Gross Capital Inflows, the U.S. Economy, and the Response of the Federal Reserve

Andre Harrison* Robert R. Reed†

August 2022

Abstract

In recent years, there has been a surge in capital inflows to the United States' treasury and corporate bond markets from other countries. How do these inflows affect economic activity in the United States? Does the Federal Reserve respond to such shocks? To address these important issues, we employ a sign-identified structural vector autoregressive (SVAR) model to see the effects of these types of capital inflows. Our results suggest that the U.S. economy and the Federal Reserve's balance sheet respond differently to shocks to these inflows. In particular, gross inflows to U.S. treasuries are contractionary while inflows to corporate debt are expansionary. Moreover, the Federal Reserve shrinks its balance sheet in response to shocks to gross capital inflows to U.S. treasury securities with little to no response to inflows to corporate securities. Interestingly, we find that the bulk of the Fed's response to both shocks is systematic. In this manner, the Federal Reserve's response to these shocks played only a minor role in the evolution of macroeconomic aggregates following such shocks.

JEL classifications: C32; E52; E58; F41; F62

Keywords: Gross Capital Inflows; Macroeconomic activity; Monetary Policy

1 Introduction

There have been many concerned about the rising current account deficit in the United States in recent years (see, for example, Bernanke, 2005; Rogoff, 2007; Christopoulos and León-Ledesma, 2010; Hoffmann et al., 2019, among others). In particular, Bernanke (2005) discusses how the current account deficit grew in the mid 2000's due to large gross capital inflows to the United States. May 2007 saw gross total inflows reach as high as $170 billion (the largest on record up

*Department of Economics, College of Liberal Arts, California State University, Long Beach, California 90840, USA. Email: Andre.Harrison@csulb.edu

†Corresponding author. Department of Economics, Finance and Legal Studies, Culverhouse College of Business, University of Alabama, Tuscaloosa, Alabama 35487, USA. E-mail address: rreed@cba.ua.edu

to that point) – months before the global financial crisis, and as low as -$78.6 billion in June 2013, around the time of the Taper Tantrum episodes.[1]

Consequently, there has been some discussion in recent years on the behavior of gross capital inflows (Forbes and Warnock, 2012; Broner et al., 2013; Avdjiev et al., 2018; Caballero and Simsek, 2020; Davis et al., 2021, among others). For example, a strand of the literature focuses on how gross inflows depress interest rates (Warnock and Warnock, 2009; Bernanke et al., 2011; Bertaut et al., 2012; Beltran et al., 2013, among others). In particular, Warnock and Warnock (2009) note that foreign holdings of U.S. treasury securities increased significantly at the turn of the century and led to lower yields. Moreover, Bertaut et al. (2012) discuss that inflows to corporate bonds add directly to domestic demand for these securities and contribute to a decline in corporate yields. Another strand of the literature is concerned with how monetary policy shocks affect gross flows (Bruno and Shin, 2015; Banerjee et al., 2016; Anaya et al., 2017, among others). For instance, Banerjee et al. (2016) show that a monetary tightening in the U.S. can reduce flows from emerging markets, as policy rates in other countries also increase with the domestic monetary contraction.

Despite these contributions, there are several questions that remain unresolved. First, how does the U.S. economy respond to gross inflows to U.S. treasury and corporate securities on a large scale? In particular, previous work has analyzed the effects of gross flows on a small scale, focusing only on individual parts of the economy rather than addressing it on a large scale where its effect on output and other components of economic activity are simultaneously considered. Second, how does the Federal Reserve respond to these flows? Third, do the actions of the Federal Reserve compound the overall effects of gross inflows?

While foreign funds flow into several types of U.S. long term securities (such as treasury, agency, corporate and equities), we choose to focus on gross inflows to U.S. treasury and corporate securities.[2] Notably, the market for U.S. treasuries is the largest sovereign debt market in the global financial system, while the U.S. corporate bond market is the world's largest corporate debt market.

Given our limited understanding of the effects of gross capital inflows to U.S. securities, this paper empirically examines how the U.S. economy and the Federal Reserve respond to shocks to both gross capital inflows of U.S. treasury and corporate bonds. In particular, the empirical analysis involves the use of a structural VAR model in which identification occurs through the use of sign restrictions.

An important element of our approach is that we jointly identify the shocks of interest. This is important because it characterizes the joint uncertainty about the set of admissible models. In other words, identifying both shocks jointly will make the full uncertainty of the

[1]These gross inflows to U.S. long term securities are actually "net" purchases – foreign purchases minus foreign sales. As a result, they can take on negative values. This aligns with the primary definition of gross capital flows. See Avdjiev et al. (2018) for a more detailed discussion.

[2]More importantly, debt flows have been the largest portion of these flows into the United States. Avdjiev et al. (2018) show that for a number of countries, including the U.S., debt flows have been the major source of gross capital flows since the mid 1990's. Moreover, Warnock and Warnock (2009) show that all types of U.S. bonds held by foreigners increased – Treasury, corporate, and agency debt securities.

impulse response functions more clear. If this were not the case, then identifying one shock and ignoring the other would misrepresent the estimation and produce identification uncertainty of the impulse response functions. Previous work such as Kilian and Murphy (2012) and Inoue and Kilian (2013) has adopted a similar point of view. Moreover, this facilitates joint inference about the set of structural impulse responses and allows for dependencies across time as well as across response functions (Inoue and Kilian, 2016).

Through our analyses, we uncover a number of interesting results. To begin, we find that the type of bond inflow can have differential effects on the U.S. economy and the Federal Reserve's balance sheet. On one hand, gross inflows to U.S. treasuries lead to rising credit spreads, an appreciation of the dollar, and declining output. Higher credit spreads can result in lower asset prices and a fall in output via the financial accelerator mechanism (Culp et al., 2018), while the higher exchange rate potentially leads consumers to demand more foreign-produced goods and substitute away from domestically produced goods. Moreover, the Federal Reserve shrinks its balance sheet in response to shocks to gross capital inflows to U.S. treasury securities. On the other hand, gross inflows to U.S. corporate securities result in reduced credit spreads and increased output. The Federal Reserve's balance sheet exhibits little to no response to this type of shock.

Further, we turn to investigate the Federal Reserve's systematic response to both shocks. In doing so, we find that the Fed exhibited very little in the way of a direct response to treasury shocks. Most of the Fed's response was systematically working through the response of macroeconomic aggregates to the shock. Put differently, the policy response to the shock was "reactionary" as opposed to "precautionary". That is, the Federal Reserve largely did not respond directly to the shock in anticipation of its effect on the other variables. Instead, it was merely responding to other economic conditions. This result was even more stark when analyzing the Fed's systematic response to corporate shocks. In particular, there was virtually no direct response to corporate shocks, with the bulk of its response working through the response of macroeconomic aggregates to the shock.

Counterfactual analyses reveal that since the Federal Reserve's direct response was minute, cutting off its ability to respond directly to the treasury shock while being allowed to respond systematically to the other variables in the system would have virtually no impact on those variables. However, when the Fed is not allowed to respond endogenously to the response of other variables to the treasury shock, those variables experience increased variability in their responses. In the case of the gross inflow shock to U.S. corporate securities, the variables would have responded in a similar manner if the Federal Reserve did not have the ability to respond directly to the shocks. This is because when presented with the opportunity to respond directly to the shocks, the Fed virtually opted against it.

To this end, historical counterfactuals show that the policy response did very little to impact fluctuations in macroeconomic aggregates – particularly before the global financial crisis. The Federal Reserve's responses to these inflows in cooling an overheating economy in the mid 2000's were negligible. In the aftermath of the global financial crisis, the Federal Reserve's response

to these shocks reduced variability in the evolution of macroeconomic aggregates. Regardless, its responses still play a minor role in fluctuations to economic activity.

At this point, we would like to contrast our contribution relative to other recent research in the literature on capital flows to the United States. This is presented in the following section. Section 3 describes the data, the structural model, the identification and the implementation procedure. Section 4 analyzes the empirical results while Section 5 concludes.

2 Related Literature

There is an extensive literature using VAR and structural VAR models to identify how monetary policy shocks affect economic activity. However, there has been little econometric research showing how monetary policy responds to shocks to openness. For example, Uhlig (2005) treats the United States as a closed economy.

Existing research which considers the U.S. to be an open economy is much different than our approach, both in terms of subject matter and methodology. First, in open economy studies, the focus has been on whether the current account responds differently to temporary versus permanent domestic shocks (for example, Trehan and Walsh, 1991; Wickens and Uctum, 1993; Obstfeld and Rogoff, 1994; Christopoulos and León-Ledesma, 2010). In particular, Obstfeld and Rogoff (1994) use a multitude of evidence to argue in favor of an intertemporal approach. Nason and Rogers (2002) examine the joint behavior of investment and the current account in order to empirically evaluate the predictions of the intertemporal, small open economy model.

In contrast to these works that look at the response of the current account to certain shocks, we identify two potential sources of U.S. current account imbalances – gross inflows to U.S. treasury and corporate securities – and investigate how they impact macroeconomic activity and the actions of the Federal Reserve.[3] Notably, Bernanke (2005) and Bernanke et al. (2011) posit that gross capital inflows from across the globe have contributed significantly to the offsetting of the U.S. current account deficit – particularly gross inflows to U.S. treasuries, while Warnock and Warnock (2009) and Bertaut et al. (2012) document the rise in gross inflows to U.S. corporate securities.

Next, Nason and Rogers (2002) use SVAR methods based upon exclusion restrictions imposed on the feedback from temporary and permanent shocks across variables in the system in order to identify shocks to the U.S. current account. This method of identification has also been adopted in the literature that looks at the impact of monetary policy shocks. However, skepticism about identification has moved large sections of the recent literature to the use of sign identification in structural autoregressive models to identify monetary policy shocks. For example, Faust (1998) developed a technique where he remains agnostic about the immediate

[3]In this manner, monetary policy is assumed to respond endogenously to gross capital inflows in these securities. A closely related paper in this regard is Kilian and Lewis (2011) who explore whether oil price shocks affect monetary policy. In particular, they consider whether there are systematic monetary policy responses to macroeconomic variables. Earlier work in this area was done by Bernanke et al. (1997). See also Hamilton and Herrera (2004). However, to the best of our knowledge, we are the first to consider these gross inflows as a part of the policy equation.

impact of an unanticipated monetary policy shock on output following World War II. Uhlig (2005) expands this approach by employing sign restrictions on certain variables that last for multiple periods.[4]

Agnostic sign restrictions in structural VAR models have not only been used to study monetary policy shocks, but also fiscal shocks (Mountford and Uhlig, 2009), technology shocks (Dedola and Neri, 2007), oil market shocks (Kilian and Murphy, 2012), labor market shocks (Fujita, 2011), and other shocks in open economies (Mumtaz and Surico, 2009). We follow this recent literature and remain agnostic about how certain variables in the system should respond to the shocks of interest. However, there have been major debates about how such agnostic models are estimated. In particular, the main problem with these contributions is that the method of estimation does not account for dependencies across the impulse response functions and thus imposes additional sign restrictions on variables that would otherwise appear to be unrestricted (Arias et al., 2013, 2018). As a result, the procedure is argued not to be truly agnostic and introduces bias in the impulse response functions (IRFs) and other statistics of interest. Arias et al. (2013, 2018) note that most of the literature imposes restrictions on the IRFs and therefore propose a "less restrictive" method in identifying sign restrictions.[5] The theorems described in Arias et al. (2013, 2018) allow them to consider a more general class of restrictions that stacks the IRFs for all the relevant horizons into a single matrix and uses selection matrices to impose sign restrictions. This alleviates problems associated with previous methods of dealing with agnostic sign-identified VAR models (see for example, Uhlig, 2005; Mountford and Uhlig, 2009; Beaudry et al., 2011) and we follow these techniques in imposing the sign restrictions of interest.

