To the problem of turbulence in quantitative easing transmission channels and transactions network channels at quantitative easing policy implementation by central banks

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Abstract – The central banks introduced a series of quantitative easing programs and decreased the long term interest rates to near zero with the aim to ease the credit conditions and provide the liquidity into the financial systems, responding to the 2007-2013 financial crisis in the USA, UK, Western Europe, and Japan. We review the U.S. Federal Reserve System, European Central bank, Bank of England and Bank of Japan monetary and financial policies with the particular focus on the quantitative easing policy implementation in the USA. Discussing some aspects of the quantitative easing policy implementation, we highlight the fact that the levels of capital change quickly in both the quantitative easing transmission channels and the transaction networks channels during the quantitative easing policy implementation, when the liquidity is added to the financial system. In agreement with the recent research findings in the econophysics, we propose that the nonlinear dynamic chaos can be generated by the turbulent capital flows in both the quantitative easing transmission channels and the transaction networks channels, when there are the laminar - turbulent capital flow transitions in the financial system. We demonstrate that the capital flows in both the quantitative easing transmission channels and the transaction networks channels in the financial system can be accurately characterized by the Reynolds numbers. We explain that the transition to the nonlinear dynamic chaos regime can be realized through the cascade of the Landau – Hopf bifurcations in the turbulent capital flows in both the quantitative easing transmission channels and the transaction networks channels in the financial system. Finally, we clarify that the general approach to the modeling of the US economy is based on both 1) the "large" empirically-motivated regression model, and 2) the Value at Risk (VAR) model with the incorporated Smets-Wouters model, which don’t take to the account the origination of the nonlinear dynamic chaos regime during the capital flow in the quantitative easing transmission channels and in the transaction networks channels in the financial system. Therefore, we completed the computer modeling, using both the Nonlinear Dynamic Stochastic General Equilibrium Theory (NDSGET) and the Hydrodynamics Theory (HT), to accurately characterize the US economy in the conditions of the QE policy implementation by the US Federal Reserve. We found that the ability of the US financial system to adjust to the different levels of liquidity depends on the nonlinearities appearance in the QE transmission channels, and is limited by the laminar – turbulent capital flows transitions in the QE transmission channels and the transaction networks channels in the US financial system. The proposed computer model allows us to make the accurate forecasts of the US economy performance in the cases, when there are the different levels of liquidity in the US financial system.

JEL Classification: E43, E51, E52, E58, E61
PACS numbers: 89.65.Gh, 89.65.-s, 89.75.Fb
Keywords: liquidity effects, monetary policy, financial policy, long-term interest rates, quantitative easing policy, large-scale asset purchases (LSAPs), financial transactions network, monetary and financial stabilities, Nonlinear Dynamic Stochastic General Equilibrium Theory (NDSGET), US Federal Open Market Committee (FOMC), US Financial Stability Oversight Council (FSOC), US Federal Reserve System, central bank.
Introduction

“The practice of monetary policy has evolved a great deal since the early 1990s. This evolution was significantly influenced by rapid developments in the theory of monetary policy. Inflation targeting has established itself as the dominant framework for monetary policy decisions,” as explained in Baltensperger, Hildebrand, Jordan (2007), Bernanke B S (1979 - 2013). For example, the monetary policy at the SNB includes the three-part monetary policy strategy in Swiss National Bank Quarterly Bulletin (2013): “1) First, it regards prices as stable when the national consumer price index (CPI) rises by less than 2% per annum. This allows it to take account of the fact that the CPI slightly overstates actual inflation. At the same time, it allows inflation to fluctuate somewhat with the economic cycle. 2) Second, the SNB summarises its assessment of the situation and of the need for monetary policy action in a quarterly inflation forecast. This forecast, which is based on the assumption of a constant short-term interest rate, shows how the SNB expects the CPI to move over the next three years. 3) Third, the SNB sets its operational goal in the form of a target range for the three-month Swiss franc Libor. In addition, a minimum exchange rate against the euro is currently in place.” However, there is a strong need for the unconventional monetary policy introduction, because of the existing economic crisis in the Western Europe and North America (see the most recent data on the GDP in the Switzerland, Euro area, U.S.A., U.K. in Fig. 1 in Swiss National Bank Financial Stability Report (2012), and the U.S. Federal Reserve System, European Central bank, Bank of Japan and Bank of England main interest rates in Fig. 2 in Fawley, Neely (2013)).
The true meaning of *quantitative easing* expression, introduced by *Werner RA* in 1995, is to increase the net credit creation in the four possible ways in *Werner (2009)*:

1) by increasing bank credit,  
2) by increasing trade credit,  
3) by increasing central bank credit, and  
4) by increasing credit created by the government.

