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Unconventional U.S. monetary policy and international financial market stability

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Abstract

From December 2008 to December 2015, the Federal Reserve held interest rates at the zero lower bound. Unable to lower short term rates further, the Fed engaged in unconventional monetary policy, buying large quantities of US assets and Treasury bonds. This paper examines the international effect of these large scale asset purchases on foreign financial markets. Using a panel VAR estimation on OECD countries, I find shocks to the Fed's unconventional monetary policy increased global stock market volatility by one standard deviation with little influence on the yield curve. I find slightly larger results for Eurozone countries. Overall, these results indicate the Fed's unconventional monetary policies had a significant impact on financial markets throughout the developed world

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1 Introduction

The Federal Reserve's response to the Great Recession pushed U.S. monetary policy into unprecedented territory. In late 2008 with economic conditions worsening, the Federal Reserve lowered the fed funds rate to the zero lower bound. However, economic conditions did not improve, leaving the Fed little choice but to continue to try for monetary stimulus using unconventional measures. In early 2009, the Fed began buying large amounts of mortgage backed securities and government sponsored entity debt, signaling to markets it would leave interest rates at zero for "an extended period of time." As economic conditions failed to improve, the Fed took extreme measures two more times, buying large amounts of Treasury securities to inject liquidity into the financial market. Over the course of the next seven years, multiple rounds of quantitative easing (QE) brought the Federal Reserve's balance sheet from roughly $800 billion in 2008 to over $4.5 trillion in 2015.

Because the Federal Reserve occupied a larger portion of the US financial market than it would have with traditional policy, it is natural for investors to have to re-balance with international assets. As investors migrate to different markets, both domestic and international, they create spillover effects of this policy. In domestic and foreign stock markets, the greater movement of investors between markets changes the pool of potential buyers, shifting volatility. Regardless of the market, this greater number of displaced investors creates spillovers from US policy as investors change their optimal asset allocation.

This paper examines these spillover effects of the Fed's unconventional monetary policy from December 2008 to December 2015 on foreign financial markets. To examine the dynamic spillover effects across a set of OECD countries, I use a Bayesian panel VAR. Results indicate that during periods of unconventional monetary policy, surprise monetary tightening increased the volatility of foreign stock markets, with results slightly larger in the Eurozone. The structure of the paper is as follows: section 2 reviews the literature surrounding US monetary policy spillovers and financial market effects of quantitative easing. Section 3 details the data and discusses the Bayesian panel VAR method in detail. Finally, section 4 provides the results of the panel VAR estimation all OECD countries and for just Eurozone countries, and section 5 concludes.

2 Literature

US monetary policy creates international spillovers through exchange rate, trade, and financial channels, with US policy driving a global factor underlying international risky assets (Davis & Zlate, 2019; Iacoviello & Navarro, 2018; Miranda-Agrippino & Rey, 2015; Tobe, 2017). Unconventional monetary policy generated distinct effects from traditional policy: large-scale asset purchases lowered domestic long-term bond yields by reducing term premia, decreased domestic stock market volatility, and reduced domestic tail risk perceptions while relaxing financial intermediaries' risk-bearing constraints (Gagnon et al., 2011; Hattori et al., 2016; Mallick et al., 2017).

These effects extended internationally as QE caused global asset rebalancing away from the US, with developed countries experiencing bond yield declines and exchange rate depreciations after policy announcements (Bauer & Neely, 2014; Fratzscher et al., 2017; Neely, 2015). Recent research has also found that unconventional monetary policy has substantial cross-border effects distinct from conventional policy, with spillovers varying by policy type, destination country characteristics, and timing (Araújo et al., 2025; Bhattarai & Neely, 2022; Carrière-Swallow et al., 2025; Stedman, 2020; Tran & Pham, 2020; Yildirim & Ivrendi, 2021).