Once sign restrictions are imposed, the next step would be to use algorithms to find impulse responses that satisfy the identification scheme. However, Rubio-Ramírez et al. (2010) note that previously established algorithms cannot be applied to small-sample estimation and inference of a SVAR with sign restrictions because a SVAR with sign restrictions can produce several structural parameters that satisfy the same restrictions. In other words, the set of structural parameters conditional on the sign restrictions will be an open set of positive measure in the set of all structural parameters. As such, finding a set of IRFs that satisfies the sign restrictions can be computationally intensive. In this regard, we follow a computationally feasible algorithm for small-sample estimation developed by Rubio-Ramírez et al. (2010).[6] In particular, the algorithm used by Rubio-Ramírez et al. (2010) gives us a convenient way of implementing a random selection of orthogonal matrices to obtain impulse responses that satisfy the sign restrictions.

[4]See also Canova and De Nicolo (2002) who were among the early employers of sign restrictions to identify monetary policy shocks.

[5]For a detailed description, see also Kilian and Lütkepohl (2017).

[6]See also Arias et al. (2013), Kilian and Lütkepohl (2017), & Arias et al. (2018) for a more detailed discussion.

3 Data and Methodology

3.1 Data

Our set of variables consists of monthly U.S. data for real estate loans held at all commercial banks (RE), the industrial production index (IP), the personal consumption expenditure index (PCE), the producer price index (PPI), the spread between the 10-year corporate and treasury yield (yC10T10), total gross inflows to U.S. treasury securities (TFOTot), total gross inflows to U.S. corporate securities (CFOTot), the real trade weighted U.S. dollar index (RExR), nonborrowed reserves (NBR), the federal funds rate (FFR), total assets held by the federal reserve (TAF), and U.S. treasury holdings held by the federal reserve (TF).[7] We follow Uhlig (2005) in constructing a VAR(12) model without intercept.

The sample period is 2003.1–2017.8. The start of the sample was chosen because as Csonto and Mora (2017) point out, there was a surge in foreign holdings – particularly of U.S. Treasury securities – starting in 2003.[8] To avoid the zero lower bound issue for the federal funds rate, we splice the funds rate after 2008:9 with the so-called 'shadow policy rate' estimated by Wu and Xia (2016).

3.2 The Model

Consider the structural vector autoregression (SVAR) model:

$$A_0 y_t = \sum_{i=1}^{p} A_i y_{t-i} + w_t \quad \text{for } 1 \leq t \leq T, \tag{1}$$

where y_t is a $n \times 1$ vector of endogenous variables, w_t is an $n \times 1$ vector of exogenous structural shocks, A_i is an $n \times n$ matrix of parameters for $0 \leq i \leq p$, p is the lag length, and T the sample size. The vector w_t, conditional on past information and the initial conditions $y_0, \ldots, y_{1-p}$, is Gaussian with mean zero and covariance matrix I_n, the $n \times n$ identity matrix. The model described above can be written as

$$A_0 y_t = A_+ x_t + w_t \quad \text{for } 1 \leq t \leq T, \tag{2}$$

where $A_+ = [A_1 \ldots A_p]$ and $x_t = [y'_{t-1} \ldots y'_{t-p}]'$ for $1 \leq t \leq T$. The dimension of A_+ is $np \times n$. The n-variate reduced-form VAR(p) model implied by (1) is:

$$y_t = B_1 y_{t-1} + B_2 y_{t-2} + \cdots + B_p y_{t-p} + e_t, \tag{3}$$

[7] Data on real estate loans held at all commercial banks, industrial production index, personal consumption expenditure index, producer price index, real trade weighted U.S. dollar index, total assets held by the federal reserve, U.S. treasury holdings held by the federal reserve, nonborrowed reserves and the federal funds rate were gathered from the FRED database. The corporate and treasury yields were gathered from the Federal Reserve Bank of New York while data on foreign holdings of U.S. treasury (net), foreign holdings of U.S. corporate bonds (net) were gathered from the U.S. Department of Treasury.

[8] See also Bernanke et al. (2011) who also made a similar point.

for $t = 1, \ldots, T$ where $B_1 = A_0^{-1}A_1 \ldots B_p = A_0^{-1}A_p$, $e_t = A_0^{-1}w_t$ and $e_t \overset{\text{iid}}{\sim} N(0_{n\times 1}, \Sigma)$ where $\Sigma = (A_0 A_0')^{-1}$ is positive definite. We assume that A_0 is invertible. Next, we write (3) as

$$Y = XB + e \tag{4}$$

where $Y = [y_1 \ldots y_T]', X = [X_1 \ldots X_T]', X_t = [y_{t-1}' \ldots y_{t-p}']', B = [B_1 \ldots B_p]'$ and $e = [e_1 \;\; e_2 \ldots e_T]'$.

From (2), it follows that if (A_0, A_+) is any set of structural parameters and Q is any element of the set of orthogonal matrices, $O(n)$, then (A_0, A_+) and (A_0Q, A_+Q) are observationally equivalent. In particular, this mapping is given by $(B, \Sigma, Q) \mapsto (A^{-1}Q, BA^{-1}Q)$, where $\Sigma = AA'$ is the Cholesky decomposition of Σ such that A is a lower triangular matrix with positive diagonal and $Q \in O(n)$. Since (A^{-1}, BA^{-1}) is observationally equivalent to $(A^{-1}Q, BA^{-1}Q)$, the likelihood is flat over the space of orthogonal matrices. As a result, the likelihood at the reduced form parameters (B, Σ) will be equal to the likelihood at the structural parameters (A^{-1}, BA^{-1}). Therefore, once we have a prior on the reduced-form parameters, this implies that the unrestricted posterior is the product of the posterior distribution of the reduced-form parameters and the uniform distribution with respect to the Haar measure on $O(n)$. Further, the posterior will have the multivariate normal inverse Wishart distribution if the prior on the reduced-form parameters is conjugate.

The conventional approach in the literature, which we follow in this paper, is to specify a normal-inverse Wishart prior distribution for the reduced-form VAR parameters:

$$\text{vec}(B)|\Sigma \sim \mathcal{N}(\text{vec}(\bar{B}_0, \Sigma \otimes N_0^{-1}),$$

$$\Sigma \sim IW_n(\upsilon_0 S_0, \upsilon_0)$$

where N_0 is an $np \times np$ positive definite matrix, S_0 is an $n \times n$ covariance matrix, and $\upsilon_0 > 0$. The posterior is then given by:

$$\text{vec}(B)|\Sigma \sim \mathcal{N}(\text{vec}(\bar{B}_T, \Sigma \otimes N_T^{-1}),$$

$$\Sigma \sim IW_n(\upsilon_T S_T, \upsilon_T),$$

where $\upsilon_T = T + \upsilon$, $N_T = N_0 + X'X$, $\bar{B}_T = N_T^{-1}(N_0\bar{B}_0 + X'X\hat{B})$, $S_T = \frac{\upsilon_0}{\upsilon_T}S_0 + \frac{T}{\upsilon_T}\hat{\Sigma} + \frac{1}{\upsilon_T}(\hat{B} - \bar{B}_0)'N_0N_T^{-1}X'X(\hat{B} - \bar{B}_0)$, $\hat{B} = (X'X)^{-1}X'Y$ and $\hat{\Sigma} = (Y - XB)'(Y - XB)/T$.

Let $\tilde{A} = AQ$ where A is the lower triangular Cholesky decomposition of Σ and Q is an orthogonal matrix as defined earlier. In particular, $\tilde{A}$ represents a possible solution for the unknown structural impact multiplier matrix. Importantly, $\tilde{A}\tilde{A}' = AQQ'A' = AA' = \Sigma$ since by construction, $QQ' = I_n$. Moreover, Uhlig (2005) notes that the prior distribution for Q is a uniform distribution defined on the space of orthogonal matrices $O(n)$. We use the method of Rubio-Ramírez et al. (2010) to draw from the uniform distribution with respect to the Haar measure on $O(n)$. This method is computationally feasible for moderately large SVAR systems such as ours. Further, we apply the transformation discussed in Inoue and Kilian (2019) when $|Q| = -1$.

3.3 Identification of Shocks

As previously mentioned, we are largely interested in identifying two shocks: a shock to net foreign holdings of U.S. treasury securities, and a shock to net foreign holdings of U.S. corporate securities. In both cases, the "net" defines the amount of U.S. assets purchased by foreigners minus the amount of U.S. assets sold by foreign holders. From the U.S. perspective, this is described as gross capital inflows.[9] Hence, a positive shock to either variable can be seen as an increase in gross capital inflows.

Gross capital inflows to the U.S. could be driven by different factors. For example, they could result from an increase in saving abroad, which leads to an inflow of capital into the U.S., a deterioration of the U.S. current account, and an appreciation of the dollar.[10] Another reason for capital inflows to the United States is political instability abroad. For instance, if a war or revolution breaks out in another country, investors around the world will try to withdraw their assets from that country and seek a "safe haven" in a stable country such as the United States. Finally, a monetary-policy expansion abroad would reduce foreign interest rates and increase the relative attractiveness of U.S. assets, also leading to capital inflows to the United States (Sá and Wieladek, 2015).[11]

3.3.1 Distinguishing between gross inflow shocks

An obvious concern is that since both shocks are gross capital inflow shocks, how do we distinguish between them? To answer this, we explore each flow's relationship with the spread between the 10-year corporate yield and the 10-year treasury yield. We use this spread to assess the relative risk between holding both assets over the long term.[12] In particular, an unanticipated increase in foreign holdings of U.S. treasury securities will depress treasury yields, thus increasing the spread between the corporate and treasury yield. This is based on the view that an increase in demand for treasuries will lower those yields, and the lower yields on Treasuries increases the corporate-treasury yield spread. Further, an unanticipated increase in foreign holdings of U.S. corporate securities lead to a decline in corporate yields over treasury yields, thus reducing the spread.

Such ideas are also supported in the literature. To begin, Du and Rousse (2018) note that Treasury and corporate-bond markets interact through "reach for yield" and "flight to quality", and this interaction affects the credit spread. Through a recursively identified VAR model, they show that corporate inflows reduce the spread, while inflows to Treasuries increase the spread (which they argue could be the result of "flight to quality"). Further, Bertaut et al. (2012)

[9] See, for example, Forbes and Warnock (2012); Broner et al. (2013); Avdjiev et al. (2018); Caballero and Simsek (2020); Davis et al. (2021), among others.

[10] The famous discussion of the global savings glut by Bernanke (2005) serves as an example of this.

[11] See Krishnamurthy et al. (2018) who look at the timeline for monetary expansion in the Eurpoean Union (EU). See also Bertaut et al. (2012).

[12] This is usually referred to as the "credit spread". However, Huang and Huang (2012) note that credit risk is only part of a long list of factors that contribute to this spread. Other factors include illiquidity, asymmetry in the tax treatment of corporate and treasury bonds, call and conversion characteristics of some corporate bonds, default probabilities and loss rate given default, among others. See also Culp et al. (2018).

note that foreign inflows to the Treasury market lowers yields on safe assets, which raises the spread and increases demand for riskier assets. Meanwhile, inflows to corporate bonds add directly to domestic demand for these securities and contributes to a decline in their spreads over Treasury yields. Moreover, they use the "reach for yield" phenomenon to explain the rise of gross inflows to U.S. corporate debt between 2003 and 2007 – a time when the global savings glut had driven treasury yields to low levels.[13]

We next look at some anecdotal evidence in an attempt to further address their correlation. This is not easy, because ideally, we would want to look at historical behavior of the yield spread when one of the holdings changed significantly and the other did not. Fortunately, there are some moments throughout the sample where this could be observed.

