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BREAKING PAR: SHORT-TERM DETERMINANTS OF YEN-DOLLAR SWAP DEVIATIONS

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Abstract

This paper analyses deviations in yen-dollar cross-currency swap markets between 2007 and 2017. Using weekly-frequency data on money market-related and capital market-related financial variables, we analyse how the cross-currency basis is influenced by differences in returns and different types of risk. We study these dynamics using state-dependent impulse responses obtained from local projections. Our results show that differences in bond yields, particularly short-term and medium-term government bond yields, are a quantitatively relevant driver of the cross-currency basis in the post-crisis period. We argue that spreads opening up in these markets provide an incentive for cross-border financial flows and corresponding hedging demand, which in turn drive the basis in the post-crisis period. We further find some evidence for the relevance of central bank balance sheet policies, relative corporate bond market performance, and general market volatility. Overall, the impulse responses for the immediate crisis period are considerably more indeterminate and quantitatively less relevant than the responses in the post-crisis state.

Keywords: foreign currency swaps, currency basis, yen-dollar, covered interest parity, international finance

JEL Classification: F31, G15, G2

Contents

1. INTRODUCTION

The deviations in foreign exchange (FX) swap markets observed since the global financial crisis have been one of the most significant developments in international finance in recent years. Prior to the global financial crisis, swap markets only diverged during times of severe financial stress. However, in recent years swap deviations have remained even as immediate crises have passed. This raises questions about the underlying driving forces.

FX swaps are important financial instruments that are used by investors around the world to hedge foreign exchange risk. At 2.46 trillion USD average daily turnover,[1] swaps are among the largest and most liquid foreign exchange instruments, ahead of spot transactions and outright forwards (BIS, 2016). Traditionally, swap prices have closely followed the interest rate differential between money market rates on the currencies involved, in essence mirroring the covered interest parity condition that is found in most textbooks on international finance. Since 2007, however, swap prices have systematically diverged in such a way as to make US dollar funding through swaps more expensive, giving rise to a "cross-currency basis". This development has been most pronounced within the Japanese yen-US dollar swap market.

In this paper, we analyse the driving factors behind these deviations. By using weekly-frequency data on money market-related and capital market-related financial variables covering the period from January 2007 to June 2017, we analyse how the cross-currency basis is influenced by differences in returns and different types of risk. We study these dynamics using impulse responses obtained from local projections (Jordà, 2005). This is a time series method that is more robust to model misspecification than traditional approaches and which allows us to incorporate a range of different factors in a flexible way. To account for changes in financial regulation and non-linearities, we specify state-dependent impulse responses conditional on changes in regulatory capital and liquidity standards.

We identify differences in short-term and medium-term interest rates (government bond yields) as quantitatively relevant drivers of the cross-currency basis in the post-crisis period. On this basis, we argue that spreads opening up in these markets provide an incentive for cross-border financial flows and corresponding hedging demand, which in turn drive the basis in the post-crisis period. We further find some evidence for the relevance of central bank balance sheet policies, relative corporate bond market performance, and general market volatility. Overall, the impulse responses for the immediate crisis period are considerably more indeterminate and quantitatively less relevant than the responses in the post-crisis state. This supports the argument that the dynamics in swap markets have changed together with changes in regulatory standards (Sushko et al., 2016).

Given the size and importance of swap markets, we argue that swap market deviations have far-reaching consequences. We particularly draw attention to the interaction between monetary policy, swap prices and financial stability, which is likely to pose a challenge for policymakers and regulatory authorities going forward.

[1] This figure is for for FX swaps and cross-currency swaps combined.

The paper is structured as follows. Following this introduction and accompanying literature review, Section 2 introduces the theoretical underpinnings of swap pricing and its relationship with the covered interest parity. Section 3 introduces the methodology and our estimation results. Section 4 discusses the results. The final section concludes this paper.

1.1. Literature review

Research on swap market deviations has grown rapidly in recent years. Empirical analyses can be divided into studies that focus on the global financial crisis and studies that examine the long-term swap market deviations after the crisis.

Examples of papers analysing the immediate crisis period include Baba et al. (2008), Baba & Packer (2009), Coffey et al. (2009), Genberg et al. (2009), Hui et al. (2011), Levich (2012), and Choi et al. (2017). In general, these authors identify differences in counterparty and credit risk, liquidity shortages, and institutional and structural characteristics of global dollar funding markets as factors driving swap market deviations.

In comparison, analyses focusing on long-term swap market deviations are somewhat more diverse. The influence of regulatory changes and limits to balance sheet capacity and arbitrage feature more prominently here. Authors such as Arai et al. (2016), Borio et al. (2016), Du et al. (2017), Iida et al. (2016), Pozsar (2016, 2017), and Sushko et al. (2016) place hedging demand at the center of their analyses, arguing that cross-border financial flows from economies with low interest rates to economies with higher interest rates depress the swap basis against low-yielding currencies due to limits to balance sheet space. Against this background, the divergence of monetary policies occupies a central position, both in terms of interest rates (see, e.g., Arai et al., 2016; Du et al., 2017; He et al., 2017; Iida et al., 2016) and balance sheet policies (see, e.g., Baran & Witzany, 2017; He et al., 2017; Pozsar, 2017). At the same time, some analyses still emphasize financial sector credit risk and market volatility (e.g. Baran & Witzany, 2017; Wong et al., 2017).

Overall, studies focusing on the immediate crisis period tend to gravitate towards factors broadly related to market instability (especially counterparty and credit risk), whereas studies taking a more long-term perspective tend to focus more on regulation and hedging demand. While theoretical work on swap market deviations is beyond the scope of this paper, important work also has been done in this area. Du et al. (2017) contain an overview of the recent contributions.

2. THEORETICAL BACKGROUND

To tie our empirical analysis to practical policy questions, this section gives a brief overview of the mechanics of FX swaps and cross-currency swaps. Both types of swaps are over-the-counter (OTC) financial instruments that allow investors to protect themselves (i.e. "hedge") against exchange rate fluctuations when funding investment denominated in a foreign currency. The pricing of swaps is closely related to the covered interest parity condition.

2.1. Foreign exchange swaps

The mechanics of FX swaps are best illustrated by example. Suppose that a Japanese investor wants to invest in the United States (e.g. buy a US bond). To do so, the investor would first need to obtain US dollars by purchasing them on foreign exchange markets using Japanese yen. At a specified future date, when the investment yields a return (e.g. when the bond matures), the Japanese investor will want to exchange the US dollars earned back into Japanese yen, which requires another transaction in foreign exchange markets. Because the future exchange rate is unknown at the time the original investment is made, investors face the risk of having their gains from the investment eroded by exchange rate changes–in this case a depreciation of the US dollar. To protect against this risk, investors can lock in a future exchange rate, known as a "forward rate", using a swap.

In theory, the forward rate is determined by today's spot exchange rate and by the interest rate differential between Japan and the United States. Formally:

$$\frac{F}{S} = \frac{1+r}{1+r^*} \tag{1}$$

where S is the spot rate in units of US dollars per foreign currency unit, F is the forward exchange rate, r is the US dollar interest rate, and r^* is the foreign interest rate.[2] This relationship is known as the *covered interest parity*, a standard no-arbitrage condition commonly found in textbooks on international finance and international macroeconomics.

The relationship between these variables is commonly quoted in swap points $F - S$. Rearranging equation 1 yields

$$F - S = S\left[\frac{1+r}{1+r^*}\right] - S \tag{2}$$

In practice, an FX swap is constructed as a contact where one party borrows a currency from a second party and simultaneously lends a currency to the second party. Because the mutual repayment obligations serve as collateral, a swap in essence allows for risk-free, collateralised borrowing and lending in foreign currencies (Baba et al., 2008; Borio et al., 2016).

A deviation from equations 1 and 2 would open up arbitrage opportunities that market participants could exploit. If a swap is priced in such a way that the left-hand side of equation 2 is (much) larger than the right-hand side, then, for example, then the US dollar exchange rate is higher (i.e. the US dollar depreciates) on the forward leg of the swap

[2]The notation here follows Borio et al. (2016)

than warranted by the covered interest parity condition. In other words, borrowing US dollars through such a swap is more expensive than raising US dollars in onshore money markets. Market participants could respond to this gap and, if arbitrage activity is sufficient in volume terms, close the gap.

2.2. Cross-currency basis swaps

Cross-currency basis swaps are a closely related type of instrument that serves the same purpose as FX swaps but which are structured slightly differently. Cross-currency basis swaps are more long-term than FX swaps, traditionally one year or more (Baba et al., 2008).

Whereas FX swaps are reversed at the forward rate, cross-currency basis swap contracts are reversed at the same exchange rate as the original spot rate. Therefore, cross-currency basis swaps make no reference to the forward rate. Instead, the counterparties who are involved regularly (typically quarterly) exchange interest rate payments plus a basis b during the term of the swap. The basis b here serves as an adjustment factor to ensure parity with FX swaps in the case where the covered interest parity fails to hold. For the simple case of one-period maturity, the pricing of cross-currency basis swaps follows

$$F - S = S\left[\frac{1+r+b}{1+r^*}\right] - S \tag{3}$$

If the covered interest parity holds, then the basis b is zero. However, during periods of financial stress, such as the "Japan Premium" episode of the late-1990s or the recent global financial crisis (Baba & Packer, 2009), the basis has diverged, at times significantly. However, the basis has failed to revert after the global financial crisis, as shown for the yen-dollar cross in Figure 1. The negative basis shown in this graph indicates that Japanese investors who raise US dollars through swaps need to pay a premium over money market rates, signalling strong demand for US dollars.

Figure 1: Japanese yen-dollar cross-currency basis

Note: Data up to sample end date (June 2017).
Source: Bloomberg, Borio et al. (2016)

2.3. Swap market deviations

For the covered interest parity condition to hold, arbitrage needs to take place. If the cross-currency basis deviates from zero in either direction, then institutions operating in international money markets can in theory offer swaps that are priced closer to equilibrium by virtue of the fact that they have access to money markets in different jurisdictions. If this arbitrage activity is large enough, then the basis should theoretically decline to zero.

