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# Asset purchase programmes and the exchange rate

This paper examines how country-specific COVID-era asset purchase programmes affected bilateral exchange rates against the US dollar

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February 24, 2026

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# 1 Introduction

Asset purchase programmes (APPs) have played a prominent role in policymaking since the global financial crisis (GFC). With the onset of the COVID-19 pandemic, the set of countries adopting these policies broadened with more advanced economies and many emerging market central banks adopting APPs for the first time. While advanced economies primarily turned to APPs when policy rates were near or at the zero lower bound, emerging markets' adoption was generally associated with policy rates above the zero lower bound. More generally, the pandemic highlighted the critical distinction between APPs used for financial stability versus those employed for monetary policy objectives.[1]

This paper studies the impact of asset purchase programmes on the bilateral U.S. dollar exchange rate during the COVID-19 era for 23 emerging markets (EMs) that adopted these policies for the first time, compared to seven advanced economies (AEs). I find that asset purchase surprises cause currency appreciation in EMs, unlike the depreciation observed in AEs during the post-GFC period and also contrary to the theory prediction on the transmission of these interventions to the exchange rate (Greenwood, Hanson, Stein, & Sunderam, 2023; Gourinchas, Ray, & Vayanos, 2025).

The monetary policy transmission to the exchange rate is a long-standing and critical issue, extensively explored both for conventional (Eichenbaum & Evans, 1995; Bjørnland, 2009) and unconventional (Joyce, Lasaosa, Stevens, & Tong, 2010; Rogers, Scotti, & Wright, 2014; Boeckx, Dossche, & Peersman, 2014; Rogers, Scotti, & Wright, 2018; Swanson, 2021) monetary policies, particularly for AEs. However, the exchange rate plays a special role in EMs for two main reasons. First, exchange rate fluctuations matter for domestic financial stability in EMs, where reliance on foreign currency borrowing is higher. Second, inflation in EMs is more sensitive to exchange rate movements, driven by the greater share of tradable goods in their consumption baskets (Alberola, Cantú, Cavallino, & Mirkov, 2021). Therefore, it is crucial for emerging market policymakers to understand the impact of domestic policies on exchange rates.

To examine the impact of APPs on the bilateral U.S. dollar exchange rate, I start by constructing an event set for asset purchase programme announcements during 2020-2021. The event set is comprehensive in that it covers 23 EMs and seven major AEs, consisting of 98 announcements on asset purchase programmes. The event set also accounts for simultaneous policy announcements made by each country on the day of the APP announcement.[2] This is crucial for accurately capturing the true response of the exchange rate, as countries implemented various measures during the pandemic.

To evaluate the exchange rate response to APPs, I utilise an event study analysis, which is based on the idea that asset prices adjust in response to unexpected information (Kuttner, 2001). My approach builds on the methodology of Rogers et al. (2018), where

[1] Quantitative easing (QE) encompasses a range of distinct policies, as highlighted by Ricardo Reis in his talk, "The Original Sin of QE (and QT)." These policies can generally be categorised into two main objectives: (i) providing monetary stimulus and (ii) ensuring financial stability. A clear illustration of this distinction is the Bank of England's intervention in September 2022, when it halted its quantitative tightening (QT) programme and reverted to QE to prevent a domestic financial crisis in the pensions system.

[2] Simultaneous announcements can be classified into five broad categories: foreign exchange intervention (FXI), swap agreements, repo operations, measures targeting the banking sector or corporate sector, policy rate decisions.

they regress changes in 10-year Treasury futures on target and forward guidance surprises. The residuals from this regression are then defined as asset purchase surprises, capturing variations in long-term interest rates associated with asset purchases announced by the Federal Open Market Committee (FOMC). However, extracting asset purchase surprises for EMs presents a challenge due to the limited availability of futures markets, commonly used to measure monetary policy surprises in AEs. I address this issue with a parsimonious two-step approach. First, I extract the unexpected component of APSs by isolating shifts in long-term yields from changes in short-term yields and other control variables. Then, I evaluate the impact of these unexpected parts of APP announcements on exchange rates.

First, I regress two-day changes in long-term government bond yields on corresponding changes in short-term government bond yields around APP announcements, using daily data to account for cross-country differences in trading hours. This short window supports a causal interpretation, by attributing any changes around the announcements to APPs while also accounting for slower information transmission in EMs. The residuals from this regression represent the variation in long-term rates beyond short-term rate changes, serving as a proxy for APSs. Second, I regress exchange rate changes on these APSs, using bootstrapped standard errors to address estimation uncertainty inherent in the APSs. I also validate this approach by applying the same methodology to selected AEs for APPs adopted in the post-GFC period. This analysis yields findings that are consistent with the previous literature.

To establish a causal effect of country-specific asset purchase surprises on the exchange rate, it is important to control for potential confounding factors. The COVID-19 crisis is unique in that multiple countries responded not only simultaneously but also with a variety of policy measures. Accordingly, to isolate the pure effect of country-specific asset purchase surprises, I account for the actions of the Federal Reserve (Fed), actions of other major AE central banks, and simultaneous policy actions taken by the country itself on the day of the APP announcement.

To control for the multidimensionality of the Fed policy actions, I implement a factor analysis by broadening the information set in Swanson (2021) with covered interest rate parity (CIP) deviations, which is defined as the difference between the synthetic dollar borrowing cost of a foreign country and the direct dollar borrowing cost of the U.S. This is motivated by the need to capture the introduction of Fed swap lines, which has been shown to reduce CIP deviations (Bahaj & Reis, 2020; Kekre & Lenel, 2023). This extension results in a fourth factor, which I call the SWAP factor in addition to the typically identified three factors in the literature (Altavilla, Brugnolini, Gürkaynak, Motto, & Ragusa, 2019; Gürkaynak, Sack, & Swanson, 2004; Swanson, 2021), which are the forward guidance factor (FG), the large-scale asset purchases factor (LSAP), the federal funds rate factor (FFR).[3]

To account for the actions of major AE central banks, I incorporate a control variable defined as the average change in short-term interest rates for all major AEs considered in the analysis around the APP announcement dates. Lastly, to control for simultaneous policy actions by the country itself on the day of the country-specific APP announcement, I construct a variable that is equal to the sum of the number of simultaneous policy announcements made on the date of the APP announcement.

[3] The factors are named according to their loadings on specific variables within the information set.

The paper has two main findings. First, COVID-era APPs led to an appreciation of the exchange rate in EMs, even after accounting for confounding factors such as Fed policy actions, monetary policy by other AEs, and simultaneous policy measures by the implementing country itself. Second, while the baseline regressions indicate an appreciation of the exchange rate that is statistically significant for AEs, this significance disappears once I control for the SWAP factor, which highlights the importance of accounting for the fourth dimension in controlling for Fed policy actions.

In the second part of the paper, I investigate the mechanism behind different exchange rate responses in EMs and AEs through the lens of long-run uncovered interest rate parity (LR-UIP) deviations. The exchange rate models such as those by Greenwood et al. (2023) and Gourinchas et al. (2025) assume that long-run uncovered interest parity (LR-UIP) holds for AEs.[4] However, these studies are not able to generate an appreciation of the exchange rate following an APP under plausible assumptions.[5] To this end, I set up a no-arbitrage asset pricing model with convenience yields and sovereign credit risk building on Jiang, Krishnamurthy, and Lustig (2021), Du and Schreger (2016), and Corsetti, Lloyd, Marin, and Ostry (2023).

Empirically, I find that sovereign credit risk is the main driver of the transmission of asset purchase programmes to exchange rates in EMs, which is different from AEs. I reach this conclusion in two steps. First, I look into the two specific channels separately. Using credit default swap (CDS) spreads as a proxy for sovereign credit risk (Augustin, Chernov, & Song, 2020), I find strong evidence for the sovereign credit risk channel of APPs in EMs, which is absent in AEs. This effect is both economically and statistically significant in EMs, where an asset purchase surprise that lowers the long-term government bond yields by 100 basis points lowers the sovereign credit default swap spread by 43 to 46 basis points at 5 and 10-year maturities, respectively. In analysing the convenience yield channel, I use CIP deviations as a proxy, building on Jiang, Krishnamurthy, and Lustig (2021), and CIP deviations purified of the sovereign credit risk (Dao & Gourinchas, 2025). My findings indicate no strong evidence of a convenience yield channel in AEs during the COVID-era asset purchase programmes in contrast to the evidence for APPs during the GFC depicted by Jiang, Krishnamurthy, Lustig, and Sun (2024).[6]

Second, I look into how asset purchase surprises impact the underlying long-term risk-free rate, which is the promised yield once the convenience yields and sovereign credit risk components are accounted for. I show that asset purchase surprises do not decrease and may even increase the underlying long-term risk-free rate in EMs. This explains why asset purchase surprises appreciate the exchange rate in EMs.

This analysis has one important policy implication. EMs can potentially use APPs during times of financial distress to stabilise exchange rates without necessarily intervening in the foreign exchange rate market. The implication is that exchange rate stabilisation could, in principle, be accomplished without relying on scarce and costly to accumulate

[4]These studies feature segmented asset markets where changes in asset supply influence prices, consistent with empirical evidence showing the importance of quantity-driven effects in determining exchange rate movements, and empirical evidence that LR-UIP holds for AEs (Lustig, Stathopoulos, & Verdelhan, 2019).

[5]In Greenwood et al. (2023), an appreciation of the EM exchange rate following an APP requires U.S. short-term interest rates to react more than one-to-one to EM rates, which is empirically implausible.

[6]Accounting for credit risk in CIP deviations—referred to as pure CIP deviations (Dao & Gourinchas, 2025)—is crucial in EMs, leading to results that align more closely between EMs and AEs. This will be discussed further in Section 4.3.

foreign exchange reserves, swap lines which are limited to a very limited number of countries or IMF lending, which is conditional. Specifically, my results suggest that APPs, by reducing sovereign credit risk—the channel identified in EMs—do not necessarily lower the underlying long-term risk-free rate and can lead to exchange rate appreciation, thereby enhancing financial stability without direct intervention in the foreign exchange market. However, it is also important to recognise the associated limits, risks and preconditions for such policies to be effective, including fiscal dominance, the state of macroeconomic fundamentals - particularly fiscal sustainability, domestic financial market development, the credibility of the monetary policy framework and external balance and growth prospects (Arena et al., 2021).

**Related Literature.** This paper contributes to four main strands of the literature. The primary contribution is documenting a significant appreciation of the exchange rate in EMs in response to asset purchase programmes and explaining it through the lens of long-run uncovered interest parity (LR-UIP) deviations, where a sovereign credit risk channel is at work.

The first strand of literature explores the effects of asset purchase programmes (APPs) on exchange rates using high-frequency data, primarily focused on AEs in the pre-COVID era.[7,8] Most studies, such as Rogers et al. (2014) and Rogers et al. (2018), examine the impact of APPs at the zero lower bound (ZLB), where these programmes generally led to currency depreciation. In contrast, this paper leverages the COVID-era to investigate the effects of APPs in EMs, comparing them to major AEs using daily high-frequency data, building on the methodology of Rogers et al. (2018). Unlike prior country-specific studies, my analysis takes a comparative approach, while also controlling for swap lines, and uncovers a distinct relationship between APP surprises and exchange rate appreciation in EMs. In particular, I show that a 10 basis point policy easing corresponds to a 0.17 to 0.23 percentage point appreciation, depending on the purchase type. This finding suggests that APPs motivated by financial stability concerns can lead to currency appreciation in EMs, a response opposite to that seen in AEs during the global financial crisis (GFC) (Dedola, Georgiadis, Gräb, & Mehl, 2021).

Additional evidence highlights similar unconventional dynamics in EMs. Ha, Kim, Kose, and Prasad (2025) show that the well-documented "FX puzzle," where monetary tightening triggers currency depreciation, can be rationalised once forward-looking expectations are incorporated. De Leo, Keller, Simoncelli, Villamizar-Villegas, and Williams (2025) find that quantitative easing in EMs can appreciate the exchange rate through correlated bond–FX flows, a mechanism corroborated with Colombian transaction-level data. Similarly, Mimir and Sunel (2025) show in a small open economy DSGE model that asset purchases ease financial conditions without triggering depreciation pressures, as the decline in risk premia dominates the effect of lower interest rate differentials. These studies complement my findings and underscore that the transmission of unconventional policies in EMs differs systematically from the AE experience.

[7] High-frequency data in AEs typically means intraday data, whereas, for many EMs, the most granular data is daily. An exception is Solís (2023), which studies the impact of monetary policy surprises on the exchange rate using intraday data for Mexico.

[8] Another approach is the investigation of balance sheet policies in a structural vector autoregression (SVAR) framework (Boeckx et al., 2014; Burriel & Galesi, 2018; Gambacorta, Hofmann, & Peersman, 2014; Joyce et al., 2010).

The second strand of literature that this paper contributes to is on the impact of APPs on exchange rates and bond yields during the COVID era (Sever, Goel, Drakopoulos, & Papageorgiou, 2020; Hördahl & Shim, 2020; Arslan, Drehmann, & Hofmann, 2020; Ha & Kindberg-Hanlon, 2021; Rebucci, Hartley, & Jiménez, 2022). While similar in providing a comparison of EMs and AEs to Rebucci et al. (2022), this paper differs by covering a broader sample of 23 EMs and seven AEs from March 2020 to August 2021 and employing a methodology that isolates the unexpected component of APP announcements. By pooling data from all APP announcements across both EMs and AEs, I derive a measure of asset purchase surprises and examine their impact on exchange rates, offering a more comprehensive analysis that also accounts for simultaneous policy announcements.

A significant gap in the literature concerns the identification of the causal effect of country-specific APPs amidst broader currency movements, such as the appreciation of the dollar until April 2020, followed by its depreciation after the Fed's APP announcements. Disentangling the effects of Federal Reserve policy actions from these broader trends remains relatively unexplored in the COVID era. My paper addresses this gap by rigorously accounting for these confounding factors, including the multidimensionality of Fed policy actions through a factor analysis. In doing so, I offer a more nuanced understanding of the impact of country-specific APPs on exchange rates while isolating the broader influence of the Fed's policies.

The third strand of literature that this paper relates to builds on the literature linking covered interest rate parity (CIP) deviations, swap lines, and exchange rate markets. Bahaj and Reis (2020) find that the announcement of swap lines by the Fed helped reduce CIP deviations. Kekre and Lenel (2023) show that news about the extension of the swap lines leads to compression in CIP deviations and an appreciation of the foreign currencies. Furthermore, Bahaj and Reis (2022) provide supporting evidence of swap lines influencing exchange rate markets through their impact on forward contract prices. Building on these findings, this paper assesses the role of the Fed's swap lines in exchange rate dynamics using a factor analysis approach. I identify an additional "SWAP" factor that is highly correlated with CIP deviations.[9] It shows that when the SWAP factor is included, the significance of the asset purchase surprise coefficient on exchange rates disappears for AEs but remains significant for EMs. This evidence establishes a connection between swap lines, CIP deviations, and exchange rates during periods when countries also implemented APPs.

Finally, this paper contributes to the extensive empirical and theoretical literature on uncovered interest parity (UIP) deviations. Deviations from UIP in AEs, for both short and long maturities, are widely discussed in the literature (Meredith & Chinn, 1998; Chinn & Meredith, 2004, 2005; Boudoukh, Richardson, & Whitelaw, 2016). However, there are relatively fewer studies on EMs, particularly for UIP deviations for longer-term maturity bonds (Bansal & Dahlquist, 2000; Frankel & Poonawala, 2010; Kalemli-Ozcan & Varela, 2021; Chernov & Dahlquist, 2023). This paper adds to the literature by examining drivers of UIP deviations in EMs for longer-maturity bonds.

The theoretical literature on UIP deviations generally is built upon two main explanations: (i) time-varying risk premia (Bekaert, 1996; Verdelhan, 2010; Farhi & Gabaix, 2016)

[9] The literature typically considers three dimensions of Fed monetary policy: (i) federal funds rate, (ii) forward guidance, and (iii) large-scale asset purchases (LSAP), as discussed in Swanson (2021).

and (ii) deviations from full-information rational expectations (Bacchetta & Van Wincoop, 2010; Burnside, Han, Hirshleifer, & Wang, 2011). While long-run UIP (LR-UIP) is largely supported in AEs and forms the basis of studies like Greenwood et al. (2023) and Gourinchas et al. (2025), empirical evidence shows that LR-UIP tends not to hold in EMs (Rebucci, Toraman, & Valente, 2025). My contribution to this literature is to take a different approach by emphasising two factors driving these deviations: relative convenience yields (Jiang, Krishnamurthy, Lustig, & Sun, 2021) and sovereign credit risk (Du & Schreger, 2016). To this end, I set up a no-arbitrage asset pricing model with incomplete markets, extending Jiang, Krishnamurthy, and Lustig (2021) by including sovereign credit risk in a multi-period setting, as outlined in Corsetti et al. (2023). Specifically, I present new evidence of a "sovereign credit channel," which plays a key role in the transmission of APPs to exchange rates in EMs.

The rest of this paper is organised as follows. Section 2 outlines the event set, selection criteria, country coverage, and summary statistics. Section 3 describes the event study methodology and presents baseline results, followed by regression results that control for confounding factors. Section 4 discusses the transmission mechanism and provides empirical evidence. Section 5 presents the robustness analysis. Section 6 concludes.

## 2 Event set

To investigate the impact of asset purchase programmes on the exchange rate, I start by constructing an event set on asset purchase programme announcements covering seven advanced economies (AEs) and 23 emerging market economies (EMs) between March 2020 and August 2021. Most event dates are sourced from central bank websites, with detailed information provided in the Appendix H. Subsection 2.1 outlines the selection criteria, while subsection 2.2 discusses the country coverage. Finally, subsection 2.3 presents the summary statistics, highlighting key characteristics of the event set.

### 2.1 Selection criteria

The event set for this study includes announcements of asset purchase programmes made between March 2020 and August 2021. The hand-collected data is sourced from the official central bank website of the respective country and validated against previous studies in the literature (Fratto, Vannier, Mircheva, de Padua, & Ward, 2021; Rebucci et al., 2022). The details of the event set are reported in the Appendix H.

The event set begins in March 2020, marking the first month central banks started announcing asset purchase programmes. The endpoint is determined by the announcements by central banks on reductions in asset purchases, particularly in the third and fourth quarters of 2021. A closer examination of these announcements led to setting the cut-off date at August 24, 2021, coinciding with Hungary's decision to end its government securities purchase programme, the first scale-back among the sample countries. This cut-off date excludes two event dates for India, where APP announcements occurred after August 24, 2021. While these dates are included in the descriptive statistics, they are excluded from the regression analysis, which remains robust.

The definition of events is driven by whether they reveal new or additional information about the asset purchase programme. Specifically, the selection criteria include announcements regarding (i) the purchase of securities for the first time, whether they are government or private bonds; (ii) extensions of the existing programme, such as increases in the scale or introduction of a new type of security to the asset purchase programme; (iii) new information about the programme, including specifying the scale and details of the existing programme which were previously ambiguous; and (iv) simultaneous sale and purchase of securities, where the purchase amount is greater than the sale amount.[10]

Conversely, the criteria used for the exclusion of event dates include announcements regarding (i) the continuation of an already existing purchase programme with the same size and type of instruments; (ii) simultaneous purchase and sale of securities where the amounts for purchases and sales are the same; and (iii) scale-backs in purchases, where the scale of the programme is reduced or the pace of the purchases is slowed down.

To illustrate the exclusion criteria, consider the announcement by the Riksbank on 10/20/21. It announced that purchases of commercial paper will be made every second week instead of once a week. Since it is considered a scale-back of the purchases where the frequency of purchases is reduced, 10/20/21 is excluded from the event set. The main idea is that if no new information is released with the announcement or if there is an indication that the pace of the purchases is reduced, this particular date is not included.[11]

One unique aspect of the event set is its inclusion of simultaneous policy announcements made on the same day as the APP announcement. If an event meets the inclusion criteria, I also examine any simultaneous policy announcements, classifying them into five categories: foreign exchange intervention (FXI), swap agreements, repo operations, measures targeting the banking sector or corporate sector, and policy rate decisions.[12] If there is an introduction, extension, or expansion of one of these additional policy measures, I include them in my event set. Including these simultaneous policy announcements allows me to isolate the country-specific effect of pure APP announcements on the exchange rate.

### 2.2 Country coverage

The event set covers a diverse group of countries to provide a comprehensive analysis. Specifically, it includes 23 emerging market economies (EMs), including six Asian economies and seven major advanced economies (AEs) for comparison.

The set of AEs in the sample matches the set used in previous studies, which consists of Australia, Canada, the Euro Area (ECB), Japan, New Zealand, the United Kingdom, and Sweden. The set of EMs covered in the analysis includes Brazil, Chile, China, Colombia, Croatia, Egypt, Ghana, Hungary, Indonesia, India, Israel, Jamaica, Korea, Mexico, Mauritius, Philippines, Poland, Romania, Serbia, South Africa, Thailand, Turkey, and Uganda.[13]

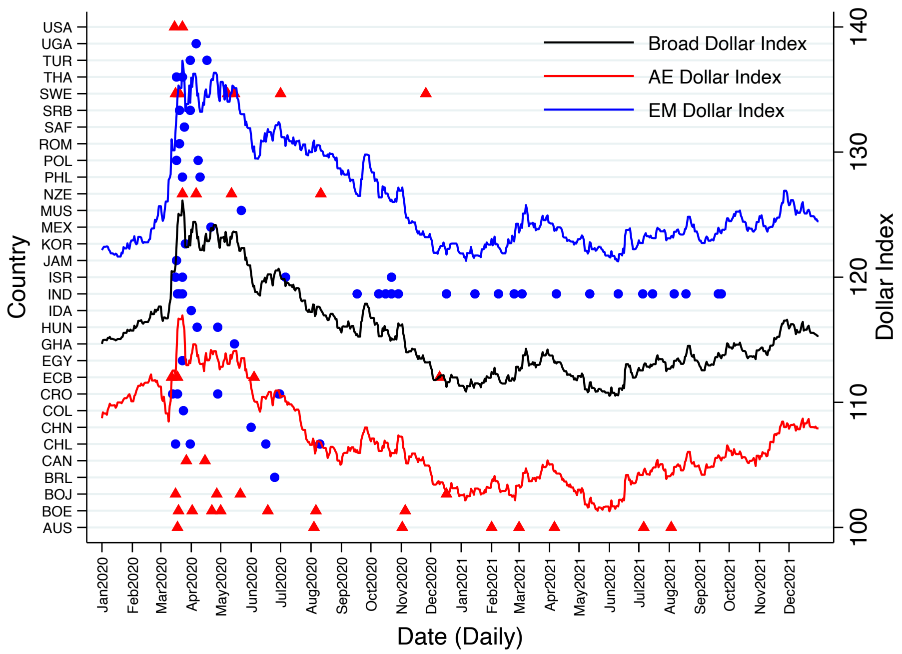
[10] For an illustration of the third point, consider Sweden's announcement on 5/8/20. India exemplifies the scenario discussed in the fourth point. For more detailed descriptions, refer to Appendix H.

[11] An analysis with a larger set of events is discussed in Section 5.3.

[12] The only explicit FXI coinciding with an APP announcement was the intervention by Croatia on March 13, 2020. However, this does not imply that it was the only FXI instance in the sample, but it is the only one that coincided with an APP announcement. Relevant examples of repo operations include reverse repo operations, the introduction of new maturities in repo operations, repurchase agreements with the U.S., and the expansion of repo operations to corporate bonds.

[13] I classify Israel and Korea as EMs following the classification used by the Federal Reserve in calculating the Emerging Market Economies Dollar Index.

Figure 1: Asset purchase programme announcements and the Dollar Index




The figure shows APP announcement dates for all countries in the sample between 2020-2021 and the Dollar indices, where an increase is a dollar appreciation. Red triangles denote AEs, and blue circles denote EMs.

Figure 1 shows the number of APP announcements for each country between 2020-2021. A key difference between AEs and EMs is the frequency of these announcements. AEs typically have more frequent updates, likely due to their preference for gradual implementation and greater transparency compared to EMs. An exception to this trend is India, which also frequently announced updates on its asset purchase programmes.[14]

### 2.3 Summary statistics

The dataset comprises a total of 98 events, including 60 observations from EMs and 38 from AEs. Table 1 presents the summary statistics for these events. The classification of events in Table 1 also includes expansions of purchase programmes. For example, if an expansion involves corporate bonds in addition to government bonds, it is classified as "private" only if no new information about government securities is provided. If the announcement contains information about purchases of both government bonds and corporate bonds, then the event is categorised under both. This method ensures clarity in distinguishing the types of securities involved in the announcements.

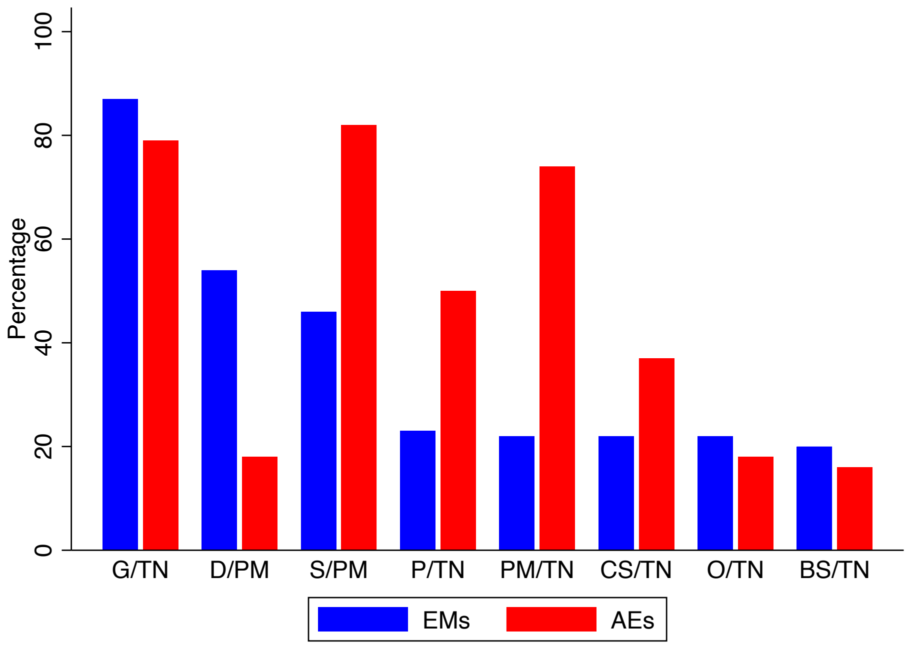
[14]Figure 1 also demonstrates that accounting for the Fed's policy actions is crucial, where the initial appreciation of the dollar at the onset of the COVID-19 pandemic is followed by a depreciation of the Dollar indices immediately after the APP announcements by the Fed. This sequence underscores the significant impact of the Fed's interventions on global markets, necessitating careful consideration of Fed policy actions when analysing the effects of country-specific APPs, which will be discussed in detail in Section 3.4.

Table 1: Summary statistics for APP announcements

| | EMs | AEs |
|---|---|---|
| Total Number of Events (TN) | 60 | 38 |
| Total Number of Policy Meetings (PM) | 13 | 28 |
| Decrease in Rate (D) | 7 | 5 |
| Same Rate (S) | 6 | 23 |
| Amount Announced | 49 | 34 |
| Government Purchases (G) | 52 | 30 |
| Private Purchases (P) | 14 | 19 |
| Corporate Sector Measures (CS) | 13 | 14 |
| Banking Sector Measures (BS) | 12 | 6 |
| FXI | 1 | 0 |
| Repo Operation | 8 | 3 |
| Swap | 4 | 4 |

The table shows the summary statistics for APP announcements and the accompanying events for EMs and AEs.

Figure 2: Summary statistics on simultaneous policy announcements




The figure shows the relevant ratios for comparing the characteristics of the APP announcements and accompanying events. O represents other events, which are the sum of FXI, repo operations, and swap agreements as defined in Table 1. D indicates the policy meetings on the announcement day where a reduction in the policy rate occurred, and S stands for those meetings where the policy rate remained constant. G denotes APP announcements that involved purchases of government bonds, whereas P represents purchases of private bonds. CS identifies policy measures aimed at the corporate sector, and BS refers to measures directed towards the banking sector. It should be noted that the ratios for specific country groups, such as EMs or AEs, may not sum to 1 due to the possibility of multiple events occurring on the same date.

Figure 2 shows the relevant statistics to compare the characteristics of the APP announcements between EMs and AEs. It shows that 22% of APP announcements in EMs are accompanied by a policy announcement, compared to 74% in AEs. This discrepancy arises because EMs often made policy decisions in separate meetings that did not necessarily reveal information about policy rates. Approximately half of these dates in EMs involve rate cuts, whereas only 18% do so in AEs. This is because policy rate cuts in AEs had either been made earlier or were constrained by the zero lower bound, while EMs had more room to reduce rates before the pandemic. For both EMs and AEs, the majority of purchases (87% and 79%, respectively) are government bonds or securities.

In terms of private securities, EMs have fewer instances of purchases of private securities (23%) as compared to AEs (50%). Approximately 30% of AE events involve simultaneous announcements of government and private securities, while this ratio is only 10% for EMs. This is because APPs in EMs typically begin with government bonds and later expand to other securities.[15] These descriptive statistics clearly underscore the importance of accounting for simultaneous policy announcements on the day of the APP announcement in the event study analysis, which will be discussed in the following section.

# 3 Event study

This section outlines the methodology used to measure asset purchase surprises and their impact on the bilateral dollar exchange rate, and reports the main results. Section 3.1 presents the methodology. Section 3.2 focuses on the measurement of asset purchase surprises. Section 3.3 presents the baseline results. Section 3.4 discusses the confounding factors and the steps taken to ensure proper identification of asset purchase surprises. Section 3.5 reports the results that include these confounding factors.

## 3.1 Methodology

Event studies are frequently used in the literature for investigating the effects of APPs on financial market variables (Kuttner, 2018; Kekre & Lenel, 2023), where the underlying assumption is that financial markets are efficient. This assumption implies that the impact of an announcement will be reflected in asset prices immediately.

The efficient market hypothesis implies that all of the impact on asset prices is observed when information is revealed, rather than at the time of the actual transaction. Another implication is that the short-term impact of the announcement approximates its long-term impact. It is also important to note that the efficient market hypothesis does not rule out the possibility that risk premia may vary, leading to differences between short-term and long-term effects. However, event study methodology typically assumes that these effects are closely aligned. These considerations are relevant regardless of the specific channels through which asset purchase programmes influence financial or macroeconomic variables.