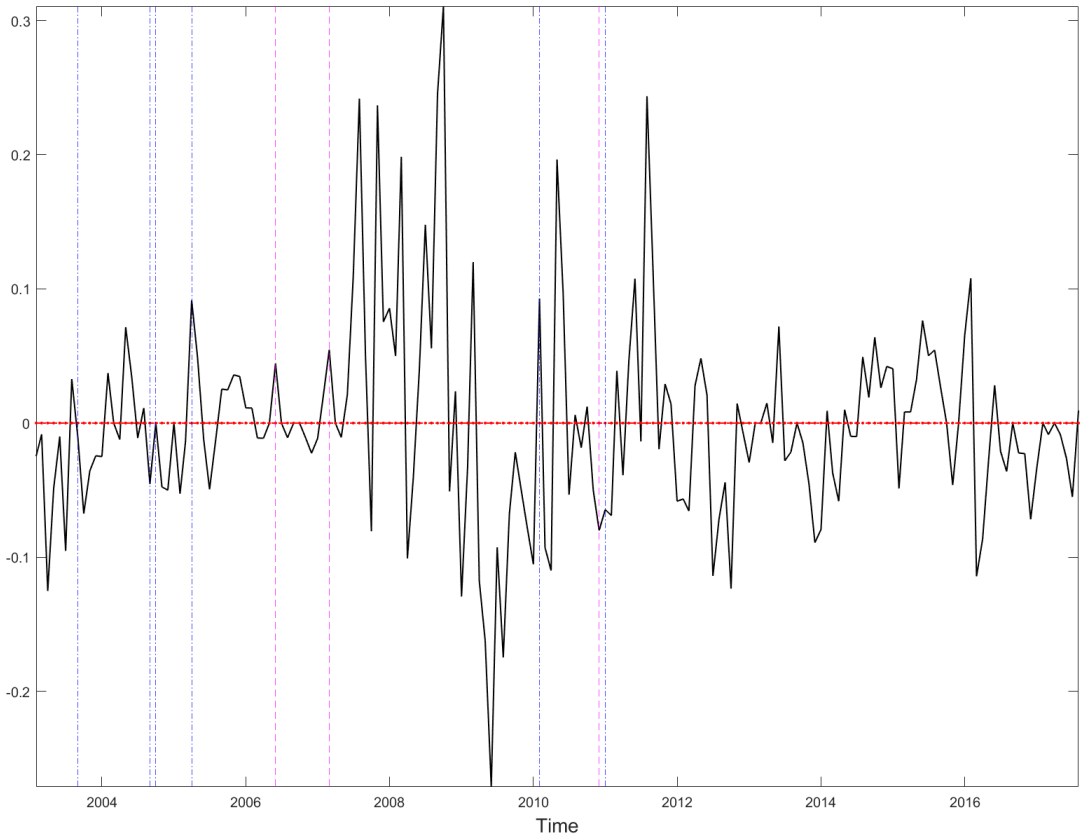

Figure 1: The growth rate (logged difference) of the spread between the 10-year corporate yield and the 10-year treasury yield. Blues lines indicate periods where a negative relationship was observed between gross inflows to corporates with little to no change in treasury holdings. Purple lines are observed positive relationship between the spread and gross treasury inflows when there was little to no change in corporate holdings.

In particular, Figure 1 shows the logged difference in the yield spread and highlights the relationship between each type of holding and the yield spread in periods where the other experienced little to no change. The logged difference was compared with the percent change

[13]See Bernanke et al. (2011), Bertaut et al. (2012) for a more detailed discussion.

in each holding across the sample. Firstly, we identified periods where the percent change in each holding was relatively unchanged from the previous period. Then, we observed the growth rate of the yield spread and the other holding at that point in time.

The dashed blue lines on Figure 1 represent the relationship between corporate holdings and the yield spread when there is little to no change in treasury holdings. For example, September 2003 saw a mere 0.05 percentage point increase in treasury holdings from the previous period.[14] In that same month, a 22% increase in gross corporate inflows was accompanied by a near 5 percentage point decline in the yield spread. A year later, an 82% increase in gross corporate inflows coincided with a 5% decline in the spread. In the following month, a 56% decline (a 138 point swing) was accompanied by a virtual offset of the previous month's decline in the spread. By April 2005, there was a 14% decline in corporate holdings and a 9% increase in the spread from the previous month. February 2010 saw a near 50% decline in corporate inflows from the previous month and 9% growth in the yield spread. In January 2011, there was a 125% decline in corporate inflows, while the yield spread was up 2 percentage points from the previous month. By April of that same year, corporate inflows fell by over 400% and yield spread grew about 4%.

On the other hand, the dashed purple lines on Figure 1 represent the relationship between treasury holdings and yield spread when there was little to no change in corporate holdings. In particular, June 2006 saw an 87% percent increase in treasury inflows and also a 4.5% increase in the yield spread. In this same month, corporate holdings experienced a meager 1.4% decline (which was about a 3-percentage point drop) from the previous month. By March 2007, a 75% increase in treasury holdings from the previous month coincided with a 5.5% increase in the yield spread. In December 2010, a 12.5% decline in treasury holdings coincided with an 8% decline in the yield spread.

These observations suggest that gross inflows to U.S. treasuries have a positive relation to the yield spread, while a negative relation exists between gross inflows to U.S. corporate securities and the yield spread. We use this observation to help differentiate between shocks to gross inflows to U.S. treasuries and shocks to gross inflows to U.S. corporate securities.

3.3.2 Sign Restrictions

Table 1: Sign restrictions on selected variables

	Treasury Shock	Corporate Shock
10-yr Corporate-Treasury Yield Spread	(+)	(−)
Gross inflows to U.S. treasury securities	(+)	
Gross inflows to U.S. corporate securities		(+)
Real Exchange Rate	(+)	(+)
Federal Funds Rate	(−)	(−)

Missing entries, both in terms of missing signs and missing variables, signify that no restrictions were imposed.

[14] In all months highlighted for the relationship between the treasury holding and the yield spread, the percent change in treasury holdings is within 10 percentage points of the previous month.

The sign restrictions employed to identify each shock are summarized in Table 1. In order identify a shock to gross inflows to U.S. treasury securities, we impose that a positive shock to gross inflows to U.S. treasury securities does not lead to a decrease in itself, the spread between the 10-year corporate yield and the 10-year treasury yield or the real exchange rate. This can be supported by economic theory as an increase in foreign holdings of U.S. treasury securities reduces the supply of U.S. dollars in the foreign exchange market, leading to an appreciation of the dollar. Anecdotally, as we have shown, treasury shocks from foreigners are associated with an increase in the spread between the 10-year corporate and treasury yields.[15]

Similarly, we impose that a positive shock to gross inflows to U.S. corporate securities does not lead to a fall in itself or the real exchange rate. However, based upon economic interpretation and the anecdotal evidence described earlier, we posit that the yield spread should respond negatively to the gross corporate inflow shock. We argue that unanticipated foreign purchases of U.S. corporate debt would reduce corporate yields more than treasury yields, leading to an increase in the spread. These, along with the aforementioned restrictions, are imposed for three months (starting at the impact period).

For both shocks, we impose that the federal funds rate will not respond positively on impact.[16] This restriction in particular rules out the possibility of gross inflows resulting from a domestic contractionary monetary policy shock: which should also induce capital inflows (foreign holdings should go up to the extent that foreign holdings are governed by return considerations) and the dollar would appreciate – but the fed funds rate would rise instead of fall. It also rules out gross inflows that can arise from demand shocks that originate in the U.S., as well as technology shocks that may induce a dollar appreciation – these would also lead to a rise in the fed funds rate instead of a decline.[17]

3.4 Algorithm for Sign Restrictions

The impulse response function for the ith variable with respect to the jth structural shock at a finite horizon h corresponds to the element in row i and column j of

$$\Theta_h = (J\mathbf{B}^h J')A_0^{-1},$$

where $\mathbf{B}$ is the companion form of the coefficient matrices estimated from the reduced-form model in (3), $J \equiv [I_n, 0_{n\times n(p-1)}]$, and A_0^{-1} the structural impact multiplier matrix. Let $L_0 = \text{chol}(\hat{\Sigma})$ be an initial guess of the structural impact multiplier matrix, A_0^{-1}. Then, candidate draws for Θ_h (denoted as L_h), are constructed from the estimated values of the reduced-form

[15] Baele et al. (2020) identify flight to safety episodes that could have lead to increased global investments in the U.S. bonds. March 2007 was a period identified as one such episode in their work. This coincided with a 75% increase in foreign holdings of U.S. treasuries.

[16] We do not impose dynamic restrictions on the federal funds rate. Warnock and Warnock (2009) shows that while foreign inflows have strong negative effects on longer term yields, the effect on short-term rates is less potent. They argue that this could be a result of the "deepness" of the market. Thus, the negative effect on the short-term rate is expected to be short-lived.

[17] See, for example, Corsetti et al. (2014) who have found that technology shocks may induce a dollar appreciation.

model. Following Arias et al. (2013, 2018), it is convenient to stack the structural impulse response matrices that we want to restrict into a single matrix denoted by $\mathbf{L}$.

The sign restrictions we want to impose on the structural impulse response functions are characterized by selection matrices S_j for $j = 1, \ldots, n$ with one non-zero entry in each row. The number of columns in S_j is equal to the number of rows in $\mathbf{L}$. Moreover, the rank of S_j is the amount of sign restrictions on the impulse response functions associated with the jth structural shock. In particular, the structural parameters satisfy the sign restrictions if and only if $S_j \mathbf{L} \tau_j > 0$ for $j = 1, \ldots, n$ where τ_j is the jth column of the identity matrix I_n. Let Q denote the solution to the QR decomposition of an $n \times n$ matrix whose columns are independent random draws from $\mathcal{N}(0, I_n)$ (Rubio-Ramírez et al., 2010). Then, the algorithm can be summarized as follows:[18]

1. From the posterior distribution of the reduced-form parameters, draw (B, Σ_e).
2. Use Theorem 9 (Rubio-Ramírez et al., 2010) to draw an orthogonal matrix Q. Apply the transformation in Inoue and Kilian (2019) where necessary.
3. Then $L_0 Q$ will be a draw from the posterior distribution of A_0^{-1} before any identifying restrictions are imposed on the implied structural impulse responses (Kilian and Lütkepohl, 2017).
4. Replace L_0 with $L_0 Q$ and recompute $\mathbf{L}$. Keep the draw if $S_j \mathbf{L} \tau_j > 0$ is satisfied for $j = 1, \ldots, n$.
5. Repeat steps 2-4 N times, then return to step 1 until the desired number of draws from the posterior of the structural impulse responses conditional on the sign restrictions has been obtained.

We construct the posterior distribution of the impulse response estimates based on $M = 3,000$ draws from the reduced-form posterior distribution with $N = 100,000$ rotations each.

4 Results

4.1 Responses to gross capital inflow shocks

Figure 2 shows the impulse responses over a 36-month horizon obtained based on the methods described earlier. In particular, the figure shows the posterior point-wise median impulse responses of the variables in the system to a positive shock to gross capital inflows to U.S. treasury securities (top) and U.S. corporate securities (bottom). The red dashed lines represent the corresponding 68% error bands.[19]

[18] See Arias et al. (2013, 2018), Kilian and Lütkepohl (2017) for a more detailed description of the procedure.

[19] It is the conventional approach to report the point-wise median impulse response and the corresponding 68% error bands in the literature. We adopt this approach as a means of exposition, despite concerns about said approach raised by Fry and Pagan (2011), Kilian and Murphy (2012), Inoue and Kilian (2013, 2019), among others.

