THESIS: DO STOCK AND FOREIGN EXCHANGE MARKETS RESPOND TO MONETARY POLICY SHOCKS AT THE ZERO LOWER BOUND?

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Résumé

Dans cette recherche nous comparons les effets des deux types de politiques monétaires (conventionnelles et non-conventionnelles) sur les marchés financiers. Les mesures conventionnelles sont celles employées par la banque centrale américaine pendant les dix années qui ont précédé la dernière crise financière de 2007. Quant aux mesures non conventionnelles, elles sont définies comme celles qui ont été employées après que le taux directeur de la banque centrale américaine eut atteint la borne inferieure communément appelée « zero lower bound (ZLB) ». Par conséquent, nous faisons la distinction entre deux types de régime monétaire, notamment le régime conventionnel qui représente la période pré-crise financière allant de janvier 1997 jusqu'au début de la dernière crise financière de 2007, et le régime non conventionnel qui fait référence à la période ZLB.

Durant la période ZLB, nous identifions deux chocs monétaires : le premier choc est capturé par la variation de taux de rendement du bon de Trésor américains de 2 ans. Cette variation est calculée à travers une courte fenêtre de temps encerclant les annonces de politique monétaire de la banque centrale ; le deuxième choc monétaire est identifié comme étant les variations du taux rendement du bon du Trésor de 10 ans qui sont orthogonales à celles du taux de rendement du bon de trésor de 2 ans.

Nos résultats indiquent que comparativement à la politique monétaire conventionnelle, les mesures monétaires non conventionnelles ont un impact plus accentué sur les marchés boursiers et les marchés de change.

Abstract

This paper compares the effects of the U.S. conventional monetary policy on global stock and foreign exchange markets with those of the unconventional policy actions that were taken after the federal funds rate was set at its effective zero lower bound (ZLB). We make the distinction between two monetary regime periods namely the conventional regime period which starts from the January 1997 until the beginning of the ZLB period that began in November 2008; the unconventional regime refers to the period during which the ZLB was binding. For the unconventional period, we identify two monetary policy shocks. The first one is called the "short" surprise, and it represents changes in the 2-year T-bill yield which are computed within a narrow time window surrounding the monetary policy announcements, and the second one is defined as the "long" surprise and it is represented by changes in the 10-year T-bill yields that are orthogonal to those of the 2-year T-bill yield. Our results indicate that in general, the efficacity of the U.S. unconventional policy in boosting the Stock and Foreign Exchange markets is more pronounced than that of conventional policy.

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1. Introduction

The nature of the interaction between asset prices and monetary policy has always been a key issue in financial economics. Central banks' primary objectives are in general expressed in terms of three main macroeconomic variables: real GDP, employment, and inflation. For instance, for the past three decades, the manipulation of short-term nominal interest rates has been the primary tool used by the U.S. central bank to dictate the stance of its monetary policy. The main conventional policy tools that have been used are changes in the federal funds target rate and its expected future trajectory, and changes in the discount rate. The manipulation of these short-term interest rates has somehow an indirect effect on the set of macroeconomic variables mentioned above, but it is also believed to have some effect on broader financial markets through the transmission mechanism of monetary policy actions. Stock and foreign exchange markets are very prompt at absorbing new market information; therefore, it is imperative to understand the interaction between monetary policy and asset prices since the latter play an important role in the global economy. Following the financial crises in the years 2000 and 2007, it became clear that central banks' monetary policy should not only focus on the inflation target and stabilize the output gap but also, they must incorporate asset price development and other financial system stability indicators (Borio and Lowe (2002)). After the 2007 financial crisis, the U.S. central bank employed unconventional monetary policy actions to stimulate its collapsing economy. Because of the extent of the last financial crisis, the conventional monetary policy actions were not suitable to contain and heal the crisis. Consequently, the U.S. central bank initiated an unprecedented increase in its lending facilities by providing high liquidity to financial markets with the intent to stimulate the economy. The unconventional monetary policy tools were of three forms: liquidity provision, asset purchases, and commitment to future monetary policy actions.

Our aim in this paper is to undertake an empirical analysis of the effects of both conventional and unconventional monetary policy actions on stock markets and foreign exchange markets (FOREX). Several studies have documented a significant relationship between the U.S. monetary policy and its equity prices. However, a consensus on the nature and direction of the interaction has yet to be reached.

As mentioned earlier, the federal funds target rate is the primary monetary policy tool used by the Federal Reserve; following the last financial crisis the central bank lowered its target rate

to a zero-lower bound (ZLB) and started using other unconventional policy tools which led to new economic conditions that had not been experienced before. Recent studies have mostly focused on the impact of unconventional monetary policy on the real cost of borrowing and foreign bonds markets with ZLB constraint in effect, and they found that the U.S. and foreign countries real costs of borrowing are in general equally sensitive to conventional and unconventional monetary policy shocks.

The goal of this paper is to determine the nature of the interaction existing between the U.S. unconventional monetary policy and broader financial markets with ZLB constraint in place. We consider two types of asset classes: stocks, and global currencies. We ask ourselves the following key questions: Are global stock markets more sensitive to unconventional monetary policy actions than the conventional ones? The same question is asked about the nature of the interaction between the U.S. monetary policy and selected foreign exchange markets.

To compare the impacts of conventional and unconventional policy we follow Gilchrist et. al (2015) empirical approach, which consists of using daily changes in the 2-year nominal Treasury yield on policy announcement days as a common instrument across the two policy regimes. The stance of the monetary policy is captured by the changes in the 2 year- T-bill yield, these movements are defined as the "Short" Surprise and are computed within a narrow window surrounding the FOMC meeting to identify unanticipated policy actions. The small window approach rules out the chances that daily changes in the 2-year T-bill yield on policy announcement day may not solely be due to changes in monetary policy stance. The underlying assumption of this approach stipulates that movements in the T-bill yields over a narrow time window surrounding an FOMC meeting are substantially due to unanticipated changes of monetary policy stance. To test the robustness of our assumption, we follow the Gilchrist et al. (2015) approach by decomposing the change in the 2-year T-bill yield into two components: the target and the path surprise, and our results show that the effect of conventional monetary policy shocks can be adequately captured by changes in the 2-year T-bill yield over the narrow window on the policy announcement day.[1]

[1] See appendix-A for more details.

The primary goal of the unconventional monetary policy actions was to influence longer-term treasure yields through the Large-Scale Asset Purchase (LSAP), this factor makes the identification of unconventional monetary policy stance more complicated than that of the conventional one. Since monetary policy actions were announced either during regular FOMC meeting or during special unscheduled FOMC meetings, we make a distinction between monetary policy actions that were LSAP related versus policy actions that were not LSAP related; this allows us to isolate the effect of the LSAP program on the studied financial assets.

Since the unconventional policy actions were intended to influence long-term interest rates, the movements in the 2-year T-bill yield surrounding the FOMC meeting during the unconventional regime are not sufficient to fully capture the impact of the unconventional policy actions. To provide a more encompassing measure of the effect of the unconventional actions, we follow the identification scheme developed by Hanson and Stein (2012). The idea is to allow an additional unanticipated component of the policy that has an independent effect on longer-term interest rates. We do so by decomposing the observed change in the 10-year treasury yield over a narrow window surrounding a policy announcement into two components: (1) an unanticipated component that accounts for the impact of policy-induced changes in the 2-year T-bill rate on longer-term yields within a time window surrounding the FOMC meeting and (2) a surprise component that is orthogonal to changes in the 2-year T-bill rate within the same interval. The second component is called the "Long" Surprise, and it is intended to capture the direct impact of unconventional monetary actions on longer-term yields. As emphasized by Swanson and William (2013), 2-year T-bill was sensitive to economic news from years 2008 until 2010, however by the end of year 2011, it stopped responding because of the zero lower bound constraint. In contrast, the 10-year T-bill yield was still reacting to economic news; this confirms the belief that influencing longer-term treasury yields was an integral part of the unconventional monetary policy.

