The Global Financial Cycle after Lehman

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The Gobal Financial Cycle denotes fluctuations in financial activity on a global scale (see Rey, 2013). It is characterized by the comovements of risky asset prices, leverage of financial intermediaries, credit growth and gross capital flows around the world. In particular, a single global factor explains an important share of the common variation of a large cross-section of risky asset prices globally. Using a medium-scale Bayesian VAR, Miranda-Agrippino and Rey (2015) show that US monetary policy is a driver of the Global Financial Cycle. US monetary contractions are followed by a significant deleveraging of global financial intermediaries, a rise in aggregate risk aversion, a contraction in the global factor in asset prices and in global credit, a widening of corporate bond spreads, and a retrenchment in gross capital flows. The effects, estimated on the period 1980-2010 (or 1990-2010) are economically significant. A 100 bps increase in the US short-term policy rate translates into a 40% decrease in the global factor in asset prices, which maps into an approximate 10% decline in broad stock markets indices. Jugulum, Mishra and Rajan (2020) show that US financial conditions also affect mergers and acquisitions around the world. Several indices of aggregate risk aversion (e.g. Bekaert, Engstrom and Xu, 2019) increase significantly when the Fed tightens. One interpretation of these results, provided in Miranda-Agrippino and Rey (2015), is that aggregate risk aversion is shaped by the heterogeneous risk-taking behaviours of different financial intermediaries, whose relative importance varies over time. Low cost of funds and high asset valuations tend to relax value-at-risk constraints; this allows the most risk-taking financial intermediaries to take on additional risk, and gain market share (see Coimbra and Rey, 2017, for a model along these lines). Between 2003 and 2008, global banks, at the time lightly regulated, were at the origin of a large share of international capital flows (see Shin, 2012). This coincided with low aggregate risk aversion, high asset valuations and high leverage, and ended with the Lehman Brothers bankruptcy of 2008, and the financial crisis that followed. The subsequent changes in regulation, such as the phasing in of Basel III and the emergence of macroprudential policies, have altered the propensity of banks to take risk, as well as their relative importance in intermediation. Asset managers and non-bank financial intermediaries have become more important in international markets. A natural question arising is whether changes in the structure of financial intermediation have had significant effects on the transmission of US monetary policy on the Global Financial Cycle (see also Burcu et al., 2020). This is the question we are exploring in this paper.

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I. US Monetary Policy and the Global Financial Cycle After Lehman

Until the onset of the zero-lower-bound (ZLB) spell, Miranda-Agrippino and Rey (2015) show that the effect of US monetary policy on domestic variables are 'textbook' ones, but that Fed policies also have important international spillovers through capital flows, asset prices, leverage of international financial intermediaries, and global credit. After 2009, the Fed policies have become less conventional, and more varied. With short-term policy rates reach-

ing historically lower levels, the Federal Reserve has resorted to alternative ways of managing expectations about future rates, in order to maintain its commitment towards its dual mandate. Most prominently, this was achieved by enhancing communication about its near-term course of action through statements (forward guidance), and through large-scale interventions in asset markets via its LSAP programmes (quantitative easing, or QE).

Because of their complexity, novelty and variety, identifying and estimating the effects of such unconventional policies has proven to be quite challenging in empirical works. In order to explore to what extent the international transmission of US monetary policy through financial markets has changed with the introduction of such policies, we rely on the work of Swanson (2017). By extending the approach of Gürkaynak, Sack and Swanson (2005), and using high-frequency reactions of a variety of asset prices to all FOMC policy announcements since 1991, Swanson (2017) is able to identify three different dimensions of US monetary policy – orthogonal to one another – that summarize movements in the entire term structure of interest rates: *(i)* a federal funds rate factor, that loads predominantly on the overnight rate, and dominates in the period until 2009; *(ii)* a communication/forward guidance factor that has higher loadings on 1 to 2-year maturity rates, and that is active throughout the entire sample; and *(iii)* an LSAP factor that mostly captures the variation at the long end of the curve (10-year Treasury rates) and is constrained to be negligible in the pre-ZLB sample by construction. High-frequency reactions are recorded in a 30-minute window bracketing each FOMC announcement between July 1991 and June 2019. The use of a variety of asset prices that cover the entire maturity spectrum allows to distill the information content of each FOMC announcement through the lens of financial markets, that act as an information aggregator.[1] The use of high-frequency price changes surrounding the announcements for the extraction of the three monetary policy factors ensures that only the unanticipated component of Fed policies enters their measurement, making them suitable for structural analysis; they constitute an innovation in the information set of market participants that is prompted by the policy announcements.