For this to work, market participants must be *willing* and *able* to take either side of a trade. However, financial crises, such as the global financial crisis, raise concerns about counterparty risk and thereby reduce willingness to enter into a swap. Limits to arbitrage, such as the tighter liquidity and capital standards adopted after the crisis[3] also make balance sheet space more expensive, which reduces institutions' ability for market-making.

In the post-crisis world, differences in liquidity conditions and returns between economies now arguably manifest themselves differently than in the crisis period. In particular, the divergence of monetary policies between major economies has become a central point of focus. Whereas the US Fed began tightening monetary policy in December 2015, other major central banks, such as the Bank of Japan and the European Central Bank, went the opposite direction by lowering policy rates into negative territory and expending their asset purchase programs (see Angrick & Nemoto, 2017, for details). Consequently, monetary policies diverged internationally, with returns in the United States gradually increasing, and those in Europe and Japan declining. Relatively higher returns in the United States incentivise financial flows towards the United States, which has been argued to increase hedging demand and pressure on swap markets (Arai et al., 2016; McCauley, 2018). Several currencies, including first and foremost the Japanese yen and the euro, now show a negative cross-currency basis. This means that market participants are paying a higher interest rate on the dollar through swaps than they would be paying in US onshore money markets (or equivalently, they are receiving a lower rate on their home currency).

The structural changes taking place in the market compound this pressure on swap markets. These changes include the declining role of foreign reserve managers (Arai et al., 2016), the increasing issuance of non-dollar-denominated bonds by US corporations (Borio et al., 2016), and the US money market fund (MMF) reform in October 2016 (Pozsar & Smith, 2016),[4] all of which lower the supply of, and increase the demand for, international dollar liquidity.

The MMF reform has brought major change to global money markets. MMF traditionally acted as major suppliers of wholesale funding (investing in government securities and commercial paper and issuing shares to a broad range of investors), but they now face much stricter regulation on portfolio holdings while simultaneously being required to enhance liquidity management (Pozsar & Smith, 2016).

Deviations in swap markets are by themselves not new. However, the present swap market deviations are considerably more persistent and apparently more systematic than those witnessed in recent history.[5] Since the US dollar remains the central funding currency for the global financial system, swap market dislocations reach beyond major cur-

[3] See US Congress (2010) for details on regulatory changes adopted as part of the Dodd-Frank Wall Street Reform and Consumer Protection Act, and FSI (2017) and BCBS (2017) for details on the Basel III process.

[4] McCauley (2018), by contrast, argues that the MMF reform did not affect the cross-currency basis.

[5] Hattori (2017) argues that cross-currency basis swaps are not the only way to measure the covered interest parity and that if returns on US dollar-denominated bonds more broadly are used instead, then the covered interest parity condition continues to hold.

rency pairs and also affect emerging markets more removed from the centers of global finance (McCauley, 2018). Aside from the practical complications that swap deviations cause for monetary policymaking and supervisory authorities, the theoretical significance of these developments is difficult to understate because, in the words of Borio et al. (2016): *"Covered interest parity verges on a physical law in international finance."*

2.4. Factors specific to Japan

While swap market dislocations have affected most major currency pairs, deviations from the covered interest parity are most pronounced within the yen-dollar pair. Japanese financial institutions have operated in an environment of low and zero interest rates for a long time, which has put pressure on profitability margins. The adoption of a negative policy rate by the Bank of Japan in early 2016 has amplified this pressure, leading Japanese financial institutions to increasingly turn outward in the search for new revenue sources.

McCauley (2018) particularly notes the efforts of Japanese banks to expand within Asia in this connection, drawing attention to a negative feedback loop where investment abroad leads to rising US dollar funding demand and hedging demand, which in turn puts pressure on the yen-dollar cross-currency basis. He argues that Japanese banks continue their expansion in spite of these costs, saying that, for the time being, the strategic imperative of foreign expansion outweighs the rising costs on their liabilities.

Rising costs of cross-border transactions combined with declining profitability of financial institutions due to low and negative interest rates do carry distinct risks, however. In early 2017, for example, the Financial Services Agency of Japan (FSA) took steps to reign in duration risk that had accumulated on the balance sheets of especially regional banks due to their overexposure to foreign bond markets (Bloomberg, 2017; Reuters, 2017).

3. EMPIRICAL ANALYSIS

On the basis of the preceding analysis, we set out to examine which factors drive deviations in yen-dollar swap markets. The following section describes our estimation approach, data, and results.

3.1. Method

We analyse our research question using local projections (LP), which is a recently popularised time series method originated by Jordà (2005). LPs have seen widespread growth in macroeconomics and they have been applied to a variety of research topics, such as monetary policy (Miranda-Agrippino, 2016; Cesa-Bianchi et al., 2016; Bahaj et al., 2016; Aikman et al., 2016; Banerjee & Mio, 2015), fiscal policy (e.g., Jordà & Taylor, 2016; Ramey et al., 2017; Miyamoto et al., 2017), private debt (Klein, 2017; Jordà et al., 2013), and inequality (Inui et al., 2017).

LPs are similar to (structural) vector autoregressive ((S)VAR) models in purpose, but they differ in formal and conceptual structure. Time series analysis using (S)VAR models follows a two-step procedure: first, a multidimensional model is estimated; and second, its estimates are inverted in accordance with the Wold theorem to obtain impulse responses.

As such, a (S)VAR model represents a linear global approximation of the data-generating process (DGP). LPs, by contrast, aim to retrieve impulse responses directly by projecting regressors onto a response variable shifted forward along impulse response horizons. Since each projection is local to its impulse horizon, LPs mirror non-parametric methods in that they are more robust to model misspecification than traditional approaches.

Although a (S)VAR model in theory produces more efficient impulse response estimates, this is only the case when the model specification correctly captures the true DGP. Otherwise, even small errors are compounded with increasingly distant impulse horizons. LPs, by contrast, remain consistent even when the model is misspecified and even when a low lag order is chosen.

Another attractive property of LPs is their flexibility. LPs can be estimated as a single equation using standard econometric packages, yet allow researchers to impose a causal ordering within the model specification that mirrors a Cholesky ordering commonly found in (S)VAR models (Barnichon & Brownlees, 2016). This greatly expands the range of possible modeling choices and allows for state-dependent and other non-linear impulse responses.

Our baseline model specification is as follows:

$$\sum_{j=1}^{h} y_{t+j} = \alpha_h + t_h + \beta_h s_h + \psi(L) z_{t-1} + \varepsilon_{t+h} \tag{4}$$

where the left-hand side is the response variable y cumulated from horizon 1 to h. The right-hand side is made up of a constant α, a linear trend term t, a vector of shock variables s, and a vector of control variables z. $\psi(L)$ is a polynomial in the lag operator, where the appropriate lag order is selected using the Hannan-Quinn information criterion (HQC). Since LP models do not need to be identical across impulse horizons, we implement a method of automatically re-determining the appropriate lag order at each impulse horizon. Here, we specify a maximum lag of three because our model is heavily parametrized. Using this specification, the coefficients β on our shock terms s and their associated standard errors will produce the LP-based impulse responses.

The specification shown in equation 4 approximates the cumulated impulse responses obtained from a (S)VAR model. We use this specification because we are interested in the cumulated effect of our regressors onto our response variable, given that level responses return to zero (given data stationarity), which limits insight.

We further specify a state-dependent model:

$$\begin{aligned}\sum_{j=1}^{h} y_{t+j} &= (1 - I_t)\left[\alpha_{A,h} + t_{A,h} + \beta_{A,h} s_{A,h} + \psi(L) z_{A,t-1}\right] \\ &\quad + I_t\left[\alpha_{B,h} + t_{B,h} + \beta_{B,h} s_{B,h} + \psi(L) z_{B,t-1}\right] + \varepsilon_{t+h}\end{aligned} \tag{5}$$

where I is a dummy variable that indicates the state of the economy; that is, state A or state B. Comparing β_A and β_B will allow us to capture the impact of the specific policies represented by I. Both formally and conceptually, a state-dependent LP model is evocative of the popular difference-in-differences (DID) methodology.

Given the nature of our data and the phenomenon that we are analysing, a method that is more robust to model misspecification than traditional approaches and which allows us to capture state-dependent responses seems appropriate. LPs offer a way to integrate a large number of different factors that drive hedging demand within one framework, while also allowing us to capture the impact of financial regulation.

3.2. Estimations

We analyse deviations from the covered interest parity condition as measured by the yen-dollar cross-currency basis for a range of different maturities. In our baseline estimations, we focus on the 3-month ($xccy3m$), 1-year ($xccy1y$), and 2-year ($xccy2y$) tenors because market liquidity is highest for short tenors.

We study how the cross-currency basis is influenced by a number of money market-related and capital market-related financial variables. Our vector of shock variables s contains the spread between the respective yield curves in Japan and the US, covering the interbank overnight rate ($juibor$) and government bond yields ($jugb1y$, $jugb5y$).[6] We aim to gain insight into the importance of diverging monetary policies through the interbank overnight rate and short-term government bond yields, and to understand the importance of market expectations through longer-term government bond yields. Spreads opening up between returns in Japan and the US are likely to trigger cross-border financial flows, which we assume drive hedging demand and the basis. We also include a variable for relative corporate bond market performance ($jucorp$) to determine if a similar effect is at work here.

We further include a variable capturing the relative expansion of commercial bank reserves held at the central bank ($jucbbs$), taking inspiration from Baran & Witzany (2017). As outlined previously, a possible link between commercial bank reserves and the cross-currency basis has been described in a number of analyses, including Du et al. (2017), Sushko et al. (2016), Bräuning & Ivashina (2016), and Pozsar & Smith (2016).[7] Our vector of shock variables also includes the Chicago Board Options Exchange (CBOE) Volatility Index, VIX (vix), to capture effect of general market instability and liquidity issues. Finally, to capture credit and counterparty risk, we include the spread between credit default swaps (CDS) on large Japanese and US banks ($jucds$) as another variable. Our vector of controls z includes lags of the response and shock variables

We chose not to include some factors due to practical limitations or for theoretical reasons. The former applies to all long-term factors that are only available at lower frequency because our analysis requires weekly data. An example for the latter are longer swap tenors which lack liquidity and, therefore, provide less insight into market dynamics.

