The U.S. Monetary Policy Transmission in Global Equity Markets*

Andrey Ermolov† **Lina Lu**‡ **Shaowen Luo**§

Fordham University Federal Reserve Bank of Boston Virginia Tech

November 5, 2024

Abstract

We examine the transmission mechanisms of the Federal Reserve's announcements to equity markets worldwide. We propose a model that explores the monetary policy spillover effects through central bank coordination and production networks. We estimate the model using spatial panel econometric methods with interactive fixed effects breaking down the overall impact of U.S. monetary policy shocks into four distinct components: 1) interest rate effects, 2) direct effects on domestic demand, 3) network effects through international demand, and 4) risk premium effects. Our findings highlight the significant contributions of all effects, with the risk premium and direct effects being the most important.

JEL code: C31, C33, E44, E52, F42, G12

Keywords: monetary policy transmission, international spillovers, spatial panel data model, stock market

*We would like to thank Falk Brauning, Yang Jiao, Ali Ozdagli, Matthew Pritsker, Viacheslav Sheremirov, Kwok Ping Tsang, seminar participants at Fordham, George Mason, and Michigan State Universities, and conference participants at the 2024 Chinese Economist Society and 2024 Society for Financial Econometrics Meeting for valuable feedback and suggestions. All remaining errors are our own. This paper was previously circulated under the title "The Global Effects of U.S. Monetary Policy on Equity and Bond Markets: A Simultaneous Spatial Panel Data Model Approach." The views expressed in the paper are those of the authors and should not be interpreted as reflecting the views of the Federal Reserve Bank of Boston, or any other person associated with the Federal Reserve System.

†Email: aermolov1@fordham.edu, Address: 45 Columbus Avenue, room 619, New York, NY 10023

‡Email: lina.lu@bos.frb.org, Address: 600 Atlantic Ave, Boston, MA 02210.

§Email: sluo@vt.edu, Address: 3016 Pamplin Hall, 880 West Campus Drive, Blacksburg, VA 24061

1 Introduction

U.S. monetary policy shocks have a large impact on asset prices across the world (among others, Wongswan, 2006, Wongswan, 2009, Ehrmann and Fratzscher, 2009, Ammer et al., 2010, Miranda-Agrippino and Rey, 2020). Understanding the economic channels through which these shocks propagate is crucial for both policymakers assessing the potential impact of their actions and asset managers considering the international diversification of their portfolios.

We study the transmission channels of U.S. monetary policy shocks in global equity markets, which represent the largest asset class worldwide. To motivate our empirical analysis, we introduce a model, where the real effects of the monetary policy arise through the combination of the cash-in-advance constraint, where consumers must have immediate cash to purchase goods, and the limited financial markets participation (e.g., Grossman and Weiss, 1983), which allows us to generate realistic real and nominal rate dynamics. International transmission occurs through coordinated monetary policies among central banks and production networks in which countries incorporate each other's goods into their domestic production processes.

Our model incorporates three channels through which U.S. monetary policy shocks propagate. First, there is the interest rate effect: for example, an expansionary U.S. monetary policy surprise would likely lead to a similar expansionary move by the Bank of Canada, decreasing the risk-free rate part of the interest rate by which future cash flows are discounted and, thus, increasing equity valuations. Second, there is the direct cash flow effect, where an expansionary policy by the Bank of Canada would stimulate domestic demand for Canadian goods. Third, there is the network cash flow effect. The expansionary monetary policies in other countries results in a greater demand for their local goods. Consequently, this higher demand for local goods triggers an increased demand for Canadian goods, given that Canadian products are used as intermediate inputs in the production of domestic goods in foreign markets. By solving the model, we obtain a simultaneous spatial panel data system, which we directly employ for estimation purposes. As the model is solved via log-linearization and investors exhibit risk neutrality, we assign the residual effect—once the three aforementioned effects are accounted for—to the component of the discount rate associated with the risk premium.

Empirically, we investigate spillover effects on aggregate stock market indices across 37 countries from 2007 to 2018. We utilize the methodology of Lu (2022), employing a simultaneous spatial panel data model with interactive fixed effects to decompose the impact of monetary policy shocks into three components. Long-term government bonds are used to isolate the interest rate effects. Our findings reveal that approximately 50% of the U.S. monetary policy shock impact is attributed to risk premium effects, 28% to direct effects, and 11% to each of network and interest rate effects.

Our primary contribution lies in the examination of the transmission of monetary policy shocks in global financial markets. Theoretically, our model, which utilizes segmented market participation to produce real effects of monetary policy, generates more realistic interest rate dynamics compared to existing models like di Giovanni and Hale (2022), which rely on wage rigidities to achieve similar effects.

Empirically, earlier studies (Ehrmann and Fratzscher, 2009, Wongswan, 2009, Ammer et al., 2010) primarily used single spatial regressions to assess the extent of the influence of US monetary policy on international equity markets. However, this approach lacked the ability to decompose the impact of shocks into different economic components, which is a key aspect of our study. Recently, di Giovanni and Hale (2022) studied the transmission of U.S. monetary policy shocks using a single spatial panel data model that accounts for both direct and network effects. They found that network effects play a more important role than direct effects. We build on their seminal work along two dimensions. First, the analysis of di Giovanni and Hale (2022) omits interest rate and risk premium effects, which we find statistically and economically significant. Second, their analysis may be vulnerable to omitted variable bias (something they openly acknowledge in Section IV.F of their work). While it is possible to mitigate these concerns by including control variables, it is not always clear which variables to incorporate, and many of them may be unobservable. We aim to address this problem by introducing interactive fixed effects, as suggested by Bai (2009). Interactive fixed effects represent unobservable common shocks and their heterogeneous impacts on the international cross-section of the US monetary policy shock responses. They can be correlated with the regressors and are estimated to optimally fit the unexplained common cross-sectional variation in the data. In our setting they can potentially control for unobserved variables such as the risk-aversion or other variables affecting the risk premium part of the discount rate. We find that incorporating interactive fixed effects greatly reduces the relative impact of the network effect while substantially increasing the significance of the direct effect, thereby reversing their relative importance.

Our work is also closely related to broader strands of the literature. First, we contribute to the research on the international network effects of monetary policy shocks. While studies such as Kim (2001) and Brauning and Sheremirov (2019) explore network effects of the U.S. monetary policy on real economic activities abroad, they do not study financial markets. Second, our paper is related to the literature on the channels through which monetary policy influences financial markets. Although this literature is extensive (among many others, Bernanke and Kuttner, 2005, Gurkaynak et al., 2005, Nakamura and Steinsson, 2018, Ozdagli and Weber, 2019, Nagel and Xu, 2024), it predominantly concentrates on the U.S. context alone. Finally, in terms of applied econometrics, our research introduces a novel economic application for simultaneous spatial panel data models. These models have been previously employed in urban economics (Jeanty et al., 2010, Baltagi and Bresson, 2011), health economics (Ho and Hite, 2008), economic growth (Gebremariam et al., 2011), and fiscal policy analysis (Allers and Elhorst, 2011; Hauptmeier et al., 2012).

2 Network Model

Our model comprises three essential components. First, it incorporates a network production mechanism based on Ozdagli and Weber (2019), wherein each country produces its own goods. These goods serve as intermediate inputs in the production processes of other countries, thereby generating network cash flow effects. Second, the model incorporates limited participation in the bond market by the population. This feature enables the realistic depiction of interest rate dynamics in response to monetary policy shocks. Finally, the model encompasses monetary policy coordination among countries, resulting in the generation of both direct and network cash flow effects.

2.1 Production Sector and Households

Production. There are N countries. Each country i has one firm which at time t produces good y_{it} following a Cobb-Douglas production function

$$y_{it} = l_{it}^{\varsigma_i} \left(\Pi_{k=1}^{N} x_{ikt}^{\omega_{ik}} \right)^{\tau_i},$$

where l_{it} represents labor and x_{ikt} represents the intermediate input imported from country k.[1] We assume constant returns to scale, that is, $\sum_{k=1}^{N} \omega_{ik} = 1, \forall i$.

The production is also subject to a fixed cost $\mathcal{F}_i$. Firms maximize the profit function

$$\max \pi_{it} = p_{it} y_{it} - \sum_{k=1}^{N} p_{kt} x_{ikt} - w_{it} l_{it} - \mathcal{F}_i,$$

where p_{it} represents time t product i price.[2]

Let $R_{it} = p_{it} y_{it}$ denote firm's revenue in country i. The first order conditions imply

$$\tau_i \omega_{ik} R_{it} = p_{kt} x_{ikt}, \tag{1}$$

$$\varsigma_i R_{it} = w_{it} l_{it}. \tag{2}$$

Thus, the profit function becomes

$$\pi_{it} = (1 - \tau_i - \varsigma_i) R_{it} - \mathcal{F}_i.$$

Households. Households in each country k consume the final product produced by the domestic economy. They maximize the following log-utility function

$$\max U(c_{k,t+s}) = E_t \left(\sum_{s=0}^{\infty} \delta^s \log(c_{k,t+s}) \right).$$

Assume that labor supply is fixed and equals to the population size of the country, $\bar{l}_k$.

[1]The labor component is not important in our framework and we include it solely for descriptive purposes as the only primary source of production, in line with the extant literature. Economically, this inclusion ensures that production is not perceived as originating from ”nowhere.”

Also note that the production process utilizes its own output as an input, thus creating a ”catch-22” scenario. This practice is common in theoretical network literature to simplify the model, as the same conclusions can be drawn using a model that employs inputs from previous time periods: see, among others, Carvalho (2014) or Acemoglu et al. (2016).

[2]Fixed costs do not hold significance in our scenario; however, they provide flexibility to our model. Specifically, they guarantee solutions for production functions beyond Cobb-Douglas. We also do not explicitly designate a numeraire good, but all prices can be considered as denominated in the currency of a single country, thus implicitly factoring in exchange rates.

There is a cash-in-advance constraint for consumption goods:

$$p_{kt}c_{kt} = M_{kt}, \tag{3}$$

where M_{kt} is country k time t money supply. However, intermediate inputs are paid after the production process through trade credit.

There are various channels through which monetary policy can induce real effects. In this paper, we adopt the approach of limited financial market participation, following, for instance, Grossman and Weiss (1983) or Alvarez et al. (2002). Compared to price or wage rigidities, as, e.g., in Ozdagli and Weber (2019) or di Giovanni and Hale (2022), limited market participation yields more realistic interest rate dynamics (refer to Occhino (2004) for a thorough comparison of different mechanisms).

The model distinguishes two types of households, traders and non-traders, and segments the financial market in the sense of excluding non-traders from it. The traders' share of the population is $\chi_k \in (0,1)$. The central bank conducts monetary policy through open market operations by trading quantity b_{kt} of one-period nominal bond paying one at maturity in exchange for money at the price of q_{kt}.