3 Data and Methodology

I run a Bayesian panel VAR on 29 non-US OECD member countries (as of 2008) using quarterly data on policy rates, bond yields, inflation, real GDP, stock market volatility, exchange rates, and US monetary policy. I exclude countries experiencing sovereign debt crises (Spain, Portugal, Ireland, Greece) to ensure results are not driven by these events, leaving 25 countries in the sample.[1]

From December 2008 to December 2015, the fed funds rate was constrained by the zero lower bound while the Fed continued to conduct policy through quantitative easing and forward guidance. Following Wu and Xia (2016), I use their constructed shadow rate to proxy for the stance of monetary policy[2]. The shadow rate uses a three-factor term structure model with a zero lower bound constraint. The model uses 3-month through 10-year U.S. Treasury yields and estimates the shadow rate via a nonlinear Kalman filter. When market rates are above zero, the shadow rate equals the federal funds rate; when the ZLB binds, it falls below zero to reflect additional accommodation from unconventional policies. This approach effectively captures unconventional policy effects because it aggregates information from large-scale asset purchases and forward guidance, both of which operated primarily through longer-term rates, into a single policy stance measure comparable to conventional policy periods. Figure 1 shows the progression of the shadow rate throughout the sample. The shadow rate bottoms out in 2014 with the ending of quantitative easing and started to rise towards zero. This allows the sample to encompass both decreases and increases in the shadow rate while the shadow rate is still below zero. Including both increases and decreases should improve the estimation because interest rates are not simply moving in one direction. Because the Wu-Xia shadow rate uses the term structure of interest rates to approximate the shadow rate, it also accounts for the effect of monetary policy on U.S. bond yields.

Consistent with Iacoviello and Navarro (2018), I use U.S. monetary policy shocks instead of policy levels to properly account for expectations. Market participants base decisions on all available information, meaning anticipated policy moves are already priced in. Only unanticipated changes (the shocks) cause sudden behavioral adjustments and spillovers to foreign economies. To identify US monetary shocks, I regress the shadow rate on current and lagged controls:

$$WX_{t,US} = \gamma_0 + \gamma_1' Z_{t,US} + \epsilon_t \tag{1}$$

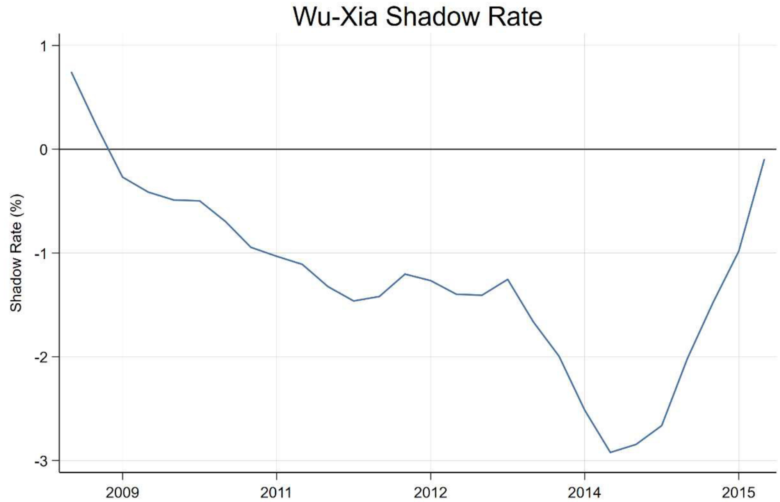
where Z_t includes real-time CPI inflation, CBO-estimated output gap, Survey of Professional Forecasters inflation expectations, and lagged policy values. The shock is the residual, ϵ_t.

I include each country's interest rate following Davis and Zlate (2019), controlling for domestic policy that could influence bond yields and isolating US monetary policy effects. Many countries hit the zero lower bound during the sample. The Reserve Bank of New

[1] Results are consistent with their inclusion, with larger effect magnitudes.

[2] Shadow rates can be downloaded for Cynthia Wu's website here.

Figure 1: The Wu-Xia Shadow Rate



Zealand calculates shadow rates for the EU, UK, and Japan using the Wu-Xia method detailed above. I use these for uniform treatment of unconventional policy in non-US central banks. Countries without shadow rates did not hit the lower bound, so I use their short-term government bond rates.