A. Setup of the Empirical Analysis

We evaluate the international transmission of US policies to the Global Financial Cycle (GFC) in the post-Lehman world using an information-rich monthly VAR.[2] The VAR includes a core set of US variables that cover domestic output and prices, and the 2-year and 10-year interest rates. The international financial variables that summarize fluctuations in the GFC are a measure of global private liquidity and one of global cross-border flows, the dollar effective exchange rate, two implied volatility indices intended to capture risk in the stock (VIX) and bond (TYVIX) markets respectively, and an extension of the global factor in world risky asset prices of Miranda-Agrippino and Rey (2015).[3] We report additional details on the data definitions and sources in the Appendix.

We use the forward guidance and LSAP factors of Swanson (2017) as external instruments (Stock and Watson, 2018) and present our results in the form of dynamic responses to these term-structure shocks, both normalized to reduce the 10-year interest rate by 100 bps on impact. The

[1] The asset prices from which the factors are extracted include federal funds rate futures (the current-month contract rate and the contract rates for each of the next six months), Eurodollar futures (the current-quarter contract rate and the contract rates for each of the next eight quarters), Treasury bond yields (3-month, 6-month, and 2-, 5-, 10-, and 30-year maturities), the stock market (S&P 500), and exchange rates (yen/dollar and dollar/euro).

[2] The setup builds on Miranda-Agrippino and Rey (2015).

[3] This novel factor is estimated using the methodology in Miranda-Agrippino and Rey (2015) on an updated and larger cross-section of asset prices that is intended to reflect compositional changes in global financial markets (Miranda-Agrippino, Nenova and Rey, 2019).

VAR is estimated using standard macroeconomic priors (Giannone, Lenza and Primiceri, 2015), with 6 lags at monthly frequency over the sample 2009:01 - 2019:04.[4] We report median IRFs together with 68% and 90% posterior coverage bands.

II. Shocks to the short end of the US yield curve

Figure 1 collects the responses to a shock identified using the forward guidance (FG) factor, which loads predominantly on interest rates at the 1-2 year maturity, and is present before and after 2009.[5] This is a shock that induces markets participants to revise their expectations of future medium-term maturity interest rates. Given that the typical time horizon covered in both implicit and explicit FG announcements roughly matches the maturity of the interest rates that mostly load on this factor, it quite naturally lends itself to being interpreted as identifying the effects of forward guidance policies. Technically, however, to the extent that the announcement and implementation of quantitative easing measures can have an impact also on expectations of interest rates at maturities other than 10 years, this shock effectively combines the effects of explicit policy communication with those of this "signalling channel" of the QE transmission mechanism (see Krishnamurthy and Vissing-Jorgensen, 2011). As a consequence, we think of it collectively as that combination of structural shocks that, spurred by the FOMC announcements, act mainly on the short-end of the US yield curve. The FG factor is constructed to be orthogonal to the changes in the fed funds rate, and hence captures variations in the short end of the yield curve above and beyond those resulting from a direct transmission from changes in the overnight interest rate. Given that our sample is dominated by the ZLB years, the factor approximates in our case all the monetary policy events that have had an effect on interest rates up to the 2-year maturity.