We make use of the ability of the LP framework to retrieve state-dependent impulse responses by specifying a binary state dummy to capture the influence of tightened financial regulation. By nature, financial regulation is a complex process that is much richer than what can be captured within an econometric model. The interplay of negotiations and anticipatory action by involved parties naturally prevents the identification of a discrete point

[6]We use the terminology "government bonds" here to refer to government securities in general, including bills and notes in addition to bonds.

[7]Relative corporate bond market performance, relative central bank balance sheet expansion, and relative stock market performance (explained later) are calculated by setting the values for the start date of our analysis to 100 and then subtracting values for the United States from those for Japan.

in time where regulation takes effect. Fortunately, LPs allow us to side-step this issue because the framework incorporates all pre-treatment and post-treatment information. As long long as the treatment date is *approximately* correct, LPs will capture a difference in impulse responses between the two states.

We chose 21 July 2010, the date when the Dodd-Frank Wall Street Reform and Consumer Protection Act became law (US Congress, 2010), as our cut-off point. The Dodd-Frank Act, despite focusing on the United States, is one of the earliest examples of regulatory reform adopted after the global financial crisis that that has had a global impact. It also foreshadowed many of the regulations adopted as part of the Basel III process, making it a sensible cut-off point to separate the "crisis state" (state A) from the "post-crisis state" (state B).

3.3. Robustness checks

To confirm the robustness of our results, we estimate responses for a number of alternative model specifications and also for slightly modified versions of our baseline estimations. First, we try a set of alternative specifications where we replace the interbank overnight rate spread by the spread between 3-month government bond yields ($jugb3m$), the 1-year spread by the 2-year spread ($jugb2y$), and the 5-year spread by the 10-year spread ($jugb10y$), while leaving all other variables unchanged. Second, we modify our baseline estimations by replacing our indicator for relative corporate bond market performance by an indicator for relative stock market performance ($justck$), and the VIX by the Libor-OIS spread ($lois$) as an indicator of money market stability and credit risk within the banking sector. Third, we re-estimate our baseline estimations without a trend term.

3.4. Data

Our estimations are based on weekly-frequency data obtained from Bloomberg and Borio et al. (2016). Level series are converted to year-on-year changes prior to estimation to ensure stationarity.[8] Our data starts in January 2007 and covers the period up to June 2017. Given the structural change in money markets after the passing of the MMF reform (see Section 2.3), we chose the end date for our sample by examining different cross-currency basis tenors after the MMF reform in October 2016 using a Bai & Perron (2003) test for structural change and taking the latest possible date from the set of breakpoints returned by the test.

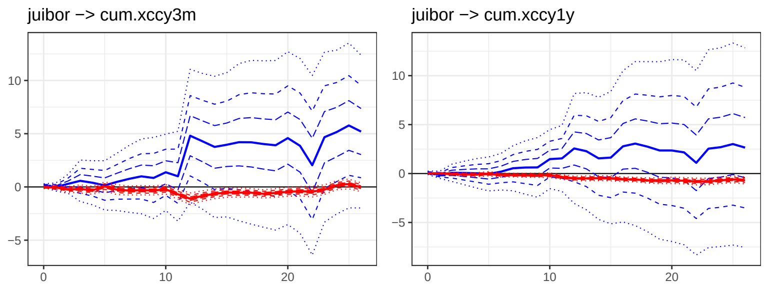
3.5. Results

Impulse responses based on the specified LP models reveal considerable heterogeneity in the relationships of the variables under study, both across tenors and between states. The full set of impulse response graphs can be found in the appendix. In our summary of the results that is given here, we particularly focus on state-dependent impulse responses.

[8] This type of transformation also removes recurring seasonal effects, which are not directly relevant to the question at hand. However, seasonal swap basis effects have been analysed in other studies. Du et al. (2017), for example, find evidence for quarter-end effects resulting from different reporting standards between the United States and Europe. Pozsar (2017) argues that quarter-end swap trades are high quality liquid asset (HQLA) swaps and are not a reliable indicator of intra-quarter activity in the foreign exchange market.

Figure 2: Impulse responses: Spread between interbank overnight rates ($juibor$)

Baseline: 3-month swap Baseline: 1-year swap

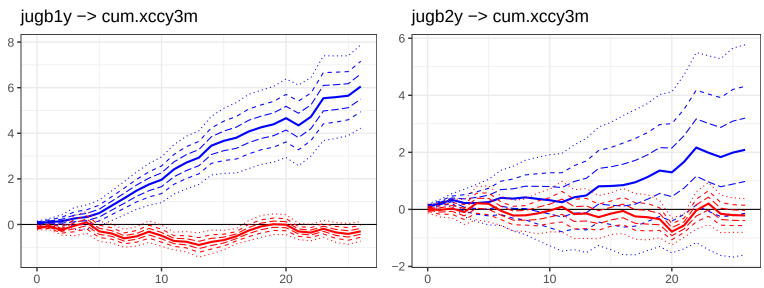


State A (red) vs. state B (blue)
90% (long dash), 68% (dashed), and 38% (dotted) confidence intervals

The spread between Japanese and US interbank overnight rates ($juibor$) generally shows a positive, quantitatively relevant albeit insignificant association with cross-currency bases[9] within the post-crisis state. By comparison, the association is indeterminate or negative and quantitatively negligible in the crisis state. The responses look similar for the spread between short-term government bond yields ($jugb3m$) used for the alternative model specifications.

Figure 3: Impulse responses: Spread between medium-term government bond yields ($jugb1y$, $jugb2y$)

Baseline: 3-month swap Alternative: 3-month swap



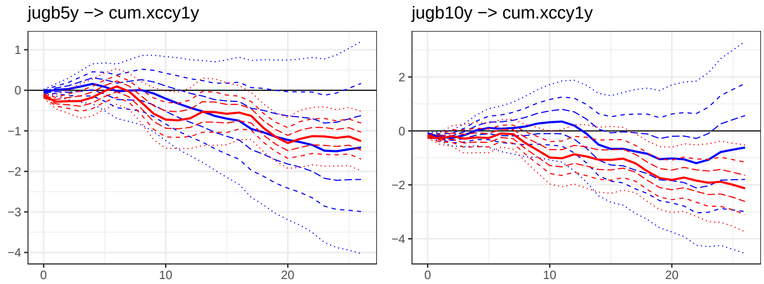
State A (red) vs. state B (blue)
90% (long dash), 68% (dashed), and 38% (dotted) confidence intervals

The spreads between medium-term government bond yields ($jugb1y$) show a strong positive association with cross-currency bases, which is most pronounced in the post-crisis state. The responses are consistently significant and quantitatively large. In several cases, the responses for the crisis state are also positive and significant, albeit quantitatively smaller than in the post-crisis state. Replacing 1-year government bond spreads by 2-year government bond spreads ($jugb2y$) for the alternative model specifications attenuates the responses somewhat but an overall positive albeit less significant association is sustained.

[9] The plural “bases” here refers to the bases corresponding to the different swap tenors examined. When used in singular “basis”, we refer to the concept laid out in Section 2.

Figure 4: Impulse responses: Spread between long-term government bond yields ($jugb5y$, $jugb10y$)

Baseline: 1-year swap Alternative: 1-year swap

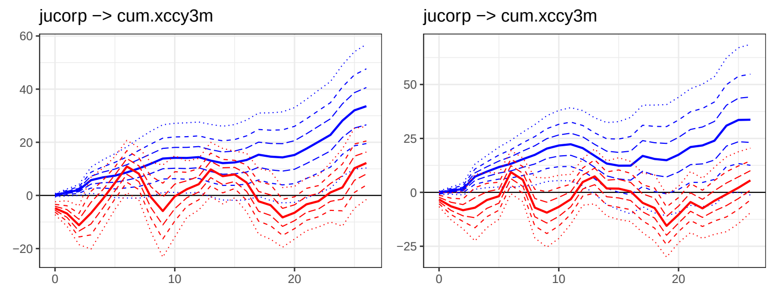


State A (red) vs. state B (blue)
90% (long dash), 68% (dashed), and 38% (dotted) confidence intervals

For longer government bond maturities, the overall picture is more varied. Both 5-year ($jugb5y$) and 10-year government bond spreads ($jugb10y$) show a negative association with 1-year and 2-year bases, and a less determinate association with the 3-month basis. However, removal of the trend term in the final set of robustness checks substantially lifts the impulse responses, particularly for the post-crisis state.

Figure 5: Impulse responses: Relative corporate bond market performance ($jucorp$)

Baseline: 3-month swap Alternative: 3-month swap

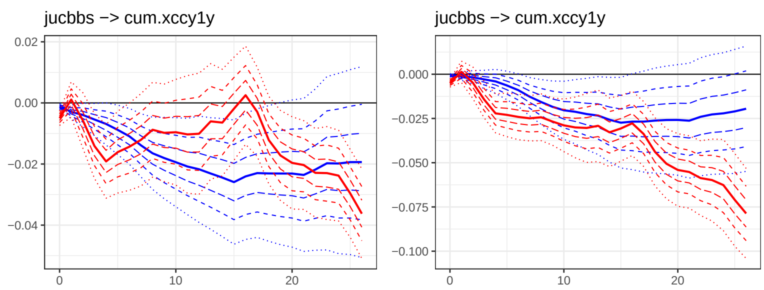


State A (red) vs. state B (blue)
90% (long dash), 68% (dashed), and 38% (dotted) confidence intervals

Relative corporate bond market performance ($jucorp$) shows a positive association with cross-currency bases within the post-crisis state, although significance varies (significance is strongest in the estimations excluding a trend term). Within the crisis state, the association is mostly negative and significant yet quantitatively smaller than the post-crisis responses. The results for relative stock market performance ($justck$) are less clear because the responses are less determinate and vary substantially in terms of significance and quantitative relevance.