Households receive wage incomes, profits, and fixed-cost transfers from firms (evenly distributed across households), but they purchase goods before receiving their incomes. The budget constraint for traders is

$$M_{kt}^{trader} = M_{k,t-1}^{trader} + b_{k,t-1} + w_{kt}\bar{l}_k + \pi_{kt} + \mathcal{F}_k - p_{kt}c_{k,t}^{trader} - q_{kt}b_{kt}.$$

The cash-in-advance constraint for traders is

$$p_{kt}c_{kt}^{trader} + q_{kt}b_{k,t} = M_{kt-1}^{trader} + b_{k,t-1}.$$

To simplify the analysis, non-traders are assumed to spend their entire cash balance on consumption goods. The budget and cash-in-advance constraints for non-traders are

$$p_{kt}c_{kt}^{non-trader} = M_{k,t-1}^{non-trader};$$

$$M_{k,t-1}^{non-trader} = w_{k,t-1}\bar{l}_k + \pi_{k,t-1} + \mathcal{F}_k.$$

Open market operations can be conducted using one of the two methods, targeting either (1) the bond price q_{kt} and clearing the bond market with the equilibrium quantity of b_{kt} or (2) trade quantity b_{kt} and clearing the market with the equilibrium price q_{kt}. Either way, open market operations affect the quantity of money circulated in the economy following $b_{kt-1} - q_{kt}b_{kt} = \Delta M_{kt}$.

The optimal level of good i traders consume follows

$$c_{kt}^{trader} = \frac{w_{k,t-1}\bar{l}_k + \pi_{k,t-1} + \mathcal{F}_k + \Delta M_{kt}/\chi_k}{p_{kt}} = \frac{(1-\tau_k)R_{k,t-1} + \Delta M_{kt}/\chi_k}{p_{kt}}.$$

The optimal level of good i non-traders consume follows

$$c_{kt}^{non-trader} = \frac{w_{k,t-1}\bar{l}_k + \pi_{k,t-1} + \mathcal{F}_k}{p_{kt}} = \frac{(1-\tau_k)R_{k,t-1}}{p_{kt}}.$$

Goods market clearing condition is

$$y_{kt} = c_{kt} + \sum_i x_{ikt} \tag{4}$$

The cash-in-advance constraint for consumption goods (Equation 3) delivers $p_{kt}c_{kt} = M_{kt}$.

Thus, substituting Equation 2 into 4 gives,

$$R_{kt} = M_{kt} + \sum_i \tau_i \omega_{ik} R_{it}. \tag{5}$$

In matrix form

$$R = (I - W' D(\tau))^{-1} M, \tag{6}$$

where D denotes diagonal matrices, and W has the (i, k)th entry of ω_{ik}.

2.2 Global Monetary Policy Coordination

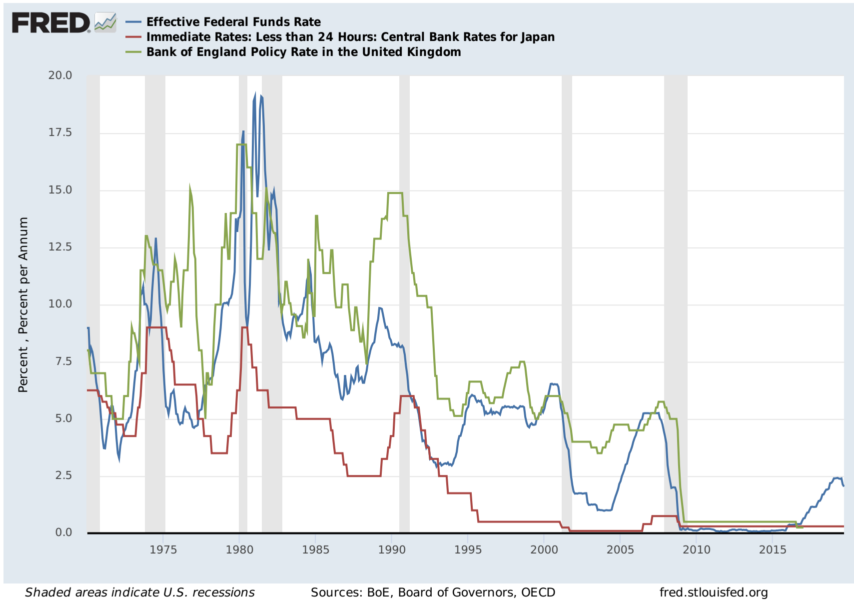
While central banks typically formulate monetary policies based on their respective domestic economic conditions, there tends to be a strong international correlation in policy rates, as illustrated, for example, in Figure 1.[3] In our theoretical framework, we explicitly account for this synchronization, but delving into its sources is beyond the scope of our study. Nonetheless, there are several plausible explanations for this behavior. For instance, in a conventional framework like Taylor (1993) rule, macroeconomic factors such as output growth and inflation tend to exhibit high cross-country correlations. Additionally, interest rate differentials among nations can result in capital outflows (as suggested by Haynes, 1988), which can motivate central bankers to broadly align their interest rate policies with those of other countries.

Assume that ΔM_{kt} follows an AR(1) process with $\Delta \hat{M}_{kt} = \theta_k \Delta \hat{M}_{k,t-1} + \epsilon_t^k$ and $\epsilon_t = \tau_u W_u' \epsilon_t + u_t$, where ϵ_t represents a vector of ϵ_t^k. Denote $\Theta_u = [I - \tau_u W_u']^{-1}$. Thus, $\epsilon_t = \Theta_u u_t$ and the vector of $\Delta \hat{M}_{kt}$ follows

$$\Delta \hat{M}_t = D(\theta) \Delta \hat{M}_{t-1} + \Theta_u u_t. \tag{7}$$

[3] See also, e.g., “Comovements in monetary policy – Revealing international correlations with FRED.” 6 June 2019, The FRED Blog, among many other references.

Figure 1: Comovements in Monetary Policy



2.3 Equity and Bond Pricing

The stochastic discount factor is the ratio of traders' marginal utilities across time periods:

$$SDF_{kt+1} = \delta \frac{c_{kt}^{trader} p_{kt}}{c_{k,t+1}^{trader} p_{k,t+1}}.$$

The bond price is an expectation of a stochastic discount factor. Given the money supply process:

$$q_{kt} = E_t(SDF_{kt+1}) = \delta \frac{M_{k,t} + (\frac{1}{\chi_k} - 1)\Delta M_{kt}}{M_{k,t} + \frac{\theta_k}{\chi_k}\Delta M_t^k}.$$

When $\chi_k < 1 - \theta_k$, a positive money supply shock increases bond price and, thus, decreases nominal interest rate.

Each country's stock market consists of that country's only firm. The market value of country i firm with profit stream $\pi_{i,t}$ is

$$V_{it} = E_t\left(\sum_{s=0}^{\infty} SDF_{i,t+s}\pi_{i,t+s}\right).$$

We can log-linearize and get

$$\hat{V}_t = S_M \hat{M}_t + S_{\Delta M} \Delta \hat{M}_t, \tag{8}$$

where

$$S_M = D((1-\delta)^{-1}\bar{V}^{-1}) D((1-\tau-\varsigma)\bar{R}) S_{RM},$$

$$S_{\Delta M} = D((1-\delta\theta)^{-1})[D(\delta\psi) + D(\delta\theta) S_M].$$

with $S_{RM} \equiv [D(\bar{R}) - W' D(\tau \bar{R})]^{-1} D(\bar{M}) \hat{M}_t$ and $D(\psi)$ denoting a diagonal matrix with diagonal element $\psi_k \equiv \frac{1-\theta_k-\chi_k}{\chi_k}$. Steady state values are labeled with bars. See Appendix A for proofs.

Thus, the immediate reaction of stock prices to a monetary policy surprise is

$$\hat{V}_t - E_{t-1}(\hat{V}_t) = (S_M + S_{\Delta M}) \Theta_u u_t \tag{9}$$

The bond price reaction is simply

$$\hat{Q}_t - E_{t-1}\hat{Q}_t = D(\psi)\Theta_u u_t. \tag{10}$$

Spatial Panel Regressions. For ease of exploration, we assume that countries are homogeneous at the steady state. This allows the reactions of asset prices to monetary policy shocks to be written in forms of spatial panel models.

If the spatial terms for trade and monetary policy coordination are the same, i.e., $W_u = W$ and $\tau = \tau_u$, then equations (9) and (10) can be written as

$$\Delta\hat{V}_t \equiv \Delta\hat{V}_t - E_{t-1}(\hat{V}_t) = \mu_1 W' \Delta\hat{V}_t + \mu_2 \Delta\hat{Q}_t + \mu_3 u_t, \tag{11}$$

$$\Delta\hat{Q}_t \equiv \hat{Q}_t - E_{t-1}\hat{Q}_t = \mu_4 W' \Delta\hat{Q}_t + \mu_5 u_t, \tag{12}$$

On the other hand, in a more general case, where $W_u \neq W$, we have

$$\Delta\hat{V}_t = \mu_1 W' \Delta\hat{V}_t + \mu_2 \Delta\hat{Q}_t + \mu_3 [I + \tau_u W_u' - \tau W'] u_t + h.o.t. \tag{13}$$

$$\Delta\hat{Q}_t = \mu_4 W_u' \Delta\hat{Q}_t + \mu_5 u_t, \tag{14}$$

where $h.o.t.$ are higher order terms. Proofs are provided in the Appendix A.

Notably, equations (11) - (14) provide spatial panel data specification for the empirical regression in the subsequent sections. Money supply shocks (u_t) have a triple impact: they directly influence equity prices ($\Delta\hat{V}_t$), operate indirectly through the network W', and through the interest rate channel $\Delta\hat{Q}_t$. Furthermore, the model suggests that changes in bond yields are unaffected by equity performance.

3 Simultaneous Spatial Panel Data Model

3.1 Simultaneous Spatial Panel Data Model Specification

In the following discussion, we describe the spatial panel data specification used to decompose the reaction of equity prices to monetary policy shocks into its direct, network, and interest rate effects. In keeping with the theoretical framework, our econometric model is given by

$$\text{Stock:} \qquad \Delta S_{it} = \rho_1 \sum_{j=1}^{N} \omega_1^{ij} \Delta S_{jt} + \gamma_1 \Delta B_{it} + \beta_1 \nu_t + \lambda_i' f_t + \alpha_{1i} + \epsilon_{1it}, \tag{15}$$

$$\text{Bond:} \qquad \Delta B_{it} = \rho_2 \sum_{j=1}^{N} \omega_2^{ij} \Delta B_{jt} + \gamma_2 \Delta S_{it} + \beta_2 \nu_t + \phi_i' f_t + \alpha_{2i} + \epsilon_{2it}, \tag{16}$$

where ν_t is the monetary policy shock.[4] ΔS_{it} is the change in the local equity index of country i. ΔB_{it} is the yield change in country i's government bonds. The first term on the right hand side of both (15) and (16) captures the network effect, where W_k $(k = 1, 2)$ represents the pre-specified weighting matrix, the (i, j)th entry of which is w_k^{ij} and a measure of the strength of the link between countries i and j. The spatial parameter ρ_1 (and ρ_2) measures the interconnectedness in the global economic network, the magnitude of which indicates the average strength of network effects. The second term (γ_1) captures the interest rate effect of monetary policy shocks on equity prices. The fourth term is the so-called interactive fixed effect, which is a generalized version of additive fixed effects that can control for potential cross-sectional correlations as well as unobserved heterogeneity (e.g, Pesaran, 2006, Bai, 2009, Bai and Li, 2014, Ando and Bai, 2015, Ando and Bai, 2016, or Li et al., 2020). Specifically, f_t is an r-dimensional vector of common shocks, termed the common factor, which can affect all countries simultaneously; λ_i and ϕ_i are the corresponding r-dimensional vectors of unobservable heterogeneous responses to the common shocks, termed the factor loadings; the number of common factor r could be larger than one when multiple common factors appear. α_1 and α_2 represent country fixed effects. Finally, the error terms ϵ_{1it} and ϵ_{2it} are assumed following $\epsilon_{1it} \sim (0, \sigma_{1i}^2)$ (mean zero and variance σ_{1i}^2) and $\epsilon_{2it} \sim (0, \sigma_{2i}^2)$. As in the real world, where the volatility of the equity or bond markets varies from country to country.

