Global Effects of U.S. Monetary Policy: Is Unconventional Policy Different?

By Travis J. Berge and Guangye Cao

The Federal Reserve Open Market Committee's (FOMC) announcement following its meeting on September 18, 2013, moved stock and bond markets worldwide. In the United States, the yield on 10-year Treasury bonds fell nearly 20 basis points in the hours following the announcement while stock prices surged higher—the S&P 500 jumped 1.2 percent. The effects of the announcement were not limited to the United States. The value of the dollar dropped during the afternoon of September 18, falling more than 1 percent against the euro and the Japanese yen, and more than 2 percent against emerging economy currencies. The Brazilian stock market added 2 percent on the news, as did Asian markets when they opened the following day. Although market participants were uncertain about what the outcome of the meeting would be, the reaction to the post-meeting announcement was striking, particularly considering that the FOMC did not change policy that day.

This article evaluates whether the reaction of asset markets on September 18 was a typical response to Federal Reserve policy. In a world with free mobility of capital, an unanticipated monetary policy action within the United States will affect asset prices both in the United States and outside of the country, as investors arbitrage away price differentials between assets with similar risk/reward characteristics. A closely related question is whether the reaction of asset prices to monetary policy

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is different at the zero lower bound. Since 2008, the conventional tool for monetary policy in the United States—the federal funds rate—has been near zero. As a result, the Federal Reserve has turned to unconventional monetary policies to provide additional accommodation. These unconventional policies may have altered the response of asset prices to Fed policy. To that end, the analysis compares the response of international asset price changes to unanticipated monetary policy actions before and after the federal funds rate hit the zero lower bound.

The analysis shows that a change in monetary policy in the United States is associated with movements in a variety of asset prices, both in the United States and abroad. Evidence of a change in the behavior of asset prices at the zero lower bound is mixed. The responses of asset prices within the United States to monetary policy do not appear to be different at the zero lower bound. However, some international asset prices do appear to react differently to policy announcements after 2007. Most notably, the response of exchange rates to monetary policy has been more volatile since the zero lower bound began to constrain conventional policies.

The analysis proceeds in two steps. The first step, described in Section I, develops a measure of monetary policy changes. Importantly, the measure of monetary policy remains valid even when the federal funds rate is constrained by the zero lower bound. The second step, described in Section II, relates the measure of monetary policy changes to movements in international asset prices. The results of the analysis are discussed in Section III.

I. MEASURING MONETARY POLICY SURPRISES

Movements of prices in the federal funds futures and Eurodollar markets on policy announcement days are used to detect unanticipated changes to policy, or monetary policy surprises. This section describes events used to isolate policy surprises and shows how price movements in federal funds futures and Eurodollar markets can be used to extract a markets-based measure of policy surprises.

Identifying monetary policy surprises poses several analytical challenges because the Federal Reserve sets policy contingent on the state of the economy. Since market participants can infer the state of the economy, they can, at least in part, anticipate monetary policy changes.

Identifying monetary policy surprises today is further complicated by the fact that policy is constrained by the zero lower bound. Following the financial crisis in the fall of 2008, the FOMC moved the federal funds rate target to near zero. Due to the sluggish recovery, and because the federal funds rate cannot turn negative, the FOMC has turned to unconventional monetary policy—forward guidance and asset purchases—to support the economy.

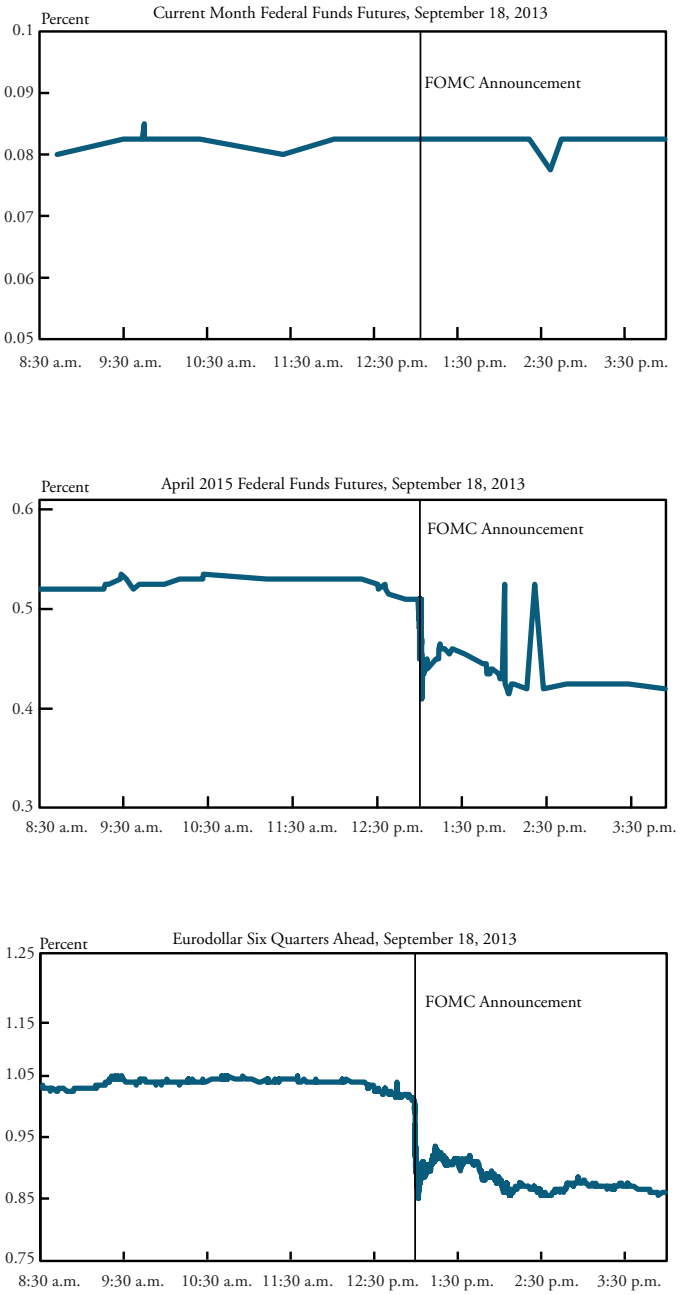
A statistical model is used to isolate policy moves that were unanticipated by financial markets. Importantly, the model can identify policy surprises even when the federal funds rate is zero. Policy surprises are extracted from changes in the prices of financial contracts with payoffs that depend directly on the realization of current and future Federal Reserve policy.[1] The prices of federal funds futures contracts are a common tool to measure market expectations for monetary policy. A federal funds futures contract is a financial contract with a payoff that depends on the average realized federal funds rate for the month on which the contract is based.[2] Thus, the surprise component of a change to monetary policy can be measured by the change in the price of the futures contract before and after an FOMC meeting.[3] Before an FOMC meeting, the price of the contract is assumed to fully incorporate market expectations of FOMC policy so that any change in the price of a federal funds futures contract following a policy announcement reflects the unanticipated change in the federal funds target rate.

