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IMPACT OF THE FED'S UNCONVENTIONAL MONETARY POLICY ON THE US FINANCIAL MARKET†

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Abstract

This paper is devoted to the unconventional monetary policy measures implemented by the US Federal Reserve (Fed) after the global financial crisis. The objective is to conduct an empirical analysis and econometric study on the effects of the US Fed non-standard monetary policy measures on the US financial market, namely by observing the reaction on the US 10-year government bond yield, the US stock market via the S&P 500 index, and the exchange rate of the US dollar versus the euro (EUR/USD). The observed period spreads from January 2009 to March 2019, with the use of monthly data. It captures the Fed's unconventional monetary policy measures, the first steps of the then planned gradual termination of quantitative easing (QE) and lifting of the interest rates, which was reverted in the course of 2019 and 2020. The results from the constructed vector error correction model suggest that Fed's monetary policy stance continues to influence the changes in the bond yields, the S&P 500 index, and the value of the US dollar through the interest rate, the portfolio balance, and the exchange rate channels. The findings show that the process of normalization of the monetary policy regarding the future interest rates path in the US under the Fed's monetary policy must be carefully guided. It must be consistent with the macroeconomic conditions and the state of the financial sector. The impact on the developed and emerging markets must be considered as well, with the main aim of avoiding potential serious risks.

Keywords: Monetary Policy, Unconventional Monetary Policy, Central Banks, Financial Markets, Quantitative Easing

JEL Classifications: E52, E58, F30

1. Introduction

In an attempt to counteract the negative effects stemming from the global financial crisis (GFC), the US Federal Reserve (Fed), the Bank of Japan (BoJ), the Bank of England (BoE), and the

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European Central Bank (ECB) embarked on unconventional monetary policy measures (IMF, 2013). These include reducing interest rates to very low or even negative nominal levels, asset purchase programs, forward guidance, and credit easing (Chen *et al.* 2017).

The Fed is among the first global central banks to undertake quantitative easing (QE) after it lowered the interest rates in the US practically to zero as a first step after the GFC. From the autumn of 2008 until the fall of 2014, the Fed bought an unprecedented amount of securities, resulting in a rise of the central bank's balance sheet to about $4.5 trillion. Later, the example was followed by other central banks, including BoE and the ECB, but not only.

In addition, the Fed was also one of the world's first leading central banks, which paved a plan for unconventional monetary policy normalization, in the view of the economic and financial conditions on which such kind of decision usually depends. Later, the course was abandoned due to the additional challenges for the economy and the further implications posed by the spread of the Covid-19 pandemic. As of the end of 2020, the Fed plans to keep the interest rates low until 2024 at least (Federal Open Market Committee, 2020). Eventually, how the monetary policy stance in the US would be normalized could serve as an example for other central banks.

The paper is devoted to the unconventional monetary policy measures implemented by the Fed after the GFC. The objective of the study is to conduct an empirical analysis and econometric study on the effects of the US Fed non-standard monetary policy measures on the US financial market, namely by observing the reaction on the US 10-year government bond yield, the US stock market via the S&P 500 index, and the exchange rate of the US dollar versus the euro (EUR/USD).

The current study builds on and complements recent research in the field of unconventional monetary policy. This study extends the observed period from January 2009 to March 2019 and complements the results of the applied global vector error correction model (GVECM) by Chen *et al*. (2015) on the effects of unconventional monetary policy measures implemented by the Fed. In the current study, a vector error correction model (VECM) for assessing the impact of the Fed's loose monetary policy stance on the US financial market is developed.

The paper is structured as follows: section 2 outlines the data and the methodology used for conducting the empirical analysis and the econometric study. The research is focused on covering the effects from the implemented unconventional monetary policy measures by the US Fed on the US financial market. One of the purposes of the paper is to examine the monetary policy transmission through the interest rate channel, the exchange rate channel, and the portfolio balance channel. The discussion of the results is presented in section 3. Finally, section 4 highlights the main findings and concludes the paper.

2. Data and methodology

This section describes the applied methodology in the paper and the characteristics of the data, which are used to conduct the empirical analysis and the econometric study outlined in section 3. It also includes a short description of the structure of the applied VECM model.

2.1. Methodology

Theoretical and methodological analysis were employed for this paper to highlight the specificities of the unconventional monetary policy conducted by the Fed. Further, a systematic approach to analyze the effects of the unconventional monetary policy of the US Fed on the US financial market was applied to conduct the research.