Model (15) and (16) can be rewritten into a matrix form

$$\Delta S_t = \rho_1 W_1 \Delta S_t + \gamma_1 \Delta B_t + \beta_1 \mathbf{1}_N \nu_t + \Lambda f_t + \alpha_1 + \epsilon_{1t}, \tag{17}$$

$$\Delta B_t = \rho_2 W_2 \Delta B_t + \gamma_2 \Delta S_t + \beta_2 \mathbf{1}_N \nu_t + \Phi f_t + \alpha_2 + \epsilon_{2t}, \tag{18}$$

[4] Our spatial panel data model contains no dynamic features, because the analysis is an event study which focuses on a tight-window reaction around the FOMC announcements. The FOMC only schedules eight meetings per year, one about every six weeks. Thus, adding the dynamic feature may complicates our analysis unnecessarily.

where $\Delta S_t = (\Delta S_{1t}, \Delta S_{2t}, \cdots, \Delta S_{Nt})'$, $\Lambda = (\lambda_1, \lambda_2, \cdots, \lambda_N)'$, $\alpha_1 = (\alpha_{11}, \alpha_{12}, \cdots, \alpha_{1N})'$, and $\epsilon_{1t} = (\epsilon_{11t}, \epsilon_{12t}, \cdots, \epsilon_{1Nt})'$; $\Delta B_t, \Phi, \alpha_2$, and ϵ_{2t} are defined similarly. Finally, $\mathbf{1}_N$ is an $N \times 1$ vector of ones.

Given the observations of ΔS_{it} and ΔB_{it}, ν_t and the pre-specified weights W_1 and W_2, we use a quasi-maximum likelihood estimation approach to estimate parameters $(\rho_1, \rho_2, \gamma_1, \gamma_2, \beta_1, \beta_2)$, the factors (f_t) and loadings (λ_i, ϕ_i), and the variances of the error terms $(\sigma_{1i}^2, \sigma_{2i}^2)$, with $i \in \{1, \cdots N\}$, following Lu (2022), see Appendix B for details.

3.2 Effect Decomposition

Having estimated the model, we further develop an approach to decompose the total monetary policy shock effect into direct, network, and interest rate effects. Lu (2022) proposes the estimation method, but not an effect decomposition method, which we develop here.

3.2.1 The Direct and Network Effects

Equations (17) and (18) can be rewritten as

$$\Delta S_t = \beta_1 \Theta_1 \mathbf{1}_N \nu_t + \gamma_1 \Theta_1 \Delta B_t + \Theta_1 \Lambda f_t + \Theta_1 \alpha_1 + \Theta_1 \epsilon_{1t}, \tag{19}$$

$$\Delta B_t = \beta_2 \Theta_2 \mathbf{1}_N \nu_t + \gamma_2 \Theta_2 \Delta S_t + \Theta_2 \Phi f_t + \Theta_2 \alpha_2 + \Theta_2 \epsilon_{2t}, \tag{20}$$

where

$$\Theta_1 \equiv (I - \rho_1 W_1)^{-1} = I + \rho_1 W_1 + (\rho_1 W_1)^2 + \cdots, \tag{21}$$

$$\Theta_2 \equiv (I - \rho_2 W_2)^{-1} = I + \rho_2 W_2 + (\rho_2 W_2)^2 + \cdots, \tag{22}$$

where I is an $N \times N$ identity matrix. The first term on the right hand side of equation (19), $\beta_1 \Theta_1 \mathbf{1}_N \nu_t$, represents the direct and network effects. The second term, $\gamma_1 \Theta_1 \Delta B_t$, represents the interest rate effect in the equity regression. We can further decompose the first term into the direct effect and the network effect separately based on partial derivatives, following Pace and LeSage (2014). The direct effect is captured by the diagonal elements of the matrix $\beta_i \Theta_i$, which estimates the response of returns to shocks initiated in the same country. The network effect is captured by the off-diagonal elements of the matrix $\beta_i \Theta_i$, which captures the spillovers through global economic networks.

Consider a two-country example. The reaction of stock prices follows

$$\begin{aligned}\begin{pmatrix} \Delta S_{1t} \\ \Delta S_{2t} \end{pmatrix} &= \beta_1 \begin{pmatrix} \Theta_1^{11} & \Theta_1^{12} \\ \Theta_1^{21} & \Theta_1^{22} \end{pmatrix} \begin{pmatrix} \nu_t \\ \nu_t \end{pmatrix} + \text{ other terms} \\ &= \underbrace{\beta_1 \begin{pmatrix} \Theta_1^{11} & 0 \\ 0 & \Theta_1^{22} \end{pmatrix} \begin{pmatrix} \nu_t \\ \nu_t \end{pmatrix}}_{direct} + \underbrace{\beta_1 \begin{pmatrix} 0 & \Theta_1^{12} \\ \Theta_1^{21} & 0 \end{pmatrix} \begin{pmatrix} \nu_t \\ \nu_t \end{pmatrix}}_{network} + \text{ other terms} \end{aligned} \tag{23}$$

where ΔS_{kt} denotes Country k's stock return ($k = 1, 2$); Θ_1^{ij} denotes the (i, j)th entry of matrix Θ_1. Other terms in Equation (23) include terms independent of the shock ν_t and terms controlling for the interest rate effects. Thus, the reaction of stock price of country 1 is

$$\Delta S_{1t} = \underbrace{\beta_1 \Theta_1^{11} \nu_t}_{direct} + \underbrace{\beta_1 \Theta_1^{12} \nu_t}_{network} + \text{ other terms.} \tag{24}$$

$\beta_1 \Theta_1^{11}$ captures the direct reaction of stock price of country 1 to the monetary policy shock. The effect is direct in the sense that it reflects the reactions of stock returns to shocks initiated in the same country.

$\beta_1 \Theta_1^{12}$ measures the reaction of stock price of country 1 to the monetary shock through the network structure. The network effect includes the reactions of country 1 to shocks initiated in country 2, captured by $\beta_1 \Theta_1^{12} = \beta_1[\rho_1 W_1 + (\rho_1 W_1)^2 + \cdots]^{12}$. The first two terms of this expression can be explained as follows. If, for example, a monetary policy expansion in country 2 increases the demand for goods there, the first order effect captures its need for more intermediate inputs from country 1, estimated by $\beta_1 \rho_1 W_1^{12}$. The higher-order spillover effects include, in addition, the reaction of country 1 to the increased demand from country 2 that has been triggered by country 1's first-order reaction, captured by $\beta_1[(\rho_1 W_1)^2]^{12}$.[5]

3.2.2 The Total and Interest Rate Effects

We can rewrite Equations (17) and (18) as

$$\begin{aligned} \Delta S_t &= \Xi_1 \left[\beta_1 \Theta_1 + \beta_2 \gamma_1 \Theta_1 \Theta_2\right] \mathbf{1}_N \nu_t + \Xi_1 [\Theta_1 \Lambda + \gamma_1 \Theta_1 \Theta_2 \Phi] f_t \\ & + \Xi_1 \Theta_1 \alpha_1 + \gamma_1 \Xi_1 \Theta_1 \Theta_2 \alpha_2 + \Xi_1 \Theta_1 \epsilon_{1t} + \gamma_1 \Theta_1 \Theta_2 \Xi_1 \epsilon_{2t}, \end{aligned} \tag{25}$$

$$\begin{aligned} \Delta B_t &= \Xi_2 \left[\beta_2 \Theta_2 + \beta_1 \gamma_2 \Theta_2 \Theta_1\right] \mathbf{1}_N \nu_t + \Xi_2 [\Theta_2 \Phi + \gamma_2 \Theta_2 \Theta_1 \Lambda] f_t \\ & + \Xi_2 \Theta_2 \alpha_2 + \gamma_2 \Xi_2 \Theta_2 \Theta_1 \alpha_1 + \Xi_2 \Theta_2 \epsilon_{2t} + \gamma_2 \Xi_2 \Theta_2 \Theta_1 \epsilon_{1t}, \end{aligned} \tag{26}$$

where Θ_1 and Θ_2 are defined in equations (19) and (20); and

$$\Xi_1 \equiv [I - \gamma_1 \gamma_2 \Theta_1 \Theta_2]^{-1} = I + \gamma_1 \gamma_2 \Theta_1 \Theta_2 + (\gamma_1 \gamma_2 \Theta_1 \Theta_2)^2 + \cdots \tag{27}$$

[5] While our approach of the direct and network effect decomposition is based on Pace and LeSage (2014), there is an alternative decomposition approach based on Acemoglu et al. (2016). The approach of Acemoglu et al. (2016) implies the direct effect can be captured by $\beta_i I$ and the higher-order network effect captured by $\beta_i(\rho_1 \Omega_1 + \rho_1^2 \Omega_1^2 + \cdots)$. The direct effect estimates the direct response to the shock, whereas the network effect contains all the higher-order terms. Thus, the network effect captures the spillovers through global economic networks, whereas the direct effect is independent of the network structure. Thus, in the two-country example, β_1 captures the direct effect, and $[(\Theta_1^{11} - 1) + \Theta_1^{12}]\beta_1$ captures the network effect. In our empirical estimation, we find that the two approaches yield similar decomposition results. Thus, we report only the results of decomposition following Pace and LeSage (2014).

$$\Xi_2 \equiv [I - \gamma_2\gamma_1\Theta_2\Theta_1]^{-1} = I + \gamma_2\gamma_1\Theta_2\Theta_1 + (\gamma_2\gamma_1\Theta_2\Theta_1)^2 + \cdots . \tag{28}$$

The first terms on the right hand side of Equations (25) and (26) capture the total effect. The total effect includes both the direct and network effects captured by $\beta_i\Theta_i$, $i \in \{1, 2\}$, as well as the interest rate effect.

