness of a number of variables associated with the prevailing monetary mandates, both in terms of price stability as well as financial stability.

3 Methodology

In order to test the hypothesis regarding the influence of center-economies on periphery-economies through the global financial cycle, we have to first identify the features of this cycle. Once we have identified these characteristics, we can identify economies which are central to it. Subsequently we can use these economies to test whether they do indeed affect the countries in their respective periphery. In this section these steps will be described and documented, using a data set of which the details are discussed in Section 4.

3.1 Global Financial Cycle

In the paper by Rey (2015), the importance of the global financial cycle was highlighted. Here Rey uses a number of variables to measure the effects of the cycle on the real economy. These are variables which can link the cycle to real economy crises (Borio et al., 2018). Credit-booms are suggested to be one of the leading indicators prior to a recession, as was for instance suggested by Ivashina and Scharfstein (2010). In their paper they describe a credit-boom in the first half of 2007, followed by a bust in the latter half of the same year. This was later followed by a major recession starting in the second half of 2008. Related to the credit growth as a result of the cycle, bank leverage has been shown to be cyclical by Nuño and Thomas (2012). Miranda-Agrippino and Rey (2015b) suggest this is due to the cyclicality of the global financial markets and as such haven used this as a measure of the global cycle itself.

Moreover, Rey (2015) clearly provides evidence for a co-movement of the financial cycle and the risk-expectations in the financial markets. This forward looking risk measure is measured through the CBOE's Volatility Index (VIX). Based on the volatility of options on the S&P 500 with a 30-day maturity, the VIX is often used as a measure of expected-risk within the U.S. market (Whaley, 2009). The risk component of the global financial cycle might therefore be of great importance for understanding its transmission to the monetary economy. It has subsequently been well established that a number of proxies for the global financial cycle exist, even if a clear indicator of the cycle itself does not. This is mainly due to the complex and multi-dimensional nature of the term itself (Borio, 2014). It is therefore natural to use such approximations as mentioned earlier to measure the impact which center-policies could have on the financial cycle. Thus such proxies are used in this paper as well.

3.2 Center-Economies

In order to identify the effects of the center-policies on the global financial cycle it is important to identify potential center-economies, which could in fact transmit their policies to the periphery through this cycle. Rey (2015) suggested that the United States acts as the main center in this sense. However, one should consider the true magnitude of the United States' role within global financial markets, and subsequently the Federal Reserve's role in monetary policy transmission, when assessing its centrality (Habib and Venditti, 2018). Although Miranda-Agrippino and Rey (2015a) provide clear evidence for the importance of U.S. monetary-policy, other nations should be considered as well for a central role to the cycles of local financial markets. There are various methods available for measuring the financial linkages between nations (Chevallier et al., 2018; Forbes and Chinn, 2004), however few conclusively differentiate center- from periphery-economies for the purpose of this paper.

We use the Bank of International Settlements' data on Locational Banking Statistics since January 2002, which specifies international debt instruments outstanding between any pair of receiving (borrower) and issuing (lender) countries, is used. This allows for determination of the main country of origin of the international credit supply for each nation over time. These relations are mapped as a network to analyze the relations between OECD-members in terms of international banking positions, as shown in Figure 3.1. One finds a few nations for which the role of center-economy would be appropriate in the context of this paper. The United States is indeed a center-country, as it is the main creditor to a few nations. Most notable however is the fact that the Euro area[3] sits right at the center of this sample of OECD-members. A number of the non-European nations use the Euro area as their largest creditor, as well as some European nations outside of the Euro area.

This simple exercise therefore shows us that the Federal Reserve (Fed) in the United States is not the only central monetary-authority which should be considered. The European Central Bank (ECB) should certainly be considered for this position as well, according to Figure 3.1. As noted by Fawley and Neely (2013), these central banks are indeed relevant to the world's financial markets and both have their own methods of conducting monetary-policy, serving different mandates and of course operating in distinct jurisdictions.

[3]For the purpose of this paper the Euro area is considered to be one economy, rather than 19 individual economies.

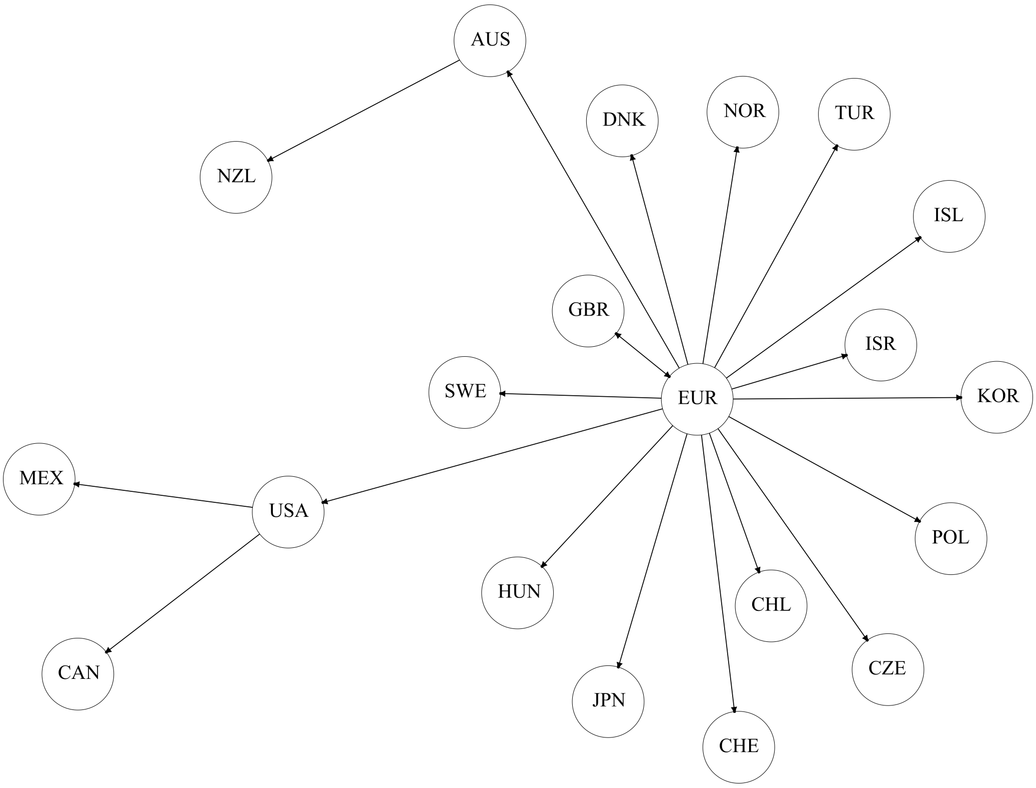

Figure 3.1: Network of Interational Bank Lending according to largest national lenders

3.3 Inflation

While assessing the transmission of center-policies, one should also consider the various other effects such a center-policy could have on economies in its periphery, besides the effects through the financial cycle. Particularly the elements which are commonly picked up in policy rules should be of interest, as they might explain how center-policies could affect the policies of the periphery. The very fact that most monetary authorities are inflation targeting, also leads to an important role for price changes within the possible transmission of foreign monetary policy. Inflation-transmission might cause policies to converge through the simple fact that inflationary-pressures are fought in similar manners.

Such inflation targeting might in fact be the true cause of monetary policy convergence if prices are affected internationally by center-policies. This is in addition to the financial variables previously discussed to approximate the financial cycle. Variables relating to financial stability, which are the variables transmitting the global financial cycle, are also likely to affect the monetary conditions in the periphery-countries. This implies that financial stability is still a goal for the central banks in the sample. It seems reasonable to assume this, given that monetary-authorities still are responsive to changes in the financial-conditions within their domestic markets (Baxa et al., 2013).

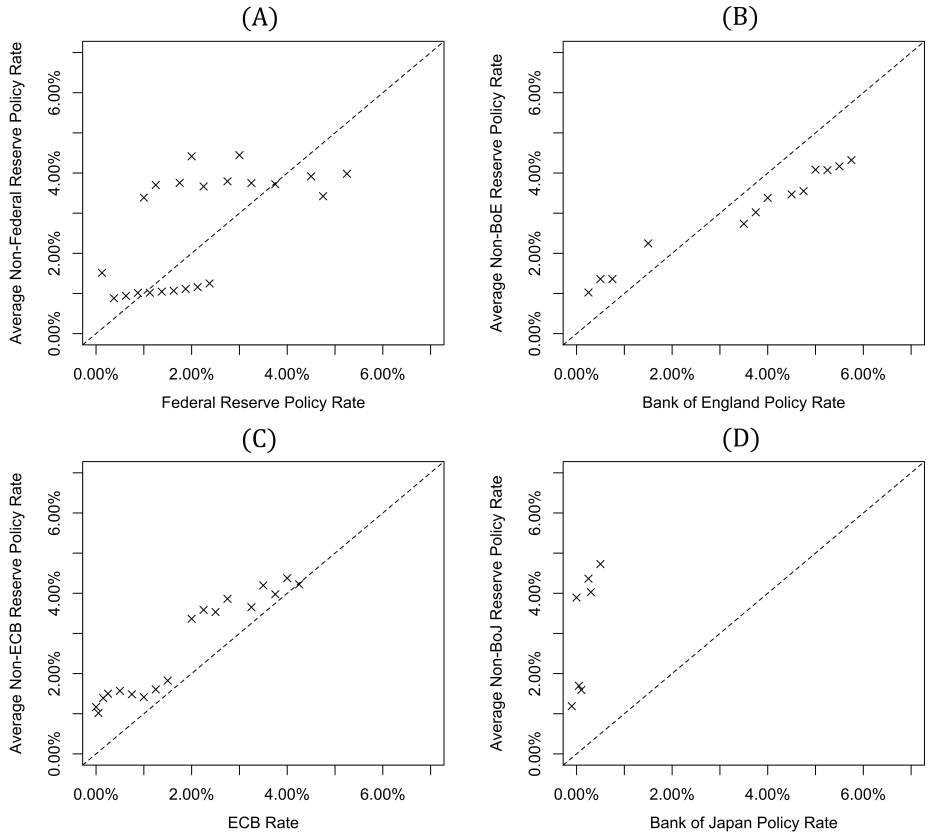

Figure 3.2: Direct relations between center- or periphery-policy rates and average periphery policy rates.

3.4 Direct relations between policy rates

Furthermore, we should consider the possibility of periphery-policies directly responding to center-policies, due to the expectation of transmission-effects. Through observation of average policy rates of the aforementioned periphery countries over the entire range of observed center-country policy rates, we can already obtain a rough idea of how policies react to a center-policy. That is, we could take the average policy rates of all other countries[4] in the data set for each policy rate level in the series of the country in question. We then plot these combinations in Figure 3.2. These graphs are indicative of the correlation between the average rate in the periphery- and the rate in the center-country in the case of the Federal Reserve (panel A) and the European Central Bank (panel C). Additionally, we observe the same for two other major global monetary-authorities, which are considered as being within the periphery through the center-definition used and depicted in Figure 3.1. These will be the Bank of England (panel B) and the Bank of Japan (panel D). The diagonal line in each plot indicates perfect correlation. We observe that neither the center-economies, nor the periphery-economies, clearly correlate to the average rates within the other economies.

[4]A full list of countries included in the data set can be found in Appendix A.

There is however quite some information to be gathered from Figure 3.2. Within panels B and C we do in fact see quite some evidence for strong correlations. Panel B shows that rates set by the Bank of England (BoE) are about in-line with the rates of other countries, as the combinations do center around the diagonal. Similarly there exists quite a strong correlation found between ECB and non-ECB rates shown in panel C. However, here we observe that the non-ECB rates are above that of the ECB itself. This suggests periphery-economies are subjected to some premium over the center-rate, to account for the fact that they are less central to global finances. On the other hand, we find that such a relation with premiums can also be found in panel D, considering the Bank of Japan (BoJ) as a center.

However, we do not observe the same relations in panel A. Panel A shows average non-Federal Reserve rates float around a large area around the diagonal, both above and below. This indicates that the correlation between U.S. rates and average non-U.S. rates is potentially weak. In panel D we equally observe a potentially weak correlation between Japanese rates and average non-Japanese rates. However, one explanation for this is the odd position which Japan has found itself in within the last two decades, which has seen extraordinarily low rates for a prolonged period of time. This had not been implemented by any other nation in the data set at the time, which therefore might explain the relation between Japanese rates and average non-Japanese rates.

The correlation estimates can be found in table 3.1, using pairwise Pearson correlations. Here the correlations as observed in Figure 4.1 can be found. It should be noted that all but one correlation coefficient are statistically significant at the 99% confidence level. These correlations show we cannot ignore the direct effect of center-policy rates on policies within the periphery. Therefore we should also look at this direct effect when analyzing the effects of center-policies on the periphery. The previously mentioned near-zero rates in Japan could explain its somewhat weaker correlation, which is only significant at the 95% confidence level.

Table 3.1: Correlation coefficients between policy rates

Country	**Coefficient**	
United States	0.614	***
Euro area	0.957	***
United Kingdom	0.989	***
Japan	0.531	**

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

3.5 Expected-risk

Rey (2015) previously used the CBOE's Volatility Index (VIX) to approximate the risk-perception within the financial cycle. This indicator is however entirely specific to the United States, being based on the futures traded on the S&P 500 Index. In order to look at domestic effects of the global financial cycle in countries other than the United States, we should consider an alternative measure. The VIX is calculated through option-prices of the S&P 500 Index. These options all have a maturity of 30-days. By measuring the volatility of these financial instruments, expected volatility, and therefore expected risk, over a one month period can be measured. Due to the fact that the finer details of options can differ across countries, VIX-calculations cannot be used for other countries.

Instead, the volatility of futures prices using data from 1st Generic Futures indices, representative for the major stock indices of each nation[5], is used. This method is comparable to the VIX, as can be see from Figure 3.3 where the similarity between the true VIX and calculated futures volatility for the S&P 500 Index is depicted. Indeed the Pearson correlation-coefficient is 0.807 ($t = 5.4623$, $df = 16$) in the period prior to 2010, after which the S&P 500 Index saw an unusual price-hike for its 1st Generic Futures. Due to the high level of co-movement between these two the volatility of future indices does seem like a viable measure of expected-risk.

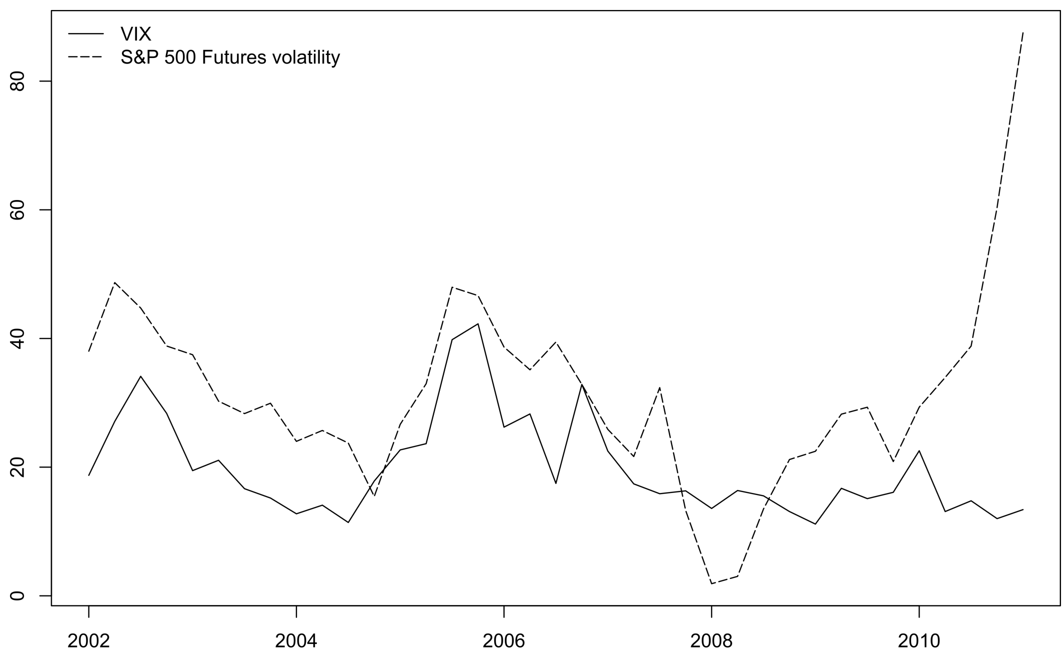

Figure 3.3: VIX and futures volatility

[5]An overview of countries and the stock indices used can be found in Appenix A.

3.6 VAR

In order to identify the transmission effects of center-policies we employ vector autoregressions in a bilateral setting. Amisano and Giannini (2012) provide a review of such estimation methods. In addition, a detailed description of the workings of Vector Autoregressions is provided by Ouliaris et al. (2016). Since the influential work of Sims (1980) Vector Autoregressive techniques have become prevalent within macroeconomics for the purpose of analyzing policies. Sims argued the advantages of these VAR-models could allow them to replace the simultaneous equation models used at the time. VAR-models yield quite some power whilst remaining relatively small, especially compared to the larger models, such as the simultaneous equation models (Schlegel, 1985). However, the complexity of a VAR-model will grow rather quickly when adding more variables. This should however not be reason for concern given the low number of variables which will be used in this study.

This paper uses a VAR-approach with the model being set up as follows. We start with the baseline VAR(p) structure as for example described by Ouliaris et al. (2016). Following the basic notation offered by Lütkepohl (2005), for a sample running from p to T for all k variables, we obtain the following reduced form.

$$y_t = \nu + A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + \mu_t \tag{1}$$

Here y represents a vector of k elements, ν is a vector of constant terms, A_i is a $k \times k$-matrix of coefficients and u_t is the k-dimensional residuals-matrix with covariance-matrix Σ_u. This can be written as follows.

$$Y = BZ + U \tag{2}$$

Which is set equal to:

$$\begin{bmatrix} y_p \\ y_{p+1} \\ y_{p+2} \\ \vdots \\ y_T \end{bmatrix} = \begin{bmatrix} \nu \\ A_1 \\ A_2 \\ \vdots \\ A_p \end{bmatrix}' \begin{bmatrix} 1 & 1 & 1 & \dots & 1 \\ y_{p-1} & y_p & y_{p+1} & \cdots & y_{T-1} \\ y_{p-2} & y_{p-1} & y_p & \cdots & y_{T-2} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ y_0 & y_1 & y_2 & \cdots & y_{T-p} \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ \vdots \\ u_T \end{bmatrix} \tag{3}$$

Using a Multivariate Least Squares method the estimation of the coefficients-vector can be performed in accordance to the method described by Lütkepohl (2005, p. 70 - 72).

There can however be, and one should be aware of the possibility of, non-stationarity within the observed variables. If this is the case two options are available. First, in case these variables are of the type $I(1)$, meaning they are integrated at the first-order, we are able to take first-differences of these variables and continue using the VAR approach described in this section. However, this method comes with significant limitations as it can no longer capture the long-run relations within the model (Papana et al., 2014).

An alternative to this would be to implement a Vector Error Correction Model (VECM) instead. The VECM allows for an error correction model in a vector autoregressive format. This then gives a VAR with an Error Correction Term (ECT) implemented within each equation, thereby allowing for non-stationarity in the variables. However, in order to perform a VECM, the co-integrating relationships need to be identified. If these co-integrating relationships are indeed present between non-stationary variables, proceeding with a Vector Error Correction Model is possible. Using these procedures we are further able to test the hypothesis of monetary autonomy, by showing that center-policies do not in fact significantly change the policies or indeed economic and financial conditions within the periphery.

If the variables suggested for implementation in the VAR contain unit-roots, the Vector Error Correction Model-approach should be considered. This leads us to the implementation of a VECM as suggested in Lütkepohl (2017, p. 237 - 352). Here it is suggested that in case of first-order integrated variables, $I(1)$, a VECM allows us to account for the integration through an added Error Correction Term. Therefore, a VECM can be estimated in a level format while accounting for the unit-roots in the series used. Following the notation of Lütkepohl (2017), we can identify the VECM as follows, using the same symbols as in the preceding VAR-equations:

$$\Delta y_t = v + \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + ... + \Gamma_{p-1} \Delta y_{t-p+1} + \mu_t \tag{4}$$

Where $\Pi = \alpha\beta'$. α and β are $k \times r$ matrices indicating adjustment rate and co-integration vectors respectively (Mukherjee and Naka, 1995). Hence, $\beta' y_t$ shows the long-term relationship and the entire term $\alpha\beta' y_t$ is the Error Correction Term. When using the Error Correction Term to account for the unit-roots within the data, level-variables can be used as their non-stationarity will not cause the issues conventionally implied by non-stationarity.

4 Data

The data in this paper stems from a number of empirical sources[6]. The main source is the Bank of International Settlements' database. It supplies the data on central bank policy rates, consumer price index changes (as a percentage change with regards to the same period in the previous year), net bank inflows (which is transformed as a percentage of GDP), total bank credit (which is transformed as a percentage of GDP) and the debt-service ratio of the private non-financial sector, which highlights the financial constraints within a country. These latter three variables in particular are used to approximate the financial cycle. Net bank inflows are measured through the total amount of bank-debt issued to a country minus the total amount of bank-debt issued by the same country. Moreover, additional data regarding long-term interest rates and short-term interest rates is gathered from the database of the OECD. Gross Domestic Product (GDP) data is gathered from the IMF's International Financial Statistics database and the 1st Generic Futures prices, used to approximated the VIX, come from the Bloomberg Terminal. All of these variables are measured at or transformed to a quarterly rate in the period from the first-quarter of 2002 until the first-quarter of 2020. In the following subsections some of the main details of the data are described in this section.