Gilchrist et al. (2015) used the approached described above to analyze the effect of monetary policy on real borrowing costs at the zero-lower bound, and they conclude that the efficacity of the unconventional policy in lowering the real borrowing cost is in general equivalent to that of conventional policy.

The general idea of this paper is to follow the same approach in identifying the stance of the monetary policy and study the nature of the relationship between the unconventional monetary policy and two financial markets, namely the stock and the forex markets. Several studies have tackled this subject by using a Vector Autoregression (VAR) approach and they used the target federal funds rate as their primary monetary policy proxy; in contrast, this paper addresses this issue within a nonlinear least square framework along with the alternative characterization of monetary policy as described above.

In this research, we study the effect of monetary policy actions (both conventional and unconventional) on different stock market indexes and on the forex markets. The rest of the paper is organized as follows: Section (2) goes over the literature on the relationship between monetary policy and financial markets, more specifically stock and Forex markets. Section (3) outlines our empirical approach, in subsection (3.1) we present the identification scheme used to identify the conventional monetary policy surprise, while subsection (3.2) goes into a detailed explanation of the framework used to compute the impact of unconventional monetary policy actions on asset prices. Section (4) gives an overview of our data. In section (5) we go over our results, subsection (5.1.1) presents the estimates for U.S. Stock markets, while subsection (5.1.2) contains the estimates for non-U.S. stock market indexes, subsection (5.2) shows the result of the estimation for the forex markets. Section (6) summarizes our findings and their implications.

2. Monetary policy and financial asset returns

2.1. Monetary policy and stock market returns

The most closely monitored financial market is undoubtedly the stock market; the movement of stock prices is highly sensitive to economic conditions. It is commonly believed that through the transmission mechanism, monetary policy action can impact stock prices.

Tirole (1985) used the discounted cash flow model (DCFM) to show that fundamental asset prices are equal to the present value of the expected future dividends. Using this finding, one could infer that monetary policy would have an impact on equity prices through the manipulation of the current and projected future discount rate used by the investors when evaluating a given financial asset. For instance, a restrictive monetary policy, which is often characterized by a higher discount rate and lower future dividend, using these parameters in a DCMF would yield to lower equity prices. In contrast, an expansionary monetary policy which is characterized by lower interest rates and higher expected cash flow is expected to be associated with higher equity prices. Consequently, investors pay close attention to any policy actions taken by the Federal Open Market Committee (FOMC).

The responsiveness of stock returns to monetary policy shocks has been receiving a lot of attention from the empirical literature as asset booms are often followed by bursts, leading to dramatic economic effects. As mentioned previously, researchers have yet to agree on the nature of the relationship between expansionary monetary policy actions and stock prices.

The federal funds target rate or the discount rate are the two main monetary policy proxies used in most of the studies done on this subject. Burnakee and Kuttner (2005), Lombardi and Anzuini (2010) both have found that stock returns increase significantly following an unanticipated monetary policy expansion. Thorbecke (1997) found an unexpected change in the federal target rate has a significant impact on smaller capitalization stocks; he used a VAR system in which he included monthly stock price returns, output growth, inflation data and target rate. Cassola and Morana (2004) also used a VAR approach in which they include real GDP, inflation, short-term interest yields, and real stock returns; they discover that a permanent positive monetary shock has a temporary effect on the stock market return.

Patelis (1997) tackles the question to know whether the U.S. stock market excess return is influenced by its monetary policy. He followed the Fama and French (1989) approach by using

the long-horizon regression in which he included two types of independent variables (monetary policy and financial variables). He discovered that monetary policy variables were significantly related to stocks' excess returns. His results were in accordance with the results of Bernanke and Gertler (1989, 1995).

Jensen and Johnson (1995) used the discount rate as their monetary policy proxy, and they found that the U.S. stock market returns tend to get higher following discount rate decreases. Conover, Jensen and Johnson (1999) suggest that U.S. monetary policy actions not only have an impact on its stock market, but it also impacts the financial markets of OECD countries from 1955 to 1995.

Normandin and Bouakez (2013) criticized the VAR approach used in the above studies; they argued that the VAR model imposes some exclusions that limit the interaction of the different economic variables in ways that are not consistent with the data. Consequently, they tackled the question by relaxing the assumptions made in the previous studies and estimated the interdependence between stock returns and monetary policy and concluded that the interaction is much weaker than suggested by earlier empirical studies. They used data prior to the latest financial crisis and discovered that stock returns are not very sensitive to U.S. monetary policy and have little effect on its propagation.

As we can notice most of the studies, that have tackled the question of interdependence between the monetary policy and stock market return used the VAR approach and focused on the conventional regime period (pre-crisis); the federal funds target rate and the discount rate were the primary tools used to identify the stance of the monetary policy.

2.2. Monetary policy and forex market

Several researchers have investigated the effect of shocks to U.S. monetary policy on exchange rates; there is no consensus regarding the direction and the extent to which exchange rates are affected by monetary policy shocks. Authors such as Eichebaum and Evans (1995) have found substantial evidence of a link between monetary policy and exchange rates. They used the federal funds rate as the main monetary policy proxy and discovered that contractionary shocks to U.S. monetary policy lead to significant increases in the U.S. exchanges. Some studies find that the exchange rates do not immediately overshoot their long-run level following a monetary policy shock and other studies, in contrast, find an immediate exchange rate overshoot (Normandin and

Bouakez 2015). The discrepancy in the results across studies is believed to be caused by the fact that they differ in the restrictions imposed on the interactions between the variables used in their approach. Normandin and Bouakez (2015) used a flexible SVAR approach to show that the bilateral exchange rates between the U.S. and each of the G7 countries exhibit a delayed but rapid overshooting reaching their maximal depreciation 11 months after a monetary policy shock.

It is worth mentioning that the majority of researches done on this subject also try to evaluate the validity of the uncovered interest parity (UIP) concept which predicts that higher interest rate currencies will depreciate against lower interest rate currencies (Backus 2010). Authors such as Eichenbaum and Evans 1995 and Faust and Rogers 2003 have documented breach of the UIP condition following monetary policy shocks.

As seen above, most of the studies have investigated this subject using a VAR approach, and the federal funds rate is used as the primary monetary policy proxy, and they mainly focused on the speed and time-length of the response of exchange rates to monetary shocks. By contrast, our paper tackles this issue from a different angle and with a different approach. We aim to directly compare the effect of U.S. conventional monetary policy on the foreign exchange rate with those of the unconventional measures, employed after the federal target rate was set to the zero-lower bound, and we use movements in the treasury yields as common proxies across the two regimes.

3. Empirical Framework

This section goes over the framework that we used in computing the effect of policy actions during the conventional and the unconventional regimes on the chosen financial assets. Our approach has two main aspects: the first one consists of using intraday data to infer monetary policy surprises that were initiated by the FOMC, and the second aspect consists of combining these high-frequency policy surprises along daily market data to understand the impact of the monetary policy decisions on the selected stock and forex markets.

We start this section by first discussing the dating of the two monetary policy regimes. Our sample period runs from the beginning of January 1997 until the end of October 2013. The sample is divided into two monetary policy regimes. The conventional regime is the first one, and it is associated with the period during which the federal target rate was the main monetary policy tool used. We also have an unconventional regime which reflects the period during which the Central Bank resorted to three main monetary policy actions: the federal funds target rate was set at a zero lower bound, the LSPA program, and ongoing forward guidance regarding the future trajectory for the target rate.