An alternative method is the vector autoregression (VAR) approach, but it presents challenges, especially in the context of COVID-19 pandemic. One main challenge is the

[15] Some exceptions include Brazil, Chile, Egypt, and Korea, where APPs started and continued with private securities. An interesting case is Chile, where of the four event dates, only the last one includes government bond purchases.

identification of shocks. The VAR approach requires a variable to proxy asset purchases, where the balance sheets of central banks are often used in the literature (Dedola et al., 2021). However, this can be problematic in EMs, where countries such as Poland, South Africa, and Croatia have reported conducting sterilised purchases to avoid expanding their central bank balance sheets. This poses difficulties in accurately identifying APP shocks in these markets, where misidentification can lead to incorrect conclusions about the impact of APPs. Another limitation of a VAR is that it captures the effects of policy implementation rather than the announcement. My study aims to capture the announcement effect, making event studies a more suitable approach.

Event studies also address another issue in other traditional approaches, which use a binary event dummy to differentiate between announcement dates from other dates. The problem with the binary event dummy is that it fails to differentiate between announcements that exceed, meet, or fall short of expectations. By focusing on high-frequency data, event studies can measure the magnitude of surprises in policy announcements. This not only allows for isolating the unexpected components that drive changes in asset prices (Kuttner, 2001) but is also consequential in comparing the exchange rate impact of asset purchase surprises in EMs and AEs.

### 3.2 Extracting asset purchase surprises

To capture the effects of APP announcements, it is crucial to distinguish between expected and unexpected components, as it is hard to tell what is expected and what is not expected by examining the announcement itself alone. To this end, I apply a two-step methodology where I first isolate the unexpected component of APP announcements and then examine its impact on the exchange rate.

To extract asset purchase surprises, I first estimate a regression where the change in 10-year government bond yields is regressed on the change in short-term government bond yields of the respective country around the asset purchase programme announcements. The estimated regression is given below in (1).

$$\Delta i_{i,t}^{LT} = \alpha \Delta i_{i,t}^{ST} + \varepsilon_{i,t} \qquad (1)$$

where $\Delta i_{i,t}^{LT}$ is the change in the 10-year government bond yields in basis points and $\Delta i_{i,t}^{ST}$ is the change in the short-term government bond yield in basis points for country $i$ at date $t$, where $t$ corresponds the APP announcement date for country $i$. The maturity for the short-term rate varies from 3 months to 1 year, depending on the data availability across countries. The details on the specific maturity used for each country can be found in Appendix E.

All variables are computed over the same window, corresponding to the 1-day before and 1-day after change around the asset purchase programme announcement. Given the cross-country differences in market trading hours, I use a 1-day before and 1-day after announcement window to ensure sufficient response time for the variable of interest rather than the narrowest window possible that is typically used in the identification of monetary policy shocks in the U.S. This window not only accommodates the time differences and overlapping trading hours between the U.S., Europe, and Asia, but also accounts for the slower diffusion of information in EMs allowing for a departure from the efficient market hypothesis.

All regressions are based on pooled data, where I categorised countries into EMs and AEs. This choice is driven by the limited number of announcements during 2020-2021. Running separate regressions for each country would result in a sample size that is too small, given the short period and the novelty of APPs in EMs. Pooled data, on the other hand, leverages heterogeneity and provides more precise estimates.

As a measure of conventional monetary policy surprises, I use changes in short-term government bond yields as in Zettelmeyer (2004). The underlying argument is that these yields mirror the policy targets set by policymakers for the near future, yet long enough to react only to unexpected changes in the policy rate. Other variables commonly used for monetary policy surprises include federal funds futures (Kuttner, 2001) and overnight index swap (OIS) rates (Lloyd, 2018). However, futures contracts are not consistently available for EMs.[16]

This methodology is closely related to Rogers et al. (2018). The key difference is that they use intraday data and futures contracts to extract monetary policy surprises for the U.S., which is not uniformly available for all EMs in the sample. Different from their analysis, I do not include forward guidance as a control variable, as it is of lesser significance for EMs.[17]

Residuals from (1) capture the asset purchase surprises around the APP announcements. A negative value is interpreted as an easing surprise. The intuition is that residuals, $\widehat{\varepsilon_{i,t}}$, will provide the variation in long-term government bond yields beyond the short-term government bond yields via the expectations channel. Focusing on a small window ensures that any surprise coming out from the announcement is almost by construction is an asset purchase shock. The exclusion restriction, which assumes that no other news was released during that window, allows us to make a causal statement on the effect of asset purchases.[18]

Second, equipped with a measure for asset purchase surprises, I regress the changes in the bilateral dollar exchange rate on the asset purchase surprises proxied by the residuals from (1). The estimated regression is given below in (2).

$$\Delta e_{i,t} = \beta \widehat{\varepsilon_{i,t}} + u_{i,t} \tag{2}$$

where $\Delta e_{i,t}$ is the percentage change in the bilateral exchange rate calculated as 100 times the log difference in the bilateral exchange rate of the domestic currency with respect to the U.S. dollar for country $i$ at date $t$. An increase in the exchange rate represents an appreciation of the U.S. dollar. $\widehat{\varepsilon_{i,t}}$ is the residuals derived from regression (1) around the asset purchase announcement dates. All regressions are estimated without an intercept, based on the premise that asset prices should remain unchanged in the absence of surprises within small windows.

[16] An exception is Solís (2023), where swap rates are used to measure monetary policy surprises in Mexico.

[17] The results are robust to accounting for forward guidance. The discussion can be found in the robustness analysis section, and the results are in Appendix C.

[18] There are instances where other policy announcements accompany announcements on asset purchase programmes. This is addressed in the subsection 3.4 discussing confounding factors.

### 3.3 Baseline results

The coefficient of interest is $\beta$ in regression (2). Table 2 reports OLS estimation results from regression (2). Since asset purchase surprises are estimated variables, the standard errors are subject to the generated regressors problem (Pagan, 1984). Therefore, to ensure robust and reliable inference, I employ bootstrapped standard errors across all regressions.

Specifically, to address this issue, I employ pairs bootstrapping for the standard errors (Freedman, 1981). I draw random samples with replacement from the original data, perform regression (1) with the resampled data to obtain residuals, and then perform regression (2) with the new residuals. I store the coefficients from each replication and calculate their standard errors by taking the standard deviation of these coefficients. This method ensures consistent resampling across variables, where I resample the data instead of the residuals.

When observations are selected from the entire dataset, some countries can become underrepresented or overrepresented in the samples. To address this issue, I employ a stratification procedure based on countries. This approach ensures that observations are picked with a replacement from within each country, thereby maintaining the same proportions of subgroups as in the original data. Without stratification, the resulting samples may not accurately reflect the original proportions of the subgroups.

In my baseline analysis, I consider two different sets of events: (i) event set consisting of purchases of government bonds, which can also be accompanied by the purchases of private securities (Gov. & Private), and (ii) event set consisting purchases of government bonds only (Gov. only). Any announcement that had both purchases of private and government securities is included in the former group, but not in the latter group. This means that the former group includes events when there are private and government purchases, but excludes the ones with only private purchases.

Table 2 shows that the $\beta$ coefficient is positive and significant for both sets of events and countries. For both sets of countries and both groups of events, asset purchase surprises during the pandemic appreciate the currency.

Table 2: Baseline results for the exchange rate

| | **EMs** | | **AEs** | |
|---|---|---|---|---|
| | **Gov. & Private** | **Gov. only** | **Gov. & Private** | **Gov. only** |
| $\beta$ | 0.016*** | 0.011*** | 0.055*** | 0.055*** |
| | (0.002) | (0.004) | (0.012) | (0.021) |
| N | 50 | 44 | 28 | 19 |
| $R^2$ | 0.177 | 0.083 | 0.413 | 0.391 |

This table shows the coefficient estimates from regression (2). The results are divided into two parts Gov. & Private, and Gov. only, respectively. The results are reported separately for AEs and EMs. Bootstrapped standard errors are reported in parentheses. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively.

The coefficient in AEs is much bigger than in EMs, and I justify it in two ways. First, when taking into account the average change in the long-term government bond yields around APP announcements and interpreting the coefficients accordingly, then, in fact, the impact of the exchange rate is comparable. The average change in long-term government bond yields is approximately -10 basis points in EMs and 2 basis points in AEs. Consequently, a policy easing that lowers bond yields by 10 basis points in EMs and 2 basis points in AEs results in an approximately 0.1 percentage point decrease in the exchange rate. Second, asset purchase surprises in EMs are likely to be contaminated by higher credit risk as compared to AEs, so it is not surprising that for AEs, per unit of a change in APSs has a bigger effect compared to that of EMs.

A key finding of this analysis is that the $\beta$ coefficient contradicts the sign reported in previous literature on APPs by AEs. This raises the question of whether the appreciation of the exchange rate is an artifact of the methodology. Table 3 presents estimation results for the ECB, BoE, BoJ, and a pooled event set, covering all APP announcements from 2007-2017.[19] Although the coefficients are statistically insignificant except for the ECB, at the country level, they are all negative, aligning with prior findings of exchange rate depreciation following APPs.

Table 3 also shows that when the announcement made on January 19, 2009 by BoE is excluded, the coefficient becomes significant, as reported in the last column. On January 19, 2009, BoE announced its plan to purchase high-quality private sector assets, including commercial paper and corporate bonds. Excluding this observation reveals that the insignificance of the coefficient is largely attributable to the credit risk inherent in these securities, which aligns with the focus of this paper on the role of credit risk in driving the results for EMs, as discussed in the following section.

Table 3: Post-GFC analysis for AEs using daily data

| | **ECB** | **BoE** | **BoJ** | **Pooled** | **Pooled**$^{\dagger}$ |
|---|---|---|---|---|---|
| $\beta$ | -0.067** | -0.008 | -0.074 | -0.027 | -0.046* |
| | (0.03) | (0.064) | (0.072) | (0.028) | (0.024) |
| N | 33 | 17 | 28 | 78 | 77 |
| $R^2$ | 0.183 | 0.005 | 0.046 | 0.033 | 0.104 |

The table shows the coefficient estimates from regressions (2) for ECB, BoE, and BoJ, separately and for the pooled dataset for the pre-COVID period. Bootstrapped standard errors are reported in parentheses. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively. The column "Pooled$^{\dagger}$" represents the pooled sample where one outlier from BOE is dropped.

This result is important for two reasons. First, it suggests that the transmission of the asset purchase programmes to the exchange rate during the pandemic may be different. Second, it also shows that when the same methodology is used for the GFC era, I obtain the same results as the literature, suggesting that the methodology is not biasing the results. Specifically, this finding aligns with Greenwood et al. (2023), who analysed QE announcements in the U.S., Eurozone, U.K., and Japan, showing that a 1 percentage point reduction in the foreign long-term forward rate leads to a 4.3 percentage point currency depreciation—results similar to the ones reported in the last column of Table 3.

[19] Further details and dates are provided in Appendix G.

### 3.4 Confounding factors and the multidimensionality of the Fed policy

Identifying asset purchase surprises through high-frequency event studies during the pandemic presents significant challenges. Three key elements likely to confound this identification are particularly relevant. First, the announcements made by each country during the pandemic might coincide with those made by the Federal Reserve (Fed). Second, policymakers often announced different policy interventions simultaneously, meaning that information about asset purchase programmes is frequently accompanied by other policy actions. Third, the monetary policy actions of other major AEs could also influence the monetary policy of EMs, adding another layer of complexity to the analysis.

I account for the Fed policy actions through a factor analysis where I extract factors reflecting different dimensions of monetary policy by the Fed as in Gürkaynak et al. (2004), Altavilla et al. (2019), and Swanson (2021). To this end, I extend the information set in Swanson (2021) with treasury covered interest rate parity (CIP) deviations in EMs and AEs. I use n-year CIP deviations between the government bond yields in the U.S. and country $i$ defined by Du, Im, and Schreger (2020) as follows:

$$\Phi_{i,n,t} = y_{i,n,t}^{Govt} - \rho_{i,n,t} - y_{USD,n,t}^{Govt} \tag{3}$$

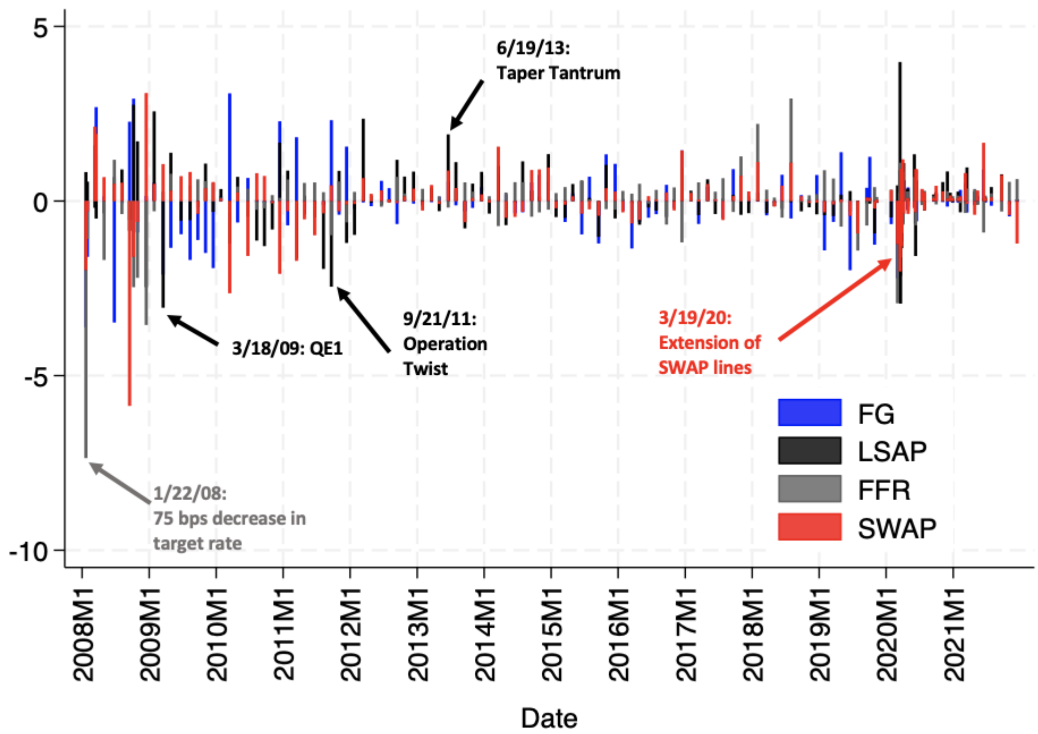
where $y_{i,n,t}^{Govt}$ is the n-year local government bond yield in country $i$, $\rho_{i,n,t}$ is the n-year market-implied forward premium for hedging currency $i$ against the U.S. dollar and $y_{USD,n,t}^{Govt}$ is the n-year U.S. Treasury bond yield. For the factor analysis, I use 5-year maturity bonds, where I collect the data from Bloomberg. The choice of 5-year maturity bonds is driven by their higher liquidity compared to other maturities. The definitions for the forward premium and the data sources are from (Du & Schreger, 2016), where I extend the dataset to cover 2020-2021. The details and the country coverage can be found in Appendix E.3.

Extending the information set with CIP deviations is motivated by two characteristics of the post-GFC period and the pandemic. As noted by Du, Im, and Schreger (2018), CIP deviations emerged post-GFC and still persist. Furthermore, during both the GFC and the pandemic, the Fed addressed dollar liquidity shortages through the introduction and expansion of the swap lines, which have been shown to place a ceiling on CIP deviations (Bahaj & Reis, 2022). Therefore, incorporating CIP deviations into the information set is crucial in capturing two aspects of the post-GFC period.

This results indicate the need for four factors to fully capture the dimensionality of the dataset in contrast to Swanson (2021), which identified only three dimensions of Fed monetary policy. The factors are (i) forward guidance factor (FG), (ii) large scale asset purchase factor (LSAP), (iii) federal funds rate factor (FFR), and (iv) SWAP factor. Details on the factor analysis can be found in Appendix A.

Each factor is named based on its correlation with an observable variable in the information set. The first factor is the forward guidance factor (FG), which has a relatively high correlation with Eurodollar futures contracts, known to measure financial market expectations. The second factor, with high correlations to variables related to treasury yields, captures expectations over the long end of the yield curve and is thus called the large scale asset purchase factor (LSAP), reflecting its impact on long-term yields. The third factor, where the third Federal funds rate futures contract has the highest correlation among other variables, is interpreted as the federal funds rate factor (FFR). Finally, the fourth factor is highly correlated with the variable related to CIP deviations, which are used as a proxy for liquidity lines. Hence, it is interpreted as the SWAP factor.

Figure 3: Fed policy factors over time




The figure shows the Fed policy factors over time between 2008-2021. Note: the figure is colour-coded where blue denotes the forward guidance (FG) factor, black denotes the large-scale asset purchase (LSAP) factor, gray denotes the federal funds rate (FFR) factor, and red denotes the SWAP factor. The y-axis is in standard deviations.

Figure 3 illustrates the Federal Reserve policy factors over time, highlighting their alignment with key announcements. For example, a score of -5 for the FFR factor indicates that, at that moment, the FFR factor is 5 standard deviations below the average, reflecting a significant decline in the federal funds rate.

The key takeaway from Figure 3 is that the SWAP factor shows comparable variation, particularly up until the end of 2012. Its significance resurfaced during the pandemic when the Fed extended its swap lines to address the global dollar liquidity shortage. Notably, one of the largest changes in the SWAP factor during the pandemic coincides with the extension of swap lines with several other central banks on March 19, 2020, which is effectively captured by the analysis.[20] The relatively larger changes in the SWAP factor during the post-GFC period, compared to those seen during the pandemic, can be explained by the fact that the swap lines were already in place and expected to be expanded if needed during the pandemic, whereas their introduction during the GFC came as a complete surprise. Additionally, there were more frequent swap-related announcements during the

[20] On March 15, 2020, the Federal Reserve announced both APPs and a coordinated central bank action on its swap lines. The analysis effectively captures these announcements, as evidenced by a larger change in both the LSAP factor and the SWAP factor compared to the other two factors.

pandemic, while such announcements were less frequent following the 2008 crisis.

Another variable likely to confound the causal interpretation of the effect of asset purchase programmes is the simultaneous policy announcements on the day of the APP announcement, as highlighted in Figure 2. This is captured by a variable that is the sum of the number of simultaneous policy announcements made by the country on the date of the APP announcement. These events consist of (i) a policy rate cut announcement, (ii) an announcement targeting the corporate sector, (iii) an announcement targeting the banking sector, and (iv) FXI, Repo, and Swap announcements. For each APP announcement date, when there is such an announcement, the defined variable takes the value "1,", and if there are multiple events on the same date, the sum is recorded in the final value of the defined variable.

Actions by other major AE central banks may also confound the identification of asset purchase surprises in EMs. To address this issue, I include a control variable defined as the average change in short-term interest rates for all other major AEs around the announcement dates. Although one could consider the actions of each AE central bank separately, I account for them with a single variable to contain dimensionality. This approach helps to capture the conventional monetary policy decisions of other AEs.

## 3.5 Results from the regressions accounting for confounding factors

Equipped with these measures, I account for the confounding factors in the first stage of the analysis with the following regressions.

$$\Delta i^{LT}_{EM,t} = \alpha \Delta i^{ST}_{EM,t} + \beta D_t F^{Fed}_t + \gamma \Delta i^{AE,ST}_t + \delta D_{EM,t} + \varepsilon_{EM,t} \tag{4}$$

$$\Delta i^{LT}_{AE,t} = \alpha \Delta i^{ST}_{AE,t} + \beta D_t F^{Fed}_t + \delta D_{AE,t} + \varepsilon_{AE,t} \tag{5}$$

where $\Delta i^{LT}_{EM,t}$ ($\Delta i^{LT}_{AE,t}$) is the change in long-term government bond yields in basis points, $\Delta i^{ST}_{EM,t}$ ($\Delta i^{ST}_{AE,t}$) is the change in short-term government bond yields in basis points for EMs (AEs), both around APP announcement dates. $D_t$ is a dummy equal to 1 if there is an announcement on that day $t$ by the Fed, and 0 otherwise. $F^{Fed}_t$ is the set of extracted factors from the four factor model described in the previous section for the corresponding date $t$ for the EM or AE. $\Delta i^{AE,ST}_t$ is the average of the change in short-term interest rates in other major AEs considered in the analysis at date $t$. $D^{EM}_t$ ($D^{AE}_t$) is a variable which is calculated as the sum of the number of simultaneous announcements that have been made on the same date as the APP announcement for the corresponding EM (AE) itself.[21]

One could also control for the confounding variables on the second stage regression given in (2). However, given that I constructed the asset purchase surprises to be orthogonal to these confounding variables, including them in the second stage would not change the coefficient estimate of $\beta$ in (2). Additionally, since the goal is to extract a clean measure for the asset purchase surprise for the domestic APP of the countries, I account for the confounding factors in the first stage and then look into how they affect the exchange rate.

Then, I re-estimate regression (2) where the coefficient of interest $\beta$ is reported in

[21] The results remain robust when this variable is replaced with a dummy of 0 or 1 indicating whether there is another policy announcement on the same day as the APP announcement.

Table 4. Table 4 confirms the finding in Table 2 on the significant and positive coefficient for asset purchase surprises for EMs. The magnitude of the estimates increased slightly with the inclusion of control variables. A policy easing that decreases the long-term yields by 10 basis points leads to a 0.17 to 0.23 percentage points decrease in the dollar exchange rate after controlling for confounding factors, including Fed policy factors.[22]

Table 4: Regression results with confounding variables

| | **EMs** | | **AEs** | | |
|---|---|---|---|---|---|
| | **Gov. & Private** | **Gov. only** | **Gov. & Private** | **Gov. only** | **Gov. only**† |
| $\beta$ | 0.023*** | 0.017*** | 0.041 | 0.109*** | 0.063 |
| | (0.003) | (0.004) | (0.037) | (0.038) | (0.039) |
| N | 50 | 44 | 28 | 19 | 18 |
| $R^2$ | 0.279 | 0.156 | 0.038 | 0.138 | 0.078 |

The table shows the coefficient estimates from regression (2), where the asset purchase surprises are extracted as residuals from (4) and (5) for EMs and AEs, respectively. The results are divided into two parts as Gov. & Private, and Gov. only, respectively. The results are reported separately for AEs and EMs. Bootstrapped standard errors are reported in parentheses. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively. "Gov. only†" represents the set of observations excluding the announcement by the ECB.

While the appreciation effect remains statistically significant for EMs, the coefficient for AEs loses its significance when confounding factors are included. The robustness of the exchange rate appreciation for EMs is confirmed by dropping one observation at a time. Notably, excluding the ECB announcement from the event set in AEs, as shown in the last column of Table 4, renders the coefficient statistically insignificant. One possible interpretation is that the observed appreciation in AEs is driven by the credit risk heterogeneity across European Monetary Union (EMU) countries. For instance, the ECB's 3/18/2020 announcement, which included a waiver for the eligibility requirements of Greek government securities under the Pandemic Emergency Purchase Programme (PEPP), highlights the variation in sovereign credit risk within the Eurozone, potentially influencing the significance of the coefficient.[23]

[22]For comparison, Rogers et al. (2014) finds that a 50 bps increase in 10-year U.S. yields due to a policy shock results in a 2 percent depreciation of the euro—an effect approximately twice the magnitude observed in EMs during the COVID era. For Mexico, Solís (2023) reports a similarly large impact on the exchange rate in response to conventional monetary policy surprises, though both studies document exchange rate responses in the opposite direction of my findings for EMs in this paper.

[23]The PEPP, introduced in response to the COVID-19 pandemic, differs from the ECB's regular APP in that it provides more flexibility in the timing and allocation of asset purchases across countries.

Table 5: Regression results (3-factors)

| | EMs | | AEs | |
|---|---|---|---|---|
| | **Gov. & Private** | **Gov. only** | **Gov. & Private** | **Gov. only** |
| $\beta$ | 0.021*** | 0.015*** | 0.054** | 0.051 |
| | (0.002) | (0.003) | (0.026) | (0.041) |
| N | 50 | 44 | 28 | 19 |
| $R^2$ | 0.264 | 0.097 | 0.199 | 0.075 |

The table shows the coefficient estimates from regression (2) where the asset purchase surprises are extracted as residuals from (4) and (5) for EMs and AEs, respectively. The analysis accounts for the multidimensionality of Fed policy actions using three factors with the same information set in Swanson (2021). The results are divided into two parts as Gov. & Private, and Gov. only, respectively. The results are reported separately for AEs and EMs. Bootstrapped standard errors are reported in parentheses. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively.

A more nuanced understanding emerges when confounding factors, particularly the SWAP factor reflecting Federal Reserve policy actions, are incorporated into the analysis. A comparison of Table 5 with Table 4 underscores the importance of considering the fourth dimension of Fed policy actions. When only three dimensions are considered, the controversial result of exchange rate appreciation remains for AEs, as indicated by the positive and significant coefficient in Table 5. However, once the SWAP factor is included, providing a cleaner measure of asset purchase surprises, the significance disappears for AEs. This adjustment not only helps interpret the puzzle for AEs in initial findings but also confirms the robustness of the results for EMs, thereby highlighting the differences between these two groups of countries.

# 4 Interpreting the results

This section explores the differences in exchange rate response to asset purchase surprises between EMs and AEs through the lens of the long-run uncovered interest rate parity (LR-UIP) deviations. I focus on two key factors contributing to deviations from LR-UIP: (i) convenience yields (Jiang, Krishnamurthy, Lustig, & Sun, 2021), and (ii) sovereign credit risk (Du & Schreger, 2016).

Section 4.1 motivates the explanation of the results with deviations from LR-UIP. Section 4.2 provides a no-arbitrage asset pricing framework under incomplete markets incorporating sovereign credit risk. Section 4.3 presents empirical evidence on the mechanism.

## 4.1 Deviations from long-run uncovered interest rate parity

Uncovered interest rate parity (UIP) posits that the expected change in the exchange rate equals the interest rate differential between two countries. Specifically, the long-run UIP (LR-UIP) states that the difference between $k$-year interest rates in two countries should match the expected change in the exchange rate over the same $k$-year horizon, where $k$ typically spans several years.[24] This relationship is consistently rejected with short-term

[24]Going forward, LR-UIP will refer to this specific definition unless stated otherwise. In the model discussed in Section 4.2, I differentiate between a long-term bond held for a single period and one held

interest rates, while evidence supports its validity for long-term interest rates in AEs in various studies (Meredith & Chinn, 1998; Chinn, 2006; Lustig et al., 2019).

Consistent with this empirical evidence, state-of-the-art models of exchange rate, such as those by Greenwood et al. (2023) and Gourinchas et al. (2025), assume that long-run uncovered interest parity (LR-UIP) holds, for AEs. These models, featuring mean-variance global bond investors, reconcile with the conventional finding that long-term bond purchases tend to depreciate the local currency in AEs. This outcome hinges on the bond term premium offsetting the foreign exchange (FX) risk premium (Lustig et al., 2019), implying that in the long run, exchange rate movements are primarily driven by fundamentals, thereby aligning with UIP at longer maturities.

However, these models fail to account for the appreciation of the exchange rate following an asset purchase programme, as observed in my findings for EMs. This limitation arises from their assumption that LR-UIP holds. According to these models, exchange rate appreciation from an APP would require U.S. short-term rates to respond more than one-to-one to EM short rates—a scenario not supported by empirical evidence. This discrepancy suggests the need for a different approach to understand the exchange rate dynamics in EMs.

Empirical evidence from Rebucci et al. (2025) shows that UIP is rejected in the long run for a set of EMs from 2000 to 2023.[25] This observation prompts two key questions. First, can deviations from LR-UIP explain the exchange rate appreciation in EMs due to APPs? Second, what factors drive these deviations from LR-UIP in EMs that APPs influence, resulting in different exchange rate effects compared to AEs? Accordingly, to address this gap, I propose a simple no-arbitrage asset pricing framework with incomplete markets that introduces deviations from LR-UIP by incorporating convenience yields and sovereign credit risk.

## 4.2 No-arbitrage asset pricing framework with incomplete markets

My conjecture is that the transmission of APPs to exchange rates in EMs operates primarily through their impact on sovereign credit risk. To explore this hypothesis, I develop a no-arbitrage asset pricing framework with incomplete markets, detailed in Appendix B. This model integrates key concepts from Jiang, Krishnamurthy, and Lustig (2021), Du and Schreger (2016) and Corsetti et al. (2023).

Specifically, Jiang, Krishnamurthy, and Lustig (2021) develop a theory of exchange rates incorporating convenience yields, while Corsetti et al. (2023) introduces a term structure for the convenience yields. Additionally, Du and Schreger (2016) examines the role of sovereign credit risk in deviations from covered interest rate parity (CIP). My framework synthesises these elements by combining sovereign credit risk, multi-period bonds, and convenience yields into a cohesive no-arbitrage asset pricing framework with incomplete markets, providing a more comprehensive understanding of how APPs influence exchange rates in EMs.

The model considers a two-country setting: the U.S. ($) and a foreign country (*). Representative investors in each country trade zero-coupon bonds of various maturities

until maturity.

[25] The empirical evidence in Rebucci et al. (2025) is built upon the definition presented in the main text.

$k = 1, 2, ..., \infty$, issued by both the U.S. and the foreign economy. The nominal exchange rate, $S_t$, denotes the foreign currency per dollar, where an increase indicates an appreciation of the U.S. dollar.

Define $y_t^{\$}$ as the nominal yield on a single-period risk-free zero coupon U.S. Treasury bond denominated in U.S. dollars. Similarly, $y_t^*$ is the nominal yield on a single-period risk-free rate on a zero coupon foreign government bond denominated in foreign currency. The stochastic discount factors for the U.S. and foreign investors are denoted by $M_t^{\$}$ and $M_t^*$, respectively.

In addition to receiving a pecuniary return at maturity in local currency units, investors also earn a non-pecuniary return from investing in sovereign bonds, known as convenience yields. The convenience yield attached by investor $i$ to the bond issued by country $j$ is denoted as $\lambda_t^{j,i}$. Foreign investors differ from U.S. investors in that they attach different convenience yields to foreign and U.S. government bonds.