Figure 6: Impulse responses: Central bank balance sheet policies ($jucbbs$)

Baseline: 1-year swap Alternative: 1-year swap

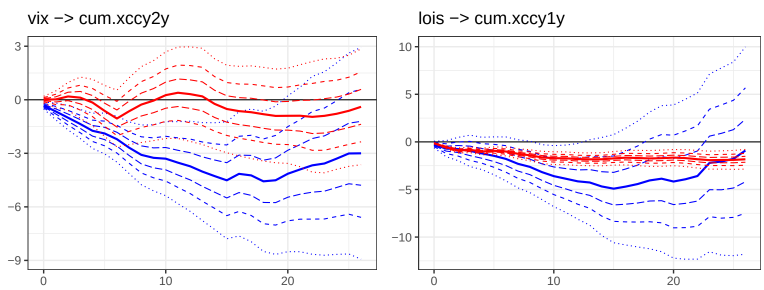


State A (red) vs. state B (blue)
90% (long dash), 68% (dashed), and 38% (dotted) confidence intervals

Central bank balance sheet policies ($jucbbs$) show a negative and significant association with cross-currency swap bases in the crisis state. While a negative association is also observable in the post-crisis state, it lacks significance. A negative association signals that relatively faster balance sheet expansion by the Bank of Japan is associated with diverging swap bases. Conversely, relatively faster balance sheet expansion by the US Fed is associated with closing swap bases. One possible interpretation would be that balance sheet expansion by the Bank of Japan depresses yields across asset classes and the term structure, which provides an incentive for financial outflows.

Figure 7: Impulse responses: Volatility Index VIX (vix) and Libor-OIS spread ($lois$)

Baseline: 2-year swap Baseline robustness: 1-year swap

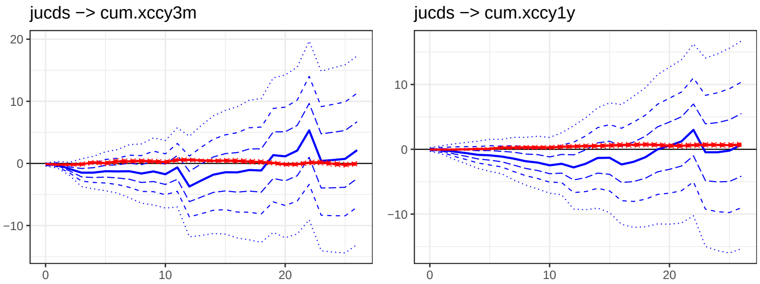


State A (red) vs. state B (blue)
90% (long dash), 68% (dashed), and 38% (dotted) confidence intervals

The association between the VIX (vix) and cross-currency bases is mostly negative within the post-crisis state, while crisis responses vary markedly across swap tenors. The most significant post-crisis responses are produced by the alternative model specifications and the estimations excluding a trend term. Meanwhile, the Libor-OIS spread ($lois$) also shows a largely negative association with cross-currency bases. While this association is also present in the crisis state, it is nevertheless quantitatively smaller than that observed in the post-crisis state.

Figure 8: Impulse responses: Bank CDS spreads ($jucds$)

Baseline: 3-month swap Without trend: 1-year swap



State A (red) vs. state B (blue)
90% (long dash), 68% (dashed), and 38% (dotted) confidence intervals

Finally, the results for credit default swap (CDS) spreads ($jucds$) between Japanese and US banks appear mixed. The responses lack significance or quantitative relevance and are less determinate than those for the other variables examined. Only for the set of alternative model specifications do CDS spreads show a degree of consistency. Here, a positive relationship is observed (although significance still varies), which indicates that cross-currency bases diverge as the CDS spreads of US banks worsen relative to those of Japanese banks.

In summary, our results show that yen-dollar cross-currency swap bases are largely associated with the spread between the Japanese and US yield curves, especially within the post-crisis state and on short to medium maturities. In other words, higher returns in the United States appear to be associated with diverging swap bases post-crisis. We find some evidence for the relevance of central bank balance sheet policies, relative corporate bond market performance, and general market volatility (as captured by the VIX).

By contrast, impulse responses for the crisis state show less evidence of a structural relationship. With the exception of central bank balance sheet policies (and, partly, the Libor-OIS spread), the responses within the crisis state show a greater degree of heterogeneity, differing more strongly in terms of determinacy, significance and quantitative relevance than their counterparts in the post-crisis state. Overall relationships between variables do not seem to follow a discernible and systematic pattern. We attribute the absence of structure during this period largely to the general breakdown of the financial system. The difference between crisis and post-crisis responses further supports the arguments that dynamics in swap markets have changed together with changes in regulatory standards.

4. DISCUSSION

Our results confirm previous studies that have analysed the role of diverging monetary policies and the covered interest parity (e.g. Sushko et al., 2016; Iida et al., 2016). As impulse responses have shown, diverging returns between Japan and the United States have noticeable effects on cross-currency bases. A conceivable transmission mechanism here would be that higher rates in the United States relative to Japan trigger financial flows from Japan to the United States, which require hedging. Since tighter financial regulation limits balance sheet space and thereby arbitrage, these financial flows and accompanying hedging demand in turn drive and sustain the cross-currency basis.

The heterogeneity of responses observed on longer bond maturities further suggests some degree of portfolio restructuring by market participants in response to price movements. Investors may choose to reallocate funds to different bond maturities or they may adjust their hedging profile, for example to take advantage of higher liquidity in shorter swap tenors. Indeed, maturity mismatches incurred due to holdings of foreign bonds recently became an issue particularly for regional Japanese banks (Bloomberg, 2017; Reuters, 2017), prompting the FSA to issue guidance to contain the build-up of risk.

At its most fundamental level, the divergence of swap markets demonstrates the continued importance of dollar funding (He et al., 2017). Our finding that balance sheet policies exhibit a relationship with the cross-currency basis supports this interpretation because balance sheet expansion by the US Fed was shown to be associated with a closing basis.

The purpose of post-crisis financial regulation was to require financial institutions to account for risk-taking and to contain excessive cross-border financial flows (Iida et al., 2016). Tighter capital and liquidity standards represent steps towards that goal. Nevertheless, swap market divergence and the associated breakdown of the covered interest parity do pose challenges for monetary policy making and regulation. If monetary easing has the side-effect of increasing the cost of hedging, then this may incentivise unhedged foreign currency exposure and create balance sheet mismatches. More broadly, if interest rates do not affect exchange rates as theory would predict, then the transmission channels of monetary policy may lose effectiveness or change in a structural way, which has manifold consequences for monetary policymaking and theory. Addressing these challenges requires a comprehensive view of the multidimensional nature of the problem that looks at monetary policy and financial regulation in an integrated way.

Future extensions of the analysis presented here can support this process in a variety of ways. Possible future areas of inquiry include cross-country comparisons and examination of a broader range of states (to capture effects such as the above-mentioned regulatory measures adopted by the FSA).

5. CONCLUSION

In this paper, we analysed deviations in yen-dollar cross-currency swap markets. Using weekly-frequency data on money market-related and capital market-related financial variables, we analysed how the cross-currency basis is influenced by differences in returns and different types of risk. We studied these dynamics using impulse responses obtained from LPs (Jordà, 2005). To account for changes in financial regulation and nonlinearities, we specified state-dependent impulse responses conditional on changes in regulatory capital and liquidity standards.

We identified differences in short-term and medium-term interest rates (government bond yields) as quantitatively relevant drivers of the cross-currency basis in the post-crisis period. On this basis, we argued that spreads opening up in these markets provide an incentive for cross-border financial flows and corresponding hedging demand, which in turn drive the basis in the post-crisis period due to tighter regulatory standards. We further found some evidence for the relevance of central bank balance sheet policies, relative corporate bond market performance, and general market volatility. In contrast, impulse responses for the immediate crisis period do not seem to follow a discernible and systematic pattern.

Given the size and importance of swap markets, we argue that swap market deviations have far-reaching consequences. We particularly draw attention to the interaction between monetary policy, swap prices and financial stability, which is likely to pose a challenge for policymakers and regulatory authorities going forward.