The top panel of Chart 1 illustrates such a change. The chart shows the price of the current-month federal funds futures contract on September 18, 2013, the date of the FOMC meeting described in the introduction. That there is no noticeable change to the current-month federal funds futures contract at the time of the FOMC announcement is no surprise. With policy constrained by the zero lower bound, markets did not expect the federal funds rate to change. However, monetary policy announcements can also carry information relevant to the federal funds rate in coming months. This is particularly true at the zero lower bound.

The middle panel of Chart 1 shows the movement in the federal funds futures contract for April 2015, a bit more than six quarters into the future. The bottom panel shows the interest-rate response on a six-quarters ahead Eurodollar contract, a financial contract similar to

Chart 1

CHANGE IN FEDERAL FUNDS FUTURES AND EURODOLLAR FUTURES ON SEPTEMBER 18, 2013



Source: Bloomberg.

federal funds futures contracts. In contrast to the current month fed funds futures rate, the price of these assets, which are closely related to expected future monetary policy, *did* move on September 18. The movement of the asset prices in the middle and bottom panels reveals that the FOMC's action altered expectations for the future path of policy even though the current federal funds rate target was not changed.

Identifying monetary policy surprises by looking at short-term reactions of asset prices is an example of an event study. Event studies measure the effect of monetary policy surprises by looking at the reaction of prices around a predefined window of the policy action. Two assumptions underpin event studies. First, event studies only measure price changes that occur within the specified window. To the extent that price changes reflect market reactions to information about monetary policy received before or after the window, event studies may misstate the true effect of the monetary policy surprise on asset prices.[4] The application in this article assumes a one-day window. Thus, asset price changes are calculated as the difference in the closing price the day of a FOMC announcement relative to the previous day's close. The second assumption is that no other market-moving news occurs during the window. This assumption is also clearly not true—other market-moving data are released on the dates of FOMC policy announcements. However, the sample is large enough that there should be enough days with "negative" news as "positive," so that on average one day provides an appropriate window for studying policy surprises.

Finally, prior to undertaking the analysis, the events also must be defined. All days on which the FOMC issues a press release with a monetary policy announcement are included in the sample. In addition, since communication is important at the zero lower bound, other days on which key communication took place are included in the event study. Doh and Connolly and Rosa find that the minutes from FOMC meetings contain market-moving information. Release dates of the minutes are therefore included as events. A handful of other events are also included in the study, such as dates of important policy speeches given by Chairman Bernanke. The data used here follow those of Doh and Connolly and include all FOMC policy-relevant dates between January 1994 and September 2013.[5]

Chart 1 shows that FOMC press releases affect expectations for future policy. In measuring the true information content of a monetary policy change, a measure of monetary policy surprises must account for changes in market expectations for the current federal funds rate as well as for the future path of the federal funds rate. The method of Gürkaynak, Sack, and Swanson explicitly measures the change in the prices of a variety of assets that depend on expectations of both current and future policy.

Specifically, instead of looking only at the change in price of the current-month federal funds futures contract (the top panel of Chart 1), Gürkaynak and others also calculate the change in the prices of contracts into the future, such as the Eurodollar contract shown in the bottom panel. The analysis in this article looks at price changes in current-month federal funds futures contracts, one-month ahead federal funds futures contracts, as well as Eurodollar futures contracts up to nine quarters into the future.[6] In total, the data set includes 10 assets that depend closely on current and future federal funds rates.

The changes in these 10 asset prices are decomposed into two summary statistics, a *target* factor and a *path* factor.[7] The target factor explains movements in the level of the assets' entire yield curve. The target factor is thus interpreted as the surprise component to a change in the current level of the federal funds rate. The path factor, on the other hand, is constructed so that it is uncorrelated with the target factor. It captures information that markets perceive in FOMC announcements about the future path of the target rate beyond that which is captured by the target factor. These two factors together account for 95 percent of the variation in the set of asset prices considered.

The target and path factors are also scaled to facilitate interpretation. The target factor is scaled so that a 10-point change is equivalent to a 10-basis-point (0.10-percentage-point) change in the implied federal funds rate from the current-month federal funds futures contract. The scaling of the path factor is less intuitive since it captures movements in the expected future path of the federal funds rate. Nevertheless, the path factor is scaled so that a 100-point change in the path factor moves the interest rate on six-quarters-ahead Eurodollar futures about 30 basis points.[8]

Table 1

SUMMARY STATISTICS FOR TARGET AND PATH FACTORS

	Target	Path
Observations	243	243
Mean	0.0	0.0
Standard Deviation	8.1	31.3
Minimum	-66.6	-149.2
Maximum	39.9	96.3

Source: Authors' calculations.