Next, I assume that foreign bonds are subject to sovereign credit risk, unlike U.S. Treasuries (Du & Schreger, 2016).[26] I model sovereign credit risk with the term $L_{t+1}^{*,*}$.[27] This is defined as the sovereign credit risk on the foreign-issued bond denominated in foreign currency. I derive the pricing conditions for bonds and the exchange rate under the no-arbitrage condition, incorporating convenience yields and sovereign credit risk. With these definitions, Euler equations for foreign and U.S. investors are given by (6) - (7) and (8) - (9), respectively.

$$E_t\left(M_{t+1}^* e^{y_t^* + L_{t+1}^{*,*}}\right) = e^{-\lambda_t^{*,*}} \tag{6}$$

$$E_t\left(M_{t+1}^* \frac{S_{t+1}}{S_t} e^{y_t^{\$}}\right) = e^{-\lambda_t^{\$,*}} \tag{7}$$

$$E_t\left(M_{t+1}^{\$} e^{y_t^{\$}}\right) = e^{-\lambda_t^{\$,\$}} \tag{8}$$

$$E_t\left(M_{t+1}^{\$} \frac{S_t}{S_{t+1}} e^{y_t^* + L_{t+1}^{*,*}}\right) = e^{-\lambda_t^{*,\$}} \tag{9}$$

Assuming that $E_t\left[\lim_{T\to\infty} L_{t+T}^{*,*}\right]$ goes to zero, $E_t\left[\lim_{T\to\infty} s_{t+T}\right] = \bar{s}$, and using the Euler equations from (6) to (9), we can derive the exchange rate determination equation for single-period bonds, as shown in (10), under the assumption of log-normality.[28]

$$\begin{aligned} s_t = E_t \sum_{\tau=0}^{\infty}\left(\lambda_{t+\tau}^{\$,*} - \lambda_{t+\tau}^{*,*}\right) + E_t \sum_{\tau=0}^{\infty}\left(y_{t+\tau}^{\$} - y_{t+\tau}^{*}\right) + E_t \sum_{\tau=0}^{\infty} cp_{t+\tau}^* - E_t \sum_{\tau=0}^{\infty} rp_{t+\tau}^* \\ + E_t\left[\lim_{T\to\infty} s_{t+T}\right] - E_t\left[\lim_{T\to\infty} L_{t+T}^{*,*}\right] \end{aligned} \tag{10}$$

[26] The framework could incorporate different perceptions of sovereign credit risk through selective default, where a sovereign might default on foreign investors while honouring obligations to domestic investors. However, for the sake of simplicity, I focus on the symmetric case where the sovereign credit risk is the same for both foreign and domestic investors.

[27] Suppose that the risk-free rate is 3% and the bond, which is subject to default risk, has a promised yield of 5% ($y_t^*$). Then, the credit risk is 2%. If there is no default, the ex-post return is also 5%; however, if there is a default, then the ex-post return is the sum of 5% and $L_{t+1}^{*,*}$.

[28] The first assumption implies that the government will meet its obligations in the long run, and hence, the probability of default is zero, and the second assumption is based on the no-bubble condition (Jiang et al., 2024; Lustig et al., 2019).

where $rp_t^* = -\operatorname{cov}_t\left(m_{t+1}^*, \Delta s_{t+1}\right) - \frac{1}{2}\operatorname{var}_t\left(\Delta s_{t+1}\right)$, $cp_t^* = -\operatorname{cov}_t\left(m_{t+1}^*, L_{t+1}^{*,*}\right) - \frac{1}{2}\operatorname{var}_t\left(L_{t+1}^{*,*}\right)$.[29] Equation (10) shows how the exchange rate is influenced by various factors, including relative convenience yields $\left(\lambda_t^{\$,*} - \lambda_t^{*,*}\right)$, interest rate differentials $\left(y_{t+\tau}^{\$} - y_{t+\tau}^{*}\right)$, credit risk $(cp_t^*)$, and foreign exchange risk premium $(rp_t^*)$. In particular, it highlights that an increase in credit risk depreciates the foreign currency, while convenience yields also play a role in determining the exchange rate.

Next, I extend the model to multi-period bonds, where I also derive expressions for the term premium and the relationship between long-term and short-term bond yields. By incorporating term premia and the term structure of convenience yields into the framework, the model provides a comprehensive view of how deviations from long-run UIP can be driven by multiple factors, including credit risk and convenience yields. In particular, the exchange rate determination equation for multi-period bonds is given in (11):

$$\begin{aligned} s_t = {} & nE_t \sum_{\tau=0}^{\infty} \left(y_{t+\tau}^{\$(n)} - y_{t+\tau}^{*(n)}\right) + E_t \sum_{\tau=0}^{\infty} \left(\lambda_{t+\tau}^{\$,*} - \lambda_{t+\tau}^{*,*}\right) - E_t \sum_{\tau=0}^{\infty} rp_{t+\tau}^* + E_t \sum_{\tau=0}^{\infty} cp_{t+\tau}^* \\ & + E_t \sum_{\tau=0}^{\infty} \left(tp_{t+\tau}^{*,*} - tp_{t+\tau}^{\$,\$}\right) + E_t \sum_{\tau=0}^{\infty} \left[\left(\lambda_{t+\tau}^{*,*} - \lambda_{t+\tau}^{*,*(n)}\right) - \left(\lambda_{t+\tau}^{\$,\$} - \lambda_{t+\tau}^{\$,\$(n)}\right)\right] + \overline{s_t} \end{aligned} \tag{11}$$

where $tp_t^{*,*(n)} = -\operatorname{cov}_t\left(m_{t+1}^*, hy_{n,t+1}^*\right)$, $tp_{t+1}^{\$,\$(n)} = -\operatorname{cov}_t\left(m_{t+1}^{\$}, hy_{n,t+1}^{\$}\right)$ capture term premia for foreign bonds and U.S. Treasuries, respectively. $hy_{n,t+1}^*$ and $hy_{n,t+1}^{\$}$ represent the difference between the holding period return of an $n$ period foreign or U.S. bond for a single period and the return to a single period foreign or U.S. bond, respectively. Equation (11) provides flexibility in explaining deviations from the LR-UIP through a combination of different factors. If LR-UIP holds, $(s_t - \overline{s_t})$ is equal to $nE_t \sum_{\tau=0}^{\infty} \left(y_{t+\tau}^{\$(n)} - y_{t+\tau}^{*(n)}\right)$. However, (11) implies that if LR-UIP fails, then it can potentially be driven by several factors: (i) relative convenience yields (ii) FX risk, (iii) credit risk, (iv) relative term premium, and (v) relative term structure of convenience yields.

One point to highlight is that depending on the perspective of the investor, equation (10) also includes a term capturing the covariance between currency depreciation and the sovereign default risk, which is called the quanto term. This term appears if the exchange rate determination equation in (10) is written from the perspective of the U.S. investor. Accordingly, equation (11) also incorporates the quanto adjustment term reflecting another potential factor that can drive deviations from LR-UIP. The corresponding equations can be found in Appendix B.

One implication of the model is that the true measure of relative convenience yields is the "pure Treasury basis," (Dao & Gourinchas, 2025) which adjusts the conventional Treasury basis for credit risk and the quanto adjustment term. Jiang, Krishnamurthy, and Lustig (2021) proxy convenience yields using the U.S. Treasury basis. However, incorporating the sovereign credit risk into their framework suggests that the refined version of the Treasury basis, which is called the "pure Treasury basis," as defined in equation (12), is the accurate measure for relative convenience yields.

[29] Following Cenedese, Payne, Sarno, and Valente (2016), we can omit the Jensen's inequality terms that appear in $rp_t^*$ and $cp_t^*$ and focus exclusively on the covariance terms.

$$
\begin{aligned}
x_t^{\text{Treas,pure}} &\equiv \underbrace{y_t^{\$} - y_t^* + \left(f_t^1 - s_t\right)}_{x_t^{\text{Treas}}} - \left(E_t\left(L_{t+1}^{*,*}\right) - cp_t^* + \text{cov}_t\left(\Delta s_{t+1}, L_{t+1}^{*,*}\right)\right) \\
&= -\left(1 - \beta^{*,*}\right)\left(\lambda_t^{\$,*} - \lambda_t^{*,*}\right)
\end{aligned} \tag{12}
$$

where $f_t^1$ is the logarithm of the forward exchange rate, and $q_t = \text{cov}_t\left(\Delta s_{t+1}, L_{t+1}^{*,*}\right)$ is the quanto term. $\beta^{*,*}$ represents the dollarness added by holding a forward position in foreign bonds, defined as the additional convenience yield from hedging the cash position in foreign bonds into dollars compared to investing in U.S. Treasuries. If $\beta^{*,*} = 1$, the hedge provided by the forward contract makes the foreign bond equivalent to the U.S. bond, and if $\beta^{*,*} = 0$, the forward position provides no dollarness benefit.

### 4.3 Empirical evidence

To seek empirical evidence on the channels of APPs, I will focus on two specific components from equation (11), which are sovereign credit risk and convenience yields. These two components are of particular importance since they matter for the determination of the underlying long-term risk-free rate, which will help elucidate the differences in exchange rate responses to APPs in EMs and AEs.

I first investigate whether there is evidence of a sovereign credit risk channel and convenience yield channel of asset purchase programmes in EMs and AEs separately. Then, I look into how the underlying long-term risk-free rate, which is the promised yield accounted for the sovereign credit risk and the convenience yield, is affected by asset purchase surprises.

In addressing these questions, we first need proxies to measure sovereign credit risk and convenience yields. I use sovereign credit default spreads as a measure of sovereign credit risk, following Augustin et al. (2020). I use Treasury CIP deviations and pure Treasury CIP deviations as suggested by Jiang, Krishnamurthy, Lustig, and Sun (2021) and Dao and Gourinchas (2025) for proxies for convenience yields. The intuition here is that if investors earn different convenience yields in U.S. Treasury markets compared to holding foreign bonds, CIP cannot hold. Therefore, CIP deviations will help us identify the relative convenience yields.

Du et al. (2018) argue that CIP deviations reflect convenience yields in AEs, while Du and Schreger (2016) claim that local currency credit risk is the main reason behind CIP deviations in EMs. In contrast, the framework developed in this paper, which incorporates sovereign credit risk, suggests that both convenience yields and sovereign credit risk contribute to CIP deviations. Accordingly, I consider adjusting CIP deviations for sovereign credit risk, which is called "pure CIP deviations," defined as follows:

$$
CIP_{i,n,t} = y_{i,n,t}^{Govt} - \rho_{i,n,t} - y_{USD,n,t}^{Govt} \tag{13}
$$

$$
PCIP_{i,n,t} = \left(y_{i,n,t}^{Govt} - CDS_{i,n,t}\right) - \rho_{i,n,t} - y_{USD,n,t}^{Govt} \tag{14}
$$

where $CIP_{i,n,t}$ is the CIP deviations as defined by Du et al. (2020), and $PCIP_{i,n,t}$ is the pure CIP deviations adjusted for the credit risk, $y_{i,n,t}^{Govt}$ is the n-year local government bond yield in country $i$, $\rho_{i,n,t}$ is the n-year market-implied forward premium for hedging currency $i$ against the U.S. dollar and $y^{Govt}_{USD,n,t}$ is the n-year U.S. Treasury bond yield, and $CDS_{i,n,t}$ is the sovereign credit default swap (CDS) spread for country $i$ of maturity $n$ at time $t$. The details on the calculation of CIP deviations are reported in Appendix E.

Then, to answer the first question, I estimate the following set of regressions with OLS where changes in CDS spreads and CIP deviations are measured in basis points for 5-year and 10-year government bonds.

$$\Delta CDS_{i,t} = \beta \widehat{\varepsilon_{i,t}} + u_{i,t} \tag{15}$$

$$\Delta CIP_{i,t} = \beta \widehat{\varepsilon_{i,t}} + u_{i,t} \tag{16}$$

$$\Delta PCIP_{i,t} = \beta \widehat{\varepsilon_{i,t}} + u_{i,t} \tag{17}$$

Tables 6 and 7 report the OLS coefficient estimates from regressions (15), (16), and (17) for two different maturities: 5-year, and 10-year, respectively. There are three main observations from the analysis. First, there is strong evidence for a sovereign credit risk channel of APPs in EMs, which is absent in AEs for both maturities. An asset purchase surprise that lowers the long-term government bond yields by 100 basis points lowers the sovereign credit default swap spread by 43 to 46 basis points in EMs. While the coefficient is positive in AEs for only 5-year maturity, it is not highly statistically significant. Additionally, the $R^2$ is bigger in EMs as compared to AEs, implying that a higher variation in the CDS spreads is being explained by the variation in asset purchase surprises in EMs as compared to AEs.

Table 6: Empirical evidence on the channels of APPs (5-year)

| | **CDS** | | **CIP** | | **Pure CIP** | |
|---|---|---|---|---|---|---|
| | **EMs** | **AEs** | **EMs** | **AEs** | **EMs** | **AEs** |
| $\beta$ | 0.435*** | 0.064* | 0.529*** | 0.134 | 0.024 | 0.057 |
| | (0.057) | (0.036) | (0.116) | (0.116) | (0.137) | (0.111) |
| N | 53 | 36 | 45 | 36 | 45 | 36 |
| $R^2$ | 0.323 | 0.084 | 0.155 | 0.047 | 0.000 | 0.007 |

The table shows the coefficient estimates from regressions (15), (16), and (17), where the asset purchase surprises are extracted as residuals from (4) and (5) for EMs and AEs, respectively for 5-year maturity. The analysis accounts for the multidimensionality of Fed policy actions using four factors. Bootstrapped standard errors are reported in parentheses. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively.

Table 7: Empirical evidence on the channels of APPs (10-year)

| | CDS | | CIP | | Pure CIP | |
|---|---|---|---|---|---|---|
| | **EMs** | **AEs** | **EMs** | **AEs** | **EMs** | **AEs** |
| $\beta$ | 0.457*** | 0.019 | 0.107 | 0.197* | -0.373** | 0.178 |
| | (0.105) | (0.044) | (0.082) | (0.115) | (0.173) | (0.109) |
| N | 53 | 36 | 45 | 36 | 44 | 36 |
| $R^2$ | 0.165 | 0.008 | 0.016 | 0.067 | 0.064 | 0.046 |

The table shows the coefficient estimates from regressions (15), (16), and (17), where the asset purchase surprises are extracted as residuals from (4) and (5) for EMs and AEs, respectively for 10-year maturity. The analysis accounts for the multidimensionality of Fed policy actions using four factors. Bootstrapped standard errors are reported in parentheses. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively.

A natural question arises regarding how asset purchases reduce sovereign credit risk, as measured by CDS spreads. This can be understood through a demand and supply system approach in asset pricing (Greenwood et al., 2023; Gourinchas et al., 2025). A shift in demand—such as a demand shock triggered by foreign investors exiting a market at the onset of COVID-19 from EMs—can initially lead to an increase in sovereign credit risk due to the sudden withdrawal of funding. To counteract this, the central bank stepping in with the APPs can help stabilise demand.[30] By doing so, central banks help re-establish market balance through APPs. Central banks reduce the supply of long-duration assets by removing specific bonds from the market, which can lower yields and, consequently, CDS spreads, reflecting a decrease in perceived sovereign credit risk.[31]

The second key finding is that there is no strong evidence of a convenience yield channel of APPs during the COVID-19 era for AEs.[32] This finding contrasts with the post-GFC period, where APPs showed a significant convenience yield channel for AEs as reported in Jiang et al. (2024). As shown in Table 7, asset purchases only weakly affect CIP deviations for AEs and only for 10-year bonds. An asset purchase surprise that reduces long-term yields by 100 basis points is associated with a decrease in CIP deviations of about 20 basis points. This reflects an increased scarcity of local safe assets, which, in turn, raises the convenience yields that foreign investors attribute to foreign bonds.

The final key finding underscores the importance of accounting for sovereign credit risk in CIP deviations in EMs. The last two columns of Tables 6 and 7 show that incorporating credit risk into CIP deviations is consequential for EMs but not for AEs. When coefficient estimates are compared for the traditional measure for CIP deviations and pure CIP deviations, the $\beta$ coefficient for EMs not only becomes significant but also changes sign at 10-year maturity. For 5-year maturity, it highlights an even more striking result,

[30] This intervention can also potentially enable domestic banks to increase their holdings, effectively stepping into the role vacated by foreign investors.

[31] Although I call it credit risk, this can potentially be interpreted as a decline in rollover risk. Central bank interventions, especially when they target specific maturities or durations of bonds, can effectively reduce rollover risk.

[32] This aligns with the literature discussing the increase in the inconvenience of Treasuries, especially after the dislocation in the U.S. Treasury bond market during March 2020 (Duffie, 2020; He, Nagel, & Song, 2022). The extensive use of swap lines during this period may have also contributed to this diminished channel, as swap lines reduced dollar funding pressures and, consequently, the convenience yield of holding Treasuries.

where considering credit risk reduces the $R^2$ to almost zero and narrows the difference in coefficient estimates between AEs and EMs.[33] This evidence highlights the importance of considering sovereign credit risk, especially in the context of EMs.

Having looked into the two specific channels that APPs work, I then look into how the underlying long-term risk-free rate is affected by asset purchase surprises. To answer this question, I estimate the following regression:

$$\Delta y^{rf}_{i,10y,t} = \beta_1 \widehat{\varepsilon_{i,t}} + \beta_2 EM_i * \widehat{\varepsilon_{i,t}} + u_{i,t} \tag{18}$$

where $\Delta y^{rf}_{i,10y,t} = \Delta y^{10y}_{i,t} - \Delta CDS_{i,n,t} + \Delta(P)CIP_{i,n,t}$ is the long-term underlying risk-free rate which is the promised yield on the 10-year government bonds, where we also account for the sovereign credit risk and convenience yields both with 5-year and 10-year maturities. Consistent with the theoretical framework developed in this paper, as well as the results reported in Tables 6 and 7, I account for convenience yields using pure CIP deviations for EMs and the traditional measure of CIP deviations for AEs. I also account for the differences between AEs and EMs with a dummy variable, $EM_i$, which takes the value of 1 if the country is an EM and 0 otherwise. The asset purchase surprises are denoted by $\widehat{\varepsilon_{i,t}}$.

Tables 8 and 9 report the OLS estimation results from regression (18). By pooling data from both EMs and AEs together, I also report results that distinguish between different subsamples. While the results are stronger at 10-year maturity, the key result is that asset purchase surprises do not necessarily decrease and may even increase the underlying long-term risk-free rate in EMs. The $\beta_1$ coefficient is positive and significant across all subsamples of events, suggesting that asset purchase surprises decrease the underlying long-term risk-free rate in AEs. In contrast, the coefficient for $\beta_2$ is negative and statistically significant. The sum of $\beta_1$ and $\beta_2$ is negative specifically for 10-year maturity, indicating that, in EMs, the long-term risk-free rate may even increase. This finding contrasts with AEs, and according to the long-run UIP framework, the evidence suggests a potential currency appreciation in EMs.

Table 8: The effect of APPs on the underlying long-term risk-free rate (5-year)

| | **Gov. & Private** | **Gov. only** |
|---|---|---|
| $\beta_1$ | 0.858*** | 0.843*** |
| | (0.226) | (0.284) |
| $\beta_2$ | -0.816*** | -0.846** |
| | (0.265) | (0.359) |
| N | 67 | 52 |

The table reports the OLS estimation results from (18), where the maturity for the CIP deviations and CDS spreads are at 5-year maturity. The bootstrapped standard errors are reported in parentheses. The results are divided into two parts as Gov. & Private, and Gov. only, respectively. *,**,*** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

[33] This is consistent with Dao and Gourinchas (2025). One difference is that I use CDS spreads to purify the CIP deviations while they use supranational bonds.

Table 9: The effect of APPs on the underlying long-term risk-free rate (10-year)

| | **Gov. & Private** | **Gov. only** |
|---|---|---|
| $\beta_1$ | 1.091*** | 1.122*** |
| | (0.260) | (0.347) |
| $\beta_2$ | -1.372*** | -1.271** |
| | (0.347) | (0.609) |
| N | 66 | 51 |

The table reports the OLS estimation results from (18), where the maturity for the CIP deviations and CDS spreads are at 10-year maturity. The bootstrapped standard errors are reported in parentheses. The results are divided into two parts as Gov. & Private, and Gov. only, respectively. *,**,*** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

# 5 Robustness analysis

To ensure the validity of the findings, I conducted a series of robustness checks. Although dividing the sample into smaller subsets poses a challenge due to its already limited size—since APPs were adopted by EMs for the first time and the focus is on the period between 2020-2021—these checks address potential concerns. Specifically, the robustness checks consider different classifications of countries in the sample, post-GFC analysis using the same methodology for selected AEs using intra-daily data, the inclusion of all monetary policy announcements for the period between 2020-2021, controlling for forward guidance in AEs, and analysing sensitivity by dropping individual observations one at a time.

## 5.1 Different classifications of countries in the sample

In addition to classifying countries as either EMs or AEs, I also consider classifications based on several other criteria. These include the exchange rate regime as per Ilzetzki, Reinhart, and Rogoff (2022), the share of foreign investors in total government debt following Arslanalp and Tsuda (2014), access to Fed swap lines, and commodity dependence based on the classification in UNCTAD's 2021 report on the state of commodity dependence.

The results from the robustness checks can be found in Appendix C. Here, I will discuss the main findings. First, I classified countries based on two criteria for the exchange rate regime as of 2019: (i) fine classification and (ii) coarse classification. Given the short sample period, I do not account for the evolution of exchange rate classifications over time as significant regime changes are unlikely within this time frame. This classification aims to determine if the appreciation effect of APPs holds for countries with flexible exchange rates, given that some countries in the sample might have managed exchange rates. The main finding indicates that the exchange rate appreciation effect of APPs remains significant for countries with a flexible exchange rate regime for both classifications.[34]

The second classification is based on the foreign investor share in total government debt following Arslanalp and Tsuda (2014). The sample of countries is divided into two groups based on whether the country has a higher or lower than median foreign investor

[34]The sample size for the managed exchange rate group is too small to yield significant results.

share in total government debt as of 2019Q4.[35] Although the results show that the $\beta$ coefficient for the exchange rate for high foreign investor share countries is statistically significant, the difference between the two groups is not as strong as it was for AEs and EMs.[36]

The third classification distinguishes countries by their access to Federal Reserve swap lines. This approach is motivated by the finding that accounting for the SWAP factor eliminates the significance of the coefficient for AEs, all of which in the sample have access to these lines. In contrast, only three EMs—Brazil, Korea, and Mexico—have access to Fed swap lines.

The fourth classification is based on countries' dependence on commodities, as defined by UNCTAD's 2021 report on commodity dependence. A country is considered commodity-dependent if more than 60% of its total merchandise exports in value terms are composed of commodities.[37] This classification is motivated by the fact that commodity-dependent countries are particularly vulnerable to global shocks and price volatility in international markets. Therefore, this classification provides a clearer understanding of how exchange rates in these countries respond to global economic shocks, such as those induced by the pandemic.

For the latter two classifications, both groups of countries exhibit significant coefficients for the event set covering both government and private bond purchases. However, the coefficients lose their statistical significance when only government bond purchases are considered. Notably, for the grouping based on access to Fed swap lines, the significance of the coefficient is driven by the ECB's announcement. As in the main analysis, excluding this particular observation restores the insignificance of the coefficient.

Overall, classifying countries based on different criteria reveals that the key discrepancy in the results hinges on whether a country is an AE or an EM.

## 5.2 Post-GFC analysis for selected AEs with the methodology of this paper

In order to check the robustness of the methodology used in this paper for the measurement of asset purchase surprises, I ran the baseline exercise for a set of selected AEs using intraday data from Rogers et al. (2014). The set of countries includes the ECB, BoE, BoJ, and the Fed, which covers the period between January 2007 and May 2014.

I use two different windows as in Rogers et al. (2014): (i) narrow window refers to 15 minutes before to 15 minutes after, and (ii) wide window refers to from 15 minutes before to 1 hour 45 minutes after the announcement. The results show that I can recover the negative coefficient for the asset purchase surprise on the exchange rate, reconciling with the previous literature finding a depreciation of the exchange rate of an asset purchase

[35]High investor share countries are Chile, Colombia, Ghana, Hungary, Indonesia, Mexico, Poland, Romania, South Africa, Turkey, Uganda, ECB, Australia and New Zealand. Note that, for ECB, I used Germany's foreign investor share. Low investor share countries are Brazil, China, Croatia, Egypt, India, Israel, Korea, Mauritius, Philippines, Thailand, United Kingdom, Japan, Canada and Sweden. The medium level of foreign investor share as of the 2019Q4 in the sample is 33%.

[36]The coefficient for the group of events including both private and government bonds is still significant for the low foreign investor share group.

[37]Commodity-exporting countries include Brazil, Chile, Colombia, Ghana, Uganda, Australia, and New Zealand. All remaining countries are not commodity exporters.

surprise. This clearly demonstrates that the appreciation effect of asset purchase surprises is not a methodological artifact but a result specific to the APPs implemented between 2020-2021.[38]

### 5.3 All monetary policy announcements

To determine whether the results are driven by the choice of event sets based on the selection criteria, I conducted the same analysis comprising all monetary policy announcements, including those on APPs. The motivation for this approach is that each monetary policy announcement may contain information about APPs. Overall, the main finding still holds. Accounting for the SWAP factor removes the significance of the coefficient for AEs, while the appreciation result remains robust even when controlling for confounding factors in EMs.

### 5.4 Controlling for forward guidance in AEs

One potential concern is that in addition to APPs, forward guidance is another policy tool adopted by AEs while it is less of a concern for EMs. Therefore, one needs to account for forward guidance in the extraction of asset purchase surprises in addition to the conventional monetary policy, which is done with the changes in the short-term government bond yields in regressions (1), (4), and (5). Motivated by this, I control forward guidance with the change in 2-year government bond yields in AEs both for the event set covering announcements on asset purchase programmes, and all monetary policy announcements. I show that the main results remain robust to accounting for forward guidance in AEs.[39]

### 5.5 Dropping individual observations one at a time

To determine whether the observed appreciation of the exchange rate in response to asset purchase surprises is driven by specific observations, I conducted a robustness check by rerunning the regressions while sequentially excluding one observation at a time.

The results for EMs remain robust to the exclusion of any single observation. For AEs, the results for the "Gov. & Private" group are also robust under this test. However, for the "Gov. only" group, where all confounding factors are considered, the significance of the coefficient disappears when excluding two specific observations: the ECB announcement on 3/12/2020 and the Reserve Bank of Australia announcement on 3/18/2020. Notably, both announcements coincided with early crisis interventions by the Federal Reserve. This finding underscores the heterogeneous nature of credit risk across European Monetary Union countries, supporting the central argument that credit risk drives the results for EMs. Additionally, it highlights the distinct impact of asset purchases on EMs compared to AEs, where such actions tend to result in currency appreciation.

[38] One exception is the Japanese yen, which yields the opposite sign.

[39] For the event set covering announcements on asset purchase programmes only, the coefficient for AEs is reported to be positive and significant for government bond only purchases. However, a closer examination of the data reveals that this significance is driven by two outliers: announcements made by the Reserve Bank of Australia on March 18, 2020, and March 1, 2021. When these two dates are excluded from the analysis, the coefficient becomes insignificant, aligning with the main results.

## 6 Conclusion

This paper examines the impact of asset purchase programmes (APPs) on the bilateral U.S. dollar exchange rate for a set of EMs compared to AEs, addressing three gaps in the literature. First, I construct a comprehensive event set for APPs during 2020-2021 for both EMs and AEs, including simultaneous policy announcements. Second, I leverage the COVID-19 period to compare the exchange rate responses to APPs between EMs and AEs. Third, I identify a novel "sovereign credit risk channel" of APPs in EMs that accounts for the observed differences in exchange rate responses to APPs between EMs and AEs.

Using an event analysis, I demonstrate that asset purchase surprises during the pandemic led to an appreciation of non-U.S. currencies in EMs, a finding that remains robust even after accounting for several confounding factors. Furthermore, I show that the positive and significant coefficient observed for AEs vanishes once confounding factors, particularly the SWAP factor, are accounted for in the analysis. These findings clearly highlight that asset purchase programmes impact exchange rates differently in EMs and AEs.

These differences are explained through the lens of long-run uncovered interest parity (LR-UIP) deviations. Drawing on a no-arbitrage asset pricing framework with incomplete markets which incorporates convenience yields (Jiang, Krishnamurthy, Lustig, & Sun, 2021), sovereign credit risk (Du & Schreger, 2016) and long-term bonds (Corsetti et al., 2023), I identify a novel sovereign credit risk channel of APPs in EMs, showing that APP surprises decrease sovereign credit risk. However, unlike in AEs, APP surprises do not necessarily lower the underlying long-term risk-free rate in EMs. Through LR-UIP, this suggests that the currency could appreciate, consistent with the observed appreciation of the exchange rate in EMs.

The analysis can be extended in several dimensions. The varying impacts of APPs across EMs and AEs likely reflect broader economic, financial, and institutional characteristics. The EMs that adopted APPs during the COVID period had, by then, developed stronger monetary policy frameworks, greater central bank credibility, and deeper local-currency bond markets with rising foreign investor participation—factors that enhanced the credibility and effectiveness of these programmes and helped reduce sovereign credit risk. Several robustness checks are conducted in this paper, and the EM–AE distinction remains the dominant dimension. Future research could more systematically examine the underlying mechanisms through which APPs lower sovereign credit risk, assess how fiscal space, market depth, and institutional quality shape their transmission, and analyse the tightening phases of these programmes. Extending the analysis of Du, Forbes, and Luzzetti (2024) on quantitative tightening in AEs to EMs would offer valuable insights into the full cycle of unconventional monetary policy.

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# Appendix

## A Obtaining factors for the Federal Reserve policy actions

I conduct a factor analysis to obtain factors that reflect the multidimensionality of Fed policy actions. I do so by extending the information set in Swanson (2021). These factors can then serve as controls to extract asset purchase surprises for EMs and AEs.

First, as in Swanson (2021), I consider a factor model which can be written as follows:

$$X = F\Lambda + \varepsilon \tag{A.1}$$

where $X$ is a $Txn$ matrix where the rows correspond to the announcement dates and columns indicate different assets. $F$ is a $Txk$ matrix consisting of $k$ unobserved factors. $\Lambda$ is a $kxn$ matrix of loadings of the responses of asset prices on $k$ factors. Lastly, $\varepsilon$ is a $Txn$ matrix of white noise residuals which are uncorrelated across assets over time. Each element $x_{i,j}$ of the $X$ matrix corresponds to the difference between the 1 day after and 1 day before the $i^{th}$ announcement of the $j^{th}$ asset. Then, the factor model can also be written as:

$$X_t = \Lambda' F_t + \varepsilon_t, t = 1, ..., T \tag{A.2}$$

where $X_t$ is an $nx1$ vector, $F_t$ is $kx1$, and $\varepsilon_t$ is an $nx1$ vector. The variance of the $\varepsilon_t$ is given as a diagonal matrix in each $t$ and serially uncorrelated over time.