Shocks that lower the short-end of the term structure impact the domestic and GFC variables in a way that is mostly similar to the pre-2009 conventional monetary policy. Expansionary monetary policy stimulates domestic inflation (not reported), but also boosts global risky asset prices, and increases world private liquidity and global cross-border flows. It depreciates the US dollar against foreign currencies, and does not have significant effects on bond market volatility, as measured by the TYVIX index.[6]

The only variable that seems to respond very differently to the expansionary shock is the VIX index, which increases sharply in the post 2009 sample, while it moved in the opposite direction pre-crisis.[7] This may be related to the findings of Forbes and Warnock (2019) who show that extreme capital flows movements are less correlated with global risk (as measured by VIX) since the crisis. Similarly, Avdjiev et al. (2017) note that the responsiveness of international bank lending to global risk conditions, again measured by the VIX, has declined steadily since 2009. More research is doubtlessly needed to confirm and understand our result: for example, did global banks play a particular role in channeling monetary policy shocks into implied volatility measures? Has this role been altered by changes in regulation?

III. Shocks to the long end of the US yield curve

Figure 2 reports the responses of the same variables to a shock that is instead identified using the LSAP factor. This is a factor that is not active pre-2009 by construc-

[4] Increasing the number of lags adds considerably to the computational burden without altering the results in significant ways.

[5] The loadings of the FG factor on the 1, 2 and 10 year rates are equal to 5.71, 4.61, and 3.85 respectively (see Table 3 of Swanson, 2017).

[6] The TYVIX index is an estimate of the expected 30-day implied volatility of 10-year Treasury futures; it is distributed by the CBOE and is available since 2003.

[7] The shock also does not seem to have any significant effect on domestic activity, measured by industrial production and not reported. This is in contrast with our pre-2009 results which estimated large and significant responses.

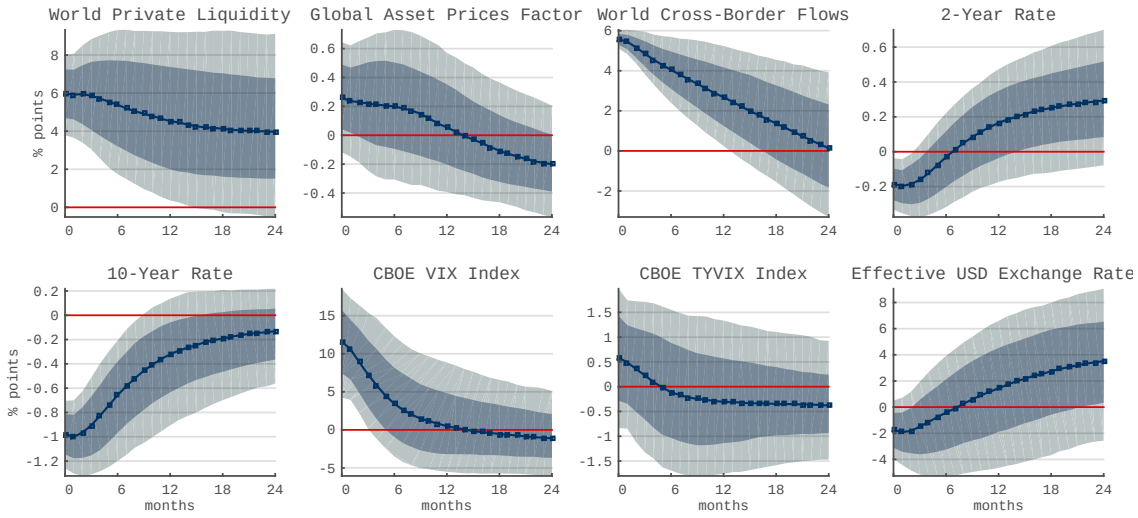

Figure 1. IRFs to a US Term-Structure Shock: Short End

Note: Median impulse response functions. Shock normalized to induce a 1% decline in the 10-year rate. Shaded areas denote 90% and 68% posterior coverage bands. VAR(6). Sample 2009:01-2019:04.

tion, and that loads predominantly on the long end of the term structure.[8] Similar to the FG case, we interpret it as identifying the combination of primitive shocks that, prompted by the FOMC announcements, leads market participants to revise their expectations about future long-term rates. Importantly, this factor is orthogonal to both changes in the overnight rate and in the FG factor. Hence, it can be thought of as capturing residual ways in which FOMC announcements alter markets' expectations about long-term rates beyond those that result from direct transmission from changes in shorter-maturity interest rates.