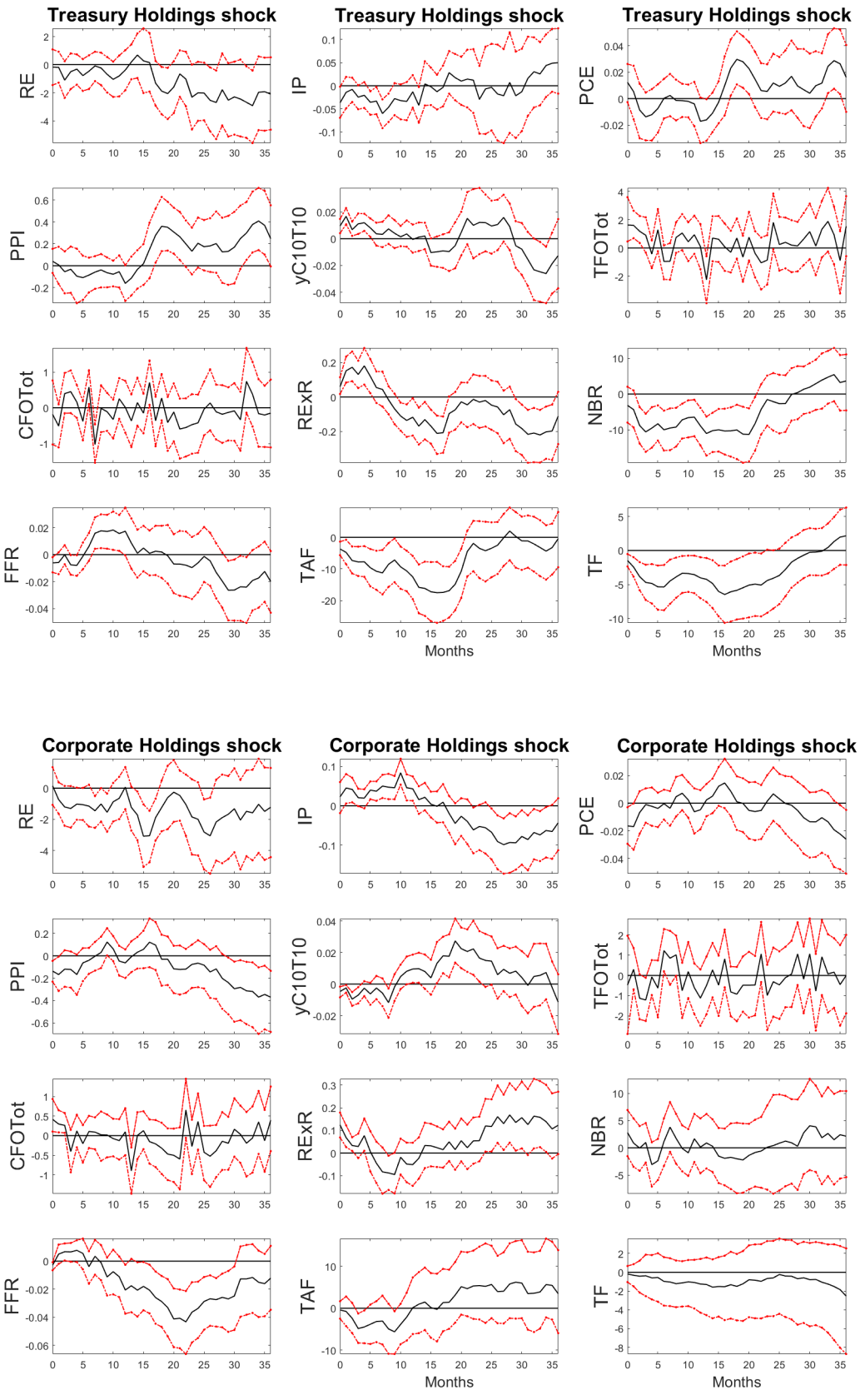

Figure 2: Impulse responses to a positive shock to gross capital inflows to U.S. treasury securities (top) and corporate securities (bottom) in the sign-identified open economy model. The solid black lines represent the point-wise posterior median responses while the red dashed lines depict the 68% point-wise posterior error bands.

The top panel of Figure 2 shows the impulse responses of the endogenous variables to a gross inflow into U.S. treasuries. To begin, we find that a positive shock to a gross inflow into U.S. treasuries has a significant impact on the actions of the Federal Reserve. In particular, the Federal Reserve reduces the size of its balance sheet by selling treasury securities in response to such shocks for the first 20 months following the shock. In addition, there is a median decline in nonborrowed reserves over the same time frame in the aftermath of the shock. Though the federal funds rate falls immediately after the shock, it increases in about 6-12 months following the shock before falling 29-32 months after the initial shock.

Turning to the impact of such shocks on the yield spread, there is also an increase in the spread for about 6 months following the shock. In terms of economic activity, there is a median fall in output for about a year with a robust increase in consumer prices about 18-20 months after the shock. There is no real median change in producer prices on impact, but it increases between 18-20 and 31-36 months after the shock. The exchange rate increases for about 6 months after the shock before becoming negative.

What is the transmission mechanism of gross inflows to U.S. treasury securities to economic activity? In the case of treasury inflows, there is an increase the real exchange rate that occurs. Presumably this dollar appreciation may lead to an increase in demand for foreign goods which lowers domestic aggregate demand. The rise in the yield spread suggests that the return on riskier assets relative to safer ones increases, meaning more costly investment and less investment demand. This result aligns with López-Salido et al. (2017) who find that the widening of the credit spread is closely associated with a reduction in economic activity.[20]

This could be offset by the decline in the federal funds rate, which would increase investment and raise aggregate demand. Given the relatively minute change in the federal funds rate on impact (and 3-4 months after the shock), one could argue that the exchange rate effect dominates and leads to lower output. In particular, Blanchard et al. (2017) note that if the policy rate is relatively unchanged, inflows lead to an appreciation and a contraction in output. Nonetheless, the effect of rising credit spreads and the exchange rate are presumably more dominant and lead to a decline in output. In particular, Culp et al. (2018) argues that higher credit spreads can result in lower asset prices and a fall in output via the financial accelerator mechanism.[21] Yet, as we have already stated, the increase in the exchange rate leads consumers to demand more foreign-produced goods and substitute away from domestically produced goods. This substitution leads to lower production and thus, less output.

The bottom panel of Figure 2 shows the impulse responses to a positive shock to gross foreign flows into U.S. corporate securities. In this setting, the Federal Reserve's balance sheet exhibits a muted response to such shock. Particularly, the median response of the treasury holdings

[20] López-Salido et al. (2017) propose a different mechanism for this result. In particular, they argue that when sentiment proxies (such as credit spreads) indicate that credit risk is aggressively priced, it tends to be followed by a subsequent widening of credit spreads. This is then followed by declining net debt issuance and rising net equity issuance, consistent with a reversal in credit-market conditions leading to an inward shift in credit supply. This in turn lowers economic activity. Du and Rousse (2018) also find that foreign inflow shocks that raise the credit spread lowers output.

[21] See Bernanke et al. (1994, 1999), among others.

of the Fed and the total assets of the Fed's balance sheet are close to zero on impact. The total assets of the Fed's balance sheet falls about 3 and 9 months after the shock, respectively, but its effect diminishes rather quickly. The federal funds rate falls on impact, but increases 3-5 months after the shock before declining about 18-30 months after the shock. The spread between the 10-year corporate and treasury yields declines for about 8 months following the shock, before increasing in the next 18-24 months. As it relates to economic activity, there is a short and long run decline in consumer and producer prices, while output increases for about 12 months following the shock before declining 25-32 months after.

What is the transmission mechanism of gross inflows to U.S. corporate securities to economic activity? In the case of corporate shocks, there is also an appreciation of the dollar which might be expected to have a negative effect on domestic aggregate demand as it did in the case of gross treasury inflows. However, the fall in the yield spread suggests that the return on riskier assets relative to safer ones falls, and this stimulates greater investment demand through lower borrowing costs.[22] Moreover, the declining yield spread that gives rise to more investment could also be due to a fall in the cost of financial intermediation.[23] These effects presumably dominate that of the dollar appreciation and lead to more output being produced. In particular, an increase in the direct demand for U.S. corporate debt by foreigners reduces the credit spread, which increases credit supply and investment spending through the financial accelerator mechanism. This, in turn, leads to greater production and hence, more output. Importantly, when investor sentiment changes in the medium term (the yield spread rises 16-22 months after the shock), it is soon followed by declining output (25-32 months after the shock) and lower prices (around 35 months after the shock). This result is in line with the argument put forward by López-Salido et al. (2017) who note that positive investor sentiment today is a sign of future declines in economic activity.

4.2 Does the Federal Reserve respond directly to gross capital inflow shocks?

As we have seen, the type of bond inflow by foreigners can have varying effects on the U.S. economy and the Federal Reserve's balance sheet. Thus, it seems useful to consider what is driving the Federal Reserve's response to the shocks discussed in the previous section. In order to do this, we decompose the response of the total assets of the Federal Reserve to the dynamics triggered by both shocks to gross inflows to U.S. treasury and corporate securities in the spirit

[22]This could also stimulate consumption as people borrow more to spend on consumption goods. Moreover, even if we contend that investors switch from riskier assets to safer assets such as government bonds, the additional government bond holdings would stimulate government spending, thus increasing aggregate demand.

[23]The financial accelerator mechanism can also apply here. In particular, falling credit spreads reduce the cost of lending. As a result, credit can be extended to more borrowers and thus, greater economic activity. Further, Blanchard et al. (2017) note that even if the policy rate is relatively unchanged, inflows may decrease the rate on non-bonds. Blanchard et al. (2017) also note that if banks have net foreign currency liabilities, an appreciation improves their balance sheet position. Banks can lend more, and firms and households can borrow more, both leading to an increase in domestic demand. This increase, in turn, may offset some or even all of the adverse effects of the appreciation on aggregate demand. See also Krugman (2014).

of Kilian and Lewis (2011).[24] In the next section, we discuss the decomposed response to both shocks in turn.

4.2.1 Systematic response to gross treasury inflow shocks

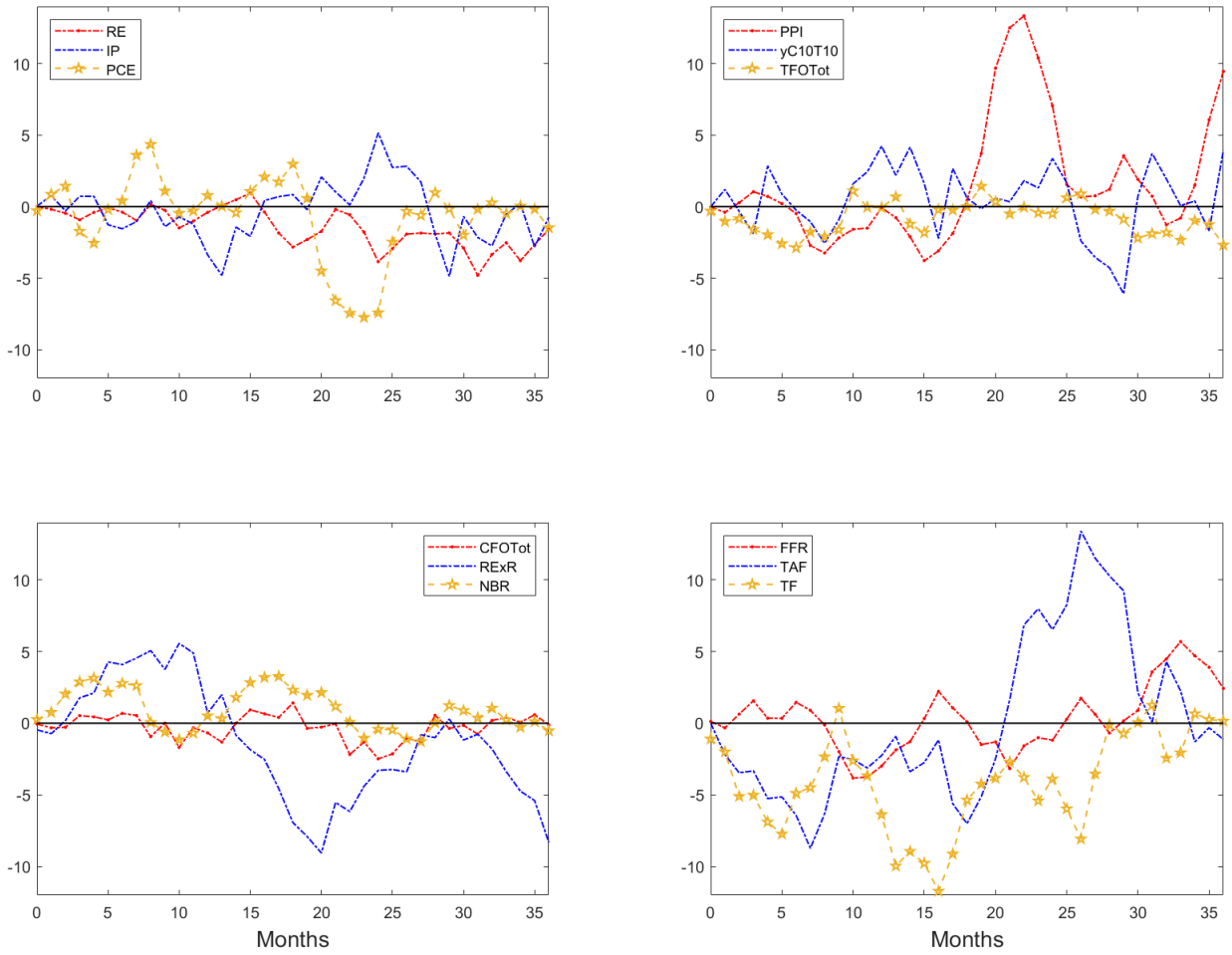

Figure 3: Decomposition of the impulse response of the total assets of the Federal Reserve to a positive shock to gross inflows to U.S. treasury securities. Each line represents the point-wise posterior median decomposition of the Federal Reserve's response to dynamics triggered by the shock to gross inflows to U.S. treasury securities.