The point of interest is to identify the columns of $F$. Accordingly, following Swanson (2021), the variables included in $X$ consist of the second, third, and fourth eurodollar futures contracts, the first and third federal funds futures contracts, and lastly, 2-year, 5-year, and 10-year treasury yields.[1,2]

When COVID-19 hit the world economy, to address the shortage in dollar liquidity, the Fed intervened in the global economy through the extension/expansion of swap lines. Accordingly, the empirical literature on swap lines uses covered interest parity (CIP) deviations as a proxy to measure the effectiveness of liquidity lines (Bahaj & Reis, 2022). To account for the announcements of the Fed on swap lines, I expanded the variables in $X$ by including deviations from CIP. The calculation of CIP deviations follows Du et al. (2020). Then, I took the average of the CIP deviations for EMs and AEs, which will provide one additional variable for the factor analysis.

I use n-year CIP deviations between the government bond yields in the United States and country $i$ defined by Du et al. (2020) as follows:

$$\Phi_{i,n,t} = y^{Govt}_{i,n,t} - \rho_{i,n,t} - y^{Govt}_{USD,n,t} \tag{A.3}$$

where $y^{Govt}_{i,n,t}$ is the n-year local government bond yield in country $i$, $\rho_{i,n,t}$ is the n-year market-implied forward premium for hedging currency $i$ against the U.S. dollar and $y^{Govt}_{USD,n,t}$ is the n-year U.S. Treasury bond yield. For the factor analysis, I use bonds with a 5-year maturity and collect the data from Bloomberg. The factor analysis is done

[1] See Swanson (2021) for a discussion on the choice of the variables.

[2] For robustness check, a factor analysis based on only the variables used in Swanson (2021) is also conducted and reported in the main text.

with a subsample of countries in the main analysis due to data unavailability.[3,4]

Generally speaking, there are three dimensions of monetary policy which are widely referred to as the federal funds rate, the forward guidance (FG), and the large-scale asset purchases (LSAP). However, including CIP deviations as another variable reveals that there is another factor that is crucial for the 2020-2021 period, which I will later call the SWAP factor.[5]

Table 1A shows the loadings from the factor analysis with four factors. The interpretation of factors can be made as follows. The first factor has a relatively high correlation with eurodollar futures contracts. Eurodollar futures contracts are known to be a good measure of financial market expectations. Accordingly, this is interpreted as the forward guidance factor (FG). The second factor, where all variables related to treasury yields have high correlations, can be interpreted as a factor capturing the expectations over the long end of the yield curve. Therefore, this factor is called the asset purchase factor (LSAP), which is known to have an impact on long-term yields.[6] The third factor, where the third Federal funds rate futures contract has the highest correlation among other variables, is interpreted as the federal funds rate factor. Finally, the fourth factor is highly correlated with the variable related to CIP deviations, which are used as a proxy for liquidity lines. Hence, it is interpreted as the SWAP factor.

Table 1A: Loadings from the factor analysis

| | **FG** | **LSAP** | **FFR** | **SWAP** |
|---|---|---|---|---|
| $FF1$ | 0.07 | 0.08 | 0.42 | 0.02 |
| $FF3$ | 0.41 | -0.06 | **0.83** | 0.36 |
| $ED2$ | **0.82** | 0.24 | 0.42 | -0.14 |
| $ED3$ | **0.90** | 0.28 | 0.26 | -0.19 |
| $ED4$ | **0.90** | 0.34 | 0.14 | -0.09 |
| $H2Y$ | 0.72 | 0.48 | 0.14 | 0.38 |
| $H5Y$ | 0.50 | **0.82** | 0.04 | 0.21 |
| $H10Y$ | 0.27 | **0.95** | 0.13 | 0.02 |
| $CIP_{average}$ | 0.09 | -0.06 | -0.10 | **-0.48** |

The table shows loadings from the factor analysis where k=4 for the $X$ matrix with size $143x9$ for the whole sample (2008-2021), where variables for CIP deviations are included. In this setting, I used the average of 5-year CIP deviations of all countries where the data is available.

These four factors will be included as controls in regression (1). This will help to capture the effect of the Fed's policy actions on both EMs and AEs. In this way, I can

[3]The sample used for calculating the mean CIP deviations differs from the baseline exercise. The set of AEs includes Australia, Canada, the ECB, Japan, New Zealand, Sweden, and the United Kingdom. The set of EMs includes Colombia, Hungary, India, Israel, Korea, Mexico, Poland, South Africa, and Turkey.

[4]The definitions for the forward premium, the data sources, and the selection of countries can be found in Appendix E.

[5]The test of the hypothesis that k factor(s) is (are) sufficient also confirms that 4 factors are needed to capture the dimensionality of the data set. The details for the test are reported in Appendix A.1.1.

[6]In Swanson (2021), the estimated effect of the Federal Funds Rate (FFR) on FF1 is the highest among all other variables. On the other hand, it appears that the estimated effects of FG and LSAP are different, where the LSAP shock has the highest impact on the 10-year treasury yields, and the FG shock has the highest impact on the ED4. Following this interpretation, we can interpret the first factor and the second factor as the FG factor and the LSAP factor, respectively.

identify the domestic effect of APPs on the dollar exchange rate.[7]

One other important point to emphasize is that the event set for the Fed is rather inclusive. It consists of the event dates for measures targeting the corporate and banking sector, announcements on swap lines in addition to FOMC meetings, and APP announcements between 2020-2021, which are complemented with the event dates from Swanson (2021) for the pre-COVID period. Doing so helps us to take into account the factors that are specific to the COVID-19 period, which are support measures and expansion/ extension of swap lines.

### A.1 The test statistic on the hypotheses that k number of factors are sufficient

The fit is done by optimizing the log-likelihood, assuming multivariate normality over the uniqueness.[8] The distribution criterion is given by Lawley and Maxwell (1962) as:

$$nlog_e(|\hat{C}|/|A|) + tr(A\hat{C}^{-1}) - p \tag{A.4}$$

where $n$ is the degrees of freedom, $p$ is the number of columns in the variance-covariance matrix, C is the variance-covariance matrix of $X$, $A$ is the sample covariance matrix whose elements are the estimates of the variance and covariance of $x_i$ with n degrees of freedom (based on the rule that the sample size is $n + 1$).[9]

Bartlett (1951) points out that the distribution criterion given in (A.4) approximates closely to that of $\chi^2$ when $n$ is replaced by the following multiplying factor given as:

$$n' = n - \frac{1}{6}(2p + 5) - \frac{2}{3}k \tag{A.5}$$

where $k$ is the number of factors.

After equations for the estimation are solved exactly, $tr(A\hat{C}^{-1}) = p$, which leads to the following expression for the distribution criterion given by

$$n'log_e(|\hat{C}|/|A|)^{10} \tag{A.6}$$

Then, the corresponding p-value can be calculated based on the $\chi^2$ statistic given by (A.6).

[7]The literature on the international spillovers of the unconventional monetary policy actions of the Fed indicates an appreciation of exchange rates in EMs. Consequently, the appreciation of non-U.S. currencies can imply the dominance of the Fed's actions and, hence, an appreciation of the non-U.S. currency. However, including factors controlling the actions of the Fed in a multidimensional way helps us to invalidate the argument in the literature on the relative strength of the actions of the Fed.

[8]Maximizing loadings for given uniqueness can be found analytically (Lawley & Maxwell, 1971)

[9]See Lawley and Maxwell (1962) for a detailed explanation of the estimation of factor loadings by the maximum likelihood method.

[10]It is important to note that if the number of iterations is not sufficient, then using (A.6) can give a completely wrong result. One can even get a negative value for $\chi^2$.

### A.1.1 Test results for selecting the number of factors

Table 2A: Test results for selecting the number of factors

| Test of the hypothesis that k factor(s) is (are) sufficient | d.o.f | Full sample | | Pre-2020 period | |
|---|---|---|---|---|---|
| | | $\chi^2$ | p-value | $\chi^2$ | p-value |
| 1 | 27 **(20)** | 508.68 | 2.5e-90 | 389.38 | 3.26e-70 |
| 2 | 19 **(13)** | 177.99 | 5.71e-28 | 163.8 | 3.35e-28 |
| 3 | 12 **(7)** | 70.2 | 2.94e-10 | 58.05 | 3.69e-10 |
| 4 | 6 **(2)** | **5.3** | **0.506** | **4.2** | **0.122** |

The table shows the results of the test for the number of factors k underlying the matrix X of the following sizes 143x9 and 100x9 for the full sample (2008-2021) and pre-2020 sample, respectively. The null hypothesis is that k factors are sufficient to capture the full dimensionality of the data set.

# B No-arbitrage asset pricing framework with incomplete markets

In this section, I introduce a theoretical framework on exchange rates, convenience yields, and sovereign credit risk building on Jiang, Krishnamurthy, and Lustig (2021) and Corsetti et al. (2023) where I also account for the sovereign credit risk (Du & Schreger, 2016). I consider a two-country setting: (i) the U.S. (\$) and (ii) the foreign economy (*). Representative investors in each country are allowed to trade zero-coupon bonds with different maturities $k = 1, 2, 3, ..., \infty$ issued by foreign and the U.S. economy. $S_t$ denotes the nominal exchange rate denoted as the foreign currency per dollar, where an increase corresponds to an appreciation of the U.S. dollar.

In addition to paying a pecuniary return at maturity in local currency units, investors also earn a non-pecuniary return from investing in sovereign bonds. This is called convenience yield, where foreign and U.S. investors attach different convenience yields to foreign and U.S. issued government bonds. What differentiates this setting is that foreign bonds are also subject to credit risk, which is different from U.S. treasuries. I derive pricing conditions for bonds and the exchange rate under no-arbitrage condition.

## B.1 Single period bonds

I define $y_t^{\$}$ as the nominal yield on a single-period risk-free zero coupon U.S. treasury bond denominated in U.S. dollars. Similarly, $y_t^*$ is the nominal yield on a single-period risk-free rate on a zero coupon foreign government bond denominated in foreign currency. The stochastic discount factors for the U.S. and foreign investors are denoted by $M_t^{\$}$ and $M_t^*$, respectively. Investors also earn a non-pecuniary return, where the convenience yield attached by investor $i$ to the bond issued by $j$ is denoted as $\lambda_t^{j,i}$. In addition, I capture the sovereign credit risk by the term $L_{t+1}^{*,*}$.[11] This is defined as the credit risk on the

[11] Note that $y_t^*$ is the promised yield. This can be best explained with an example. Suppose that the risk-free rate is 3% and the bond, which is subject to default risk, has a promised yield of 5%. Then, we say that the credit risk is 2%. If there is no default, the ex-post return is also 5%; however, if there is a default, then the ex-post return is the sum of 5% and $L_{t+1}^{*,*}$.

foreign-issued bond denominated in foreign currency. With these definitions, the Euler equations for foreign (B.1) - (B.2) and U.S. investors (B.3) - (B.4) are given by:

$$E_t\left(M^*_{t+1}e^{y^*_t+L^{*,*}_{t+1}}\right)=e^{-\lambda^{*,*}_t} \tag{B.1}$$

$$E_t\left(M^*_{t+1}\frac{S_{t+1}}{S_t}e^{y^\$_t}\right)=e^{-\lambda^{\$,*}_t} \tag{B.2}$$

$$E_t\left(M^\$_{t+1}e^{y^\$_t}\right)=e^{-\lambda^{\$,\$}_t} \tag{B.3}$$

$$E_t\left(M^\$_{t+1}\frac{S_t}{S_{t+1}}e^{y^*_t+L^{*,*}_{t+1}}\right)=e^{-\lambda^{*,\$}_t} \tag{B.4}$$

Equations (B.1) and (B.3) correspond to the Euler equations for foreign and U.S. investors investing in foreign-issued and U.S. issued government bonds, respectively. Both foreign and U.S. investors can invest in bonds issued by other countries. To do so, they first convert the local currency into the foreign counterpart, invest in the bonds issued by the other country, and finally convert them back to the local currency at time $t+1$. Corresponding Euler equations for the foreign and U.S. investors are given in (B.2) and (B.4).

Note that in this setting, foreign government bonds issued in local currency are subject to default risk, while U.S. Treasuries are assumed to be default-free. In contrast to the discussion on convenience yields, the sovereign default risk is not specific to each type of investor. Both foreign and U.S. investors have the same perception of the default risk on the local currency-denominated foreign-issued sovereign bonds.[12]

By using equations (B.1) and (B.2), we can derive an equation for the relationship between exchange rate, convenience yields, and sovereign credit risk. Let $m^*_t=log(M^*_t)$, and $\Delta s_{t+1}=log(S_{t+1})-log(S_t)$ be conditionally normal. Then, we can rewrite (B.1) and (B.2) as follows:

$$E_t\left(m^*_{t+1}\right)+y^*_t+E_t\left(L^{*,*}_{t+1}\right)+\frac{1}{2}\operatorname{var}_t\left(L^{*,*}_{t+1}\right)+\frac{1}{2}\operatorname{var}_t\left(m^*_{t+1}\right)+\operatorname{cov}_t\left(m^*_{t+1,1}L^{*,*}_{t+1}\right)+\lambda^{*,*}_t=0 \tag{B.5}$$

$$E_t\left(m^*_{t+1}\right)+y^\$_t+E_t\left(\Delta s_{t+1}\right)+\frac{1}{2}\operatorname{var}_t\left(m^*_{t+1}\right)+\frac{1}{2}\operatorname{var}_t\left(\Delta s_{t+1}\right)+\operatorname{cov}_t\left(m^*_{t+1},\Delta s_{t+1}\right)+\lambda^{\$,*}_t=0 \tag{B.6}$$

We define $RP^*_t=-\operatorname{cov}_t\left(m^*_{t+1},\Delta s_{t+1}\right)$, $CP^*_t=-\operatorname{cov}_t\left(m^*_{t+1},\Delta L^{*,*}_{t+1}\right)$ as the exchange rate risk premium and credit risk premium attached by foreign investors.

Similarly, by using equations (B.3) and (B.4), we can get equivalent versions of (B.5) and (B.6) derived from the Euler equations for U.S. investors, which are given as:

$$E_t\left(m^\$_{t+1}\right)+y^\$_t+\frac{1}{2}\operatorname{var}_t\left(m^\$_{t+1}\right)+\lambda^{\$,\$}_t=0 \tag{B.7}$$

[12]Different perceptions of sovereign credit risk would be incorporated into the framework through selective default, where the sovereign defaults on the foreigners but not the home investors. However, for the exposition of the main idea of this paper, I focus on the symmetric case.

$$E_t\left(m^{\$}_{t+1}\right)+\frac{1}{2}\operatorname{var}_t\left(m^{\$}_{t+1}\right)-E_t\left(\Delta s_{t+1}\right)+\frac{1}{2}\operatorname{var}_t\left(\Delta s_{t+1}\right)+y^*_t+E_t\left(L^{*,*}_{t+1}\right)+\frac{1}{2}\operatorname{var}_t\left(L^{*,*}_{t+1}\right)$$

$$+\operatorname{cov}_t\left(m^{\$}_{t+1},L^{*,*}_{t+1}\right)+\operatorname{cov}_t\left(-\Delta s_{t+1},m^{\$}_{t+1}\right)+\operatorname{cov}_t\left(-\Delta s_{t+1},L^{*,*}_{t+1}\right)+\lambda^{*,\$}_t=0 \tag{B.8}$$

We define $RP^{\$}_t=-\operatorname{cov}_t\left(m^{\$}_{t+1},-\Delta s_{t+1}\right)$, $CP^{\$}_t=-\operatorname{cov}_t\left(m^{\$}_{t+1},L^{*,*}_{t+1}\right)$ as the exchange rate risk premium and credit risk premium attached by U.S. investors. Note that there is an additional term capturing the covariance between currency depreciation and the credit risk, $q_t=-\operatorname{cov}_t\left(-\Delta s_{t+1},L^{*,*}_{t+1}\right)$, which we call as the quanto adjustment term. This term arises particularly from the Euler equations for the U.S. investor since they care about the return in U.S. dollars, where the local currency bonds are subject to both exchange rate risk and credit risk.[13]

Next, combining (B.5) with (B.6), and (B.7) with (B.8) yields, respectively:

$$y^{\$}_t-y^*_t+E_t\left(\Delta s_{t+1}\right)-E_t\left(L^{*,*}_{t+1}\right)+\frac{1}{2}\operatorname{var}\left(\Delta s_{t+1}\right)-\frac{1}{2}\operatorname{var}_t\left(L^{*,*}_{t+1}\right)+\operatorname{cov}_t\left(m^*_{t+1},\Delta s_{t+1}\right)$$
$$-\operatorname{cov}_t\left(m^*_{t+1},L^{*,*}_{t+1}\right)=-\left(\lambda^{\$,*}_t-\lambda^{*,*}_t\right) \tag{B.9}$$

$$y^*_t-y^{\$}_t-E_t\left(\Delta s_{t+1}\right)+E_t\left(L^{*,*}_{t+1}\right)+\frac{1}{2}\operatorname{var}\left(\Delta s_{t+1}\right)+\frac{1}{2}\operatorname{var}_t\left(L^{*,*}_{t+1}\right)+\operatorname{cov}_t\left(m^{\$}_{t+1},L^{*,*}_{t+1}\right)$$
$$+\operatorname{cov}_t\left(m^{\$}_{t+1},-\Delta s_{t+1}\right)+\operatorname{cov}_t\left(-\Delta s_{t+1},L^{*,*}_{t+1}\right)=\left(\lambda^{\$,\$}_t-\lambda^{*,\$}_t\right) \tag{B.10}$$

We further define log currency risk premia, log credit risk premia for foreign and U.S. investors as $rp^*_t=-\operatorname{cov}_t\left(m^*_{t+1},\Delta s_{t+1}\right)-\frac{1}{2}\operatorname{var}_t\left(\Delta s_{t+1}\right)$, $rp^{\$}_t=-\operatorname{cov}_t\left(m^*_{t+1},-\Delta s_{t+1}\right)-\frac{1}{2}\operatorname{var}_t\left(\Delta s_{t+1}\right)$, $cp^*_t=-\operatorname{cov}_t\left(m^*_{t+1},L^{*,*}_{t+1}\right)-\frac{1}{2}\operatorname{var}_t\left(L^{*,*}_{t+1}\right)$, $cp^{\$}_t=-\operatorname{cov}_t\left(m^{\$}_{t+1},L^{*,*}_{t+1}\right)-\frac{1}{2}\operatorname{var}_t\left(L^{*,*}_{t+1}\right)$.[14]

Finally, combining (B.9) and (B.10) allows us to obtain an expression to determine the conditions under which the convenience yields attached to U.S. treasuries relative to the domestic bonds by the U.S. and foreign investors match with each other.

$$\left(\lambda^{\$,*}_t-\lambda^{*,*}_t\right)-\left(\lambda^{\$,\$}_t-\lambda^{*,\$}_t\right)=rp^*_t+rp^{\$}_t-cp^*_t+cp^{\$}_t+q_t \tag{B.11}$$

This is equivalent to the equation derived on the convenience yields and the currency risk premia in Jiang, Krishnamurthy, and Lustig (2021)[15] with three additional terms capturing the credit risk and the covariance between the currency depreciation and the credit risk, and the quanto adjustment term. Jiang, Krishnamurthy, and Lustig (2021) claim that if currency risk premia are symmetric, i.e., $rp^*_t=-rp^{\$}_t$, then U.S. and foreign investors will agree on the relative convenience yields. On the other hand, in the context

[13] This term is reminiscent of the exposition of the idea of sovereign default risk in Du and Schreger (2016), where they show that depending on the choice of numeraire local currency credit spread also incorporates a term capturing the covariance between the default risk and currency risk.

[14] Following Cenedese et al. (2016), we can omit the Jensen's inequality terms that appear in $rp^*_t, rp^{\$}_t, cp^*_t, cp^{\$}_t$ and focus exclusively on the covariance terms.

[15] For completeness, the expression in Jiang, Krishnamurthy, and Lustig (2021) is given as

$$\left(\lambda^{\$,*}_t-\lambda^{*,*}_t\right)-\left(\lambda^{\$,\$}_t-\lambda^{*,\$}_t\right)=rp^{\$}_t+rp^*_t.$$

of equation (B.11), this boils down to the case where the last three terms on the right-hand side cancel out each other. However, once we introduce the credit risk in addition to having symmetric currency premia, in order for the U.S. and foreign investors to agree on the relative convenience yields, two additional assumptions have to be satisfied:

1. Home and foreign investors should have the same credit risk, i.e., $cp_t^* = cp_t^\$$, and

2. Exchange rate risk and credit risk are uncorrelated, i.e., $q_t = 0$.

Note that assumption (1) can simply be interpreted as a restatement of the idea that foreign and U.S. investors do not have different perceptions of credit risk on the foreign bond. On the quanto adjustment term, there is evidence in the literature that, it is not equal to zero.[16] Therefore, imposing assumption (2) can be unrealistic in some cases, especially in the context of EMs, but also in AEs.[17] Hence, an alternative case to imposing symmetry assumptions would be that the sum of all terms on the right-hand side of (B.11) cancels out each other. Then, under either of those assumptions, U.S. and foreign investors agree on the relative convenience of Treasury bonds versus foreign bonds, which is summarised by:

$$\left(\lambda_t^{\$,*} - \lambda_t^{*,*}\right) = \left(\lambda_t^{\$,\$} - \lambda_t^{*,\$}\right) \tag{B.12}$$

## B.2 Exchange Rate Determination Equation

In this section, we will discuss the implications of the theory developed on the level of the exchange rate. Through the forward iteration of equations (B.9) and (B.10), we can derive the following equations for the exchange rate is given by, which are given by (B.13) and (B.14):

$$\begin{aligned} s_t = E_t \sum_{\tau=0}^{\infty} \left(\lambda_{t+\tau}^{\$,*} - \lambda_{t+\tau}^{*,*}\right) + E_t \sum_{\tau=0}^{\infty} \left(y_{t+\tau}^{\$} - y_{t+\tau}^{*}\right) + E_t \sum_{\tau=0}^{\infty} cp_{t+\tau}^{*} - E_t \sum_{\tau=0}^{\infty} rp_{t+\tau}^{*} \\ + E_t \left[\lim_{T\to\infty} s_{t+T}\right] - E_t \left[\lim_{T\to\infty} L_{t+T}^{*,*}\right] \end{aligned} \tag{B.13}$$

$$\begin{aligned} s_t = E_t \sum_{\tau=0}^{\infty} \left(\lambda_{t+\tau}^{\$,\$} - \lambda_{t+\tau}^{*,\$}\right) + E_t \sum_{\tau=0}^{\infty} \left(y_{t+\tau}^{\$} - y_{t+\tau}^{*}\right) + E_t \sum_{\tau=0}^{\infty} cp_{t+\tau}^{\$} + E_t \sum_{\tau=0}^{\infty} rp_{t+\tau}^{\$} + E_t \sum_{\tau=0}^{\infty} \mathrm{q}_{t+\tau} \\ + E_t \left[\lim_{T\to\infty} s_{t+T}\right] - E_t \left[\lim_{T\to\infty} L_{t+T}^{*,*}\right] \end{aligned} \tag{B.14}$$

Note that equations (B.13) and (B.14) are equivalent to each other through equation (B.11). Equation (B.13) shows that the exchange rate is determined by convenience yields, interest rate differentials, currency risk premia, and credit risk premia. Equation (B.14), also has an additional term that captures the quanto adjustment term. In addition to the terms on relative convenience yields and exchange rate risk premium in Jiang, Krishnamurthy, and Lustig (2021), there is also credit risk premium and the quanto adjustment terms.

[16] The relationship between default risk and depreciation rate is referred to as the "twin Ds" in the literature (Reinhart, 2002). For instance, Chernov and Creal (2020) find a strong connection between currency risk and credit risk for Asia-Pacific countries, even outside of default episodes.

[17] For Euro area, see the study by Augustin et al. (2020), and for EMs, see Du and Schreger (2016).

Equations (B.13) and (B.14) imply that an increase in credit risk depreciates the foreign currency. The quanto adjustment term in equation (B.14) captures the additional risk that would be induced by the covariance between the default risk and the currency depreciation when we consider the dollar return from the perspective of U.S. investors. If $\text{cov}_t\left(\Delta s_{t+1}, L^{*,*}_{t+1}\right) > 0$, which means that the times with high default risk are associated with foreign currency depreciation, then a decline in the covariance term appreciates the foreign currency.

## B.3 Exchange rate process

So far, we have not defined a process for the exchange rate. If markets are complete, then there is a unique exchange rate process that is consistent with the no-arbitrage condition. This is given by:

$$\Delta s_{t+1} = m^{\$}_{t+1} - m^{*}_{t+1} \tag{B.15}$$

However, for the convenience yield as well as the sovereign credit risk to have an impact on the exchange rate, we need market incompleteness. Therefore, we need to specify an exchange rate process that satisfies all four Euler equations (B.1) to (B.4). The specified exchange rate process is given by (B.16) as:

$$\Delta s_{t+1} = m^{\$}_{t+1} - m^{*}_{t+1} + \eta_{t+1} + \lambda^{\$,\$}_t - \lambda^{\$,*}_t \tag{B.16}$$

where $\eta_{t+1}$ represents the incomplete markets wedge. The incomplete markets wedge has two contributions to our analysis. First, it allows convenience yields and credit risk to have an impact on the exchange rate. On the other hand, under complete markets, $\eta_{t+1}$ and $\lambda^{\$,\$}_t - \lambda^{\$,*}_t$ boils down to zero. Second, with market incompleteness, even under the assumption of risk-neutrality of the foreign investor, we can show that there are deviations from uncovered interest rate parity (UIP). These deviations are governed by convenience yields in Jiang, Krishnamurthy, and Lustig (2021), and here, they can also be driven by both convenience yields and credit risk. This provides us with a potential factor that drives the deviations from the UIP.

Next, I will show that we can recover the same exchange rate process given in (B.13) through forward substitution of equation (B.16) after taking expectations. Consider now the level version of equation (B.16). Imposing convenience yield valuation symmetry as per equation (B.11) above–i.e., $\left(\lambda^{\$,*}_t - \lambda^{*,*}_t\right) = \left(\lambda^{\$,\$}_t - \lambda^{*,\$}_t\right)$–and multiplying and dividing by $L^{*,*}_{t+1}$, we have:[18]

$$\frac{S_{t+1}}{S_t} = \frac{M^{\$}_{t+1} e^{\lambda^{\$,\$}_t}}{M^{*}_{t+1} e^{\lambda^{\$,*}_t}} e^{\eta_{t+1}} = \frac{M^{\$}_{t+1} e^{\lambda^{*,\$}_t + L^{*,*}_{t+1}}}{M^{*}_{t+1} e^{\lambda^{*,*}_t + L^{*,*}_{t+1}}} e^{\eta_{t+1}} \tag{B.17}$$

Next, imposing that home and foreign investors agree on the pricing of U.S. and foreign bonds and the convenience yield as in equation (B.11) above, and the exchange rate satisfies the assumed process, we have:

$$E_t\left(M^{\$}_{t+1} e^{\lambda^{\$,\$}_t}\right) = E_t\left(M^{*}_{t+1} \frac{S_{t+1}}{S_t} e^{\lambda^{\$,*}_t}\right) = E_t\left(M^{\$}_{t+1} e^{\lambda^{\$,\$}_t} e^{\eta_{t+1}}\right) = e^{-y^{\$}_t} \tag{B.18}$$

[18] This last step allows us to get the second equality in equation (B.18), which provides an equivalent condition to equation (B.19) for foreign bonds that are subject to credit risk.

$$E_t\left(M^*_{t+1}e^{\lambda^{*,*}_t+L^{*,*}_{t+1}}\right)=E_t\left(M^*_{t+1}\frac{S_t}{S_{t+1}}e^{\lambda^{*,\$}_t+L^{*,*}_{t+1}}\right)=E_t\left(M^{\$}_{t+1}e^{\lambda^{\$,\$}_t+L^{*,*}_{t+1}}e^{-\eta_{t+1}}\right)=e^{-y^*_t} \tag{B.19}$$

The first and third equalities in equations (B.18) and (B.19) follow from solving for $e^{-y^*_t}$ and $e^{-y^{\$}_t}$ from Euler equations (B.1) and (B.4) and (B.2) and (B.3), respectively. The second equality comes from equation (B.17).

Note that since the sovereign credit risk for the foreign-issued foreign currency-denominated bond is the same for both foreign and U.S. investor, they cancel out from (B.19). This leads to the same description for the exchange rate process as in Jiang, Krishnamurthy, and Lustig (2021). The difference comes through the covariance terms between the incomplete market wedge, $\eta_{t+1}$, and the foreign agent's stochastic discount factor, $m^*_{t+1}$, which will become clear below.