This study employed empirical analysis and econometric study to reveal the effects of the non-standard monetary policy measures of the US Fed on the US 10-year government bond yield, the US stock market via the S&P 500 index, and the exchange rate of the US dollar versus the euro (EUR/USD). For this purpose, a vector error correction model (VECM) to examine the influence arising from the Fed's loose monetary policy stance on the US financial market was developed.

Our analysis complements studies like those of Chen *et al.* (2015), Galati and Moessner (2020), and Chen *et al.* (2015), which used the spread between the yield of corporate bonds and the yield on the US government bonds to evaluate the effects of the QE adopted in the US on emerging economies. Chen *et al.* (2017) further examined the macroeconomic effects of the QE on 24 developed and emerging markets, using monthly data from October 2008 to June 2014 and the shadow rate developed by Lombardi and Zhu (2014). Chen *et al.* (2017) used the GVECM, which showed that cross-border effects vary and that the effects of the Fed's unconventional measures were greater than those of the ECB. Galati and Moessner (2020) studied the effects of quantitative policy rate forecasts by the Federal Reserve on real yields and inflation expectations at the zero-lower bound, by using forward rates with horizons from 2 to 10 years ahead derived from nominal and index-linked US government bonds.

Extending the observed period until March 2019, the analysis in the paper complements recent research in the field of unconventional monetary policy. Moreover, this paper follows a critical analysis of the effects of QE and low nominal interest rates as the unconventional monetary policy instruments used by the central banks.

2.2. Data and sources

For the econometric analysis employed in this paper, monthly data are used for the period from January 2009 to March 2019. The time series is composed of 123 observations, which are sufficient for the construction of the econometric models and carrying out the necessary analysis.

The observed period captures the unconventional monetary policy measures implemented by the US Fed after the GFC, the first steps of the then planned gradual termination of QE, and lifting of the interest rates before it was reverted in the course of 2019 and 2020.

The monthly data for the US 10-year government bond yield, which is denominated in the paper as the variable US_YIELD, is obtained from Investing.com. Further, the data for the monthly values and changes in the S&P 500 index (SP500) and the monthly change of the exchange rate of the US dollar against the euro (EUR/USD) are derived from Investing.com.

The variable FEDSEC is built on the monthly changes in the securities held outright, which is taken from the assets side of the balance sheet of the US Fed and provided from the database of the Federal Reserve Bank of St. Louis.

Finally, the database of Wu and Xia (2016a, 2016b) is used for the shadow interest rates of central bank (US_SH_RATE).

2.3. Description of the constructed VECM

This section is devoted to the description of the methodology of the econometric study, including the constructed vector error correction model (VECM), the results from the econometric tests, and the conclusions from the analysis. The econometric study goes through several stages, which are systematized as follows.

First, the variables, which are used in the econometric model to assess the effects of the Fed's unconventional monetary policy on the US financial market over the period under review, were selected. The choice of variables is based on the established theoretical formulations and logical links, frequency of utilization in the literature, proven application in practice while designing models concerning the topic, and the emphasis on the influence of non-standard measures on the US financial market through the monetary policy transmission mechanism channels.

Second, a robustness unit root check was performed. This was done using the augmented Dickey-Fuller test (ADF test) (Dickey and Fuller, 1979). Test results are presented in Table 4 in the Appendix.

Third, once the statistical characteristics of the time series were established, the Johansen cointegration test (1991, 1995) was applied to test the cointegration of the selected variables. The results are presented in Table 5 in the Appendix.

Finally, different econometric models were constructed using VECM to assess the effects of the Fed's unconventional monetary policy measures. The choice of the most appropriate model for assessing the effects on the US financial market was based on the Akaike Information Criterion

(AIC), one of the most widely used information criteria. The key advantage of AIC over the coefficient of determining R-squared is that the AIC prevents the inclusion of unnecessary factors or degrees in a given model (Atanasov, 2018). Thus, the model with the lowest AIC value was selected. The overall representation of the developed model is as in Equation 1.

$$Y_t = \alpha + A(L)Y_{t-1} + B(L)X_t + \nu_t \quad (1)$$

; where, Y_t is a vector of endogenous variables, α is a vector of constants, X_t is a vector of exogenous variables, A and B are matrices for endogenous and exogenous variables with the values of their respective coefficients, and v_t is vector of error terms.

After the stationarity tests of the time series and the cointegration tests, the paper proceeds with the econometric study, which is focused on examining the effects of the unconventional monetary policy of the Fed on the US financial market during the observed period from January 2009 to March 2019.