The key date of the sample is November 25, 2008, which marks the end of the conventional regime and the beginning of the unconventional regime; the FOMC decided to meet on that day outside of their regularly scheduled meetings to announce the start of its plan to purchase debt obligations GSE MBS [2] to support the collapsing housing market. The FOMC met one week later outside of its regular schedule again to announce the beginning of its controversial LPSAs program which mainly consisted of purchasing longer-term securities. Given the rapidly deteriorating condition of the financial system, on December 16, the FOMC announced its decision to lower the federal funds target rate to a range of 0 to 0.25 percent at its effective lower bound.

[2] *Government Sponsored Enterprise (GSE) mortgage-backed securities (MBS)*

3.1. Conventional Monetary Policy Regime

As emphasized by authors such as Cook and Haan (1989) and Bernanke and Kuttner (2005), the conventional regime stance is generally characterized by one main factor, namely the unanticipated component of the change in the federal funds target rate commonly called the target surprise. However, Swanson et al. (2005a) deemed this one single factor definition to be incomplete. To fully capture the effect of conventional policy on asset prices, they added a factor that captures the change in expected future policy rates. This second factor is called the path surprise, and it is closely related to the FOMC statements that announce changes in the federal target rate. After the target rate was set to its effective zero lower bound, the path surprise factor assumed even greater importance, as it was the main monetary tool used by the Central Bank to communicate the stance of its policy.

To compare the efficacity of the conventional and unconventional monetary policy, we follow the approach used by Gilchrist et al. (2015), which assumes that the change in the 2-year nominal T-bill rates over a narrow window surrounding an FOMC meeting statement reflects the confluence of the target and path surprises. Under this assumption, it can be inferred the effect of unanticipated conventional monetary policy actions on asset prices to be as followed:

$$\Delta \boldsymbol{s_t} = \boldsymbol{\beta_s} \tilde{\Delta} \boldsymbol{y_t}(\mathbf{2}) + \boldsymbol{u_t} \qquad \textbf{(1)}$$

Where Δs_t represents the daily change in a vector of financials asset prices that are relevant to this study, β_s denotes the relative impact of conventional monetary policy shocks (an unanticipated change in the 2-year T-bill yield) on our asset prices, $\tilde{\Delta} y_t(2)$ is the intraday change in the 2-year nominal T-bill yields computed over a 30 minutes window bracketing the FOMC meeting (10 minutes before the statement and 20 minutes after) on day *t*, and u_t captures all non-policy shocks that may have an impact on the asset prices on day *t.* The small window approach rules out the chances that daily changes in the 2-year T-bill yield on policy announcement day may not solely be due to changes in monetary policy stance.

The conventional regime period consists of 83 FOMC meeting statements and equation (1) is estimated by OLS. We consider two assets classes: The first one is the daily change in vectors of stock market indexes return (4 U.S. stock indexes, 2 Canadian, 2 European, and 1 Japanese) and

the second type of asset is daily USD exchange rates (USD INDEX, USD/CAD, USD/EUR, USD/GBP, USD/JPY).

3.2. Unconventional Monetary Policy Regime

After the FOMC lowered the target rate to a zero-lower bound (ZLB) in December 2008 and once the short-term interest rates hit the ZLB, the effectiveness of the monetary policy only depended on the central bank's ability to dictate the path of future short-term interest rates or its ability to influence the term premia associated with long-term financial assets. To jump-start the economy the FOMC has taken numerous policy actions, and Table-3.1 summarizes how the FOMC stance on the future path of the policy rate evolved during the unconventional regime period. On its initial meeting on December 16, 2008, the FOMC stated its intention to keep the federal funds target rate at an exceptionally low level "for some time." In March 2009, the timeline stance was changed, and they announced that low funds rate would be maintained for "an extended period." In August 2011, the committee announced that the low fund rate would remain in place "at least until June 2013," and finally in January 2012 the forward guidance was changed to "at least through late 2014".

The FOMC also used unconventional monetary policy actions; it conducted a Large-Scale Asset purchase (LSAP) program which consisted of an expansion of the Fed's balance sheet and commonly referred to as quantitative easing (QE). Through the LSAP, the Fed purchased government securities and other securities from the market to lower interest rates. As shown in Table-3.1 the first LSAP action was initiated November 25, 2008 which marks the beginning of the unconventional regime. The first step of the program consisted of buying a large quantity of agency debt and agency guaranteed mortgage-backed securities; the scope of the program was then extended to include the purchase of treasury bills.

Table 3.1: Key unconventional monetary policy actions

Date	Time	FOMC*	Highlights
Nov-25-2008	8:15:00 AM	N	Announcement that starts LSAP-I.
Dec-01-2008	8:15:00 AM	N	Announcement indicating potential purchases of Treasury securities
Dec-16-2008	2:20:00 PM	Y	Target federal funds is lowered to its effective lower bound; statement indicating that the Federal Reserve is considering using its balance sheet to further stimulate the economy; first reference to forward guidance: "... economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time."
Jan-28-2009	2:15:00 PM	Y	"Disappointing" FOMC statement because of its lack of concrete language regarding the possibility and timing of purchases of longer-term Treasuries.
Mar-18-2009	2:15:00 PM	Y	Announcement to purchase Treasuries and increase the size of purchases of agency debt and agency MBS; also, first reference to extended period: "... interests rates are likely to remain low for an extended period ..."
Aug-10-2010	2:15:00 PM	Y	Announcement that starts LSAP-II.
Aug-27-2010	10:00:00 AM	N	Chairman's speech at Jackson Hole.
Sep-21-2010	2:15:00 PM	Y	Announcement reaffirming the existing reinvestment policy.
Oct-15-2010	8:15:00 AM	N	Chairman's speech at the Federal Reserve Bank of Boston.
Nov-03-2010	2:15:00 PM	Y	Announcement of additional purchases of Treasury securities.
Aug-09-2011	2:15:00 PM	Y	Y First "calendar-based" forward guidance: "... anticipates that economic conditions are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013."
Aug-29-2011	10:00:00 AM	N	Chairman's speech at Jackson Hole.
Sep-21-2011	2:15:00 PM	Y	Announcement of the Maturity Extension Program (MEP).
Jan-25-2012	12:30:00 PM	Y	Second "calendar-based" forward guidance: "... keep the federal funds rate exceptionally low at least through late 2014."
Jun-20-2012	12:30:00 PM	Y	Announcement of continuation of the MEP through end of 2012.
Aug-31-2012	10:00:00 AM	N	Chairman's speech at Jackson Hole.
Sep-13-2012	12:30:00 PM	Y	Third "calendar-based" forward guidance: "... likely maintain the federal funds rate near zero at least through mid-2015." In addition, first forward guidance regarding the pace of interest rates after lift-off: "... likely maintain low rates for a considerable time after the economic recovery strengthens," and announcement of LSAP-III (flow-based; $40 billion per month of agency MBS).
Dec-12-2012	12:30:00 PM	Y	Announcement of an increase in LSAP-III (from $40 billion to $85 billion per month); first "threshold-based" forward guidance: maintain the funds rate near zero for as long as unemployment is above 6.5%, inflation (1–2 years ahead) is below 2.5%, and long-term inflation expectations remain well-anchored.
Jun-19-2013	2:00:00 PM	Y	Forward guidance lays out plans to start tapering asset purchases later that year (unemployment rate below 7.5%); and end LSAP-III by mid-2014, when the unemployment rate is around 7%.
Jul-17-2013	8:30:00 AM	N	Chairman's semiannual Monetary Policy Report to the Congress.
Sep-18-2013	2:15:00 PM	Y	"Asset purchases are not on a preset course ..."

NOTE: LSAP-related announcements have their meeting dates in bold (see the text for details).