Under the assumption of log normality, (B.18) and (B.19) yield equations (B.20) and (B.21):

$$\text{cov}_t\left(m^{\$}_{t+1},\eta_{t+1}\right)=-E_t\left(\eta_{t+1}\right)-\frac{1}{2}\text{var}_t\left(\eta_{t+1}\right) \tag{B.20}$$

$$\text{cov}_t\left(m^*_{t+1},\eta_{t+1}\right)=-E_t\left(\eta_{t+1}\right)+\frac{1}{2}\text{var}_t\left(\eta_{t+1}\right)-\text{cov}_t\left(\eta_{t+1},L^{*,*}_{t+1}\right) \tag{B.21}$$

Finally, rearranging and taking expectations in equation (B.16), we have:

$$s_t=-E_t\left[m^{\$}_{t+1}\right]+E_t\left[m^*_{t+1}\right]-E_t\left[\eta_{t+1}\right]-\lambda^{\$,\$}_t+\lambda^{\$,*}_t+E_ts_{t+1} \tag{B.22}$$

To derive expressions for $E_t\left(m^*_{t+1}\right)$ and $E_t\left(m^{\$}_{t+1}\right)$, recall that

$$E_t\left(M^{\$}_{t+1}e^{\lambda^{\$,\$}_t}\right)=e^{-y^{\$}_t} \tag{B.23}$$

$$E_t\left(M^*_{t+1}e^{\lambda^{*,*}_t+L^{*,*}_{t+1}}\right)=e^{-y^*_t} \tag{B.24}$$

which yield:

$$E_t\left[m^*_{t+1}\right]=-y^*_t-\frac{1}{2}\text{var}_t\left[m^*_{t+1}\right]-\lambda^{*,*}_t-\frac{1}{2}\text{var}_t\left[L^{*,*}_{t+1}\right]-E_t\left(L^{*,*}_{t+1}\right)-\text{cov}_t\left(m^*_{t+1},L^{*,*}_{t+1}\right) \tag{B.25}$$

$$E_t\left[m^{\$}_{t+1}\right]=-y^{\$}_t-\frac{1}{2}\text{var}_t\left[m^{\$}_{t+1}\right]-\lambda^{\$,\$}_t \tag{B.26}$$

Then, equation (B.22) becomes:

$$\begin{aligned} s_t=&\left(y^{\$}_t-y^*_t\right)+\left(\lambda^{\$,*}_t-\lambda^{*,*}_t\right)+\frac{1}{2}\left[\text{var}_t\left(m^{\$}_{t+1}\right)-\text{var}_t\left(m^*_{t+1}\right)-E_t\left[\eta_{t+1}\right]\right]\\ &-\left[\text{cov}_t\left(m^*_{t+1},L^{*,*}_{t+1}\right)+\frac{1}{2}\text{var}_t\left[L^{*,*}_{t+1}\right]\right]-E_t\left(L^{*,*}_{t+1}\right)+E_ts_{t+1}\end{aligned} \tag{B.27}$$

Note now that, as long as the incomplete market wedge satisfies the following restrictions:

$$\text{cov}_t\left(m^{\$}_{t+1},\eta_{t+1}\right)=-E_t\left(\eta_{t+1}\right)-\frac{1}{2}\text{var}_t\left(\eta_{t+1}\right) \tag{B.28}$$

$$\text{cov}_t\left(m^*_{t+1},\eta_{t+1}\right)=-E_t\left(\eta_{t+1}\right)+\frac{1}{2}var_t\left(\eta_{t+1}\right) \tag{B.29}$$

We have that $\frac{1}{2}\left[\operatorname{var}_t\left(m^*_{t+1}\right) - \operatorname{var}_t\left(m^{\$}_{t+1}\right)\right] + E_t\left[\eta_{t+1}\right] = rp^*_t$,
while $-\left[\operatorname{cov}_t\left(m^*_{t+1}, L^*_{t+1}\right) + \frac{1}{2}\operatorname{var}_t\left[L^*_{t+1}\right]\right] = cp^*_t$.

Finally, iterating forward equation (B.27), we can recover the same exchange rate determination equation given in (B.13) for foreign investors:

$$\begin{aligned} s_t = E_t \sum_{\tau=0}^{\infty}\left(\lambda^{\$,*}_{t+\tau} - \lambda^{*,*}_{t+\tau}\right) + E_t \sum_{\tau=0}^{\infty}\left(y^{\$}_{t+\tau} - y^*_{t+\tau}\right) + E_t \sum_{\tau=0}^{\infty} cp^*_{t+\tau} - E_t \sum_{\tau=0}^{\infty} rp^*_{t+\tau} \\ + E_t\left[\lim_{T\to\infty} s_{t+T}\right] - E_t\left[\lim_{T\to\infty} L^{*,*}_{t+T}\right] \end{aligned} \tag{B.30}$$

## B.4 From single-period to multi-period bonds

This framework also speaks to long-term Uncovered Interest Parity (UIP) deviations. To demonstrate this, I will utilise an equation that links long-term bonds, short-term bonds, and the bond term premium together. First, I will derive an expression for the term premium, which reflects a covariance with the stochastic discount factors (SDFs) of investors. This can be derived by examining the following Euler equations for single-year and multi-year foreign bonds, where foreign bonds are subject to sovereign default risk.

$$e^{-\lambda^{*,*(1)}_t} = E_t\left[M^*_{t+1} e^{y^{*(1)}_t + L^{*,*}_{t+1}}\right] \tag{B.31}$$

$$e^{-\lambda^{*,*(n)}_t} = E_t\left[M^*_{t+1} \frac{e^{n\left(y^{*(n)}_t + L^{*,*}_{t+1}\right)}}{e^{(n-1)\left(y^{*(n-1)}_{t+1} + L^{*,*}_{t+2}\right)}} e^{-\lambda^{*,*(n-1)}_{t+1}}\right] \tag{B.32}$$

Then, taking logarithms of (B.31) and (B.32) gives us:

$$-\lambda^{*,*(1)}_t = E_t\left(m^*_{t+1}\right) + \frac{1}{2}\operatorname{var}_t\left(m^*_{t+1}\right) + E_t\left(L^{**}_{t+1}\right) + \frac{1}{2}\operatorname{var}_t\left(L^{*,*}_{t+1}\right) + \operatorname{cov}_t\left(m^*_{t+1}, L^{*,*}_{t+1}\right) \tag{B.33}$$

$$\begin{aligned} -\lambda^{*,*(n)}_t = {} & E_t\left(m^*_{t+1}\right) + \frac{1}{2}\operatorname{var}_t\left(m^*_{t+1}\right) + n y^{*,(n)}_t + E_t\left[nL^{*,*}_{t+1} - (n-1)L^{*,*}_{t+2}\right] - E_t\left[\lambda^{*,*(n-1)}_{t+1}\right] \\ & - (n-1)E_t\left(y^{*(n-1)}_{t+1}\right) + n^2 \operatorname{var}_t\left(L^{*,*}_{t+1}\right) + (n-1)^2 \operatorname{var}_t\left(L^{*,*}_{t+2}\right) \\ & + (n-1)^2 \operatorname{var}_t\left(y^{*(n-1)}_{t+1}\right) + \operatorname{var}_t\left(\lambda^{*,*(n-1)}_{t+1}\right) + n \operatorname{cov}_t\left(m^*_{t+1}, L^{*,*}_{t+1}\right) \\ & - \operatorname{cov}_t\left(m^*_{t+1}, \lambda^{*,*(n-1)}_{t+1}\right) - (n-1)\left[\operatorname{cov}_t\left(m^*_{t+1}, y^{*(n-1)}_{t+1}\right) + \operatorname{cov}_t\left(m^*_{t+1}, L^{*,*}_{t+2}\right)\right] \\ & + (n-1)\left[\operatorname{cov}_t\left(\lambda^{*,*(n-1)}_{t+1}, y^{*(n-1)}_{t+1}\right) + \operatorname{cov}_t\left(\lambda^{*,*(n-1)}_{t+1}, L^{*,*}_{t+2}\right)\right] \\ & + (n-1)^2 \operatorname{cov}_t\left(y^{*(n-1)}_{t+1}, L^{*,*}_{t+2}\right) - n(n-1)\operatorname{cov}\left(y^{*(n-1)}_{t+1}, L^{*,*}_{t+1}\right) \\ & - n(n-1)\operatorname{cov}_t\left(L^{*,*}_{t+2}, L^{*,*}_{t+1}\right) - n\operatorname{cov}_t\left(L^{*,*}_{t+1}, \lambda^{*,*(n-1)}_{t+1}\right) \end{aligned} \tag{B.34}$$

Now, let's define the holding period return of an $n$ period bond for a single period as

$$h^*_{n,t+1} = n y^{*(n)}_t + nL^{*,*}_{t+1} - (n-1)y^{*(n-1)}_{t+1} - (n-1)L^{*,*}_{t+2} + \lambda^{*,*(n)}_t - \lambda^{*,*(n-1)}_{t+1} \tag{B.35}$$

and define $hy^*_{n,t+1}$ as the difference between $h^*_{n,t+1}$ and the return to holding a single period bond:

$$\begin{aligned} hy^*_{n,t+1} = h^*_{n,t+1} - \left(y_t^{*(1)} + L^{*,*}_{t+1} + \lambda_t^{*,*(1)}\right) \\ = n\left(y_t^{*(n)} - y_t^{*(1)}\right) - (n-1)\left[L^{*,*}_{t+2} - L^{*,*}_{t+1} - \left(y_{t+1}^{*(n-1)} + y_t^{*(1)}\right)\right] \\ + \left(\lambda_t^{*,*(n)} - \lambda_t^{*,*(1)}\right) - \lambda_{t+1}^{*,*(n-1)} \end{aligned} \tag{B.36}$$

Then, we have:

$$\begin{aligned} \operatorname{var}_t\left(hy_{n,t+1}\right) = (n-1)^2\left[\operatorname{var}_t\left(\Delta L^{*,*}_{t+2}\right) + \operatorname{var}_t\left(y_{t+1}^{*(n-1)}\right) + \operatorname{var}_t\left(\lambda_{t+1}^{*,*(n-1)}\right)\right. \\ +2(n-1)^2\operatorname{cov}_t\left(\Delta L^{*,*}_{t+2}, y_{t+1}^{*(n-1)}\right) + 2(n-1)\operatorname{cov}_t\left(\Delta L^{*,*}_{t+2}, \lambda_{t+1}^{*,*(n-1)}\right) \\ +2(n-1)\operatorname{cov}_t\left(y_{t+1}^{*(n-1)}, \lambda_{t+1}^{*,*(n-1)}\right) \end{aligned} \tag{B.37}$$

$$\begin{aligned} &\operatorname{cov}_t\left(hy_{n,t+1}, m^*_{t+1}\right) \\ &= -(n-1)\operatorname{cov}_t\left(m^*_{t+1}, \Delta L^{*,*}_{t+2}\right) - (n-1)\operatorname{cov}_t\left(m^*_{t+1}, y_{t+1}^{*(n-1)}\right) \\ &\quad - \operatorname{cov}_t\left(m^*_{t+1}, \lambda_{t+1}^{*,*(n-1)}\right) \end{aligned} \tag{B.38}$$

$$\begin{aligned} &E_t\left(hy_{n,t+1}\right) = ny_t^{*(n)} - (n-1)E_t\left(y_{t+1}^{*(n-1)}\right) - y_t^{*(1)} - (n-1)E_t\left(\Delta L^{*,*}_{t+2}\right) + \lambda_t^{*,*(n)} - \lambda_t^{*,*(1)} \\ &- E_t\left(\lambda_{t+1}^{*,*(n-1)}\right) \end{aligned} \tag{B.39}$$

where $\Delta L^{*,*}_{t+2} = L^{*,*}_{t+2} - L^{*,*}_{t+1}$.

Then, we can rewrite (B.34) as:

$$\begin{aligned} &-\lambda_t^{*,*(n)} = E_t\left(m^*_{t+1}\right) + ny_t^{*(n)} - (n-1)E_t\left[y_{t+1}^{*(n-1)}\right] - (n-1)E_t\left[\Delta L^{*,*}_{t+2}\right] + E_t\left[L^{*,*}_{t+1}\right] \\ &- E_t\left[\lambda_{t+1}^{*,*(n-1)}\right] + \operatorname{cov}_t\left(m^*_{t+1}, L^{*,*}_{t+1}\right) - (n-1)\operatorname{cov}_t\left(m^*_{t+1}, \Delta L^{*,*}_{t+2}\right) \\ &- (n-1)\operatorname{cov}_t\left(m^*_{t+1}, y_{t+1}^{*(n-1)}\right) - \operatorname{cov}_t\left(m^*_{t+1}, \lambda_{t+1}^{*,*(n-1)}\right) \\ &+ (n-1)^2\operatorname{cov}_t\left(y_{t+1}^{*,(n-1)}, \Delta L^{*,*}_{t+2}\right) - (n-1)\operatorname{cov}_t\left(y_{t+1}^{*(n-1)}, L^{*,*}_{t+1}\right) \\ &+ (n-1)\operatorname{cov}_t\left(y_{t+1}^{*(n-1)}, \lambda_{t+1}^{*,*(n-1)}\right) - (n-1)\operatorname{cov}_t\left(\Delta L^{*,*}_{t+2}, L^{*,*}_{t+1}\right) \\ &+ (n-1)\operatorname{cov}_t\left(\Delta L^{*,*}_{t+2}, \lambda_{t+1}^{*,*(n-1)}\right) - \operatorname{cov}_t\left(\lambda_{t+1}^{*,*(n-1)}, L^{*,*}_{t+1}\right) \\ &+ \frac{(n-1)^2}{2}\left[\operatorname{var}_t\left(y_{t+1}^{*(n-1)}\right) + \operatorname{var}_t\left(\Delta L^{*,*}_{t+2}\right)\right] + \frac{1}{2}\operatorname{var}_t\left(L^{*,*}_{t+1}\right) + \frac{1}{2}\operatorname{var}_t\left(\lambda_{t+1}^{*,*(n-1)}\right) \\ &+ \frac{1}{2}\operatorname{var}_t\left(m^{*,*}_{t+1}\right) \end{aligned} \tag{B.40}$$

Rearranging equation (B.40) gives us:

$$
\begin{aligned}
n & \left(y_t^{*,(n)}-y_t^{*(1)}\right) \\
& =(n-1) E_t\left[y_{t+1}^{*(n-1)}-y_t^{*(1)}\right]+(n-1) E_t\left[\Delta L_{t+2}^{*,*}\right]+\left(\lambda_t^{*,*(1)}-\lambda_t^{*,*(n)}\right) \\
& +E_t\left(\lambda_{t+1}^{*,*(n-1)}\right)+(n-1)\left[\operatorname{cov}_t\left(y_{t+1}^{*(n-1)}, L_{t+1}^{*,*}\right)+\operatorname{cov}_t\left(\Delta L_{t+2}^{*,*}, L_{t+1}^{*,*}\right)\right] \\
& +\operatorname{cov}_t\left(\lambda_{t+1}^{*,*(n-1)}, L_{t+1}^{*,*}\right)-\frac{1}{2} \operatorname{var}_t\left(h y_{n, t+1}^*\right)-\operatorname{cov}_t\left(h y_{n, t+1}^*, m_{t+1}^*\right)
\end{aligned} \tag{B.41}
$$

We can also derive a similar relationship for U.S. Treasuries. A key difference is that, unlike foreign bonds, U.S. Treasuries are assumed to be free of default risk. To illustrate this, consider the following Euler equations for U.S. investors who invest in a single-period U.S. Treasury and an $n$ period U.S. Treasury, holding it for a single period:

$$
e^{-\lambda_t^{\$,\$(1)}}=E_t\left[M_{t+1}^{\$} e^{y_t^{\$(1)}}\right] \tag{B.42}
$$

$$
e^{-\lambda_t^{\$,\$,(n)}}=E_t\left[M_{t+1}^{\$} \frac{e^{n\left(y_t^{\$(n)}\right)}}{e^{(n-1)\left(y_{t+1}^{\$(n-1)}\right)}} e^{-\lambda_{t+1}^{\$,\$(n-1)}}\right] \tag{B.43}
$$

Following the same steps as for foreign investors, we can obtain:

$$
\begin{aligned}
y_t^{\$(n)}-y_t^{\$(1)}= & -\frac{1}{2 n} \operatorname{var}_t\left(h y_{n, t+1}^{\$}\right)+\frac{n-1}{n} E_t\left(y_{t+1}^{\$(n-1)}-y_{t+1}^{\$(1)}\right)+\frac{n-1}{n} E_t \Delta y_{t+1}^{\$(1)} \\
& +\frac{1}{n} E_t\left[\lambda_{t+1}^{\$,\$(n-1)}\right]+\frac{1}{n}\left[\lambda_t^{\$,\$(1)}-\lambda_t^{\$,\$(n)}\right]-\frac{1}{n} \operatorname{cov}_t\left(m_{t+1}^{\$}, h y_{n, t+1}^{\$}\right)
\end{aligned} \tag{B.44}
$$

where

$$
h_{n, t+1}^{\$}=n y_t^{\$(n)}-(n-1) y_{t+1}^{\$(n-1)}+\lambda_t^{\$,\$(n)}-\lambda_{t+1}^{\$,\$(n-1)} \tag{B.45}
$$

$$
h y_{n, t+1}^{\$}=h_{n, t+1}^{\$}-\left(y_t^{\$(1)}+\lambda_t^{*,*(1)}\right) \tag{B.46}
$$

$$
\operatorname{var}_t\left(h y_{n, t+1}^{\$}\right)=(n-1)^2 \operatorname{var}_t\left(y_{t+1}^{\$(n-1)}\right)+\operatorname{var}_t\left(\lambda_{t+1}^{\$,\$(n-1)}\right)+2(n-1) \operatorname{cov}_t\left(y_{t+1}^{*(n-1)}, \lambda_{t+1}^{*,*(n-1)}\right) \tag{B.47}
$$

$$
\operatorname{cov}_t\left(m_{t+1}^{\$}, h y_{n, t+1}^{\$}\right)=-(n-1) \operatorname{cov}_t\left(m_{t+1}^{\$}, y_{t+1}^{\$(n-1)}\right)-\operatorname{cov}_t\left(m_{t+1}^{\$}, \lambda_{t+1}^{\$,\$(n-1)}\right) \tag{B.48}
$$

Now, defining $tp_{t+1}^{\$,\$(n)}=-\operatorname{cov}_t\left(m_{t+1}^{\$}, hy_{n,t+1}^{\$}\right)$ the term premium for U.S bonds for U.S. investors and combining (B.44)-(B.48), we obtain the following expression for $y_t^{\$(1)}-y_t^{*(1)}$:

$$
\begin{aligned}
y_t^{\$(1)}-y_t^{*(1)}= & n\left(y_t^{\$(n)}-y_t^{*(n)}\right)+\left[\left(\lambda_t^{*,*(1)}-\lambda_t^{*,*(n)}\right)-\left(\lambda_t^{\$,\$(1)}-\lambda_t^{\$,\$(n)}\right)\right] \\
& -(n-1) E_t\left[y_{t+1}^{\$(n-1)}-y_{t+1}^{*(n-1)}\right]+E_t\left[\lambda_{t+1}^{*,*(n-1)}-\lambda_{t+1}^{\$,\$(n-1)}\right]+(n-1) E_t\left(\Delta L_{t+2}^{*,*}\right) \\
& -\left[tp_t^{\$,\$}-tp_t^{*,*}\right]+\frac{1}{2}\left[\operatorname{var}_t\left(h y_{n, t+1}^{\$}\right)-\operatorname{var}_t\left(h y_{n, t+1}^*\right)\right] \\
& +(n-1)\left[\operatorname{cov}_t\left(y_{t+1}^{*(n-1)}, L_{t+1}^{*,*}\right)+\operatorname{cov}_t\left(\Delta L_{t+2}^{*,*}, L_{t+1}^{*,*}\right)\right] \\
& +\operatorname{cov}_t\left(\lambda_{t+1}^{*,*(n-1)}, L_{t+1}^{*,*}\right)
\end{aligned} \tag{B.49}
$$

where $\Delta L^{*,*}_{t+2} = L^{*,*}_{t+2} - L^{*,*}_{t+1}$.

Then, going back to the exchange rate determination equation we derived for single-period bonds, we can rewrite $y^{\$(1)}_{t+\tau} - y^{*(1)}_{t+\tau}$, by using (B.49). For simplicity, if we ignore the term $\text{var}_t\left(hy^{*}_{n,t+1}\right) - \text{var}_t\left(hy^{\$}_{n,t+1}\right)$ appearing due to Jensen's inequality, equation (B.44) simplifies into:

$$\begin{aligned} y^{\$(1)}_t - y^{*(1)}_t =& n\left(y^{\$(n)}_t - y^{*(n)}_t\right) + \left[\left(\lambda^{*,*(1)}_t - \lambda^{*,*(n)}_t\right) - \left(\lambda^{\$,\$(1)}_t - \lambda^{\$,\$(n)}_t\right)\right] \\ & - (n-1)E_t\left[y^{\$(n-1)}_{t+1} - y^{*(n-1)}_{t+1}\right] + E_t\left[\lambda^{*,*(n-1)}_{t+1} - \lambda^{\$,\$(n-1)}_{t+1}\right] + (n-1)E_t\left(\Delta L^{**}_{t+2}\right) \\ & - \left[tp^{\$,\$}_t - tp^{*,*}_t\right] + (n-1)\left[\text{cov}_t\left(y^{*(n-1)}_{t+1}, L^{*,*}_{t+1}\right) + \text{cov}_t\left(\Delta L^{*,*}_{t+2}, L^{*,*}_{t+1}\right)\right] \\ & + \text{cov}_t\left(\lambda^{*,*(n-1)}_{t+1}, L^{*,*}_{t+1}\right) \end{aligned} \tag{B.50}$$

If we further assume that there are no immediate convenience yield benefits if the bond is not held until maturity, we can further assume that $E_t\left(\lambda^{*,*(n-1)}_{t+1} - \lambda^{\$,\$(n-1)}_{t+1}\right) = 0$.[19] Then we are left with:

$$\begin{aligned} & y^{\$(1)}_t - y^{*(1)}_t = n\left(y^{\$(n)}_t - y^{*(n)}_t\right) + \left[\left(\lambda^{*,*(1)}_t - \lambda^{*,*(n)}_t\right) - \left(\lambda^{\$,\$(1)}_t - \lambda^{\$,\$(n)}_t\right)\right] \\ & - (n-1)E_t\left[y^{\$(n-1)}_{t+1} - y^{*,(n-1)}_{t+1}\right] + (n-1)E_t\left(\Delta L^{*,*}_{t+2}\right) - \left[tp^{\$,\$}_t - tp^{*,*}_t\right] \\ & + (n-1)\left[\text{cov}_t\left(y^{*(n-1)}_{t+1}, L^{*,*}_{t+1}\right) + \text{cov}_t\left(\Delta L^{*,*}_{t+2}, L^{*,*}_{t+1}\right)\right] \\ & + \text{cov}_t\left(\lambda^{*,*(n-1)}_{t+1}, L^{*,*}_{t+1}\right) \end{aligned} \tag{B.51}$$

where $\lambda^{*,*(1)}_t - \lambda^{*,*(n)}_t$ and $\lambda^{\$,\$(1)}_t - \lambda^{\$,\$(n)}_t$ capture the term structure of convenience yields. Another point to highlight in this setting is that the term premium on bonds also depends on the perspective of foreign or U.S. investors. This is captured by the differential between $tp^{\$,\$}_t - tp^{*,*}_t$ in (B.51).

Furthermore, if we assume a random walk process for the credit risk and assume that $\text{cov}_t\left(y^{*(n-1)}_{t+1}, L^{*,*}_{t+1}\right) = 0, \text{cov}_t\left(\lambda^{*,*(1)}_{t+1}, L^{*,*}_{t+1}\right) = 0$, then we have:

$$\begin{aligned} y^{\$(1)}_t - y^{*(1)}_t =& n\left(y^{\$(n)}_t - y^{*(n)}_t\right) + \left[\left(\lambda^{*,*(1)}_t - \lambda^{*,*(n)}_t\right) - \left(\lambda^{\$,\$(1)}_t - \lambda^{\$,\$(n)}_t\right)\right] \\ & - (n-1)E_t\left[y^{\$(n-1)}_{t+1} - y^{*(n-1)}_{t+1}\right] + (n-1)E_t\left(\Delta L^{*,*}_{t+2}\right) - \left[tp^{\$,\$}_t - tp^{*,*}_t\right] \end{aligned} \tag{B.52}$$

This equation allows us to rewrite the exchange rate determination equation, where we can speak to LR-UIP deviations. Then, we can rewrite (B.30) by using (B.52). I also assume that $E_t\left[\lim_{T\to\infty} L^{*,*}_{t+T}\right]$ goes to zero.[20] In addition, $E_t\left[\lim_{T\to\infty} s_{t+T}\right] = \bar{s}$ under the assumption no-bubble condition (Jiang et al., 2024; Lustig et al., 2019).

[19] This assumption is based on the discussion in the lecture notes on international finance by Jiang (2023).

[20] This assumption essentially means that from the perspective of the risk-neutral investors, the probability of default is zero in the long run. The assumption implies that the government will meet its obligations in the long run, and hence, the probability of default, from the perspective of risk-neutral investors, diminishes as the time horizon extends.

$$s_t = nE_t\sum_{\tau=0}^{\infty}\left(y_{t+\tau}^{\$(n)} - y_{t+\tau}^{*(n)}\right) + E_t\sum_{\tau=0}^{\infty}\left(\lambda_{t+\tau}^{\$,*} - \lambda_{t+\tau}^{*,*}\right) - E_t\sum_{\tau=0}^{\infty} rp_{t+\tau}^{*} + E_t\sum_{\tau=0}^{\infty} cp_{t+\tau}^{*}$$
$$+ E_t\sum_{\tau=0}^{\infty}\left(tp_{t+\tau}^{*,*} - tp_{t+\tau}^{\$,\$}\right) + E_t\sum_{\tau=0}^{\infty}\left[\left(\lambda_{t+\tau}^{*,*} - \lambda_{t+\tau}^{*,*(n)}\right) - \left(\lambda_{t+\tau}^{\$,\$} - \lambda_{t+\tau}^{\$,\$(n)}\right)\right] + \overline{s_t} \quad \text{(B.53)}$$

Equivalently, by using (B.11), (B.53) can be rewritten as follows:

$$s_t = nE_t\sum_{\tau=0}^{\infty}\left(y_{t+\tau}^{\$(n)} - y_{t+\tau}^{*(n)}\right) + E_t\sum_{\tau=0}^{\infty}\left(\lambda_{t+\tau}^{\$,\$} - \lambda_{t+\tau}^{*,\$}\right) + E_t\sum_{\tau=0}^{\infty} rp_{t+\tau}^{\$} + E_t\sum_{\tau=0}^{\infty} cp_{t+\tau}^{\$}$$
$$+ E_t\sum_{\tau=0}^{\infty}\left(tp_{t+\tau}^{*,*} - tp_{t+\tau}^{\$,\$}\right) + E_t\sum_{\tau=0}^{\infty}\left[\left(\lambda_{t+\tau}^{*,*} - \lambda_{t+\tau}^{*,*(n)}\right) - \left(\lambda_{t+\tau}^{\$,\$} - \lambda_{t+\tau}^{\$,\$(n)}\right)\right] + E_t\sum_{\tau=0}^{\infty} q_{t+\tau} + \overline{s_t} \quad \text{(B.54)}$$

Equations (B.53) and (B.54) give us the flexibility through which we can explain the deviations from the LR-UIP condition with several factors. If LR-UIP holds, $s_t - \overline{s_t}$ is equal to $nE_t\sum_{\tau=0}^{\infty}\left(y_{t+\tau}^{\$(n)} - y_{t+\tau}^{*(n)}\right)$. However, (B.53) implies that if LR-UIP fails, then it can potentially be driven by several factors: (i) relative convenience yields (ii) FX risk, (iii) credit risk, (iv) relative term premium, (v) relative term structure of convenience yields, and (vi) quanto adjustment term.[21]

In the literature, Jiang et al. (2024) discusses the effect of convenience yield term. Equation (B.52) has additional terms capturing other potential factors that can potentially drive the deviations from LR-UIP in the context of EMs. A higher convenience yield on the U.S. bonds relative to the foreign bonds and a higher quanto adjustment term, which implies a higher covariance between the expected depreciation of the foreign currency and the default loss in foreign bonds, leads to a stronger dollar. A lower credit risk premium, on the other hand, leads to a stronger foreign currency.

## B.5 Pure treasury basis, convenience yields, credit risk, and dollarness

The relative convenience yield term, $\lambda_t^{\$,*} - \lambda_t^{*,*}$, that appears in the exchange rate equation can be inferred from the treasury basis adjusted for the credit risk, and the quanto adjustment term, which we call as the "pure treasury basis." In order to see this, consider the following Euler equation given in (B.55) for the foreign investor. This includes an investment strategy where the foreign investor buys a foreign bond and then swaps into dollars in the forward market as in Jiang, Krishnamurthy, and Lustig (2021).

$$E_t\left(M_{t+1}^{*}\frac{S_{t+1}}{S_t}\frac{S_t}{F_t^1}e^{y_t^{*}+L_{t+1}^{*,*}}\right) = e^{-\lambda_t^{*,*}-\beta^{*,*}\left(\lambda_t^{\$,*}-\lambda_t^{*,*}\right)} \quad \text{(B.55)}$$

where $F_t^1$ is the forward exchange rate. $\beta^{*,*}$ represents the extra convenience yield added by the dollarness. If $\beta^{*,*} = 1$, the hedge provided by the forward contract makes the foreign bond equivalent to the U.S. bond, and if $\beta^{*,*} = 0$, there is no "dollarness" benefit created by the forward position.

[21] The quanto adjustment term appears depending on the type of the investors, i.e., whether it is a foreign or U.S. investor.

Then, combining (B.55) with (B.2) gives us the following equation (B.56):

$$\begin{aligned} x_t^{\text{Treas,pure}} &\equiv \underbrace{y_t^{\$} - y_t^{*} + \left(f_t^{1} - s_t\right)}_{x_t^{\text{Treas}}} - \left(E_t\left(L_{t+1}^{*,*}\right) - cp_t^{*} + \text{cov}_t\left(\Delta s_{t+1}, L_{t+1}^{*,*}\right)\right) \\ &= -\left(1-\beta^{*,*}\right)\left(\lambda_t^{\$,*} - \lambda_t^{*,*}\right) \end{aligned} \tag{B.56}$$

Jiang, Krishnamurthy, and Lustig (2021) argue that the CIP deviations reflect relative convenience yields, whereas Du and Schreger (2016) claim that for EMs, local currency credit risk is the main reason behind CIP deviations. With equation (B.56), we can reconcile two approaches claiming that both convenience yields and credit risk matter, as in Dao and Gourinchas (2025). In addition, there is a third term in (B.56), which is the quanto adjustment term capturing the covariance between the credit risk and the currency depreciation. Overall, one needs to account for all these terms to be able to measure the true CIP deviation and hence the relative convenience yields.[22]

Next, calling $y_t^{\$} - y_t^{*} + \left(f_t^{1} - s_t\right)$ as the conventional measure for the treasury basis, and then accounting for credit risk and quanto adjustment, we can derive the pure treasury basis $x_t^{\text{Treas, pure}}$, and use this measure in the exchange rate equation as follows:

$$\begin{aligned} s_t = &-E_t\sum_{\tau=0}^{\infty}\frac{x_t^{\text{Treas,pure}}}{\left(1-\beta^{*,*}\right)} + nE_t\sum_{\tau=0}^{\infty}\left(y_{t+\tau}^{\$(n)} - y_{t+\tau}^{*(n)}\right) - E_t\sum_{\tau=0}^{\infty} rp_{t+\tau}^{*} + E_t\sum_{\tau=0}^{\infty} cp_{t+\tau}^{*} \\ &+E_t\sum_{\tau=0}^{\infty}\left(tp_{t+\tau}^{*,*} - tp_{t+\tau}^{\$,\$}\right) + E_t\sum_{\tau=0}^{\infty}\left[\left(\lambda_{t+\tau}^{*,*} - \lambda_{t+\tau}^{*,*(n)}\right) - \left(\lambda_{t+\tau}^{\$,\$} - \lambda_{t+\tau}^{\$,\$(n)}\right)\right] + \overline{s_t} \end{aligned} \tag{B.57}$$

[22]Equation (B.56) is reminiscent of the measurement of the Treasury basis adjusted for the credit risk as it is done in Appendix V of Jiang, Krishnamurthy, and Lustig (2021). They account for the credit risk by subtracting the respective country's credit default swap spreads from $y_t^{\$}$ and $y_t^{*}$, which is given as

$$x_t^{\text{Treas}} \equiv \left(y_t^{\$} - cds_t^{\$}\right) + \left(f_t^{1} - s_t\right) - \left(y_t^{*} - cds_t^{*}\right)$$

With equation (B.56), I provide a theoretical motivation as to why this is necessary, specifically in the context of EMs.