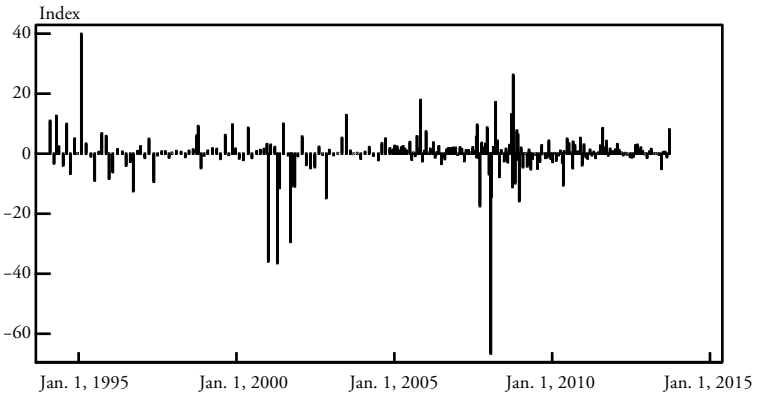
Table 1 provides summary statistics for the two factors. The measures of monetary policy surprise have a mean of zero by construction. But both factors vary considerably: the target factor has a standard deviation of nearly 10 basis points, with a minimum realization of -67 basis points and a maximum of 40 basis points. The path factor also varies considerably.

Chart 2 shows the target factor. The chart shows the tightening cycle of 1994-95 included several unexpected changes to the federal funds rate, while the loosening cycle of 2000-01 included several large unexpected reductions in the target rate during the recession and following the terrorist attacks of September 11, 2001. The top panel of Table 2 lists the dates of the five largest movements in the target factor. These dates reveal the target factor largely corresponds to unexpected movements in the federal funds rate. The largest surprise movement in the target factor occurred in January 2008 during the fervor of the financial crisis. The tightening cycle of 1994 involves a series of large positive shocks to the target factor. The loosening cycle in response to the 2001 recession also contains several surprises.

The path factor is shown in Chart 3, and its five largest realizations are listed in the bottom half of Table 2. The five largest realizations of the path factor indicate the path factor reacts to different information than the target factor. The largest movements are associated with explicit statements about future policy. For example, on December 16, 2008, the FOMC lowered the fed funds target rate to zero to 0.25 percent but also stated that it "is evaluating benefits of purchases of longer-term securities." Similarly, on March 18, 2009, it noted that it "anticipates

Chart 2

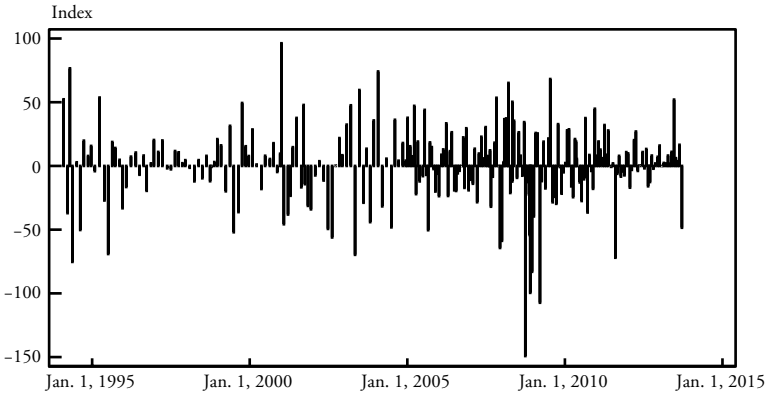
THE TARGET FACTOR



Note: See text for details regarding the scaling of the factor.
Source: Authors' calculations.

Chart 3

THE PATH FACTOR



Note: See text for details regarding the scaling of the factor.
Source: Authors' calculations.

Table 2
LARGEST MOVEMENTS IN TARGET AND PATH FACTORS

Five Largest Movements in Target Factor

Date	Target	Path	Commentary
1/22/08	-67	3	Funds rate lowered by 75 basis points to 3.5 percent. "Appreciable downside risks remain."
2/1/95	40	-4	Increased discount rate 50 basis points on inflation fears.
4/18/01	-36	-23	Lowered federal funds rate by 50 basis points in face of weakening economy.
1/3/01	-36	96	Intermeeting ease of policy; Fed perceived as "ahead of curve" and thus easing less in future.
9/17/01	-29	48	Federal funds rate lowered by 50 basis points (intermeeting move).

Five Largest Movements in Path Factor

Date	Target	Path	Commentary
9/29/08	-11	-149	Flight to safety as Congress rejects bank bailout plan–S&P 500 falls -8.8 percent.
3/18/09	-4	-110	Announce purchase of $750 billion of AMBs and agency debt, and purchase of $300 billion longer-term treasury. Launched Term Asset-Backed Securities Loan Facility.
11/25/08	-2	-100	Initial annoucement of QE1; Fed announces purchases totaling $600 billion.
1/3/01	-36	97	Intermeeting ease of policy; Fed perceived as "ahead of curve" and easing less in the future.
12/16/08	-16	-86	Lowered federal funds target to range of zero to 0.25 percent and "is evaluating benefits of purchases of longer-term securities."

Source: Authors' calculations.

that economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an extended period."

II. THE EFFECT OF MONETARY POLICY SURPRISES ON ASSET PRICES

The reaction in global financial markets to the news that the FOMC would not begin to reduce its purchases of financial assets in September 2013 was dramatic. This section analyzes whether the events of September were a typical reaction to U.S. monetary policy decisions or simply a one-time event. The analysis relates monetary policy surprises produced in the previous section to asset price changes for a variety of asset types and countries. The analysis finds that, while assets in both emerging and advanced economies respond to United States monetary policy surprises, the reaction of foreign assets is attenuated relative to domestic assets. Evidence of a different response of asset prices to monetary policy shocks at the zero lower bound is limited.