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7. APPENDIX

7.1. Overview of data series

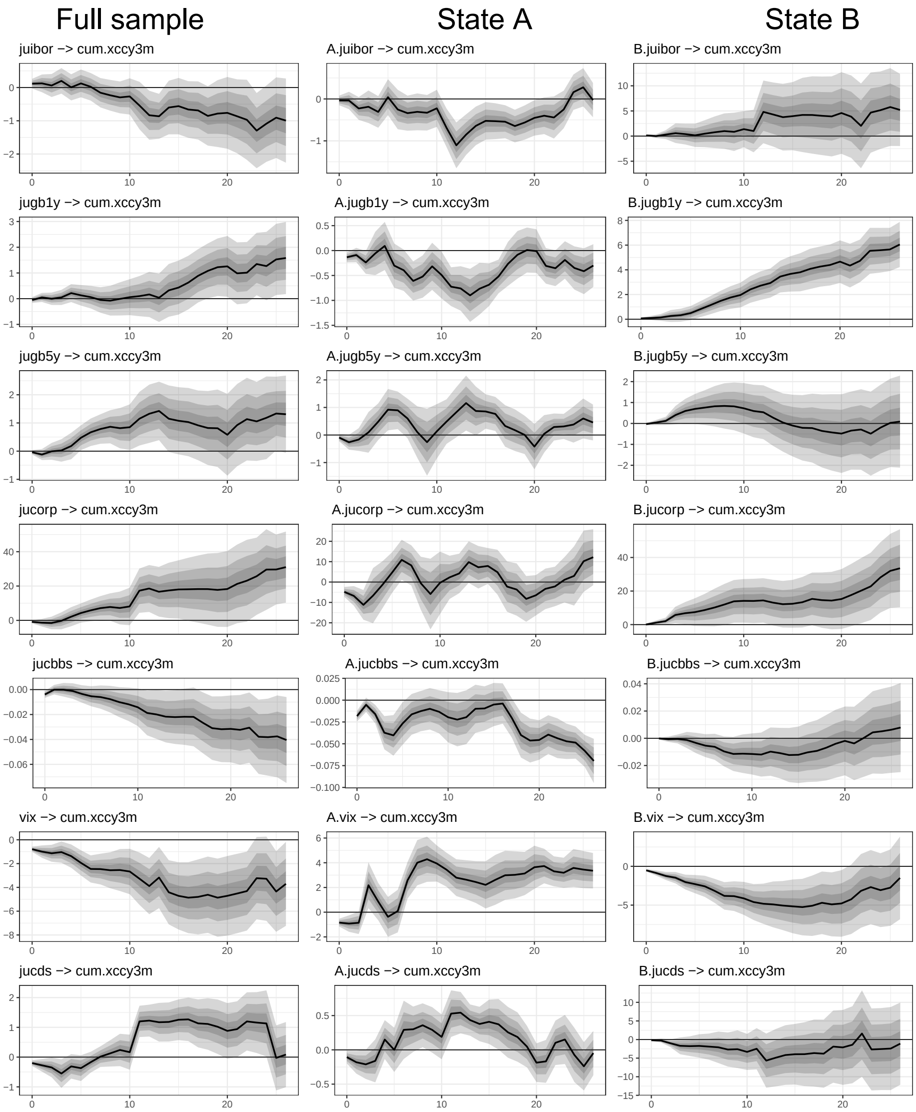
Figure 9: Data series

Variable	Concept	Interpretation	Unit
$xccy$	Cross-currency basis swap basis, mid	Downward movement signals USD premium and greater deviation from covered interest parity	bp, year-on-year difference
$juibor$	Difference between interbank overnight rates, Japan uncollateralised overnight call rate minus US Federal Funds	Downward movement signals a higher interbank rate in US relative to Japan	bp, year-on-year difference
$jugb$	Difference between government bond yields, Japanese government bonds (JGBs) minus US Treasuries	Downward movement signals higher government bond yields in US relative to Japan	bp, year-on-year difference
$jucorp$	Difference between corporate bond market performance, indices set 100 for sample start date, Japanese minus US bonds	Downward movement signals superior performance of US corporate bonds relative to Japan	index, year-on-year difference
$justck$	Difference between stock market indices, set to 100 for sample start date, Japanese Nikkei 225 minus US S&P 500	Downward movement signals better performance of US stocks relative to Japanese stocks	index, year-on-year difference
$jucbbs$	Difference between commercial bank reserves on central bank balance sheet, set to 100 for sample start date, BOJ minus US Fed reserve balances	Downward movement signals faster balance sheet expansion by US Fed than by Bank of Japan	index, year-on-year difference
vix	Chicago Board Options Exchange (CBOE) Volatility Index, a measure of stock market volatility, and an indicator for market stability and liquidity conditions	Downward movement signals less market volatility, higher stability, absence of liquidity issues	index, year-on-year difference
$lois$	Difference between Libor and Overnight Index Swap (OIS) rate (3m), indicator for stress in money markets and credit risk	Downward movement signals lower levels of stress, absence of credit risk	bp, year-on-year difference
$jucds$	Difference between 5 year senior credit default swap (CDS) spreads for large banks, Japanese banks minus US banks	Downward movement signals higher credit risk for US banks	bp, year-on-year difference

Note: bp = basis points (one hundredth of a percent)

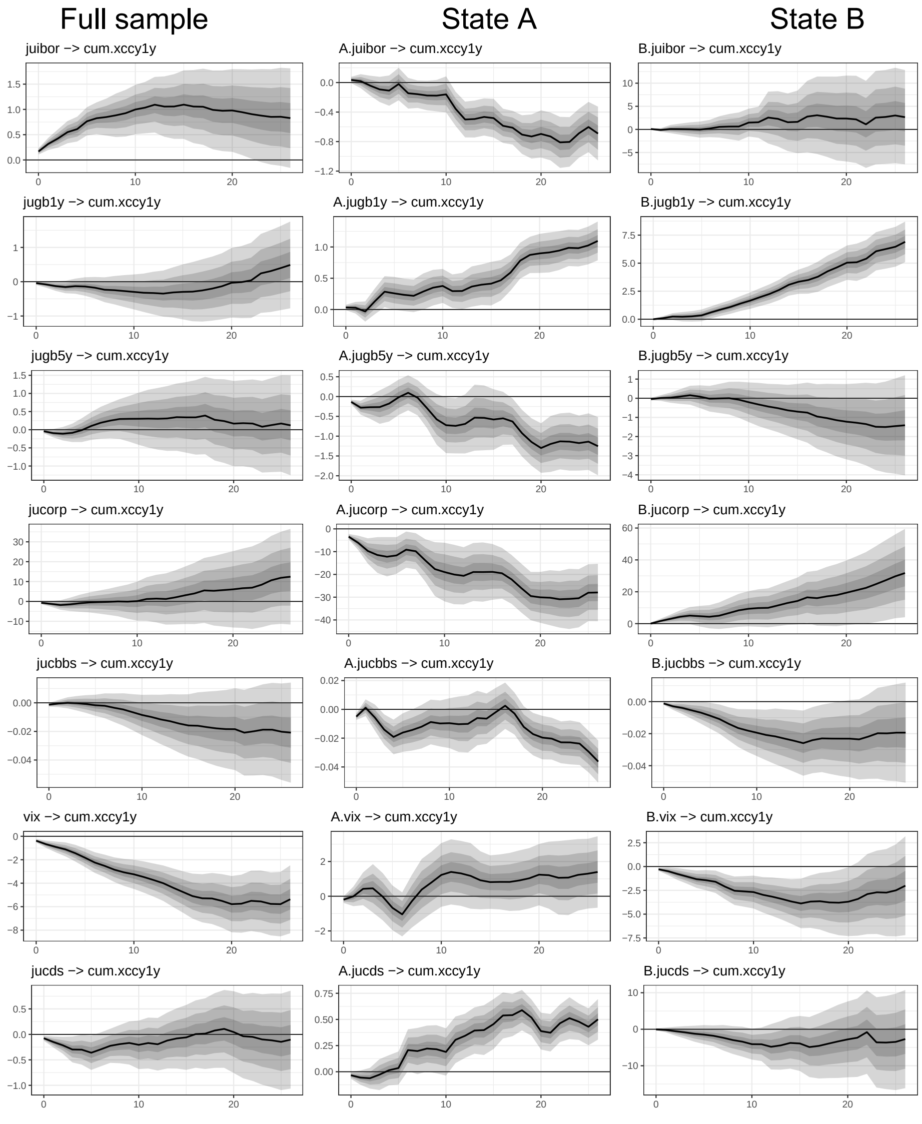
7.2. Impulse responses for main estimations

Figure 10: LP impulse responses for 3-month cross-currency basis



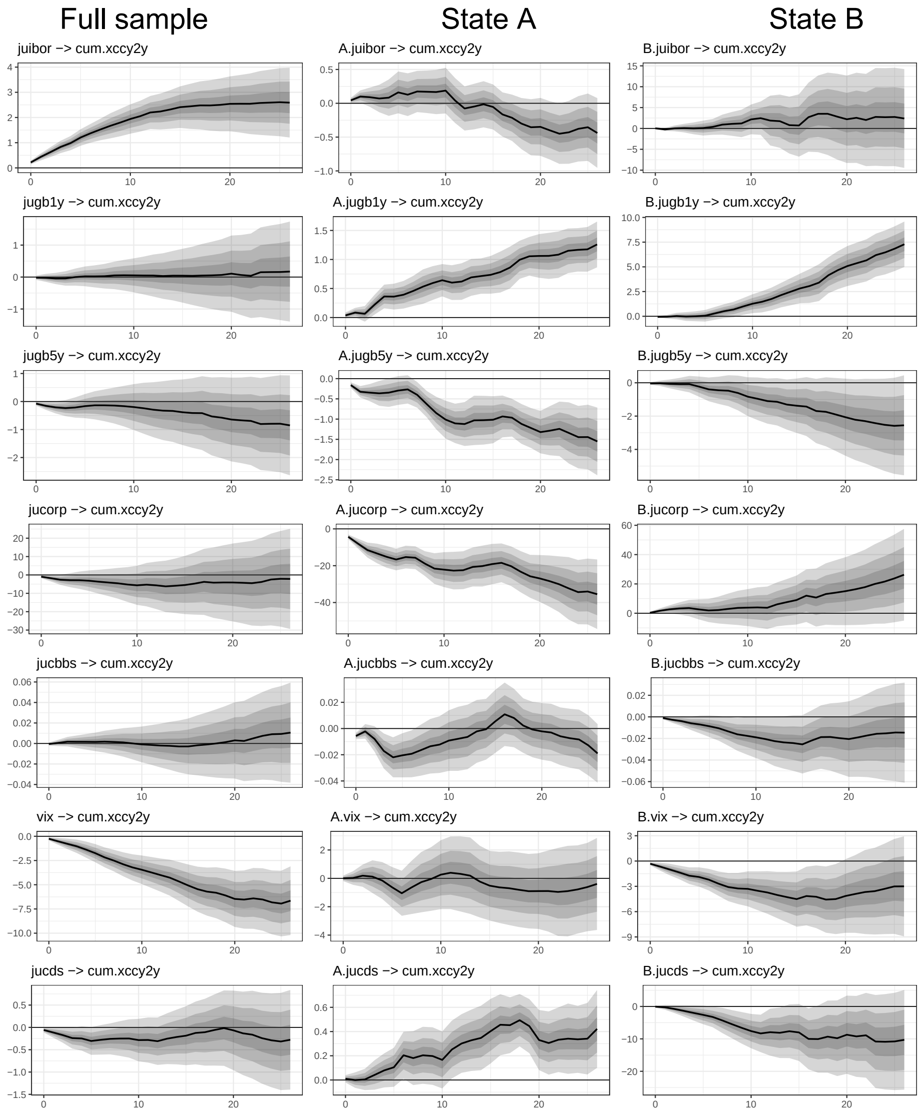
Note: 90%, 68%, and 38% confidence intervals