# C Robustness analysis

## C.1 Post-GFC analysis for selected AEs using the methodology of this paper

Table 1C: Post-GFC analysis for AEs using intraday data (narrow window)

| | **GBP** | **Yen** | **Euro** |
|---|---|---|---|
| $\beta$ | -2.624*** | -2.750* | -3.241*** |
| | (0.765) | (0.914) | (1.267) |
| N | 53 | 53 | 53 |
| $R^2$ | 0.248 | 0.195 | 0.242 |

The table shows the coefficient estimates from regressions (2) for the effect of Fed QE announcements on the euro, British pound, and yen for the pre-COVID period using intraday data from Rogers et al. (2014). The yen-dollar exchange rate is defined as yen per dollar, the euro-dollar exchange rate is defined as dollar per euro, and the pound-dollar exchange rate is defined as dollar per pound. Bootstrapped standard errors are reported in parentheses. An asset purchase surprise by the Fed appreciates the U.S. dollar against the yen and depreciates the U.S. dollar against the euro and the pound. Note: A narrow window is used. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively.

Table 2C: Post-GFC analysis for AEs using intraday data (wide window)

| | **GBP** | **Yen** | **Euro** |
|---|---|---|---|
| $\beta$ | -4.247*** | -5.151*** | -5.002*** |
| | (1.289) | (1.244) | (1.531) |
| N | 53 | 53 | 53 |
| $R^2$ | 0.098 | 0.191 | 0.099 |

The table shows the coefficient estimates from regressions (2) for the effect of Fed QE announcements on the euro, British pound, and yen for the pre-COVID period using intraday data from Rogers et al. (2014). The yen-dollar exchange rate is defined as yen per dollar, the euro-dollar exchange rate is defined as dollar per euro, and the pound-dollar exchange rate is defined as dollar per pound. Bootstrapped standard errors are reported in parentheses. An asset purchase surprise by the Fed appreciates the U.S. dollar against the yen and depreciates the U.S. dollar against the euro and the pound. Note: A wide window is used. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively.

## C.2 All monetary policy announcements

Table 3C: All monetary policy announcements

| | **EMEs** | | | **AEs** | | |
|---|---|---|---|---|---|---|
| | **Baseline** | **FA3** | **FA4** | **Baseline** | **FA3** | **FA4** |
| $\beta$ | 0.010*** | 0.009*** | 0.009*** | 0.034** | 0.029* | 0.006 |
| | (0.003) | (0.003) | (0.003) | (0.015) | (0.017) | (0.015) |
| N | 379 | 379 | 379 | 113 | 113 | 113 |
| $R^2$ | 0.055 | 0.046 | 0.044 | 0.093 | 0.054 | 0.02 |

The table shows the coefficient estimates from regression (2) where the event set consists of all monetary policy announcements between 2020-2021 including those on asset purchase programmes. Asset purchase surprises are extracted in three different ways: (i) baseline, where no confounding variables are accounted for; (ii) FA3, where surprises are extracted where Fed policy actions are accounted for by 3 factors; and (iii) FA4, where surprises are extracted where Fed policy actions are accounted for by 4 factors. The results are reported separately for AEs and EMs. Bootstrapped standard errors are reported in parentheses. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively.

## C.3 Controlling for forward guidance in AEs

Table 4C: Controlling for forward guidance in AEs (APP announcements only)

| | **Baseline** | | **FA4** | |
|---|---|---|---|---|
| | **Gov. & Private** | **Gov. only** | **Gov. & Private** | **Gov. only** |
| $\beta$ | 0.065** | 0.090*** | 0.048 | 0.112** |
| | (0.027) | (0.033) | (0.043) | (0.052) |
| N | 28 | 19 | 28 | 19 |
| $R^2$ | 0.303 | 0.344 | 0.041 | 0.103 |

The table shows the coefficient estimates from regressions where forward guidance is controlled with changes in 2-year government bond yields for AEs in the first stage. The results are divided into two parts as Gov. & Private, and Gov. only, respectively. Bootstrapped standard errors are reported in parentheses. An increase in the exchange rate denotes an appreciation of the U.S. dollar and a depreciation of the non-U.S. currency. *, **, *** indicates statistical significance at the 10%, 5% and 1% level, respectively.

Table 5C: Controlling for forward guidance in AEs (All monetary policy announcements)

| | **Baseline** | **FA3** | **FA4** |
|---|---|---|---|
| $\beta$ | 0.047** | 0.043* | 0.020 |
| | (0.023) | (0.024) | (0.024) |
| N | 113 | 113 | 113 |
| $R^2$ | 0.109 | 0.071 | 0.012 |

The table shows the coefficient estimates from regressions where forward guidance is controlled with changes in 2-year government bond yields for AEs in the first stage. The event set includes all monetary policy announcements, including the asset purchase programmes. An increase in the exchange rate denotes an appreciation of the U.S. dollar and a depreciation of the non-U.S. currency. Bootstrapped standard errors are reported in parentheses. *, **, *** indicates statistical significance at the 10%, 5% and 1% level, respectively.

## C.4 Swap vs. Non-swap countries

Table 6C: Classification based on access to Fed swap lines

| | Non-swap | | Swap | |
|---|---|---|---|---|
| | **Gov. & Private** | **Gov. only** | **Gov. & Private** | **Gov. only**[†] |
| $\beta$ | 0.016*** | 0.007 | 0.051** | 0.063 |
| | (0.004) | (0.006) | (0.021) | ( 0.039) |
| N | 48 | 43 | 29 | 18 |
| $R^2$ | 0.156 | 0.024 | 0.094 | 0.038 |

The table shows the coefficient estimates from regression (2), where the asset purchase surprises are extracted as residuals from (5). The countries are grouped on whether they have access to Fed swap lines or not. The analysis accounts for the multidimensionality of Fed policy actions using four factors. The results are divided into two parts: Gov. & Private, and Gov. only. Bootstrapped standard errors are reported in parentheses. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively. The group "Gov. only[†]" excludes the ECB 3/12/2020 announcement.

## C.5 Foreign investor base

Table 7C: Classification based on foreign investor share in total government debt

| | High Foreign Investor Share | | Low Foreign Investor Share | |
|---|---|---|---|---|
| | **Gov. & Private** | **Gov. only** | **Gov. & Private** | **Gov. only** |
| $\beta$ | 0.019*** | 0.016*** | 0.040* | 0.026 |
| | (0.002) | (0.004) | (0.024) | (0.027) |
| N | 32 | 24 | 45 | 38 |
| $R^2$ | 0.221 | 0.148 | 0.109 | 0.038 |

The table shows the coefficient estimates from regression (2), where the asset purchase surprises are extracted as residuals from (5) for the foreign investor share in total government debt. If the foreign investor share as of 2019Q4 is above the median level among the sample of countries, then the country is classified as a high group and low otherwise. The analysis accounts for the multidimensionality of Fed policy actions using four factors. The results are divided into two parts as Gov. & Private, and Gov. only. Bootstrapped standard errors are reported in parentheses. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively.

## C.6 Commodity dependent countries

Table 8C: Classification based on commodity dependence

| | **Commodity Dependent** | | **Not Commodity Dependent** | |
|---|---|---|---|---|
| | **Gov. & Private** | **Gov. only** | **Gov. & Private** | **Gov. only** |
| $\beta$ | 0.021*** | 0.033 | 0.009* | 0.005 |
| | (0.001) | (0.050) | (0.005) | (0.005) |
| N | 16 | 15 | 57 | 46 |
| $R^2$ | 0.178 | 0.018 | 0.034 | 0.012 |

The table shows the coefficient estimates from regression (2) where the asset purchase surprises are extracted as residuals from (5). The countries are grouped based on whether they are classified as commodity-dependent or not. The results are divided into two parts as Gov. & Private, and Gov. only. Bootstrapped standard errors are reported in parentheses. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively.

## C.7 Exchange rate regime

Table 9C: Classification based on the exchange rate regime (fine classification)

| | **Flexible** | | **Managed** | |
|---|---|---|---|---|
| | **Gov. & Private** | **Gov. only** | **Gov. & Private** | **Gov. only** |
| $\beta$ | 0.0188*** | 0.0160*** | 0.00380 | -0.000271 |
| | (0.003) | (0.005) | (0.011) | (0.021) |
| N | 62 | 49 | 16 | 14 |
| $R^2$ | 0.127 | 0.045 | 0.004 | 0.000 |

The table shows the coefficient estimates from regression (2) where the asset purchase surprises are extracted as residuals from (5) for the fine classification based on Ilzetzki et al. (2022). If the score is greater than or equal to 9, the country is classified as having a flexible exchange rate regime as of 2019 and managed otherwise. The analysis accounts for the multidimensionality of Fed policy actions using four factors. The results are divided into two parts as Gov. & Private, and Gov. only. Bootstrapped standard errors are reported in parentheses. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively.

Table 10C: Classification based on the exchange rate regime (coarse classification)

| | **Flexible** | | **Managed** | |
|---|---|---|---|---|
| | **Gov. & Private** | **Gov. only** | **Gov. & Private** | **Gov. only** |
| $\beta$ | 0.0187*** | 0.0162*** | 0.00658 | 0.00636 |
| | (0.003) | (0.005) | (0.007) | (0.006) |
| N | 58 | 48 | 20 | 15 |
| $R^2$ | 0.133 | 0.046 | 0.011 | 0.014 |

The table shows the coefficient estimates from regression (2) where the asset purchase surprises are extracted as residuals from (5) for the coarse classification based on Ilzetzki et al. (2022). If the score is greater than or equal to 3, the country is classified as having a flexible exchange rate regime as of 2019 and managed otherwise. The analysis accounts for the multidimensionality of Fed policy actions using four factors. The results are divided into two parts as Gov. & Private, and Gov. only. Bootstrapped standard errors are reported in parentheses. *,**,*** indicates statistical significance at the 10%, 5% and 1% level, respectively.

# D Summary statistics for asset purchase surprises

Table 1D: Descriptive Statistics for Asset Purchase Surprises (APSs) (Gov. & Private)

| | Mean | | Std. Dev. | | Min | | Max | | Obs. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | EMs | AEs | EMs | AEs | EMs | AEs | EMs | AEs | EMs | AEs |
| **Baseline** | | | | | | | | | | |
| APSs | -6.89 | -0.89 | 32.01 | 16.98 | -133.98 | -54.79 | 80.03 | 49.58 | 50 | 28 |
| APSs $> 0$ | 10.28 | 10.75 | 15.75 | 14.10 | 0.07 | 0.50 | 80.03 | 49.58 | 27 | 12 |
| APSs $< 0$ | -31.11 | -10.25 | 35.48 | 13.78 | -133.98 | -54.79 | -1.00 | -0.88 | 20 | 15 |
| **All controls** | | | | | | | | | | |
| APSs | -3.01 | -1.25 | 29.09 | 6.67 | -103.07 | -16.27 | 70.73 | 10.62 | 50 | 28 |
| APSs $> 0$ | 13.27 | 4.11 | 15.36 | 3.23 | 0.07 | 0.19 | 70.73 | 10.62 | 29 | 14 |
| APSs $< 0$ | -25.50 | -6.60 | 28.76 | 4.51 | -103.07 | -16.27 | -0.37 | -0.53 | 21 | 14 |

Table 2D: Descriptive Statistics for Asset Purchase Surprises (APSs) (Gov. only)

| | Mean | | Std. Dev. | | Min | | Max | | Obs. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | EMs | AEs | EMs | AEs | EMs | AEs | EMs | AEs | EMs | AEs |
| **Baseline** | | | | | | | | | | |
| APSs | -2.88 | -1.71 | 26.61 | 18.25 | -90.00 | -61.60 | 80.83 | 39.12 | 44 | 19 |
| APSs $> 0$ | 9.95 | 10.48 | 16.08 | 11.88 | 0.09 | 2.01 | 80.83 | 39.12 | 26 | 8 |
| APSs $< 0$ | -25.69 | -11.64 | 29.11 | 17.74 | -90.00 | -61.60 | -1.00 | -3.07 | 15 | 10 |
| **All controls** | | | | | | | | | | |
| APSs | -1.50 | -1.37 | 24.31 | 5.37 | -87.66 | -11.26 | 40.51 | 9.22 | 44 | 19 |
| APSs $> 0$ | 11.32 | 4.06 | 11.96 | 3.20 | 0.11 | 0.00 | 40.51 | 9.22 | 27 | 7 |
| APSs $< 0$ | -21.86 | -4.54 | 25.25 | 3.45 | -87.66 | -11.26 | -0.13 | 0.00 | 17 | 12 |

# E Data sources and descriptions

## E.1 Emerging markets

| Countries | Source | Variable | Ticker |
|---|---|---|---|
| BRL | Refinitiv | 3m benchmark rate | BR3MT=RR |
| CHL | Refinitiv | 1y benchmark rate | CL1YT=RR |
| CHN | Refinitiv | 1y benchmark rate | CN1YT=RR |
| COL | Refinitiv | 1y rate | CO040522F= |
| CRO | Refinitiv | 3y benchmark rate | HR3YT=RR |
| EGY | Refinitiv | 3m benchmark rate | EG3MT=RR |
| GHA | Refinitiv | 3m benchmark rate | GH3MT=RR |
| HUN | Refinitiv | 3m benchmark rate | HU3MT=RR |
| IDA | Refinitiv | 3m benchmark rate | ID3MT=RR |
| IND | Refinitiv | 3m benchmark rate | IN3MT=RR |
| ISR | Refinitiv | 3m benchmark rate | IL3MT=RR |
| JAM | Refinitiv | cds derived 6month usd point | JMGVCUSD6M= |
| KOR | Refinitiv | 3m benchmark rate | KRKTB3MAV= |
| MEX | Refinitiv | 3m benchmark rate | MX3MT=RR |
| MUS | Refinitiv | 6m benchmark rate | MU6MT=RR |
| PHL | Refinitiv | 3m benchmark rate | PH3MT=RR |
| POL | Refinitiv | 1y benchmark rate | PL1YT=RR |
| ROM | Refinitiv | 6m benchmark rate | RO6MT=RR |
| SAF | Refinitiv | 3m benchmark rate | ZA3MT=RR |
| THA | Refinitiv | 1y benchmark rate | TH1YT=RR |
| TUR | Refinitiv | 3m benchmark rate | TR3MT=RR |
| UGA | Refinitiv | 3m benchmark rate | UG3MT=RR |
| SRB | Refinitiv | 1y benchmark rate | RS1YT=RR |

Table 1E: The table shows the descriptions of the daily data on the short-term interest rates for EMs.

| Countries | Source | Variable | Ticker |
|---|---|---|---|
| BRL | Refinitiv | 10y benchmark rate | BR10YT=RR |
| CHL | Refinitiv | 10y benchmark rate | CL10YT=RR |
| CHN | Refinitiv | 10y benchmark rate | CN10YT=RR |
| COL | Refinitiv | 10y rate | CO180930F= |
| CRO | Refinitiv | 10y benchmark rate | HR10YT=RR |
| EGY | Refinitiv | 10y benchmark rate | EG10YT=RR |
| GHA | Refinitiv | 10y benchmark rate | GH10YT=RR |
| HUN | Refinitiv | 10y benchmark rate | HU10YT=RR |
| IDA | Refinitiv | 10y benchmark rate | ID10YT=RR |
| IND | Refinitiv | 10y benchmark rate | IN10YT=RR |
| ISR | Refinitiv | 10y benchmark rate | IL10YT=RR |
| JAM | Refinitiv | cds derived 10-year usd point | JMGVCUSD10Y= |
| KOR | Refinitiv | 10y benchmark rate | KR10YT=RR |
| MEX | Refinitiv | 10y benchmark rate | MX10YT=RR |
| MUS | Refinitiv | 10y benchmark rate | MU10YT=RR |
| PHL | Refinitiv | 10y benchmark rate | PH10YT=RR |
| POL | Refinitiv | 10y benchmark rate | PL10YT=RR |
| ROM | Refinitiv | 10y benchmark rate | RO10YT=RR |
| SAF | Refinitiv | 10y benchmark rate | ZA10YT=RR |
| THA | Refinitiv | 10y benchmark rate | TH10YT=RR |
| TUR | Refinitiv | 10y benchmark rate | TR10YT=RR |
| UGA | Refinitiv | 10y benchmark rate | UG10YT=RR |
| SRB | Refinitiv | 10y benchmark rate | RS10YT=RR |

Table 2E: The table shows the descriptions of the daily data on the long-term interest rates for EMs.

| Countries | Source | Variable | Ticker |
|---|---|---|---|
| BRL | Refinitiv | exchange rate | BRL= |
| CHL | Refinitiv | exchange rate | CLP=RCFX |
| CHN | Refinitiv | exchange rate | CNY= |
| COL | Refinitiv | exchange rate | COP= |
| CRO | Refinitiv | exchange rate | HRK= |
| EGY | Refinitiv | exchange rate | EGP= |
| GHA | Refinitiv | exchange rate | GHS= |
| HUN | Refinitiv | exchange rate | HUF= |
| IDA | Refinitiv | exchange rate | IDR= |
| IND | Refinitiv | exchange rate | INR= |
| ISR | Refinitiv | exchange rate | ILS= |
| JAM | Refinitiv | exchange rate | JMD= |
| KOR | Refinitiv | exchange rate | KRW= |
| MEX | Refinitiv | exchange rate | MXN= |
| MUS | Refinitiv | exchange rate | MUR= |
| PHL | Refinitiv | exchange rate | PHP= |
| POL | Refinitiv | exchange rate | PLN= |
| ROM | Refinitiv | exchange rate | RON= |
| SAF | Refinitiv | exchange rate | ZAR= |
| THA | Refinitiv | exchange rate | THB= |
| TUR | Refinitiv | exchange rate | TRY= |
| UGA | Refinitiv | exchange rate | UGX= |
| SRB | Refinitiv | exchange rate | RSD= |

Table 3E: The table shows the descriptions for the daily data on the bilateral exchange rate with respect to the U.S. dollar for EMs. An increase in the exchange rate represents an appreciation of the U.S. dollar and a depreciation of the non-U.S. currency.

## E.2 Advanced economies

| Countries | Source | Variable | Ticker |
|---|---|---|---|
| ECB | Refinitiv | 3m benchmark rate | EU3MT=RR |
| BoJ | Refinitiv | 3m benchmark rate | JP3MT=RR |
| BoE | Refinitiv | 3m benchmark rate | GB3MT=RR |
| AUS | Refinitiv | 1y benchmark rate | AU1YT=RR |
| CAN | Refinitiv | 3m benchmark rate | CA3MT=RR |
| NZE | Refinitiv | 3m benchmark rate | NZ3MT=RR |
| SWE | Refinitiv | 3m benchmark rate | SE3MT=RR |

Table 4E: The table shows the descriptions for the data on the short-term interest rates for AEs.

| Countries | Source | Variable | Ticker |
|---|---|---|---|
| ECB | Refinitiv | 10y benchmark rate | EU10YT=RR |
| BoJ | Refinitiv | 10y benchmark rate | JP10YT=RR |
| BoE | Refinitiv | 10y benchmark rate | GB10YT=RR |
| AUS | Refinitiv | 10y benchmark rate | AU10YT=RR |
| CAN | Refinitiv | 10y benchmark rate | CA10YT=RR |
| NZE | Refinitiv | 10y benchmark rate | NZ10YT=RR |
| SWE | Refinitiv | 10y benchmark rate | SE10YT=RR |

Table 5E: The table shows the descriptions for the daily data on the long-term interest rate for AEs.

| Countries | Source | Variable | Ticker |
|---|---|---|---|
| ECB | Refinitiv | exchange rate | USDEUR=R |
| BoJ | Refinitiv | exchange rate | JPY= |
| BoE | Refinitiv | exchange rate | USDGBP=R |
| AUS | Refinitiv | exchange rate | USDAUD=R |
| CAN | Refinitiv | exchange rate | CAD= |
| NZE | Refinitiv | exchange rate | USDNZD=R |
| SWE | Refinitiv | exchange rate | SEK= |

Table 6E: The table shows the descriptions for the daily data on the bilateral exchange rate with respect to the U.S. dollar for AEs. An increase in the exchange rate represents an appreciation of the U.S. dollar.

## E.3 Factor analysis

| Variables | Source | Code | Description |
|---|---|---|---|
| **Federal Funds Futures Rate** | Bloomberg | FF1 COMB Comdty | Close |
| | Bloomberg | FF3 COMB Comdty | Close |
| **Eurodollar futures** | Bloomberg | ED2 COMB Comdty | Close |
| | Bloomberg | ED3 COMB Comdty | Close |
| | Bloomberg | ED4 COMB Comdty | Close |
| **Treasury yields** | Bloomberg | H15T2Y Index | Last Price |
| | Bloomberg | H15T5Y Index | Last Price |
| | Bloomberg | H15T10Y Index | Last Price |

Table 7E: The table shows the descriptions for the variables used in the factor analysis for the U.S. Note: Data is collected from Bloomberg at daily frequency.

| Country | Forward Premium (Definition) |
|---|---|
| BRL | NDS-TBS3v6_USD/100-IRS_USD |
| CHN | NDS - TBS3v6_USD/100 - IRS_USD |
| CHL | IRS -BS/100+TBS3v6_USD-IRS_USD |
| COL | NDS-TBS3v6_USD/100-IRS_USD |
| HUN | IRS+BS/100+BS_EUR/100-IRS_USD |
| IDA | NDS-TBS3v6_USD/100-IRS_USD |
| IND | NDS - TBS3v6_USD/100 - IRS_USD |
| ISR | IRS+BS/100-IRS_USD |
| KOR | NDS-TBS3v6_USD/100-IRS_USD |
| MEX | IRS-BS/100+TBS1v3_USD/100-IRS_USD |
| PHL | NDS-TBS3v6_USD/100-IRS_USD |
| POL | IRS+BS/100+BS_EUR/100-IRS_USD |
| SAF | IRS+BS/100-IRS_USD |
| THA | IRS+BS/100-TBS3v6_USD-IRS_USD |
| TUR | CCS-IRS |
| AUS | IRS+BS/100-IRS_USD |
| CAN | IRS+BS/100-IRS_USD |
| ECB | IRS+BS/100-IRS_USD |
| BoE | IRS+BS/100-IRS_USD |
| BoJ | IRS+BS/100-IRS_USD |
| NZE | IRS+BS/100-IRS_USD |
| SWE | IRS+BS/100-IRS_USD |

Table 8E: The table shows the definitions for the calculation of forward premia for each country used in the analysis. Note: See Du et al. (2020) for the definition and the tickers from Bloomberg of the variables used in the analysis.

# F Extension of the announcement dates for the factor analysis for the Fed announcements

Table 1F shows the event dates for the announcements, including FOMC meetings, asset purchases, swap line agreements, and measures directed towards banking and corporate sectors (labelled as "Support") for the 2020-2021 period for the Fed.

Table 1F: Announcement dates for the Fed Factors extraction

| Date | **Description** | **Classification** |
|---|---|---|
| 1/29/20 | Federal Reserve issues FOMC statement | FOMC |
| 3/3/20 | Federal Reserve issues FOMC statement | FOMC |
| 3/15/20 | Federal Reserve issues FOMC statement | FOMC + Swap +APP |
| 3/17/20 | Federal Reserve Board announces establishment of a Primary Dealer Credit Facility (PDCF) to support the credit needs of households and businesses. Federal Reserve Board announces establishment of a Commercial Paper Funding Facility (CPFF) to support the flow of credit to households and businesses | Support |
| 3/18/20 | Federal Reserve Board broadens programme of support for the flow of credit to households and businesses by establishing a Money Market Mutual Fund Liquidity Facility (MMLF) | Support |

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Table 1F: Announcement dates for the Fed Factors extraction (Continued)

| | | |
|---|---|---|
| 3/19/20 | Federal Reserve announces the establishment of temporary U.S. dollar liquidity arrangements with other central banks | Swap |
| 3/20/20 | Coordinated central bank action to further enhance the provision of U.S. dollar liquidity, Federal Reserve Board expands its programme of support for flow of credit to the economy by taking steps to enhance liquidity and functioning of crucial state and municipal money markets | Swap |
| 3/23/20 | Federal Reserve issues FOMC statement, Federal Reserve announces extensive new measures to support the economy, Federal Reserve Board announces technical change to support the U.S. economy and allow banks to continue lending to creditworthy households and businesses | FOMC + Support +APP |
| 3/26/20 | Federal Reserve offers regulatory reporting relief to small financial institutions affected by the coronavirus | Support |
| 3/27/20 | Agencies announce two actions to support lending to households and businesses | Support |
| 3/31/20 | Federal Reserve announces establishment of a temporary FIMA Repo Facility to help support the smooth functioning of financial markets | Support |
| 4/1/20 | Federal Reserve Board announces temporary change to its supplementary leverage ratio rule to ease strains in the Treasury market resulting from the coronavirus and increase banking organisations' ability to provide credit to households and businesses | Support |
| 4/6/20 | Federal Reserve will establish a facility to facilitate lending to small businesses via the Small Business Administration's Paycheck Protection Programme (PPP) by providing term financing backed by PPP loans | Support |
| 4/27/20 | Federal Reserve Board announces an expansion of the scope and duration of the Municipal Liquidity Facility | Support |
| 4/29/20 | Federal Reserve issues FOMC statement | FOMC |
| 4/30/20 | Federal Reserve Board announces it is expanding the scope and eligibility for the Main Street Lending Programme, Federal Reserve expands access to its Paycheck Protection Programme Liquidity Facility (PPPLF) to additional lenders, and expands the collateral that can be pledged | Support |
| 6/3/20 | Federal Reserve Board announces an expansion in the number and type of entities eligible to directly use its Municipal Liquidity Facility | Support |
| 6/8/20 | Federal Reserve Board expands its Main Street Lending Programme to allow more small and medium-sized businesses to be able to receive support | Support |
| 6/10/20 | Federal Reserve issues FOMC statement | FOMC |

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Table 1F: Announcement dates for the Fed Factors extraction (Continued)

| | | |
|---|---|---|
| 6/15/20 | Federal Reserve Board announces updates to Secondary Market Corporate Credit Facility (SMCCF), which will begin buying a broad and diversified portfolio of corporate bonds to support market liquidity and the availability of credit for large employers | Support |
| 7/15/20 | Federal Reserve Board announces extension of rule change to bolster effectiveness of the Small Business Administration's Paycheck Protection Programme | Support |
| 7/17/20 | Federal Reserve Board modifies Main Street Lending Programme to provide greater access to credit for nonprofit organisations such as educational institutions, hospitals, and social service organisations | Support |
| 7/23/20 | Federal Reserve Board announces expansion of counterparties in the Term Asset-Backed Securities Loan Facility, Secondary Market Corporate Credit Facility, and Commercial Paper Funding Facility | Support |
| 7/28/20 | Federal Reserve Board announces an extension through December 31 of its lending facilities that were scheduled to expire on or around September 30 | Support |
| 7/29/20 | Federal Reserve issues FOMC statement, Federal Reserve Board announces the extensions of its temporary U.S. dollar liquidity swap lines and the temporary repurchase agreement facility for foreign and international monetary authorities (FIMA repo facility) through March 31, 2021 | Swap |
| 9/16/20 | Federal Reserve issues FOMC statement | FOMC |
| 9/30/20 | Federal Reserve Board announces it will extend for an additional quarter several measures to ensure that large banks maintain a high level of capital resilience | Support |
| 11/5/20 | FOMC Rate Decision (Upper Bound)<br>FOMC Rate Decision (Lower Bound) | FOMC |
| 11/30/20 | Federal Reserve Board announces extension through March 31, 2021, for several of its lending facilities that were generally scheduled to expire on or around December 31 | Support |
| 12/16/20 | FOMC Rate Decision (Upper Bound)<br>FOMC Rate Decision (Lower Bound) | FOMC + Swap |
| 12/29/20 | Federal Reserve extends termination date of Main Street Lending Programme facilities to January 8, 2021 to allow more time to process and fund loans that were submitted to Main Street lender portal on or before December 14, 2020 | Support |
| 1/27/21 | FOMC Rate Decision (Upper Bound)<br>FOMC Rate Decision (Lower Bound) | FOMC |
| 2/9/21 | Federal Reserve Board announces the second extension of a rule to bolster the effectiveness of the Small Business Administration's Paycheck Protection Programme (PPP) | Support |
| 3/8/21 | Federal Reserve Board announces it will extend its Paycheck Protection Programme Liquidity Facility, or PPPLF, by three months to June 30, 2021 | Support |
| 3/17/21 | Federal Reserve issues FOMC statement | FOMC |
| 4/28/21 | Federal Reserve issues FOMC statement | FOMC |
| 5/14/21 | Federal Reserve Board announces the third extension of a rule to bolster the effectiveness of the Small Business Administration's Paycheck Protection Programme (PPP) | Support |

Continued on next page

Table 1F: Announcement dates for the Fed Factors extraction (Continued)

| | | |
|---|---|---|
| 6/16/21 | Federal Reserve issues FOMC statement, Federal Reserve announces the extension of its temporary U.S. dollar liquidity swap lines with nine central banks through December 31, 2021 | Swap |
| 6/25/21 | Federal Reserve Board announces it will extend for a final time its Paycheck Protection Programme Liquidity Facility, or PPPLF, by an additional month to July 30, 2021 | Support |
| 7/28/21 | Federal Reserve issues FOMC statement | FOMC |
| 9/22/21 | Federal Reserve issues FOMC statement | FOMC |
| 11/3/21 | Federal Reserve issues FOMC statement | FOMC |
| 12/15/21 | Federal Reserve issues FOMC statement | FOMC |