Regression analysis is used to systematically measure the impact of a monetary policy surprise on asset price movements. The effect of a change in the target and path components of monetary policy on an asset of type *i* in country *j* is measured with the following regression:

$$\Delta R_{ijt} = \alpha + \beta_{\text{target}} \times \text{target}_t + \beta_{\text{path}} \times \text{path}_t + \varepsilon_{ijt} \qquad (1)$$

for each event t described above.[9] The dependent variable in the regression described in Equation 1 is the change in the price of asset *i* in country *j* on event-date *t*. To capture a wide range of asset price movements, the analysis considers the effect of monetary policy surprises on four different asset prices for each country in the sample: the major stock index; the yield on both short-term and long-term government debt; and the U.S. dollar-foreign currency nominal exchange rate. Table A1 gives summary statistics for asset price movements that occurred on event days.[10] The number of observations for each country-asset pair differs depending on data availability and other country-specific idiosyncrasies. The primary data source is the Global Financial Data database, supplemented with Bloomberg data when possible (*www.globalfinancialdata.com*).

The effect of monetary surprises on U.S. asset prices

As shown in Table 3, monetary policy surprises—measured as a 100-basis-point shock—have meaningful effects on domestic financial markets. Equity prices respond to monetary policy surprises as measured in both the target and the path factors. A contractionary monetary policy surprise of 25 basis points is typically associated with a decline in the stock market of about 1.0 percent. (This is calculated as one-fourth the effect of a 100-basis-point shock.) The response of the stock market to the path factor is less dramatic but remains economically meaningful. The yield on the three-month Treasury bill responds only to movements to the target component of monetary policy and not the path of future monetary policy. Specifically, a surprise shock of 25 basis points to the target rate would decrease the yield on the three-month Treasury bill by about half the size of the shock—12.5 basis points. The yield on a 10-year Treasury bond responds to the path factor but not the target. This is consistent with the expectations hypothesis of the determinants of long-term interest rates, which states

Table 3

IMPACT OF MONETARY POLICY SURPRISES ON U.S. ASSET PRICES

Asset	Number of Observations	Target	Path
Wilshire 5000	240	-3.7**	0.9**
		(1.3)	(0.3)
Three-Month Treasury Bill	240	50.5**	1.3
		(4.3)	(1.1)
10-Year Treasury-Bond	240	4.0	21.4**
		(3.3)	(0.8)

* Significant at 90 percent level

** Significant at 95 percent level

Notes: Coefficients give the response to a 100-basis-point surprise. Change in stock market index measured as percent change from previous day's close. Change in bond yield measured as basis-point change from previous day's close. Heteroskedasticity-robust standard errors in parentheses.

Source: Authors' calculations.

that the current yield on a long-term bond should equal the expected path of future short-term interest rates.

An important mechanism for the transmission of monetary policy to asset prices is the portfolio balance channel. In the portfolio balance channel, investors have preferences for distinct assets and demand a certain quantity of each asset type. Central bank actions can change the relative supply of the assets demanded by investors. For example, an asset purchase of Treasury bonds directly reduces the supply of Treasury bonds available to the public, increasing their price and reducing their interest rate. Similarly, forward guidance about future policy provides information about the supply and demand for particular assets in the future, which alters the price of those assets (Woodford). When the central bank affects the relative supply of the assets demanded by investors, investors arbitrage away differences in the price of assets with similar risk-reward characteristics.[11]

The effect of monetary surprises on foreign asset prices

The previous section demonstrated that monetary policy surprises affect U.S. asset prices in a systematic and economically meaningful way. However, the logic of the portfolio balance channel extends to the prices of assets that are outside of the United States. For example, an investor in the United States could be deciding between purchasing U.S. Treasury bonds and U.K. gilts, the government debt of the

United Kingdom. If monetary policy alters the interest rate in the United States relative to that in the United Kingdom, it also alters the demand for gilts relative to Treasury bonds. Asset prices will respond to this change in relative demand as investors reallocate funds accordingly.

That said, asset prices in different countries might have differential reactions to monetary policy surprises in the United States. Economies with close economic ties to the United States will respond to U.S. monetary policy through international trade in goods and services. As an example, a simulative monetary policy surprise from the Federal Reserve will increase income in the United States, which in turn stimulates demand for imports. Foreign companies that export to the United States should expect higher profits as Americans buy more of their goods. Higher profits, in turn, cause equity prices to rise. Berge also finds that economies with close trade ties have closely related business cycles. Similarly, countries that are more integrated into international financial markets are likely to have a strong response to changes in international asset prices, providing another channel through which U.S. monetary policy could affect foreign asset prices. Lastly, the choice of a country's exchange rate regime will influence how domestic asset prices respond to changes in U.S. monetary policy. An economy whose exchange rate cannot move in response to U.S. monetary policy will likely see other asset prices react more strongly to a surprise to U.S. monetary policy. This is because movements in the exchange rate serve as an "automatic stabilizer," reducing the influence of U.S. policy on the rest of the world. Removing this stabilizing mechanism only amplifies the response of foreign asset price movements to U.S. monetary policy surprises.

Table 4 displays the response of asset prices for a mix of advanced and emerging market economies. The table is analogous to Table 3, except that it also includes the response of the dollar exchange rate with each country. Exchange rates are defined so that an increase represents an appreciation of the dollar. The table also reports regression results for three different country groups: all foreign countries, advanced economies, and emerging market economies. Advanced economies are meant to include the largest economies in the world, and are defined as essentially the G-10 economies, with a few additions. Emerging market economies are defined following the grouping of countries produced