Table 4.1: Summary statistics of variables

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Source**
Policy Rate	689	2.15	2.16	-0.75	9.75	BIS
Yield Curve	689	1.08	0.99	-1.55	3.51	OECD
Net Bank Inflows	665	$-1.120727 * 10^{-5}$	0.00	-0.001	0.001	BIS
Credit	689	94.51	39.71	8.40	171.80	BIS
Debt-Service Ratio	689	16.52	5.28	3.10	24.40	BIS
Futures Volatility	689	123.04	273.47	0.11	1833.402	Bloomberg

From Table 4.1 we observe fewer observations in the Net Bank Inflows variable compared to the other variables in the data set. The final data set contains the 665 observations for which a Net Bank Inflows-value is available. This variable is measured as the gross amount of credit supplied to a country through bank loans minus the gross amount of credit supplied to foreign countries by the domestic country through bank loans, as a percentage of the gross domestic product. The values for this variable are rather small. Futhermore, futures volatility is transformed to a logarithmic form to keep all variables on a percentual scale.

[6]See Appendix A for more details.

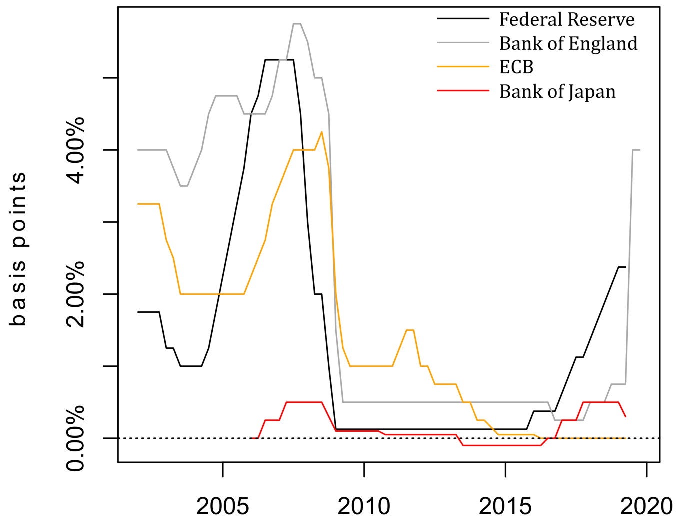

Figure 4.1: Central Bank policy rates

4.1 policy rates

Central bank policy rates are the main indicators of monetary policy stance. The rates of center-countries are each stored as a variable on their own, to be matched with the data of any periphery-economy in order to find bilateral transmission effects. This allows for a center-policy rate and a periphery-policy rate to be included in the VAR proposed earlier. Center and periphery policy rates of the central banks discussed previously are plotted within Figure 4.1. We can clearly identify that within the period leading up to the global financial crisis of 2008, policy rates remain well-above 0%, except for that of the Bank of Japan[7].

However, as mentioned in countless articles written since the crisis, in the post-crisis period we observe that the four central banks all at some point approached the zero lower bound. Subsequently, all of these central banks turned to unconventional monetary policy, which cannot be captured effectively by the policy rate. The policy rates are therefore only effective in identifying monetary stances in the pre-crisis period (2002 Q1 - 2008 Q3). As can be seen in Figure 4.1, these rates varied widely leading up to the Great Financial Crisis and have been pushed to near-zero since then. As a result, this measure is used in the years leading up to the Great Financial Crisis but we turn to an alternative measure after it. Hence a measure for the unconventional policies in the post-crisis period is used in the years after the 2008-crisis.

[7] The Bank of Japan started using unconventional monetary policy well before other nations did (Spiegel, 2006).

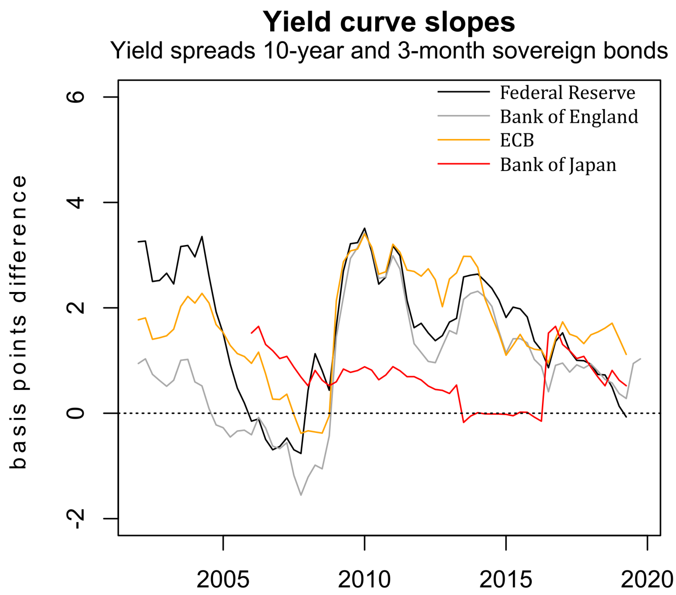

Figure 4.2: Yield curve slopes

Yield spreads between 10-year and 3-month sovereign bonds.

4.2 unconventional policy

When interbank rates hit the so-called "Zero Lower Bound", central banks can no longer conduct monetary policy through their standard set of operating tools (Wu and Xia, 2016). As a result, many authorities opted for unconventional monetary policy, such as quantitative easing and forward guidance, in the wake of the global financial crisis (Dell'Ariccia et al., 2018). These tools are aimed at lowering long-term interest rates, thereby flattening the yield curve. This effectively entails that the differential between the short-term and long-term interest rates, i.e. the slope of the yield curve, should decrease (Dell'Ariccia et al., 2018). Indeed we find evidence of this when plotting such differentials, as can be seen in Figure 4.2.

A first important observation from Figure 4.2 is the fact that prior to the crisis starting in September 2008, following the collapse of the Lehman Brothers investment bank, all yield curves became inverted. This is in line with empirical literature which says that crises are usually preceded by yield curve inversions (Chauvet and Potter, 2005; Wright, 2006). The inversion was followed by sharp increases in the yield curve slopes, as short-term interest rates fell to zero. We also observe a seemingly procyclical movement of these yield curve slopes since the start of the Great Financial Crisis.

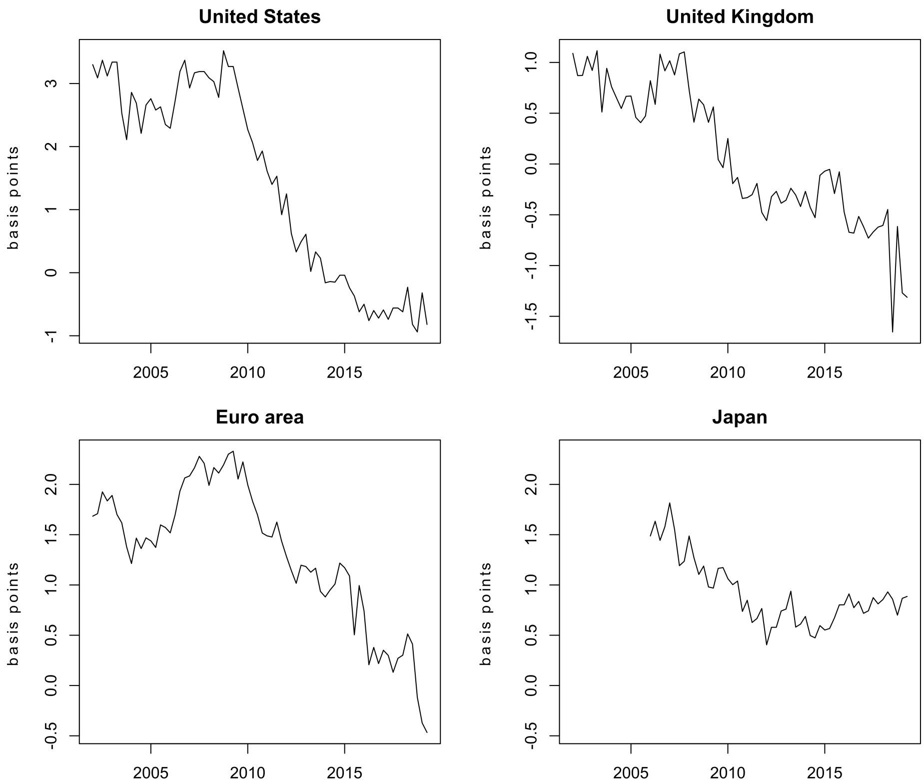

Figure 4.3: Long-term interest rates

10-year sovereign bond yields.

Due to the long-lasting nature of unconventional-policy programs, one expects to see a long-lived decrease in the slope of the yield curve as a result of unconventional monetary policy. In Figure 4.3 we plot the long-term interest rates of the four central banks considered to be most relevant to the global financial system. We observe, similarly to the findings of Christensen and Rudebusch (2012), that the effects of quantitative easing upon the long-term interest rate are not always the same. Moreover, the effects of quantitative easing don't always last for the same amount of time. Especially the effects upon the long-term interest rates can vary significantly.

Expectations play a major role in the effects of quantitative easing, which in fact led to the initialization of forward guidance. Due to expectations, decreasing long-term interest rates prior to the actual start of certain programs can be found. This can be exemplified through the ECB's Asset Purchasing Programme, which was long anticipated before its start in January 2015. Previous signaling of the possibility of such a policy being initiated in May 2009, already lowered the interest rate significantly beforehand. None the less, as unconventional policy programs ran for long periods of time and decreasing long-term rates are eventually found. Although some decreases occurred before the start of such programs, the measure of a yield curve slope might still be valid for the purpose of measuring the effects of unconventional monetary policy.

This is in addition to the fact that alternatives such as balance sheet data are not widely available for all central banks within the OECD. Subsequently using the difference between short-term and long-term interest rates yields an appropriate proxy for unconventional monetary policy stance in the post-crisis period (Baumeister and Benati, 2010; Krippner, 2014). The yield curves in Figure 4.2 show that generally speaking, slopes have decreased after the respective institution initiated its unconventional monetary policy. We should consider the very nature of unconventional policy aims in the interpretation of this figure. In a situation where short-term interest rates cannot be decreased any further through the conventional tools, unconventional tools provide methods to reduce the long-term interest rates instead. Therefore these policies all aim at flattening the yield curve and thus the yield curve analysis holds valid for all types of unconventional monetary policy.

4.3 Stationarity

As mentioned previously, issues regarding stationarity of variables can be expected. This paper uses a panel-data set from which bilateral relationships, effectively in the form of time-series, are extracted. As a result, one could look at stationarity in the panel-data sense and stationarity in the time-series sense. For panel-stationarity Im-Pesaran-Shin, Levin-Lin-Chu and Choi's modified unit-root tests are used. The results of which are reported in table 4.2. This shows that the policy rate variable and the debt-service ratio variable are both non-stationary according to these tests. However, these variables can still be argued to be stationary from a theoretical standpoint. Time-series stationarity is tested through an Augmented Dickey-Fuller test. This allows for testing of the bilateral relations, the results of which can be found at the end of this section, in tables 7.22, 7.23 and 7.24.

Table 4.2: Choi's modified Unit Root Test

Variable	Im-Pesaran-Shin		Levin-Lin-Chu		Choi's modified	
Policy Rate	-0.988		-1.745	**	0.833	
Yield Curve Slope	-3.975	***	-2.894	***	5.450	***
Inflation	-1.792	**	-0.219		1.700	**
Net Bank Inflows	-1.496	*	-1.499	*	2.527	***
Credit	-0.673		-2.787	***	2.434	***
Debt-Service Ratio	-0.740		-1.261		0.899	
log(Futures Volatility)	-4.155	***	-2.985	***	6.429	***

Critical values reported with statistical significance for Im-Pesaran-Shin Unit-Root Test (Z), Levin-Lin-Chu Unit-Root Test (Z), Choi's modified Unit-Root Test (Pm). Existance of a unit-root forms the null hypothesis of each test. $\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

In Table 4.2 we find panel-stationarity for the yield curve, inflation, bank inflows, credit and log(futures volatility) variables. This can be concluded through the fact that for each of these variables at least two out of the three tests performed concluded the absence of a unit-root. For the yield curve and log(futures volatility) variables, all three tests even reach the same conclusion. The policy rate and debt-service ratio however are commonly considered as non-stationary in these panel unit-root tests. However, we should also consider these variables in light of bilateral time-series. This is available from Tables 4.3, 4.4 and 4.5.

In Table 4.3 we find the results of an Augmented Dickey-Fuller test on each of the series in the data. Few variables are identifiably stationary according to this test. Among those which could be argued to be stationary are the policy rate and yield curve variables. Table 4.4 meanwhile shows the results of the same test with a drift included. Using a drift tells us that inflation and log(futures volatility) can also be argued to be stationary as well. Lastly, Table 4.5 shows the results of an Augmented Dickey-Fuller test incorporating both a drift as well as a trend. We see that variables identified as potentially stationary in the previous tests are also potentially trend-stationary.

We also consider the economic theoretical merits of these stationarity-tests for each of these series. Theory should be able to point out whether or not processes are supposed to be stationary, as some variable are bound by their theoretical limits. Let us also recall a simple technical definition of stationarity, which is a stochastic process for which the joint distribution in any period, denoted as $F_X(x_{t_1}, ..., x_{t_n})$, equals the joint distribution of any other period of the same length. That is

$$F_X(x_{t_1}, ..., x_{t_n}) = F_X(x_{t_{1+\tau}}, ..., x_{t_{n+\tau}}) \tag{5}$$

This would entail that the mean, variance and covariance are constant across time in the series X. Using this concept, we can already draw some conclusions about stationarity on a technical basis for the variables described previously. Moreover, through some economic theoretical argumentation, we can equally eliminate the possibility of stationarity within certain variables.

Hence we will look at each variable both from a technical and theoretical point of view. In doing so we aim to ensure the stability of the VAR-model employed in this paper. Some technical argumentation is also described in more details in Appendix B. In what follows, the technical arguments will therefore refer to Appendix B for further details. The theoretical arguments rely purely on economic insights regarding the underlying processes of these variables.

Despite appearing explosive, some variables might arguably be stationary when using economic theory and technical aspects of both stationarity and unit-root tests, which are further discussed in Appendix B. First of all, policy rates are in fact not stochastic but deterministic processes. Tests for stationarity can therefore not be applied to them in the conventional sense, due to the infrequent resetting of policy rates which are subsequently held constant for longer periods of time. These deterministic processes are shown in Figure 7.3 of Appendix A, where time-series for each variable and each country in the sample are plotted. These plots allow for greater insight regarding the potential stationarity of each variable in the data set. Instead of judging the policy rate variable's stationary purely through an Augmented Dickey-Fuller test, we should rely on the idea that policy rates would never actually become highly non-stationary, meaning it will never become explosive. The issue of deterministic processes and stationarity is discussed in more detail in Appendix B, where it is indeed shown the Augmented Dickey-Fuller test can fail for deterministic processes, such as policy rates. I subsequently argue for the stationarity of this variable due to its partially deterministic characteristics, which restrict its values to a certain range. Hence this variable is deemed to be stationary.

Similarly, the yield curve's stationarity can perhaps not be tested through the conventional stationarity-tests, as it is in fact based on a non-stochastic process which determines the short-term interest rates. Again, we can argue in favor of stationarity through the idea that the yield curve will in fact never turn into an explosive process, as long as inflation is kept under control using the short-term rate. This is shown in Figure 7.4 in Appendix A. Moreover, we see in Table 4.3 that the yield curve can be stationarity even without a drift or trend, possibly due to the stochastic long-term interest rate component. For those countries where stationarity for this variable cannot be proven through the Augmented Dickey-Fuller test, the arguments brought forward in the previous discussion of the policy rate hold as well.

Inflation is a stochastic process by design, for which we find evidence of stationarity both within theoretical argumentation and within the Augmented Dickey-Fuller test in Table 4.4. Here it is shown that inflation indeed is stationarity once we account for a drift. This drift is in fact due to the targeted inflation level, part of the monetary policy of most nations in the sample. Usually this level is about two percent. Indeed the inflation series fluctuate around a two percent level, as seen in the distributions of Figure 7.5 in Appendix A. Although some exceptions can be found, which either experience lower or higher levels of inflation by default, generally speaking inflation seems to follow a process centered around a country-specific drift term. Finding evidence of the condition described by equation 5 is therefore likely.

Meanwhile, net bank inflows experience a form of trend-stationarity in which a breaking point can be observed. This can be seen in Figure 7.6 within Appendix A. This breaking of the trend occurs around the Global Financial Crisis for the majority of countries. Indeed if we account for differences between the pre- and post-crisis periods, as is done in this paper, trend-stationarity is still conceivably. For some economies the amount of foreign borrowing by domestic banks, which accounts for the gross bank inflows, has decreased since the Global Financial Crisis. This opposes the growth of inflows seen before the crisis. Other economies meanwhile saw an increase in their gross bank outflows prior to the crisis, which has since turned into a decrease. These countries show an increasing net inflows trend in the post-crisis period, opposing the decreasing trend in the pre-crisis period. The result is that trend-stationarity within each period separately is still possible. Such a form of stationarity is further discussed in Appendix B, including trend breaking points.

Similarly, the amount of credit as a percentage of gross domestic product breaks its trend around the Great Financial Crisis. Whereas this variable increased consistently prior to the crisis, a number of countries experienced a decreasing trend after it. This can be seen in Figure 7.7 in Appendix A. Once we account for a trend in these periods separately, we are likely to find stationary processes after all. A few countries, such as Canada, Switzerland, Mexico and Poland, have experienced continued credit growth after the crisis, albeit following an alternative trend. Although these trend breaks are less obvious, one could still argue for their existence as we observe either a shift upwards or a change in the slope, i.e. the growth rate, of the credit process. Moreover, other countries have experienced visibly negative trends following the crisis, as a result of the recovery from the adverse effects of this event. In any case, clear trends can be observed in both the pre- and post-crisis periods. As discussed in Appendix B, stationarity is still likely and this variable will therefore be considered to be stationary.

The debt-service ratio reacted quite significantly to the Great Financial Crisis. In Figure 7.8 we see that for most countries, the increasing debt-service ratio before the crisis turns into a sharp decrease after the crisis. Following the crisis, debt was restructured and as such the amount of debt-servicing relative to income has decreased. However, for Canada, Switzerland, Sweden and Mexico the ratio has continued to increase following the crisis. Despite this, even in these countries a break in the trend is found as a result of the crisis. Stationarity with a trend might exist in these series if we look at both periods separately. The process in Sweden might even be argued to be stationary without a trend, by simply looking at the pre- and post-crisis periods in turn. This case is again argued in Appendix B, as it is another form of a trend break.

Lastly, we look at the logarithm of futures volatility in light of stationarity. In Figure 7.9 we observe how these series are in fact relatively stationary. It is for this reason that stationary exists for Australia, Japan, South Korea, Mexico and Sweden when only accounting for a drift term, as seen in Table 4.4. We see large drops in the volatility of futures around the Great Financial Crisis in some economies, due to a sharp decrease in the demand for futures directly following the crisis. Hence, these series are stationary as well when splitting the total sample into a pre- and post-crisis period, as discussed in Appendix B.

Based on the arguments above we proceed with the Vector Autoregression approach. This has the additional advantage of being comparable to previous research, notably to the work of Rey (2015) who started this line of research. From a methodological point of view, it is indeed preferable for new research to be in line with work previously published on the same issues. Therefore the viability of the Vector Autoregression approach is quite high, having been used in previous studies. In fact, Rey (2015) uses a Pesaran panel unit-root test, concluding that her variables are stationary. Hence, using the arguments mentioned previously, the panel unit-root tests in Table 4.2 and the Augmented Dickey-Fuller tests in Tables 4.3, 4.4, 4.5, the decision to opt for a Vector Autoregression approach as opposed to a Vector Error Correction Model approach is made. Moreover, a study by Kim (2001a) equally used a Vector Autoregression to provide an insight into monetary transmission channels. This approach will therefore be used in this paper as well.

Table 4.3: Augmented Dickey-Fuller-test for unit-roots

Country	Policy Rate	Yield Curve	Inflation	Net Bank Inflows	Credit	Debt-Service Ratio	Futures Volatility
Australia	-1.0155	-3.453 ***	-1.3281	-0.3323	1.7357	0.2382	-0.6036
Canada	-1.2341	-2.1373 **	-1.3623	-1.1915	2.7946	1.5708	-1.0753
Switzerland	-1.8304 *	-1.7522 *	-3.2844 ***	-0.26	4.1608	0.7636	0.0186
Denmark	-1.6515 *	-2.0394 **	-1.5417	-1.9483 *	0.45	-0.1462	-1.1914
United Kingdom	-1.4195	-1.8776 *	-1.138	-1.558	0.0212	-0.3502	-0.2022
Japan	-1.2574	-2.9893 ***	-2.4207 **	-1.1324	1.7373	-1.3992	-0.218
South Korea	-1.1585	-2.4584 **	-1.1906	-1.632 *	1.4825	0.3576	-2.083 **
Mexico	-0.2145	-1.9634 **	-0.7126	-0.5161	3.5551	1.3007	-0.7586
Poland	-2.2841 **	-2.3889 **	-1.4429	N/A	1.2464	-0.7952	-1.1317
Sweden	-2.2668 **	-1.7417 *	-2.1824 **	-0.952	2.9176	0.898	-0.5115
United States	-1.4568	-1.8121 *	-1.7306 *	0.4298	0.4541	-0.3223	-0.1276
Euro area	-1.7467 *	-1.302	-1.4889	-1.1709	0.1401	0.0273	-0.511

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***. Critical values can be found int Table 7.22 of Appendix C.