Figure 11: LP impulse responses for 1-year cross-currency basis



Note: 90%, 68%, and 38% confidence intervals

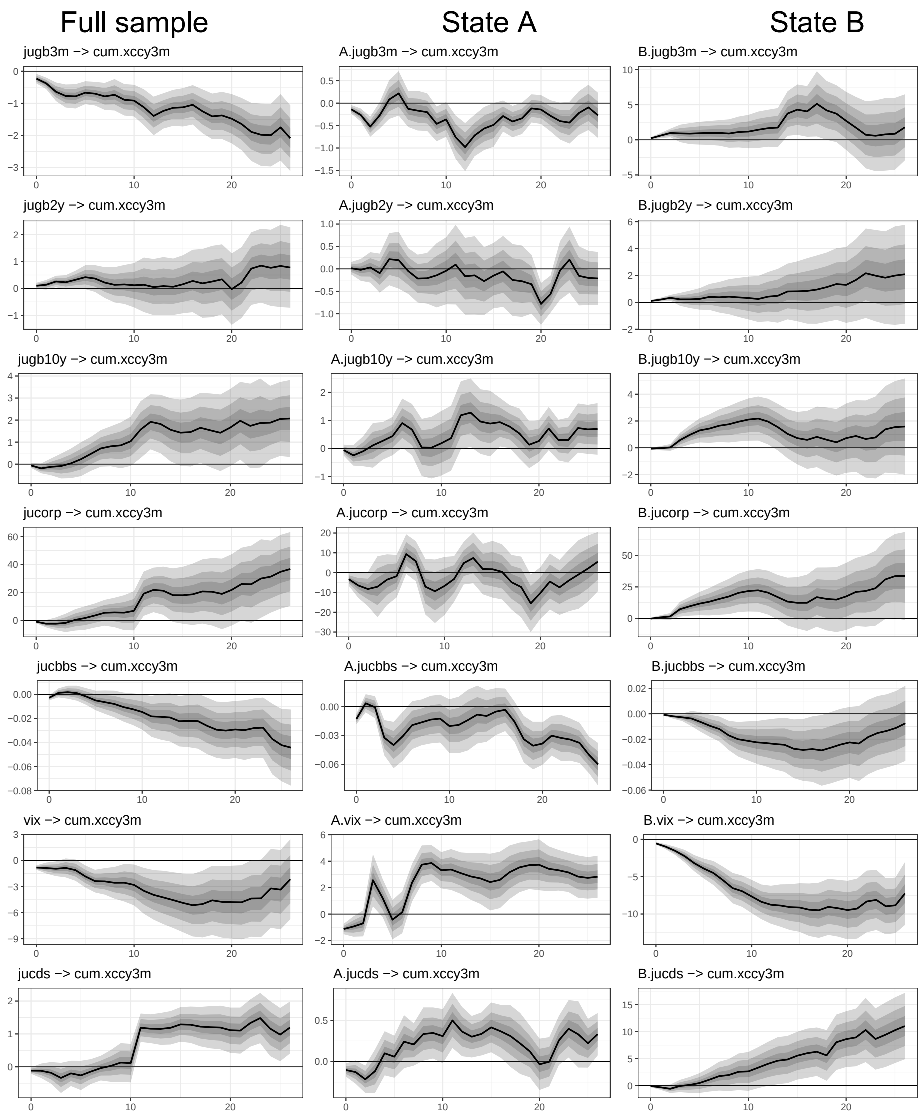
Figure 12: LP impulse responses for 2-year cross-currency basis



Note: 90%, 68%, and 38% confidence intervals

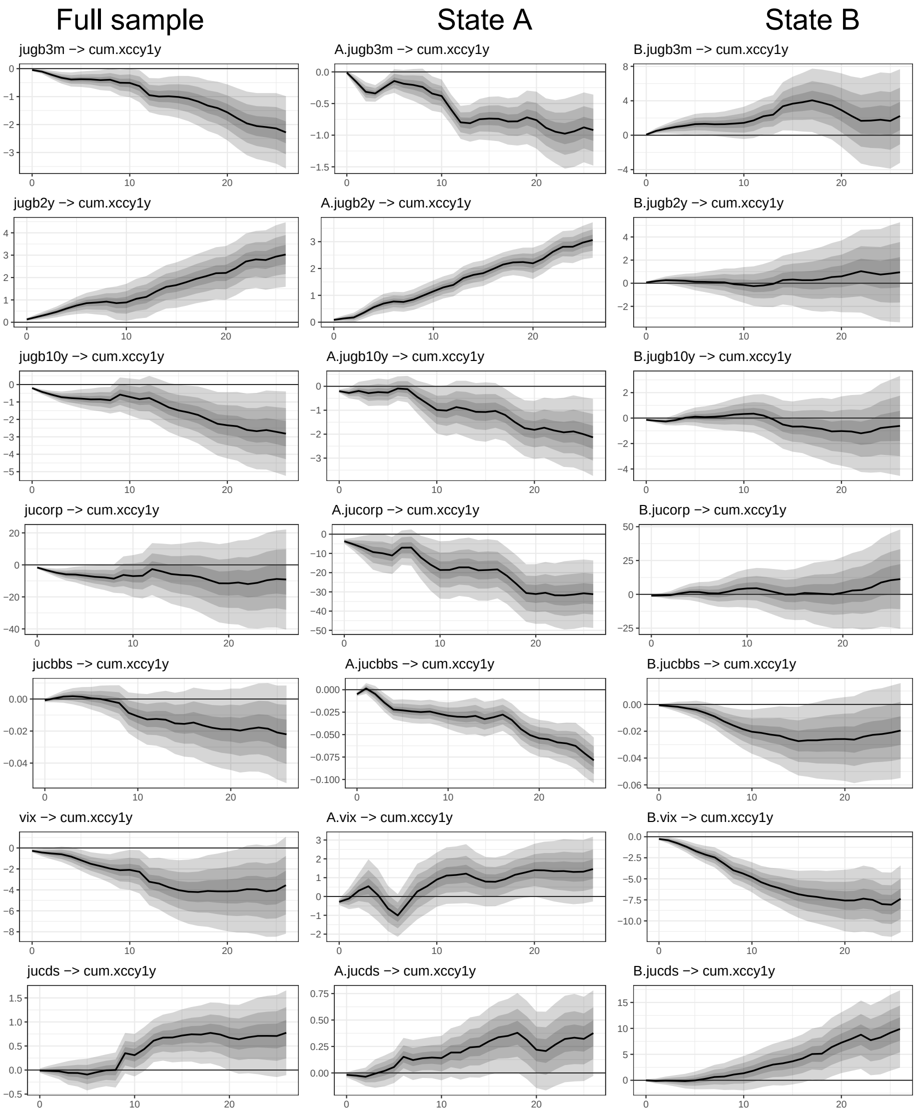
7.3. Alternative specification

Figure 13: LP impulse responses for 3-month cross-currency basis



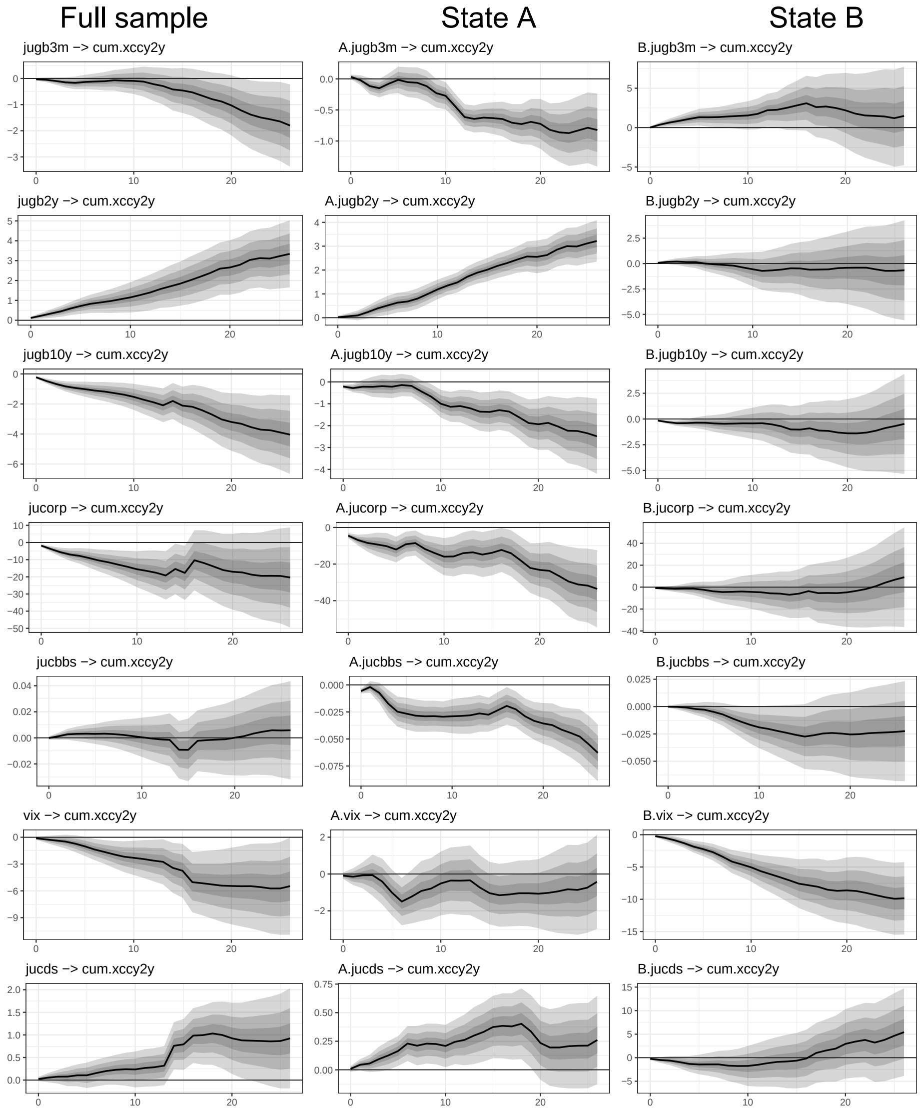
Note: 90%, 68%, and 38% confidence intervals