Table 4

IMPACT OF MONETARY POLICY SURPRISES ON FOREIGN ASSET PRICES

Asset	Number of Observations	Target	Path
A. All Countries			
Equity index	10,458	-2.8** (0.4)	0.0 (0.1)
Exchange rate	11,772	0.8** (0.1)	0.3** (0.1)
Three-month yield	8,045	12.4** (4.9)	2.2** (0.9)
10-year yield	8,611	5.9** (2.2)	5.2** (0.8)
B. Advanced Market Economies			
Equity index	3,235	-2.2** (0.6)	0.0 (0.1)
Exchange rate	3,400	1.0** (0.1)	0.5** (0.1)
Three-month yield	2,697	9.3* (5.0)	1.8** (0.6)
10-year yield	3,220	6.5** (1.8)	7.2** (1.2)
C. Emerging Market Economies			
Equity index	3,191	-3.7** (0.7)	0.0 (0.1)
Exchange rate	3,640	0.9** (0.2)	0.0 (0.1)
Three-month yield	2,477	25.7* (13.9)	4.6* (2.4)
10-year yield	1,940	13.3** (4.5)	4.4* (1.3)

* Significant at 90 percent level

** Significant at 95 percent level

Notes: Coefficients give the response to a 100-basis-point surprise. Change in stock market index measured as percent change from previous day's close. Change in bond yield measured as basis-point change from previous day's close. Heteroskedasticity-robust standard errors in parentheses.

Source: Authors' calculations

by JPMorgan Chase in its Emerging Market Global Bond Index. There are many countries that are not included in the advanced economies group or the emerging market group. These countries are included in the analysis but are not included in the group-specific analysis. Table A1 lists the countries in each group.

Panel A shows the average response of international equity indexes, exchange rates, and government bond yields to U.S. monetary policy

surprises. The responses of international asset prices are similar to the responses for U.S. asset prices in Table 3. Equity indexes respond to shocks to the target factor but not to path. Yields on three-month government bonds respond to both the target and path factors, but only weakly. Interestingly, long-term yields respond to both the path and target factors, whereas U.S. long-term yields only respond to the path factor.

Exchange rates also respond strongly to both the target and path factors. A monetary policy surprise that moves the target factor up by 25 basis points is, on average, associated with an appreciation in the dollar of about 0.2 percent. As before, the coefficients in the table report the response to a 100-basis-point surprise so that the response to a 25-basis-point surprise requires dividing the estimated coefficient by four. The estimated response of exchange rates to the path factor is less than the response to the target factor. That a positive monetary policy shock leads to a contemporaneous dollar appreciation is consistent with the idea that dollar-denominated assets are now more attractive, increasing demand for those assets and appreciating the dollar. It is interesting to note that uncovered interest parity—an economic theory that relates expected future movements of exchange rates to interest rate differentials—implies that an increase in U.S. interest rates should lead to an expected future depreciation in the dollar. The contemporaneous appreciation of the dollar is consistent with the "overshooting" behavior of exchange rates, since it may lead to an expected future depreciation of the dollar (Dornbusch).

The magnitudes of the responses of international asset prices are attenuated relative to the response of U.S. assets. For example, a hypothetical 25-basis-point surprise to the target factor is associated with a movement in foreign equity markets of -0.7 percent (-2.8/4), whereas for the United States the shock would be associated with a -1.0-percent move in the stock market. The reaction of foreign bond markets to U.S. monetary policy is also reduced relative to domestic bond market reactions. That the prices of foreign assets respond less strongly than prices of U.S. assets are consistent with the observation that foreign assets are a small portion of all the assets held in the United States.

Panels B and C of Table 4 separately show the responses of advanced market assets and emerging market assets. The responses are very similar to one another. Equity indexes respond negatively to a

positive shock to the target factor of U.S. monetary policy. Exchange rates, short-term, and long-term interest rates react to both the target and path factors. Differences in the magnitude of response in asset-price movements in advanced market economies compared to the response in emerging market economies are generally not statistically significant.[12]

To more fully understand the reaction of financial markets in individual countries, Table 5 displays the countries whose asset prices respond most strongly to U.S. monetary policy surprises. Specifically, the regression defined by Equation 1 is estimated for each country in the sample. The 10 countries with the largest response to the target and path factors are listed in decreasing order.

Economies that respond to U.S. monetary policy surprises tend to have close economic ties to the United States. Advanced economies that respond to U.S. monetary policy include Canada, Japan, South Korea, and several European countries. The emerging market economies that appear on the list also tend to have close economic ties to the United States, such as Mexico, Brazil, and Turkey. However, among each group of 10 countries, the distribution between advanced economies and emerging market economies is fairly evenly distributed.

Has the response of asset prices to monetary policy changed?

The FOMC's use of unconventional policy during and after the financial crisis may have had a different effect on asset markets than conventional policy. To explore this possibility, Equation 1 is estimated again, splitting the sample at December 2007 into the periods before and after the financial crisis.[13] As above, auxiliary regressions that are not shown test the significance of any change in the regression coefficients before and after the crisis.

Table 6 shows that the response of domestic asset prices to monetary policy surprises is unchanged since 2007. The magnitudes of some of the regression coefficients are somewhat different—for example, equity prices become responsive to news regarding the future path of policy after the crisis. However, only one regression coefficient—shown in bold—is different from its pre-crisis value in a statistically meaningful sense. The response of the 10-year yield to the path factor in the post-crisis period is larger

Table 5

COUNTRIES WITH THE STRONGEST RESPONSE TO U.S. MONETARY POLICY ACTIONS

Exchange Rate		Equity Index		Three-Month Interest Rate		10-Year Interest Rate	
Target	**Path**	**Target**	**Path**	**Target**	**Path**	**Target**	**Path**
Brazil	Japan	Hong Kong	Peru	Phillipines	India	Brazil	Turkey
New Zealand	Switzerland	Brazil	Brazil	Turkey	Indonesia	Iceland	Brazil
Israel	Slovenia	Mexico	Argentina	India	Venezuela	Argentina	Australia
Poland	Denmark	Indonesia	Slovenia	Switzerland	Turkey	Indonesia	Hong Kong
South Africa	Ireland	S. Korea	Norway	Israel	Phillipines	India	Canada
Chile	France	Russia	Canada	Ireland	Chile	Turkey	Mexico
S. Korea	Italy	Canada	Thailand	Hong Kong	Brazil	Thailand	New Zealand
Hungary	Spain	Indonesia	Indonesia	Chile	Peru	Mexico	Iceland
Norway	Netherlands	Finland	Australia	Brazil	France	Poland	France
Estonia	Finland	Singapore	Ireland	Canada	Canada	Russia	Argentina

Notes: Countries with the greatest estimated response to surprises in U.S. monetary policy as measured by the Target and Path factors. Asset-country pairs with fewer than 30 observations are excluded.