Table 4.4: Augmented Dickey-Fuller-test for unit-roots with a drift term

Country	Policy Rate		Yield Curve		Inflation		Net Bank Inflows		Credit	Debt-Service Ratio	Futures Volatility	
Australia	-1.557		-3.6634	***	-4.2876	***	-2.5307		-2.0602	-2.2056	-3.5014	**
Canada	-1.9106		-2.5301		-4.436	***	-0.9431		-0.0229	0.1837	-2.1408	
Switzerland	-1.6259		-2.3341		-3.6666	***	-2.441		0.1635	-0.5471	-1.837	
Denmark	-1.3055		-2.8673	*	-2.6446	*	-2.7466	*	-2.2201	-1.3095	-2.5425	
United Kingdom	-1.4243		-2.2739		-3.2289		-0.6831		-1.366	-0.6653	-1.9948	
Japan	-1.3279		-2.0301		-2.4089		-1.1408		-0.9669	-1.1353	-2.6306	*
South Korea	-1.7944		-3.2948	**	-1.9977		-1.821		-0.9815	-1.8575	-3.4847	**
Mexico	-2.2525		-2.4877		-3.0608	**	-1.7849		-0.0586	0.9758	-3.536	***
Poland	-2.8828	*	-3.98	***	-2.6667	*	N/A		-1.3254	-2.2263	-2.6212	*
Sweden	-2.388		-3.4188	**	-3.4331	**	-2.1446		-1.6522	-1.0092	-2.3912	
United States	-2.0177		-2.1669		-3.9767	***	-2.8694	*	-1.6495	-1.4836	-2.1157	
Euro area	-1.7525		-2.3942		-3.1153	**	-0.6667		-1.4253	-1.2577	-3.7829	***

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***. Critical values can be found in Table 7.23 of Appendix C.

Table 4.5: Augmented Dickey-Fuller-test for unit-roots with a drift and trend term

Country	Policy Rate		Yield Curve		Inflation		Net Bank Inflows		Credit	Debt-Service Ratio	Futures Volatility	
Australia	-3.8211	**	-3.9071	**	-5.4393	***	-2.2836		-0.897	-2.0189	-3.4464	*
Canada	-2.3129		-2.6868		-4.7399	***	-2.4513		-2.4425	-2.4384	-2.1775	
Switzerland	-2.1474		-2.9811		-3.9784	**	-2.0492		-2.4467	-2.2096	-2.0857	
Denmark	-2.1177		-2.9293		-3.3037	*	-2.7374	*	-1.3834	-1.2273	-2.2752	
United Kingdom	-2.1543		-2.3496		-3.1988	*	-1.9004		-1.7065	-2.1808	-2.1509	
Japan	-4.0008	**	-2.9287		-2.4616		-1.5081		-2.5039	-1.8059	-2.9132	
South Korea	-3.2692	*	-3.3403	*	-3.1459		-1.6603		-1.9169	-2.3271	-3.3919	*
Mexico	-2.3989		-2.4872		-3.0425		-2.2693		-1.8505	-1.3239	-3.5098	**
Poland	-4.9871	***	-4.35	***	-2.778		N/A		-0.7425	-2.8056	-3.0124	
Sweden	-3.8898	**	-3.5609	**	-3.4002	*	-1.6995		-0.5841	-1.6901	-2.485	
United States	-2.0537		-2.1696		-4.3268	***	-3.8168	**	-2.0291	-2.3693	-2.3473	
Euro area	-2.8159		-2.3682		-3.6447	**	-1.876		-1.1797	-0.3853	-3.8883	**

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***. Critical values can be found in Table 7.24 of Appendix C.

5 Empirical Analysis

In this section bilateral relations between economies are discussed in order to uncover the potential transmission-effects of center-policy rates on policy rates in a number of countries. We look at both the United States and the Euro area as center-economies. Bilateral relations between both these two centers as well as between these centers and their potential peripheries are discussed. For the sake of uniformity, all the following VARs use a lag-structure of $p = 2$, as this was the consistent outcome of the Schwarz Criterion (also known as the Bayesian Information Criterion, BIC) in the pre-crisis period. In addition, the same lag-structure was used by Rey (2015). Both the pre- and post-crisis periods are analyzed, as mentioned when discussing measures for unconventional monetary policy in Section 4. Identification of causal effects is done through Granger causality, as was also used by for example Kuersteiner (2010).

Granger causality was first defined by its name-giver Granger (1969). This method was later confirmed and refined by both Granger (1980) and Sims (1972). Granger identified causality between X and Y through time, where X is said to cause Y in a Granger sense, only if the lagged value of X can help in predicting Y even in conjunction with the lagged value of Y itself. Hence we obtain the following equation for the estimation of Granger-causality

$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i * X_{t-i} + \sum_{j=1}^{p} \beta_j * Y_{t-j} + \varepsilon_t \tag{6}$$

From this unrestricted model, a Wald-test is performed to test the null-hypothesis of $\sum_{i=1}^{p} \beta_i = 0$. If we can reject the null hypothesis, this is evidence in favor of Granger-causality. In other words, X causes Y in a Granger sense. A practical application which proves to be useful can be found in Greene (1999). Using the notation mentioned by Greene, the following adjusted statement can be made for a VAR with any lag-structure (Greene, 1999, p. 742 - 743):

$$y_t = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} * y_{t-1} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \tag{7}$$

Where $y_t = [Y_t, X_t]'$. In case X Granger-causes Y, the coefficient β_{12} should not equal zero. According to (Lütkepohl, 2005, p. 102 - 116) a Wald-test will test the null hypothesis of this coefficient being equal to zero. In case the Wald-test concludes statistically significant differences from zero for the coefficient we can conclude X Granger-causes Y. R-code created by the author for the purpose of bivariate Granger-causality analysis is also provided at the end of this paper.

The Vector Autoregression procedure previously discussed in Section 3 is applied in this section. An additional term to account for possible trending data is included in this VAR. This will allow us to deal with possible trend-stationary variables, as also discussed in Appendix B. The full VAR-specification includes the inflation, net bank inflows, credit, debt-service ratio and log(futures volatility) variables, as well as two variables pertaining to the policy stances of both the periphery-economy, to which the values of the previous variables belong, and the center-economy. This policy stance is approximated by the policy rate in the pre-crisis period and by the yield curve slope in the post-crisis period.

Moreover, a reduced form of this Vector Autoregression is used for countries for whom the data set is not complete. Here we estimate a five-variable VAR, which includes the two variables pertaining to the policy stance, as well as inflation, credit and debt-service ratio. This allows estimation for multiple member-states of the European Union, who do not provide full data on their futures volatility and bank inflows for the sample period of this paper.

We estimate the following equation in both the full VAR and the reduced VAR.

$$y_t = \nu + A_1 y_{t-1} + A_2 y_{t-2} + B_1 t + \mu_t \tag{8}$$

This equals equation (1), but with the addition of the term $B_1 t$ and a lag structure of $p = 2$. Here B_1 is a $k \times k$ matrix of coefficients for the trend term t. In the full VAR $k = 7$, whereas in the reduced VAR $k = 5$ to account for missing variables as discussed in Table 7.1 in Appendix A. The variables net bank inflows and log(futures volatility) will be omitted in this reduced VAR.

In the Impulse Response Functions (IRFs) that follow in this section a 95% confidence interval is considered, indicated by dashed lines around the predicted values. Policy rates are reported as basis points, whereas yield curve slopes are reported as basis points differences. Other variables are all reported as percentage points. The Impulse Response Functions and confidence intervals are bootstrapped through the use of a replication factor of 1000. In each case an increase to the center-country's policy rate is administered in the pre-crisis period, whereas in the post-crisis period a decrease of the yield curve slope is administered. In both cases the shock equals one standard-deviation of the variable being shocked.

5.1 Bilateral-relation United States on Euro area

We first discuss a center-to-center relation, where the United States' effect on the Euro area is highlighted. This relation is important as it can tell a lot about the centrality of both economies. The United States is generally accepted as being the financial center within the world economy and as such fulfilled an important role in transmitting various shocks throughout history. Therefore, it is logical that the United States potentially affects another economy.

First a Vector Autoregression for the pre-crisis period is performed, as previously mentioned. Using this VAR, Impulse Response Functions are created for a shock in the U.S. policy rate with a size of one standard-deviation. These IRFs are shown within Figure 5.1. In this figure we can see that the ECB's policy rate does increase following the shock. However, it does so with zero being within the 95% confidence interval, meaning the policy rate is not significantly higher than the original value. Given the fact that inflation does not significantly react to the shock in the U.S. policy rate in the long-run, it is sensible that the ECB's policy rate equally doesn't increase. The ECB is inflation targeting in nature and therefore should not react to this shock if it does not affect inflation. Had inflation been affected by the shock, we should indeed find a resulting shift in the policy rate within the Euro area. Financial variables are equally unaffected by the shock in the U.S. policy rate, as none of them show any significant deviations. Again, this explains the absence of any movement of the Euro area's policy rate.

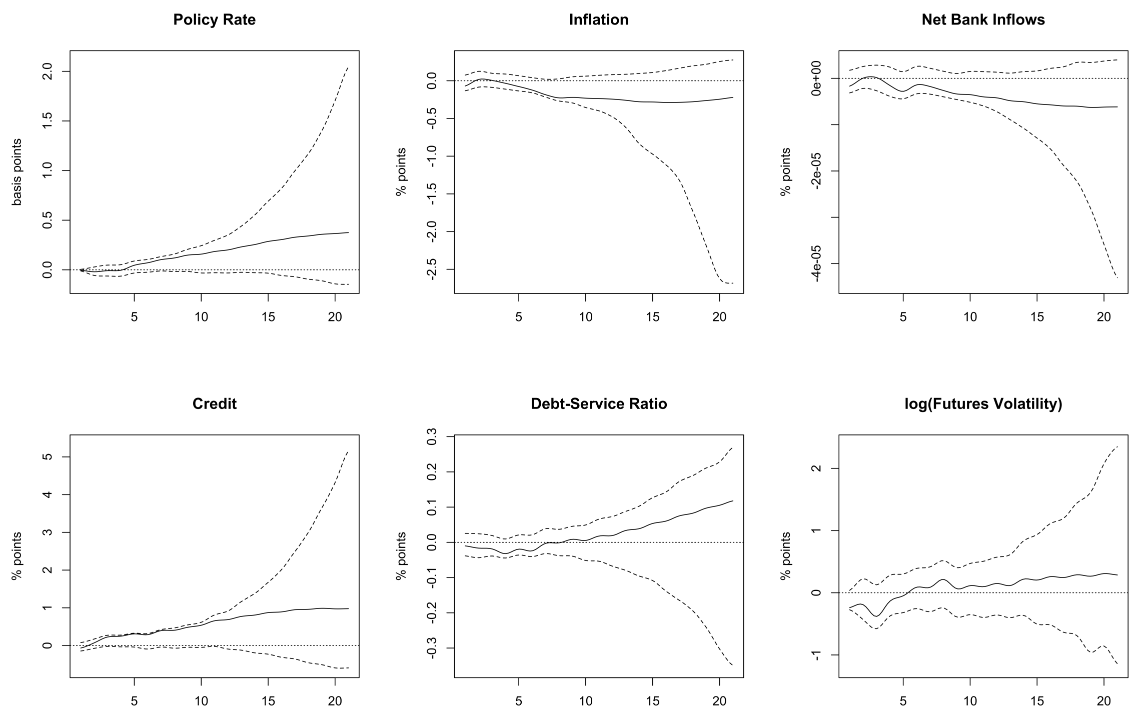

Figure 5.1: Pre-crisis IRFs of U.S. policy rate shock on Euro area

Next, a Vector Autoregression for the post-crisis period is performed. Here the policy rate is substituted by the yield curve variable, as was discussed in Section 4. To emulate the direction expected when implementing unconventional monetary policy, this shock is implemented in the negative direction, thereby decreasing the yield curve slope. The size of the shock remains one standard-deviation. This shows the exact response to unconventional monetary policy in the United States, which by design should decrease the sloped of the yield curve. We observe its IRFs in Figure 5.2.

The Euro area's yield curve initially decreases significantly in response to the U.S.'s yield curve decrease. However, we do not find evidence for the direct cause of this yield curve decrease within the financial variables such as net bank inflows, credit, debt-service ratio or futures volatility. The yield curve quickly reverses back to normal values after about two or three quarters. This decrease could be a result of the integration between the two center-economies considered. The yield curves could be intertwined as a result of this, meaning that a sharp decrease in the U.S.'s yield curve might automatically lead to a similar decrease in Europe, potentially with a short lag, without any changes to the underlying fundamentals in Europe. Indeed the notion of European yield curves responding to U.S. yield curve movements was also mentioned by Briere and Ielpo (2007). The financial variables do not respond in any statistically significant way to the shock in the yield curve. The same can be said for inflation, which increases but does not yield any statistical significance.

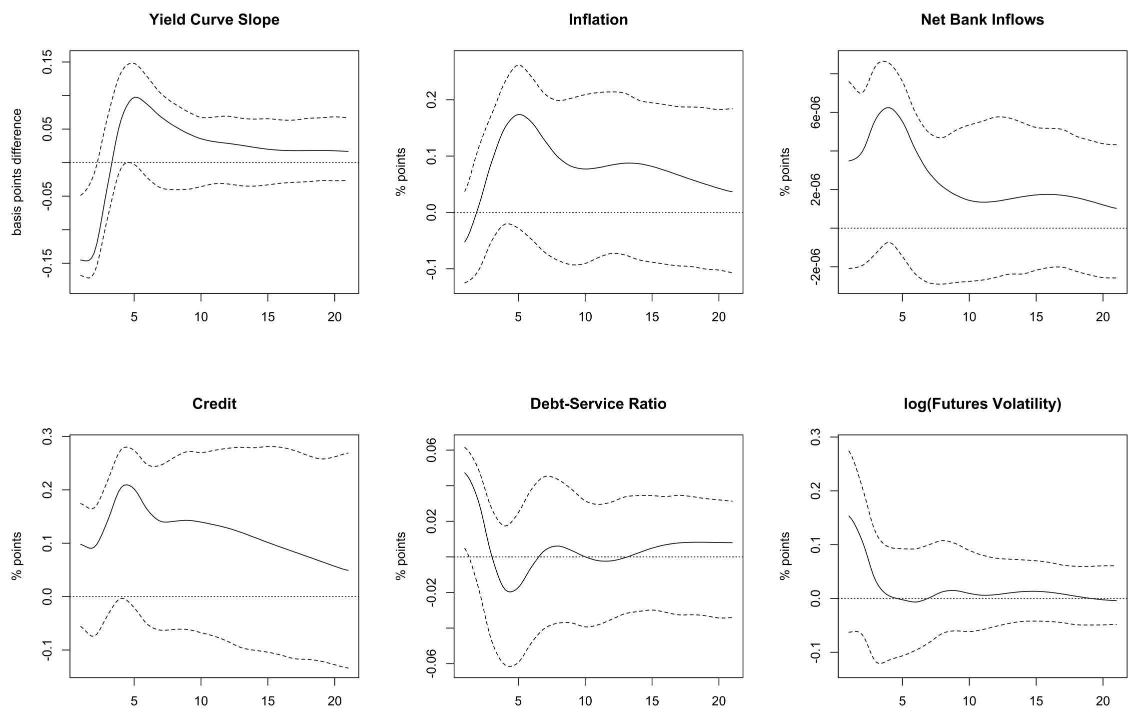

Figure 5.2: Post-crisis IRFs of U.S. yield curve shock on Euro area

5.2 Bilateral-relation Euro area on Switzerland

We further look at the effects which center-economies have on their periphery. This will first be done by looking at the Euro area as the main center, using Switzerland as its periphery. This relation was confirmed earlier in Figure 3.1. The Impulse Response Functions of Figure 5.3 show the effect of a one standard-deviation shock to the ECB's policy rate. The Swiss policy rate is shown to deviate upwards for about two and a half years after the shock in the Euro area. This deviation does however not appear to be statistically significant.

The reasons for such a potential increase are equally insignificant, as neither the financial variables nor the inflation deviate significantly. In case of policy-transmission we would expect inflation to decrease as a result of a positive shock to the Euro area's policy rate, as monetary conditions in the Euro area affect the Swiss economy. It therefore seems unlikely the Swiss policy rate will increase as a result of the ECB's policy rate shock. Increases in the net bank inflows, debt-service ratio and futures volatility are observed but none are statistically significant. Interestingly credit seems to move little, even in its predicted values. A potential explanation for this can be found in Switzerland's position within the global banking industry, which is generally regarded as a tax haven (Johannesen and Zucman, 2014). Having served as a tax haven, a majority of foreign holders in Switzerland are likely not to move their credit even in the event conditions within the country change. This could explain the virtually non-moving credit variable, which is measured through the amount of deposits held within this country.

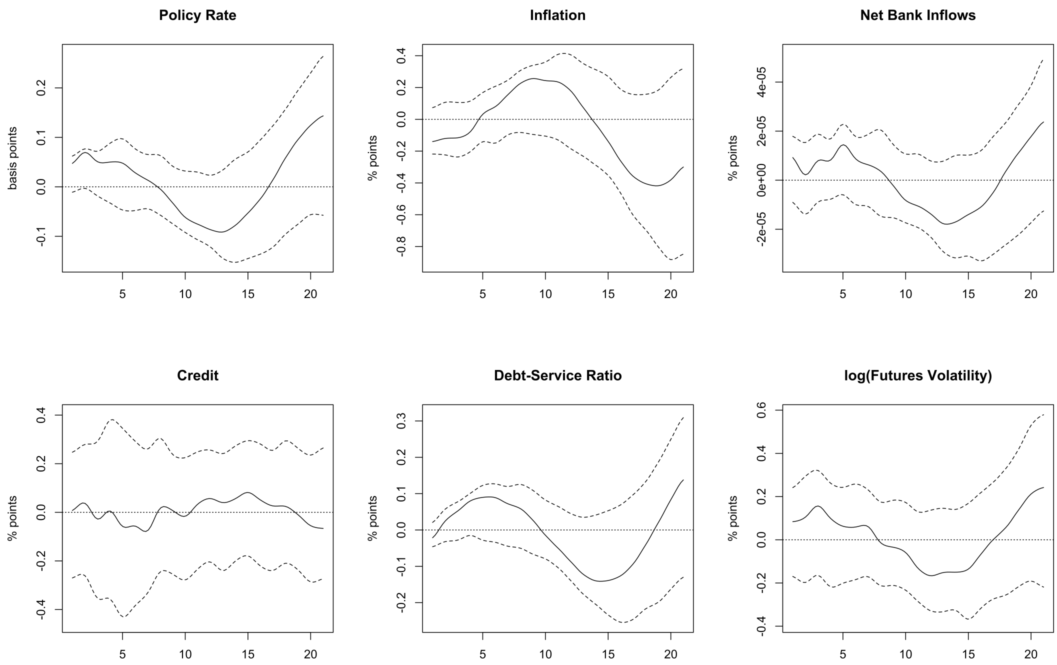

Figure 5.3: Pre-crisis IRFs of Euro area policy rate shock on Switzerland

The responses for the post-crisis VAR can be found in Figure 5.4. Here we observe the fact that Euro area yield curve movements have not had any statistically significant effects on the Swiss economy in terms of its financial indicators. However, inflation does appear to decrease following the Euro area's implementation of unconventional monetary policy, although this effect is equally non-significant. These results could be interpreted as a contradiction to the Euro areas central position, as unconventional monetary policy is expected to raise inflation, as opposed to the lowering that is found in Figure 5.4. Another possible interpretation relies on the fact that the European Central Bank and the Swiss National Bank were quite late in terms of unconventional monetary policy implementation. As such, the Euro area's yield curve slope indeed stayed well above contemporary yield curve slopes, as was already shown in Figure 4.2.

Indeed the data confirms the idea of the Swiss yield curve makes similarly timed movements as the Euro yield curve throughout the period following the global financial crisis, see Figure 7.2 in Appendix A. Hence, due to the late implementation of unconventional monetary policy in both the Euro area and Switzerland, yield curve movements might have happened rapidly after one another, which makes distinguishing the causality harder. Subsequently the Swiss yield curve movements don't appear to be caused by the Euro yield curve movements. This will however be formally tested in the Granger causality subsection later on. As the two economies seem to be co-moving their yield curves, one can perhaps argue that the Euro area transmits its policies on to Switzerland, as it does seem to affect the inflation levels within this country.

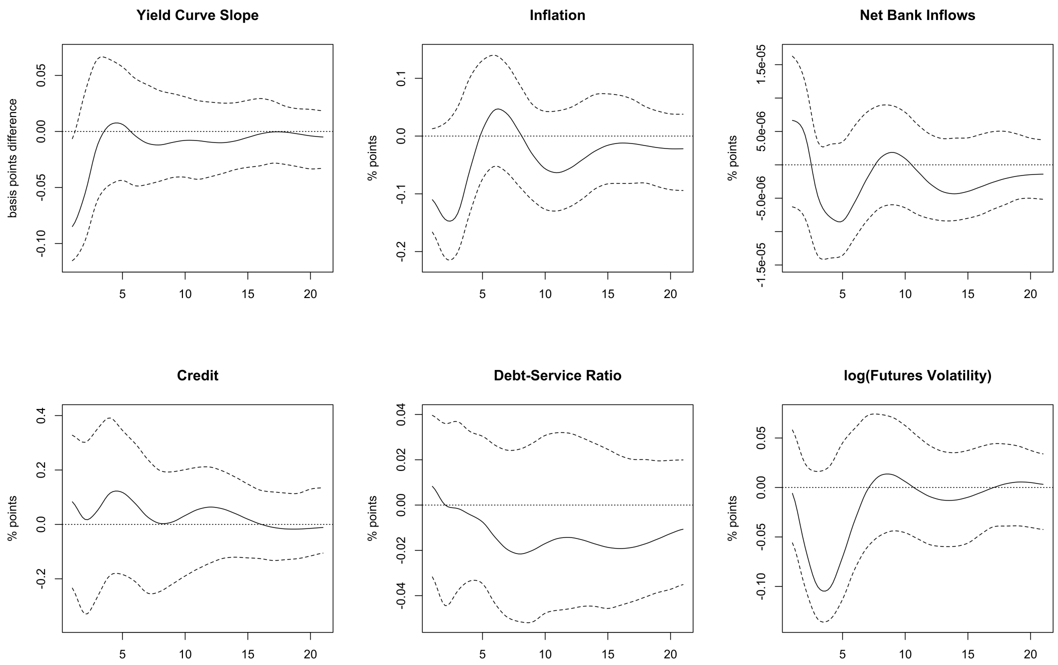

Figure 5.4: Post-crisis IRFs of Euro area yield curve shock on Switzerland

5.3 Bilateral-relation United States on Canada

To observe the centrality of the United States we look at the bilateral relation to one of its periphery-economies. Canada is a good example of this, having been specified as a periphery-economy to the United States previously. The Impulse Response Functions for this bilateral relation are projected in Figure 5.5.