The VECM is constructed with three endogenous variables; namely, the first difference of the yield on the US 10-year Treasuries (US_YIELD), the monthly percentage changes in the S&P 500 index (SP500), and the monthly percentage changes in the exchange rate of the US dollar versus the euro (EURUSD), and two exogenous variables, which are the monthly percentage changes in the Fed's securities held outright (FEDSEC) and the levels of the US shadow rate (US_SH_RATE).

3. Results and discussion

3.1. Empirical analysis

Before Covid-19, the GFC was dubbed as the worst crisis since the Great Depression. The global financial system experienced huge challenges from 2007 to 2009. In the US, the Fed responded to the crisis by taking a series of unprecedented decisions and bold actions, aiming to provide liquidity and ensure the stability of the financial markets. Labonte (2020) classified those actions into three categories: changes in the federal funds rate, direct assistance to the financial sector by performing the central banks' function as lender of last resort, and deployment of large-scale asset purchases (LSAP), which are extensively referred in the literature as QE.

When it comes to the interest rates in the US, what is referred to in this paper is the Federal funds rate. With the onset of the GFC, the Fed lowered the rate tenfold. The rate was at 5.25% in August 2007, and Fed decreased it to 0.25% by the end of December 2008. That rate remained unchanged for eight consecutive years. Later, Fed raised the rate to 0.5% until December 2015 (Board of Governors of the Federal Reserve System, 2015). The Fed provided additional stimulus through unsterilized purchases of US Treasuries and mortgage-backed securities (MBS), while the interest rates in the US were anchored at the zero-lower bound (Labonte, 2020).

In December 2016, the Fed funds rate rose to 0.75%, and it was lifted three times in 2017; in March, June, and December to 1%, 1.25%, and 1.5%, respectively (Federal Open Market Committee, 2017a). After the first interest rate increase to 1.75% in March 2018, the rate was raised to the range of 1.75 to 2% in June 2018 and the range of 2 to 2.2% in September, and the range of 2.25-2.5% in December 2018.

The expectations for the interest rate in 2019 were to stay unchanged implying the start the monetary policy normalization, but the Fed decided to lower the interest rates once again. Decreases were made in the course of 2019 and the interest rates remained near zero in 2020, with the expectation that the Fed's monetary policy would stay loose, in terms of the level of the interest rates, at least until 2024.

The dynamics of the US effective federal funds rate and the respective trends of the shadow rate as calculated by Wu and Xia (2016a) could be traced back to 1999 in Figure 1.

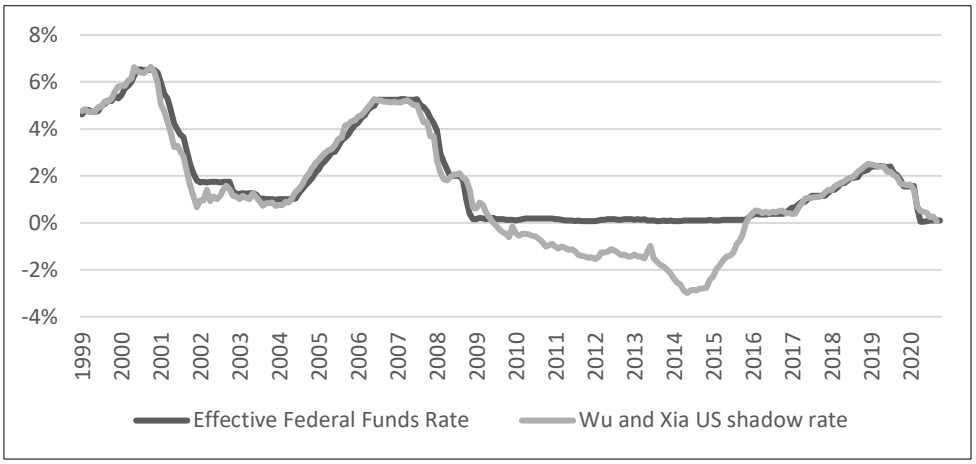

Figure 1. Effective Federal funds rate and US shadow rate dynamics (January 1999 - October 2020)

Source: Federal Reserve System (2020c) and Wu and Xia (2016a, 2016b) shadow rates

The Fed was among the first central banks to undertake QE after lowering the interest rates practically to zero and maintaining that level for nearly a decade. In particular, the Fed undertook three rounds of QE. From the autumn of 2008 until the fall of 2014, the Fed bought an unprecedented amount of treasury bonds and mortgage-backed and US agency securities in the open market, resulting in a rise in the central bank's balance sheet to about $4.5 trillion. Although the Fed's balance sheet figure increased more than fourfold since the end of 2008, the money supply in the same period grew by only 50%, as much of the money returned to the Fed, mostly in the form of banks' excess reserves, and inflation rate failed to reach the Fed's target of near 2% (Trifonova *et al.* 2017).