The responses to this shock reported in the figure are dominated by a strong central bank information effect: the monetary policy announcement mostly signals to market participants deteriorating economic conditions ahead, which leads them to flee into the 10-year US Treasuries, considered to be a safe haven.[9] Another way to look at it is that, once changes at the shorter end and their transmission along the curve have been controlled for, longer term interest rates seem to move during FOMC announcements mostly because of the news about the economy that are more or less explicitly disclosed by the announcements themselves.

At the domestic level, the shock translates into a severe contraction of real activity, and a relatively muted response of inflation (not shown). Bad news seems to travel fast internationally as well: world private liquidity decreases, and so do global risky asset prices summarized by the global factor, and cross-border flows. Perceived risk (VIX) rises, and the US dollar appreciates sharply (flight to quality). The monetary policy information channel whose effects we document here is specific to the exceptionally bad news conveyed by the Fed during the financial crisis. By definition, and consistent with the extraction of the policy factor, it was not there before 2009. Its propagation mechanism is consistent with theory both for what concerns domestic variables, and for the Global Financial Cycle vari-

[8] The loadings of the QE factor on the 2, 5 and 10 year rates are equal to 0.1, 3.41 and 5.36 respectively (see Table 3 of Swanson, 2017).

[9] Stavrakeva and Tang (2019) provide a thorough analysis of this effect specifically for what concerns forward guidance announcements in the post 2009 sample. Miranda-Agrippino and Ricco (2018) discuss information effects in FOMC announcements in the pre-ZLB sample.

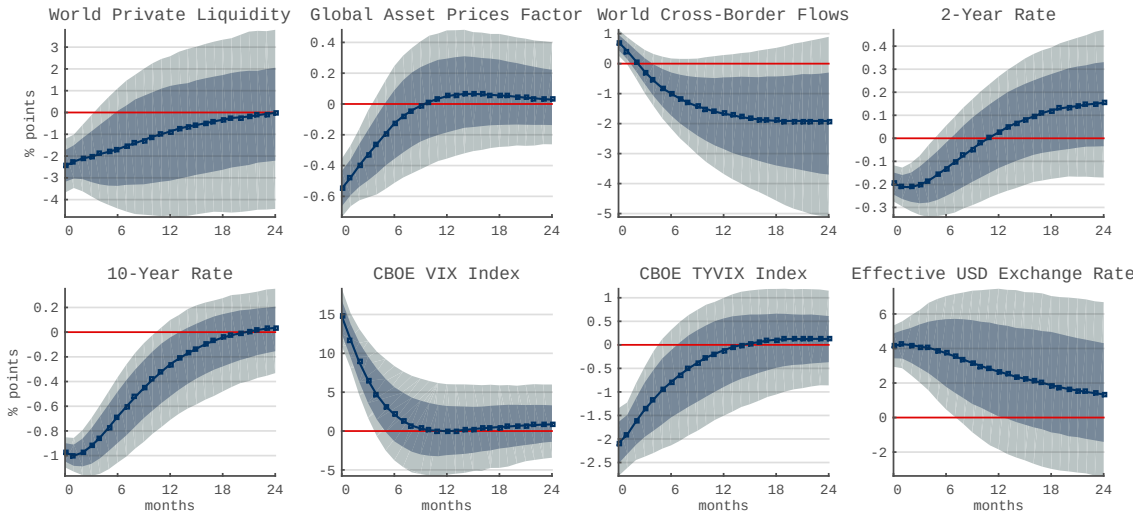

FIGURE 2. IRFS TO A US TERM-STRUCTURE SHOCK: LONG END

Note: Median impulse response functions. Shock normalized to induce a 1% decline in the 10-year rate. Shaded areas denote 90% and 68% posterior coverage bands. VAR(6). Sample 2009:01-2019:04.

ables. Finally, we note that 10-year Treasury volatility goes down, which may reflect market participants' purchases of US Treasuries – in particular the 10 year – due to the aforementioned flight to safety.

IV. Conclusion

The analysis we perform in this paper has to be taken with some caution, as we assume that 2009 is a break date, and perform our analysis on the entire 2009-2019 period which in fact includes the North Atlantic financial crisis, the Euro Area sovereign debt crisis, and the post-crisis period. Focusing on sub-periods would be ideal, but the time series nature of our approach does not afford us that flexibility.