Figure 3 shows the point-wise posterior median decomposition of the response of the total assets of the Federal Reserve to dynamics triggered by the shock to gross inflows to U.S. treasury securities. To improve the visibility and readability of the graph, the results are shown in four separate plots. On impact, the total assets of the Fed's balance sheet are largely driven by the

[24] Gambacorta et al. (2014) and Anaya et al. (2017), among others, have shown that shocks to the size of the Federal Reserve's balance sheet can be seen as an unconventional monetary policy shock. In particular, Anaya et al. (2017) cite the fact since the financial crisis, the Fed introduced a plethora of new policy tools that altered the size of the balance sheet. As a result, responses of the Fed's balance sheet to economic events can be seen as unconventional monetary policy response. Over most of our sample, the Federal Reserve engaged in unconventional monetary policy.

median response of the Fed's treasury holdings (as seen in the lower right panel of Figure 3) and the exchange rate (as seen in the lower left panel of Figure 3). The total assets of the Fed are essentially unresponsive to the responses of the other variables in the system, including the treasury shock, as can be seen in the upper right panel of Figure 3.

In the first year following the shock, the Fed largely reduced the total assets of its balance sheet due to dynamics in its own treasury holdings dynamics triggered by the shock. Moreover, dynamics in the exchange rate and consumer prices as a result of the shock were important drivers of the Fed's response. In particular, for about 3-12 months after the shock, the Fed expanded its balance sheet in response to the rise in the exchange rate (possibly to offset its negative impact on domestic demand or to implicitly keep the exchange rate at some target).[25] It had the same reaction to consumer prices 1-2 and 6-9 months after the shock while it reduced its total assets in response to consumer prices 3-5 months after the shock. Apart from nonborrowed reserves (in which the Federal Reserve adds to its balance sheet to offset the decline), the response of the Fed's balance sheet does not seem to be working through any other variable during the first year following the shock. Though there is a steady decline in the Fed's balance sheet in direct response to the treasury shock (perhaps in anticipation that the shock would be expansionary), it is small and there is essentially no direct response to the treasury shock beyond this period.

Over the subsequent years reported in the graphs, the Fed was responding largely to dynamics in the exchange rate, producer prices and its own holdings of treasury securities resulting from the shock. Consumer prices, output and the spread between the 10-year corporate and treasury yield were less important drivers of Federal Reserve's response over this time. In the main, this result suggests that the Federal Reserve did not respond to the shock directly. Put differently, the policy response to the shock was "reactionary" as opposed to "precautionary". That is, the Federal Reserve largely did not respond directly to the shock before it started to have an effect on the other variables.

4.2.2 Systematic response to gross corporate inflow shocks

Here we discuss the decomposed response of the total assets of the Federal Reserve to the dynamics triggered by shocks to gross inflows to U.S. corporate securities. The Federal Reserve's systematic response in shown below in Figure 4.

Figure 4 shows the point-wise posterior median decomposition of the Federal Reserve's response to dynamics triggered by the shock to gross inflows to U.S. corporate securities. In particular, there is little in the form of a direct response to the corporate shock by the Fed's balance sheet (as seen in the lower left panel of Figure 4). Almost all of the response of the total assets of the Federal Reserve on impact is driven by the exchange rate dynamics triggered by the corporate shock. There is essentially no contemporaneous response to any of

[25] Blanchard et al. (2017) point out that the central bank can intervene in the exchange rate market by taking a position opposite to foreigners. In particular, as foreigners decrease their holdings of foreign assets and increase their demand for domestic bonds, the central bank decreases its demand for domestic bonds and increases its holdings of foreign assets. This can offset the effects of inflows on the exchange rate.

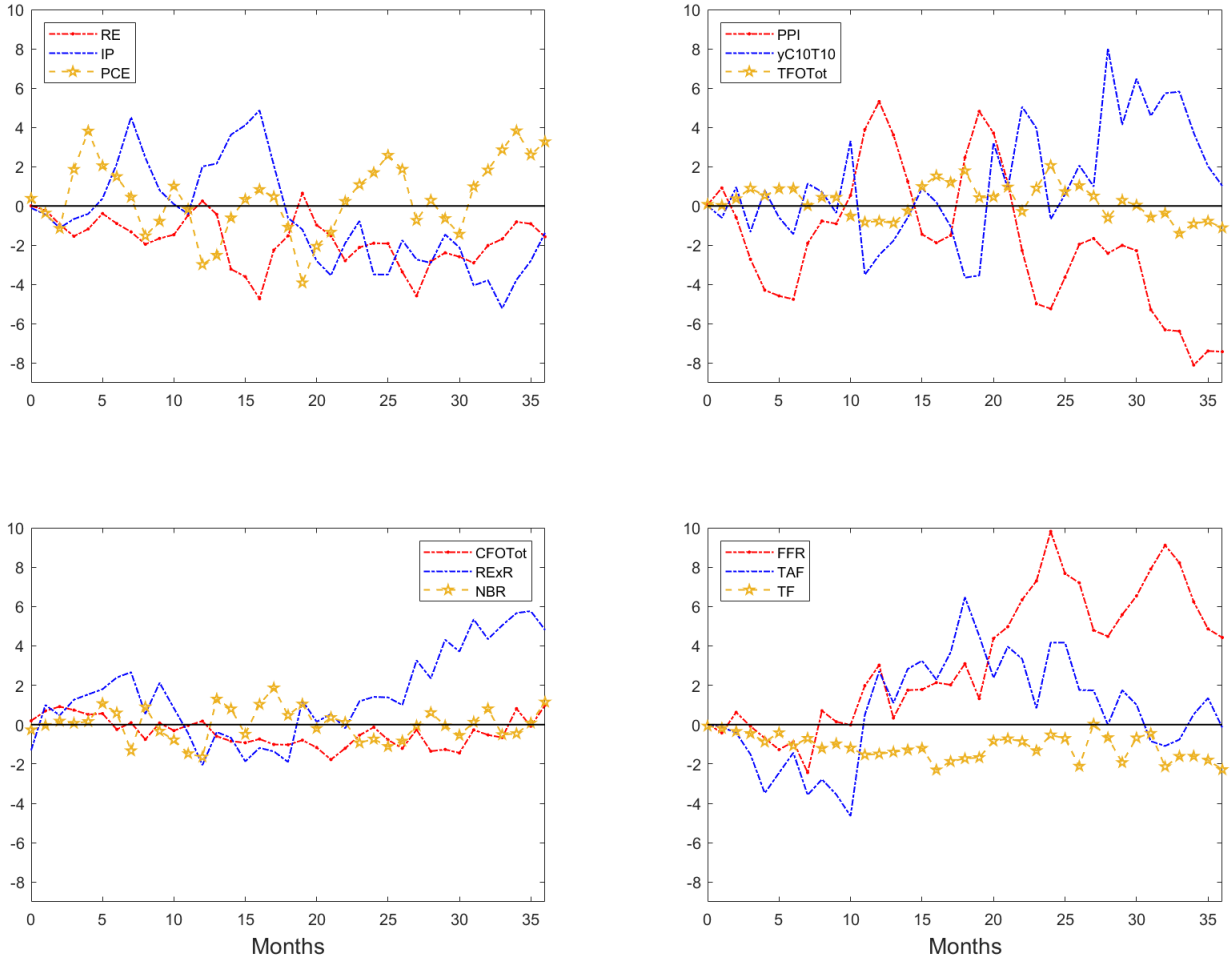

Figure 4: Decomposition of the impulse response of the total assets of the Federal Reserve to a positive shock to gross inflows to U.S. corporate securities. Each line represents the point-wise posterior median decomposition of the Federal Reserve's response to dynamics triggered by the shock to gross inflows to U.S. corporate securities.

the other variables in the system. In the following 9 months after the shock, the dynamics of macroeconomic aggregates as a result of the shock are the largest drivers in the Federal Reserve's response. In particular, the Fed responds to consumer price dynamics 4-8 months after the shock by expanding its balance sheet (as seen in upper left panel of Figure 4). The response to output dynamics were the same about 4 months later (as seen in upper left panel of Figure 4), while it reduced the balance sheet in response to producer price dynamics 4-10 months after the shock (as seen in upper right panel of Figure 4). Again, the result suggests that the Federal Reserve aimed its policies at stabilizing the economy in the face of falling consumer and producer prices (as signified by its positive response to the fall in consumer prices and by responding negatively to the fall in producer prices).

In addition to its own lags, these price dynamics continue to be large drivers of the balance sheet's response well beyond 9 months after the shock. To a lesser extent, dynamics in the spread between the 10-year corporate and treasury yields and the federal funds rate are also

important drivers of the Federal Reserve's response beyond 9 months after the shock. Thus, as in the case with the treasury shock, the response of the Fed's balance sheet seems to work systematically through the response of economic activity to the corporate shock.

With several concerns raised in the mid 2000's about the rise in gross capital inflows, this analysis is important in showing that the Federal Reserve's balance sheet did not respond directly to such shocks but instead, responded largely to changes in macroeconomic aggregates as a result of these shocks. This suggests that the Fed's response to these shocks was reactionary and not precautionary. For instance, the Federal Reserve may not have responded directly to the shocks because it did not see them as having the potential to cause significant fluctuations in economic activity.

4.3 Counterfactual Analysis

In light of the decomposition exercise performed earlier, we move on to construct counterfactual analysis. In particular, does it matter if the Federal Reserve's balance sheet can respond directly to the shocks? How much of a difference does it make? As a benchmark to answer these questions, we examine how certain variables would have responded if the Federal Reserve's balance sheet not been able to respond to shocks to gross capital inflows.

We explore two counterfactuals in this section. Firstly, we follow Kilian and Lewis (2011) to construct a counterfactual where the Federal Reserve's balance sheet is allowed to respond endogenously to the reaction of other variables to the shocks, with only its direct response to the shocks shut down. We refer to this as the KL counterfactual. Secondly, following Bernanke et al. (1997), we construct a counterfactual in which the the total assets of the Federal Reserve's balance sheet is fixed after the shocks occur. In this case, the Federal Reserve's balance sheet does not respond in any way to the dynamics in the other variables in the system. This is known as the BGW (Bernanke-Gertler-Watson) counterfactual.[26]

4.3.1 Counterfactual Analysis for gross treasury inflow shocks

Here we discuss the counterfactual analysis where the total assets of the Federal Reserve (1) do not respond directly to shocks to gross inflows to U.S. treasury securities but is allowed to respond endogenously to the other variables or (2) remains constant. The counterfactuals along with the original median response are shown below in Figure 5.