The first round of quantitative easing (QE1) in the US started in November 2008. The first round, which was initiated three months after the collapse of Lehman Brothers, lasted for 17 months. It was successful in terms of execution and initially expected effects. In that period, the Fed purchased $100 billions of MBS every month, bringing the total purchases to $1.7 trillion, even though MBS were considered as a financial instrument bearing higher credit or liquidity risk than the US Treasuries (Gagnon *et al.* 2011). Considering the success of the first QE round, the Fed initiated the second round of quantitative easing (QE2) 7 months after the end of QE1, performed from November 2010 to June 2011. In that period, the US Fed purchased US long-term treasuries for $85 billion per month. Later, on 13 September 2012, the third round of quantitative easing (QE3) was announced, as the Fed issued an open-ended commitment to buy MBS for another $40 billion per month. In December 2012, the Fed added to that volume the purchase of US Treasuries of $45 billion per month. The Fed aimed to conduct bond purchases until the US economy is fully recovered from the crisis, while the purchases of long-term securities reduced long-term interest rates after the Fed already lowered the short-term interest rates to zero. Purchases were suspended on 29 October 2014, after the Fed's balance sheet rose to $4.5 trillion, which was five times its size before the crisis.

After the end of QE, the Fed planned the process to wind down its balance sheet. It remained relatively steady from 2015 to 2018, and it even declined in 2019. Since September 2017, the Fed has begun to shrink the size of its balance sheet, but only at a very modest speed.

According to Labonte (2020), the US Fed used two tools to manage the interest rate increases in the presence of a large balance sheet. The first one was to pay banks interest on their reserves held at the Fed, and the second one was to engage in reverse repos (reverse repurchase agreements) using a new overnight facility. By providing forward guidance, the Fed underlined in January 2019 that it would continue to use those instruments permanently when setting the interest rates. In August 2019, the US Fed paused the reduction of its balance sheet, totaling $3.8 trillion at that point in time. Meanwhile, the Fed was gradually replacing MBS with treasuries until they mature. In September 2019, there was turmoil in the US repo market, which was interrelated with the Federal fund market. To prevent the spikes in repo rates for a transition

to an upside movement of the Fed funds rate, the Fed intervened on the repo market and expanded its balance sheet again in October 2019.

The course of gradual reduction of the Fed balance sheet was reverted in 2020 due to the widespread negative economic impact of the Covid-19 pandemic. As a means to cushion the potential harmful effects from the pandemic in March and April 2020, the Fed implemented a variety of measures to limit the economic damage from the pandemic, including lending support to households, employers, financial markets, and state and local governments of up to $2.3 trillion (Cheng *et al.* 2021). At the end of October 2020, the balance sheet of the US Fed stood at the amount of nearly $7.15 trillion compared to $4.17 trillion at the end of 2019.

The dynamics of the Fed's total assets and securities held outright, including holdings of US Treasuries, MBS, and agency debt, for the period January 2003 to October 2020 could be observed in Figure 2.

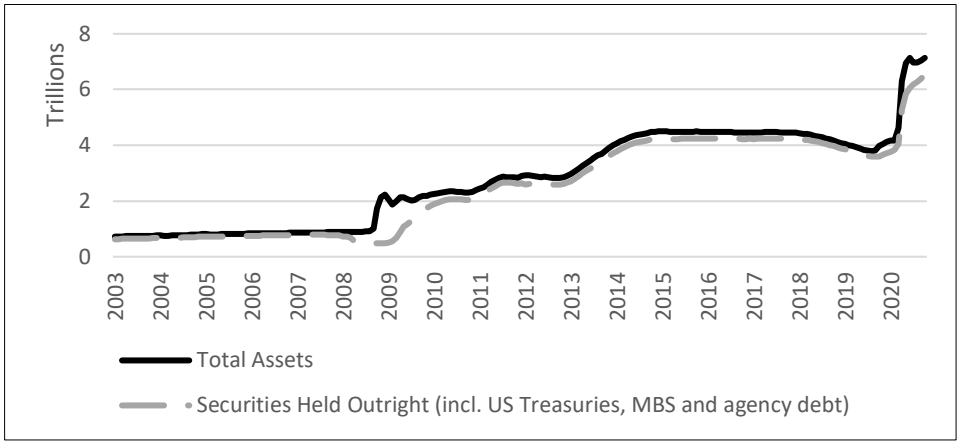

Figure 2. US Fed balance sheet dynamics (January 2003 - October 2020)
Source: Federal Reserve System (2020a, 2020b)

In an attempt to mitigate the severe effects of the Covid-19 pandemic and address the new challenges posed by the coronavirus, the US Congress approved several laws providing direct financial assistance to businesses and households. In addition, the Fed lowered the interest rates, expanded the volume of asset purchases, restored previous emergency credit facilities, and created new and fostered the use of its discount window. According to Weinstock (2021), these policies managed to mitigate the deterioration of broader economic conditions in the short run.