The following expression of the total effect presents the direct, network and interest rate effects separately:

$$\Delta_S = \underbrace{\beta_1 diag(\Theta_1)}_{\text{direct}} + \underbrace{\beta_1(\Theta_1 - diag(\Theta_1))}_{\text{network}} + \underbrace{\Xi_1[\beta_1\Theta_1 + \beta_2\gamma_1\Theta_1\Theta_2] - \beta_1\Theta_1}_{\text{interest rate}},$$

$$\Delta_B = \underbrace{\beta_2 diag(\Theta_2)}_{\text{direct}} + \underbrace{\beta_2(\Theta_2 - diag(\Theta_2))}_{\text{network}} + \underbrace{\Xi_2\left[\beta_2\Theta_2 + \beta_1\gamma_2\Theta_2\Theta_1\right] - \beta_2\Theta_2}_{\text{interest rate}},$$

where $diag()$ extracts the diagonal of the matrix in the parenthesis. We summarize and present the equations for the effect decomposition in Table 1.

Table 1: Effects Decomposition

	Stock	Bond
	(a) Effects	
Total	$\Delta_S \equiv \Xi_1\left[\beta_1\Theta_1 + \beta_2\gamma_1\Theta_1\Theta_2\right]$	$\Delta_B \equiv \Xi_2\left[\beta_2\Theta_2 + \beta_1\gamma_2\Theta_2\Theta_1\right]$
Direct	$D_S \equiv \beta_1 diag(\Theta_1)$	$D_B \equiv \beta_2 diag(\Theta_2)$
Network	$N_S \equiv \beta_1(\Theta_1 - diag(\Theta_1))$	$N_B \equiv \beta_2(\Theta_2 - diag(\Theta_2))$
Interest rate	$S_S \equiv \Delta_S - \Theta_1\beta_1$	$S_B \equiv \Delta_B - \Theta_2\beta_2$
	(b) Average effects	
Average total	$\bar{\Delta}_S \equiv \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{N}\Delta_S^{ij}$	$\bar{\Delta}_B \equiv \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{N}\Delta_B^{ij}$
Average direct	$\bar{D}_S \equiv \frac{1}{N}\sum_{i=1}^{N}D_S^{ii}$	$\bar{D}_B \equiv \frac{1}{N}\sum_{i=1}^{N}D_B^{ii}$
Average network	$\bar{N}_S \equiv \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{N}N_S^{ij}$	$\bar{N}_B \equiv \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{N}N_B^{ij}$
Average interest rate	$\bar{\Delta}_S - \bar{D}_S - \bar{N}_S$	$\bar{\Delta}_B - \bar{D}_B - \bar{N}_B$

Notes: The average total, direct, network and interest rate effects, are defined as the sum of all elements in the corresponding effect matrix then divided by the number of countries in the sample. A^{ij} represents the (i, j)th element of matrix A.

Consider the previous two-country example. The reaction of stock price can be written as

$$\begin{pmatrix} \Delta S_{1t} \\ \Delta S_{2t} \end{pmatrix} = \underbrace{\beta_1 \begin{pmatrix} \Theta_1^{11} & 0 \\ 0 & \Theta_1^{22} \end{pmatrix} \begin{pmatrix} \nu_t \\ \nu_t \end{pmatrix}}_{\text{direct}} + \underbrace{\beta_1 \begin{pmatrix} 0 & \Theta_1^{12} \\ \Theta_1^{21} & 0 \end{pmatrix} \begin{pmatrix} \nu_t \\ \nu_t \end{pmatrix}}_{\text{network}} + \underbrace{\mathcal{S} \begin{pmatrix} \nu_t \\ \nu_t \end{pmatrix}}_{\text{interest rate}} + \text{other terms}, \quad (29)$$

with

$$\mathcal{S} = \begin{pmatrix} \Xi_1^{11} & \Xi_1^{12} \\ \Xi_1^{21} & \Xi_1^{22} \end{pmatrix} \left[\beta_1 \begin{pmatrix} \Theta_1^{11} & \Theta_1^{12} \\ \Theta_1^{21} & \Theta_1^{22} \end{pmatrix} + \beta_2\gamma_1 \begin{pmatrix} \Theta_1^{11} & \Theta_1^{12} \\ \Theta_1^{21} & \Theta_1^{22} \end{pmatrix} \begin{pmatrix} \Theta_2^{11} & \Theta_2^{12} \\ \Theta_2^{21} & \Theta_2^{22} \end{pmatrix} \right] - \beta_1 \begin{pmatrix} \Theta_1^{11} & \Theta_1^{12} \\ \Theta_1^{21} & \Theta_1^{22} \end{pmatrix}$$

Other terms in equation (29) include terms independent of the shock ν_t. The interest rate effect captures that the stock prices respond to ν_t shocks through the reactions of bond yields. For example, the reaction of B_1 to monetary policy shock ν_t in Country 1 affects S_1 through $\beta_2\gamma_1$.

3.2.3 Average Effects

Finally, we define four scalars to measure the average total, direct, network and interest rate effects, which are defined as the sum of all elements in the corresponding effect matrix then divided by the number of countries in the sample. Mathematical details are presented in Panel (b) of Table 1. In our empirical analysis, we report the average effects both in levels and in percentage of the total effect.

4 Data

Monetary Policy Shock. Following Nakamura and Steinsson (2018), we use tick-by-tick data for federal funds futures and eurodollar futures, obtained from the Chicago Mercantile Exchange Group, to construct the U.S. monetary policy shock. In particular, we construct the monetary policy shock ν_t as the first principal component of the change in five expected interest rates including the federal funds rate and the eurodollar rates at various horizons.[6] We calculate the implied interest rate difference between the last trade that occurred more than 10 minutes before and the first trade that occurred more than 20 minutes after the FOMC announcement. We obtain the dates and times of the FOMC meetings up to 2014 from Gurkaynak et al. (2005) and Nakamura and Steinsson (2018) and the information about the remaining FOMC meetings from the Federal Reserve Board's website.[7] The shock ν_t is scaled such that its effect on the one-year Treasury yield is 100 basis points.[8] The advantage of using this approach to construct monetary policy shocks is that it extracts variations in both short and longer-term yields. Our baseline sample contains 87 observations of monetary policy shocks for the period from 2007/6/28 - 2018/3/21. The sample is determined by the availability of the network and asset pricing data, as we will discuss next. Figure 2 plots the constructed monetary policy surprises with the sample used in our benchmark analysis colored in dark blue. Although our sample is somewhat constrained by data availability, our monetary policy shocks closely resemble those that occurred in the late 1990s and early 2000s.

Equity Price and Bond Yield. The responses of the local stock market indexes and government sovereign bond yields to the U.S. monetary announcements are constructed using daily data obtained from Bloomberg.[9] Specifically, we measure the percentage changes in stock market indexes and the yield changes in sovereign bonds before and after the U.S. FOMC meetings.

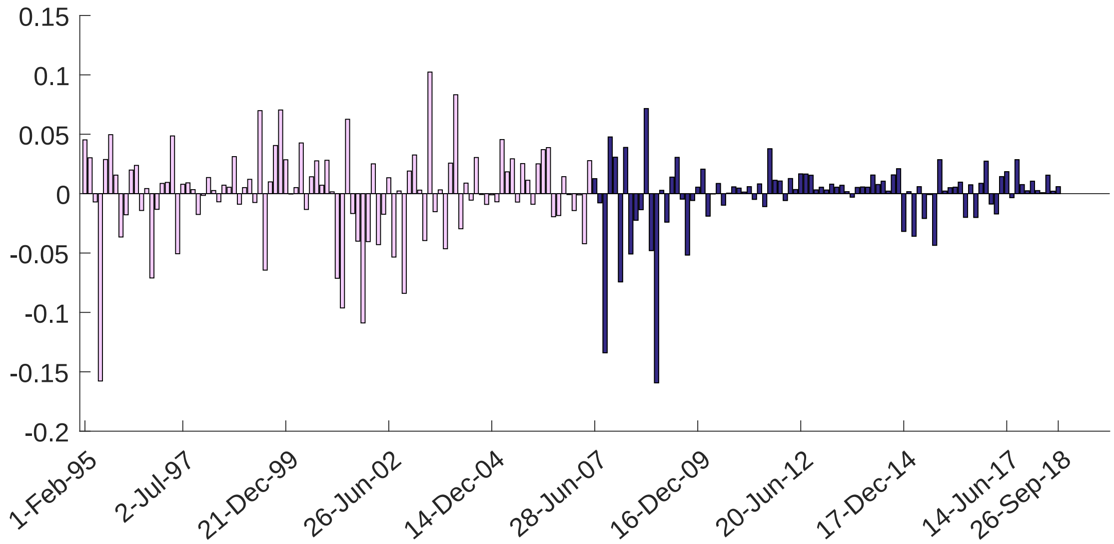
[6]The variables include the change in the expected federal funds rate over the remainder of the month in which the FOMC meeting occurred and at the time of the next scheduled meeting and the change in the expected eurodollar rates at the horizons of two, three, and four quarters in the future. The construction method follows that of Nakamura and Steinsson (2018).

[7]FOMC meeting information website: http://www.federalreserve.gov/monetarypolicy/fomccalendars.htm

[8]In the rest of the paper, we will refer to monetary policy shocks by the number of basis points they affect the one-year Treasury yield. For example, a monetary policy shock that impacts the one-year treasury yield by 10 basis points will be labeled as a 10 basis point monetary policy shock.

[9]We use a daily window to construct asset price responses instead of a 30-minutes window, due to data availability.

Figure 2: Monetary Policy Surprises



Our primary results are based on 10-year government bonds. This choice is influenced by Weber (2018), who estimated that the average equity cash flow duration in the US is 18.77 years. The 10-year maturity aligns closely with the availability of liquid bonds across all countries, as 20-year bonds are only accessible in select countries and often less liquid. Nevertheless, in Section 5.3 (Table 4), we provide additional robustness checks with varying bond maturity choices. In theory, we could include multiple bond maturities in our empirical specification, but this would further complicate an already intricate numerical optimization problem.

Global Network. The international topology can be approximated in various ways. We use trade flows to construct the spatial matrix W_1. The IMF Direction of Trade Statistics (DOTS) provides the value of merchandise exports and imports on bilateral level for the construction of the trade network. We use capital flows to approximate W_2. The IMF Coordinated Portfolio Investment Survey (CPIS) provides information on the amount of assets issued by all partner countries that was held by each of the countries participating in the survey. The data includes cross-border portfolio investment holdings of equity securities, long-term debt securities, and short-term debt securities listed by country of the issuer's residence. The economic concept behind this measure is that when countries are more financially interconnected, their central banks must coordinate their monetary policies more closely. Without such coordination, capital outflows are more likely to occur. As this choice is less obvious than for W_1, we provide robustness checks with alternative W_2 matrices.