# G Post-GFC - Pre-COVID APP announcement dates for BOE, BOJ, and ECB

| Dates | Announcement | Source |
|---|---|---|
| **1/19/09** | APF: HMT statement: "The BoE will set up an asset purchase programme [...]. The Bank will be authorised by the Treasury to purchase high quality private sector assets, including paper issued under the Credit Guarantee Scheme, corporate bonds, commercial paper, syndicated loans and a limited range of asset backed securities created in viable securitisation structures. The Treasury will authorise initial purchases of up to £50bn." | Serra and Ferreira (2019), Hesse et al. (2018) and Rogers et al. (2014) |
| **1/29/09** | Asset Purchase Facility announcement | Rogers et al. (2014) |
| **2/11/09** | Inflation report and press conference | Rogers et al. (2014) |
| **3/5/09** | Asset purchases increased to £75 billion, now financed by central bank reserves rather than Treasury bills and including purchases of gilts in the secondary market. APF announcement: $75 billion of Gilts, 5-25 years; bank rate decreased to 0.5%. APF: MPC statement: "The BoE should finance £75 billion of asset purchases by the creation of central bank reserves." | Serra and Ferreira (2019), Hesse et al. (2018) and Rogers et al. (2014) |
| **5/7/09** | Asset purchases increased to £125 billion | Serra and Ferreira (2019), Hesse et al. (2018) and Rogers et al. (2014) |
| **8/6/09** | Asset purchases increased to £175 billion. | Serra and Ferreira (2019), Hesse et al. (2018) and Rogers et al. (2014) |
| **11/5/09** | Asset purchases increased to £200 billion. | Serra and Ferreira (2019), Hesse et al. (2018) and Rogers et al. (2014) |
| **2/4/10** | APF will be maintained at $200 billion | Rogers et al. (2014) |
| **10/6/11** | APF: MPC statement: "The BoE should finance a further £75 billion of asset purchases by the issuance of central bank reserves, implying a total quantity of £275 billion of such asset purchases." | Serra and Ferreira (2019), Hesse et al. (2018) and Rogers et al. (2014) |
| **11/29/11** | APF: HMT statement: "Maximum private asset purchases reduced: HMT lowered the ceiling on Asset Purchase Facility private asset holdings from £50 billion to £10 billion." | Serra and Ferreira (2019) |
| **2/9/12** | APF: MPC statement: "The BoE should finance a further £50 billion of asset purchases by the issuance of central bank reserves, implying a total quantity of £325 billion of such asset purchases." | Serra and Ferreira (2019), Hesse et al. (2018) and Rogers et al. (2014) |
| **7/5/12** | Asset purchases increased to £375 billion. | Serra and Ferreira (2019), Hesse et al. (2018) and Rogers et al. (2014) |
| **7/13/12** | FLS: MPC statement: "The Funding for Lending Scheme is designed to incentivise banks and building societies to boost their lending to UK households and non-financial companies. The Funding for Lending Scheme will do this by providing funding to banks and building societies for an extended period [...]." | Serra and Ferreira (2019) |
| **4/24/13** | FLS:MPC statement: "Extension to the Funding for Lending Scheme [...] an extension to the FLS by one year to allow drawdowns up to the end of January 2015." | Serra and Ferreira (2019) |
| **8/7/13** | FG: MPC statement: "The MPC intends not to raise Bank Rate from its current level of 0.5% at least until [...] the unemployment rate has fallen to a threshold of 7% [...]. The MPC stands ready to undertake further asset purchases while the unemployment rate remains above 7% if it judges that additional monetary stimulus is warranted." | Serra and Ferreira (2019) |
| **2/12/14** | FG: MPC statement: "The MPC sets policy to achieve the 2% inflation target [...] there remains scope to absorb spare capacity further before raising Bank Rate [...]. The MPC intends to maintain the stock of purchased assets at least until the first rise in Bank Rate." | Serra and Ferreira (2019) |
| **8/4/16** | APF (CBPS): MPC statement: " The BoE will purchase sterling corporate bonds [...] of up to £10 billion. [...] an expansion of the asset purchase scheme for UK government bonds of £60 billion, taking the total stock of these asset purchases to £435 billion." | Serra and Ferreira (2019) and Hesse et al. (2018) |

Table 1G: The table shows the dates for APP announcements, descriptions, and sources for BoE in the pre-COVID era.

| Dates | Announcement | Source |
|---|---|---|
| **3/19/01** | CAB increased to U5 tr | Rogers et al. (2014) |
| **12/19/01** | CAB increased to U10-15 tr | Rogers et al. (2014) |
| **2/28/02** | increase LT bond purchases | Rogers et al. (2014) |
| **10/30/02** | CAB increased to U15-20 tr | Rogers et al. (2014) |
| **3/25/03** | CAB increased to U17-22 tr | Rogers et al. (2014) |
| **4/30/03** | CAB increased to U22-27 and 27-30 tr | Rogers et al. (2014) |
| **6/25/03** | BoJ starts buying ABS | Rogers et al. (2014) |
| **1/20/04** | CAB increased to U30-35 tr | Rogers et al. (2014) |
| **3/9/06** | QEP ended | Rogers et al. (2014) |
| **10/5/10** | Implementation of the Comprehensive Monetary Easing (CME) programme to increase base money by ¥35 trillion yen (7% of GDP): ¥30 trillion for loans against collateral and ¥5 trillion for the Asset Purchase Programme (APP). The assets to be purchased included government securities (JGBs), commercial paper (CP), corporate bonds, equity index ETFs, and REITs. BoJ also pursued the virtually zero interest rate policy, APP - U35 trillion. | Charoenwong et al. (2019) and Rogers et al. (2014) |
| **10/28/10** | Set up the cap for ETF purchases to be conducted by Dec. 2011, APP details | Charoenwong et al. (2019) and Rogers et al. (2014) |
| **11/5/10** | Specified target ETFs tracking the Tokyo Stock Price Index (TOPIX) or the Nikkei 225 index; with ETF purchases proportional to ETF market values. | Charoenwong et al. (2019) |
| **3/14/11** | Increased the ETF purchasing cap to ¥0.9 trillion and extended the purchasing programme to Jun. 2012.APP extended to U40 tr | Charoenwong et al. (2019) and Rogers et al. (2014) |
| **8/4/11** | Increased the ETF purchasing cap to ¥1.4 trillion and extended the purchasing programme to Dec. 2012, APP extended to U50 tr | Charoenwong et al. (2019) and Rogers et al. (2014) |
| **8/14/11** | CAB increased to U6 tr | Rogers et al. (2014) |
| **10/27/11** | APP extended to U55 tr | Rogers et al. (2014) |
| **2/14/12** | APP extended to U65 tr | Rogers et al. (2014) |
| **4/27/12** | Increased the ETF purchasing cap to ¥1.6 trillion.APP extended to U70 tr | Charoenwong et al. (2019) and Rogers et al. (2014) |
| **7/12/12** | No increase in APP, shift in composition | Rogers et al. (2014) |
| **9/19/12** | APP extended to U80 trillion | Rogers et al. (2014) |
| **10/30/12** | Increased the ETF purchasing cap to ¥2.1 trillion, APP extended to U91 tr | Charoenwong et al. (2019) and Rogers et al. (2014) |
| **12/20/12** | APP extended to U101 tr | Rogers et al. (2014) |
| **1/22/13** | Announced a monthly purchase policy and extended the purchasing programme to Dec. 2013, APP extended to U13 tr monthly. | Charoenwong et al. (2019) and Rogers et al. (2014) |
| **4/4/13** | Quantitative and Qualitative Monetary Easing | Rogers et al. (2014) |
| **4/4/13** | New BoJ governor launched the Quantitative and Qualitative Easing (QQE) to increase the monetary base by ¥60-70 trillion per year; and set an annual target for ETF purchases. | Charoenwong et al. (2019) |
| **10/31/14** | Tripled annual ETF purchases. | Charoenwong et al. (2019) |
| **11/19/14** | BoJ purchases can include ETFs tracking JPX-NIKKEI 400. | Charoenwong et al. (2019) |
| **3/15/16** | Increased annual ETF purchases to 3.3 trillion. | Charoenwong et al. (2019) |
| **7/29/16** | Increased annual ETF purchases to ¥6 trillion. | Charoenwong et al. (2019) |
| **9/21/16** | Revised purchasing weights: ¥2.7 trillion for ETFs tracking TOPIX only; remainder allocated proportionally by ETF market value across the other three indices. | Charoenwong et al. (2019) |

Table 2G: The table shows the dates for APP announcements, descriptions, and sources for BoJ in the pre-COVID era.

| Dates | Announcement | Source |
|---|---|---|
| **8/22/07** | Supplementary LTRO (announcement) | Rogers et al. (2014) |
| **8/23/07** | Supplementary LTRO (allotment) | Rogers et al. (2014) |
| **3/28/08** | LTRO: ECB press release: "The Governing Council decided to conduct supplementary Longer-Term Refinancing Operations with a maturity of six months." | Serra and Ferreira (2019) and Rogers et al. (2014) |
| **5/7/09** | CBPP1: ECB press conference: "The Eurosystem will purchase euro-denominated covered bonds issued in the Euro Area." | Serra and Ferreira (2019) and Rogers et al. (2014) |
| **6/4/09** | CBPP1: ECB press release: "Following-up on its decision to purchase euro-denominated covered bonds issued in the Euro Area, the Governing Council decided upon the technical modalities today. [. . . ] T he purchases, for an amount of €60 billion [. . . ]." | Serra and Ferreira (2019) and Rogers et al. (2014) |
| **12/3/09** | LTRO: ECB press release: "The Governing Council has decided to carry out the last six-month Longer-Term Refinancing Operations on 31 March 2010." | Serra and Ferreira (2019) and Rogers et al. (2014) |
| **3/4/10** | GC meeting, Phasing out of 3m LTROs, indexation | Rogers et al. (2014) |
| **5/9/10** | Securities Market Programme (SMP) | Rogers et al. (2014) |
| **5/10/10** | SMP: ECB press release: "The Governing Council decided to conduct interventions in the Euro Area public and private debt securities markets (Securities Markets Programme) | Serra and Ferreira (2019) |
| **6/30/10** | CBPP1: ECB press release: "Today, the Covered Bond Purchase Programme has indeed been fully implemented. [. . . ] The Eurosystem central banks intend to keep the purchased covered bonds until maturity." | Serra and Ferreira (2019) |
| **3/3/11** | GC meeting, FRFA extended to July 2011 | Rogers et al. (2014) |
| **8/4/11** | LTRO: ECB press release: "The Governing Council has today decided to conduct a liquidity-providing supplementary Longer-Term Refinancing Operations with a maturity of approximately six months." | Dedola et al. (2021), Serra and Ferreira (2019) and Rogers et al. (2014) |
| **8/7/11** | SMP: Statement by the President of the ECB: "[. . . ] It is on the basis of the above assessments that the ECB will actively implement its Securities Markets Programme." | Serra and Ferreira (2019) and Rogers et al. (2014) |
| **10/6/11** | CBPP2: ECB press release: "The Governing Council has today decided to launch a new Covered Bond Purchase Programme (CBPP2). Purchases will be for an intended amount of €40 billion." | Dedola et al. (2021), Serra and Ferreira (2019) and Rogers et al. (2014) |
| **11/3/11** | CBPP2: ECB press release: "Further to its decision to launch Covered Bond Purchase Programme 2, the Governing Council decided today upon the technical modalities of the programme." | Serra and Ferreira (2019) |
| **12/8/11** | LTRO: ECB press release: "The Governing Council has decided to conduct two Longer-Term Refinancing Operations with a maturity of 36 months." | Dedola et al. (2021), Serra and Ferreira (2019) and Rogers et al. (2014) |
| **12/21/11** | Results of first 3-year LTRO | Rogers et al. (2014) |
| **2/28/12** | Results of second 3-year LTRO | Rogers et al. (2014) |
| **7/26/12** | FG: Speech by Mario Draghi, President of the ECB, at the Global Investment Conference: "Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough.", "Whatever it takes" London speech. | Serra and Ferreira (2019) and Rogers et al. (2014) |
| **8/2/12** | OMT: ECB press conference: "The Governing Council may undertake outright open market operations. This effort will be focused on the shorter part of the yield curve." | Serra and Ferreira (2019) and Rogers et al. (2014) |
| **9/6/12** | OMT: ECB press release: "The Governing Council has today taken decisions on a number of technical features regarding the Eurosystem's outright transactions in secondary sovereign bond markets. [. . . ] These will be known as Outright Monetary Transactions." | Serra and Ferreira (2019) and Rogers et al. (2014) |
| **10/31/12** | CBPP2: ECB press release: "Today, the Covered Bond Purchase Programme 2 ends. A nominal amount of €16.418 billion was purchased [. . . ]. The Eurosystem central banks intend to keep these covered bonds until maturity." | Serra and Ferreira (2019) |
| **6/5/14** | TLTRO: ECB press release: "The Governing Council has decided to conduct a series of Targeted Longer-Term Refinancing Operations [. . . ] over a window of two years." | Dedola et al. (2021) and Serra and Ferreira (2019) |
| **7/3/14** | TLTRO: ECB press release: "The Governing Council decided today on further technical details of a series of Targeted Longer-Term Refinancing Operations." | Serra and Ferreira (2019) |
| **9/4/14** | APP:ECB press conference: "The Eurosystem will purchase a broad portfolio of simple and transparent asset-backed securities with underlying assets consisting of claims against the Euro Area non-financial private sector under an Asset-Backed Securities Purchase Programme. [...] will also purchase a broad portfolio of euro-denominated covered bonds issued by Monetary Financial Institutions domiciled in the Euro Area under a new Covered Bond Purchase Programme (CBPP3)." | Dedola et al. (2021) and Serra and Ferreira (2019) |
| **10/2/14** | APP: ECB press release: "ECB announces operational details of Asset-Backed Securities Purchase Programme and Covered Bond Purchase Programme 3. Programmes will last at least two years." | Dedola et al. (2021) and Serra and Ferreira (2019) |
| **11/6/14** | FG: ECB press conference: "In response to the request of the Governing Council, ECB staff and the relevant Eurosystem committees have stepped up the technical preparations for further measures." | Serra and Ferreira (2019) |
| **1/22/15** | APP: ECB press conference: "The Governing Council decided that asset purchases should be expanded to include a secondary markets Public Sector Purchase Programme [...]. The combined monthly purchases of public and private sector securities will amount to €60 billion. They are intended to be carried out until end-September 2016 [...]." | Dedola et al. (2021) and Serra and Ferreira (2019) |
| **3/5/15** | APP details | Dedola et al. (2021) |
| **9/3/15** | Increase of PSPP issue limit | Dedola et al. (2021) |
| **12/3/15** | APP: ECB press conference: "We decided to extend the expanded Asset Purchase Programme. The monthly purchases of €60 billion under the expanded Asset Purchase Programme are now intended to run until the end of March 2017, or beyond, if necessary." | Serra and Ferreira (2019) |
| **3/10/16** | APP: ECB press release: "ECB adds Corporate Sector Purchase Programme to the expanded Asset Purchase Programme [. . . ]. Investment-grade euro-denominated bonds issued by non-bank corporations established in the Euro Area will be included in the list of assets eligible for regular purchases under a new Corporate Sector Purchase Programme [...]. Combined monthly purchases under the expanded Asset Purchase Programme are to increase to €80 billion from €60 billion." | Dedola et al. (2021) and Serra and Ferreira (2019) |
| **4/21/16** | APP: ECB press release: "ECB announces details of the Corporate Sector Purchase Programme." | Dedola et al. (2021) and Serra and Ferreira (2019) |
| **6/2/16** | CSPP Implementation details | Dedola et al. (2021) |
| **12/8/16** | APP: ECB press release: "The Governing Council decided to continue its purchases under the APP at the current monthly pace of €80 billion until the end of March 2017. From April 2017, the net asset purchases are intended to continue at a monthly pace of €60 billion until the end of December 2017 [. . . ]." | Dedola et al. (2021) and Serra and Ferreira (2019) |
| **10/26/17** | Extension of APP | Dedola et al. (2021) |

Table 3G: The table shows the details for APP announcements for the ECB in the pre-COVID era.

# H Central bank announcements

## H.1 Emerging markets

### H.1.1 Brazil

On 6/25/20, Banco Central Do Brasil (BC) announced a package of measures for alleviating the effects of Covid-19 on the economy (https://www.bcb.gov.br/detalhenoticia/464/noticia). BC announced that it will conduct purchases of private securities on the secondary market. Regarding the amount of the purchase, a limit of R$1 billion is specified (https://www.bcb.gov.br/pre/normativos/busca/downloadVoto.asp?arquivo=/Votos/BCB/2020164/Voto_do_BC_164_2020.pdf). Therefore, the event date is taken as 6/25/20. BC also announced several measures targeting micro, small, and medium-sized companies and the banking sector on the same date. These measures can be listed as follows: (i) a reduction in the capital requirements for small institutions, (ii) "working capital for business preservation," (iii) a measure allowing financial institutions to deduct credit operations applicable to micro and small sized companies, (iv) a reduction in the risk weighting factor from 50% to 35% for time deposit operations with a special guarantee, (v) the allowance for the use of the same property as collateral for more than one loan. On that specific date, no announcements regarding the policy rate have been made.

### H.1.2 China

On 6/1/20, The People's Bank of China posted a notice in its official website that starting from June 1st, 2020, it will use RMB400b worth of special quotas from central bank lending in order to conduct purchases of 40% of the newly issued MSB credit loans which are issued in between 03/01/20-12/31/20, by certain qualified locally incorporated banks (http://www.pbc.gov.cn/en/3688110/3688172/4048269/4034523/index.html). No policy rate-related announcement was made on that specific date. The event date is taken to be 6/1/20.

### H.1.3 Chile

On 3/16/21, the Central Bank of Chile announced at a special monetary policy meeting that it decided to lower the monetary policy-related interest by 75 basis points to 1% (https://www.bcentral.cl/en/content/-/details/special-monetary-policy-meeting-march-2020). It announced the banking bond purchase programme with an amount of up to U.S.$4 billion. Central Bank of Chile also announced measures targeting both the banking sector and the corporate sector. The measures include (i) conditional funding facility (FCIC) for banks and (ii) inclusion of corporate bonds as eligible collateral for all the effective liquidity operations conducted in pesos, which also includes FCIC.

On 3/31/20, the Central Bank of Chile announced that it decided to lower the monetary policy-related interest rate by 50 basis points to 0.5% (https://www.bcentral.cl/es/web/banco-central/contenido/-/details/monetary-policy-meeting-march-2020). Along with this, the Bank also decided to expand the previously announced bond purchase programme by U.S.$4,000 million. At the same time, the Bank also decided to terminate the term restriction imposed on the eligible instruments.

On 6/16/20, the Central Bank of Chile announced that it will keep the monetary policy-related interest rate constant at 0.50% and expand its use of unconventional instruments (https://www.bcentral.cl/es/web/banco-central/contenido/-/details/monetary-policy-meeting-june-2020). The expanded measures include (i) special asset purchase programme with an amount equivalent to U.S.$8 billion over the six months, (ii) phase 2 of the FCIC with an amount equivalent to U.S.$16 billion which will be effective for eight months.

On 8/8/20, the Central Bank of Chile (CBC) announced a law that will allow the CBC to purchase bonds issued by Chile's Treasury in the secondary market (https://som.yale.edu/blog/chile-s-central-bank-injects-liquidity-in-financial-markets).

Therefore, the event dates are taken to be 3/16/21, 3/31/20, 6/16/20, and 10/8/20. 10/8/20 is taken to be the event date since it is the first trading date after the announcement.

### H.1.4 Colombia

On 3/23/20, The Central Bank of Colombia announced to inject liquidity through the purchases of both public and private debt instruments (https://www.banrep.gov.co/en/banco-republica-central-bank-colombia-injects-permanent-liquidity-economy-purchasing-public-and). The first auction which was scheduled to take place on 4/24/20 was announced to be equivalent to an amount of COP $2 trillion. No announcement for the policy rate has been made. Following Rebucci et al. (2022), since 3/23/20 was St. Joseph's Day, the next trading day, which is 3/24/20, is taken as the event date.

### H.1.5 Croatia

On 3/13/20, the Croatian National Bank (CNB) made an announcement on the initiation of the purchases of the Republic of Croatia bonds (https://www.hnb.hr/en/-/savjet-hnb-a-hrvatska-narodna-banka-najavljuje-strukturnu-operaciju-i-zapocinje-kupovati-obveznice-rh). The bank announced that it purchased securities of the Republic of Croatia with a value equivalent to HRK 212.88 million (https://www.hnb.hr/en/-/croatian-national-bank-purchases-securities-of-the-republic-of-croatia). The bank also announced that EUR 1,214.35m worth of foreign exchange had been sold(https://www.hnb.hr/en/-/savjet-hnb-a-hrvatska-narodna-banka-najavljuje-strukturnu-operaciju-i-zapocinje-kupovati-obveznice-rh). No announcement related to the monetary policy related rate has been made.
On 3/18/20, the CNB announced purchases of Republic of Croatia securities with a value of HRK 4.075 billion (https://www.hnb.hr/en/-/cnb-purchases-rc-securities-at-a-nominal-value-of-hrk-4.075bn).
On 4/28/20, the CNB announced purchases of Republic of Croatia securities with a value of HRK 9.529 billion (https://www.hnb.hr/en/-/cnb-purchases-rc-securities-in-a-nominal-value-of-hrk-9.529bn).
On 6/29/20 and 6/30/20, the CNB announced the purchase of Republic of Croatia securities with a value of HRK 2.753 billion (https://www.hnb.hr/en/-/cnb-purchases-rc-securities-in-the-nominal-amount-of-hrk-2.753bn) and HRK 1.316 billion, respectively (https://www.hnb.hr/en/-/cnb-purchases-rc-securities-in-the-nominal-amount-of-hrk-1.316bn).
Therefore, the event dates are taken to be 3/13/20, 3/18/20, 4/28/20, 6/29/20 and 6/30/20.

### H.1.6 Egypt

The Arab Republic of Egypt Presidency did not make an official announcement regarding the asset purchases. Therefore, the related information is collected from the news (https://enterprise.press/issues/2020/03/23/cbe-launch-egp-20-bn-share-purchase-programme-halt-egx-sell-off/). On 3/23/20, the Central Bank of Egypt (CBE) is said to launch a purchase programme of equities with an amount of EGP 20 billion with the objective of supporting the stock exchange. In the news, it is also stated that the CBE announced a stimulus and bailout package with an amount of EGP 100 billion. Accordingly, the event date is taken to be 3/23/20. No announcement related to the monetary policy-related rate has been made.

### H.1.7 Ghana

On 5/15/20, the Bank of Ghana announced that it purchased government bonds with a value of GH ¢5.5 billion (https://www.bog.gov.gh/wp-content/uploads/2020/05/MPC-Press-Release-15th-May-2020-2.pdf). The Bank added that it can continue with the purchases with a limit of up to GH¢10 billion. In the same announcement, the Bank also communicated about the relief measures directed to the SDI sector and the Repurchase Agreement with a value of U.S.$1 billion signed with the U.S. Federal Reserve. At the same date, the monetary policy-related rate is kept the same at 14.5%. The event date is taken to be 5/15/20.

### H.1.8 Hungary

On 3/24/20, Magyar Nemzeti Bank (MNB) announced that it is assessing the possibility of relaunching the mortgage bond purchase programme for the purposes of increasing the bank liquidity (https://www.mnb.hu/en/monetary-policy/the-monetary-council/press-releases/2020/press-release-on-the-monetary-council-meeting-of-24-march-2020).
On 4/7/20, MNB officially stated that it decided to launch the government security purchase programme to be conducted in the secondary market, with the amount being unspecified. The amount for the bond purchase programme is stated to be HUF 450 billion (https://www.mnb.hu/en/monetary-policy/the-monetary-council/press-releases/2020/press-release-on-the-monetary-council-meeting-of-7-april-2020). Additional measures targeting the banking sector and the small and medium-sized firms are also announced: (i) reintroduction of mortgage bond purchase programme increasing the supply of funds to the banking sector and (ii) provision of affordable funding for small and medium-sized firms. No announcement related to the monetary policy related rate has been made on that date.
On 4/28/20, MNB announced the purchases of government securities to be conducted at the secondary market and mortgage bond purchases to be conducted at both primary and secondary markets. The amount of the programme has been announced to be HUF 1 trillion (https://www.mnb.hu/en/monetary-policy/the-monetary-council/press-releases/2020/

press-release-on-the-monetary-council-meeting-of-28-april-2020). Both programmes are announced to be launched on 5/4/20. The monetary policy related rates are decided to be kept the same. Since 3/24/20 is just a statement of reconsidering the introduction of the asset purchase programme and not an announcement for its implementation, it is excluded from the event set. Therefore, 4/7/20 and 4/28/20 are taken to be the event dates.
On 8/24/21, MNB decided to begin withdrawing the purchase programme of government securities.

### H.1.9 Indonesia

On 4/1/20, the Bank of Indonesia announced the expansion of BI to purchase long-term government securities (SBN) and government Islamic securities (SBSN) to be conducted in the primary market (https://www.bi.go.id/en/publikasi/ruang-media/news-release/Pages/sp_222620.aspx). In addition to the announcement of asset purchases, the Bank also introduced measures targeting the banking sector, including (i) purchasing repo securities held by the Deposit Insurance Corporation (LPS) for the purposes of handling the solvency issues that systemic and non-systemic banks face, (ii) a decrease in the foreign currency reserve requirements, (iii) a decrease in the rupiah reserve requirements. No announcement related to the monetary policy related rate has been made on that date. Accordingly, 4/1/20 is taken as the event date.

### H.1.10 India

On 3/18/20, the Reserve Bank of India (RBI) announced open market operations (OMO) of the Government of India dated securities with an aggregate amount of 10,000 crores to be conducted on 3/20/20. (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=49534).
On 3/20/20, the RBI announced OMO of the Government of India dated securities with an aggregate amount of 30,000 crores in tranches to be conducted on 3/24/20 and 3/30/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=49545).
On 3/23/20, the RBI announced that it advanced the OMO purchase scheduled for 3/30/20 to 3/26/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=49554).
On 4/23/20, the RBI announced that it decided to conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores each on 4/27/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=49712).
On 6/29/20, the RBI announced that it decided to conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores each on 7/2/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50012).
On 8/25/20, the RBI announced that it decided to conduct simultaneous purchase and sale of government securities under OMO for an aggregate amount of 20,000 crores in two tranches of equal amount to be conducted on 8/27/20 and 9/3/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50252).
On 9/7/20, the RBI announced that it decided to conduct simultaneous purchase and sale of government securities under OMO for 20,000 crores in two tranches of equal amount. The first one is scheduled for 9/10/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50319).
On 9/14/20, the RBI announced that it decided to conduct simultaneous purchase and sale of government securities under OMO for 20,000 crores in two tranches of equal amount on 9/7/20. The second one is announced to be scheduled for 9/17/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50353).
On 9/17/20, the RBI announced that it decided to conduct purchases of government securities under OMO for 10,000 crores on 9/24/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50372).
On 9/24/20, the RBI announced that it decided to conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores each on 10/01/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50408).
On 10/9/20, the RBI announced that it decided to conduct purchases of government securities under OMO for 20,000 crores on 10/25/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50481).
On 10/16/20, the RBI announced that it decided to conduct purchases of State Development Loans (SDL) under OMO for 10,000 crores on 10/22/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50524).
On 10/22/20, the RBI announced that it decided to conduct purchases of government securities under OMO for 20,000 crores on 10/29/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50552).
On 10/29/20, the RBI announced that it will conduct purchases of SDLs under OMO for 10,000 crores on 11/6/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50590).

On 11/5/20, the RBI announced that it will conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores of equal amount on 11/12/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50624).
On 11/12/20, the RBI stated that it will conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores in two tranches of equal amounts on 11/19/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50654).
On 11/19/20, the RBI stated that it will conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores of equal amount on 11/26/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50686).
On 12/11/20, the RBI stated that it will conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores of equal amount on 12/17/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50787).
On 12/17/20, the RBI announced that it will conduct purchases of SDLs under OMO for 10,000 crores on 12/23/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50821).
On 12/24/20, the RBI stated that it will conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores of equal amount on 12/30/20 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50859).
On 12/31/20, the RBI stated that it will conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores in two tranches of equal amount on 1/7/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50889).
On 1/7/21, the RBI stated that it will conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores of equal amount on 1/14/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50931).
On 1/15/21, the RBI stated that it will conduct purchases of government securities under OMO for 10,000 crores on 1/21/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=50981).
On 2/8/21, the RBI stated that it will conduct purchases of government securities under OMO for 20,000 crores on 2/10/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51092).
On 2/15/21, the RBI stated that it will conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores of equal amount on 2/25/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51129).
On 2/24/21, the RBI stated that it will conduct simultaneous purchase and sale of government securities under OMO for 15,000 crores of equal amount on 3/4/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51170).
On 3/4/21, the RBI stated that it will conduct simultaneous purchase and sale of government securities under OMO for 20,000 crores under purchase and 15,000 crore under sale on 3/10/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51224).
On 3/10/21, the RBI stated that it will conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores of equal amount on 3/18/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51249).
On 3/18/21, the RBI stated that it will conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores of equal amount on 3/25/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51289).
On 4/8/21, the RBI announced that under the G-SAP 1.0 programme, the first purchase of government securities of 25,000 crores will be conducted on 4/15/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51394).
On 4/29/21, the RBI stated that it will conduct simultaneous purchase and sale of government securities under OMO for 10,000 crores of equal amount on 5/6/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51497).
On 5/12/21, the RBI announced that under the G-SAP 1.0 programme, the second purchase of government securities of 35,000 crores will be conducted on 5/10/21 (rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51564).
On 6/10/21, the RBI announced that under the G-SAP 1.0 programme, the third purchase of government securities of 40,000 crores will be conducted on 6/17/21. The RBI also announced that the purchase of SDLs can be up to 10,000 crores (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51712).
On 7/5/21, the RBI announced that under the G-SAP 2.0 programme, the first purchase of government securities of 20,000 crores will be conducted on 7/8/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51854).
On 7/15/21, the RBI announced that under the G-SAP 2.0 programme, the next purchase of government securities of 20,000 crores will be conducted on 7/22/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=51900).
On 8/6/21, the RBI announced that under the G-SAP 2.0 programme, it will purchase government securities of 25,000 crores on 8/12/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx

?prid=52012).
On 8/18/21, the RBI announced that under the G-SAP 2.0 programme, it will purchase government securities of 25,000 crores on 8/26/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=52077).
On 9/20/21, the RBI announced that under the G-SAP 2.0 programme, it will purchase government securities of 15,000 crores on 9/23/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=52256).
On 9/23/21, the RBI announced that under the G-SAP 2.0 programme, it will purchase government securities of 15,000 crores on 9/30/21 (https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=52280).
No announcement related to the monetary policy related rate has been made on any of those dates except 8/6/21 when the policy rate is kept constant.
The event dates are chosen based on whether one of the following criteria is satisfied: (i) when there is only an announcement for the purchases of securities (not simultaneous sale and purchases), (ii) when there is an announcement for the purchases of another type of security, (iii) when there is an increase in the specified amount of the purchases compared to the previous one, and (iv) when there is an announcement of simultaneous sale and purchases of securities, the purchase amount is greater than the sale amount. Accordingly, the chosen event dates are 3/18/20, 3/20/20, 3/23/20, 9/17/20, 10/9/20, 10/16/20, 10/22/20, 10/29/20, 12/17/20, 1/15/21, 2/8/21, 2/24/21, 3/4/21, 4/8/21, 5/12/21, 6/10/21, 7/5/21, 7/15/21, 8/6/21, 8/18/21, 9/20/21 and 9/23/21.