Debates on whether the pandemic-related legislation in the US could have potential adverse consequences are heating up. One of the main issues, which have been raised by economists and scientists, is related to the possible spark of inflation leading to a further debt increase due to stimulus payments. According to the US Federal Reserve, the legislation, including reliefs and stimulus, is expected to boost the US gross domestic product (GDP) in the short run. The most recent projection incorporates an increase of the real GDP by 6.5% in 2021 (Board of Governors of the Federal Reserve System, 2021).

3.2. Econometric study

After describing the interest rate dynamics in the US and the changes in the Fed's balance sheet, this section continues with the econometric study for identifying and assessing some quantitative effects from the Fed's unconventional monetary policy on the US financial market.

One of the main goals is to check the influence of the Fed's monetary policy stance on the US 10-year government bond yield, the changes in the S&P 500 index, and the US dollar exchange rate against the euro. The analytical representation of the vector error correction model for the US 10-year government bond yield with the values of the coefficients, including the significance levels, is summarized in Table 1.

Table 1. VECM model for bond yield as the dependent endogenous variable

Variables	Coefficient	Std. Error	t-Statistic	Prob.
ECT(-1)	-0.4541	0.0935	-4.8588	0.0000***
D(DUS_YIELD(-1))	-0.2749	0.1093	-2.5147	0.0124**
D(DUS_YIELD(-2))	-0.2560	0.0948	-2.6993	0.0073***
D(DUS_YIELD(-3))	-0.0960	0.0780	-1.2304	0.2194
D(SP500(-1))	2.6889	0.6497	4.1386	0.0000***
D(SP500(-2))	1.4812	0.6552	2.2608	0.0244**
D(SP500(-3))	0.9830	0.5613	1.7513	0.0808*
D(EURUSD(-1))	-3.5512	0.9079	-3.9115	0.0001***
D(EURUSD(-2))	-1.5499	0.9070	-1.7088	0.0884*
D(EURUSD(-3))	-1.2195	0.7368	-1.6552	0.0988*
C	-0.0069	0.0203	-0.3411	0.7333
FEDSEC	0.4118	0.4566	0.9018	0.367
DDUS_SH_RATE	0.5683	0.1214	4.6794	0.0000***
R-squared	0.6303			
S.E. equation	0.2079			
F-statistic	15.6279			
Akaike AIC	-0.2034			
Schwarz SC	0.09384			

Note: ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.
Source: Authors' calculations

The results from the estimated VECM[1] showed that the change of the US 10-year government bond yield had a positive relationship with the Fed's securities on its balance sheet, but there is a lack of statistical significance. Instead, the US 10-year government bond yield showed a significantly positive relationship with the US shadow rate at a 5% level (with assumed risk of error $\alpha = 0.05$). Ceteris paribus, a change of the US shadow rate by 1 percentage point leads to a change of the US 10-year government bond yield by 0.568 percentage points on average. This finding illustrates a pass-through of the US Fed monetary policy via the interest rate transmission channel. Next, Table 2 provides the representation of the model for the changes in the S&P 500 index.

Table 2. VECM model for S&P 500 index as the dependent endogenous variable

Variables	Coefficient	Std. Error	t-Statistic	Prob.
ECT(-1)	-0.0702	0.0184	-3.8098	0.0002***
D(DUS_YIELD(-1))	0.0194	0.0215	0.9026	0.3674
D(DUS_YIELD(-2))	0.0114	0.0187	0.6100	0.5423
D(DUS_YIELD(-3))	0.00002	0.0154	0.0015	0.9988
D(SP500(-1))	-0.4351	0.1280	-3.3980	0.0008***
D(SP500(-2))	-0.2757	0.1291	-2.1351	0.0335**
D(SP500(-3))	-0.1843	0.1106	-1.6661	0.0966*
D(EURUSD(-1))	-0.5617	0.1789	-3.1360	0.0019***
D(EURUSD(-2))	-0.4793	0.1788	-2.6810	0.0077***
D(EURUSD(-3))	-0.1370	0.1452	-0.9438	0.3460
C	-0.0029	0.0040	-0.7419	0.4587
FEDSEC	0.2445	0.0900	2.7163	0.0069***
DDUS_SH_RATE	-0.0314	0.0239	-1.3098	0.1912
R-squared	0.5323			
S.E. equation	0.0410			
F-statistic	10.4323			
Akaike AIC	-3.4515			
Schwarz SC	-3.1543			

Note: ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.
Source: Authors' calculations

[1] The cointegration equation and the implied long-run relationship with the respective coefficient values are presented in Table 6 in the Appendix.