We observe a small and statistically insignificant increase in the Canadian policy rate following the shock of the U.S. policy rate. Inflation is shown to not react to the shock, with its predicted value sticking closely to the pre-shock values. Similarly the net bank inflows do not seem to differ compared to its values before the shock. Moreover, none of the finance-related variables is predicted to deviate from their original values. Most interesting is the fact that the futures volatility is predicted not to significantly deviate from this original value, as Canada seems a very likely candidate for financial cycle transmission from the United States. This is due to the close proximity of the Canada to the U.S., which usually entails trade and finance relations between the two nations are be quite strong. It is therefore surprising to find that the U.S.' policy shock has little effect on the financial conditions within Canada. One might also expect capital to move to the U.S. when short-term rates increase within this country, which would entail a downward shift in the amount of bank inflows and the amount of credit being held in Canada. However, this is not corroborated by the VAR.

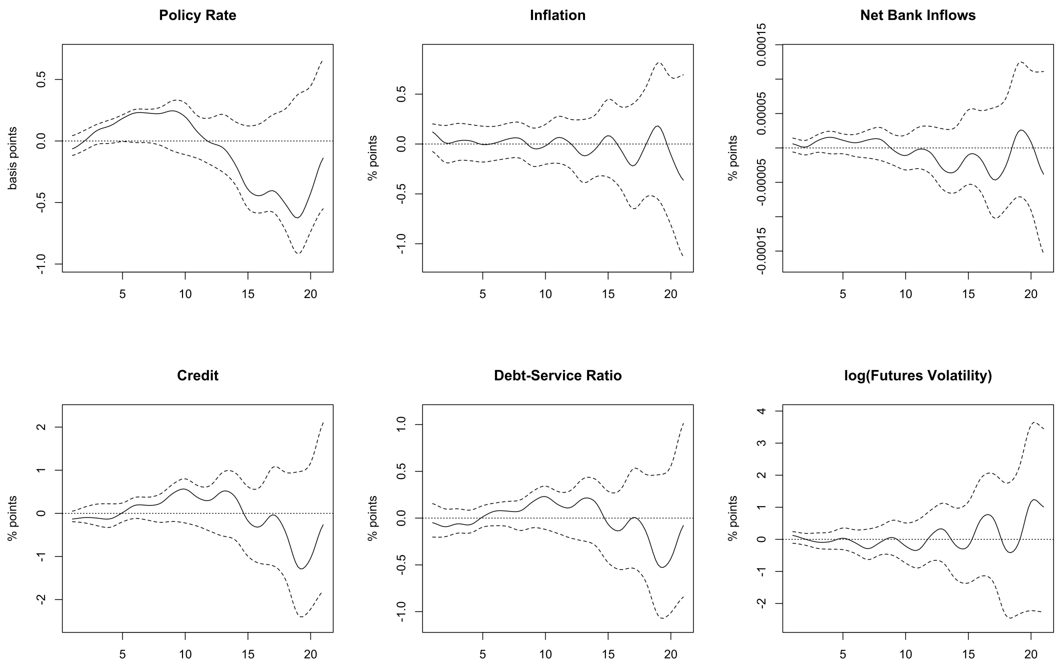

Figure 5.5: Pre-crisis IRFs of U.S. policy rate shock on Canada

The post-crisis responses are graphed in Figure 5.6. The results show that the U.S. yield curve change does significantly affect the yield curve in Canada for the first few quarters following the initial shock to the U.S. yield curve. This could possibly be explained through expectations, rather than real policy-shifts. Due to the financial integration of Canada with the United States, yield curve movements indeed occur at similar moments, as can be seen in Figure 7.1, found in Appendix A. Indeed the similarly timed movements of the yield curve movements might also be able to explain the transmission of yield curve slopes between these countries, as observed in Figure 5.6.

Interestingly, there seem to be no real fundamental changes to the Canadian economic and financial variables. Inflation fluctuates somewhat, but does not do so with any statistical significance. Net bank inflows seem to decrease and quickly recover following the shock, but again with no statistical significance. Interestingly, this decrease occurs simultaneously with the decrease of the yield curve slope. Meanwhile credit increases, while the debt-service ratio and the futures volatility decrease, all without being statistically significant. Log(futures volatility) decreases in its predicted value following the shock, meaning uncertainty about the future decreases. At the same time credit's predicted value increases for about three quarters, albeit not within the 95% confidence interval, presumably due to the lower long-term interest rates implied by the decreasing yield curve slope.

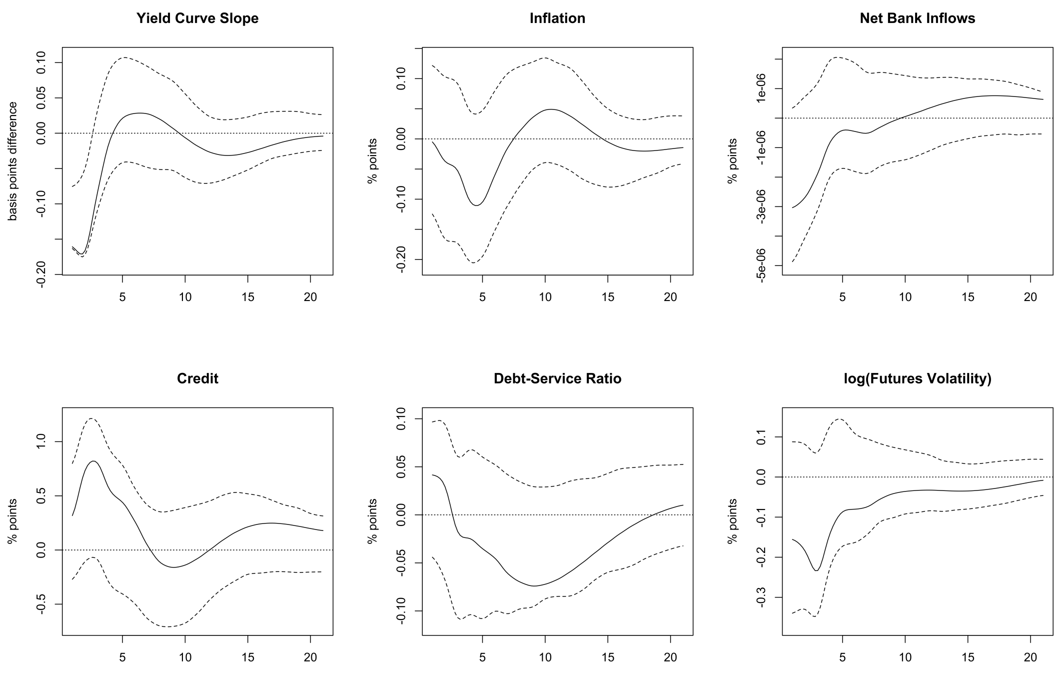

Figure 5.6: Post-crisis IRFs of U.S. yield curve shock on Canada

5.4 Bilateral-relation United States on Australia

The previous results looked at center-periphery relations between economies with geographic proximity to one another, such as between the Euro area and Switzerland or the United States and Canada. It has however been suggested that the United States' center-position is of such strength that it would be able to affect nations far-afield. We will test this by looking at a relation that was not found by Figure 3.1. Here we will test whether the United States can affect the Australian economy and impose a policy change in this nation. Figure 5.7 shows the Impulse Response Functions for the pre-crisis period.

We observe that the change in the U.S. policy rate does not seem to affect the Australian policy rate when considering a 95% confidence interval of statistical significance. In fact the predicted value of the policy rate does not show much change from its original value. The same can be said for inflation, net bank inflows, credit, debt-service ratio and log(futures volatility). Such results are in line with the results of Figure 3.1, opposing the idea that the United States acts as a center to every country of the world. The U.S. indeed has little impact on the Australian economy, as Australia is potentially outside of its periphery. The fact we find predicted values sticking closely to their original values and not moving with any statistical significance does indeed provide some evidence of the limited influence of the United States on to economies far-afield and potentially outside of its periphery.

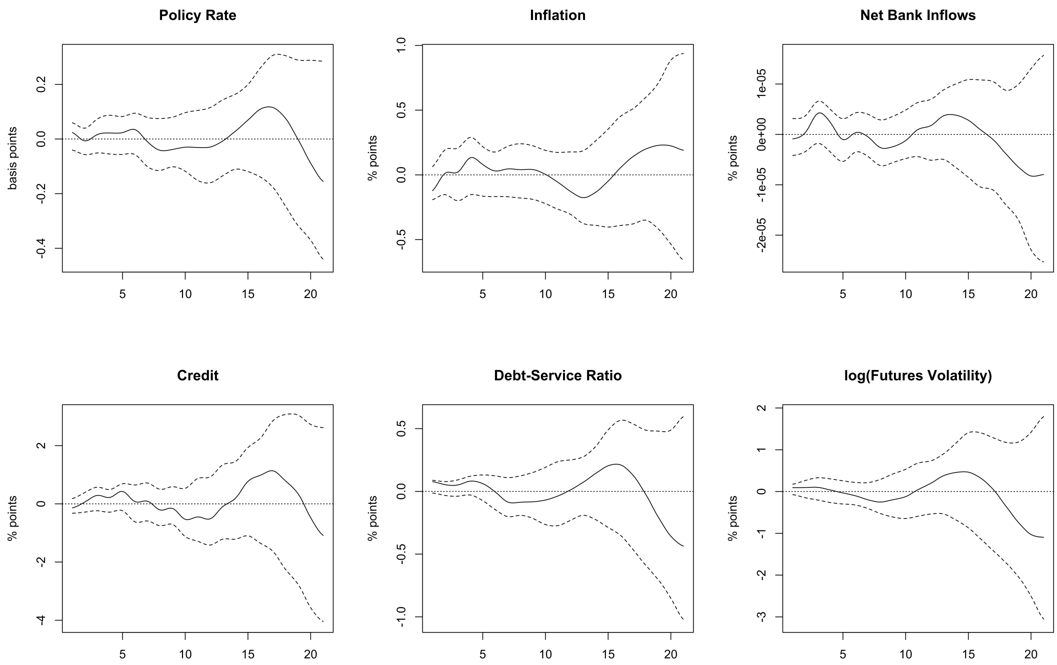

Figure 5.7: Pre-crisis IRFs of U.S. policy rate shock on Australia

Figure 5.8 depicts the Impulse Response Functions for Australia in the post-crisis period. The Impulse Response Functions show that the Australian yield curve slope decreases following the yield curve slope decrease in the U.S. This decrease lasts for about two quarters, reverting back to original values quite rapidly.

We do however not find any statistically significant changes in underlying factors in the first two quarters following the shock. Inflation is predicted to decrease, however this cannot be proven to be statistically significant. Moreover, the debt-service ratio decreases according to the predicted value, although this is again not statistically significant. On the contrary, log(futures volatility) increases following the shock, but reverts back to its prior values as quickly as the yield curve slope does. Again, this increase is however non-significant at a 95% confidence level.

In fact, we see that after about ten quarters following the shock, variables such as inflation, net bank inflows, credit, debt-service ratio and log(futures volatility) seem to return to their original values through the values predicted by the Impulse Response Functions. Hence, the results of a shock in the United States is predicted to die out more quickly than it did in the case of Canada, although in both cases the effects were insignificant. Therefore we can potentially conclude that the United States' effects outside of its periphery are limited, even in the post-crisis period.

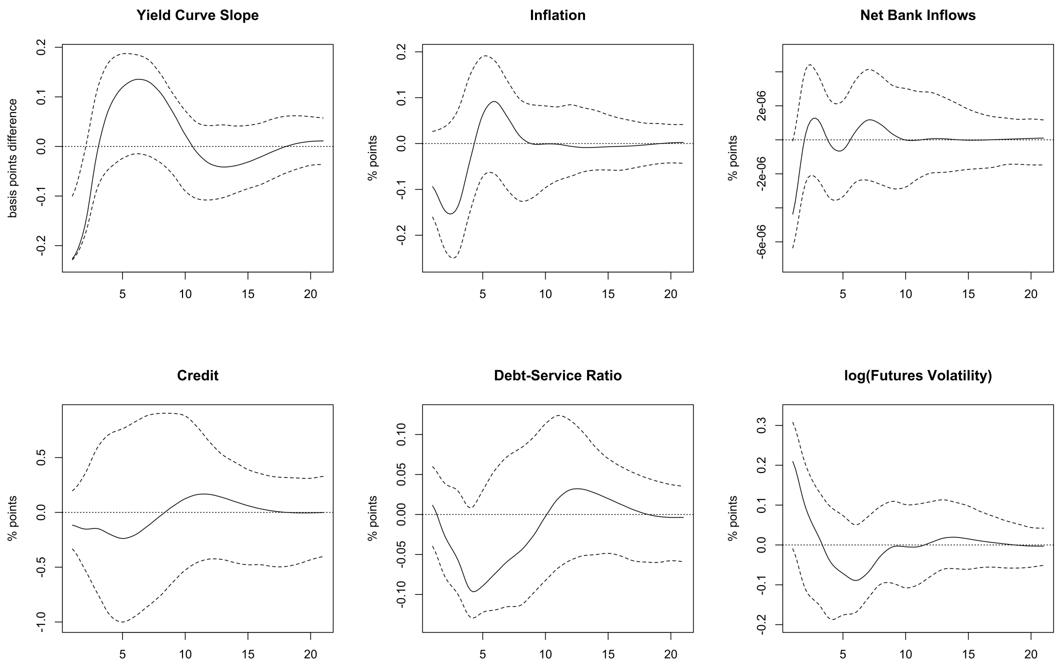

Figure 5.8: Post-crisis IRFs of U.S. yield curve shock on Australia

5.5 Bilateral-relation Euro area on Poland

It is important to further identify the relations of periphery-economies to the largest center-economy, according to Figure 3.1. As the Euro area is quite important to the whole of the European continent, and the European Union in particular, it seems plausible that relations to other countries within the European Union might be stronger than the previously discussed relation to Switzerland, which is not part of the European Union. Hence, as previously discussed, we use a reduced VAR to identify the relation of the ECB to Poland and Hungary, two non-Euro area members of the European Union.

In Figure 5.9 we find the IRFs to a reduced VAR in the pre-crisis period for the case of Poland. We do not find any significant changes to the variables included in this VAR as a result of the shock in the ECB's policy rate. This comes despite the fact that Poland relies heavily on Euro area economies in terms of its finances. As a result, the Polish economy is expected to react significantly to a shock to these Euro area economies. However no significant effects can be observed from the reduced VAR. Inflation is predicted to rise by about 0.2 percentage points, but such a change is insignificant at a 95% confidence level. Moreover, both credit and debt-service ratio are expected to rise by about 0.5 and 0.1 percentage points respectively, both increases being non-significant as well. These increases are all relatively small and surprisingly insignificant considering the dependence of the Polish economy on the Eurozone in general.

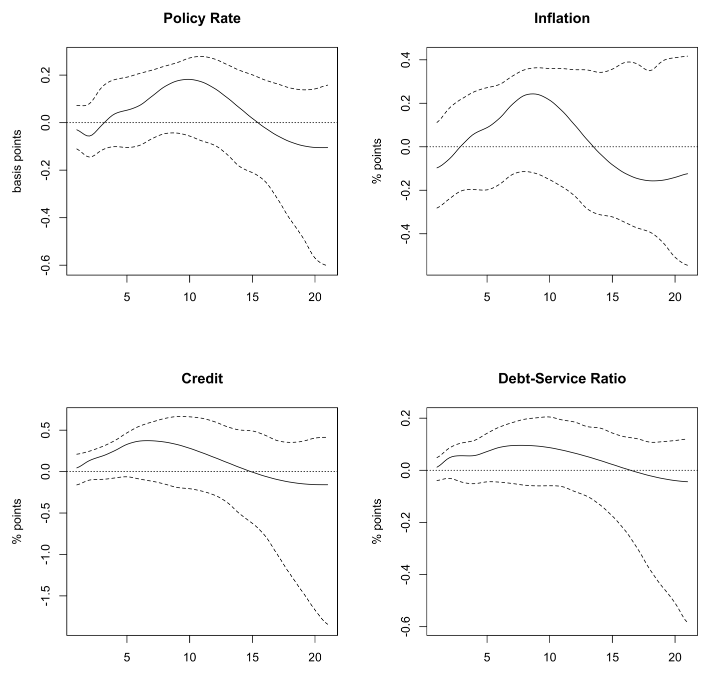

Figure 5.9: Pre-crisis IRFs of Euro area policy rate shock on Poland

Figure 5.10 shows the Impulse Response Functions to the reduced VAR for Poland in the post-crisis period. Interestingly, we see a significant, but very short-lived, reaction in terms of the yield curve slope as well as inflation in Poland. However, the financial responses are once again insignificant. As such, we can conclude that the Polish real economy does potentially respond to the change in financial conditions within the Euro area through inflation, even though the Polish financial conditions do not. In fact, the results show that unconventional monetary policy within the Euro area might transmit to Poland, both by reducing inflation, briefly, and reducing the yield curve slope. This reduction of inflation, as opposed to increase, is likely due to the Euro depreciating, which effectively appreciates the Polish złoty. This subsequently leads to deflation within Poland in the short-run.

Another possible conclusion is that these yield curves move in a somewhat synchronized fashion. As the yield curve is also used as an indicator for oncoming recessions, it could be the case that the Polish economy simply reacts to the Euro area's economic fluctuations. Indeed, considering the economic linkages between the two, this could explain the observed co-movements. If a yield curve inversion occurs within the Euro area, a similar inversion might take place in Poland. This is beyond the implementation of unconventional monetary policy which can also be uncovered through the yield curve. Subsequently, this might not be the result of policy-transmission, but rather recession-transmission. However, recession-transmission would usually take a longer period then it does within the IRFs. Such an explanation does however account for the decrease in inflation within the first quarter following the shock.

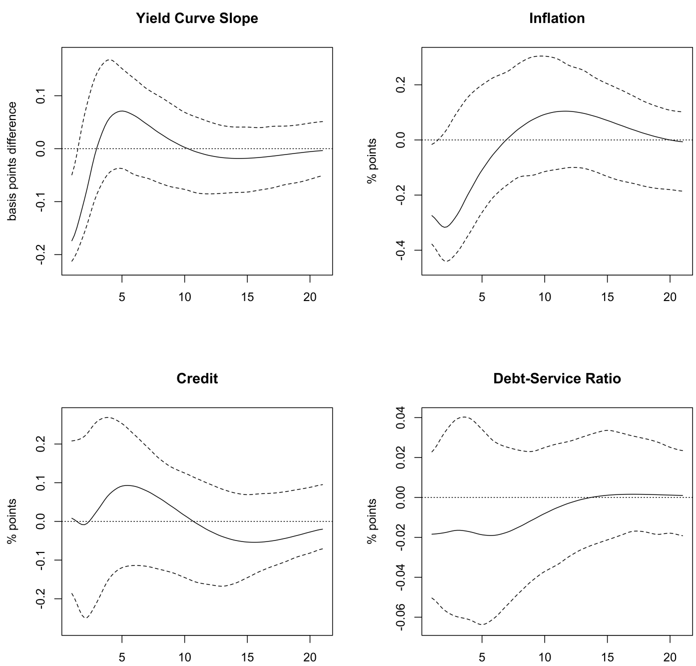

Figure 5.10: Post-crisis IRFs of Euro area yield curve shock on Poland

5.6 Bilateral-relation Euro area on Hungary

Figure 5.11 shows the Impulse Response Functions for the reduced VAR in the case of Hungary for the pre-crisis period. Here we observe that the Hungarian National Bank's policy rate does not respond to a shock in the European Central Bank's policy rate.

Inflation seems to experience an increase of its predicted value, albeit a statistically insignificant one. Credit fluctuates quite a lot, according to its predict value, around the starting value it obtained prior to the shock, eventually returning to its pre-shock values, although these fluctuations are non-significant as well. Interestingly, the debt-service ratio sees a large, short-lived, increase following a decrease in the short-term interest rate in the Euro area. After about two quarters this turns into a large decrease however. This short-run increase can be explained through the heavy dependence of Hungary on Euro area funding. Subsequently, when funding-costs in the Euro area decrease, debt-servicing costs in Hungary can indeed be expected to decrease. The argument for this relies entirely on the Hungarian dependence for short-term credit from Euro area sources, entailing that a significant portion of Hungarian debt is serviced at the ECB's policy rate. Thus the costs of servicing the debt increases in the short-run. However, this result is again not statically significant at the 95% confidence level. Therefore we cannot actually conclude a real change to the conditions in Hungary as a result of a shock to the Euro area's policy rate. Hence, we also cannot conclude that the change of the European Central Bank's monetary stance causes a change in the monetary conditions of Hungary.