Based on the theoretical results discussed in Section 2, the weighting matrix can be approximated using column-normalized DOTS data, with the ij-th entry measuring the exports of Country i to Country j, or using column-normalized CPIS data, with the ij-th entry measuring Country j's holding of Country i's asset. To abstract from the effect of stock and bond markets on the global topology, we fix the weighting matrices at their 2006 values, i.e., one year before the beginning of our sample period. We also perform robustness checks using alternative weighting matrices based on 2019 values, which is one year after our sample ended.

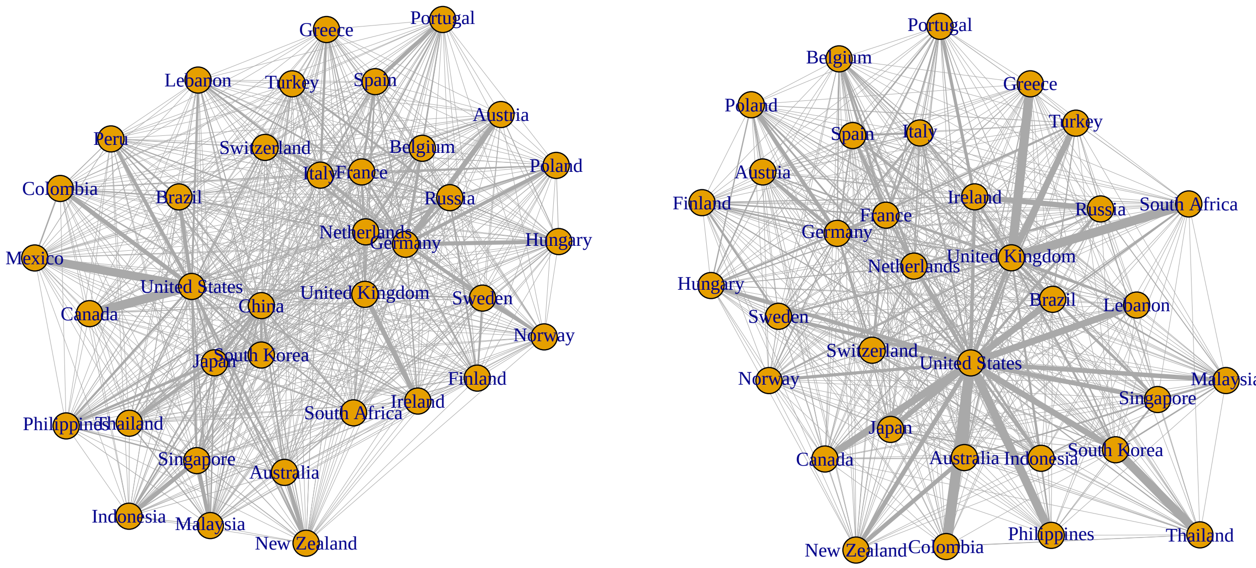
Figure 3 illustrates the weighting matrices. Our sample contains 37 countries with asset prices and network data 2007-2018.

5 Empirical Findings

We begin by presenting initial evidence from a basic panel dataset, which confirms the results found in existing literature. Building upon that, we move on to report our primary findings using a simultaneous spatial panel data model.

Figure 3: Global Network

(a) Trade Network (b) Finance Network



Note: This figure visualizes the trade and finance networks for our sample of 37 countries in 2006. The line width indicates the relative size of flows between each pair of countries.

5.1 Panel Data Model

We first study the total effect of monetary policy shocks on international equity markets using the following OLS panel data regression:

$$\Delta S_{it} = \beta_1 \nu_t + \alpha_{1i} + \epsilon_{1it}, \tag{30}$$

Table 2 reports the results. Clearly, a positive federal funds rate shock generates significant negative effects on stock returns. A policy shock of 10 basis points would, on average, decrease stock indexes by 1.1 percent. This magnitude is consistent with extant literature (e.g., Ehrmann and Fratzscher, 2009, or Ammer et al., 2010).

Table 2: Panel Data Regression Results

β_1	-11.5459***
	(0.8491)
Country Fixed Effects	Yes
R^2	0.0555
Observations	3182

Note: OLS standard errors are in parentheses. The asterisks, ***, indicate the statistical significance at the 1% level.

5.2 Simultaneous Spatial Panel Data Model

In this section, we provide the main empirical results by running simultaneous spatial panel regressions based on the implied theoretical framework in equations (15) and (16), which we reproduce for the reader's convenience below

$$\text{Stock:} \qquad \Delta S_{it} = \rho_1 \sum_{j=1}^{N} \omega_1^{ij} \Delta S_{jt} + \gamma_1 \Delta B_{it} + \beta_1 \nu_t + \lambda_i^{'} f_t + \alpha_{1i} + \epsilon_{1it},$$

$$\text{Bond:} \qquad \Delta B_{it} = \rho_2 \sum_{j=1}^{N} \omega_2^{ij} \Delta B_{jt} + \gamma_2 \Delta S_{it} + \beta_2 \nu_t + \phi_i^{'} f_t + \alpha_{2i} + \epsilon_{2it}.$$

In our main analysis, we employ two different weighting matrices: the trade network matrix for stocks and the financial network matrix for bonds. This choice stems from our theoretical framework, which suggests that stock markets are primarily interconnected through trade, whereas bond markets are primarily linked through financial channels. Given our primary focus on equity markets, we relegate the bond results to the Appendix (Table 6).

Table 3 presents our results. Following the approach of di Giovanni and Hale (2022), we initially begin with specification 1 (presented in column 1), which includes only country fixed effects. Notably, we introduce the interest rate effect in our analysis, which proves to be both statistically significant (Panel B) and economically substantial (Panel C), accounting for approximately 30%

of the impact of monetary policy shocks. The economic magnitude of the interest rate effect - a roughly 0.16% stock price drop after a 10 basis points monetary policy shock - falls in between estimates of Bernanke and Kuttner (2005) and Nagel and Xu (2024) for the US. Most importantly, our primary conclusion aligns very closely with di Giovanni and Hale (2022): the network effect is dominant and its magnitude is approximately twice the magnitude of the direct effect.

Table 3: Stock Response to Monetary Policy Shocks - Simultaneous Spatial Panel Model Approach

	(1)	(2)
W_1	Trade	Trade
W_2	Financial	Financial
	Panel A. Point Estimates	
β_1	-1.8707***	-2.1870***
	(0.6372)	(0.7454)
ρ_1	0.6021***	0.2953***
	(0.0220)	(0.0422)
γ_1	-2.2029***	-2.5975***
	(0.2625)	(0.2656)
Country FE	Yes	Yes
Interactive FE	No	Yes
R2	0.2617	0.5208
Adj R2	0.0565	0.2315
Observations	2752	2752
	Panel B. Effect Decomposition	
Total Effect	-6.7571***	-4.6686***
	(1.3778)	(0.9186)
Direct Effect	-1.8707***	-2.2033***
	(0.6610)	(0.7473)
Network Effect	-2.8313***	-0.9003***
	(0.8419)	(0.2270)
Interest Rate Effect	-2.0552***	-1.5651***
	(0.3394)	(0.2013)
	Effect Decomposition in percentages	
Direct Effect	27.68%	47.19%
Network Effect	41.90%	19.28%
Interest Rate Effect	30.42%	33.53%

Note: Bootstrap standard errors computed from 1,000 bootstrap runs are in parentheses. The asterisks, ***, correspond to statistical significance at the 1 percent level.

Moving on to specification 2 (presented in column 2), we introduce interactive fixed effects into our analysis. These effects account for unobserved common shocks that may affect equity markets differently in various countries. To justify this choice, we first conduct a test for the joint significance of interactive fixed effects versus country fixed effects alone, following Bai (2009). We find that interactive fixed effects (both the loadings and the unobserved factor itself) are jointly strongly statistically significant with the p-value of less than 1%. The methodology of Bai (2009) also indicates that the optimal number of interactive fixed effects is one.

With the significance of interactive fixed effects established, the results in specification 2 diverge substantially from those in specification 1. The direct effect now emerges as the clear dominant factor, accounting for 47% of the overall impact, while the network effect and interest rate effect contribute around 19% and 34%, respectively.

Note that Table 3 is aligned with our theoretical framework, encompassing only direct, network, and interest rate effects. However, as outlined in Section 2.3, the model is solved using log-linearization, thereby excluding the risk premium component.[10] We can estimate the risk premium component by comparing the total effect of the monetary policy shock in Table 2 with the combined effect of the three aforementioned effects in Table 3: 11.5459 - 4.6686 = 6.8773 (equivalent to approximately a 0.69% impact on the stock market for a 10 basis points monetary policy shock), or 59% of the monetary policy shock total impact in percentage terms. It is important to recognize that these calculations are approximations, because solving the model exactly would introduce nonlinear terms. These terms could impact both the overall magnitude of the effect and, by covarying with other terms, the relative contributions of different components. However, as we use interactive fixed effects and the optimal model specification identifies only one unobserved

[10] Although these mechanisms are absent in our model, theoretically, monetary policy shock can affect the risk premium, for instance, by impacting risk aversion (e.g., Campbell et al., 2014) or uncertainty regarding macroeconomic fundamentals (e.g., Song, 2017).

interactive fixed effect, the economic significance of these terms should be rather limited. Thus, the overall decomposition suggested by our analysis indicates that 59% of the monetary policy shock equity impact is attributed to the risk premium effect, $\frac{2.2033}{11.5459} = 19\%$ to the direct effect, $\frac{1.5651}{11.5459} = 14\%$ to the interest rate effect, and $\frac{0.9003}{11.5459} = 8\%$ to the network effect.

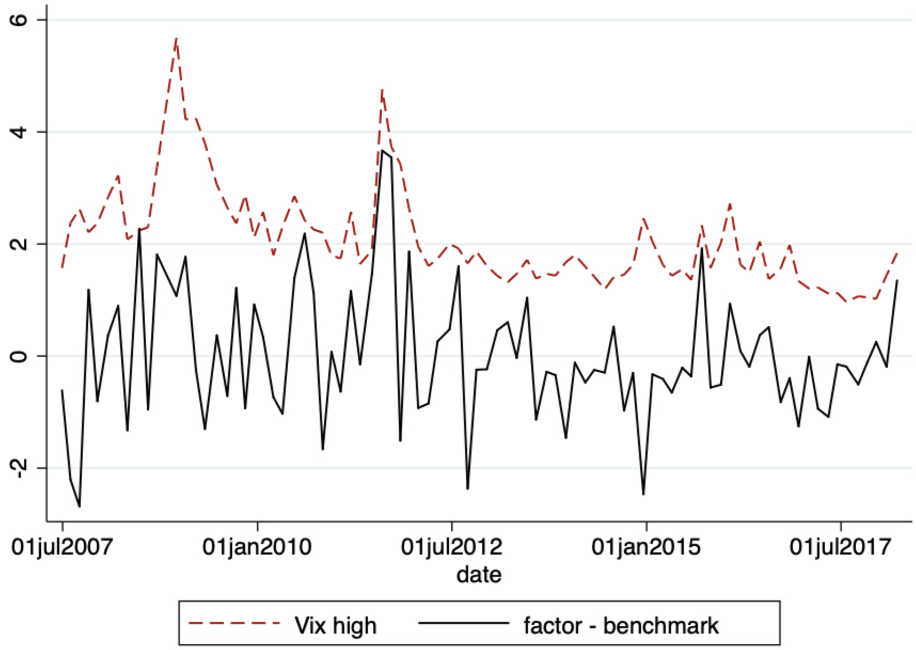
Given the crucial role of interactive fixed effects in our findings, it becomes pertinent to explore the nature of unobserved common shocks in equity markets. Our maximum likelihood methodology allows us to estimate a common shock, which is depicted in Figure 4. While a comprehensive examination of the nature of this shock is beyond the scope of our study, we anticipate it to be linked to the equity premium, a component absent from both our theoretical framework and empirical analysis. Although measuring the conditional equity premium is notably challenging, Goyal et al. (2024) have demonstrated that the Chicago Board Options Exchange volatility index (VIX) and its variants serve as effective proxies within our dataset.[11] Figure 4 depicts a significant correlation between our interactive fixed effect and the VIX, with a correlation coefficient of 0.36, statistically significant at the 1% level.