The estimates concerning the effects on the changes in the S&P 500 index showed a positive and statistically significant relationship with the Fed's securities on its balance sheet at a 5% level. That said, ceteris paribus, a change of the Fed's securities by 1%, corresponding to a volume of securities around $60 billion a month, led to a change in the S&P 500 index by 0.24 percentage point on average in the observed period. This finding proved the pass-through of the US Fed balance sheet policy via the portfolio rebalance transmission channel as monetary policy reflects the continuing interactions among the Fed, financial institutions, and financial markets (Meulendyke, 1998).

In this context, the changes in the volume of the Fed's balance sheet continue to influence the developments on the stock market, represented by the S&P 500 index in the model, as the major stock market indices in the US chase new record highs, which could be followed in Figure 3. Furthermore, the estimates regarding the effects on the changes in the US shadow rate on the S&P 500 index are not statistically significant even though there is a negative relationship, which is expected from a theoretical point of view.

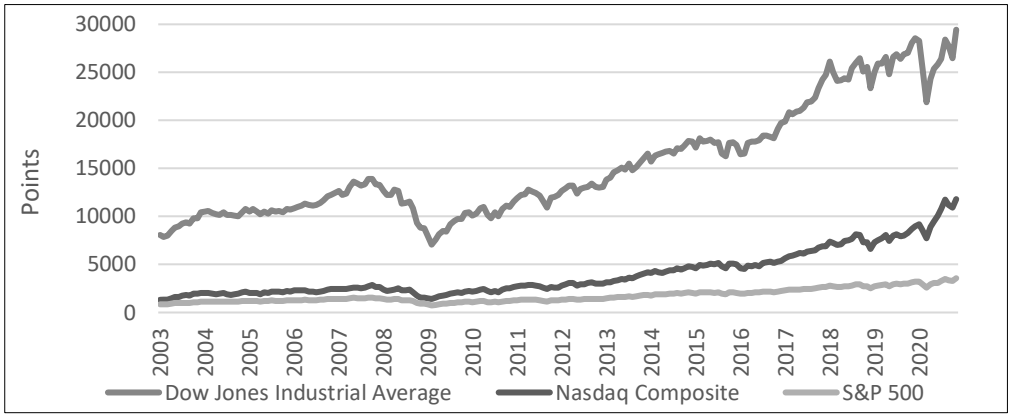

Figure 3. Dow Jones industrial average, S&P 500 and Nasdaq Composite dynamics – monthly changes (January 2003 – November 2020)
Source: Investing.com

The model for the exchange rate, including the coefficient of the variables and the significance levels, is represented in Table 3.

Table 3. VECM model for EUR/USD as the dependent endogenous variable

Variables	Coefficient	Std. Error	t-Statistic	Prob.
ECT(-1)	0.0217	0.0135	1.6061	0.1092*
D(DUS_YIELD(-1))	-0.0361	0.0158	-2.2849	0.0230**
D(DUS_YIELD(-2))	-0.0270	0.0137	-1.9694	0.0497**
D(DUS_YIELD(-3))	-0.0290	0.0113	-2.5701	0.0106***
D(SP500(-1))	-0.1386	0.0939	-1.4756	0.1410
D(SP500(-2))	-0.0775	0.0947	-0.8178	0.4141
D(SP500(-3))	-0.0453	0.0812	-0.5577	0.5774
D(EURUSD(-1))	-0.6883	0.1313	-5.2439	0.0000***
D(EURUSD(-2))	-0.4605	0.1311	-3.5112	0.0005***
D(EURUSD(-3))	-0.0968	0.1065	-0.9085	0.3643
C	-0.0016	0.0029	-0.5577	0.5774
FEDSEC	0.0928	0.0660	1.4062	0.1606
DDUS_SH_RATE	-0.0277	0.0176	-1.5781	0.1155
R-squared	0.5779			
S.E. equation	0.0301			
F-statistic	12.552			
Akaike AIC	-4.0712			
Schwarz SC	-3.7740			

Note: ***, **, and * represent significance levels at 1%, 5%, and 10%, respectively.
Source: Authors' calculations

The results suggest that there is no statistical significance (at the 5% level) between the changes in the EUR/USD exchange rate and the Fed's asset purchases and the changes in the US shadow rate. There might be other factors influencing the changes in the exchange rate. For example, the introduction of fiscal policy measures and/or the course of the foreign policy conducted by the US towards China and the EU in recent years may have two of those factors.