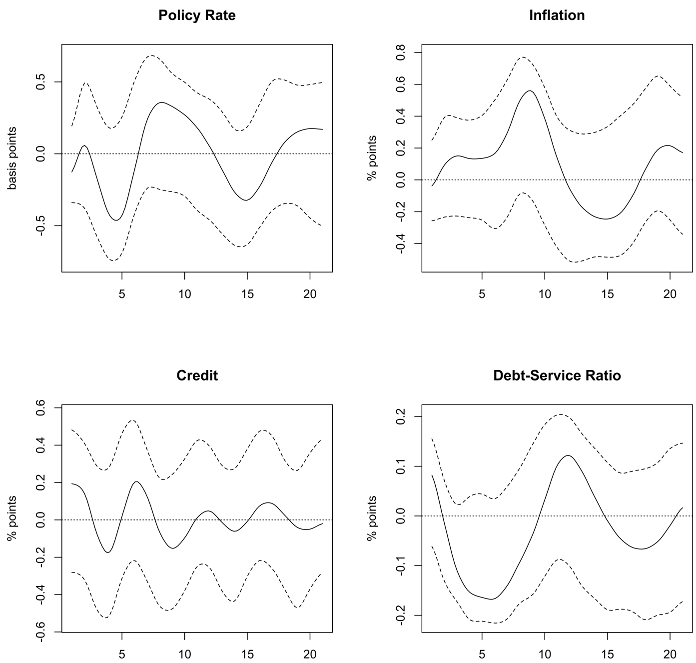

Figure 5.11: Pre-crisis IRFs of Euro area policy rate shock on Hungary

The Impulse Response Functions of the reduced VAR in the post-crisis period for the Hungarian case can be found in Figure 5.12. We observe that, although the yield curve slope responds just as it did in the case of Poland, inflation remains unaffected by the shock. Moreover, credit and debt-service ratio remain statistically unaffected. Credit does however appear to suffer a decrease in the first year following the shock, although this decrease is statistically insignificant.

This result is intriguing as we observe in Figure 7.2, found in Appendix A, that the Hungarian yield curve has behaved far differently from the Euro area's yield curve. The Euro area's and Hungarian yield curves are not as related to one another as the Euro area's and Swiss yield curves are. Therefore the idea of the yield curve in Hungary reacting to a decrease in the slope of the Euro area yield curve is perhaps surprising. This is especially true given the non-significant responses of inflation, credit and the debt-service ratio. However, the predicted decrease of the credit in Hungary might in fact be a result of the decrease in the Hungarian yield curve. This will again be investigated using bivariate Granger-causality tests later in this section. The underlying reasons for the Hungarian yield curve reacting to a shock in the Euro area seem to be missing within this reduced VAR however.

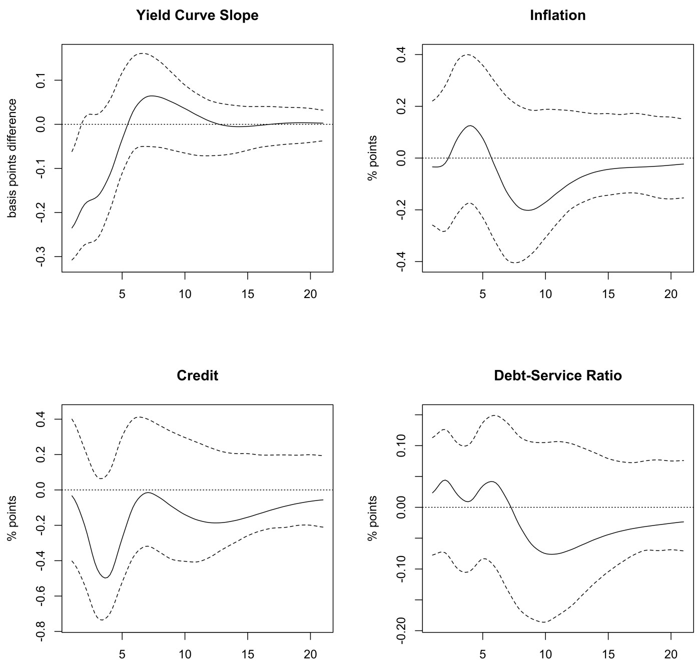

Figure 5.12: Post-crisis IRFs of Euro area yield curve shock on Hungary

5.7 Granger causality

Granger causality tests are performed using the previously described procedure, testing for direct causality between two variables. The results of these tests are shown in tables within Appendix A. These tables are provided for each case within this section, both for the full and reduced VARs. Critical values for these matrices are to be found in any Chi-square table.

Table 7.3 indicates a high degree of causality running from the Federal Reserve's policy rate to the European Central Bank's policy rate. However, the reverse also shows to be statistically significant, although only at a 95% confidence level, rather than a 99% confidence level. We also see that the Fed's policy rate individually Granger-causes net bank inflows and credit. It does however not cause the volatility of futures in the Euro area. It is also interesting to note that net bank inflows and credit individually both Granger-cause the ECB policy rate, but inflation does not. Hence, the Fed's policies might be transmitted through credit or net bank inflows, although the VAR does not corroborate this idea. This result therefore only seems to hold in a bivariate setting.

In Table 7.4 the Granger-causalities for the Euro area affected by the U.S. yield curve in the post-crisis period are shown. We find an opposing result to Table 7.3, as the U.S. yield curve slope does not Granger-cause the Euro areas yield curve slope in the post-crisis period. Reverse causality is not proven either. Instead we see that all finance related variables and inflation, with the exception of log(futures volatility), seem to Granger-cause the Euro area's yield curve. We also see U.S. yield curve causing the Euro area's credit and debt-service ratio, both of which also Granger-cause the Euro area's yield curve, thus forming a potential transmission channel.

We observe the Granger-causality matrix for the Swiss pre-crisis case in Table 7.5. We find that although the European Central Bank's policy rate does seem to Granger-cause the Swiss policy rate, the same can also be said for the Swiss policy rate Granger-causing the ECB's policy rate. As previously noted, this could be due to the high degree of co-movement between policy rate. In fact, the Swiss policy rate is prone to moving prior to the ECB moving its policy rate due to the longer decision-making process within the Euro area. As such, it is much more fitting to look at the underlying conditions' causality. We find net bank inflows, credit, debt-service ratio and log(futures volatility) all Granger-cause the Swiss policy rate. The latter two also cause the ECB's policy rate. A potential transmission channel can be found through the debt-service ratio, which is individually Granger-caused by the ECB's policy rate, and itself Granger-causes the Swiss policy rate.

Granger-causality from the Euro area's yield curve to the Swiss yield curve cannot be confirmed in Table 7.6. However, the reverse can be confirmed. Again a high-degree of co-movement forms a likely explanation of this observation and the underlying variables causing such movements are of greater interest. We see that the Swiss yield curve is Granger-caused by both net bank inflows and credit. Credit is in turn Granger-caused by the Euro area's yield curve movements. Hence a transmission through credit is possible. However, it should be noted that the Euro area and Swiss yield curve are both Granger-caused by the net bank inflows and credit, making the actual distinction of causality through credit quite difficult.

Table 7.7 showcases the Granger-causality matrix for pre-crisis Canada. Here we can clearly identify direct Granger-causality running from the Federal Reserve's policy rate to the Canadian policy rate. The reverse cannot be found and as such it does seem likely that the United States can directly cause movements in the Canadian policy rate. However, this only is the case when not accounting for other factors, as we saw in Figure 5.5. The Federal Reserve's policy rate seems to Granger-cause the debt-service ratio and futures volatility in Canada. However, neither of these variables Granger-cause the Canadian policy rate. Therefore we cannot really identify any transmission channels in this matrix.

The post-crisis results are found in Table 7.8. We observe no Granger-causality between the U.S. and Canadian yield curves, in either direction. Although the U.S. yield curve movements appear to Granger-cause inflation in Canada. Inflation in turn does not Granger-cause any Canadian yield curve movements. The Canadian yield curve movements do appear to be Granger-caused by the net bank inflows, credit and debt-service ratio instead. In turn the Canadian yield curve Granger-causes inflation and credit.

For the case of Australia, Table 7.9 shows the Granger-causality results for the pre-crisis period. We can see that individually, the Federal Reserve's policy rate Granger-causes the Australian policy rate. However, this result was not corroborated in the Vector Autoregression. This can be explained through the multi-variate nature of the VAR. At a bivariate level net bank inflows, credit and debt-service ratio seem to Granger-cause the policy rate in Australia as well, which again is not corroborated by the VAR.

The post-crisis results shown in Table 7.10 indicate that at a bivariate level the Australian yield curve Granger-causes the U.S. yield curve, rather than the U.S. Granger-causing the Australian yield curve. In fact, none of the variables used can be shown to Granger-cause the Australian yield curve. On the contrary, the yield curve Granger-causes the debt-service ratio. We also see that inflation, net bank inflows, credit and debt-service ratio each Granger-cause the yield curve of the U.S. in a bivariate analysis of Granger-causality. A likely explanation of this is a high degree of co-movement between these variables and their counterparts in the U.S., which affect the yield curve.

The reduced form of the Vector Autoregression leads us to the Granger-causality matrix for Poland in the pre-crisis period in Table 7.11. Although we cannot conclude that the ECB's policy rate causes the policy rate in Poland, the reverse is shown to be marginally significant. This finding is possibly due to slower reactions by the ECB as opposed to the Polish National Bank, as the ECB's decision-making process is much more complex. The Polish policy rate seems to be determined by both inflation and credit. Credit is in fact also Granger-caused by the ECB's policy rate and as such this is a potential transmission channel which can be observed. However, credit in Poland also appears to Granger-cause the policy rate in the Euro area.

Table 7.12 shows bivariate Granger-causality between variables of the reduced VAR for Poland in the post-crisis period. Here we see that the Euro area yield curve Granger-causes the yield curve in Poland. Indeed credit and debt-service ratio both individually Granger-cause the Polish yield curve as well. The Euro area yield curve also causes credit in Poland, which could indeed be a transmission channel of the Euro area yield curve to the Polish yield curve. Equally, the debt-service ratio is also caused by the Euro area's yield curve.

Hungary's pre-crisis Granger-causality matrix is shown in Table 7.13. We see no causality running in either direction between the policy rate of Hungary and the ECB. We do however find that the Hungarian policy rate is Granger-caused by the country's debt-service ratio. Although this variable is not Granger-caused by the ECB policy rate in turn. Hence we cannot identify any potential transmission channel for the Hungarian, pre-crisis case.

The post-crisis results of the bivariate Granger-causality tests are available in Table 7.14. No causality in either direction can be found between the yield curves of Hungary and the Euro area. However the Hungarian yield curve is Granger-caused by both credit and debt-service ratio in a bivariate setting. Credit is also Granger-caused by the Euro area yield curve, as is the debt-service ratio. Hence, these two variables are potential transmission channels.

6 Discussion

The results discussed in section 5 are quite contradictory to the conclusions drawn by Rey (2015), with regards to the Mundell-Fleming trilemma. The Vector Autoregressions based on pre-crisis data showed little effective transmission of center-economies on to periphery-economies. In general net bank inflows and credit, both of which were in fact argued to be important transmission mechanisms by Rey (2015), did not show to respond to a shock in the policy rate of center-economies. This was tested on a number of periphery-economies for two of the large center-economies found in both the literature and the data.

The Impulse Response Functions indicated how predicted values fluctuate following a policy rate shock. However, these fluctuations never turned statistically significant at the 95% confidence level. This goes against the ideas brought forward by Rey (2015), who claimed monetary policy changes in a center-economy would significantly change certain financial conditions within the periphery. However, the results of the post-crisis analysis are indeed different. Here we can in fact find some short-run deviations of the yield curve slopes as a result of center-economy's employing unconventional monetary policy. Potentially these deviations are indeed caused through financial transmission, as statistically significant deviations in terms of net bank inflows and debt-service ratios are occasionally found in the Impulse Response Functions. However, most often deviations in terms of the yield curve slope are found to not be caused by financial variables and therefore could perhaps be explained through market expectations instead.

A bivariate Granger-causality analysis shows limited evidence for monetary-transmission through financial variables as well. Although some potential channels can be identified, they cannot be found in the multivariate Vector Autoregression analyses. It is therefore questionable whether such transmission mechanisms do really exist. An alternative explanation for these findings, especially the bi-directional findings, could be the use of quarterly data. Although this kind of data-frequency is often used within macroeconomic research, it potentially prohibits a clear identification of Granger-causality. Transmission of monetary policy is likely to occur within a one quarter period and subsequently we might observe either no causality at all or bi-directional causality. In this case, we observe movements of both the causing and caused variables in the same period. As Granger-causality depends on the timing of such movements, this is a potential issue for identifying this type of causality.

7 Conclusion

Rather than finding countries which are financially open to be subjected to the fluctuations of a foreign monetary authority, we find that conditions are not affected by these foreign policies. This is line with the original Mundell-Fleming trilemma, stating that countries with free flows of capital and a floating exchange rate are still free to set their own monetary policies. Moreover, it contradicts the original findings presented by Rey (2015). The Vector Autoregressions were unable to identify policy rate-to-policy rate transmission and only found some transmission when approximating policy-stances through yield curve slopes.

The results in section 5 show that OECD-members experience no identifiable form of policy transmission. Neither the financial variables nor inflation are specifically affected by a policy shock in the identified center-economy in the pre-crisis period. In the post-crisis period some transmission through inflation, net bank inflows and the debt-service ratio might be possible. The yield curves subsequently respond significantly to a shock in the center-economy. However, an alternative explanation for these findings is available. The yield curve happens to equally be a leading predictor of an oncoming recession, and as recessions tend to be transmitted globally, so does the inversion of the yield curve. One might therefore be able to conclude that in case of a recession, conditions on which monetary policies are often based could be affected by a global financial cycle. This means it is possible for recession-transmission to occur through co-moving yield curves, which change local conditions in periphery-economies. Moreover, expectations play an important role in yield curves and as such, expectations could equally explain some of the results found in section 5.

The main results of the analysis within this paper are deemed statistically insignificant. One would usually however like to obtain significant results, as they usually are considered more relevant to science and are therefore easier to publish. However, Abadie (2020) brings forward some arguments for non-significant results being equally, if not more, relevant to science. This is especially true given increasingly large data sets, which cause the prior probability of the rejection of the null hypothesis to increase accordingly. Therefore, a study using a large data set, such as the one use in this paper, might be more relevant if it is not in fact able to lead to the rejection of the null hypothesis. Hence, providing evidence for the null hypothesis used by Rey (2015), instead of providing a rejection of it, might yield a lot of information according to Abadie. Subsequently, we report non-significant results in this paper, allowing for further discussion regarding the issue of monetary autonomy.

The notion of capital controls as a requirement for monetary independence however, as Rey (2015) suggested, subsequently appears to some extent none sensible. Such controls would be costly and potentially do more harm than good. Nonetheless, given the interesting points brought on by Rey's proposed dilemma, the importance of macroprudential policy in assuring the continued existence of monetary sovereignty should not be underestimated either. As we move towards even greater financial integration, it is possible for the global financial cycle to gain significance. To assure monetary autonomy is retained however, macroprudential policy should indeed be implemented. This will allow for a strict separation between monetary and macroprudential goals, and therefore will continue to support monetary autonomy. This is especially true for the OECD-members discussed in this paper, as all member-states in the OECD are on a path of increasing financial integration at the global level. Therefore Rey's arguments in favor of macroprudential-policy are valid and should be taken seriously. The dilemma is subsequently of significant importance moving forward with greater financial integration.

Appendix A

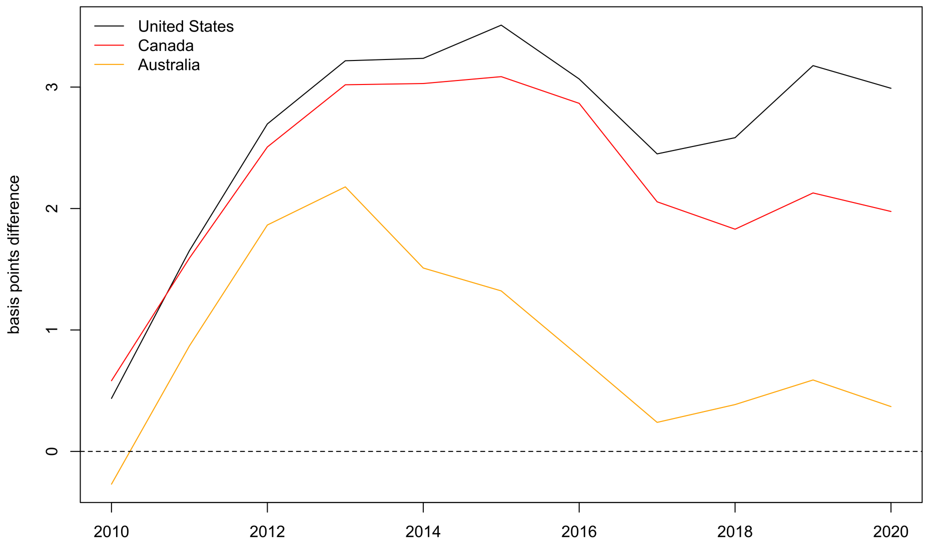

Figure 7.1: Yield curve slopes of the U.S., Canada and Australia

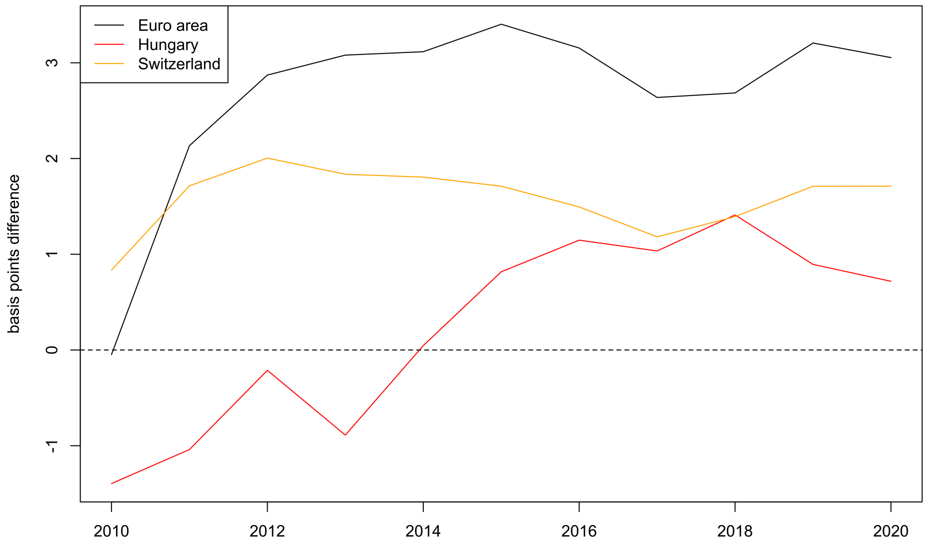

Figure 7.2: Yield curve slopes of the ECB, Hungary and Switzerland

Table 7.1: Data availability by country

Country	Policy Rate	Yield Curve	Net Bank Inflows	Credit	Debt-Service Ratio	Futures Volatility
Australia	Yes	Yes	Yes	Yes	Yes	Yes
Canada	Yes	Yes	Yes	Yes	Yes	Yes
Chile	Yes	Yes	Yes	Yes	No	No
Colombia	No	No	No	No	No	No
Czech Republic	Yes	Yes	Yes	Yes	Yes	No
Denmark	Yes	Yes	Yes	Yes	Yes	Yes
Euro area	Yes	Yes	Yes	Yes	Yes	Yes
Hungary	Yes	Yes	Yes	Yes	Yes	No
Israel	Yes	Yes	Yes	Yes	No	No
Japan	Yes	Yes	Yes	Yes	Yes	Yes
South Korea	Yes	Yes	Yes	Yes	Yes	Yes
Mexico	Yes	Yes	Yes	Yes	Yes	Yes
New Zealand	Yes	Yes	Yes	Yes	No	No
Norway	Yes	Yes	Yes	Yes	Yes	No
Poland	Yes	Yes	Yes	Yes	Yes	Yes
Sweden	Yes	Yes	Yes	Yes	Yes	Yes
Switzerland	Yes	Yes	Yes	Yes	Yes	Yes
Turkey	Yes	No	Yes	Yes	Yes	Yes
United Kingdom	Yes	Yes	Yes	Yes	Yes	Yes
United States	Yes	Yes	Yes	Yes	Yes	Yes

Only in case of total data availability will the country be part of the data set.