** Y = an announcement made during regularly-scheduled FOMC meetings; N = an announcement associated with out of the scheduled meeting.*

The central bank pumped $85 billion into the economy every month, resulting in a rise of the Federal Reserve assets from $800 billion in 2007 (pre-crisis) to $3.5 trillion in October 2014 (post-crisis).

The rationale behind the LSAP was based on the "preferred habitat" economic theory which suggests that changes in the Federal Reserve holding of longer term can lead to changes in longer-term interest rate if investors have a preference in keeping part of their holding in government securities as they have high marketability and are default-free. Since financial assets' prices are directly influenced by the quantity of assets available to investors, (all else equal) a reduction in the supply of longer-term government obligations relative to the supply of other financial assets would lead to investors decreasing their holding in government bonds and consequently increase their holdings of other financial assets such as stocks (Gilchrist et al. (2015)).

After the fed ended its LSAP program, it kept funding liquidity into the economy the old-fashioned way, by holding its interest rates at a zero-lower bound (ZLB).

Since LSAPs were an integral part of the policy actions taken by the FOMC during the unconventional regime period, changes in the 2-year T-bill yields would fail to capture the full effect unconventional policy action on asset prices.

To fully catch the impact, we follow Swanson and al (2005) approach by adding an extra dimension to the unconventional policy by assuming:

$$\tilde{\Delta}\boldsymbol{y_t}(\mathbf{10}) = \boldsymbol{\gamma_u}\tilde{\Delta}\boldsymbol{y_t}(\mathbf{2}) + \Delta\boldsymbol{m_t^L} \qquad \textbf{(2)}$$

Where $\tilde{\Delta}y_t(10)$ represents the movements in the 10-year nominal T-bill yield over a narrow window surrounding a FOMC meeting announcement on day t, and $\tilde{\Delta}y_t(2)$ denotes the change in the 2-year T-bill over the same window, and Δm_t^L denotes the unanticipated component of the unconventional monetary policy that potentially can impact long term interest rates.

Let s_t denote the same vector of assets as the one estimated in the conventional regime, then the total impact of an unanticipated unconventional monetary policy action on the financial assets can be inferred from:

$$\Delta \boldsymbol{s_t} = \boldsymbol{\beta_s}\tilde{\Delta}\boldsymbol{y_t}(\mathbf{2}) + \boldsymbol{\beta_L}\tilde{\Delta}\boldsymbol{m_t^L} + \boldsymbol{u_t} \qquad \textbf{(3)}$$

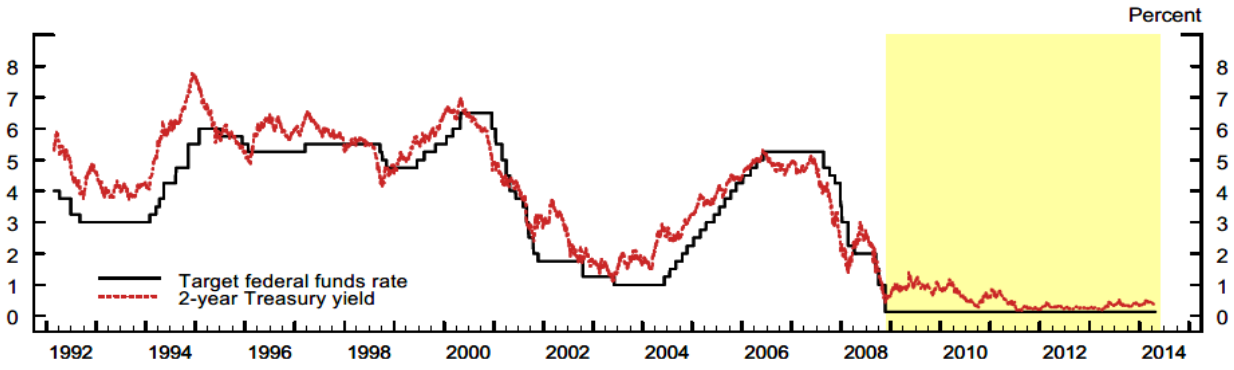
The FOMC made 47 announcements during the unconventional regime period from November 25, 2008, to October 31, 2013. Using a nonlinear least square (NLS), we jointly estimate the parameters of equations (2) and (3); this approach allows us to consider the specified cross-equation restrictions. The coefficient β_s denotes the estimate of the response to an unanticipated change in the 2-year T-bill yield (short surprise) and β_L represents the estimate of the response coefficient to an unanticipated change in the 10-year T-bill yield that is orthogonal to the surprise in the 2-year T-bill yield (long surprise).

The sample of 47 meeting announcements consists not only of information about LSAPs and forms forward guidance, but some announcements also include key speeches and testimonies. Through these testimonies and speeches, policymakers had a chance to clarify to market participants the various aspects of the unconventional policy. As a result, market participants would take more time to digest the news provided by the FOMC. This factor is taken into consideration by using a wider 60-minute window surrounding an announcement (10 minutes before to 50 minutes after) to compute the daily changes in the 2- and 10-year treasury yields.

In this study, we try to separate the effect of unconventional policy actions that involved LPSAs from other forms of unconventional measures. A subsample of the unconventional policy period is considered, it excludes 12 FOMC announcements that were related to the quantitative easing program. The unconventional sample includes 47 LSAP and non-LSAP related policy decisions and 35 non-LSAP related policy decisions.

The following three figures depict the interest rate paths and implied monetary policy shocks that we are considering in our model.[3]

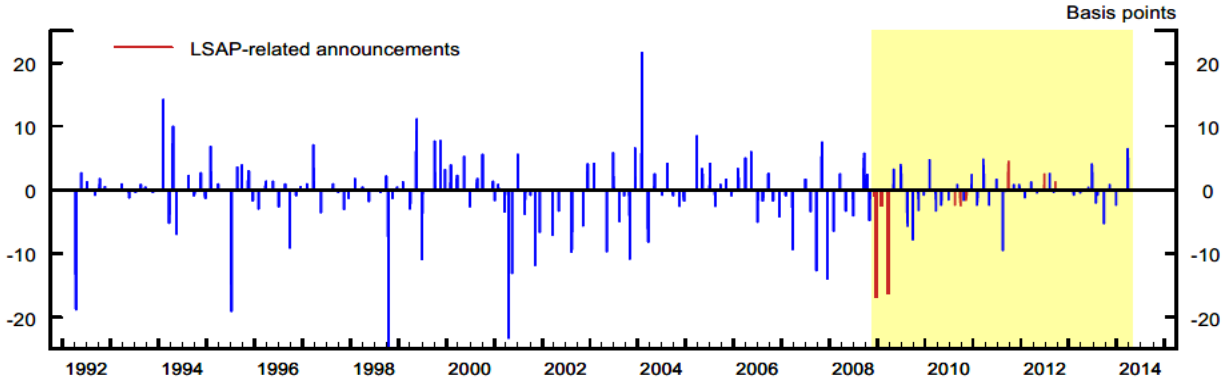
[3] Gilchrist et al. (2015)