There is more empirical evidence in the literature (Clarida and Gali, 1994; Cristiano *et al.* 1994; Faust *et al.* 2003; Scholl and Uhlig, 2008; Bouakez and Normandin, 2010), which showed that the exchange rate of the US dollar declines on average after cuts of the Federal funds rate in the pre-crisis period characterized by a conventional monetary policy stance. Glick and Leduc (2013) assessed how the US dollar exchange rate responds to surprise changes in the Fed's unconventional monetary policy after the Federal funds rate reached zero in December 2008 and compared this effect with the effects resulting from changes in conventional monetary policy prior to that period. Glick and Leduc (2013) used daily data to measure the US dollar exchange rate against the currencies of the US main trading partners using time intervals following the Fed's announcement. The study finds that the dollar depreciated after news on both conventional monetary policy and unconventional monetary policy changes. For example, changes in unconventional monetary policy measures resulted in a dollar depreciation of nearly 40 basis points within 60 minutes, whereas changes in conventional measures led to changes about 5 to 6 basis points.

The approach of Glick and Leduc (2013) differed from that of Neely (2010) even though it was largely based on it. Relying on the event study approach, Neely (2010) found that QE in the United States lowered bond yields in other developed economies by between 20 to 80 basis points and led to a fall of the US dollar between 4% to 11%. Neely (2010) concluded that the program significantly reduced the yield on the 10-year government bonds of Australia, Canada, Germany, Japan, and the UK and led to a depreciation of the US dollar against the currencies of these countries in QE1. Also, Glick and Leduc (2013) explored the effects of surprising messages in the context of the monetary policy stance by observing not only the first but also the second and third QE conducted by the Fed. Swanson (2011) found the cumulative effect of announcements concerning QE2 on longer-term treasury yields as highly statistically significant but moderate, amounting to about 15 basis points.

Overall, the VECM was checked for normality of the residuals, using the Jarque-Bera Test. The obtained significance level was 0.6067, which was greater than the assumed risk of error ($\alpha = 0.05$). Therefore, there is no reason to reject the null hypothesis, and thus, the alternative hypothesis was accepted, which means that the residuals have a normal distribution.

The heteroskedasticity test (White test) showed that the null hypothesis for lack of heteroskedasticity was accepted because the significance level was 0.0834 and was greater than the assumed risk of error ($\alpha = 0.05$).

The serial correlation test (VEC residual serial correlation LM tests) indicated that the null hypothesis should be assumed for lack of autocorrelation in residuals.

Thus, the outcomes from all the tests are desirable, which is evidence for robust results. Given that, conclusions and proposals could be made concerning the future interest rates path under a future monetary policy normalization of the US Fed.

If the Fed decides to undertake a policy normalization course, also called "exit strategy", it should judge the decision based on the current conditions of the economy and the prospects for its future development, which could allow for higher interest rates. The process of normalization of the monetary policy could include a series of actions. For example, those could incorporate a possible increase of the Fed funds rate, reducing the Fed's balance sheet and asset transformation. The implementation of those actions would allow the Federal Open Market Committee (FOMC) to conduct monetary policy in the same way as before the GFC, thus returning to a traditional monetary policy stance.

Those series of actions are described in several statements under the title "Policy Normalization Principles and Plans" (Board of Governors of the Federal Reserve System, 2014; Federal Open Market Committee, 2017b, 2019). In these statements, the FOMC members presented and explained their plans for monetary policy normalization, including three key measures forming the challenges on how the monetary policy should go forward (Bullard, 2015).

The first one is to raise the Federal funds rate and other short-term money market interest rates as a means to terminate the practice of zero interest rates which lasted for an extremely long period. The second one is to reduce the Fed balance sheet. Finally, the third measure is to transform the Fed's assets into its pre-crisis composition. This transformation involves a reduction in the average maturity and a transition to a securities portfolio consisting mainly of government securities.

During the normalization phase, the Fed takes the following measures. To bring the interest rate within the range determined by FOMC, Fed not only adjusts the interest rate it pays on excess reserve balances but also uses the overnight reverse repurchase agreement facility as well as other tools to maintain the funds rate (Board of Governors of the Federal Reserve System, 2014).