Source: Authors' calculations.

Table 6

CHANGES IN THE RESPONSE OF ASSET PRICES IN THE UNITED STATES TO U.S. MONETARY POLICY

	January 1994 - December 2007			December 2007 - September 2013		
Asset	**Number of observations**	**Target**	**Path**	**Number of observations**	**Target**	**Path**
United States						
Wilshire 5000	140	-5.3**	-0.3	100	-1.8	2.1**
		(1.2)	(0.3)		(2.3)	(0.6)
Three-month yield	140	52.9**	3.9**	100	47.6**	-1.2
		(5.8)	(1.5)		(6.3)	(1.6)
10-year yield	140	3.4	17.7**	100	6.2	**25.3****
		(2.8)	(0.7)		(6.2)	(1.5)

* Significant at 90 percent level

** Significant at 95 percent level

Notes: Coefficients give the response to a 100-basis-point surprise. Regression estimates from Equation 1 and splitting the sample at December 2007. Heteroskedasticity-robust standard errors in parentheses. A bold entry in the December 2007 to September 2013 regression results indicates that one can reject the null that the post-2007 slope coefficient is not different than the pre-2007 slope coefficient at the 90 percent confidence level.

Source: Authors' calculations.

than its pre-crisis response. This likely reflects the use of forward guidance during the period that policy is constrained by the zero lower bound.

Table 7 shows that the relationship between U.S. monetary policy and international assets has changed somewhat since December 2007. Bold entries indicate that the estimated response differs in a statistically significant way before and following December 2007. In particular, the effect of policy surprises on exchange rates has been stronger since 2007. Prior to the crisis, an upward movement in the target factor typically corresponded to a slight depreciation of the dollar. However, since 2007 the response of exchange rates to movements in the target factor is the opposite: a *decrease* in target is associated with a depreciation of the dollar. To the extent the target factor after 2007 reflects the use of asset purchases in the United States, this finding is consistent with asset purchase programs resulting in appreciations of foreign currencies.

Yields on sovereign debt also have responded differently to U.S. monetary policy since 2007. Prior to the crisis, both short- and long-term yields in foreign economies responded to surprises in the target factor. After 2007, foreign yields no longer respond to surprises to the target factor. The response of yields to the path factor does not appear

Table 7

CHANGES IN THE RESPONSE OF FOREIGN ASSET PRICES TO U.S. MONETARY POLICY

	January 1994 - December 2007			December 2007 - September 2013		
Asset	**Number of observations**	**Target**	**Path**	**Number of observations**	**Target**	**Path**
A. All Countries						
Equity index	6,180	-2.5**	-0.3**	4,318	-3.0**	**0.2**
		(0.4)	(0.1)		(0.6)	**(0.1)**
Exchange rate	6,915	-0.2**	0.3**	4,906	**2.0****	0.2**
		(0.1)	(0.0)		**(0.2)**	(0.1)
Three-month yield	4,210	24.7**	0.9	3,835	**2.3**	3.3**
		(9.1)	(1.0)		**(5.1)**	(1.3)
10-year yield	4,518	10.8**	5.6**	4,093	**2.1**	5.1**
		(1.5)	(0.9)		**(3.5)**	(1.1)
B. Advanced Market Economies						
Equity index	1,910	-2.1**	-0.3**	1,325	-2.4**	**0.2**
		(0.6)	(0.1)		(0.7)	**(0.2)**
Exchange rate	1,986	-0.3**	0.5**	1,414	**2.4****	0.5**
		(0.1)	(0.1)		**(0.2)**	(0.2)
Three-month yield	1,552	21.5**	0.7	1,145	**-3.8**	**2.9****
		(3.6)	(0.6)		**(6.8)**	**(0.8)**
10-year yield	1,889	9.2**	7.0**	1,331	**3.5**	7.5**
		(1.7)	(1.4)		**(2.4)**	(1.0)
C. Emerging Market Economies						
Equity index	1,835	-3.4**	-0.1	1,356	-4.1**	0.1
		(1.0)	(0.1)		(1.3)	(0.3)
Exchange rate	2,125	-0.2	0.1	1,515	**2.1****	**-0.1***
		(0.3)	(0.1)		**(0.4)**	**(0.1)**
Three-month yield	1,115	38.6	1.1	1,362	18.1	6.6**
		(36.9)	(3.6)		(11.1)	(2.7)
10-year yield	869	18.3**	2.7	1,071	10.2*	5.5**
		(5.4)	(2.1)		(5.7)	(1.8)

* Significant at 90 percent level

** Significant at 95 percent level

Notes: Coefficients give the response to a 100-basis-point surprise. Regression estimates from Equation 1 and splitting the sample at December 2007. Heteroskedasticity-robust standard errors in parentheses. A bold entry in the December 2007 to September 2013 regression results indicates that one can reject the null that the post-2007 slope coefficient is not different than the pre-2007 slope coefficient at the 90 percent confidence level.

Source: Authors' calculations.

to have changed substantially since 2007. This pattern appears to be true for yields in both advanced and emerging economies.

III. CONCLUSION

Monetary policy in the United States affects asset prices in U.S. markets and across the world. However, different asset classes respond differently to changes in U.S. monetary policy. Within the United States, movements in the level of the federal funds rate affect equity markets and short-term interest rates. Long-term interest rates respond to changes in the expectation for future policy instead. Assets in foreign countries are also affected by U.S. monetary policy. International assets respond primarily to the level of the federal funds rate, although expectations about future U.S. monetary policy are associated with movements in long-term interest rates in foreign economies.