Table I reports summary statistics and panel diagnostics. GDP and the price level are seasonally adjusted by the OECD; interest rate spreads, exchange rates, and shadow rates are not seasonally adjusted as these financial variables do not exhibit systematic seasonal patterns. GDP enters the model as annual growth, inflation as the annual growth in the price index, the yield spread as the difference between 10-year and 3-month government bond yields, exchange rates as first differences, domestic monetary policy as the level of the shadow rate (or short-term rate for countries not at the ZLB), and stock market volatility as the change in the standard deviation of daily returns. Stock market data comes from WRDS World Indices, with market volatility measured as the standard deviation of daily returns over each quarter. Exchange rates are standardized to units of domestic currency per dollar for uniform interpretation. The panel covers 25 countries over 32 quarters (800 observations).

The diagnostic tests in Table I reveal substantial cross-sectional dependence across all variables, with Pesaran CD (Pesaran, 2004) ranging from 12.14 (inflation) to 56.52 (exchange rates). This dependence reflects the globally integrated nature of financial markets during the sample period and motivates both the panel structure and the use of second-generation unit root tests. The Im-Pesaran-Shin (IPS) test rejects the unit root null for most variables in growth or differenced form, while the Pesaran (2007) CIPS test, which accounts for cross-sectional dependence, confirms stationarity for inflation, exchange rate changes, domestic monetary policy, and stock volatility. The yield spread shows some persistence under both tests, consistent with the highly accommodative and slowly evolving policy environment during the ZLB period.

I estimate effects using a Bayesian panel VAR following Canova and Ferroni (2019). Panel VARs allow variables to be endogenous and interdependent as in a standard VAR

Table I: Data Summary and Panel Diagnostics

	Summary Stats	CS Dependence	Unit Root Tests	Slope Het.
Variable	Mean	CD	W[t-bar] (IPS)	$\tilde{\Delta}_{adj}$
GDP Growth	1.00 (3.24)	46.33***	−11.47*** (−1.62)	18.77***
CPI Inflation	1.77 (1.67)	12.14***	−3.98*** (−2.36**)	5.84***
10yr–3mo Spread	1.88 (1.61)	40.75***	−1.21 (−2.30*)	27.14***
Exchange Rate Change	0.01 (0.05)	56.52***	−9.52*** (−2.31*)	3.60***
Domestic monetary policy rate	0.54 (2.43)	47.67***	4.13 (−2.50**)	18.03***
Stock Volatility (Δ)	1.00 (0.49)	55.16***	−10.84*** (−3.169***)	−0.98
U.S. Monetary Shock (exogenous)	−0.09 (0.19)	–	–	–
N (obs.)		800		

Notes: ***, **, * denote significance at 1%, 5%, and 10%. Summary stats report mean (SD). CS dependence reports Pesaran (2004) CD. Unit-root tests report IPS with CIPS in parentheses (Pesaran, 2007); $\tilde{\Delta}_{adj}$ is the Pesaran and Yamagata (2008) bias-adjusted slope homogeneity test.

while incorporating a cross-sectional dimension. The model takes the form

$$y_{i,t} = \alpha_i + \sum_{\ell=1}^{p} A_\ell y_{i,t-\ell} + C w_t + u_{i,t} \tag{2}$$

where $y_{i,t}$ is the $G \times 1$ vector of endogenous variables for country i at time t, α_i is a country-specific fixed effect, A_ℓ is the matrix of autoregressive coefficients common across all countries at lag ℓ, w_t is the U.S. monetary policy shock entering as an exogenous variable, C is the associated coefficient vector, and $u_{i,t}$ is a vector of disturbances. In estimation, I remove country fixed effects by demeaning each endogenous variable within country, so the model is identified from within-country dynamics over time. In the baseline specification, I set $p = 2$, as selected by BIC. One common challenge in panel VAR estimation is over-parameterization: with a moderate number of endogenous variables and lags, the parameter count quickly exceeds what can be reliably estimated from limited observations. This can produce imprecise estimates and impulse response functions. Bayesian shrinkage can address this problem by placing priors on the autoregressive coefficients that pull estimates toward parsimony, improving estimation without arbitrarily dropping variables or imposing restrictive exclusions (Koop, Korobilis, et al., 2010).