Figure 5 compares the posterior point-wise median counterfactuals with the median impulse responses to the treasury shock constructed from the procedure described in Section 3. Under the KL counterfactual, shutting down the Fed's direct response to treasury shocks has virtually no effect on economic activity or the federal funds rate, particularly on impact. In particular, the federal funds rate would have only been about a basis point lower on impact, while output and consumer prices would have responded almost the same as when the Fed could respond directly to the shock. Producer prices would have been virtually unresponsive under this

[26] See also Hamilton and Herrera (2004) and Sims and Zha (2006) for a description of the construction of this counterfactual.

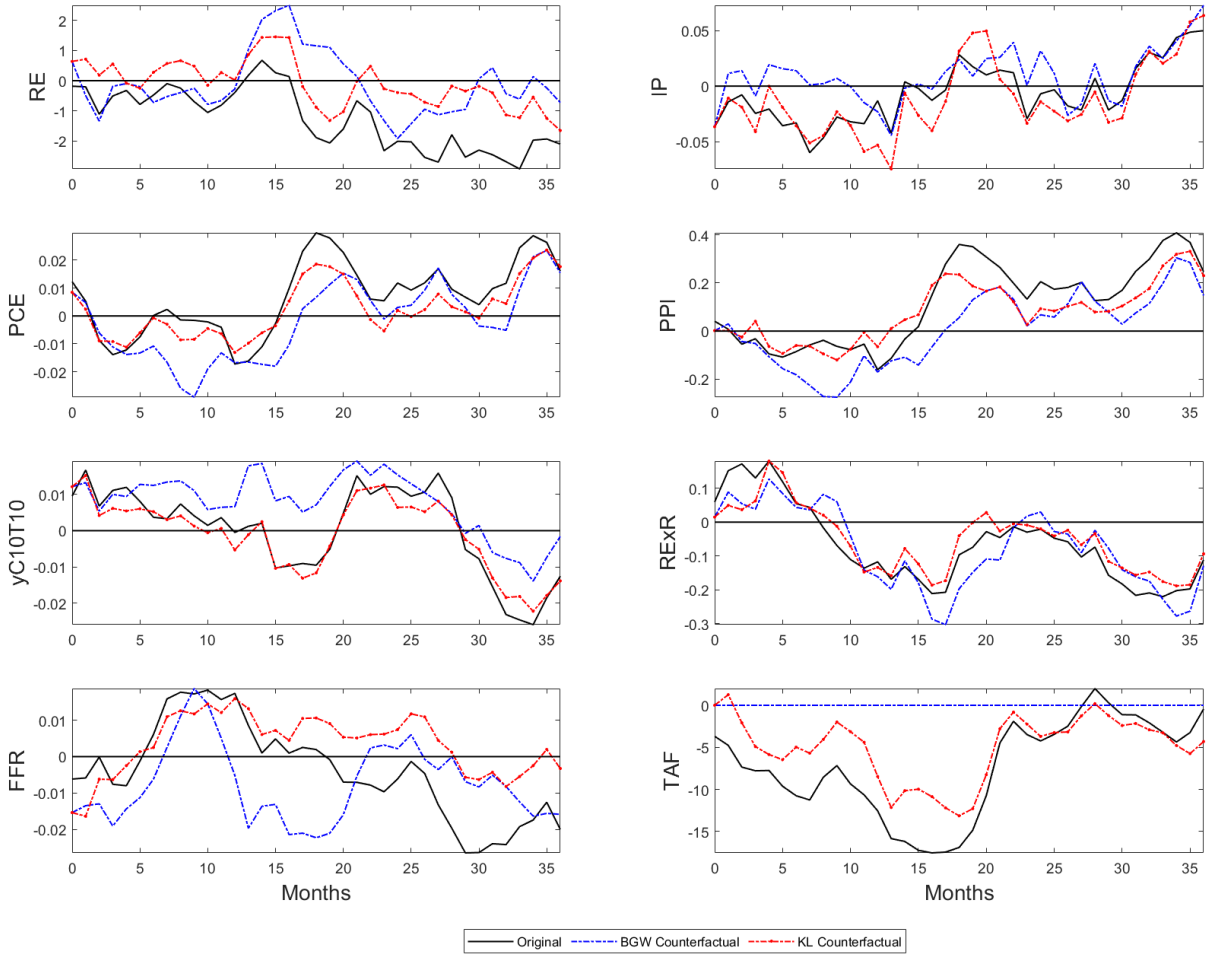

Figure 5: Counterfactual analysis to treasury shocks for selected variables. *Original* refers to the posterior point-wise median impulse response to a positive treasury holdings shock. *BGW counterfactual* refers to the posterior point-wise median counterfactual of holding the total assets of the Federal Reserve constant, while *KL counterfactual* refers to the posterior point-wise median counterfactual of only shutting down the direct response of the Federal Reserve's total assets to treasury shocks.

counterfactual. The exchange rate would have been slightly lower while the yield spread would have been roughly the same.

Absent the ability of the Fed to respond directly to the treasury shock, output would have been lower for about 13 months after the shock while prices follow closely the unrestricted median response over the horizons reported following the shock. For the federal funds rate, it follows the unrestricted median response closely up to about 16 months after the shock. After that, it would have remained positive 18-27 months after the shock (instead of falling). However, output and the federal funds rate would have been slightly higher in the 36 months after the shock.

The total assets of the Federal Reserve's balance sheet would have increased (instead of falling) one month after the shock, but would have fallen thereafter. The median response would have been less aggressive for about 18 months after the shock but still moves closely

with the original response. Beyond 18 months, the Federal Reserve's balance sheet appears to normalize and is practically the same as the original response. This suggests that the Federal Reserve resumed asset purchases (though less than the baseline) which would be expected to lower the real exchange rate because there would be more dollars circulating in the global financial system. This could explain the decline in the real exchange rate over the last twelve months and the long run increase in output.

In the main, these results should not be surprising since the previous section shows that the Federal Reserve's systematic response works through macroeconomic aggregates rather than directly through the treasury shock. Therefore, since the Federal Reserve's direct response was minute, cutting of its ability to respond directly to the treasury shock while being allowed to respond systematically to the other variables in the system would have virtually no impact on the those variables.

Under the BGW counterfactual, the Federal Reserve's balance sheet remains constant by construction. In this case, Figure 5 shows that economic activity would respond more aggressively to the treasury shock at certain horizons which may be expected since the Federal Reserve is not allowed to respond to changes in economic activity. In particular, consumer prices would have been lower 6-9 and 29-32 months after the shock (instead of rising). Otherwise, the response follows the original closely. For producer prices, the response would have been lower in magnitude 3-12 months after the shock while closely following the original response in other periods. Output would have risen 5-10 and 24-25 months after the shock instead of falling while closely following the original response in other periods. The response in real estate lending would have been positive (instead of negative) 18-20 months following the shock.

The yield spread would have responded positively between 14 and 20 months after the shock (instead of falling), while the real exchange rate follows the original median response closely. In addition, the federal funds rate would have responded much more aggressively to the Treasury shock had the Federal Reserve's balance sheet remained constant. For instance, the response would have been negative 12-18 months after the shock (instead of positive) and positive 21-25 months after the shock (instead of negative). The increased variability in the responses of these variables should not be surprising since in this case, since the Fed cannot respond systematically to the dynamics of macroeconomic aggregates triggered by the treasury shock. Nevertheless, these results show the importance of the Federal Reserve having the ability to respond systematically to the treasury shock in stabilizing the economy.

4.3.2 Counterfactual Analysis for gross corporate inflow shocks

Figure 6 compares the posterior point-wise median counterfactuals with the median impulse responses to the corporate shock.

In this case, shutting down the direct response to corporate shocks (KL counterfactual) would have essentially no impact on economic activity. In particular, all variables reported would have responded in the same way, had the Fed been able to respond to the shock. The total assets of the Fed balance sheet would have slightly higher 13-20 months after the shock

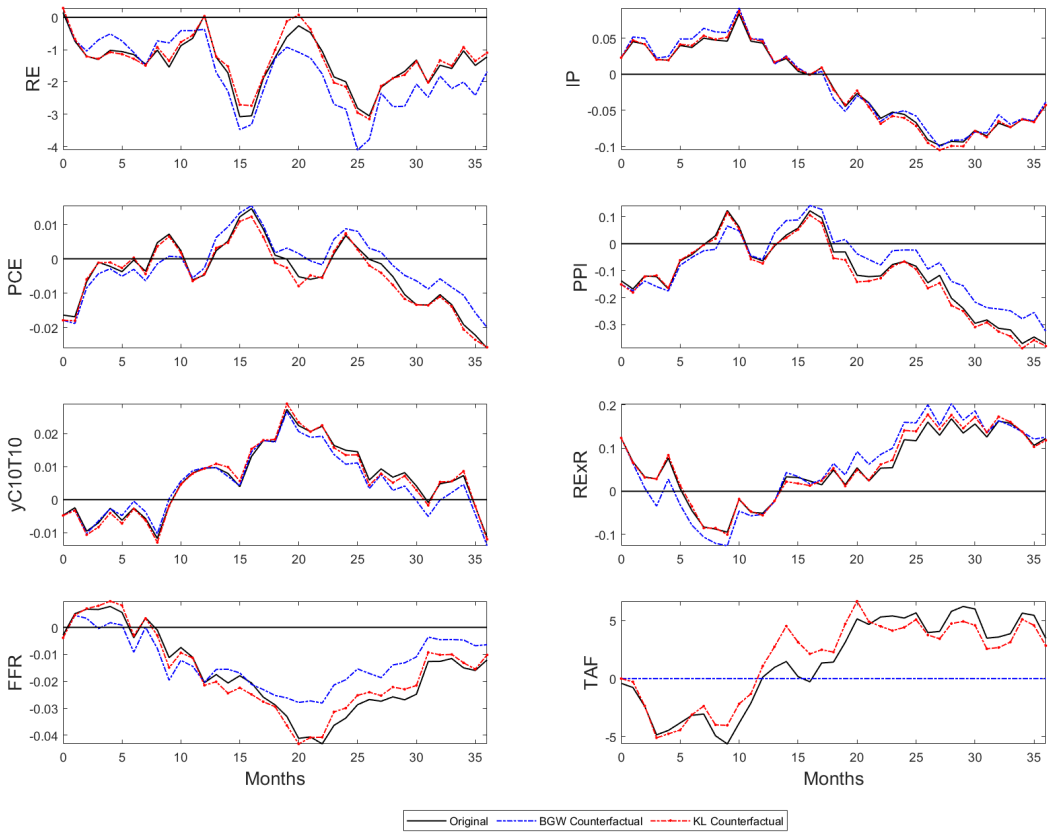

Figure 6: Counterfactual analysis to corporate shocks for selected variables.. *Original* refers to the posterior point-wise median impulse response to a positive corporate holdings shock. *BGW counterfactual* refers to the posterior point-wise median counterfactual of holding the total assets of the Federal Reserve constant, while *KL counterfactual* refers to the posterior point-wise median counterfactual of only shutting down the direct response of the Federal Reserve's total assets to corporate shocks.

and slightly lower 27-36 months from the initial period of the shock.

Under the BGW counterfactual, the Federal Reserve's balance sheet would remain constant in response to the corporate shock by construction. Otherwise, the story is similar to that under the KL counterfactual. In particular, Figure 6 shows that the selected variables move very closely to the unrestricted response to the corporate shock. Real estate lending would have been slightly lower from about 18 months after the shock while prices and the federal funds rate would have been slightly higher.

These results support those from the previous section. In particular, the Federal Reserve's direct response to gross capital inflow shocks was essentially non existent. Consequently, the variables would have responded in a similar manner if the Federal Reserve did not have the ability to respond directly to the shocks. This is because when presented with the opportunity to respond directly to the shocks, the Fed virtually opted against it. Instead, the bulk of the Federal Reserve's response to the shocks is systematic.