(a) Selected U.S. interest rates

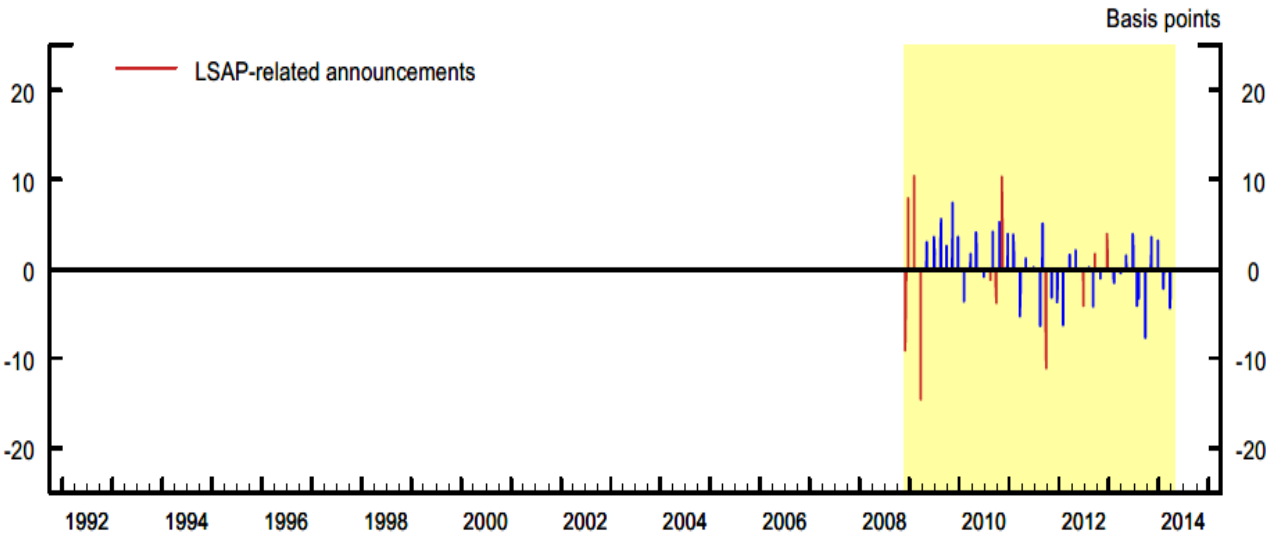
Figure (a) illustrates the movements of the 2-year T-bill yields and federal target rate over both monetary regimes. This exhibit shows several key monetary policy phases. We can point out three main phases: The first one is the monetary tightening that happened in 1994–95 following the unemployment recovery at the beginning of the 1990s. The second is the expansionary monetary policy phase that was initiated to deal with the financial crisis caused by the "tech bubble" in 2001. The last stage represents a substantial monetary policy easing measures that started at the beginning of the previous financial crisis in 2007, a period marked by the federal funds target rate hitting the zero lower bound.

Figure (b) and (c) depicts monetary policy surprises.



(b) "Short" U.S. monetary policy shocks

Figure (b) shows the "short" surprise { $\tilde{\Delta} y_t(2)$ } entailed by every single monetary policy actions during the entire sample period.



(c) "Long" U.S. monetray policy shocks

Figure (c) shows the long monetary policy surprises $\{\tilde{\Delta} y_t(10)\}$ that took place during the unconventional regime. As depicted by the red spikes, during the unconventional regime the largest "long" monetary surprises are the ones associated with the LSAP announcements.

4. Data and descriptive Statistics

This section presents the descriptive statistics of our sample data. The first subsection goes over the stock market return data and the second one shows the foreign exchange market data. The data are obtained from the Wharton Research Data Services (WRDS).

4.1. Stock Markets returns

We employ daily stock price data from ten stock indexes. The sample consists of:

- Five U.S. stock indexes: Standard and Poor's (SP500) which is based on the market capitalizations of 500 large U.S. companies; Dow Jones Industrial Average (DJIA) consists of thirty large companies, NASDAQ index is made of 3000 stocks, RUSSELL-2000 is a benchmark for small market capitalization stocks.
- Two Canadian stock indexes: Toronto Stock Exchange (TSX), and Thomson Reuters Canada 50 (TRX50CAP).
- Two European stock indexes: FTSE 100 Index and the CAC 40 which are respectively benchmarks for UK and France stock markets.
- NIKKEI-225 is our tenth index, and it is a benchmark for the Japanese stock market.

Table-4.1 Descriptive statistics for daily nominal stock returns					
Variable	Obs	Mean	Std. Dev.	Min	Max
sp500	4204	0.00%	2.01%	-100.00%	10.79%
Djia	4202	0.02%	1.21%	-7.87%	10.88%
Nasdaq	4205	0.04%	1.71%	-9.67%	14.17%
russell2000	4202	0.04%	1.54%	-11.85%	8.49%
Ussmallcap	4004	0.04%	1.62%	-11.85%	8.49%
treuters50	4202	0.02%	1.17%	-9.75%	10.46%
toronto_tsx	4202	0.02%	1.19%	-9.32%	9.82%
cac40	4102	0.02%	1.51%	-9.04%	10.09%
ftse100	3129	0.01%	1.27%	-8.85%	9.84%
Nikkei	3023	0.02%	1.59%	-11.41%	14.15%

Table-4.1 presents the summary statistic for daily stock returns over the sample period (January 2, 1997 to October 31, 2013). The NASDAQ, RUSSELL-2000 and U.S. Small Capitalization indexes show the highest daily mean returns (0.04%), while the lowest mean return and the highest standard deviation belong to the SP500, and they stand respectively around 0.0016% and 2%.

Table-4.2 : Shapiro-Francia W' test for normal data					
Variable	Obs	W'	V'	z	Prob>z
sp500	4204	0.43	1403.00	18.16	0.00001
Djia	4202	0.93	168.35	12.85	0.00001
Nasdaq	4205	0.96	132.18	12.24	0.00001
russell2000	4202	0.95	115.27	11.90	0.00001
Ussmallcap	3187	0.95	87.45	11.02	0.00001
TR-50	2881	0.89	192.14	12.88	0.00001
TSX	3579	0.91	184.25	12.95	0.00001
cac40	4102	0.95	102.73	11.59	0.00001
ftse100	3129	0.93	29.66	11.97	0.00001

Table-4.2 shows the Shapiro-Francial test for normality; the result indicates that at a 99% confidence level we can reject the null hypothesis and conclude that the daily returns of all ten stock indexes are not normally distributed, the result is not surprising as high-frequency stock returns are known for their non-normality.

Table 4.3: Stock indexes Correlation

	sp500	djia	nasdaq	russell2k	ussmallcap	TR-50	TSX	cac40	ftse100	nikkei
sp500	100%									
djia	97%	100%								
nasdaq	94%	90%	100%							
russell2000	92%	87%	92%	100%						
ussmallcap	92%	87%	92%	100%	100%					
TR-50	75%	70%	68%	70%	70%	100%				
TSX	75%	70%	69%	70%	70%	99%	100%			
cac40	27%	26%	26%	25%	25%	14%	14%	100%		
ftse100	54%	54%	49%	46%	46%	54%	56%	-2%	100%	
nikkei	12%	13%	12%	10%	10%	23%	24%	-3%	33%	100%

Table 4.3 shows the correlation coefficients between the stock indexes; the correlation is almost positive for all stock indexes. The Canadian stock market is highly correlated with the U.S. stock market, with an average coefficient of 70%, which underscores the tight interaction of the two neighboring economies. The Japanese and French stock markets (CAC40 and NIKKEI225) are the least correlated with the U.S. stock market; their respective average correlation coefficient stands at around 10% and 25% respectively.

4.2. Bilateral foreign exchanges

Our foreign exchange market data consists of: (1) the U.S. Dollar index which measures the value of the U.S. dollar against six major world currencies, namely the Canadian dollar, British pound, euro, Swiss franc, and the Swedish Krona; and (2) The bilateral exchange rates between the U.S. and the corresponding countries of the selected foreign stock indexes. The bilateral exchange rates are the following: (1) Canadian dollar to USD (CAD/USD); (2) Euro to USD (EUR/USD); Pound Sterling to USD (GBP/USD); and Japanese Yen to USD (JPY/USD).