A related issue is whether dynamics are homogeneous or heterogeneous across countries. Under homogeneity, pooled estimation is efficient, but under heterogeneity, pooling can bias results, favoring Bayesian approaches. Table 1 reports the Pesaran and Yamagata (2008) bias-adjusted slope homogeneity test ($\tilde{\Delta}_{adj}$) for each equation in the VAR specification. The test rejects homogeneity for most variables (GDP growth, inflation, yield spread, exchange rate changes, and domestic monetary policy), indicating significant cross-country heterogeneity. Only stock volatility fails to reject homogeneity. Given this evidence, I estimate a

Bayesian panel VAR with country fixed effects and Minnesota priors, which helps control over-parameterization while accounting for persistent cross-country differences. The prior centers coefficients near zero and applies stronger shrinkage to longer lags with the overall tightness parameter set to 0.2. Posterior summaries are based on 2,000 independent draws from the conjugate posterior, so burn-in and thinning do not apply; only stable draws are retained when computing impulse responses.

Finally, I include US monetary shocks as exogenous, reflecting that the Fed primarily focuses on US variables when setting policy. However, international participants form expectations based on US data and respond accordingly, consistent with literature showing US monetary policy as the global hegemon.

4 Results

The Bayesian panel VAR uses a 2 lags with Minnesota priors, and results are from a 1 percentage point contractionary shock to the U.S. shadow rate (i.e. a 100 basis point innovation to the estimated residual). For ease of interpretation, the impulse responses are normalized to this shock size; the standard deviation of the monetary shock is 0.19%. Figure 2 shows the response of each variable to a shock of this size. A contractionary shock to the U.S. shadow rate significantly raises the change in foreign stock market volatility on impact. The response reverses in the following quarter, implying a temporary increase in the level of volatility before it returns to steady state.[3] These results are consistent with the domestic effects of unconventional policy seen in Mallick et al. (2017) and Hattori et al. (2016).

Interestingly, the spread between 10-year and 3-month government bonds responds only marginally upon impact of the contractionary shock, with the spread increasing by 40 basis points, though this result is not statistically significant. At first, this appears to run counter to the results in Bauer and Neely (2014) that QE depressed longer term bond yields internationally. However, as the Fed and other central banks lowered interest rates to respond to the crisis and slowing economic conditions, international short term (3-month) interest rates responded by about as much as longer term interest rates as investors knew interest rates would be low for the duration of a short term bond. In this, QE still depressed bond yields while causing the slope of international yield curves to steepen only marginally. As can be seen from the figure, these shadow rate shocks modestly depressed international output and had a small effect on inflation, though neither results are statistically significant. In response to the contractionary shock, foreign central banks also raised their policy rates by roughly 0.3 p.p., with rates only slowly declining afterwards. In turn, the exchange-rate measure rises on impact, consistent with a temporary appreciation of the dollar across the panel.

Given that a shock to policy caused a modest decline in foreign bond yields and a small change in the slope of the yield curve, this volatility suggests two things: first, a surprise tightening signals reduced market liquidity, causing international participants to tighten their risk-bearing constraints, consistent with Hattori et al. (2016). Second, because the Fed occupied a larger portion of the US bond market during this period, a contractionary surprise

[3] The VAR uses the change in volatility, so the response shows an increase in *the level* of volatility, followed by a decline as conditions normalize. A short-lived response is common for a financial variable at a quarterly frequency, as markets are quick to price in any new information.

may trigger portfolio re-balancing, increasing uncertainty about the pool of international buyers and raising volatility. Taken together, these results show unconventional US monetary policy creates different spillovers than those seen from traditional policy in Iacoviello and Navarro (2018) and Miranda-Agrippino and Rey (2015).