4.3.3 The Lucas Critique

A concern of this analysis is that the construction of any counterfactual is subject to the Lucas (Lucas, 1976) critique (Leeper and Zha, 2003; Hamilton and Herrera, 2004; Sims and Zha, 2006, among others). In light of this, Leeper and Zha (2003) develop a framework to examine whether a counterfactual VAR analysis would run afoul of the Lucas Critique. In particular, their framework allows identification of whether linear forecasts are reliable when counterfactual policy actions are implemented. In this manner, one can examine if these counterfactual policy actions would significantly alter beliefs about actual policy actions.

Forecasts computed from a VAR model under a set of policy actions that do not include any impacts due to changes in agents' beliefs are referred to as *direct effects*. Direct effects are calculated as:

$$\nu_{TAF,t+H} = \sum_{i=0}^{H-1} \Theta_i \tilde{w}_{TAF,t+H-i} \tag{5}$$

where Θ_i is the impulse response function at horizon i and $\tilde{w}_{TAF,t+H-i}$ is a vector of counterfactual policy actions. As a result, agents' actions and by extension, the structure of the economy would be largely unaffected. If this is not the case, then *expectations–formation effects* may arise and the counterfactual policy action would induce agents to alter their beliefs under the counterfactual policy action.

To test formally if counterfactuals are subject to the Lucas critique, Leeper and Zha (2003) develop a modesty statistic ($\nu^*_{TAF,t+H}$) that indicates whether direct effects are improbably large relative to their normal historical variation. The statistic is computed by scaling (5) by its standard variation, $\sqrt{\sum_{i=0}^{H-1} \Theta_i^2}$. In particular, the policy surprises that each counterfactual entails is considered to be modest if for horizon H, the absolute value of the standardized direct effect of variable j is less than 2.[27] In this sense, the policy changes needed to implement the counterfactual are small enough not to affect the structure of the economy materially (Kilian and Lewis, 2011).

Table 2 reports the posterior point-wise median modesty statistic obtained from the set of admissible models 36 months ahead. In particular, these statistics are calculated for counterfactual policy actions needed to implement both the BGW and KL counterfactuals for each shock. For each variable in the system, we see that the policy change was modest, since the statistic is less than 2. Consequently, the median counterfactual policy actions would not cause the variables to deviate significantly from their historical paths.

4.4 Historical Decompositions

Thus far, our results suggest that the Fed had a small direct response to gross capital inflow shocks into treasuries and essentially no direct response to corporate shocks. However, we are

[27] See Leeper and Zha (2003) for a more detailed discussion. See also Hamilton and Herrera (2004) who use this method to assess results in Bernanke et al. (1997).

Table 2: Modesty statistics for Counterfactuals

	$\nu^*_{TAF,t+H}(H=36)$			
	Treasury Shock		Corporate Shock	
Variable	BGW	KL	BGW	KL
RE	-1.0425	0.0042	0.6998	-0.0291
IP	0.1468	0.0490	-0.6267	0.0709
PCE	0.2757	-0.0865	0.4390	0.0348
PPI	-0.3432	-0.0852	0.1019	0.0494
yC10T10	-0.4374	0.0777	0.9702	-0.0855
TFOTot	-0.6684	0.0252	0.1376	-0.0370
CFOTot	0.1139	0.0144	-0.0633	0.0166
RExR	-0.7265	0.0904	0.1124	-0.0111
NBR	-0.0562	-0.0624	-1.9322	0.0053
FFR	-1.8862	0.0764	0.4015	-0.0526
TAF	1.7206	0.0618	-0.9956	-0.0623
TF	-0.2837	-0.1043	-1.7600	0.1116

BGW refers to the posterior point-wise median modesty statistic for each variable under the counterfactual of holding the total assets of the Federal Reserve constant with respect to treasury and corporate shocks 36 months ahead, while *KL* refers to the posterior point-wise median modesty statistic for each variable under the counterfactual of only shutting down the direct response of the Federal Reserve's total assets to both shocks over the same horizon.

now concerned with the historical contribution of the Fed's response to fluctuations in economic activity at certain points in time. To do this, we construct the historical decompositions as counterfactuals. The counterfactual series indicates how the variable of interest would have evolved, had one been able to replace all realizations of the Federal Reserve's response to each shock by zero, while preserving the remaining endogenous responses in the model. Therefore, in this section, we look at the historical contribution of the Federal Reserve's response to each shock to economic activity, the federal funds rate, and the Fed's balance sheet. We discuss these next.

4.4.1 Historical Decomposition of the Federal Reserve's response to gross treasury inflow shocks

The top panel of Figure 7 compares the posterior point-wise median historical counterfactual with the actual series between January 2004 and December 2007 – before the global financial crisis.[28] The counterfactuals show that in the absence of the Federal Reserve's response to the treasury shock, macroeconomic aggregates would have been essentially the same for much of the period considered. In particular, real estate lending would have been virtually the same up to January 2007, only being slightly higher after that. This means that the Federal Reserve's response to the shock lowered real estate lending. Output would only have been marginally

[28] In a separate exercise not reported to conserve space, we use the federal funds rate as the monetary policy tool before the global financial crisis and analyze the posterior point-wise median historical contribution of its response to the shocks to fluctuations in the variables. The results show that the policy response the shocks would virtually have no impact on the historical paths of the variables in the system.

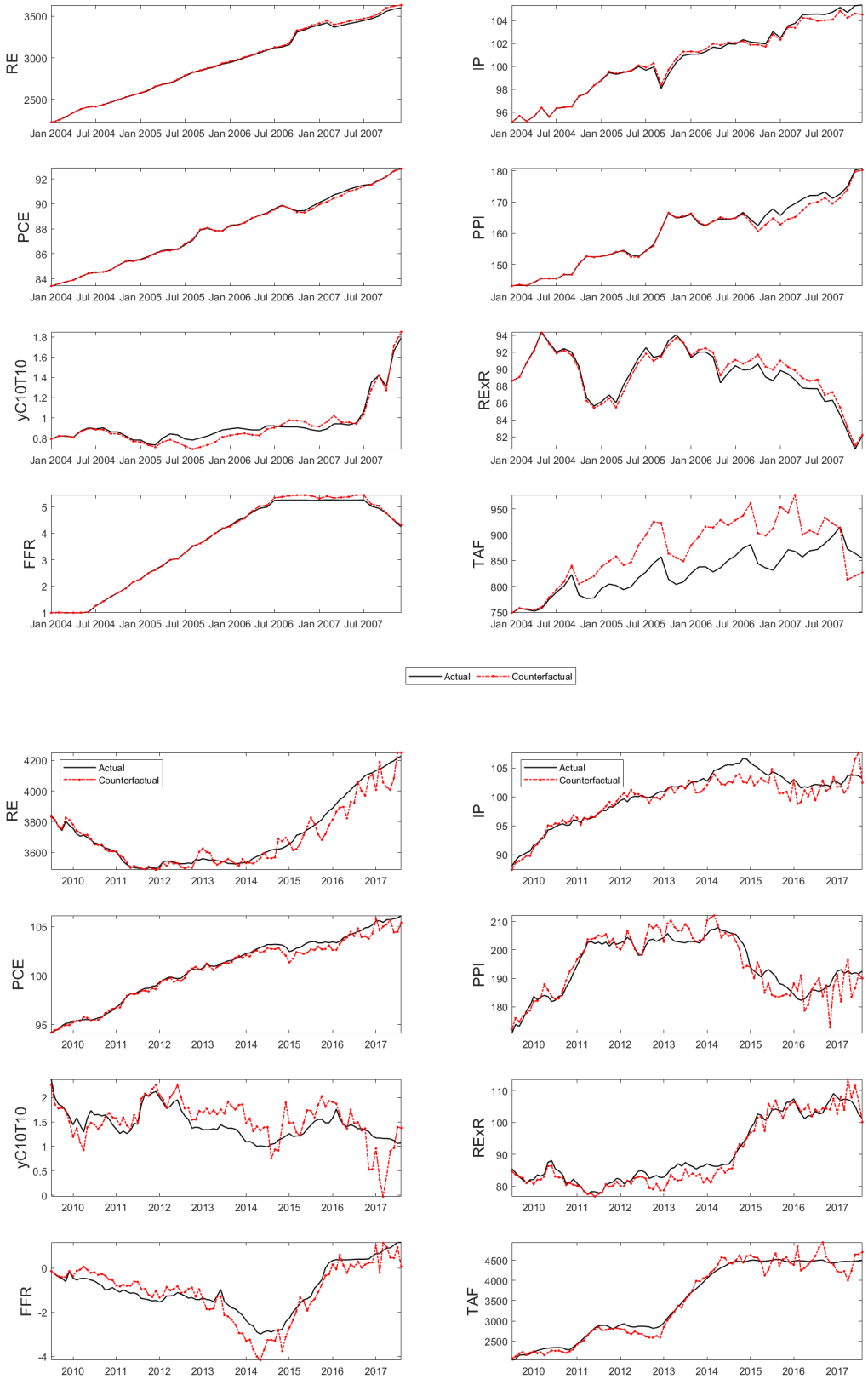

Figure 7: Historical counterfactual for selected variables for the Federal Reserve's response to treasury shocks before (top) and after (bottom) the global financial crisis. *Actual* refers to the observed series, while *Counterfactual* refers to the posterior point-wise median historical counterfactual of essentially replacing all realizations of the Federal Reserve's response to the treasury shock by zero, while preserving the remaining responses to the shock in the model.

higher between May 2005 and May 2006 (which means the Fed's response to the shock lowered output) and slightly lower after January 2007 (which means the Fed's response to the shock raised output). However, prices would have been relatively lower from December 2006 - August 2007 (which suggests that the Fed's response to the shock helped to keep prices high).

The yield spread would have been lower from March 2005 - June 2006 (which means that the Fed's response to the shock kept it high) and would have been higher between August 2006 and April 2007. The real exchange rate would have been marginally lower between June 2004 and October 2005, and slightly higher between February 2006 and August 2007.

The federal funds rate would have been virtually unaffected up until June 2006, where it would have been slightly higher before rates started to fall in late 2007. In this manner, the Federal Reserve's response to the treasury shock kept the federal funds rate from increasing further at this point in time. The total assets of the Fed would have been much higher between September 2004 and June 2007 in the absence of its response to the treasury shock. At these points in time, the Federal Reserve's response to the treasury shock shrunk the Fed's balance sheet. In late 2007, the Fed's response to the shock increased the size of its balance sheet.

In contrast, the bottom panel of Figure 7 compares the posterior point-wise median historical counterfactual with the actual series between July 2009 and August 2017 – after the global financial crisis. It shows that in the absence of the Federal Reserve's response to the treasury shock, macroeconomic aggregates would have been slightly different and more volatile in specific periods. For example, real estate lending would have been consistently lower from September 2015 - January 2017, and from March - June 2017. Likewise, output would have been lower from September 2013 - August 2016 (with the only exception being July 2015). Consumer prices would have been lower from December 2013 - May 2016, while producer prices would have been lower in the latter half of 2014 and 2015. In this manner, the Federal Reserve's response to the treasury shock kept these variables high during these periods.

While the Fed's response to the treasury shock kept the yield spread high about a year after the global financial crisis (presumably by keeping interest rates low), its response to the shock kept the spread consistently lower for the next 6 years (with the notable exception being August - October 2014). This coincided with the Taper Tantrum episode, as the Fed announced that it was slowing down its asset purchases. From November 2009 - August 2014, the Fed's response to the shock kept the real exchange rate high when compared to what it would have been absent the policy response. Since then, the Fed's response to the treasury shock has had a negligible impact on the real exchange rate.

Absent the monetary policy response, the shadow rate would have been higher up to December 2012, but would have largely been lower since then. The total assets of the Fed would have been marginally lower from February 2010 - April 2013 (suggesting that the policy response to the treasury shock increased the size of the Fed's balance sheet), and much more volatile since then.