Table 7.2: 1st Generic Futures by country

Country	**Ticker**	**Index**	**Availability**
Australia	XP1:IND	S&P/ASX 200	Yes
Canada	PT1:IND	S&P/TSX 60	Yes
Switzerland	SM1:IND	Swiss Market	Yes
Chile		S&P/CLX IGPA (CLP) TR	No
Czech Republic		Prague Stock Exch. Index	No
Denmark	OMW1:IND	OMX Copenhagen 25	Yes
United Kingdom	Z 1:IND	FTSE 100	Yes
Hungary		Budapest Stock Exch. Index	No
Israel		TA-35 Index	No
Japan	NK1:IND	Nikkei 225	Yes
South Korea	KM1:IND	KOSPI 200	Yes
Mexico	IS1:IND	Mexican IPC	Yes
Norway		OSE Index	No
New Zealand		S&P/NZX 50	No
Poland	KRS1:IND	WIG20	Yes
Sweden	QC1:IND	OMX Stockholm 30	Yes
Turkey	A51:IND	BIST 30	Yes
United States	ES1:IND	S&P 500 mini	Yes
Euro area	VG1:IND	Euro STOXX 50	Yes

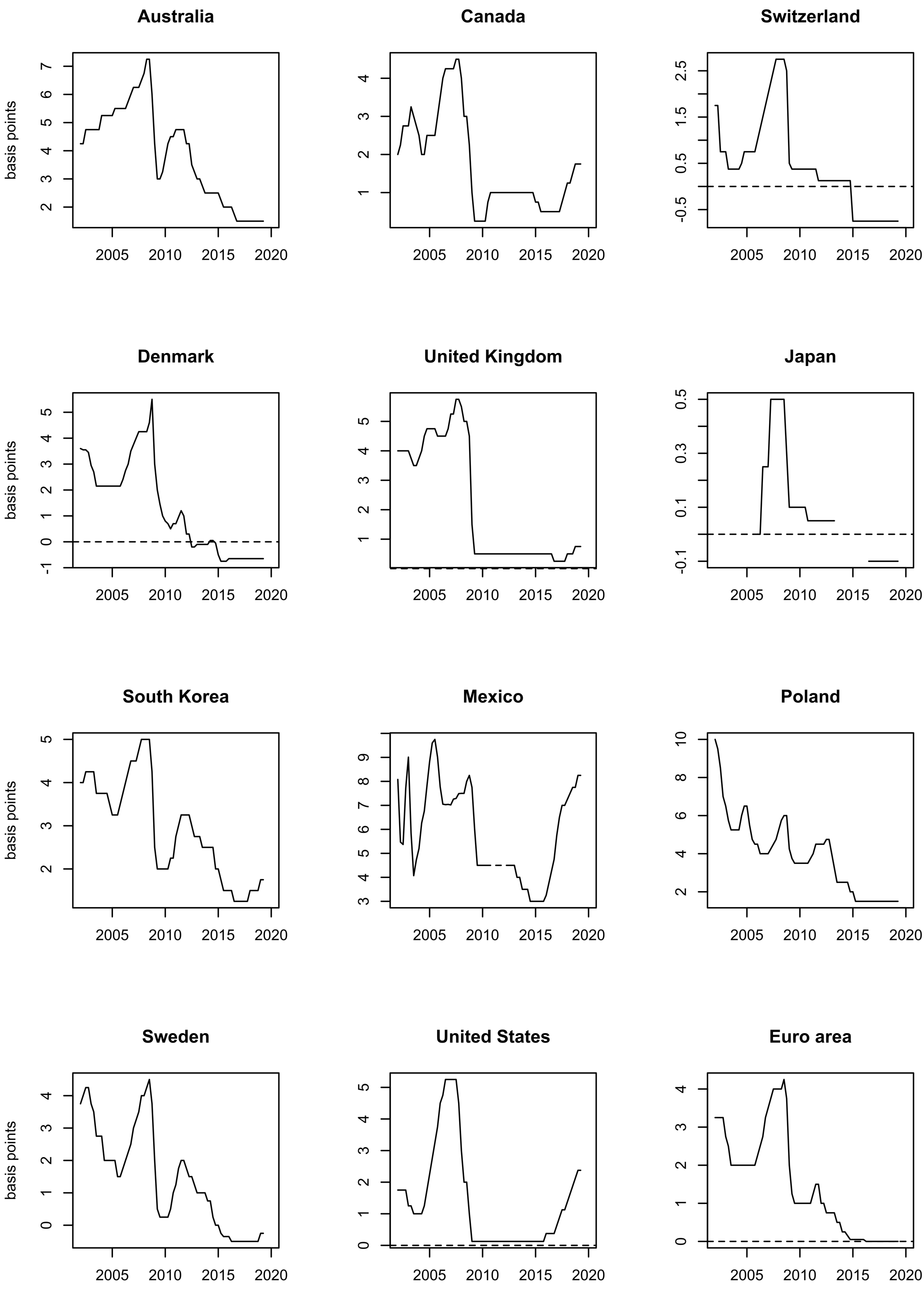

Figure 7.3: Policy rate plot

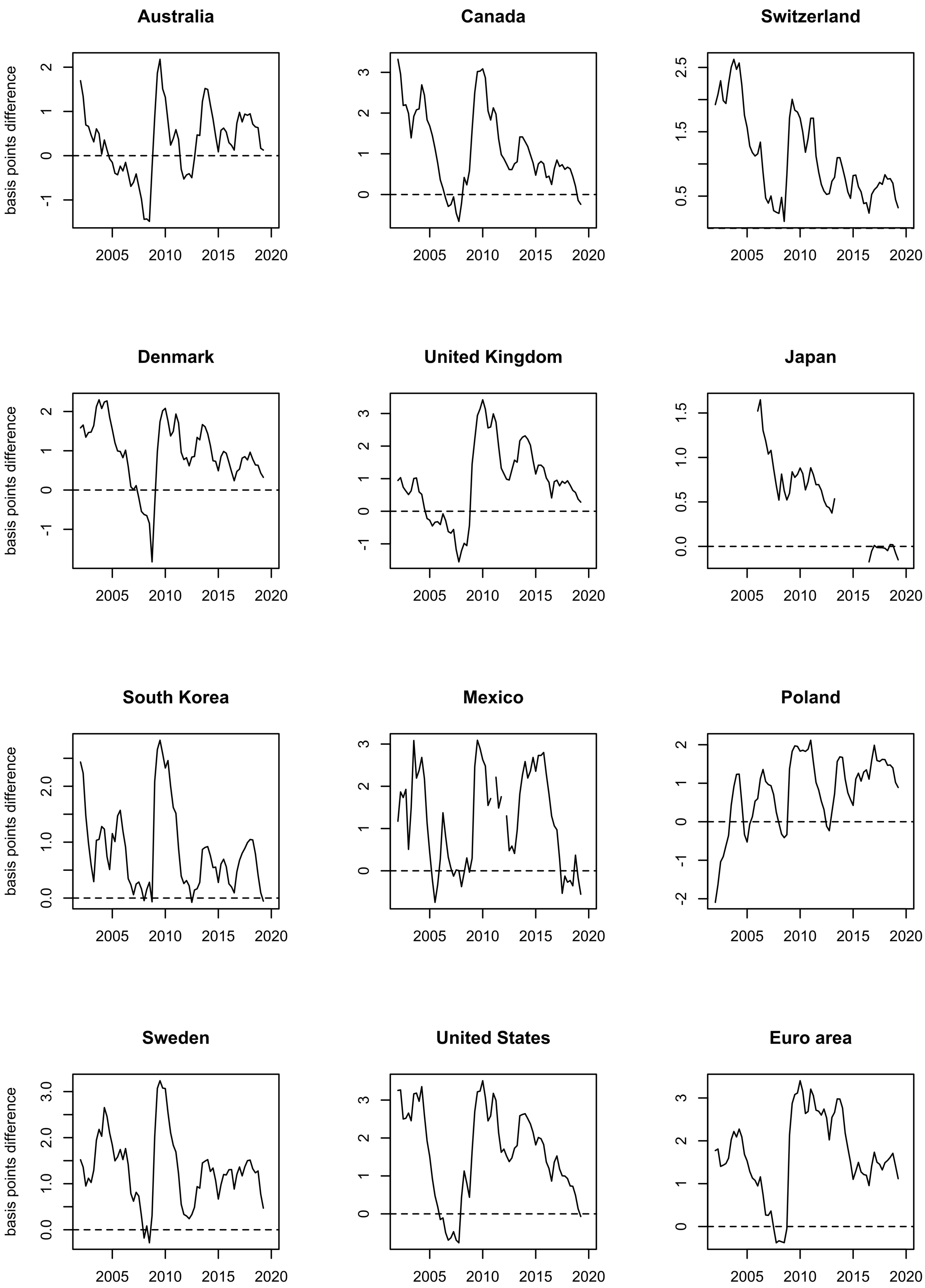

Figure 7.4: Yield curve plot

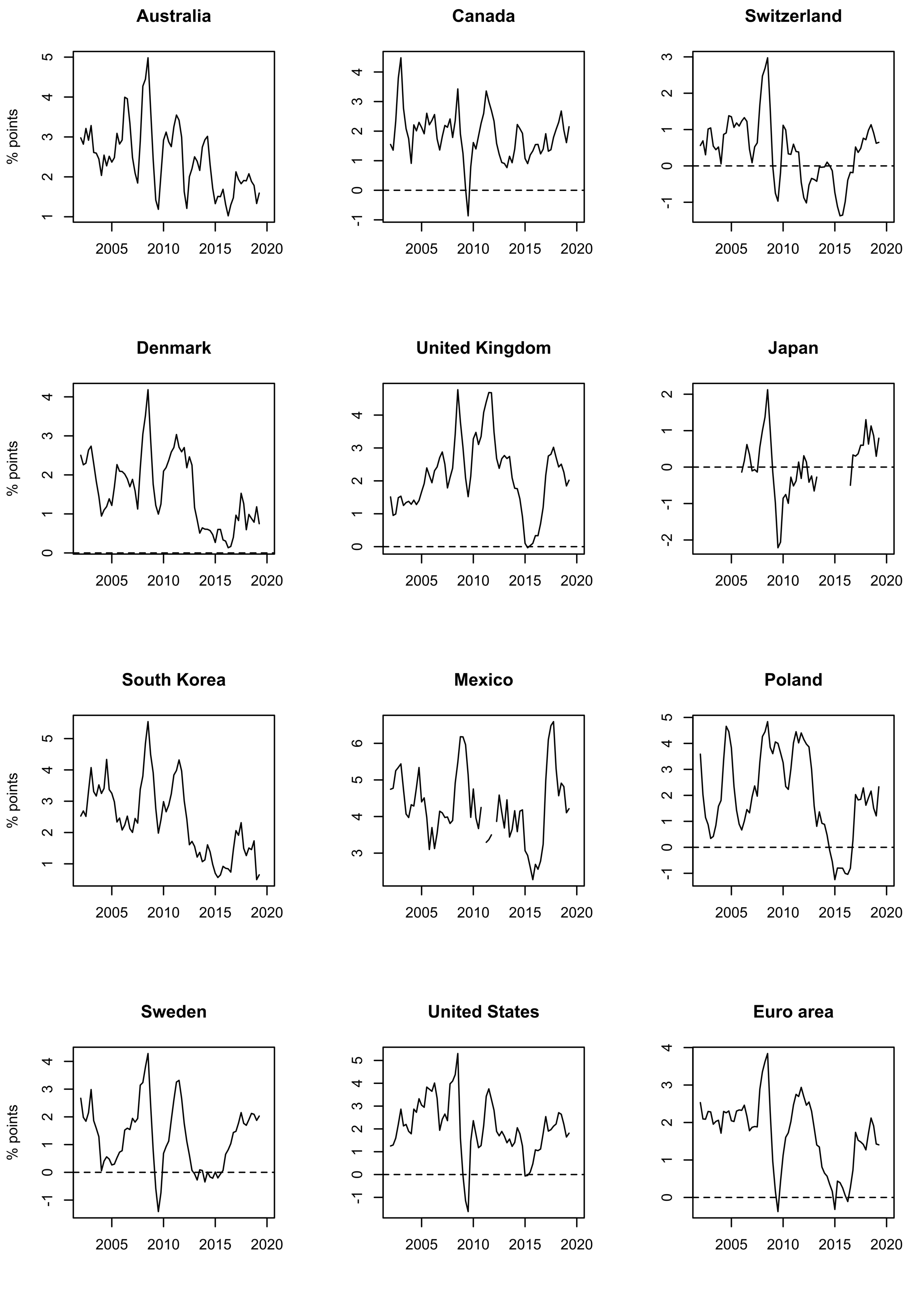

Figure 7.5: Inflation plot

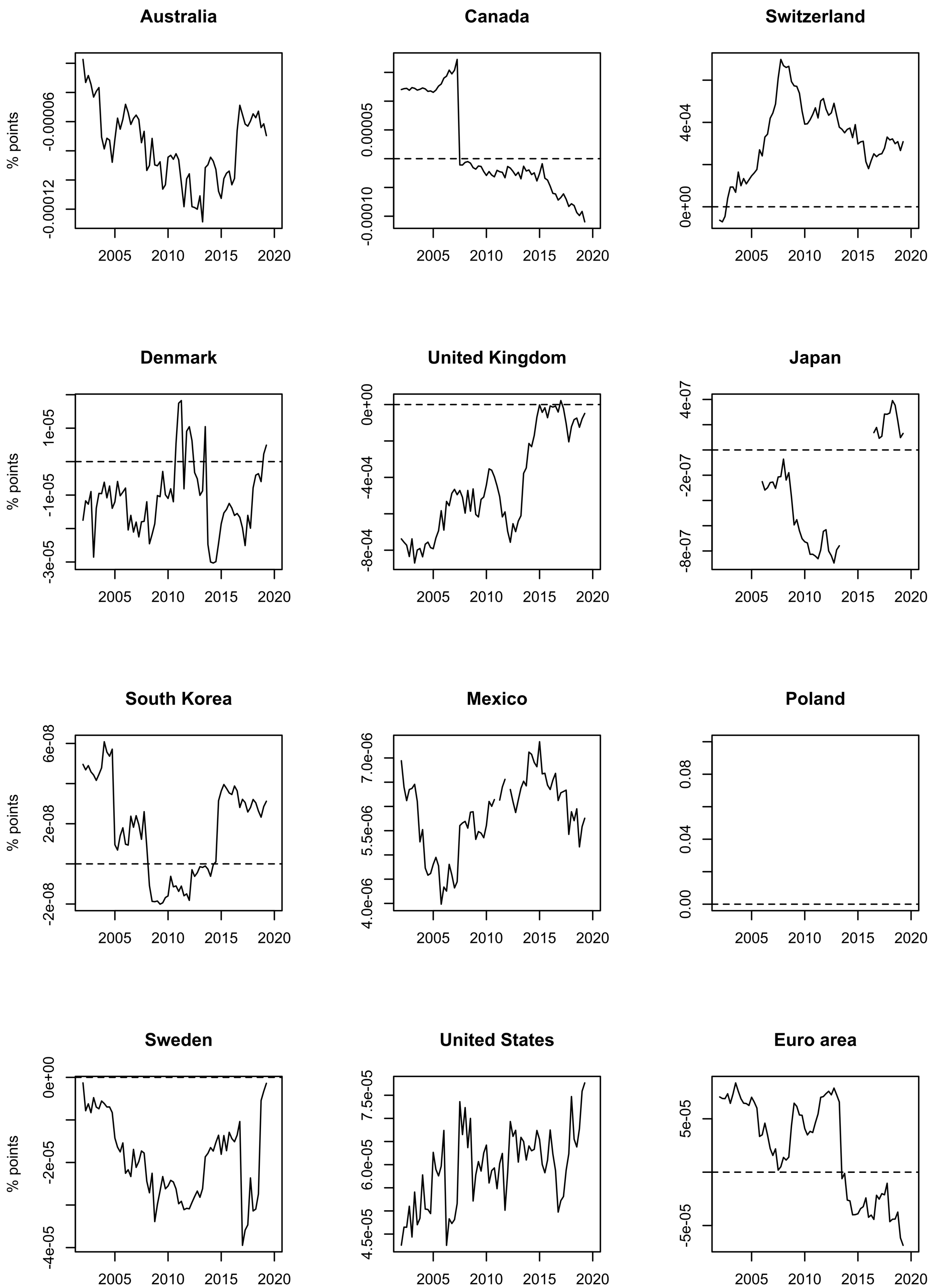

Figure 7.6: Net bank inflows plot

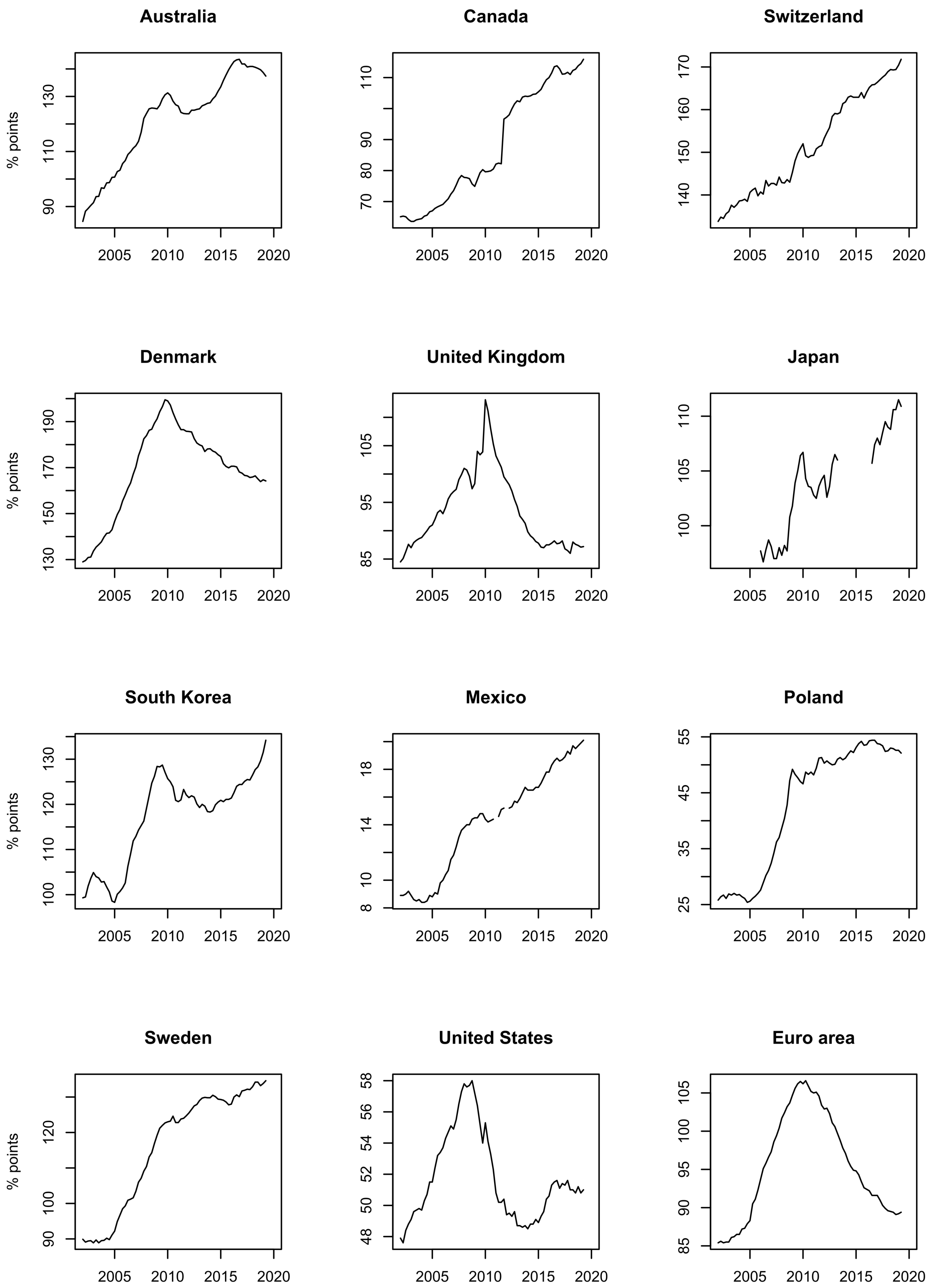

Figure 7.7: Credit plot

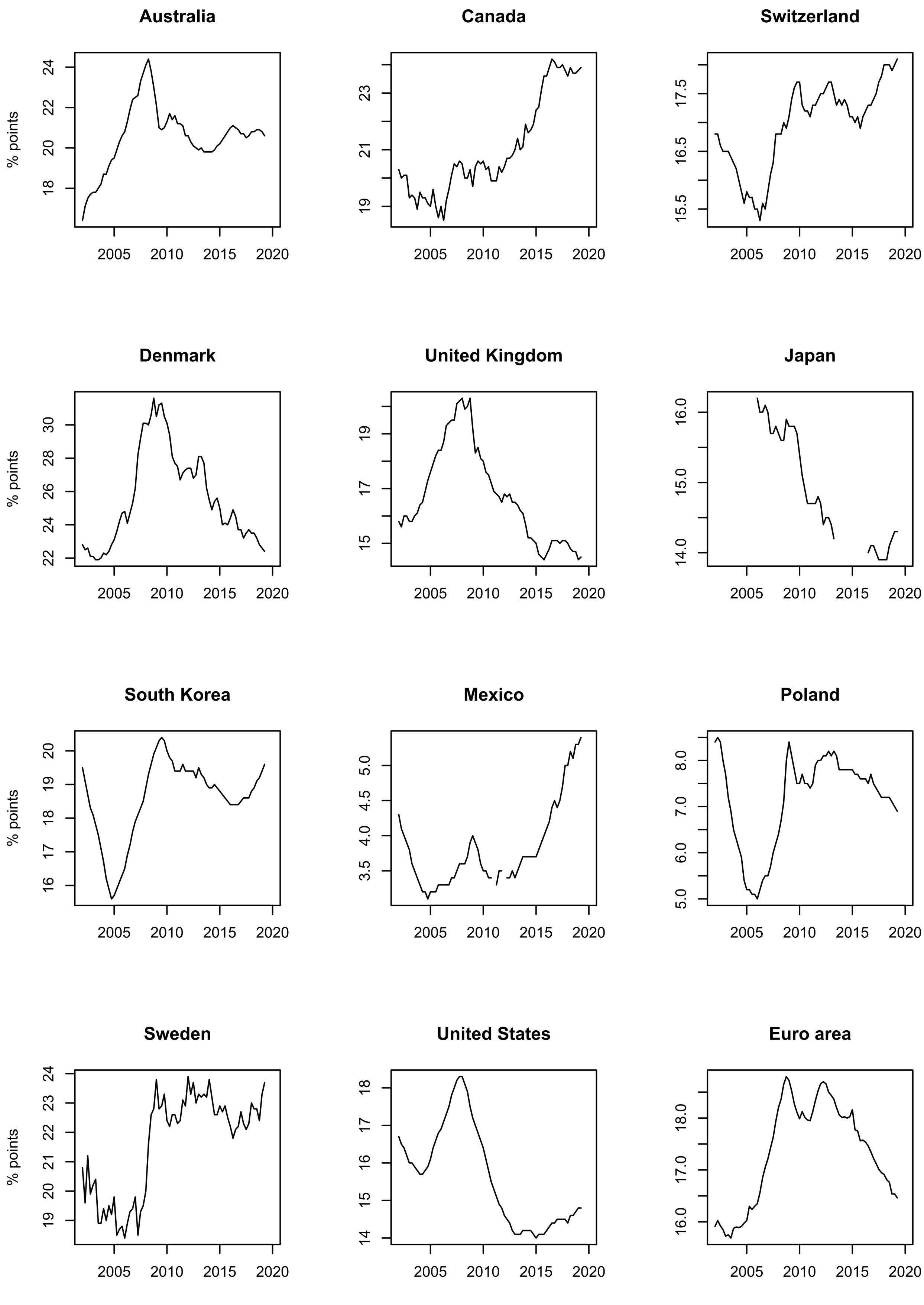

Figure 7.8: Debt-service ratio plot

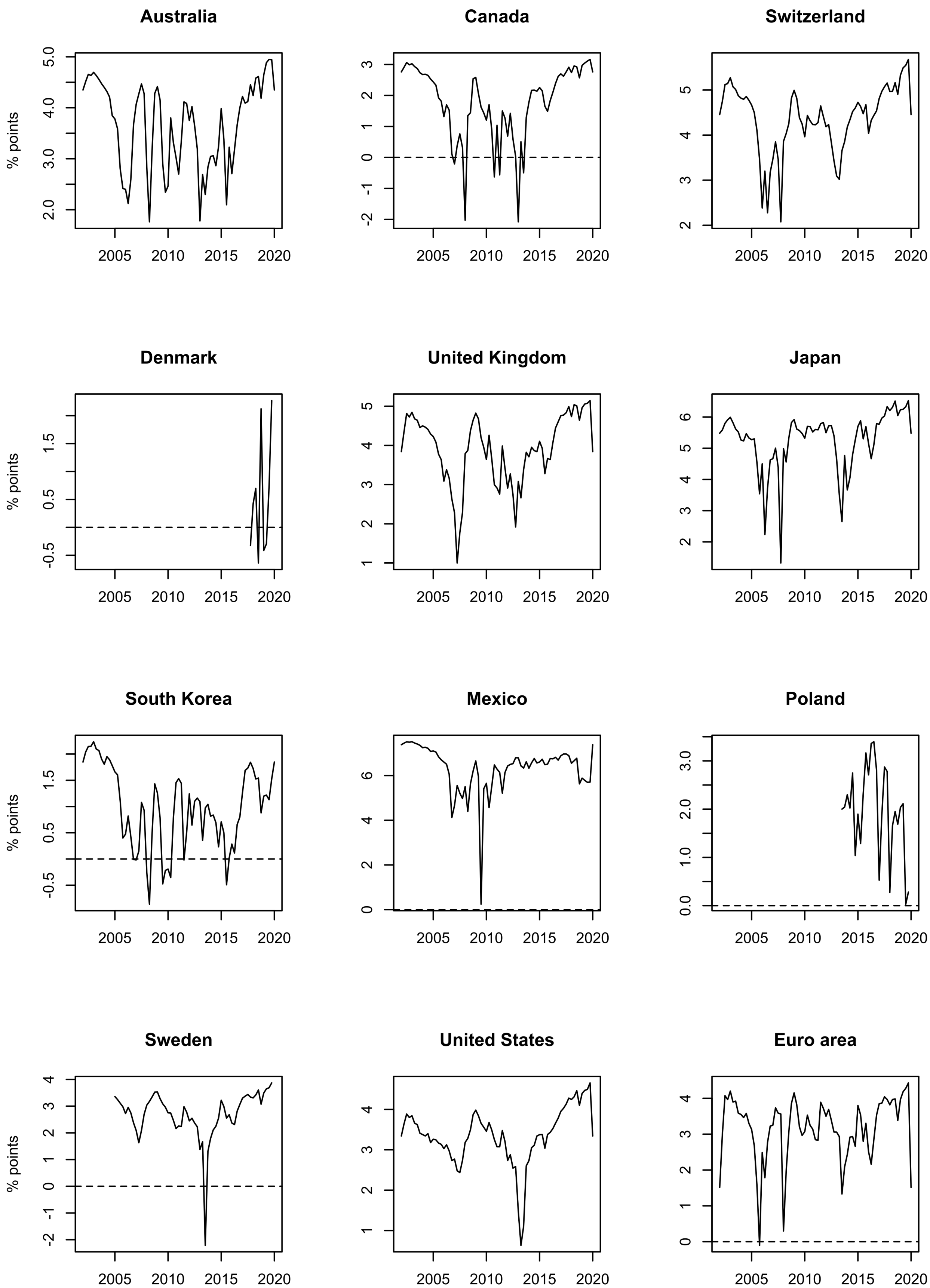

Figure 7.9: Log(Futures Volatility) plot

Table 7.3: Granger-causality matrix for Euro-area pre-crisis

	Dependent Variable						
Causing Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
(1) Policy Rate	-	7.22 **	3.85	2.77	7.57 **	4.76	0.02
(2) U.S. Policy Rate	11.79 ***	-	3.00	9.15 **	6.71 **	4.07	0.71
(3) Inflation	0.35	1.24	-	0.32	0.23	0.46	8.81 **
(4) Net Bank Inflows	6.43 **	0.94	3.75	-	0.28	6.18 **	1.47
(5) Credit	9.24 ***	1.16	2.87	28.44 ***	-	21.42 ***	2.73
(6) Debt-Service Ratio	5.37	0.99	7.32 **	3.93	5.37	-	1.26
(7) log(Futures Volatility)	5.44	6.01 **	0.28	1.54	1.56	0.80	-

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

Table 7.4: Granger-causality matrix for Euro-area post-crisis

	Dependent Variable						
Causing Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
(1) Yield Curve	-	2.78	2.37	1.15	8.41 **	5.83 *	1.53
(2) U.S. Yield Curve	0.36	-	1.21	0.35	5.80 *	7.38 **	1.78
(3) Inflation	7.46 **	8.28 **	-	1.80	3.65	8.80 **	0.71
(4) Net Bank Inflows	32.09 ***	7.15 **	1.75	-	1.61	1.85	2.84
(5) Credit	43.70 ***	16.32 ***	1.66	5.76 *	-	14.58 ***	3.14
(6) Debt-Service Ratio	14.10 ***	20.62 ***	1.85	4.81 *	0.33	-	8.41 **
(7) log(Futures Volatility)	0.90	1.61	3.45	0.30	0.42	2.34	-

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

Table 7.5: Granger-causality matrix for Switzerland pre-crisis

	Dependent Variable						
Causing Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
(1) Policy Rate	-	10.21 ***	3.61	1.83	1.40	11.38 ***	0.81
(2) ECB Policy Rate	5.54 *	-	1.70	3.99	0.57	25.69 ***	1.74
(3) Inflation	0.52	0.53	-	2.22	0.21	0.25	0.87
(4) Net Bank Inflows	29.05 ***	4.12	4.78 *	-	5.21 *	18.25 ***	3.51
(5) Credit	23.86 ***	4.15	3.25	0.38	-	16.02 ***	9.93 ***
(6) Debt-Service Ratio	10.30 ***	4.89 *	0.51	2.32	2.48	-	5.27 *
(7) log(Futures Volatility)	7.98 **	12.88 ***	0.57	0.91	0.35	6.16 **	-

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

Table 7.6: Granger-causality matrix for Switzerland post-crisis

	Dependent Variable						
Causing Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
(1) Yield Curve	-	14.52 ***	1.14	0.74	8.22 **	2.47	0.55
(2) Euro Yield Curve	1.30	-	0.63	0.60	4.61 *	4.65 *	1.00
(3) Inflation	2.44	6.43 *	-	4.38	7.48 **	3.80	7.27 **
(4) Net Bank Inflows	10.43 ***	40.85 ***	3.13	-	1.50	2.81	5.30 *
(5) Credit	11.65 ***	39.05 ***	1.67	5.19 *		1.02	4.83 *
(6) Debt-Service Ratio	1.42	0.83	9.99 ***	0.56	0.85	-	0.77
(7) log(Futures Volatility)	0.53	3.31	3.40	2.31	2.70	9.89 ***	-

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

Table 7.7: Granger-causality matrix for Canada pre-crisis

	Dependent Variable						
Causing Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
(1) Policy Rate	-	4.21	1.71	3.00	1.49	6.08 **	6.04 **
(2) U.S. Policy Rate	13.98 ***	-	0.58	3.52	3.73	4.99 *	12.93 ***
(3) Inflation	3.57	0.15	-	0.14	2.06	2.48	0.13
(4) Net Bank Inflows	7.39 **	7.47 **	0.19	-	16.59 ***	1.66	0.59
(5) Credit	2.02	0.85	5.45 *	5.14 *	-	5.61 *	21.31 ***
(6) Debt-Service Ratio	1.49	7.43 **	4.71 *	8.77 **	6.86 *	-	1.61
(7) log(Futures Volatility)	4.40	2.14	1.01	12.33 ***	19.53 ***	5.64 *	-

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

Table 7.8: Granger-causality matrix for Canada post-crisis

	Dependent Variable						
Causing Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
(1) Yield Curve	-	2.46	7.23 **	0.14	6.11 **	3.07	1.86
(2) U.S. Yield Curve	1.91	-	6.46 **	1.33	4.24	1.82	0.63
(3) Inflation	4.40	5.57 *	-	1.38	4.87 *	0.57	1.43
(4) Net Bank Inflows	4.75 *	20.02 ***	0.99	-	0.00	4.79 *	3.66
(5) Credit	17.75 ***	14.75 ***	0.23	2.71	-	5.42 *	6.19 ***
(6) Debt-Service Ratio	5.28 *	13.52 ***	0.81	6.45 **	2.91	-	5.30 *
(7) log(Futures Volatility)	1.49	3.57	3.89	1.72	5.22 *	1.99 -	

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

Table 7.9: Granger-causality matrix for Australia pre-crisis

Causing Variable	Dependent Variable (1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Policy Rate	-	0.35	0.95	1.63	1.31	4.95 *	6.25 **
(2) U.S. Policy Rate	5.49 *	-	2.06	3.66	1.62	1.80	3.18
(3) Inflation	2.62	2.05	-	3.38	4.16	1.37	5.13 *
(4) Net Bank Inflows	9.80 ***	0.34	0.71	-	1.85	0.17	8.01 **
(5) Credit	19.14 ***	3.58	3.44	1.78	-	2.81	7.65 **
(6) Debt-Service Ratio	9.41 ***	0.54	4.33	1.65	2.08	-	5.59 *
(7) log(Futures Volatility)	0.14	6.29	1.15	1.19	2.97	1.04	-

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

Table 7.10: Granger-causality matrix for Australia post-crisis

Causing Variable	Dependent Variable (1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Yield Curve	-	9.11 **	1.72	1.88	0.98	10.47 ***	1.06
(2) U.S. Yield Curve	1.88	-	8.67 **	5.05 *	1.18	3.06	3.73
(3) Inflation	0.45	6.47 **	-	2.89	5.51 *	9.16 **	0.23
(4) Net Bank Inflows	0.86	4.52 *	0.60	-	0.59	1.76	11.38 ***
(5) Credit	0.39	10.07 ***	9.61 ***	12.78 ***	-	3.32	12.14 ***
(6) Debt-Service Ratio	2.07	10.85 ***	0.10	2.31	4.02	-	2.65
(7) log(Futures Volatility)	1.71	0.88	2.81	3.31	1.73	4.98 *	-

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

Table 7.11: Granger-causality matrix for Poland pre-crisis

	Dependent Variable				
Causing Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
(1) Policy Rate	-	4.74 *	1.65	3.64	0.43
(2) ECB Policy Rate	1.84	-	0.54	5.38 *	11.41
(3) Inflation	19.47 ***	0.47	-	0.53	0.18
(4) Credit	10.08 ***	16.81 ***	2.17	-	7.30 *
(5) Debt-Service Ratio	4.38	16.93	1.11	3.70	-

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

Table 7.12: Granger-causality matrix for Poland post-crisis

	Dependent Variable				
Causing Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
(1) Yield Curve	-	4.29	1.34	3.23	14.23 ***
(2) Euro Yield Curve	5.64 *	-	1.59	5.07 *	5.84 *
(3) Inflation	2.03	15.67 ***	-	4.39	1.68
(4) Credit	6.26 **	46.98 ***	3.28	-	2.10
(5) Debt-Service Ratio	4.80 *	11.06 ***	3.62	2.42	-

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

Table 7.13: Granger-causality matrix for Hungary pre-crisis

	Dependent Variable				
Causing Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