Table II reports diagnostics for the Bayesian panel VAR estimation. The Geweke convergence statistics indicate consistent MCMC chain convergence, with over 90% of parameters in both samples achieving Z-statistics below the 1.96 threshold and mean Z-statistics well below unity. All eigenvalues of the companion matrix lie inside the unit circle for both samples, indicating the overall model is stable. As a result, impulse responses will converge to steady state over time rather than exhibiting explosive behavior.

Table II: Panel VAR Estimation Diagnostics

	OECD Sample	Eurozone Sample
Sample Characteristics		
Number of countries	25	12
Total observations	800	384
MCMC Convergence		
Mean absolute Z-statistic (Geweke)	0.679	0.867
Parameters converged (%)	97.6	91.7
VAR Stability		
Max eigenvalue modulus	0.9885	0.9592
System stable	Yes	Yes
Model Fit		
AIC (approx.)	2,471	1,437
BIC (approx.)	2,926	1,811

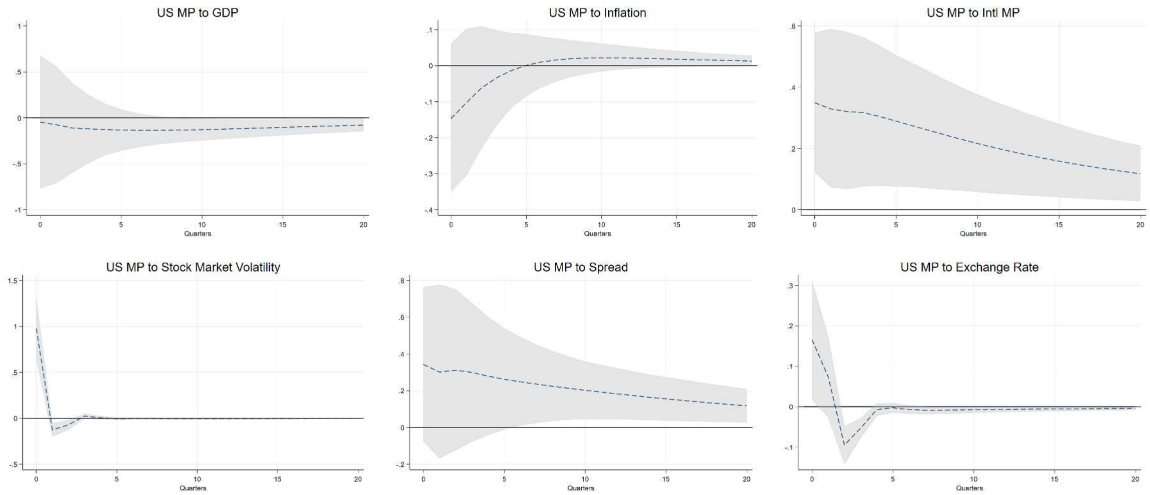
Note: Geweke Z-statistics test convergence of MCMC draws; values below 1.96 indicate convergence. Eigenvalues represent the companion matrix eigenvalues; all values below unity indicate a stable system.

4.1 Results for Eurozone Countries

Next, I limit the panel VAR to countries in the Eurozone. Doing this allows each country to share the same monetary policy and exchange rate with the dollar, so the estimated responses should be interpreted as average cross-country responses within a common policy and exchange-rate environment. The results for Eurozone countries are given in Figure 3. Overall, the results mirror those for the full panel, though the effect is somewhat larger. A shadow rate shock still has a statistically significant contemporaneous effect on the change in volatility. The impact response is roughly 15% larger for the Eurozone than for the full panel, implying a somewhat stronger temporary increase in volatility.

This shadow rate shock still has little significant influence over output and inflation in the short term, though output is lower towards the end of the response. The ECB mirrors the Fed's increase in rates more than the full sample, raising the Euro shadow rate by 1 percentage point in response to the 1 percentage point shock. Taken together, these

Figure 2: OECD response to a 1 p.p. shock to the U.S. Wu-Xia Shadow Rate. Shaded areas indicate 95% credible intervals from the posterior distribution.