On average, emerging market economies and advanced economies respond similarly to monetary policy surprises in the United States. However, assets in certain countries do have strong responses to U.S. monetary policy surprises. One possible reason is that some countries have close economic and financial ties to the United States, and are, therefore, more directly affected by U.S. monetary policy. This appears to be the case, as asset prices in major European countries and Latin American countries with close ties to the United States respond most strongly to U.S. monetary policy.

Finally, the response of domestic asset prices to monetary policy surprises is largely unchanged since the Federal Reserve began to implement monetary policy with unconventional tools. However, the response of international asset prices to U.S. monetary policy is somewhat different at the zero lower bound. Foreign equity markets do not appear to have changed since the onset of the zero lower bound. However, exchange rates have reacted more strongly to Federal Reserve policy announcements since 2007. In addition, foreign interest rates no longer appear to respond to movements in the target level of monetary policy, instead responding somewhat more strongly to the expected path of policy.

Table A1
SUMMARY STATISTICS BY COUNTRY

Country	AME	EME		Equity Market (percent change)	Exchange Rate (percent change)	Three-Month Yield (basis points)	10-Year Yield (basis points)
Argentina		x	N	222	242	3	147
			Mean	0.4	0.0	24.7	-1.1
			SD	2.1	0.6	54.0	35.0
Australia	x		N	230	243	218	236
			Mean	0.2	-0.1	0.1	-0.9
			SD	1.2	0.9	4.0	8.7
Austria			N	225	243	230	235
			Mean	0.1	-0.1	-0.5	-0.2
			SD	1.6	0.7	3.4	6.3
Belgium	x		N	234	243	231	234
			Mean	0.0	-0.1	-0.3	-0.2
			SD	1.4	0.7	10.6	6.2
Brazil		x	N	211	243	207	93
			Mean	0.6	0.0	0.4	-1.8
			SD	2.3	1.3	26.0	12.8
Canada	x		N	225	243	223	222
			Mean	0.2	-0.1	0.1	-0.2
			SD	1.4	0.6	5.3	6.0
Chile		x	N	221	243	137	138
			Mean	0.1	0.0	-12.5	-0.5
			SD	0.9	0.7	220.8	4.8
China		x	N	206	243	157	110
			Mean	0.1	0.0	0.4	-0.2
			SD	1.9	0.2	3.6	2.8
Czech Republic			N	224	241	55	171
			Mean	0.1	-0.2	0.2	-0.2
			SD	1.7	0.9	5.9	5.9
Denmark	x		N	234	243	116	230
			Mean	0.0	-0.1	-1.5	-0.6
			SD	1.2	0.7	6.8	6.1
Estonia			N	30	243	0	0
			Mean	0.1	-0.1		
			SD	2.9	0.7		

Table A1 Continued

Country	AME	EME		Equity Market (percent change)	Exchange Rate (percent change)	Three-Month Yield (basis points)	10-Year Yield (basis points)
Finland			N	237	243	203	230
			Mean	0.1	-0.1	-0.7	-0.2
			SD	2.0	0.7	3.7	6.6
France	x		N	238	243	231	237
			Mean	-0.1	-0.1	-1.3	-0.4
			SD	1.5	0.7	6.9	5.5
Germany	x		N	235	243	124	237
			Mean	0.0	-0.1	-0.5	-0.2
			SD	1.5	0.7	7.1	5.7
Greece			N	229	243	185	236
			Mean	0.1	-0.1	1.1	7.2
			SD	1.8	0.7	24.2	58.2
Hong Kong			N	221	243	209	196
			Mean	0.3	0.0	-2.5	0.5
			SD	2.2	0.0	17.6	22.1
Hungary		x	N	219	242	203	177
			Mean	-0.1	-0.2	-1.2	-1.5
			SD	2.0	1.0	14.7	13.9
Iceland			N	232	242	218	145
			Mean	0.0	0.0	-2.3	1.9
			SD	1.3	1.3	36.1	44.8
India		x	N	173	243	208	208
			Mean	0.1	0.0	1.5	-0.2
			SD	1.7	0.4	59.1	16.7
Indonesia		x	N	216	243	161	149
			Mean	0.4	0.0	-3.0	-1.6
			SD	1.9	0.9	28.3	20.9
Ireland			N	237	243	230	234
			Mean	0.1	-0.1	-0.2	0.0
			SD	1.7	0.7	6.2	8.4
Israel			N	121	239	191	138
			Mean	0.2	-0.1	-0.6	0.6
			SD	1.1	0.6	11.9	15.7
Italy	x		N	236	243	200	235
			Mean	-0.1	-0.1	-0.8	-0.3
			SD	1.5	0.7	6.6	6.8

Table A1 Continued

Country	AME	EME		Equity Market (percent change)	Exchange Rate (percent change)	Three-Month Yield (basis points)	10-Year Yield (basis points)
Japan	x		N	219	243	196	236
			Mean	0.1	0.0	0.1	-0.2
			SD	1.7	0.8	1.2	3.6
S. Korea	x		N	227	241	0	192
			Mean	0.3	-0.1		-1.2
			SD	1.9	1.0		7.0
Malaysia		x	N	194	243	59	174
			Mean	0.0	0.0	-1.6	0.2
			SD	0.8	0.4	14.3	16.5
Mauritius			N	219	220	0	0
			Mean	0.3	0.0		
			SD	1.2	0.5		
Mexico		x	N	223	241	147	58
			Mean	0.3	-0.1	-0.3	-0.8
			SD	1.7	1.3	5.8	8.1
Netherland	x		N	234	243	235	229
			Mean	0.0	-0.1	-0.5	-0.3
			SD	1.5	0.7	3.0	5.6
New Zealand			N	229	243	230	227
			Mean	0.1	0.0	-0.4	0.3
			SD	0.8	1.0	6.9	6.9
Norway	x		N	231	243	233	233
			Mean	0.1	-0.1	-0.6	-1.0
			SD	1.5	0.8	10.1	5.8
Pakistan			N	123	242	129	129
			Mean	0.1	0.0	0.1	0.7
			SD	1.2	0.4	4.6	7.0
Peru		x	N	222	243	153	71
			Mean	0.1	0.0	-0.8	0.1
			SD	1.7	0.4	21.2	8.1
Philippines		x	N	224	242	214	95
			Mean	0.3	0.0	0.5	-0.6
			SD	1.5	0.4	71.9	26.8
Poland		x	N	227	242	203	178
			Mean	0.2	-0.2	0.3	0.2
			SD	2.0	1.0	9.2	6.7