(1) Policy Rate	-	2.45	6.84 **	2.11	2.17
(2) ECB Policy Rate	0.64	-	4.45 *	0.07	0.21
(3) Inflation	0.09	0.94	-	0.75	3.63
(4) Credit	4.40	5.70 *	2.52	-	3.56
(5) Debt-Service Ratio	14.34 ***	3.38	2.96	0.14	-

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

Table 7.14: Granger-causality matrix for Hungary post-crisis

	Dependent Variable				
Causing Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
(1) Yield Curve	-	38.90	0.48	4.49	15.76 ***
(2) Euro Yield Curve	0.70	-	2.01	4.84 *	13.73 ***
(3) Inflation	1.99	15.34 ***	-	5.62 *	4.42
(4) Credit	7.79 **	42.26 ***	0.89	-	2.44
(5) Debt-Service Ratio	4.79 *	42.06 ***	0.52	0.67	-

$\alpha \leq 0.1$ is *, $\alpha \leq 0.05$ is **, $\alpha \leq 0.01$ is ***.

Appendix B

In this appendix we discuss the issues with stationarity-tests on deterministic processes and trend-stationary processes. A simulation of process is performed and the code for this procedure within the statistical software R is given. Here the URCA-package by Bernhard Pfaff, Eric Zivot and Matthieu Stigler is used to implemented the Dickey-Fuller test. First we define a stationary stochastic process $x \sim N(0, 1)$ over a period of 100 periods, defined as $t = 100$. The next step is the creation of a deterministic-process similar to a policy rate process.

```
set.seed(97)
t = c(1:100)
x = rnorm(100, 0, 1)
y = c(rep(2,5), rep(3,5), rep(3.5,10), rep(3,15), rep(2,10), rep(1.5,10),
    rep(1,5), rep(0.5,10), rep(1,20), rep(2.5,10))
```

Using these series we can make a time-series plot, so as to visually observe the stationarity of both series. The following code generates Figure 7.10.

```
plot(c(0,100), c(-5,5), type = "n", xlab = "Time", ylab = " ")
abline(h=0, lty = 2)
lines(x, col = "black")
lines(y, col = "red")
legend("topleft", legend = c("x", "y"), col = c("black", "red"), lty = 1)
```

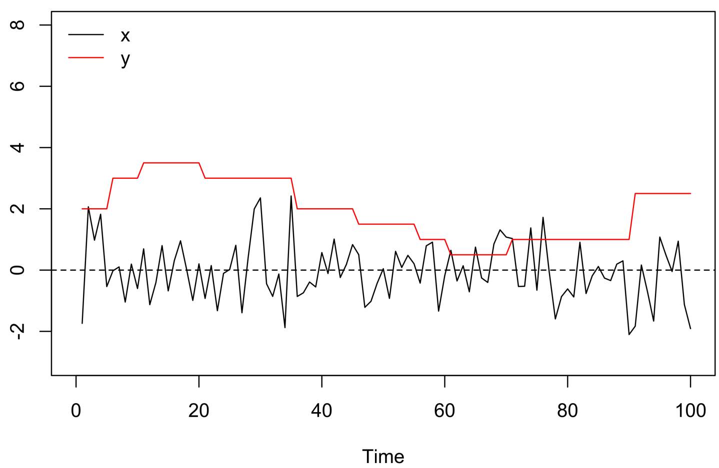

Figure 7.10: x and y series

According to Dickey and Fuller (1979), one way of showing whether a series is stationary or not is to check whether $\rho = 0$ in the following regression equation:

$$\Delta x_t = \gamma x_{t-1} + \delta_1 \Delta x_{t-1} + \varepsilon_t$$

If $\rho = 0$, the series does not contain a unit root and is thus not stationary. Hence, using this regression will provide information about the stationarity of both x and y. Let's first prove the stationarity of x.

```
summary(ur.df(x))
summary(ur.df(y))
```

Table 7.15: Dickey-Fuller test on x

	Estimate	Std. Error	t-value	Pr(>|t|)	
x_{t-1}	-1.02029	0.14602	-6.987	3.69e-10	***
Δx_{t-1}	0.04295	0.10063	0.427	0.67	

This linear regression show that the coefficient of a lagged value of x is significantly different from zero and as such x is determined to be stationary. Moreover, the Dikcey-Fuller test-statistic is -6.9873, with a critical value in the Dickey-Fuller distribution of -2.6 at $\alpha = 0.01$. This will be the benchmark result for stationary-processes, according to Dickey and Fuller (1979). However, one can find that non-stochastic processes such as y will always turn out statistically stationary within these kinds of unit root-tests. Moreover, it is stationary without any drift as the mean value in $N(0, 1)$ equals zero.

Table 7.16: Dickey-Fuller test on y

	Estimate	Std. Error	t-value	Pr(>|t|)
y_{t-1}	-0.003788	0.011380	-0.333	0.74
Δy_{t-1}	0.002635	0.102310	0.026	0.98

Performing the same Dickey-Fuller test on the series y however gives us very different results. That is despite the fact that the series appears stationary in Figure 7.10. However, the Dickey-Fuller test indicates that $\gamma = 0$ and subsequently y contains a unit root according to the Dickey-Fuller test. This is confirmed by the test-statistic being -0.3329, where the critical value is -1.61 at $\alpha = 0.1$. However, one should be careful when interpreting this result in the case of a deterministic variable such as policy rate.

Similarly, a trend-stationary variable cannot be stationary in this form of the Dickey-Fuller test. However, in such a case accounting for the trend itself can provide evidence for stationarity and a lack of unit-roots. This can be seen by creating a trending variable out of x, using the following code.

```
z = x + 0.25*t
```

From this code we again plot both x and z, to show that we indeed are dealing with a stationary and trend-stationary process.

```
plot(c(0,100), c(-5,25), type = "n", xlab = "Time", ylab = " ")
abline(h=0, lty = 2)
lines(x, col = "black")
lines(z, col = "red")
legend("topleft", legend = c("x", "z"), col = c("black", "red"), lty = 1)
```

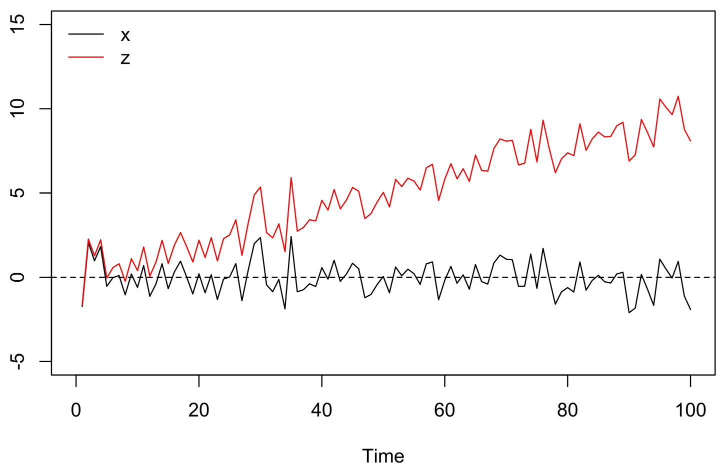

Figure 7.11: x and z series

As we saw before, the Dickey-Fuller test confirms the stationarity of x. However, the very same test will show that z is non-stationary, confirming it contains a unit root. Such a conclusion would be in line with Figure 7.11, when not considering the possibility of trend-stationarity. The test-statistic is 0.0776 compared to the critical value of -1.61 at $\alpha = 0.1$.

```
summary(ur.df(z))
```

Table 7.17: Dickey-Fuller test on z

	Estimate	Std. Error	t-value	Pr(>|t|)	
z_{t-1}	0.001591	0.020503	0.078	0.938	
Δz_{t-1}	-0.457016	0.087249	-5.238	9.58e-07	***

Indeed non-stationarity of z is confirmed and subsequently, as we are aware of its trend-stationary nature, we can adjust the Dickey-Fuller test to account for the trend. That is we add a trend term and a drift term to the linear regression used.

$$\Delta z_t = \alpha_0 + \rho z_{t-1} + \delta_1 \Delta z_{t-1} + \beta_1 t + \varepsilon_t$$

```
summary(ur.df(z, "trend"))
```

Table 7.18: Dickey-Fuller test on z

	Estimate	Std. Error	t-value	Pr(>|t|)	
z_{t-1}	-1.04836	0.14772	-7.097	2.38e-10	***
Δz_{t-1}	0.05392	0.10105	0.534	0.595	
t	0.10075	0.01468	6.863	7.14e-10	***
constant	0.24193	0.19549	1.238	0.219	

Here we can therefore conclude that, as long as a trend is considered, stationarity can in fact be concluded. The test-statistic is -7.0972 compared to the critical-value -4.04 at $\alpha = 0.01$. This holds for a number of variables in the data set used in this paper. Moreover, if a trending series such as z can be stationary, deterministic processes such as y are potentially stationary in reality as well. Clearly, z possesses less obvious stationary features than y, however it can still be proven to be a stationary process. This raises the question whether y can really not be stationary or whether this is simply a case for which the standard tests for unit-roots cannot provide conventional evidence for stationarity. To this extent we can argue that the variables in the data set used for this paper are in fact stationary.

Futhermore, we can see potential trend-stationarity with structural breaks within the data. Here the structural breaks often occur around the Great Financial Crisis. Again, the conventional test by Dickey and Fuller (1979) fails in this instance. Let us define a trend-stationary process q whith a structural break at $t = 75$.

```
t[76:100] = c(25:1)
q = x + 0.1*t
```

Which yields the following process, where q contains a structural break at $t = 75$.