Table-4.4: descriptive statistics for USD index return and bilateral exchange rates

Variable	Obs	Mean	Std. Dev.	Min	Max
USD index	4204	0.00%	0.46%	-4.02%	2.18%
cad-usd	4144	0.01%	0.55%	-3.19%	3.96%
eur-usd	4171	0.01%	0.65%	-2.74%	3.80%
gbp-usd	4180	0.01%	0.58%	-3.89%	3.52%
Jpy-usd	4174	0.00%	0.72%	-6.71%	5.35%

As depicted in Table-4.4 the highest mean daily return is associated with the CAD/USD, while JPY/USD shows the lowest mean return and the highest standard deviation.

Table-4.5 : Shapiro-Francia W' test for normal data (FOREX)

Variable	Obs	W'	V'	z	Prob>z
USD INDEX	4204	0.97	64.62	10.45	0
cadusd	4144	0.96	86.1	11.16	0
eurusd	4171	0.99	23.27	7.88	0
gbpusd	4180	0.97	62.46	10.36	0
usdjpy	4174	0.96	91.15	11.31	0

Table-4.5 shows the Shapiro normality for the foreign exchange data sample, the null hypothesis is rejected at a 99% confidence level, inferring that the data are not normally distributed.

5. Empirical results

5.1.1 Monetary policy and U.S. stock markets

The effects of conventional and unconventional monetary policy on the U.S. stock market is summarized respectively in Tables 5.1 and 5.2.

TABLE-5.1 CONVENTIONAL REGIME : U.S STOCK MARKET

VARIABLES	Short coefficient	Std. Err.	z	P>|z|
SP500	**-0.1*** **	0.03	-1.91	0.057
DJIA	**-0.1*** **	0.02	-2.21	0.027
NASDAQ	**-0.1*** **	0.04	-2	0.045
SMALL CAP	-0.03	0.03	-1.16	0.246
RUSS-2K	**-0.04*** **	0.03	-1.16	0.246

Note: For the conventional policy regime, entries under the column heading "Target" denote the estimates of the response coefficients to an unanticipated change in the 2-year Treasury yield. All specifications include a constant (not reported) and are estimated by OLS (see the text for details); a 83 FOMC announcements (Jan-04-1999–Nov-24-2008).
* p < 0.10; ** p < 0.05; and *** p < 0.01. Pr > Z denotes the p-value of the test of the null hypothesis that the implied passthrough coefficient is equal to one.

Table-5.1 shows the results of the OLS estimations of equation (1), with the U.S. stock market as the dependent variable. According to the entries in the Table-5.1, during the conventional period, a short U.S. policy shock which is translated by an unanticipated easing of monetary policy that lowers the 2-year nominal T-bill yield by 10 basis points (bps) leads to an increase of 1 bps in the daily returns of 3 U.S. stock indexes, namely the SP500, DJIA and NASDAQ. The responses are statistically significant, but they are also weak in magnitude. Our results are consistent with Normandin and Bouakez (2013) who suggested that the interaction between stock returns and monetary policy before the last financial crisis is much weaker than shown by previous studies.

TABLE-5.2 : UNCONVENTIONAL REGIME US. STOCK MARKETS								
	ESTIMATION WITH LSAP ANNOUCEMENTS				ESTIMATION WITHOUT LSAP ANNOUCEMENTS			
Variable	coefficient	Std. Err.	Z	P>|z|	coefficient	Std. Err.	z	P>|z|
Short- sp500	**-0.2*** **	0.06	-3.41	0.001	**-0.2*** **	0.06	-3.41	0
Long-Sp500	0.1	0.04	1.91	0.456	0.1	0.04	1.91	0.46
Short-DJIA	**-0.2*** **	0.05	-3.05	0.002	**-0.2*** **	0.05	-3.05	0
Long-DJIA	0.1	0.03	1.93	0.353	0.1	0.03	1.93	0.35
Short NASDAQ	**-0.2*** **	0.06	-3.12	0.002	**-0.2*** **	0.06	-3.12	0
Long- NASDAQ	0.1	0.04	2.28	0.323	0.1	0.04	2.28	0.28
Short-Small Cap	**-0.3*** **	0.07	-3.41	0.001	**-0.3*** **	0.07	-3.41	0
Long-Small Cap	0.1	0.05	1.28	0.199	0.1	0.05	1.28	0.3
Short-RUS2K	**-0.3*** **	0.07	-3.41	0.001	**-0.3*** **	0.07	-3.41	0
Short-RUS2K	0.1	0.05	1.29	0.198	0.1	0.05	1.29	0.3

Note: For the unconventional policy regime, entries under the column heading "Short" denote the estimates of the response coefficients to an unanticipated change in the 2-year Treasury yield, while entries under the column heading "Long" denote the estimates of the response coefficients to an unanticipated change in the 10-year Treasury yield that is orthogonal to the surprise in the 2-year Treasury yield. All specifications include a constant (not reported).

The unconventional regime consists of 47 LSAP- and non-LSAP-related policy announcements (Nov-25-2008–Oct-31-2013). The unconventional – LSPA consists of 35 non-LSAP-related policy announcements (Nov-25-2008–Oct-31-2013).

* $p < 0.10$; ** $p < 0.05$; and *** $p < 0.01$. Pr > Z denotes the p-value of the test of the null hypothesis that the implied passthrough coefficient is equal to one.

As emphasized in Table-5.2, during the zero lower bound period, the impact of a short U.S. policy shock which is translated by an unanticipated easing of monetary policy that lowers the 2-year nominal T-bill yield by 10 bps leads to a statistically significant rise in the daily stock return. The impacts are economically more pronounced than the ones estimated for the conventional regime. A short unconventional policy shock leads to increases in the daily stock return ranging from 2 to 3 bps. It is also important to point out that Smaller capitalization stock indexes such as

RUSSELL2000 and US-SMALL-CAP 2000 seems to show more significant responses to the unconventional short policy shocks than the others. This result aligns with Thorbecke (1997) who noted that smaller capitalization stocks are relatively more responsive to monetary policy shocks.

The U.S. "long" monetary policy shock does not have a separate effect on U.S. equity prices. The exclusion of announcements that were related to the LSPA program yields a very similar result, as a result, we can conclude that the LSPA program does not have an isolated effect on the U.S. stock market.

5.1.2 Monetary policy and foreign stock markets

This section contains our analysis regarding the impact of the U.S. monetary policy shocks on foreign stock markets. Our results for the conventional and the unconventional regimes are respectively shown in Tables 5.3 and 5.4.

TABLE-5.3 : CONVENTIONAL REGIME FOREIGN STOCK MARKETS

Variable	Short coeff	Std. Err.	z	P>|z|
CAC40	-0.03	0.04	-0.78	0.29
FTSE	-0.05	0.04	-1.18	0.32
NIKKEI	-0.08	0.05	-1.45	0.3
TRX50CAP	-0.02	0.03	-0.69	0.28
TSX	-0.03	0.00	2.24	0.4

Note: For the conventional policy regime, entries under the column heading "Short" denote the estimates of the response coefficients to an unanticipated change in the 2-year Treasury yield. All specifications include a constant (not reported).The Conventional regime has 83 FOMC announcements (Jan-04-1999–Nov-24-2008).
* p < 0.10; ** p < 0.05; and *** p < 0.01. Pr > W denotes the p-value of the test of the null hypothesis that the implied passthrough coefficient is equal to one.

According to Table-5.3, during the conventional regime, a short U.S. policy shock which is defined as an unanticipated easing that lowers the 2-year nominal T-bill yield by 10 bps does not lead to a statistically significant impact on all five foreign stock indexes.

In contrast, according to Table-5.4 below which shows the results of the unconventional regime, two Canadian stock indexes have responded to the "short" U.S. policy shock, as measured by a policy-induced change in the 2-year T-bill yield during the unconventional period. This finding highlights the close relationship between the two neighbouring economies.