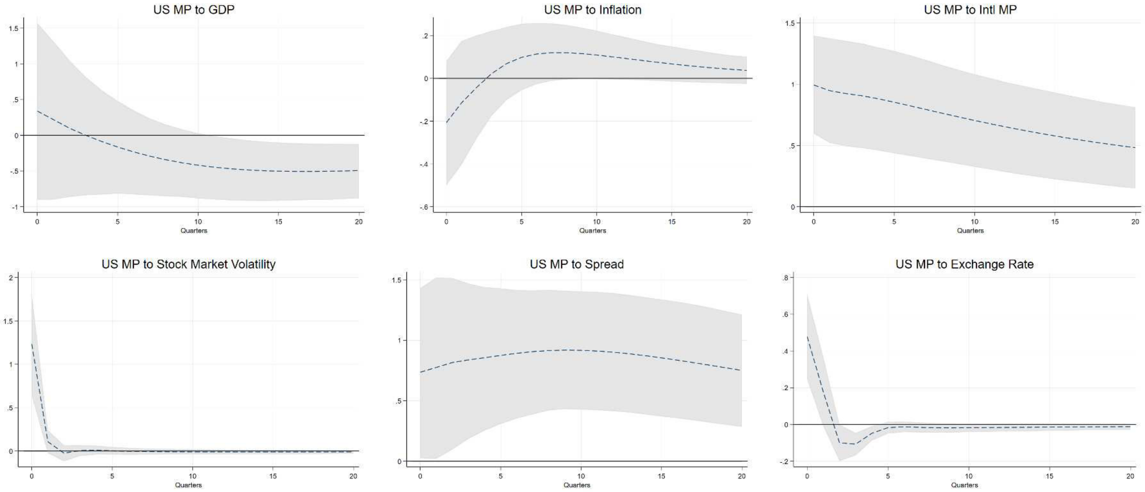
responses are consistent with a temporary appreciation of the dollar relative to the euro. With the ECB raising interest rates, the yield curve steepens modestly (the 10-year to 3-month yield spread increases), and this effect is persistent. This points to one of two things: global investors could worry about the impact of the increase in interest rates on European financial stability. Alternatively, it could point to a larger presence of foreign bond investors in the European bond market as a result of the Fed's involvement in the US market.

5 Conclusion

This paper estimates the effect of the Fed's unconventional monetary policies on foreign financial markets. Overall, U.S. monetary shocks raise changes in foreign stock market volatility on impact, consistent with a temporary increase in the level of volatility. This largely follows intuition, as sudden reductions in U.S. monetary accommodation or hawkish policy surprises can trigger international portfolio rebalancing and increase volatility. While a contractionary shock caused a noticeable appreciation in the value of the dollar internationally, it had a small effect on the slope of yield curves, though the effect on European markets was larger. This points to a similar movement in short term and long term rates in response to Fed involvement. U.S. policy had little effect on real economic outcomes throughout OECD countries. Real GDP and inflation respond only slightly to shocks to the U.S. monetary policy. These results largely held true when limited to Eurozone countries. European stock market volatility also shows a larger impact response than in the full panel, consistent with a somewhat stronger temporary increase in volatility.

Taken as a whole, these results shed light on how unconventional monetary policy can have different spillover effects. Moreover, as other countries have undertaken unconventional monetary policies in recent years, it shows how such policies can influence global financial markets. These results shed light on a potential driver behind the financial channel for US monetary policy spillovers discussed in Iacoviello and Navarro (2018) and Miranda-Agrippino and Rey (2015). Future research should focus on how the effect varies between when policy

Figure 3: Eurozone countries response to a 1 p.p. shock to the U.S. Wu-Xia Shadow Rate. Shaded areas indicate 95% credible intervals from the posterior distribution.



is easing v.s. when it is tightening, as well as how unconventional policy influences emerging market economies, both through financial sectors and through capital flows.

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