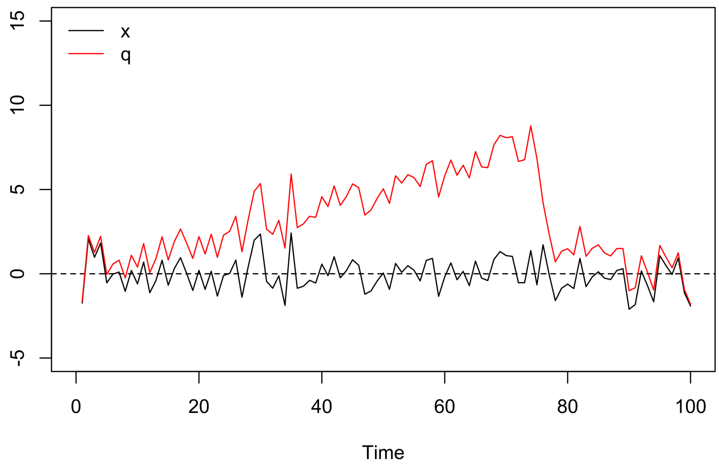

Figure 7.12: x and q series

We already know from the previously defined process z that we do indeed find trend-stationarity if there has not been a structural break. However, this break causes the Dickey-Fuller test to fail. As we know where the break occurs exactly, we can equally show that the two parts of q, namely that of $t \leq 75$ and $t > 75$, both are stationary although the process as a whole is not, according to the Dickey-Fuller test.

```
summary(ur.df(q, "trend"))
summary(ur.df(q[1:75], "trend"))
summary(ur.df(q[76:100], "trend"))
```

Table 7.19: Dickey-Fuller test on q

	Estimate	Std. Error	t-value	Pr(>|t|)	
z_{t-1}	-0.069127	0.053426	-1.294	0.19888	
Δz_{t-1}	-0.321066	0.095431	-3.364	0.00111	***
t	-0.004886	0.004468	-1.094	0.27696	
constant	0.430088	0.2911478	1.477	0.14296	

Here the test-statistic equals -1.2939 while the critical value at $\alpha = 00.1$ is -3.15. Hence the process as a whole is non-stationary according to this test. However, when performing the test on the two individual parts of q we obtain different results.

Table 7.20: Dickey-Fuller test on q from 1 till 75

	Estimate	Std. Error	t-value	Pr(>|t|)	
z_{t-1}	-1.07126	0.17040	-6.287	2.54e-08	***
Δz_{t-1}	0.03568	0.11552	0.309	0.758	
t	0.10974	0.01799	6.099	5.47e-08	***
constant	0.04727	0.22005	0.215	0.831	

Table 7.21: Dickey-Fuller test on q from 76 till 100

	Estimate	Std. Error	t-value	Pr(>|t|)	
z_{t-1}	-1.30340	0.30545	-4.267	0.000416	***
Δz_{t-1}	0.34897	0.20599	1.694	0.106572	
t	-0.12107	0.03959	-3.058	0.006472	***
constant	2.66469	0.78360	3.401	0.003000	***

For the first section the test-statistic is -6.2866 and for the second one it is -4.2672, which is compared to the critical values at $\alpha = 0.01$ of -4.04 and -4.38 respectively. Hence, both the individual sections are stationary. This raises the idea of stationarity with structural breaks. This allows us to imply stationarity within certain variables when accounting for these structural breaks by separating the periods before and after the Great Financial Crisis.

Appendix C

Table 7.22: Dickey-Fuller Table

N	$\alpha = 0.01$	$\alpha = 0.05$	$\alpha = 0.1$
$N < 25$	-2.66	-1.95	-1.60
$25 \leq N < 50$	-2.62	-1.95	-1.61
$50 \leq N < 100$	-2.60	-1.95	-1.61
$100 \leq N < 250$	-2.58	-1.95	-1.62
$250 \leq N < 500$	-2.58	-1.95	-1.62
$N \geq 500$	-2.58	-1.95	-1.62

Critical values curtosy of the URCA package by Bernhard Pfaff, Eric Zivot and Matthieu Stigler.

Table 7.23: Dickey-Fuller Table, with drift

N	$\alpha = 0.01$	$\alpha = 0.05$	$\alpha = 0.1$
$N < 25$	-3.75	-3.00	-2.63
$25 \leq N < 50$	-3.58	-2.93	-2.60
$50 \leq N < 100$	-3.51	-2.89	-2.58
$100 \leq N < 250$	-3.46	-2.88	-2.57
$250 \leq N < 500$	-3.44	-2.87	-2.57
$N \geq 500$	-3.43	-2.86	-2.57

Critical values curtosy of the URCA package by Bernhard Pfaff, Eric Zivot and Matthieu Stigler.

Table 7.24: Dickey-Fuller Table, with drift and trend

N	$\alpha = 0.01$	$\alpha = 0.05$	$\alpha = 0.1$
$N < 25$	-4.38	-3.60	-3.24
$25 \leq N < 50$	-4.15	-3.50	-3.18
$50 \leq N < 100$	-4.04	-3.45	-3.15
$100 \leq N < 250$	-3.99	-3.43	-3.13
$250 \leq N < 500$	-3.98	-3.42	-3.13
$N \geq 500$	-3.96	-3.41	-3.12

Critical values curtosy of the URCA package by Bernhard Pfaff, Eric Zivot and Matthieu Stigler.

References

Abadie, A. (2020). Statistical Nonsignificance in Empirical Economics. *American Economic Review: Insights*, 2(2):193–208.

Aizenman, J. (2019). A modern reincarnation of Mundell-Fleming's trilemma. *Economic Modelling*, 81:444–454.

Amisano, G. and Giannini, C. (2012). *Topics in Structural VAR Econometrics*. Springer Science & Business Media.

Baumeister, C. and Benati, L. (2010). Unconventional Monetary Policy and the Great Recession - Estimating the Impact of a Compression in the Yield Spread at the Zero Lower Bound. SSRN Scholarly Paper ID 1691633, Social Science Research Network, Rochester, NY.

Baxa, J., Horváth, R., and Vašíček, B. (2013). Time-varying monetary-policy rules and financial stress: Does financial instability matter for monetary policy? *Journal of Financial Stability*, 9(1):117–138.

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

Borio, C. (2014). The financial cycle and macroeconomics: What have we learnt? *Journal of Banking & Finance*, 45:182–198.

Borio, C., Drehmann, M., and Xia, D. (2018). The financial cycle and recession risk. *BIS Quarterly Review*, (December).

Bredin, D. and Fountas, S. (1998). Testing for monetary policy convergence in European countries. *Journal of Economic Studies*, 25(5):353–369.

Briere, M. and Ielpo, F. (2007). Yield Curve Reaction to Macroeconomic News in Europe: Disentangling the US Influence. SSRN Scholarly Paper ID 1054861, Social Science Research Network, Rochester, NY.

Cerutti, E., Claessens, S., and Rose, A. K. (2019). How Important is the Global Financial Cycle? Evidence from Capital Flows. *IMF Economic Review*, 67(1):24–60.

Chauvet, M. and Potter, S. (2005). Forecasting recessions using the yield curve. *Journal of Forecasting*, 24(2):77–103.

Chevallier, J., Nguyen, D. K., Siverskog, J., and Uddin, G. S. (2018). Market integration and financial linkages among stock markets in Pacific Basin countries. *Journal of Empirical Finance*, 46:77–92.

Christensen, J. H. E. and Rudebusch, G. D. (2012). The Response of Interest Rates to US and UK Quantitative Easing. *The Economic Journal*, 122(564):F385–F414.

De Haan, J., Pilat, D.-J., and Zelhorst, D. (1991). On the relationship between Dutch and German interest rates. *De Economist*, 139(4):550–565.

De Nicolò, G. and Juvenal, L. (2014). Financial integration, globalization, and real activity. *Journal of Financial Stability*, 10:65–75.

Dell'Ariccia, G., Rabanal, P., and Sandri, D. (2018). Unconventional Monetary Policies in the Euro Area, Japan, and the United Kingdom. *Journal of Economic Perspectives*, 32(4):147–172.

Delsen, L. and de Jong, E. (2012). *The German and Dutch Economies: Who Follows Whom?* Springer Science & Business Media.

Dickey, D. A. and Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, 74(366a):427–431.

Edison, H. J., Levine, R., Ricci, L., and Sløk, T. (2002). International financial integration and economic growth. *Journal of International Money and Finance*, 21(6):749–776.

Fawley, B. W. and Neely, C. (2013). Four stories of quantitative easing. *Review*, (Jan):51–88.

Fleming, J. M. (1962). Domestic financial policies under fixed and floating exchange rates. *Staff Papers (International Monetary Fund)*, 9(3):369–380.

Forbes, K. J. and Chinn, M. D. (2004). A Decomposition of Global Linkages in Financial Markets Over Time. *The Review of Economics and Statistics*, 86(3):705–722.

Galati, G. and Moessner, R. (2013). Macroprudential Policy – a Literature Review. *Journal of Economic Surveys*, 27(5):846–878.

Granger, C. W. J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica*, 37(3):424–438.

Granger, C. W. J. (1980). Testing for causality: A personal viewpoint. *Journal of Economic*

Dynamics and Control, 2:329–352.

Grauwe, P. D. and Schnabl, G. (2005). Nominal Versus Real Convergence – EMU Entry Scenarios for the New Member States. *Kyklos*, 58(4):537–555.

Greene, W. H. (1999). *Econometric Analysis*. Prentice Hall, Upper Saddle River, N.J, 4th edition edition.

Habib, M. M. and Venditti, F. (2018). The global financial cycle: Implications for the global economy and the euro area. *Economic Bulletin Articles*, 6.

Hothorn, T., Zeileis, A., Farebrother, R. W., Cummins, C., Millo, G., and Mitchell, D. (2019). Lmtest: Testing Linear Regression Models.

Inklaar, R., Jong-A-Pin, R., and de Haan, J. (2008). Trade and business cycle synchronization in OECD countries—A re-examination. *European Economic Review*, 52(4):646–666.

Ivashina, V. and Scharfstein, D. (2010). Bank lending during the financial crisis of 2008. *Journal of Financial Economics*, 97(3):319–338.

Johannesen, N. and Zucman, G. (2014). The End of Bank Secrecy? An Evaluation of the G20 Tax Haven Crackdown. *American Economic Journal: Economic Policy*, 6(1):65–91.

Kim, S. (2001a). Effects of monetary policy shocks on the trade balance in small open European countries. *Economics Letters*, 71(2):197–203.

Kim, S. (2001b). International transmission of U.S. monetary policy shocks: Evidence from VAR's. *Journal of Monetary Economics*, 48(2):339–372.

Krippner, L. (2014). Measuring the Stance of Monetary Policy in Conventional and Unconventional Environments. SSRN Scholarly Paper ID 2381654, Social Science Research Network, Rochester, NY.

Kuersteiner, G. M. (2010). Granger-Sims causality. In Durlauf, S. N. and Blume, L. E., editors, *Macroeconometrics and Time Series Analysis*, The New Palgrave Economics Collection, pages 119–134. Palgrave Macmillan UK, London.

Lütkepohl, H. (2005). *New Introduction to Multiple Time Series Analysis*. Springer Science & Business Media.

Lütkepohl, H. (2017). Estimation of structural vector autoregressive models. *Communications* *for Statistical Applications and Methods*, 24(5):421–441.

Milesi-Ferretti, G.-M. and Tille, C. (2011). The great retrenchment: International capital flows during the global financial crisis. *Economic Policy*, 26(66):289–346.

Miranda-Agrippino, S. and Rey, H. (2015a). US Monetary Policy and the Global Financial Cycle. Working Paper 21722, National Bureau of Economic Research.

Miranda-Agrippino, S. and Rey, H. (2015b). World Asset Markets and the Global Financial Cycle. SSRN Scholarly Paper ID 2691541, Social Science Research Network, Rochester, NY.

Mishkin, F. S. (2010). Monetary policy flexibility, risk management, and financial disruptions. *Journal of Asian Economics*, 21(3):242–246.

Mukherjee, T. K. and Naka, A. (1995). Dynamic Relations Between Macroeconomic Variables and the Japanese Stock Market: An Application of a Vector Error Correction Model. *Journal of Financial Research*, 18(2):223–237.

Mundell, R. A. (1963). Capital Mobility and Stabilization Policy Under Fixed and Flexible Exchange Rates. *Canadian Journal of Economics and Political Science*, 29(4):475–485.

Nuño, G. and Thomas, C. (2012). Bank Leverage Cycles. SSRN Scholarly Paper ID 2084115, Social Science Research Network, Rochester, NY.

Obstfeld, M. (2000). Globalization and Macroeconomics. *NBER Reporter*, page 18.

Obstfeld, M., Shambaugh, J. C., and Taylor, A. M. (2005). The Trilemma in History: Tradeoffs Among Exchange Rates, Monetary Policies, and Capital Mobility. *The Review of Economics and Statistics*, 87(3):423–438.

Ouliaris, S., Pagan, A., and Restrepo, J. (2016). *Quantitative Macroeconomic Modeling with Structural Vector Autoregressions { An EViews Implementation.* IMF.

Papana, A., Kyrtsou, K., Kugiumtzis, D., and Diks, C. G. H. (2014). Identifying causal relationships in case of non-stationary time series. Technical Report 14-09, Universiteit van Amsterdam, Center for Nonlinear Dynamics in Economics and Finance.

Potjagailo, G. (2017). Spillover effects from Euro area monetary policy across Europe: A factor-augmented VAR approach. *Journal of International Money and Finance*, 72:127–147.

Rey, H. (2015). Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence. Working Paper 21162, National Bureau of Economic Research.

Rey, H. (2016). International Channels of Transmission of Monetary Policy and the Mundellian Trilemma. *IMF Economic Review*, 64(1):6–35.

Schlegel, G. (1985). Vector Autoregressive Forecasts of Recession and Recovery: Is Less More? *Economic Review*.

Sims, C. A. (1972). Money, Income, and Causality. *The American Economic Review*, 62(4):540–552.

Sims, C. A. (1980). Macroeconomics and Reality. *Econometrica*, 48(1):1–48.

Smets, F. (2014). Financial Stability and Monetary Policy: How Closely Interlinked? *International Journal of Central Banking*, 10(2):263–300.

Spiegel, M. M. (2006). Did quantitative easing by the Bank of Japan "work"? *FRBSF Economic Letter*.

Taylor, J. B. (2013). International monetary coordination and the great deviation. *Journal of Policy Modeling*, 35(3):463–472.

von Hagen, J. and Fratianni, M. (1990). German dominance in the EMS: Evidence from interest rates. *Journal of International Money and Finance*, 9(4):358–375.

Whaley, R. E. (2009). Understanding the VIX. *The Journal of Portfolio Management*, 35(3):98–105.

Wright, J. H. (2006). The Yield Curve and Predicting Recessions. SSRN Scholarly Paper ID 899538, Social Science Research Network, Rochester, NY.

Wu, J. C. and Xia, F. D. (2016). Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound. *Journal of Money, Credit and Banking*, 48(2-3):253–291.

Data Sources

Bank of International Settlements (2020), Central Bank Policy Rates.
doi: https://stats.bis.org/#ppq=CBP_M_24M

Bank of International Settlements (2020), Consumer Prices Year-to-Year changes.
doi: https://stats.bis.org/#ppq=CPI_YOYCHG;pv=1~3~1,0,0~both

Bank of International Settlements (2020), International Banking.
doi: https://stats.bis.org/#ppq=LBS_DE_BANKS_IN_ALLRC_XB_C_L;pv=2,9~1,12~

Bank of International Settlements (2020), Total Credit.
doi: https://stats.bis.org/#ppq=CRE_BNK_TO_PRIV_NF;pv=1~7~1,0,0~both

Bank of International Settlements (2020), Debt-Service Ratio.
doi: https://stats.bis.org/#ppq=DSR_PRIV_NF_SEC_BRKDWN_17CTY;pv=1,2~3~1,0,0~both

Bloomberg Terminal (2020), 1st Generic Futures.
doi: N/A

OECD (2020), Long-term interest rates.
doi: 10.1787/662d712c-en

OECD (2020), Short-term interest rates.
doi: 10.1787/2cc37d77-en

Packages

urca (1.3-0) by Bernhard Pfaff, Eric Zivot and Matthieu Stigler.
Unit Root and Cointegration Tests for Time Series Data.
`https://cran.r-project.org/web/packages/urca/urca.pdf`

vars (1.5-3) by Bernhard Pfaff and Matthieu Stigler.
VAR Modelling.
`https://cran.r-project.org/web/packages/vars/vars.pdf`

plm (7.0.2) by Yves Croissant, Giovanni Millo, Kevin Tappe, Ott Toomet, Christian Kleiber, Achim Zeileis, Arne Henningsen, Liviu Andronic and Nina Schoenfelder.
A set of estimators and tests for panel data econometrics
`https://cran.r-project.org/web/packages/plm/plm.pdf`

lmtest (0.9-37) by Torsten Hothorn, Achim Zeileis, Richard W. Farebrother, Clint Cummins, Giovanni Millo and David Mitchell.
A collection of tests, data sets, and examples for diagnostic checking in linear regression models. Furthermore, some generic tools for inference in parametric models are provided.
`https://cran.r-project.org/web/packages/lmtest/lmtest.pdf`

Abbreviations

BoE	Bank of England.
BoJ	Bank of Japan.
CBOE	Chicago Board Options Exchange.
ECB	European Central Bank.
ECT	Error Correction Term.
EMU	Economic and Monetary Union.
ERM	European Exchange Rate Mechanism.
ESRB	European Systemic Risk Board.
Fed	Federal Reserve.
IRFs	Impulse Response Functions.
OECD	Organisation for Economic Co-operation and Development.
VAR	Vector Autoregression.
VECM	Vector Error Correction Model.
VIX	Volatility Index.

Glossary

1st Generic Futures	Futures contracts which are not month-specific but instead are issued in each month of the year. These are standardized contracts which are often traded within the global financial markets..
Capital Mobility	The extent to which capital is able to move across international borders.
Center Economy	Economies which are central to the global economy as a whole.
European Currency Unit	A basket of European community currencies, used as a unit of account prior to the introduction of the Euro o January 1st 1999.
European Exchange Rate Mechanism	A European Economic Community system aimed at reducing exchange rate volatility and thus create monetary stability prior to the intial introduction of the Euro.
European Monetary System	An institution created throught the European Economic Community. It's aimed at co-operation on monetary policy issues..
Fixed Exchange Rate	An exchange rate regime in which the central bank of the nation in question has an obligation to intervene in the foreign exchange market to maintain a set value between the domestic currency and some foreign currency, possibly within a bandwidth.
Forward Guidance	An unconventional policy tool used to guide market expectations about future monetary operations.

Global Financial Cycle	Movements in capital flows common across countries. The term was operationalized by Rey (2015, p. 2), who suggested these cycles are "characterised by large common movements in asset prices, gross flows and leverage.".
Impossible Trinity	The situation outlined by Mundell (1963) and Fleming (1962),as thaught in most macroeconomic textbooks and visualized in Figure 1.1.
Interbank Rates	The interest rates on short-term loans issued between banks. Often these rates are equal to the set policy rates.
Macroprudential Policy	Financial regulatory policy aimed at reducing systemic risks within financial markets, using a macro-oriented framework.
Monetary Autonomy	*See Monetary Sovereignty.*
Monetary Policy	Regulation of money markets through central bank policies.
Monetary Sovereignty	The extent to which a central bank is able to set its own policies without having to take foreign policies into account.
Mundell-Fleming Model	*See the Mundell-Fleming trilemma.*
Mundell-Fleming Trilemma	*See the impossible trinity.*
Perihpery Economy	Economies which are subjected to center economies. These economies are generally of less importance to the global economy.
Policy Rate	Interest-rate targetted by the central bank.
Quantitative Easing	An unconventional policy tool used involving the purchasing of government bonds and other financial assets to provide greater liquidity to the economy.

Unconventional Monetary Policy	Policy options outside of the conventional policy-toolset used by central banks. Generally these options are aimed at lowering the long-term interest rates, instead of the short-term interest rates.
Vector Autoregressions	A method which is often employed within macroeconomics to identify interdependencies between time series.
Yield Curve	Curve of yields to maturity of debt obligations with different maturities, issued by the same debt issuer, often a sovereign government.
Zero Lower Bound	Point at which short-term interest rates are so low that a liquidity trap occurs. This makes conventional interest rate setting through monetary policy virtually ineffective, as lower short-term interest rates will not induce the desired increase in overall spending.

Bivariate Granger-matrix function for R

The following code produces a matrix of bivariate Granger-causalities between all variables within a dataframe. Granger-causality is tested using a Wald-test. Any lag-length can be specified through "p". The function makes use of the "waldtest()"-function, courtesy of Hothorn et al. (2019). The function can produce both Chi-square as well as F-statistics as a result.

```
granger.matrix = function(data, p, test){
  options(warn = -1)
  require("dplyr")
  vars = dim(data)[2]
  var.names = colnames(data)
  matrix = c()
  prob.matrix = c()
  for(i in 1:vars){
    col = data[,i]
    for(j in 1:vars){
      if(j == i){
        matrix = append(matrix, NA, after = length(matrix))
        prob.matrix = append(prob.matrix, NA, after = length(prob.matrix))
      } else {
        row = data[,j]
        reg = c()
        for(n in 1:p){
          temp.col = paste("lag(col,", n, ")", sep = "")
          reg = append(reg, temp.col)}
        reform.reduced = reformulate(reg, "col")
        model.reduced = lm(reform.reduced)
        for(m in 1:p){
          temp.row = paste("lag(row,", m, ")", sep = "")
          reg = append(reg, temp.row)}
        reform.full = reformulate(reg, "col")
        model.full = lm(reform.full)
        x = lmtest::waldtest(model.full, model.reduced, test = test)
        stat = x[2,3]
        prob = x[2,4]
        matrix = append(matrix, stat, after = length(matrix))
        prob.matrix = append(prob.matrix, prob, after = length(prob.matrix))}}}
  matrix = as.numeric(format(round(matrix, 3), nsmall = 3))
  table = matrix(matrix, nrow = vars, ncol = vars, byrow = FALSE)
  rownames(table) = var.names
  prob.matrix = as.numeric(format(round(prob.matrix, 3), nsmall = 3))
  prob.table = matrix(prob.matrix, nrow = vars, ncol = vars, byrow = FALSE)
  rownames(prob.table) = var.names
  output = list(table, prob.table)
  if(test == "Chisq"){names(output) = c("Chi-square", "Prob.")}
  if(test == "F"){names(output) = c("F", "Prob.")}
output}
```