5.3 Robustness Checks

In this subsection, we present several alternative estimates as robustness checks. First, we decompose the three effects of monetary policy shocks on equity prices by examining the responses of bond yields at different maturities. Table 4 displays the stock responses obtained from the simultaneous spatial panel model, where different bond maturities are utilized to account for the interest rate effect. The complete results can be found in Appendix C Table 7. Statistically, the interest rate

[11] There is also a substantial body of theoretical literature that connects VIX and the equity premium. Notable contributions include works by Bollerslev et al. (2009), Drechsler and Yaron (2011), and Bekaert et al. (2023), among others.

Figure 4: Common Factor and 0.1*VIX Index



Note: VIX is scaled by 1/10. Source: Chicago Board Options Exchange.

effect exhibits a slight downward trend across bond maturities, although its economic magnitude stays very similar.

Second, while we focus on the trade (financial) network as the primary measure of the equity (bond) market connection, we conduct analyses using different weighting matrices to explore the robustness of our findings. Specifically, we explore alternative approaches by using the trade network as a weighting matrix for both the equity and bond markets, and by applying networks from a different year - 2019, one year after the end of our sample - versus 2006, one year before the start of our sample in our baseline analysis.

Table 5 displays the stock responses obtained from the simultaneous spatial panel model under different weighting matrices. The complete results can be found in Appendix C Table 8. Column (2) shows that the findings on the relative magnitude of the effects are generally consistent with the benchmark specification when the trade network is used to construct both W_1 and W_2. There are, however, some differences worth discussing. For instance, the combined effect of three effects explicitly present in the model is now higher: 6.9769 in specification 2 versus 4.6686 in the benchmark specification, reducing the relative contribution of the residual risk premium effect to approximately $\frac{11.5459-6.9769}{11.5459} = 39.57\%$. Thus, the risk premium effect contribution in this specification becomes essentially equal to that of the direct effect ($\frac{4.2969}{11.5459} = 37.21\%$). The contributions of the interest rate effect and the network effect are now $\frac{1.1416}{11.5459} = 9.89\%$ and $\frac{1.5384}{11.5459} = 13.32\%$, respectively. Column (3) of Table 5 shows that the results are unaffected by spatial matrices being constructed in 2019 versus 2006.

6 Conclusion

We examine how U.S. monetary policy shocks affect international stock markets, making two contributions. First, in addition to the direct effects on domestic demand and the network effects on international demand explored in existing research, we also estimate the interest rate and risk premium effects, which we find to be economically substantial and statistically significant. Second, we demonstrate that incorporating interactive fixed effects into our empirical analysis significantly amplifies the importance of direct effects compared to network effects.

Our findings open up several avenues for future research. For instance, the insights gained on the international transmission channels can be used in normative research on optimal monetary policy in an open economy. Additionally, our framework can be applied to study other asset classes.

Table 4: Stock Response to Monetary Policy Shocks - Various Bond Maturities

	(1)	(2)	(3)
W_1	Trade	Trade	Trade
W_2	Financial	Financial	Financial
Bond maturity	5-yr	10-yr	30-yr
β_1	-1.7838**	-2.1870***	-0.5845
	(0.8365)	(0.7454)	(1.0025)
ρ_1	0.3221***	0.2953***	0.3935***
	(0.0483)	(0.0422)	(0.0470)
γ_1	-2.0486***	-2.5975***	-0.5353***
	(0.2127)	(0.2656)	(0.1409)
Country FE	Yes	Yes	Yes
Interactive FE	Yes	Yes	Yes
R2	0.5199	0.5208	0.5269
Adj R2	0.2332	0.2315	0.2382
Observations	3128	2752	2610
	Panel B. Effect Decomposition		
Total Effect	-4.2759***	-4.6686***	-1.4281
	(1.0857)	(0.9186)	(1.4414)
Direct Effect	-1.7987**	-2.2033***	-0.5938
	(0.8395)	(0.7473)	(1.0124)
Network Effect	-0.8326***	-0.9003***	-0.3699
	(0.3021)	(0.2270)	(0.4752)
Interest Rate Effect	-1.6446***	-1.5651***	-0.4644***
	(0.1833)	(0.2013)	(0.1070)
	Panel C. Effect Decomposition in Percentages		
Direct Effect	42.07%	47.19%	41.58%
Network Effect	19.47%	19.28%	25.90%
Interest Rate Effect	38.46%	33.53%	32.52%

Note: This table reports results of stock market responses using simultaneous spatial panel data regressions. Bootstrap standard errors computed from 1,000 bootstrap runs are in parentheses. The asterisks, ** and ***, correspond to statistical significance at the 5 and 1 percent levels, respectively.

Table 5: Stock Response to Monetary Policy Shocks - Various Spatial Matrices

	(1)	(2)	(3)
W_1	Trade	Trade	Trade 2019
W_2	Financial	Trade	Financial 2019
	Panel A. Point Estimates		
β_1	-2.1870***	-4.2735***	-2.3941**
	(0.7454)	(0.7676)	(0.9902)
ρ_1	0.2953***	0.2676***	0.3203***
	(0.0422)	(0.0362)	(0.0430)
γ_1	-2.5975***	-2.4514***	-2.6278***
	(0.2656)	(0.2390)	(0.3076)
Country FE	Yes	Yes	Yes
Interactive FE	Yes	Yes	Yes
R2	0.5208	0.4994	0.5174
Adj R2	0.2315	0.2098	0.2279
Observations	2752	3010	2752
	Panel B. Effect Decomposition		
Total Effect	-4.6686***	-6.9769***	-5.2907***
	(0.9186)	(0.9687)	(1.1396)
Direct Effect	-2.2033***	-4.2969***	-2.4142**
	(0.7473)	(0.7699)	(0.9928)
Network Effect	-0.9003***	-1.5384***	-1.1079***
	(0.2270)	(0.3367)	(0.3066)
Interest Rate Effect	-1.5651***	-1.1416***	-1.7686***
	(0.2013)	(0.1436)	(0.2282)
	Panel C. Effect Decomposition in Percentages		
Direct Effect	47.19%	61.59%	45.63%
Network Effect	19.28%	22.05%	20.94%
Interest Rate Effect	33.53%	16.36%	33.42%

Note: Bootstrap standard errors computed from 1,000 bootstrap runs are in parentheses. The asterisks, ** and ***, correspond to statistical significance at the 5 and 1 percent levels, respectively.

References

Acemoglu, Daron, Ufuk Akcigit, and William Kerr (2016), "Networks and the macroeconomy: An empirical exploration." *NBER Macroeconomics Annual*, 30, 273–353.

Allers, Maarten A. and J. Paul Elhorst (2011), "A simultaneous equations model of fiscal policy interactions." *Journal of Regional Science*, 51(2), 271–291.

Alvarez, Fernando, Andrew Atkeson, and Patrick J.Kehoe (2002), "Money, interest rates,and exchange rates with endogenously segmented markets." *Journal of Political Economy*, 110, 73–112.

Ammer, John, Clara Vega, and Jon Wongswan (2010), "International transmission of U.S. monetary policy shocks: Evidence from stock prices." *Journal of Money, Credit and Banking*, 42, 179–198.

Ando, Tomohiro and Jushan Bai (2015), "Asset pricing with general multifactor structure." *Journal of Financial Econometrics*, 13, 556–604.

Ando, Tomohiro and Jushan Bai (2016), "Panel data models with grouped factor structures under unknown group membership." *Journal of Applied Econometrics*, 31, 163–191.

Bai, Jushan (2009), "Panel data models with interactive fixed effects." *Econometrica*, 77, 1229–1279.

Bai, Jushan and Kunpeng Li (2014), "Theory and methods of panel data models with interactive effects." *The Annals of Statistics*, 42, 142–170.

Baltagi, Badi H. and Georges Bresson (2011), "Maximum likelihood estimation and lagrange multiplier tests for panel seemingly unrelated regressions with spatial lag and spatial errors: An application to hedonic housing prices in Paris." *Journal of Urban Economics*, 69(1), 24–42.

Bekaert, Geert, Eric Engstrom, and Andrey Ermolov (2023), "The variance risk premium in equilibrium models." *Review of Finance*, 27, 1977–2014.

Bernanke, Ben and Kenneth Kuttner (2005), "What explains the stock market's reaction to Federal Reserve policy." *Journal of Finance*, 60, 1221–1257.

Bollerslev, Tim, George Tauchen, and Hao Zhou (2009), "Expected stock returns and variance risk premia." *Review of Financial Studies*, 22, 4463–4492.

Brauning, Falk and Viacheslav Sheremirov (2019), "Output spillovers from U.S. monetary policy: the role of international trade and financial linkages." Working Paper.

Campbell, John, Carolin Pflueger, and Luis Viceira (2014), "Monetary policy drivers of bond and equity risks." Working Paper.

Carvalho, Vasco (2014), "From micro to macro via production networks." *Journal of Economic Perspectives*, 28, 23–48.

di Giovanni, Julian and Galina Hale (2022), "Stock market spillovers via the global production network: Transmission of U.S. monetary policy." *Journal of Finance*, 77, 3373–3421.

Drechsler, Itamar and Amir Yaron (2011), "What's vol got to do with it." *Review of Financial Studies*, 24, 1–45.

Ehrmann, Michael and Marcel Fratzscher (2009), "Global financial transmission of monetary policy shocks." *Oxford Bulletin of Economics and Statistics*, 71, 739–759.

Gebremariam, Gebremeskel H., Tesfa G. Gebremedhin, and Peter V. Schaeffer (2011), "Employment, income and migration in Appalachia: A spatial simultaneous equations approach." *Journal of Regional Science*, 51(1), 102–120.

Goyal, Amit, Ivo Welch, and Athanasse Zafirov (2024), "A comprehensive look at the empirical performance of equity premium prediction II." *Review of Financial Studies*, forthcoming.

Grossman, Sanford and Laurence Weiss (1983), "A transactions-based model of the monetary transmission mechanism." *American Economic Review*, 73, 871–880.