Nevertheless, we find that the transmission of US monetary policy to the variables that characterize the Global Financial Cycle – world liquidity, cross-border flows, and global asset prices –, has remained relatively similar before and after 2009. Looser policy, defined as a decrease of short-term rates, leads to an increase in all the GFC variables. This with the exception of the VIX index: a loosening of US monetary policy led to a decrease in the VIX pre-2009, and instead seems to lead to an increase in the post-2009 sample. More research is needed to confirm this result, and to understand it.

We also document evidence consistent with the existence of a very powerful information effect of monetary policy that mostly impacted on longer terms interest rates in the years after 2009, when the Federal Reserve's statements and actions also conveyed bad news about the economic outlook. This information effect is associated with a decline in the global factor in asset prices, a sharp increase in the VIX, a decrease in liquidity and a strong appreciation of the US dollar. Flight to safety into US Treasuries during times global crisis offer a way to rationalize these last set of results (Gourinchas, Rey and Govillot, 2017; Stavrakeva and Tang, 2019).

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Data Appendix

Table A1 reports the variables that we use in the paper.

We obtain the measures of world private liquidity (WORLDPLIQ) and cross-border flows (WORLDCBFLOW) from CrossBorder Capital Ltd, an independent fund management firm specialized in the monitoring of global liquidity flows. Private sector liquidity measures net credit generated by all credit providers: traditional commercial banks, and 'shadow banks'. It is computed by aggregating data originally distributed by the national central banks, national funds associations, bankers' associations, mortgage bankers associations, stock exchanges, and finance ministries. The world cross-border flows variable instead measures the value of banking and portfolio equity and bond flows into the given country. It excludes capital gains in reported series. It is estimated from monthly national trade and current account data, foreign exchange reserve movements and (interpolated) quarterly data on net FDI flows. The variable is obtained by aggregating data form national central banks, national statistical offices, the UNCTAD, and the IMF.

Table A1—Data Series in Bayesian VARs

Code	Variable	Source
WORLDPLIQ	World Private Liquidity	Cross-Border Capital Ltd.
GFCFAC	Global Asset Prices Factor	Own Calculations
WORLDCBFLOW	World Cross-Border Flows	Cross-Border Capital Ltd.
GS2	2-Year Rate	St. Louis Fed FRED Database
GS10	10-Year Rate	St. Louis Fed FRED Database
VIX	CBOE VIX Index	Chicago Board Options Exchange
TYVIX	CBOE TYVIX Index	Chicago Board Options Exchange
USDEER	Effective USD Exchange Rate	Bank of International Settlements
INDPRO	Industrial Production	St. Louis Fed FRED Database
PCEPILFE	Core PCE Deflator	St. Louis Fed FRED Database
FWGFAC	Forward Guidance Factor	Swanson (2017)
LSAPFAC	LSAP Factor	Swanson (2017)

The global factor in risky asset prices (GFCFAC) is estimated by applying the methodology of Miranda-Agrippino and Rey (2015) to a panel of 1004 prices series over the sample 1980:01-2019:04 (see Miranda-Agrippino, Nenova and Rey, 2019). Compared to the earlier vintage, the new panel includes a larger number of Chinese stocks in the later part of the sample.

The CBOE/CBOT 10-year US Treasury Note Volatility Index (TYVIX) is obtained by applying the CBOE's VIX methodology to measure a constant 30-day expected volatility of 10-year Treasury Note futures prices, and is calculated based on pricing from CBOT's actively traded options on the T-Note futures. Historical data are available since 2003.

The forward guidance and LSAP factors (FWGFAC, LSAPFAC) are estimated in Swanson (2017) from a panel of 30-min high frequency price changes around FOMC announcements in a collection of asset prices (see Footnote I). The forward guidance factor is identified by imposing a zero loading on the current federal funds rate. The LSAP factor is identified by imposing a zero loading on the current federal funds rate and by minimizing its sum of squared values in the pre-2009 sample. The procedure also identifies a federal funds rate factor. The data runs from July 1991 to June 2019.