Moreover, the "long" U.S. policy shock does not affect the foreign stock market yields, and the exclusion LSPA related announcement does have an impact on our result as the estimated response coefficients are very similar to ones calculated by the all-inclusive model.

TABLE-5.4 : UNCONVENTIONAL REGIME FOREIGN STOCK MARKETS

	ESTIMATION WITH LSAP ANNOUCEMENTS				ESTIMATION WITHOUT LSAP ANNOUCEMENTS			
Variables	coefficient	Std. Err.	z	P>|z|	coefficient	Std. Err.	z	P>|z|
Short- CAC40	-0.06	0.07	-3.41	0.36	-0.06	0.07	-3.41	0.36
Long-CAC40	0.08	0.06	1.91	0.18	0.08	0.06	1.91	0.18
Short-FTSE	-0.02	0.04	-3.05	0.67	-0.02	0.04	-3.05	0.67
Long-FTSE	0.09	0.02	1.93	0.00	0.09	0.02	1.93	0.00
Short-NIKKEI	-0.01	0.08	-3.12	0.90	-0.01	0.08	-3.12	0.90
Long- NIKKEI	0.01	0.07	2.28	0.84	0.01	0.07	2.28	0.84
SHORT TSX50CAP	**-0.13*** **	0.05	-3.41	0.01	**-0.13*** **	0.05	-3.41	0.01
LONG TS50CAP	0.06	0.03	1.28	0.04	0.06	0.03	1.28	0.04
Short-TSX	**-0.11*** **	0.07	-3.41	0.00	**-0.11*** **	0.07	-3.41	0.00
Long-TSX	0.1	0.05	1.29	0.20	0.1	0.05	1.29	0.20

Note: For the conventional policy regime, entries under the column heading "Short" denote the estimates of the response coefficients to an unanticipated change in the 2-year Treasury yield. For the unconventional policy regime, entries under the column heading "Short" denote the estimates of the response coefficients to an unanticipated change in the 2-year Treasury yield, while entries under the column heading "Long" denote the estimates of the response coefficients to an unanticipated change in the 10-year Treasury yield that is orthogonal to the surprise in the 2-year Treasury yield. All specifications include a constant (not reported).The Conventional regime has 83 FOMC announcements (Jan-04-1999–Nov-24-2008).
The unconventional regime consists of 47 LSAP- and non-LSAP-related policy announcements (Nov-25-2008–Oct-31-2013).
The unconventional – LSPA consists of 35 non-LSAP-related policy announcements (Nov-25-2008–Oct-31-2013).
* p < 0.10; ** p < 0.05; and *** p < 0.01. Pr > W denotes the p-value of the test of the null hypothesis that the implied passthrough coefficient is equal to one.

5.2. U. S monetary policy and foreign exchange markets

This section goes over the estimation of foreign exchange markets' responses to monetary policy shocks. The results for the conventional and unconventional regimes are respectively shown in Tables-5.5 and 5.6.

Table 5.5 : CONVENTIONAL REGIME : USD & bilateral exchanges

Variable	coefficient	Std. Err.	Z	P>|z|
USD INDEX	0.009	0.006	1.37	0.17
CAD/USD	**-0.02*** **	0.010	-2.36	0.01
EUR/USD	**-0.02*** **	0.010	-2.36	0.01
GBP/USD	-0.013	0.009	-1.51	0.23
JPY/USD	**-0.04*** **	0.011	3.86	0

Note: For the conventional policy regime, entries under the column heading "Target" denote the estimates of the response coefficients to an unanticipated change in the 2-year Treasury yield. All specifications include a constant (not reported) and are estimated by OLS (see the text for details); a 83 FOMC announcements (Jan-04-1999–Nov-24-2008).
* p < 0.10; ** p < 0.05; and *** p < 0.01. Pr > Z denotes the p-value of the test of the null hypothesis that the implied passthrough coefficient is equal to one.

The estimation results for the conventional regime are reported in Table-5.5. According to our results, a short conventional monetary policy shock, which is implied by an unanticipated decrease of the 2-year nominal T-bill yield by 10 bps, has little to no effect on the bilateral exchange rates.

TABLE-5.6 : UNCONVENTIONAL REGIME : USD & bilateral exchanges

	ESTIMATION WITH LSAP ANNOUCEMENTS				ESTIMATION WITHOUT LSAP ANNOUCEMENTS			
Variables	coefficient	Std. Err.	Z	P>|z|	coefficient	Std. Err.	z	P>|z|
Short USD-INDEX	0.02	0.01	1.35	0.18	0.02	0.01	1.35	0.18
Long USD-INDEX	-0.01	0.01	-1.21	0.23	-0.01	0.01	-1.21	0.23
Short CAD/USD	**-0.15*** **	0.01	-12.69	0.00	**-0.15*** **	0.01	-12.69	0.00
Long CAD/USD	0.02	0.01	1.84	0.27	0.02	0.01	1.84	0.27
Short EUR/USD	**-0.2*** **	0.02	-8.84	0.00	**-0.2*** **	0.02	-8.84	0.00
Long EUR/USD	0.01	0.02	-2.03	0.04	0.01	0.02	-2.03	0.04
Short GBP/USD	**-0.11*** **	0.02	-6.04	0.00	**-0.11*** **	0.02	-6.04	0.00
Long GBP/USD	0.00	0.02	0.09	0.93	0.00	0.02	0.09	0.93
Short JPY/USD	**-0.11*** **	0.02	5.05	0.00	**-0.11*** **	0.02	5.05	0.00
Long JPY/USD	0.10	0.02	3.68	0.00	0.10	0.02	3.68	0.00

Note: For the unconventional policy regime, entries under the column heading "Short" denote the estimates of the response coefficients to an unanticipated change in the 2-year Treasury yield, while entries under the column heading "Long" denote the estimates of the response coefficients to an unanticipated change in the 10-year Treasury yield that is orthogonal to the surprise in the 2-year Treasury yield. All specifications include a constant (not reported).

The unconventional regime consists of 47 LSAP- and non-LSAP-related policy announcements (Nov-25-2008–Oct-31-2013). The unconventional – LSPA consists of 35 non-LSAP-related policy announcements (Nov-25-2008–Oct-31-2013).

* p < 0.10; ** p < 0.05; and *** p < 0.01. Pr > Z denotes the p-value of the test of the null hypothesis that the implied passthrough coefficient is equal to one.

Table-5.6 reports the estimates of the direct impact of unconventional policy on the USD index and the selected bilateral exchange rates. During the unconventional regime, the effect of a monetary easing that lowers the 2-year nominal T-bill yield by 10 bps (short surprise) has no economic effect on the USD index. However, the same monetary stimulus leads to a statistically significant drop of USD against its foreign counterparts, the decline ranges from 1 to 2bps. For instance, following the unconventional "short" monetary policy surprise, the Euro and CAD increase respectively by 2 and 1.5 bps against the USD.

The LSAP program does not seem to have an isolated impact on the interaction between U.S. monetary policy and the forex market; the exclusion of the LSAP related FOMC announcement does not change the result.

6. Conclusion

This paper analyzes the effects of monetary policy shocks on stock and foreign exchange markets. Our estimates are done across two monetary policy regimes: the conventional regime refers to the period during which the stance of the monetary policy was communicated through a change in the current and future path of the federal funds target rate; and the unconventional regime is characterized by the period during which the FOMC set the target rate at its lower bound and employed the forward guidance and the LSAP as its primary monetary policy tool. Changes in the 2-year T-bill yields are computed over a narrow window surrounding an FOMC meeting, and these changes are used as a common instrument across the two monetary regimes. For the unconventional regime period, we allow for an additional policy surprise with intent to capture the extra dimension of the unconventional policy. The additional policy surprise is captured by the changes in the 10-year T-bill yields that are orthogonal to the changes in the 2-years T-bill yields.