Gurkaynak, Refet S., Brian Sack, and Eric T. Swanson (2005), "Do actions speak louder than words? The response of asset prices to monetary policy actions and statements." *International Journal of Central Banking*.

Hauptmeier, Sebastian, Ferdinand Mittermaier, and Johannes Rincke (2012), "Fiscal competition over taxes and public inputs." *Regional Science and Urban Economics*, 42(3), 407–419.

Haynes, Stephen (1988), "Identification of interest rates and international capital flows." *Review of Economics and Statistics*, 70, 103–111.

Ho, Chau-Sa and Diane Hite (2008), "The benefit of environmental improvement in the southeastern United States: Evidence from a simultaneous model of cancer mortality, toxic chemical releases and house values." *Papers in Regional Science*, 87(4), 589–604.

Jeanty, P. Wilner, Mark Partridge, and Elena Irwin (2010), "Estimation of a spatial simultaneous equation model of population migration and housing price dynamics." *Regional Science and Urban Economics*, 40, 343–352.

Kim, Soyoung (2001), "International transmission of U.S. monetary policy shocks: Evidence from VARs." *Journal of Monetary Economics*, 48, 339–372.

Li, Kunpeng, Guowei Cui, and Lina Lu (2020), "Efficient estimation of heterogeneous coefficients in panel data models with common shocks." *Journal of Econometrics*, 216(2), 327–353.

Lu, Lina (2022), "Simultaneous spatial panel data models with common shocks." *Journal of Business and Economic Statistics*, 41, 608–623.

Miranda-Agrippino, Silvia and Helene Rey (2020), "U.S. monetary policy and the global financial cycle." *The Review of Economic Studies*, 87, 2754–2776.

Nagel, Stefan and Zhengyang Xu (2024), "Movements in yields, not the equity premium: Bernanke-Kuttner redux." Working Paper.

Nakamura, Emi and Jón Steinsson (2018), "High frequency identification of monetary non-neutrality: The information effect." *Quarterly Journal of Economics*, 133, 1283–1330.

Occhino, Filippo (2004), "Modeling the response of money and interest rates to monetary policy shocks: a segmented markets approach." *Review of Economic Dynamics*, 7, 181–197.

Ozdagli, Ali and Michael Weber (2019), "Monetary policy through production networks: Evidence from the stock market." Working Paper.

Pace, R. Kelley and James P. LeSage (2014), "Interpreting spatial econometric models." In *Handbook of Regional Science* (M. M. Gischer and P. Nijkamp, eds.), Springer, New York, NY.

Pesaran, M. H. (2006), "Estimation and inference in large heterogeneous panels with a multifactor error structure." *Econometrica*, 74, 967–1012.

Song, Dongho (2017), "Bond market exposures to macroeconomic and monetary policy risks." *Review of Financial Studies*, 30, 2761–2817.

Taylor, John (1993), "Discretion versus policy rules in practice." Working Paper.

Weber, Michael (2018), "Cash flow duration and the term structure of equity returns." *Journal of Financial Economics*, 128, 486–503.

Wongswan, Jon (2006), "Transmission of information across international equity markets." *Review of Financial Studies*, 19, 1157–1189.

Wongswan, Jon (2009), "The response of global equity indexes to U.S. monetary policy announcements." *Journal of International Money and Finance*, 28, 344–365.

The Global Effects of U.S. Monetary Policy on Equity and Bond Markets: A Spatial Panel Data Model Approach
Online Appendix

A Proofs for Section 2.3

Log-linearizing $SDF_{k,t+1}$ yields:

$$E_t(S\hat{D}F_{k,t+1}) = \left(\frac{1-\theta_k-\chi_k}{\chi_k}\right)\Delta\hat{M}_t = \psi_k\Delta\hat{M}_{kt}.$$

Steady state $S\bar{D}F$ is δ.

Log-linearizing Equation (6) yields:

$$\hat{R}_t = [D(\bar{R}) - W'D(\tau\bar{R})]^{-1}D(\bar{M})\hat{M}_t.$$

The market value of country-i with profit stream $\pi_{i,t}$ is

$$V_{it} = E_t\left(\sum_{s=0}^{\infty} SDF_{i,t+s}\pi_{i,t+s}\right)$$

$$= \pi_{i,t} + E_t\left(SDF_{i,t+1}V_{i,t+1}\right).$$

Applying $\pi_{i,t} = (1-\tau_i-\varsigma_i)R_{i,t} - \mathcal{F}_i$ and $\bar{\pi}_i\hat{\pi}_{i,t} = (1-\tau_i-\varsigma_i)\bar{R}_i\hat{R}_{it}$, then

$$\bar{V}_i\hat{V}_{i,t} = (1-\tau_i-\varsigma_i)\bar{R}_i\hat{R}_{it} + E_t\left(D(\delta)\bar{V}_i(\hat{V}_{it+1} + D(\psi)\Delta\hat{M}_t)\right),$$

$$D(\bar{V})\hat{V}_t = D((1-\tau-\varsigma)\bar{R})\hat{R}_t + E_t\left(D(\delta)D(\bar{V})(\hat{V}_{t+1} + D(\psi)\Delta\hat{M}_t)\right). \tag{A.1}$$

By the method of undetermined coefficients, guess that

$$\hat{V}_t = S_M\hat{M}_t + S_{\Delta M}\Delta\hat{M}_t.$$

Applying $\hat{R}_t = [D(\bar{R}) - W'D(\tau\bar{R})]^{-1}D(\bar{M})\hat{M}_t \equiv S_{RM}\hat{M}_t$, then

$$D(\bar{V})(S_M\hat{M}_t+S_{\Delta M}\Delta\hat{M}_t) = D((1-\tau-\varsigma)\bar{R})S_{RM}\hat{M}_t+E_t\left(D(\delta)D(\bar{V})(S_M\hat{M}_{t+1} + S_{\Delta M}\Delta\hat{M}_{t+1} + D(\psi)\Delta\hat{M}_t)\right). \tag{A.2}$$

Applying $E_t\Delta\hat{M}_{t+1} = D(\theta)\Delta\hat{M}_t$, then

$$D(\bar{V})(S_M\hat{M}_t + S_{\Delta M}\Delta\hat{M}_t)$$

$$= D((1-\tau-\varsigma)\bar{R})S_{RM}\hat{M}_t + E_t\left\{D(\delta)D(\bar{V})\left[S_M\hat{M}_t + (D(\theta)S_M + D(\theta)S_{\Delta M} + D(\psi))\Delta\hat{M}_t\right]\right\}.$$

Matching coefficients:

$$D(\bar{V})S_M = D((1-\tau-\varsigma)\bar{R})S_{RM} + D(\delta)D(\bar{V})S_M,$$

$$D(\bar{V})S_{\Delta M} = D(\delta)D(\bar{V})(D(\theta)S_M + D(\theta)S_{\Delta M} + D(\psi)),$$

so

$$S_M = D((1-\delta)^{-1}\bar{V}^{-1})D((1-\tau-\varsigma)\bar{R})S_{RM},$$

$$S_{\Delta M} = D((1-\delta\theta)^{-1})[D(\delta\psi) + D(\delta\theta)S_M].$$

Thus, the immediate reaction of stock prices to monetary policy surprise is

$$\hat{V}_t - E_{t-1}(\hat{V}_t) = (S_M + S_{\Delta M})\Theta_u u_t \tag{A.3}$$

$$= \left[D((1-\delta)^{-1}\bar{V}^{-1})D((1-\tau-\varsigma)\bar{R})S_{RM} + D((1-\delta\theta)^{-1})[D(\delta\psi) + D(\delta\theta)S_M]\right]\Theta_u u_t.$$

The bond price reaction is simply $D(\psi)\Theta_u u_t$.

Connection to reduced-form equations. From now on, we assume that $\bar{R}$, τ, θ_k and χ_k are homogeneous across countries for ease of exploration. Equation A.1 can be written as

$$D(\bar{V})\hat{V}_t = D((1-\tau-\varsigma)\bar{R})\hat{R}_t + E_t\left(\delta D(\bar{V})(\hat{V}_{t+1} + \hat{Q}_t)\right)$$

where V represents stock value, Q is bond price.

$$D(\bar{V})\hat{V}_t = D((1-\tau-\varsigma)\bar{R})\hat{R}_t + E_t\left\{\delta D(\bar{V})\left[S_M\hat{M}_t + \theta(S_M + S_{\Delta M})\Delta\hat{M}_t + \hat{Q}_t\right]\right\}$$

$$D(\bar{V})\hat{V}_t = D((1-\tau-\varsigma)\bar{R})S_{RM}\hat{M}_t + \delta D(\bar{V})\left[S_M\hat{M}_t + \theta(S_M + S_{\Delta M})\Delta\hat{M}_t + \hat{Q}_t\right]$$

Apply $S_M = D((1-\delta)^{-1}\bar{V}^{-1})D((1-\tau-\varsigma)\bar{R})S_{RM}$,

$$\hat{V}_t - E_{t-1}(\hat{V}_t) = \left[D((1-\tau-\varsigma)\bar{R}\bar{V}^{-1})\left\{I + \delta(1+\theta+\frac{\delta\theta^2}{1-\delta\theta})D((1-\delta)^{-1})\right\}S_{RM} + \frac{\delta^2\theta}{1-\delta\theta}D(\psi)\right]\Theta_u u_t$$

$$+\delta D(\bar{V})[\hat{Q}_t - E_{t-1}(\hat{Q}_t)]$$

Or

$$\hat{V}_t - E_{t-1}(\hat{V}_t) = [D(\alpha_1)S_{RM} + D(\alpha_2)]\,\Theta_u u_t + \delta D(\bar{V})[\hat{Q}_t - E_{t-1}(\hat{Q}_t)]$$

with $D(\alpha_1) \equiv D((1-\tau-\varsigma)\bar{R}\bar{V}^{-1})\left\{I + \delta(1+\theta+\frac{\delta\theta^2}{1-\delta\theta})D((1-\delta)^{-1})\right\}$ and $D(\alpha_2) \equiv \frac{\delta^2\theta}{1-\delta\theta}D(\psi)$.

Combining with the bond shock:

$$\hat{V}_t - E_{t-1}(\hat{V}_t) = [D(\alpha_1)S_{RM} + D(\alpha_3)]\,\Theta_u u_t$$

with $D(\alpha_3) \equiv D(\alpha_2) + \delta D(\psi\bar{V})$.