Table A1 Continued

Country	AME	EME		Equity Market (percent change)	Exchange Rate (percent change)	Three-Month Yield (basis points)	10-Year Yield (basis points)
Portugal			N	235	243	204	233
			Mean	0.0	-0.1	1.0	-0.7
			SD	1.3	0.7	20.6	10.6
Russia		x	N	190	243	159	106
			Mean	-0.1	0.0	-8.2	-1.5
			SD	2.9	0.8	58.0	13.9
Singapore			N	225	243	194	189
			Mean	0.1	0.0	-0.3	-0.4
			SD	1.4	0.4	5.8	5.1
Slovakia			N	220	242	0	177
			Mean	0.1	-0.1		-0.9
			SD	1.2	0.7		11.0
Slovenia			N	184	225	0	168
			Mean	-0.1	-0.1		-0.1
			SD	1.4	0.7		9.2
South Africa		x	N	231	243	215	169
			Mean	0.3	-0.1	-0.1	-0.4
			SD	1.4	1.2	5.0	8.6
Spain	x		N	234	243	230	236
			Mean	0.0	-0.1	-0.6	-0.1
			SD	1.6	0.7	6.1	7.9
Sweden	x		N	232	243	229	230
			Mean	0.1	-0.1	-0.5	-0.5
			SD	1.6	0.8	5.0	7.0
Switzerland	x		N	228	243	230	234
			Mean	0.0	-0.1	-3.5	0.2
			SD	1.2	0.8	20.2	3.6
Taiwan			N	210	243	196	196
			Mean	0.1	0.0	-0.2	0.0
			SD	1.7	0.2	2.2	2.9
Thailand		x	N	211	243	160	158
			Mean	0.2	0.0	-0.2	-1.0
			SD	1.8	1.3	2.3	8.0
Turkey		x	N	223	243	94	56
			Mean	0.3	-0.1	2.4	0.5
			SD	2.7	1.0	37.8	18.5

Table A1 Continued

Country	AME	EME		Equity Market (percent change)	Exchange Rate (percent change)	Three-Month Yield (basis points)	10-Year Yield (basis points)
United Kingdom	x		N	232	243	231	235
			Mean	0.0	-0.1	-0.3	-0.5
			SD	1.2	0.7	4.6	6.9
United States			N	242	N/A	242	243
			Mean	0.2		-1.1	-0.2
			SD	1.6		6.6	7.8
Venezuela			N	215	215	164	164
			Mean	0.1	0.0	-1.7	0.9
			SD	1.3	0.4	22.1	21.9

Source: Author's calculations

ENDNOTES

[1]Other papers have used a similar method to identify shocks to monetary policy. See, for example, Campbell; Kuttner; Kuttner and Bernanke; Gürkaynak and others; Hausman and Wongswan; and Doh and Connolly.

[2]The contracts are publicly traded on the Chicago Board of Trade. See *http://www.cmegroup.com/trading/interest-rates/stir/30-day-federal-fund.html* for more information.

[3]Because the contract's settlement price is based on the average effective federal funds rate that month, price changes must be scaled by a factor related to the number of days that remain in the month. See Gürkaynak and others.

[4]For example, Foerster and Cao argue this assumption is not true for event studies analyzing the impact of large-scale asset purchase programs. They argue event studies should be interpreted as providing lower-bound estimates of the effect of LSAPs on asset price movements.

[5]A comprehensive list of dates is in the Appendix of Doh and Connolly, and is extended through September 2013.

[6]Federal funds futures contracts for the month of, and the month following, an FOMC action, as well as Eurodollar contracts one to nine quarters ahead, are included in the data set.

[7]Principal component analysis is applied to the 10 asset prices to produce the two factors. The factors are then rotated and rescaled following Gürkaynak and others to facilitate interpretation.

[8]Specifically, the path factor is scaled so that a 100-basis-point movement in it has the same effect on the six-quarters ahead Eurodollar rate as a 100-basis-point movement in the target factor. The relationship is estimated to be 31 basis points.

[9]Since the target and path factors come from a first-stage estimation, the standard errors associated with the regression in Equation 1 need to be adjusted for the presence of generated regressors. However, the standard errors computed from a bootstrap that incorporates this first-stage uncertainty are not qualitatively different from the usual heteroskedasticity-robust standard errors. As a consequence, all tables show heteroskedasticity-robust standard errors.

[10]For equity indices and exchange rates, the change in the asset price is defined as the percent change from the previous day's value. The change in the value of debt instruments is measured as the basis point change from the previous day's value.

[11]The portfolio balance channel is one of several possible channels through which monetary policy impacts asset prices. See Krishnamurthy and Vissing-Jorgensen.

[12]Slope coefficients of advanced and emerging economies are tested for statistical significance with a Chow test. The hypothesis that the coefficients are not different is rejected for only the exchange rate equation.

[13]December 2007 is used to split the sample because the NBER declared this month to be the start of the recession. However, the analysis is robust to other choices of the date at which to split the sample.

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