4.4.2 Historical Decomposition of the Federal Reserve's response to gross corporate inflow shocks

The top panel of Figure 8 compares the posterior point-wise median historical counterfactual with the actual series between before the global financial crisis. The counterfactuals show that in the absence of the Federal Reserve's response to the corporate shock, macroeconomic aggregates would have been essentially the same for almost the entire period considered. In particular, real estate lending and consumer prices would have essentially been unchanged over the period. This suggests that the Federal Reserve's response to the corporate shock had no impact on these variables. Output would have been slightly lower in 2007 and producer prices would have been marginally higher from June - December 2007.

The federal funds rate would have been relatively higher than 5.25% from June 2006 - April 2007, but otherwise, no real difference. Additionally, the Federal Reserve's response to corporate shocks had no major difference compared to the evolution of the total assets of the Fed's balance sheet up until March 2005. Since then, the total assets of the Fed would have been lower in the event that there was no direct response to the corporate shock. In this manner, its direct response to the corporate shock increased the size of the Fed's balance sheet.

Alternatively, the bottom panel of Figure 8 compares the posterior point-wise median historical counterfactual with the actual series after the global financial crisis. In terms of macroeconomic aggregates, the results are mixed. For example, real estate lending would have been largely higher from April 2010 - July 2015 and August 2016 - 2017. In this manner, the Fed's response to the corporate shock kept real estate lending low during these periods. A similar story holds for output from July 2009 - August 2010, while it would have been more volatile since then. Apart from being slight higher between November 2015 and December 2016 (and lower from January - August 2017), consumer prices would have been largely unchanged in the absence of Federal Reserve's policy response to the corporate shock. The same could be said for producer prices between April 2015 and September 2016 (and November 2016 - August 2017).

The yield spread would have largely been lower between April 2014 and October 2015, and from September 2016 - May 2017. In this manner, the Fed's response to the corporate shock increased the yield spread during these periods. The spread would have been relatively unchanged in other periods in the absence of the monetary policy response. The real exchange rate would have been largely higher between October 2010 and March 2014, which means that the Fed's response to the corporate shock depreciated the value of the dollar during these periods. In other periods, the Fed's response to the shock had virtually no impact on the real exchange rate.

The shadow rate would have been slightly lower from July 2015 - January 2017 in the absence of the Federal Reserve's response to the corporate shock (which means the response helped to raise rates), while it was relatively unimportant in other periods after the crisis. The total assets of the Fed's balance sheet would have been slightly higher up to March 2014, and between May 2015 to the end of the sample (suggesting that Fed's response to the corporate shock reduced its balance sheet), while being slightly lower in other periods (which suggests

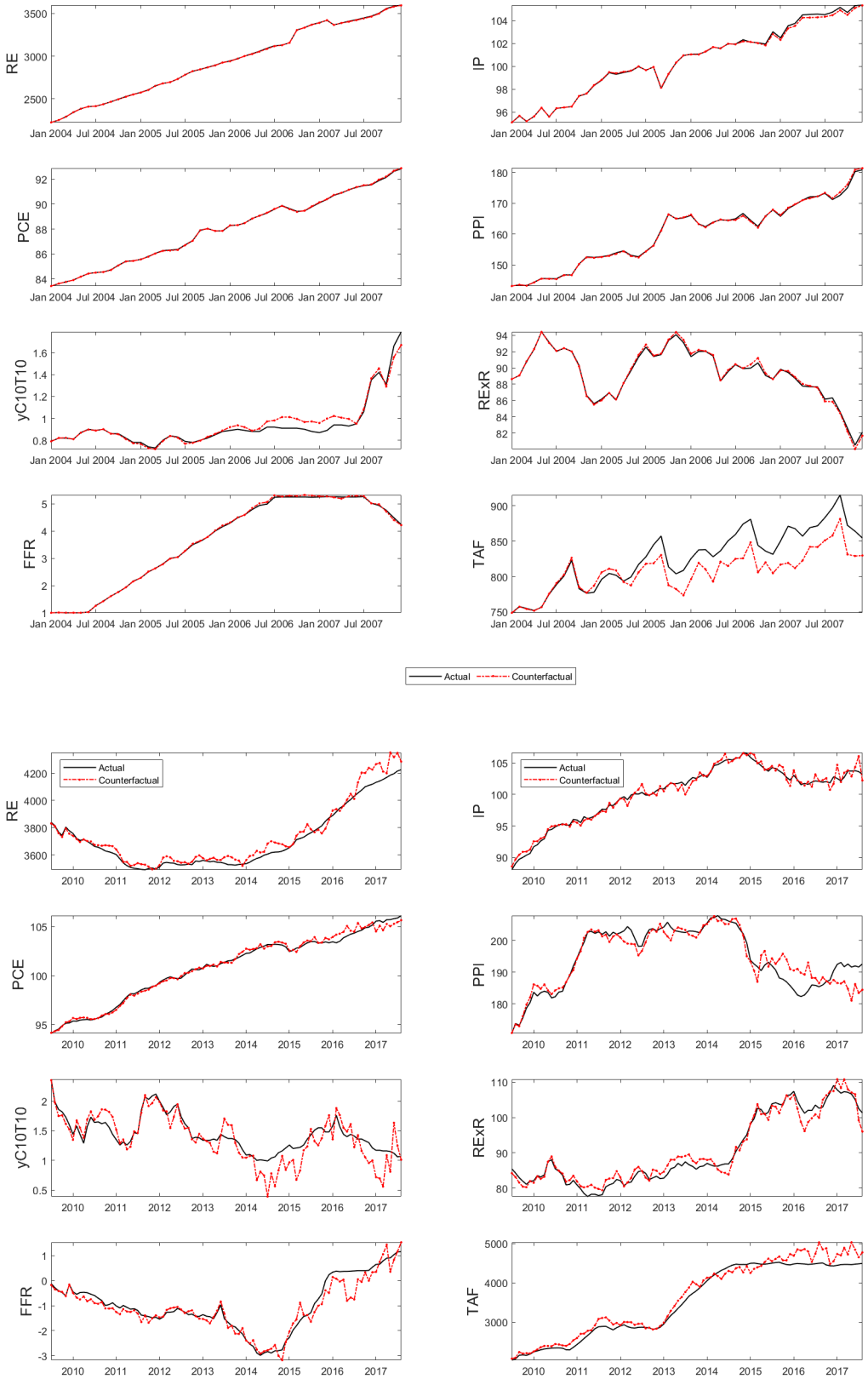

Figure 8: Historical counterfactual for selected variables for the Federal Reserve's response to corporate shocks before (top) and after (bottom) the global financial crisis. *Actual* refers to the observed series, while *Counterfactual* refers to the posterior point-wise median historical counterfactual of essentially replacing all realizations of the Federal Reserve's response to the corporate shock by zero, while preserving the remaining responses to the shock in the model.

that the policy response contributed to an increase in the Fed's balance sheet).

4.5 What is the role of monetary policy in the face of gross capital inflow shocks?

There were several concerns raised about the rising current account deficit in the U.S. fueled in large parts by capital inflows to treasury and corporate securities in the mid 2000's (see Bernanke, 2005, among others). Despite this, the historical counterfactuals in the previous section show that Federal Reserve's policy responses to these inflows was not a major contributor to economic activity in the mid 2000's. In particular, the Federal Reserve's responses to these inflows in cooling an overheating economy at the time were negligible. Moreover, there is no evidence that U.S. economic activity would have been much different in the mid 2000s. Consequently, the results suggests that monetary policy reactions to gross inflow shocks have only a minor role (if any) in the evolution of macroeconomic variables during this time.

Since the global financial crisis, an absence of the Federal Reserve's response to these inflows would have lead to more variable fluctuations in economic activity. Moreover, we observe that an absence of the Federal Reserve's responses to these inflows would have lead to the most distinct fluctuations in the credit spread since the crisis. In particular, the Fed's response to these shocks lowered credit spreads, which would mitigate a decline in economic activity by increasing credit supply (see López-Salido et al., 2017; Culp et al., 2018, among others). Despite this, economic activity followed the same path (albeit with more volatility) in the absence of the policy response to these shocks. The results suggest that even though the Fed has taken these inflows more seriously after the financial crisis, its responses to these shocks (though easing economic uncertainty) still play a minor role in fluctuations to economic activity.

4.6 Robustness Checks

We employ several robustness checks. In particular, it is well known that up until the great recession of 2007-2009, the literature has concurred that the federal funds rate has been essentially controlled by the Federal Reserve (see, for example, Bernanke et al., 1997; Bernanke, 2005, among others). Therefore, we find it useful to perform the same exercises with the federal funds (shadow) rate as the policy response variable instead of the total assets of the Federal Reserve. Our results are largely unaltered.

To account for a possible "flight to safety" as well as to capture stress in financial markets, we replace real estate lending with the VIX index and the results from the impulse responses are largely the same. As an alternative robustness check, we exclude foreign official holdings of U.S. securities from the gross capital inflows and recalculated the posterior impulse response functions. The response to both shocks were largely unaltered.[29]

[29] In particular, Warnock and Warnock (2009) note that foreign officials may not be keen on corporate bonds due to a lack of interest in doing business with foreign corporations. However, what makes our results more compelling is that despite the fact that foreign officials hold the majority of treasury holdings held by all foreigners (Warnock and Warnock, 2009), our results are still proven to be robust.

Alternatively, we exclude foreign private holdings of both assets from the gross inflows and the impulse responses are largely unaffected.[30] This is important because it implies that the economy does not differentiate between the type of holder of the asset (whether private or public), but instead between the type of asset held (treasury or corporate).

5 Conclusion

In this paper we employ disaggregate data in a SVAR framework to examine how economic activity and the Federal Reserve respond to gross capital inflows to U.S. treasury and corporate securities. To begin, we find that the type of bond inflow by foreigners can have varying effects on the U.S. economy and the Federal Reserve's balance sheet. In particular, gross inflows to U.S. treasuries lead to rising credit spreads, an appreciation of the dollar, and declining output. Moreover, the Federal Reserve shrinks its balance sheet in response to shocks to gross capital inflows to U.S. treasury securities. Contrarily, gross inflows to U.S. corporate securities result in reduced credit spreads and increasing output. The Federal Reserve's balance sheet exhibits little to no response to this shock.

We further investigate the Federal Reserve's systematic response to both shocks. In doing so, we find that the Fed exhibited very little in the way of a direct response to treasury shocks. Instead, most of the Fed's response was systematically working through the response of macroeconomic aggregates to such shocks. Put differently, the policy response to the shock was "reactionary" as opposed to "precautionary". This result was even more stark when analyzing the Fed's systematic response to corporate shocks. In particular, there was virtually no direct response to the corporate shock, with the bulk of its response working through the response of macroeconomic aggregates to the shock.

Counterfactual analyses show that since the Federal Reserve's direct response was minute, cutting of its ability to respond directly to the treasury shock while being allowed to respond systematically to the other variables in the system would have virtually no impact on the those variables. However, when the Fed is not allowed to respond endogenously to the response of other variables to the treasury shock, those variables experience increased variability in their responses. In the case of the gross inflow shock to U.S. corporate securities, the variables would have responded in a similar manner if the Federal Reserve did not have the ability to respond directly to the shocks. This is because when presented with the opportunity to respond directly to the shocks, the Fed virtually opted against it.

To this end, historical counterfactuals show that the policy response did very little to impact fluctuations in macroeconomic aggregates – particularly before the global financial crisis. The Federal Reserve's responses to these inflows in cooling an overheating economy in the mid 2000's were negligible. In the aftermath of the global financial crisis, the Federal Reserve's response to these shocks reduced variability in the evolution of macroeconomic aggregates. Regardless, its responses still play a minor role in fluctuations to economic activity.

[30]The results from these robustness checks were not reported because of their similarity to the main results and space constraints. However, they can be made available upon request.

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