### H.1.11 Israel

On 3/15/20, the Bank of Israel announced that it will conduct open market operations and will purchase government bonds in the secondary market with the amount being unspecified. On the same date, the Bank of Israel announced the conduct of repo operations with financial institutions with government bonds as collateral. In addition, the Bank also announced measures targeting the banking sector and business, including (i) provision of loans to small and medium-sized businesses and (ii) permission to banks to increase the credit facility for both businesses and households . No announcement related to the monetary policy related rate has been made on that date.
On 3/23/20, the Bank of Israel announced that it will purchase government bonds with an amount equivalent to NIS 50 billion . No announcement related to the monetary policy related rate has been made on that date.
On 7/6/20, the Bank of Israel announced that it will purchase corporate bonds with a scope of NIS 15 billion on the secondary market. The bank also announced the renewal of the special plan targeting the expansion of supply and bank credit to small businesses as well as the expansion of the assets that can be considered as collateral against the credit. On the same date, the Bank announced that it will keep the interest unchanged at 0.1%.
On 10/22/20, the Bank of Israel announced an increase in the government bond purchase programme by NIS 35 billion in the secondary market. In addition, the Bank announced that it will implement an additional measure to extend the credit to the small and micro businesses. On the same date, the Bank announced that it will keep the interest unchanged at 0.1%.
Therefore, the event dates are taken as 3/16/20, 3/23/20, 7/6/20 and 10/22/20. Since 3/15/20 is a Sunday, 3/16/20 is taken as the event date.

### H.1.12 Jamaica

On 3/17/20, the Bank of Jamaica announced that it is ready to purchase GOJ securities on the secondary market with the amount being unspecified. On the same date, the Bank also announced measures targeting the liquidity in the banking system. These are (i) removal of the limits imposed on the overnight borrowing of the deposit-taking institutions (DTIs) without being charged a penalty rate and (ii) relaunching the facility that provides Jamaica Dollar liquidity to the DTIs up to six months by the central bank (https://boj.org.jm/uploads/news/boj_press_release_-__access_to_liquidity.pdf). No announcement related to the monetary policy related rate has been made on that date. Accordingly, the event date is taken to be 3/17/20.

### H.1.13 Korea

On 3/26/20, the Bank of Korea announced that it will buy bonds in repo auctions with the amount being unlimited and the auction period is specified to be April 2020 – June 2020 (https://www.bok.or.kr/eng/bbs/E0000634/view.do?nttId=10057338&menuNo=400069&searchWrd=&searchCnd=1&sdate=2020-01-01&edate=2021-12-31&pageIndex=35). No announcement related to the monetary policy related rate has been made on that date. Accordingly, the event date is taken to be 3/26/20.

### H.1.14 Mexico

On 4/21/20, the Banco de México announced that it will open a facility allowing the repurchase of government securities at longer terms in contrast to the regular OMOs. The specified amount for the programme is limited up to MXN $100 billion. In addition, the Bank announced a corporate securities repurchase facility for an amount up to MXN $100 billion, which will help to provide liquidity to short-term corporate securities as well as long-term corporate debt. The bank also announced various other measures targeting both the banking sector and businesses. These include: (i) extension of the securities that are eligible for the Ordinary Additional Liquidity Facility (FLAO), foreign exchange hedging programme operations and USD credit operations, (ii) extension of access to FLAO to development banks, (iii) provision of a temporary securities swap window, (iv) provision of swaps for government securities, (v) provision of resources to banking sector for them to channel credit to micro, small, and medium-size businesses as well as individuals affected by the pandemic, (vi) provision of a facility for collateralised financing to commercial banks with corporate bonds, which will enable them to finance micro, small, and medium-sized businesses (https://www.banxico.org.mx/publications-and-press/other-announcements/%7B6F7FECBA-44CB-6AA5-4E4B-269DDBD9B5A8%7D.pdf). On that same date, the monetary policy related rate is decreased by 50 basis points to 6% (https://www.banxico.org.mx/publications-and-press/announcements-of-monetary-policy-decisions/%7BC86C9AC8-0121-9382-1F3D-0F1E6B8CF318%7D.pdf).

### H.1.15 Mauritius

On 5/22/20, the Bank of Mauritius announced that it will provide a one-off exceptional contribution with an amount equivalent to Rs60 billion. (https://www.bom.mu/sites/default/files/supporting_systemic_economic_operators_and_financial_stability.pdf). No announcement related to the monetary policy related rate has been made on that date. Accordingly, the event date is taken to be 5/22/20.

### H.1.16 Philippines

On 3/22/20, the local date for Philippines, the Bangko Sentral ng Pilipinas (BSP) announced that it is authorized to conduct purchases of government securities from the Bureau of Treasury (BTr) under a repurchase agreement with an amount equivalent to Php 300 billion where the maximum repayment period is set to six months (https://www.bsp.gov.ph/SitePages/MediaAndResearch/MediaDisp.aspx?ItemId=5221). No announcement related to the monetary policy related rate has been made on that date.
On 4/9/20, the local date for the Philippines, the BSP announced extraordinary measures in order to support domestic liquidity. The BSP announced an expansion of the purchase of government securities (GS) on the secondary market to all peso-denominated GS issuances. The window is stated to remain open between April 2020 – June 2020. In addition, the BSP announced a repurchase agreement with the National Government (NG) amounting to P300 billion (https://www.bsp.gov.ph/SitePages/MediaAndResearch/MediaDisp.aspx?ItemId=5242). No announcement related to the monetary policy related rate has been made on that date.
Due to the differences in local time, one of the event dates is taken to be 3/23/20. For the announcement made on 4/9/20, following Rebucci et al. (2022), since 4/9/20 was Thursday and the coming day was a Good Friday, the following Monday, which is 4/13/20, is included as another event date.

### H.1.17 Poland

On 3/17/20, the Narodowy Bank Polski (NBP) announced that it decided to purchase government bonds on the secondary market with the amount being unspecified. On the same date, the NBP announced a measure targeting the banking and corporate sector, which is to offer a bill discount credit targeting the refinancing of the new loans given to economic entities by banks. In addition, the NBP stated that it will conduct repo transactions to provide liquidity to the banking sector. The monetary policy-related rate is also reduced by 50 basis points to 1% on the same date.
On 4/8/20, the NBP announced that it will conduct purchases of government securities and government-guaranteed debt securities on the secondary market with the timing and the scale of the purchases remaining unspecified. The monetary policy-related rate is also reduced by 50 basis points to 0.5% on the same date.
Accordingly, the event dates are taken to be 3/17/20 and 4/8/20.

### H.1.18 Romania

On 3/20/20, the Banca Nationala a Romanei (NBR) announced that it will conduct purchases of leu-denominated government securities in the secondary market, with the amount being unspecified. The NBR also announced to provide liquidity to credit institutions with repurchase transactions in government securities (https://www.bnr.ro/page.aspx?prid=17617). On the same date, the monetary policy-related rate is also cut by 50 basis points to 2%. Accordingly, 3/20/20 is taken as the event date.

### H.1.19 South Africa

On 3/25/20, the South African Reserve Bank (SARB) announced that it will start a programme for purchasing government securities on the secondary market with the amount being unspecified (https://www.resbank.co.za/en/home/publications/publication-detail-pages/media-releases/2020/9805). No announcement related to the monetary policy related rate has been made on that date. Accordingly, the event date is taken as 3/25/20.

### H.1.20 Thailand

On 3/17/20, in the news, it was stated that the Bank of Thailand (BOT) injected Bt35 billion into the financial market the previous week. The BOT is stated to have injected both short-term and long-term government bonds with an amount equivalent to Bt35 billion (https://www.nationthailand.com/business/30384264).
On 4/8/20, the BOT announced in its edited minutes of the monetary policy committee meeting on 3/20/20 that the BOT provided liquidity by conducting a large amount of purchases of government bonds. The BOT stated the need to accelerate debt restructuring for SMEs and households. In the same statement, the BOT observes the need to support government bond purchases with other measures. In the same meeting held on 3/20/20 (special meeting), the BOT decided to decrease the policy rate by 25 basis points to 0.75%. Moreover, in another statement made on 3/22/20, the BOT is said to conduct a government bond purchase programme of an amount equivalent to 100 billion baht between 13-20 March 2020. The minutes published by the BOT, as well as the statement made on 3/22/20, both verify the news made on 3/17/20. Therefore, as the first published news is made on 3/17/20, the first event date is taken to be 3/17/20.
On 3/22/20, the BOT published a statement saying that it will conduct purchases of both corporate and government bonds. Under this statement, the BOT announced the establishment of a facility to provide liquidity to mutual funds via commercial banks with 70-100 billion baht worth of Corporate Bond Stabilisation Fund. Accordingly, since 3/22/20 is a Sunday, the subsequent date, 3/23/20, is taken as another event date. No announcements related to the monetary policy-related rate have been made on those dates.

### H.1.21 Turkey

On 3/31/20, the Central Bank of the Republic of Turkey (CBRT) announced that it will conduct outright purchases of Turkish government bonds, with the exact amount being unspecified. On the same day, the CBRT announced measures targeting the banking and corporate sector. These measures include (i) the inclusion of asset-backed securities and mortgage-backed securities into the collateral pool for the operations conducted at CBRT with the Turkish lira and foreign exchange and (ii) an increase in the limits of the additional liquidity facilities designed to guarantee uninterrupted credit flow to the corporate sector. In addition, the CBRT decided to hold Turkish lira currency swap auctions with a maturity of six months (https://www.tcmb.gov.tr/wps/wcm/connect/EN/TCMB+EN/Main+Menu/Announcements/Press+Releases/2020/ANO2020-21). No announcement related to the monetary policy related rate has been made on that date.
On 4/17/20, the CBRT announced the maximum limit for the OMO from 5% to 10% of the total assets of the CBRT balance sheet (https://www.tcmb.gov.tr/wps/wcm/connect/EN/TCMB+EN/Main+Menu/Announcements/Press+Releases/2020/ANO2020-22). No announcement related to the monetary policy related rate has been made on that date.
Accordingly, the event dates are taken to be 3/31/20 and 4/17/20.

### H.1.22 Uganda

On 4/6/20, the Bank of Uganda announced that it will purchase Treasury Bonds held by Microfinance Deposit-taking Institutions (MDIs) as well as Credit Institutions (CIs). The BoU also announced measures targeting the banking sector and corporate sector. These measures include (i) grant of exceptional permission to Supervised Financial Institutions (SFIs) for restructuring the loans given to corporations and individuals and (ii) provision of exceptional liquidity assistance to commercial banks. In addition, the BoU decided to provide liquidity to commercial banks through the issuance of reverse REPOs up to 60 days at the Central Bank Rate (CBR) for a longer period. On the same date, the policy related rate is reduced by 100 basis points to 8%. Accordingly, the event date is taken to be 4/6/20.

### H.1.23 Serbia

On 3/20/20, the Bloomberg News released a headline of "Serbian Central Bank will purchase government bonds in March 24 auctions". Verifying this headline, on 3/20/20, the National Bank of Serbia announced

on its website that it will provide support through holding two repo auctions to purchase dinar government securities with the amount being unspecified (https://nbs.rs/en/scripts/showcontent/index.html?id=15336). On the same date, the Bank announced an additional FX swap auction to be held on March 23. Following this, the bank announced on 3/24/20 that with the securities repo purchase auctions, it provided additional liquidity of an amount equivalent to RSD 25.2 billion (https://nbs.rs/en/scripts/showcontent/index.html?id=15345).
On 3/31/20, the National Bank of Serbia announced that it held an auction of repo purchases of dinar government securities, which amounted to a supply of RSD 1.0 billion for a period of seven days to banks (https://nbs.rs/en/scripts/showcontent/index.html?id=15372). On the same date, the Bank announced that EUR 56 million worth of NBS swap had been sold and EUR 25 million worth of NBS swap had been bought (https://nbs.rs/en/scripts/showcontent/index.html?id=15372).
Accordingly, the event dates are taken to be 3/20/20 and 3/31/20.
No announcements related to the monetary policy-related rate have been made on those dates.
On 9/15/21, the NBS announced that it decided to discontinue the repo purchase of securities starting from 10/7/21 (https://nbs.rs/en/scripts/showcontent/index.html?id=17348).
Accordingly, the event dates are taken to be 3/20/20 and 3/31/20.

## H.2 Advanced Economies

### H.2.1 United States

On 3/15/20, the Fed announced that it will increase the holdings of treasury securities and mortgage-backed securities by at least $500 billion and $200 billion, respectively (https://www.federalreserve.gov/newsevents/pressreleases/monetary20200315a.htm). In addition, various other announcements have also been made. These include (i) the expansion of the overnight and term repurchase agreement operations by the Open Market Desk, (ii) measures targeting the banking sector and businesses that are related to bank capital and liquidity buffers, discount window, intraday credit, reserve requirements (https://www.federalreserve.gov/newsevents/pressreleases/monetary20200315b.htm) and, (iii) the U.S. dollar liquidity swap line arrangements in coordination with the other central banks including the Bank of Canada, the Bank of England, the Bank of Japan, the European Central Bank, and the Swiss National Bank (https://www.federalreserve.gov/newsevents/pressreleases/monetary20200315c.htm). On the same date, both the upper bound and lower bound of the FOMC rate are reduced by 100 basis points to 0.25% and 0%, respectively.
On 3/23/20, the Fed will continue to conduct purchases of Treasury securities and mortgage-backed securities with the scale of the purchases specified as "...the amount needed to support the smooth market functioning..." (https://www.federalreserve.gov/newsevents/pressreleases/monetary20200323a.htm). The Fed also announced new measures to support various parts of the economy. These include (i) the establishment of the Primary Market Corporate Credit Facility (PMCCF) and the Secondary Market Corporate Credit Facility (SMCCF) to facilitate the new bond/loan issuance and enhance the liquidity of corporate bonds, respectively, (ii) the establishment of the Term Asset-Backed Securities Loan Facility (TALF) to support the flow of credit to businesses and consumers (https://www.federalreserve.gov/newsevents/pressreleases/monetary20200323b.htm). No announcement related to the monetary policy related rate has been made on that date.
Accordingly, the event dates are taken to be 3/15/20 and 3/23/20.

### H.2.2 European central bank

On 3/12/20, the European Central Bank (ECB) made an announcement on temporary additional asset purchases worth €120 billion and additional longer-term refinancing operations (LTROs) (https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.mp200312~8d3aec3ff2.en.html). The interest rates were kept unchanged.
On 3/18/20, the ECB announced its Pandemic Emergency Purchase Programme (PEPP) with an amount equivalent to €750 billion for both public and private securities. In addition, the ECB announced the (i) expansion of the range of securities eligible for the corporate sector purchase programme (CSPP) and (ii) easing in the standards for the collaterals (https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr200318_1~3949d6f266.en.html). The interest rates were kept unchanged.
On 6/4/20, the ECB announced the expansion of the PEPP by €600 billion to €1350 billion (https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.mp200604~a307d3429c.en.html). The interest rates were kept unchanged.
On 12/10/20, the ECB announced the expansion of the PEPP by €500 billion to €1850 billion. The ECB also announced measures including the (i) extension of the TLTRO III, (ii) extension of the duration of the collateral easing measures to June 2022, (iii) introduction of four additional pandemic emergency longer-term refinancing operations (PELTROs) in 2021 and, (iv) extension of all

temporary swap and repo lines with the central banks in the non-euro area as well as the Eurosystem repo facility for central banks (EUREP) (https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.mp201210~8c2778b843.en.html). The interest rates were kept unchanged.
Accordingly, the event dates are taken to be 3/12/20, 3/18/20, 6/4/20 and 12/10/20.

### H.2.3 United Kingdom

On 3/19/20, the Bank of England (BoE) announced at its special meeting that it will increase its holdings of UK government bonds and sterling non-financial investment-grade corporate bonds by £200 billion, with the total amount being £645 billion (https://www.bankofengland.co.uk/monetary-policy-summary-and-minutes/2020/monetary-policy-summary-for-the-special-monetary-policy-committee-meeting-on-19-march-2020). On the same date, the BoE announced a Term Funding Scheme for SMEs (TFSME) (https://www.bankofengland.co.uk/markets/market-notices/2020/apf-asset-purchases-and-tfsme-march-2020). The bank rate is reduced by 15 basis points to 0.1%.
On 4/2/20, the BoE announced that it will increase the maximum purchase size per bond from £10 million to £20 million in each auction for the non-financial corporate bonds (https://www.bankofengland.co.uk/markets/market-notices/2020/asset-purchase-facility-additional-corporate-bond-purchases#footnotes). No announcement related to the monetary policy related rate has been made on that date.
On 4/22/20, the BoE released a statement announcing the decision to increase the Asset Purchase Facility's (APF) gilt holdings available each day to UK Debt Management Office (DMO) (https://www.bankofengland.co.uk/news/2020/april/statement-on-increase-to-apf-gilt-lending-limits). No announcement related to the monetary policy related rate has been made on that date.
On 5/1/20, the BoE announced it will purchase additional corporate bonds worth at least £10 billion, which will take the stock of corporate bonds to an amount worth at least £20 billion (https://www.bankofengland.co.uk/markets/market-notices/2020/apf-additional-corporate-bond-purchases-may-2020). No announcement related to the monetary policy related rate has been made on that date.
On 6/18/20, the BoE announced that it will increase the purchases of the UK government bonds by an additional £100 billion, which will take the stock of asset purchases to £745 billion (https://www.bankofengland.co.uk/markets/market-notices/2020/asset-purchase-facility-gilt-purchases-june-2020). On the same date, the Bank Rate was decided to be kept at 0.1% (https://www.bankofengland.co.uk/monetary-policy-summary-and-minutes/2020/june-2020).
On 8/6/20, the BoE announced that it will increase the purchases of the UK government bonds by an additional £100 billion (https://www.bankofengland.co.uk/markets/market-notices/2020/asset-purchase-facility-gilt-purchases-august-2020). On the same date, the Bank Rate was decided to be kept at 0.1% (https://www.bankofengland.co.uk/monetary-policy-summary-and-minutes/2020/august-2020).
On 11/5/20, the BoE announced that it will increase its target for the stock of purchased UK government bonds by an additional amount of £150 billion, which will take stock of government bond purchases to £1875 billion (https://www.bankofengland.co.uk/monetary-policy-summary-and-minutes/2020/november-2020). On the same date, the Bank Rate was decided to be kept at 0.1%.
Therefore, the event dates are taken to be 3/19/20, 4/2/20, 4/22/20, 5/1/20, 6/18/20, 8/6/20 and 11/5/20.

### H.2.4 Japan

On 3/16/20, the Bank of Japan (BoJ) announced that it will purchase Japanese government bonds (JGBs) with the exact amount being unspecified and increase the purchases of CP and corporate bonds by an amount equivalent to 2 trillion yen. The BoJ announced various other actions that are taken in response to the COVID-19. These include (i) measures to ease corporate financing with the introduction of a new operation, (ii) active purchases of Japan real estate investment trusts (J-REITs) and exchange-traded funds (ETFs), (iii) establishment of the Special Funds-Supplying Operations aimed to facilitate corporate financing, (iv) coordinated action with other central banks including the Bank of Canada, the Bank of England, the European Central Bank, the Federal Reserve, and the Swiss National Bank for the purposes of U.S. dollar liquidity (https://www.boj.or.jp/en/mopo/mpmdeci/state_2020/k200316b.htm/). On the same date, the policy rate was kept unchanged at -0.1%.
On 4/27/20, the local date for Japan, the BoJ announced that it will increase the purchases of CP and corporate bonds and conduct further purchases of JGBs and treasury discount bills (T-Bills). On the same date, the BoJ also announced that to facilitate financing, it will strengthen the Special Funds-Supplying Operations (https://www.boj.or.jp/en/mopo/mpmdeci/state_2020/k200427a.htm/). The policy rate was kept unchanged at -0.1%.
On 5/22/20, the local date for Japan, the BoJ announced that it will conduct additional purchases with the upper limit being specified as 7.5 trillion yen for each asset. The BoE also announced that it will increase the annual pace of the purchases of ETFs and J-REITs, with the upper limit being specified as

12 trillion yen and 180 billion yen, respectively (https://www.boj.or.jp/en/mopo/mpmdeci/state_2020/k200522b.htm/). On the same date, the policy rate was kept unchanged at -0.1%.
On 12/17/20, the local date for Japan, the BoJ announced that it will conduct additional purchases of CP and corporate bonds. The bank decided to continue purchases of assets with an upper limit of 20 trillion yen, of which 15 trillion yen will be used for the additional purchases of CP and corporate bonds (https://www.boj.or.jp/en/mopo/mpmdeci/state_2020/k201218a.htm/). The policy rate was kept unchanged at -0.1%.
The dates reported on Bloomberg are taken as the event dates. Therefore, 3/16/20, 4/27/20, 5/21/20, and 12/17/20 are taken as the event dates. 4/27/20 is taken as the event date since 4/26/20 was a Sunday.

### H.2.5 Australia

On 3/19/20, the local date for Australia, the Reserve Bank of Australia (RBA) announced that it will conduct purchases of Government bonds and semi-government securities on the secondary market that will start the next day. The scale of the purchases is stated to be unlimited. The RBA announced other measures targeting the banking sector and businesses. These include (i) the establishment of a term funding facility for the banking system, which will support providing credit to small and medium-sized enterprises, and (ii) a change in the remuneration of exchange settlement balanced at the Reserve Bank (https://www.rba.gov.au/media-releases/2020/mr-20-08.html). The RBA policy rate is reduced by 25 basis points to 0.25%.
On 8/4/20, the RBA announced that it will purchase Australian Government Securities (AGS) on the secondary market. No specific announcement regarding the amount has been made; however, the bank stated that it will buy until the yields on 3-year bonds are consistent with the target (https://www.rba.gov.au/media-releases/2020/mr-20-18.html). Therefore, the scale can be considered as unlimited as it is more like a “whatever it takes” kind of approach. The policy rate is kept unchanged at 0.25%.
On 11/3/20, the local date for Australia, the RBA announced that it will conduct purchases of government bonds worth of $100 billion with maturities of 5 to 10 years over the next six months. The bank also announced a decrease in the interest rates to 0.1% for the new drawings under the Term Funding Facility (https://www.rba.gov.au/media-releases/2020/mr-20-28.html). On the same date, the policy rate is reduced by 15 basis points to 0.1%.
On 2/2/21, the local date for Australia, the RBA announced that it decided to conduct purchases of an additional $100 billion worth of government bonds (https://www.rba.gov.au/media-releases/2021/mr-21-01.html). The policy rate is kept unchanged at 0.1%.
On 3/1/21, the local date for Australia, the RBA announced that it decided to conduct purchases of an additional $100 billion worth of government bonds, which will follow the completion of the initial programme (https://www.rba.gov.au/media-releases/2021/mr-21-03.html). The policy rate is kept unchanged at 0.1%.
On 4/6/21, the RBA announced the initial government bond purchase programme worth $100 billion is almost complete, and it will be followed by another $100 billion worth programme starting next week (https://www.rba.gov.au/media-releases/2021/mr-21-04.html). The policy rate is kept unchanged at 0.1%.
On 7/6/21, the RBA announced the decision to continue purchasing government bonds at a rate of $4 billion per week, lasting at least until mid-November (https://www.rba.gov.au/media-releases/2021/mr-21-13.html). The policy rate is kept unchanged at 0.1%.
On 8/3/21, the RBA announced that it will continue to purchase government securities at the rate of $5 billion per week until early September and added that it will continue at a pace of $4 billion per week lasting at least until mid-February 2022 (https://www.rba.gov.au/media-releases/2021/mr-21-14.html). The policy rate is kept unchanged at 0.1%.
The dates reported on Bloomberg are taken as the event dates. Therefore, 3/18/20, 8/4/20, 11/2/20, 2/1/21, 3/1/21, 4/6/21, 7/6/21 and 8/3/21 are taken as the event dates.

### H.2.6 Canada

On 3/27/20, the Bank of Canada (BoC) announced that it will start buying Government of Canada securities on the secondary market, with the amount of purchases being specified as $5 billion per week. In addition, the bank announced the Commercial Paper Purchase Programme (CPPP), which was established to help businesses for funding purposes (https://www.bankofcanada.ca/2020/03/press-release-2020-03-27/). The policy rate is reduced by 50 basis points to 0.25%.
On 4/15/20, the BoC announced a new Corporate Bond Purchase Programme. Under the programme, the Bank is stated to conduct purchases of investment-grade corporate bonds with an amount of up to $10 billion on the secondary market. The Bank also announced that it will further enhance the term repo facility to permit funding for up to two years (https://www.bankofcanada.ca/2020/04/fad-press-release-2020-04-15/). The policy rate is kept unchanged at 0.25%.
Accordingly, the event dates are taken to be 3/27/20 and 4/15/20.

### H.2.7 New Zealand

On 3/23/20, the local date for New Zealand, the Reserve Bank of New Zealand (RBNZ) announced that it will implement a Large Scale Asset Purchase (LSAP) programme of New Zealand government bonds with the amount being specified as $30 billion. The purchases are announced to be done over the next 12 months on a range of maturities (https://www.rbnz.govt.nz/news/2020/03/rbnz-to-implement-30bn-large-scale-asset-purchase-programme-of-nz-govt-bonds). The policy rate is kept unchanged at 0.25%.
On 4/7/20, the local date for New Zealand, the RBNZ announced the expansion of the LSAP programme by $3 billion, which will increase the total size of the purchases to $33 billion over the 12 months (https://www.rbnz.govt.nz/news/2020/04/expanded-large-scale-asset-purchases). The policy rate is kept unchanged at 0.25%.
On 5/13/20, the local date for New Zealand, the RBNZ announced the expansion of the LSAP programme and that the limit for purchases is set at $60 billion over the next 12 months. The range of asset classes eligible for the purchases is specified to be NZ Government Bonds, Local Government Funding Agency Bonds, and NZ Government Inflation-Indexed Bonds (https://www.rbnz.govt.nz/news/2020/05/large-scale-asset-purchases-expanded). The policy rate is kept unchanged at 0.25% (https://www.rbnz.govt.nz/monetary-policy/monetary-policy-statement/mps-may-2020).
On 8/12/20, the local date for New Zealand, the RBNZ announced the expansion of the LSAP programme and that the limit for purchases is taken to $100 billion by June 2022 (https://www.rbnz.govt.nz/monetary-policy/monetary-policy-statement/mps-august-2020). The policy rate is kept unchanged at 0.25%.
The dates reported on Bloomberg are taken as the event dates. Since 3/22/20 is a Sunday, 3/23/20 is taken as the event date. Other event dates are 4/6/20, 5/12/20 and 8/11/20 are taken as the other event dates.

### H.2.8 Sweden

On 3/16/20, the Riksbank announced to increase the asset purchases by an additional amount of SEK 300 billion (https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/press-releases/2020/the-riksbank-to-increase-asset-purchases-and-take-measures-to-facilitate-credit-supply/). No announcement related to the monetary policy related rate has been made on that date.
On 3/19/20, the Riksbank announced that it intends to include purchases of securities issued by non-financial companies (commercial paper). The Bank announced several measures to mitigate the effects of the pandemic. These measures include (i) Riksbank offering loans in U.S. dollars to Swedish companies and (ii) removal of the limits for mortgage bonds (covered bonds) (https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/press-releases/2020/additional-measures-to-mitigate-the-effects-of-the-corona-pandemic-on-the-swedish-economy/). On the same date, central banks consisting of Federal Reserve, Reserve Bank of Australia, Reserve Bank of New Zealand, Bank of Korea, Monetary Authority of Singapore, Danmarks Nationalbank, Norges Bank, and Sveriges Riksbank announced a temporary swap agreement (https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/press-releases/2020/central-banks-have-entered-into-swap-agreements-in-us-dollars-with-the-federal-reserve/). No announcement related to the monetary policy related rate has been made on that date.
On 3/20/20, the Riksbank announced that as a next step, it will purchase covered bonds issued in Swedish kronor issued by the Swedish institutions with an amount equivalent to SEK 10 billion (https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/press-releases/2020/the-riksbank-to-buy-covered-bonds/). No announcement related to the monetary policy related rate has been made on that date. On 5/8/20, the Riksbank announced that it will make a purchase of SEK 32 billion worth of commercial paper between 8 April and 31 May (https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/press-releases/2020/commercial-paper-purchases-continue/). No announcement related to the monetary policy related rate has been made on that date.
On 5/15/20, the Riksbank announced that it will make purchases of municipal bonds worth SEK 15 billion between 1 July and 30 September. It has also been specified that it is a part of the SEK 300 billion worth of programme announced earlier (https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/press-releases/2020/continued-purchases-of-municipal-bonds/). No announcement related to the monetary policy related rate has been made on that date.
On 7/1/20, the Riksbank announced the expansion of the asset purchase from SEK 300 billion to SEK 500 billion until the end of June 2021. In addition, the Bank announced that it will include corporate bonds in its purchase programme in September. Previously, the purchases were being made on government bonds, mortgage bonds, municipal bonds, and commercial paper (https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/press-releases/2020/

further-measures-to-alleviate-the-economic-consequences-of-the-pandemic/). On the same date, the policy rate is kept unchanged at 0% (https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/press-releases/2020/minutes-of-the-monetary-policy-meeting-held-on-30-june-2020/).
On 11/26/20, the Riksbank announced the extension of asset purchases from SEK 500 billion to SEK 700 billion until 31 December 2021. The programme also includes purchases of treasury bills, both sovereign and municipal green bonds (https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/press-releases/2020/zero-policy-rate-and-extended-asset-purchases/).
The policy rate is kept unchanged at 0%.
Accordingly, the event dates are taken to be 3/16/20, 3/19/20, 3/20/20, 5/8/20, 5/15/20, 7/1/20 and 11/26/20.

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