Our results show that during the conventional monetary regime period, a policy-induced decline in the 2-year T-bill yield of 10 bps which is defined as the "short surprise" has an economically small effect on three out five U.S. stock indexes. Our results align with Normandin and Bouakez (2013) who found a weak interaction between stock markets and monetary policy, but they are also in sharp contrast with the studies that found a strong and positive relationship between stock market return and monetary policy easing during the conventional period. During the ZLB period, by contrast, a short surprise of the same magnitude boots daily U.S. stock market returns up to 3 bps. The exclusion of the LSAP announcement from our estimation does not change our results. In sum, during the conventional monetary regime, short policy shocks are estimated to lead to statistically significant, though economically low increases in the daily returns of the U.S. stock market; by contrast, during the unconventional regime, the predicted responses increase by threefold, and LSPA program does not influence stock market return.

The estimated responses of foreign stock markets to U.S. monetary policy shocks is not statistically significant during the convention period. By contrast, when the zero lower bound is binding, an unconventional short surprise leads to an average increase of 1.5 bps in the Canadian stock market daily return. The U.S. "long" monetary policy surprise and LSAP program do not have any separate impact on the foreign stock market which is the same case as for the U.S. stock market.

In this study we also estimated the response of the U.S. dollar index and four bilateral U.S. exchange rates to monetary policy shocks during both periods. Our results show that during the conventional regime, a "short" monetary policy shock has no economically significant effect on the selected exchange rates. By contrast, during the unconventional regime, a "short" monetary policy shock that reduces the 2-year T-bill rate by 10 bps, leads to a decline of the U.S. dollar against the selected foreign currencies. The estimated declines range from 1 to 2 bps. The estimated impacts are economically modest and statistically significant. The bilateral exchange rates are not impacted by the "long" policy shock and LSPA program.

To sum up, our analysis indicates that "short" monetary policy shocks had a more pronounced effect on the North American stock markets and selected bilateral exchange rates during the unconventional regime period which is characterized by the zero lower bound constraint. The "long" monetary policy shocks and the asset purchase program do not impact any of the selected financial assets classes.

Appendix-A

A1. Conventional Monetary Policy: A 2-Factor Model

In this section, we test the robustness of our estimates to an alternative specification of the conventional monetary policy. To measure the stance of the conventional monetary policy, we follow the Gilchrist et al. (2015) approach which consists of decomposing the conventional monetary policy into two orthogonal factors that have an impact on the asset prices. The first factor is the "target" surprise, and it occurs whenever an FOMC announcement is associated with an unanticipated change in the federal funds rate. The second factor corresponds to the "path" surprise, and it happens when a policy announcement contains information about the future trajectory of the policy rates.

The model is formalized as follows: letting the change in the 2-year nominal T-bill yield over a 30-minute window surrounding an FOMC meeting announcement on day t, be denoted as $\tilde{\Delta}\boldsymbol{y_t(2)}$**,** we assume that:

$$\tilde{\Delta}\boldsymbol{y_t(2)} = \boldsymbol{\varphi_c}\tilde{\Delta}\boldsymbol{m_t^T} + \tilde{\Delta}\boldsymbol{m_t^P} \qquad \textbf{(A)}$$

Where $\tilde{\Delta}m_t^T$ and $\tilde{\Delta}m_t^P$ represent respectively the target and the path surprises and are assumed to be orthogonal to the unexpected change in the federal funds rate. The target surprise is computed following the approach of Kuttner (2001), which assumes the target surprise as the difference between the newly announced target federal funds rate and the expected future rate. The expected future rate is assumed to be given by the federal funds futures contracts rate computed during the narrow window surrounding a policy announcement. The path surprise ($\tilde{\Delta}m_t^P$) in this model is assumed to be the OLS residual from a regression of $\tilde{\Delta}y_t(2)$ on the target surprise $\tilde{\Delta}m_t^T$.

It can be inferred that the change in the 2-year T-bill on a policy announcement day *t*, denoted $\Delta y_t(2)$ is given by:

$$\Delta\boldsymbol{y_t(2)} = \boldsymbol{\delta_T}\tilde{\Delta}\boldsymbol{m_t^T} + \boldsymbol{\delta_P}\tilde{\Delta}\boldsymbol{m_t^P} + \boldsymbol{\varepsilon_t(2)} \quad \textbf{(B)}$$

$\varepsilon_t(2)$ captures all other shocks that potentially can impact the movement of the 2-year T-bill rate on the day of the monetary policy announcement. δ_T and δ_P respectively capture the relative impact of the "target" and "path" surprises.

Using this approach, the effect of conventional monetary policy shocks on stock market returns is given by

$$\Delta \boldsymbol{s_t} = \boldsymbol{\beta_T}\tilde{\Delta}\boldsymbol{m_t^T} + \boldsymbol{\beta_P}\tilde{\Delta}\boldsymbol{m_t^P} + \boldsymbol{u_t} \quad \textbf{(C)}$$

Where s_t denotes the vector of the selected daily stock market returns; the parameters of equations (A) and (C) are jointly estimated by NLS; this approach allows us to consider the specified cross equation restrictions. The coefficient β_T denotes the estimate of the response to a "target" surprise and β_P represents the estimate of the response coefficient to a "path" surprise.

A2. Estimation results

Table A-1 below shows our results using the 2-factor model described above; the "Total" column shows the combined effect of the "path" and "target" surprise. For comparison purpose, we have also included the estimates obtained from the 1-factor model which we have used for the conventional regime in this research. The 1-factor model implicitly combines the effect of the monetary policy surprises. We have limited our estimation to the impact of the conventional monetary policy on stock markets returns.

Our results show that the "Total" effect of the two monetary policy shocks in the 2-factor model is relatively very similar to the one obtained from the 1-factor model. Both models have about the same explanatory power of monetary policy induced variability in the stock market on a FOMC announcement day.

To summarize, our results show that the effects of the conventional monetary policy can adequately be captured by changes in the 2-year T-bill yield over the narrow window on the policy announcement day.

Table A-1: Conventional Monetary Policy and Selected stock markets returns

	2-Factor Model				1-Factor Model	
Dependent Variable	**Target**	**Path**	**Total**	**R-Sqare**	**Total**	**R2**
SP500	-0.025	-0.040	-0.065	0.012	-0.048	0.012
DJIA	-0.026	-0.044	-0.070	0.012	-0.052	0.012
NASDAQ	-0.048	-0.075	-0.124	0.016	-0.092	0.016
RUSSEL2K	-0.012	-0.030	-0.042	0.015	-0.032	0.015
US_SMALL_CAP	-0.012	-0.030	-0.042	0.015	-0.032	0.015
CAC_40	0.033	-0.041	-0.008	0.014	-0.012	0.015
FTSE	-0.031	-0.046	-0.077	0.016	-0.057	0.017
NIKKEI	0.017	-0.141	-0.124	0.021	-0.104	0.021
TSX	-0.077	0.001	-0.075	0.407	-0.048	0.011

Note: Sample: 83 FOMC announcements (Jan-04-1999–Nov-24-2008). For the 2-factor model, entries under the column heading "Target" denote the estimates of the response coefficients to an unanticipated change in the target federal funds rate; entries under the column heading "Path" denote the estimates of the response coefficients to an unanticipated change in the 2-year Treasury yield that is orthogonal to the surprise in target federal funds rate; and entries under the column heading "Total" are the estimates of the combined effect of the two policy surprises. For the 1-factor model—the baseline model used in the paper—entries under the column heading "Total" denote the estimates of the response coefficients to an unanticipated change in the 2-year Treasury yield. All specifications include a constant (not reported) and are estimated by OLS (see the text for details)

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