Figure 14: LP impulse responses for 1-year cross-currency basis



Note: 90%, 68%, and 38% confidence intervals

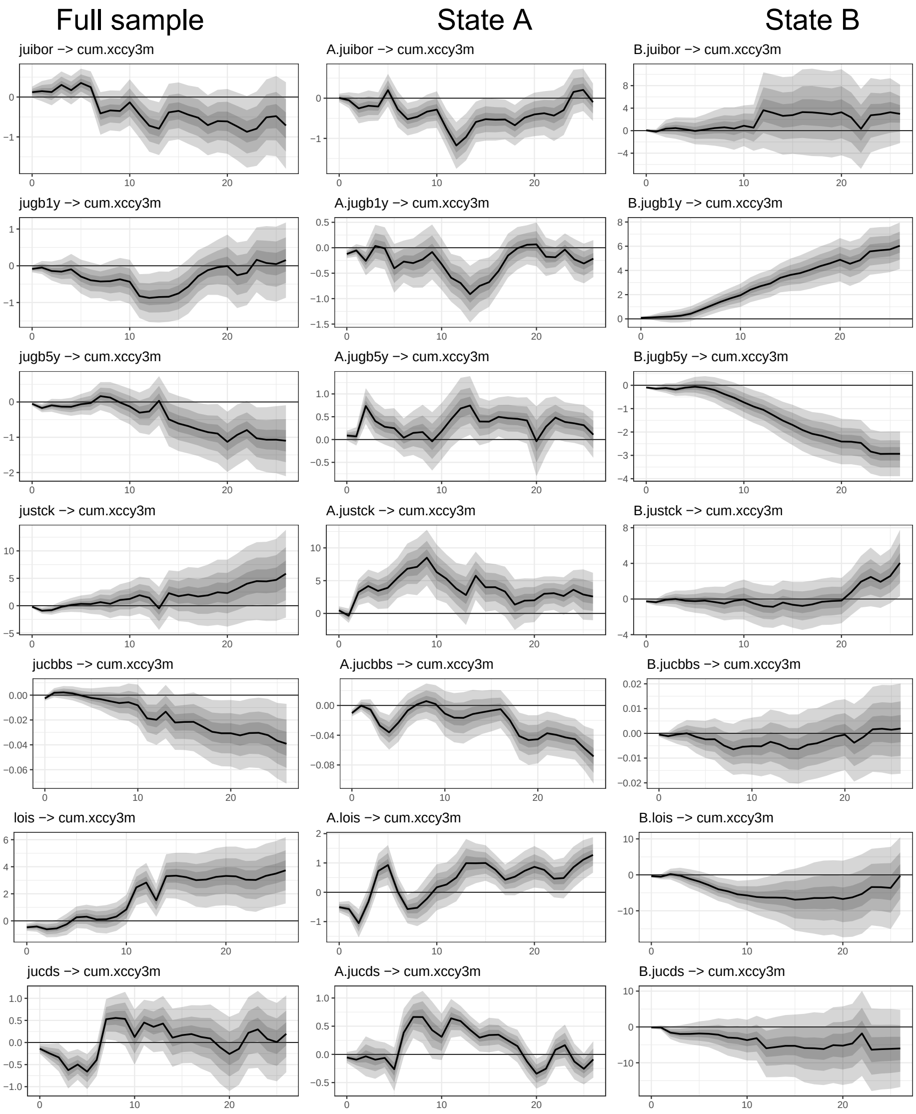
Figure 15: LP impulse responses for 2-year cross-currency basis



Note: 90%, 68%, and 38% confidence intervals

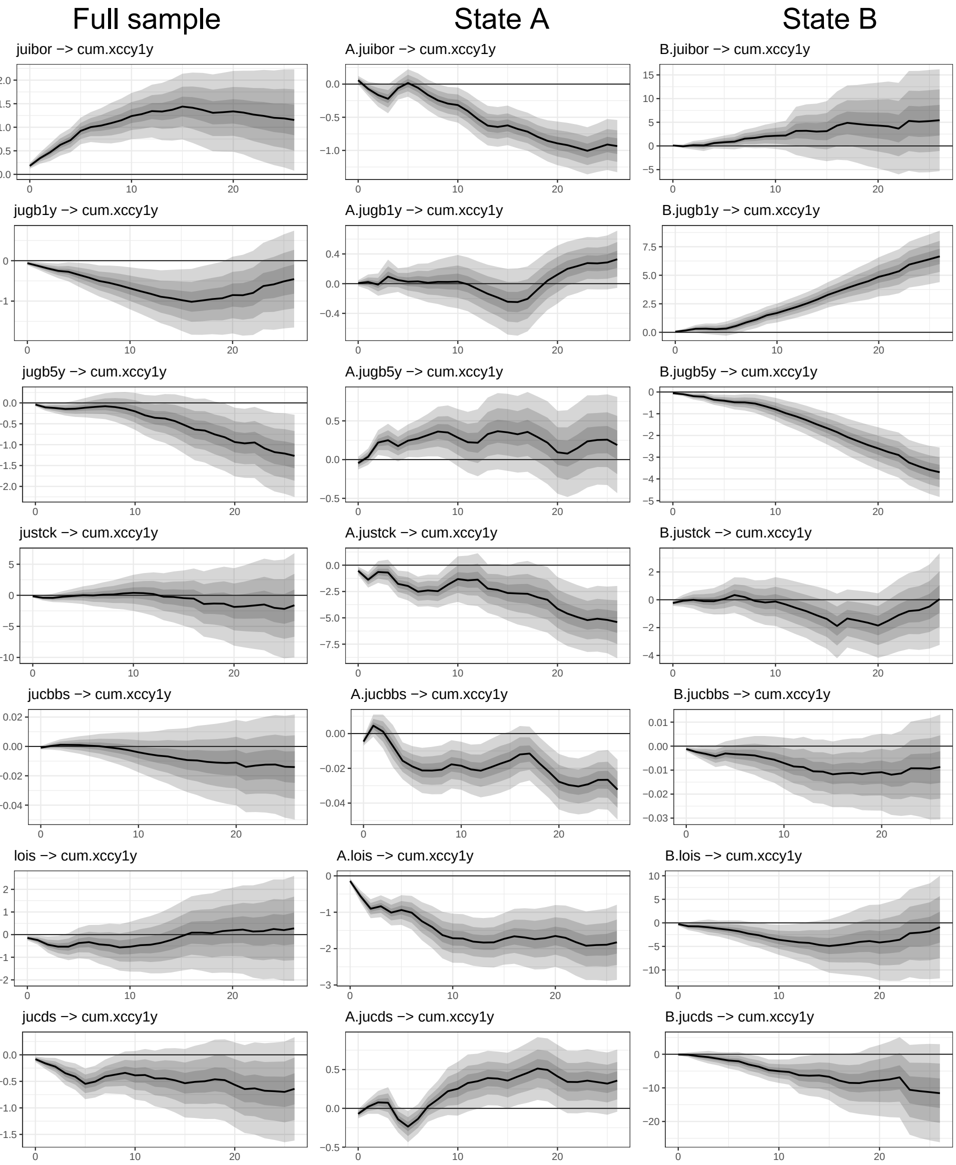
7.4. Robustness checks for main estimations

Figure 16: LP impulse responses for 3-month cross-currency basis



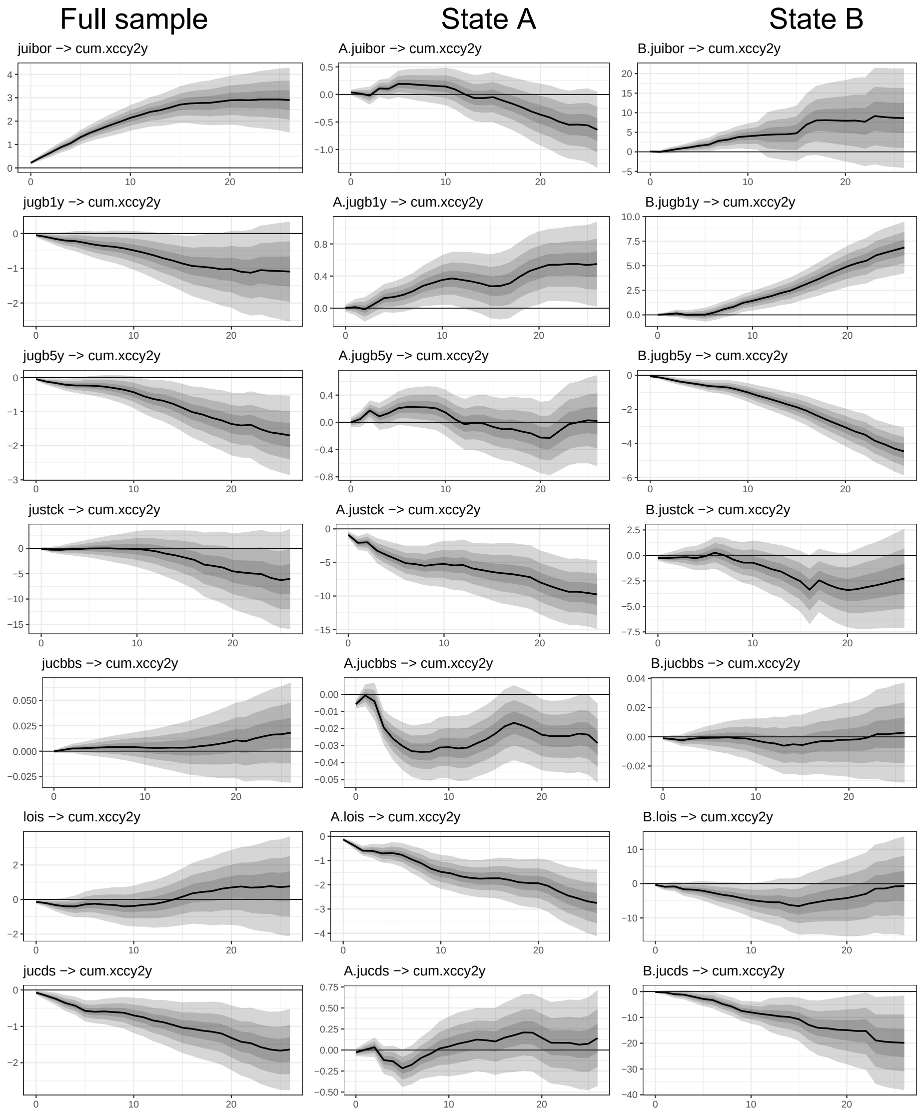
Note: 90%, 68%, and 38% confidence intervals