If W_u is proportional to W and we define them as the master weighting matrix W' and $\Theta \equiv (I - \tau W')^{-1}$,

$$\Delta\hat{V}_t \equiv \hat{V}_t - E_{t-1}(\hat{V}_t) = [D(\alpha_1)\Theta + D(\alpha_3)]\,\Theta u_t$$

$$\Delta\hat{Q}_t \equiv \hat{Q}_t - E_{t-1}\hat{Q}_t = D(\psi)\Theta u_t$$

$\Rightarrow$

$$\Delta\hat{V}_t = D(\rho_1)W'\Delta\hat{V}_t + D(\rho_2)\Delta\hat{Q}_t + D(\rho_3)u_t$$

$$\Delta\hat{Q}_t = D(\rho_4)W'\Delta\hat{Q}_t + D(\rho_5)u_t$$

In other cases:

$$S_{RM}^{-1}\Delta\hat{V}_t = \left[D(\alpha_1) + D(\alpha_3)S_{RM}^{-1}\right]\Theta_u u_t$$

$\Rightarrow$

$$\begin{aligned}\Delta\hat{V}_t &= D(\mu_1)W'\Delta\hat{V}_t + D(\mu_2)\Delta\hat{Q}_t + D(\mu_3)[I - D(\tau)W']\Theta_u u_t \\ &= D(\mu_1)W'\Delta\hat{V}_t + D(\mu_2)\Delta\hat{Q}_t + D(\mu_3)[I - D(\tau)W'][I - D(\tau_u)W_u']^{-1}u_t \\ &= D(\mu_1)W'\Delta\hat{V}_t + D(\mu_2)\Delta\hat{Q}_t + D(\mu_3)[I + D(\tau_u)W_u' - D(\tau)W']u_t + h.o.t.\end{aligned}$$

$$\Delta\hat{Q}_t = D(\mu_4)W_u\Delta\hat{Q}_t + D(\mu_5)u_t$$

B Likelihood function and estimation method

We estimate the simultaneous spatial panel data model using maximum likelihood method, following the IGPC approach proposed in Lu (2022). Let θ be the collection of all parameters we are estimating, the log-likelihood function is given by

$$\begin{aligned} LogL(\theta) \;=\; & -\frac{T}{2}\ln(2\pi) - \frac{T}{2}\sum_{i=1}^{N}(\ln\sigma_{1i}^2 + \ln\sigma_{2i}^2) + T\cdot\ln\left|\Upsilon(\rho_1,\rho_2,\gamma_1,\gamma_2)\right| \\ & - \sum_{t=1}^{T}\sum_{i=1}^{N}\left(\Delta S_{it} - \alpha_{1i} - \rho_1\sum_{j=1}^{N}\omega_{ij}\Delta S_{jt} - \gamma_1\Delta B_{it} - \lambda_i' f_t - \beta_1\Delta i_t\right)^2/\sigma_{1i}^2 \\ & - \sum_{t=1}^{T}\sum_{i=1}^{N}\left(\Delta B_{it} - \alpha_{2i} - \rho_2\sum_{j=1}^{N}\omega_{ij}\Delta B_{jt} - \gamma_2\Delta S_{it} - \phi_i' f_t - \beta_2\Delta i_t\right)^2/\sigma_{2i}^2 \end{aligned}$$

where N is the total number of countries, T is the total number of FOMC days included in the sample, σ_{1i}^2 and σ_{2i}^2 are the variance for the error terms in stock and bond equations, respectively. The term involving matrix $\Upsilon(\rho_1, \rho_2, \gamma_1, \gamma_2)$ is due to the simultaneous equation nature of the model, and $\Upsilon(\rho_1, \rho_2, \gamma_1, \gamma_2)$ is defined as a $2N \times 2N$ matrix, with its (i, j)th block, a 2×2 matrix, equal to:

$$\Upsilon_{ij}(\rho_1, \rho_2, \gamma_1, \gamma_2) = \begin{cases} \begin{bmatrix} 1 & -\gamma_1 \\ -\gamma_2 & 1 \end{bmatrix} & \text{if } i = j \\ \begin{bmatrix} -\rho_1 w_{ij} & 0 \\ 0 & -\rho_2 w_{ij} \end{bmatrix} & \text{if } i \neq j \end{cases} \tag{B.1}$$

C Additional Empirical Results

Table 6: Simultaneous Spatial Panel Data Model Results - With and Without Interactive Fixed Effects

Asset Weight Matrix	(1) stock Trade	(2) bond Financial	(3) stock Trade	(4) bond Financial
	Panel A. Point Estimates			
β_1	-1.8707***		-2.1870***	
	(0.6372)		(0.7454)	
ρ_1	0.6021***		0.2953***	
	(0.0220)		(0.0422)	
γ_1	-2.2029***		-2.5975***	
	(0.2625)		(0.2656)	
β_2		0.3397***		0.3327***
		(0.0321)		(0.0331)
ρ_2		0.2479***		0.2267***
		(0.0195)		(0.0184)
γ_2		0.0090***		0.0009
		(0.0007)		(0.0010)
Country FE	Yes		Yes	
Interactive FE	No		Yes	
R2	0.2617		0.5208	
Adj R2	0.0565		0.2315	
Observations	2752		2752	
	Panel B. Effect Decomposition			
Total Effect	-6.7571***	0.3712***	-4.6686***	0.4246***
	(1.3778)	(0.0412)	(0.9186)	(0.0398)
Direct Effect	-1.8707***	0.3397***	-2.2033***	0.3336***
	(0.6610)	(0.0322)	(0.7473)	(0.0331)
Network Effect	-2.8313***	0.1120***	-0.9003***	0.0966***
	(0.8419)	(0.0122)	(0.2270)	(0.0106)
Interest Rate Effect	-2.0552***	-0.0805***	-1.5651***	-0.0056
	(0.3394)	(0.0176)	(0.2013)	(0.0063)
	Panel C. Effect Decomposition in Percentages			
Direct Effect	27.68%	91.51%	47.19%	78.57%
Network Effect	41.90%	30.17%	19.28%	22.75%
Interest Rate Effect	30.42%	-21.68%	33.53%	-1.32%

Note: Bootstrap standard errors computed from 1,000 bootstrap runs are in parentheses. Asterisks, ***, indicate the statistical significance at the 1% level.

Table 7: Simultaneous Spatial Panel Data Model Results - Various Bond Maturities

Weight Matrix	(1) stock Trade	(2) bond 5-year Financial	(3) stock Trade	(4) bond 10-year Financial	(5) stock Trade	(6) bond 30-year Financial
Panel A. Point Estimates						
β_1	-1.7838**		-2.1870***		-0.5845	
	(0.8365)		(0.7454)		(1.0025)	
ρ_1	0.3221***		0.2953***		0.3935***	
	(0.0483)		(0.0422)		(0.0470)	
γ_1	-2.0486***		-2.5975***		-0.5353***	
	(0.2127)		(0.2656)		(0.1409)	
β_2		0.4460***		0.3327***		0.4485***
		(0.0397)		(0.0331)		(0.0437)
ρ_2		0.1805***		0.2267***		0.1475***
		(0.0144)		(0.0184)		(0.0134)
γ_2		0		0.0009		0
		(0.0010)		(0.0010)		(0.0011)
Country FE	Yes		Yes		Yes	
Interactive FE	Yes		Yes		Yes	
R2	0.5199		0.5208		0.5269	
Adj R2	0.2332		0.2315		0.2382	
Observations	3128		2752		2610	
Panel B. Effect Decomposition						
Total Effect	-4.2759***	0.5442***	-4.6686***	0.4246***	-1.4281	0.5261***
	(1.0857)	(0.0439)	(0.9186)	(0.0398)	(1.4414)	(0.0498)
Direct Effect	-1.7987**	0.4467***	-2.2033***	0.3336***	-0.5938	0.4491***
	(0.8395)	(0.0397)	(0.7473)	(0.0331)	(1.0124)	(0.0438)
Network Effect	-0.8326***	0.0976***	-0.9003***	0.0966***	-0.3699	0.0770***
	(0.3021)	(0.0087)	(0.2270)	(0.0106)	(0.4752)	(0.0093)
Interest Rate Effect	-1.6446***	0	-1.5651***	-0.0056	-0.4644***	0
	(0.1833)	(0.0060)	(0.2013)	(0.0063)	(0.1070)	(0.0033)
Panel C. Effect Decomposition in Percentages						
Direct Effect	42.07%	82.07%	47.19%	78.57%	41.58%	85.36%
Network Effect	19.47%	17.93%	19.28%	22.75%	25.90%	14.64%
Interest Rate Effect	38.46%	0.00%	33.53%	-1.32%	32.52%	0.00%

Note: Bootstrap standard errors computed from 1,000 bootstrap runs are in parentheses. The asterisks, ** and ***, correspond to statistical significance at the 5 and 1 percent levels, respectively.

Table 8: Simultaneous Spatial Panel Data Model Results - Various Spatial Matrices

	(1)	(2)	(3)	(4)	(5)	(6)
Asset	stock	bond	stock	bond	stock	bond
Weight Matrix	Trade	Financial	Trade	Trade	Trade 2019	Financial 2019
Panel A. Point Estimates						
β_1	-2.1870***		-4.2735***		-2.3941**	
	(0.7454)		(0.7676)		(0.9902)	
ρ_1	0.2953***		0.2676***		0.3203***	
	(0.0422)		(0.0362)		(0.0430)	
γ_1	-2.5975***		-2.4514***		-2.6278***	
	(0.2656)		(0.2390)		(0.3076)	
β_2		0.3327***		0.2424***		0.3373***
		(0.0331)		(0.0305)		(0.0316)
ρ_2		0.2267***		0.2892***		0.2628***
		(0.0184)		(0.0205)		(0.0181)
γ_2		0.0009		0.0000		0.0000
		(0.0010)		(0.0011)		(0.0009)
Country FE	Yes		Yes		Yes	
Interactive FE	Yes		Yes		Yes	
R2	0.5208		0.4994		0.5174	
Adj R2	0.2315		0.2098		0.2279	
Observations	2752		3010		2752	
Panel B. Effect Decomposition						
Total Effect	-4.6686***	0.4246***	-6.9769***	0.3410***	-5.2907***	0.4575***
	(0.9186)	(0.0398)	(0.9687)	(0.0394)	(1.1396)	(0.0425)
Direct Effect	-2.2033***	0.3336***	-4.2969***	0.2440***	-2.4142**	0.3387***
	(0.7473)	(0.0331)	(0.7699)	(0.0306)	(0.9928)	(0.0317)
Network Effect	-0.9003***	0.0966***	-1.5384***	0.0907***	-1.1079***	0.1188***
	(0.2270)	(0.0106)	(0.3367)	(0.0133)	(0.3066)	(0.0146)
Simultaneous Effect	-1.5651***	-0.0056	-1.1416***	0.0000	-1.7686***	-0.0000
	(0.2013)	(0.0063)	(0.1436)	(0.0106)	(0.2282)	(0.0064)
Panel C. Effect Decomposition in percentage						
Direct Effect	47.19%	78.57%	61.59%	71.55%	45.63%	74.04%
Network Effect	19.28%	22.75%	22.05%	28.45%	20.94%	25.96%
Simultaneous Effect	33.53%	-1.32%	16.36%	0.00%	33.42%	0.00%

Note: Bootstrap standard errors computed from 1,000 bootstrap runs are in parentheses. The asterisks, ** and ***, correspond to statistical significance at the 5 and 1 percent levels, respectively.