Therefore, the rate of interest paid on excess reserves (IOER) is becoming the Fed's primary tool to move its funds rate into the target range. According to Fischer (2015), this action would create an upward pressure on short-term interest rates since banks would be unlikely to lend at a rate lower than the rate, they can earn on balances maintained at the Fed. As Potter (2015) argued, the FOMC is committed to adjust the details of its policy normalization approach in light of the most recent economic and financial developments. Further, Potter (2015) stated that flexibility is a crucial element of the Fed's policy normalization stance.

Nevertheless, the exit, when the right time for such occurs, should be gradual and carefully addressed to the counterparties of the Fed for them to adjust to the new market realities and depend on the rate of economic recovery. Until now, the Fed has managed to meet these conditions when addressing changes in its monetary policy course, as observed by Claeys and Darvas (2015).

4. Conclusion

The stance on the monetary policy conducted by the Fed in the years after the GFC is an illustrative example of the typical indication of unconventional measures and programs. These measures combine the maintaining of low-key interest rates over a long period of time with QE. The aim is to support economic activity and price stability.

The US Fed, like other major central banks, has been experiencing difficulties in reaching the inflation target for years. This proves to be one of the challenges to the effectiveness of non-standard monetary policy measures, while other effects, such as those on the real economy, materialized in different and diverse ways.

The results from the constructed vector error correction model (VECM) suggest that Fed's monetary policy stance continues to influence the changes in the bond yields and the changes in the S&P 500 index more than the changes in the value of the US dollar. The estimates showed that, ceteris paribus, a change in the US shadow rate by 1 percentage point would lead to a change in the US 10-year government bond yield by 0.568 percentage point on average and that a change in the Fed's securities by 1%, corresponding to a volume of securities around $60 billion per month, lead to a change in the S&P 500 index by 0.24 percentage point on average in the observed period.

Overall, every monetary policy normalization process has to be carefully guided. Above all, for the US, it must be consistent with the macroeconomic conditions and the state of the financial sector within the country, but its impact on the developed and emerging markets must be considered to avoid serious risks. Undoubtedly, the Fed's actions could serve as an example for the other leading global central banks, which are still pursuing an unconventional course of monetary policy.

Regarding the direction for further research, an analysis of the measures of the US Federal Reserve implemented to tackle the outbreak of Covid-19 and their effects on the US financial markets could be pursued. A comparative analysis of the impact of the unconventional monetary policy measures prior to and after the Covid-19 pandemic could be employed for future research. A possible limitation could stem from the still ongoing coronavirus pandemic, leading to uncertainty in the economy, which could potentially lead to the central bank's new monetary policy measures.

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Appendix

Table 4. ADF unit root test results

Variables		Level	First differences	Second differences	Order of integration
Description	**Label**	**Probability value (Prob.)**	**Probability value (Prob.)**	**Probability value (Prob.)**	
Yield on the US 10-year Treasuries	**US_YIELD**	0.5531	0.0000		I(1)
S&P 500 index	**SP500**	0.0000			I(0)
Exchange rate of the US dollar versus the euro	**EURUSD**	0.0001			I(0)
Fed's Securities Held Outright	**FEDSEC**	0.0046			I(0)
US shadow rate	**US_SH_RATE**	0.3858	0.0559	0.0000	I(2)

Source: Authors' calculations

Table 5. Johansen cointegration test results

Hypothesis for number of cointegrating equation(s)	Eigenvalue	Trace Statistic	Critical Value (5%)	Prob.
None *	0.2712	137.9400	69.8189	0.0000
At most 1 *	0.2319	77.8299	47.8561	0.0000
At most 2	0.0961	27.7077	29.7970	0.0855
At most 3	0.0327	8.5019	15.4947	0.4134
At most 4	0.0114	2.1804	3.84147	0.1398

Result and notes: Trace test indicates 2 cointegrating equation(s) at 5%, * denotes rejection of the hypothesis at 5% level.

Source: Authors' calculations

Table 6. Cointegrating equation, long run relationship, and estimates of the best chosen VECM model based on the AIC value

Variables	Coefficient	Std. Error	t-Statistic
DUS_YIELD(-1)	1.0000		
SP500(-1)	5.5963	1.4966	3.7392
EURUSD(-1)	-8.0516	2.3163	-3.4761
CONS.	-0.0581		
Akaike information criterion	-8.1646		
Schwarz criterion	-7.2043		

Source: Authors' calculations