Figure 17: LP impulse responses for 1-year cross-currency basis



Note: 90%, 68%, and 38% confidence intervals

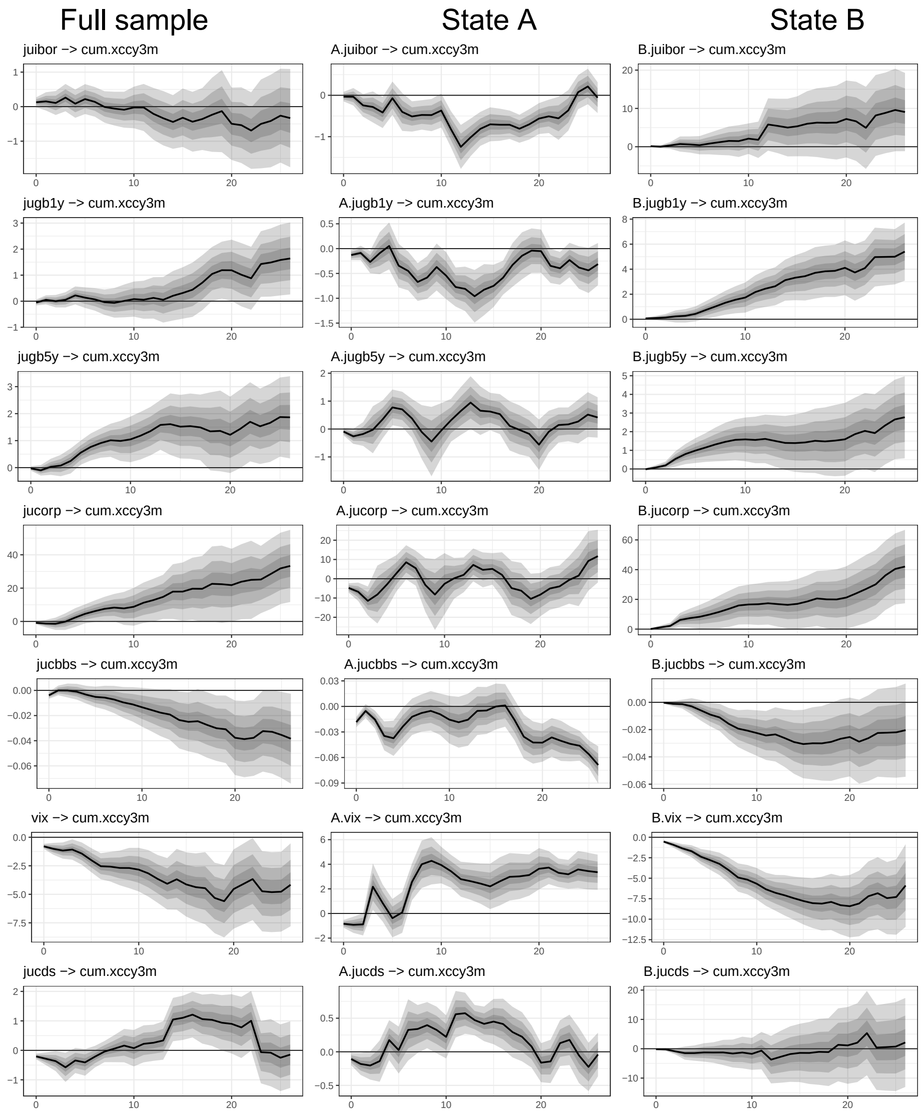
Figure 18: LP impulse responses for 2-year cross-currency basis



Note: 90%, 68%, and 38% confidence intervals

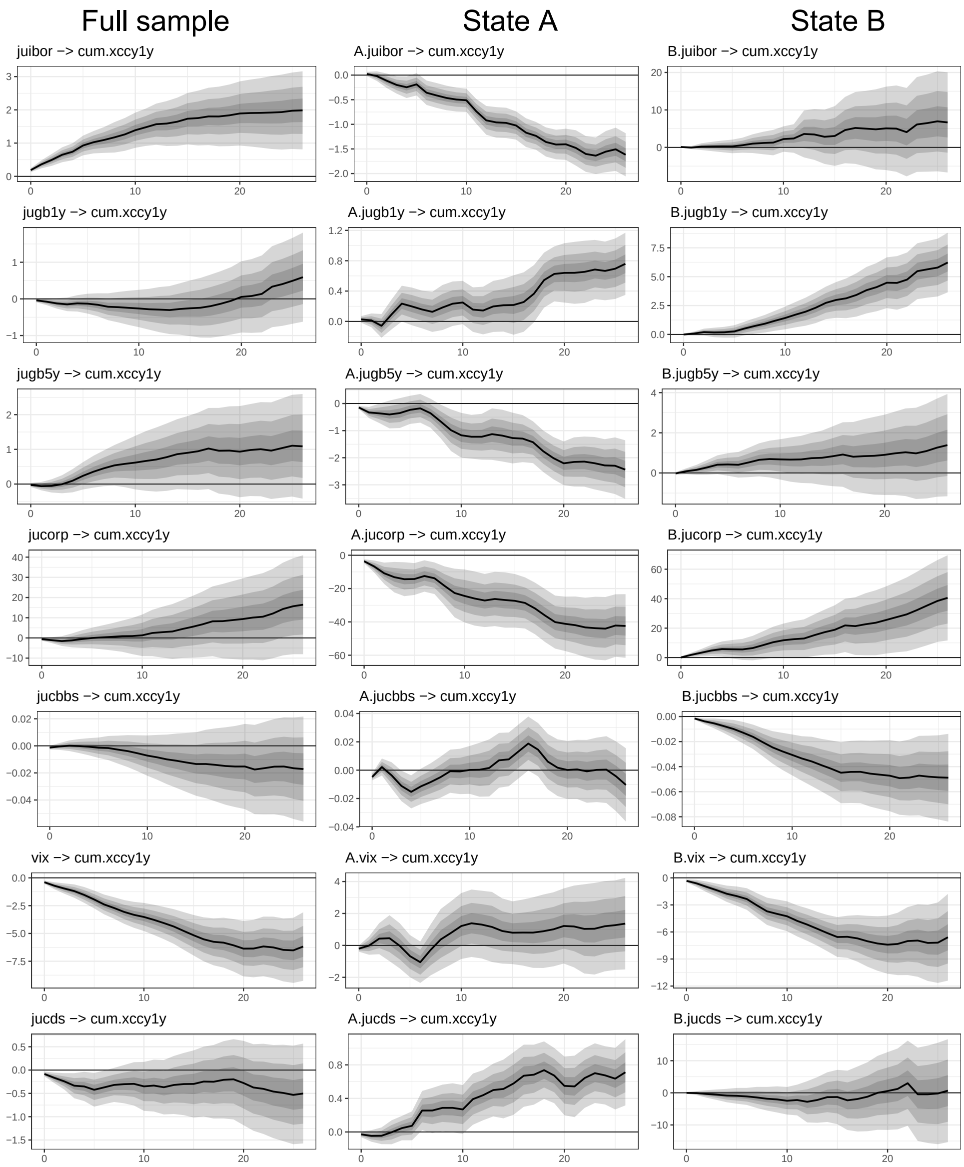
7.5. Remove trend from main estimations

Figure 19: LP impulse responses for 3-month cross-currency basis



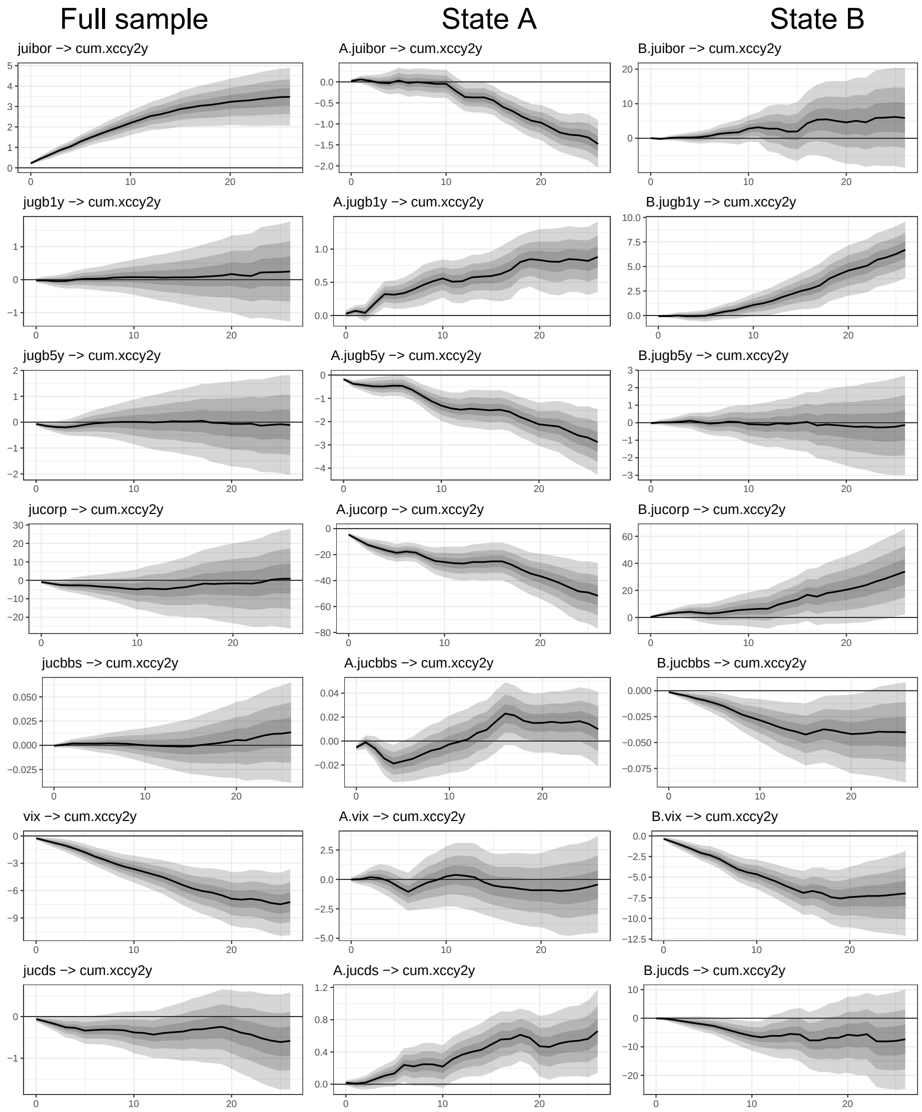
Note: 90%, 68%, and 38% confidence intervals

Figure 20: LP impulse responses for 1-year cross-currency basis



Note: 90%, 68%, and 38% confidence intervals

Figure 21: LP impulse responses for 2-year cross-currency basis



Note: 90%, 68%, and 38% confidence intervals