The *Bank of Japan* used the *quantitative easing* expression to describe its monetary policy to increase the *Bank of Japan* reserves. The *Japanese* expression for the *quantitative easing* (*量的金融緩和*, *ryōteki kin'yū kanwa*) was frequently used by the *Bank of Japan* in *Japan* in *Bank of Japan (2001)*, *Hiroshi Fujiki et al (2001)*, *Shirakawa (2002)*. The concise definition of the *quantitative easing* policy is provided in *Wikipedia (2013)*: *“Quantitative Easing (QE) is an unconventional monetary policy used by central banks to stimulate the national economy when standard monetary policy has become ineffective”* in *Bank of England (2011a)*. A central bank implements quantitative easing by buying financial assets from commercial banks and other private institutions, thus creating money and injecting a pre-determined quantity of money into the economy. This is distinguished from the more usual policy of buying or selling government bonds to change money supply, in order to keep market interest rates at a specified target value in *Bank of England (2011b)*. Expansionary monetary
policy typically involves the central bank buying short-term government bonds in order to lower short-term market interest rates in *European Central Bank* (2008). However, when short-term interest rates are either at, or close to, zero, normal monetary policy can no longer lower interest rates. *Quantitative easing* may then be used by the monetary authorities to further stimulate the economy by purchasing assets of longer maturity than only short-term government bonds, and thereby lowering longer-term interest rates further out on the yield curve in *Bernanke* (2009). *Quantitative easing* raises the prices of the financial assets bought, which lowers their yield in *Larry* (2009). *Quantitative easing* can be used to help ensure that inflation does not fall below target in *Bank of England* (2011b). Risks include the policy being more effective than intended in acting against deflation – leading to higher inflation in *Bowlby* (2009) or of not being effective enough if banks do not lend out the additional reserves in *Isidore* (2010). According to the IMF and various other economists, *quantitative easing* undertaken since the global financial crisis has mitigated the adverse effects of the crisis in *Klyuev, de Imus, Srinivasan* (2009).”

Let us sum up the above information by saying that, the *quantitative easing* policy introduction and implementation means that the central bank releases the sufficient capital to the commercial and investment banks in order to add the liquidity to the national banking system with the goal to improve the existing situation in the national economy.

Let us briefly review the present developments toward the *QE* policy implementation with the help of the *large-scale asset purchases (LSAPs)* in the U.S.A. in *Christensen, Rudebusch* (2012), *D’Amico, King* (2011), *Gagnon, Raskin, Remache, Sack* (2011). The U.S. Federal Reserve System held between US$700 billion and US$800 billion of Treasury notes on its balance sheet before the recession. Presently, the U.S. Federal Reserve System holds around US$2.5-3.0 trillion of bank debt, mortgage-backed securities, and Treasury notes in *Wikipedia* (2013). The U.S. Federal Reserve System conducted the following *QE* programs in *Wikipedia* (2013):

1.  *QE1*: the purchase of US$600 billion in the mortgage-backed securities in 2008 - 2010;
2.  *QE2*: the purchase of US$600 billion in the treasury securities in 2010 - 2011;
3.  *QE3*: the purchase of US$40 billion of mortgage-backed securities (*MBS*) per month since September, 2012 until 2015.

*Christensen, Rudebusch* (2012), *Fawley, Neely* (2013) summarized the information on some of the U.S. Federal Reserve System *QE* programs announcements in Tabs. 1, 2. The U.S. Federal Reserve bank assets are shown in Fig. 3 in *Fawley, Neely* (2013).
| No. | Date       | Event                        | Description                                                                 |
|-----|------------|------------------------------|-----------------------------------------------------------------------------|
| I   | Nov. 25, 2008 | Initial LSAP announcement    | Fed announces purchases of $100 billion in GSE debt and up to $500 billion in MBS. |
| II  | Dec. 1, 2008 | Bernanke speech              | Chairman Bernanke indicates that the Fed could purchase long-term Treasury securities. |
| III | Dec. 16, 2008 | FOMC statement              | The first FOMC statement that mentions possible purchases of long-term Treasuries. |
| IV  | Jan. 28, 2009 | FOMC statement              | FOMC states that it is ready to expand agency debt and MBS purchases and to purchase long-term Treasuries. |
| V   | Mar. 18, 2009 | FOMC statement              | Fed will purchase an additional $750 billion in agency MBS and $100 billion in agency debt. Also, it will purchase $300 billion in long-term Treasury securities. |
| VI  | Aug. 12, 2009 | FOMC statement              | Fed is set to slow the pace of the LSAP. The final purchases of Treasury securities will be in the end of October instead of mid-September. |
| VII | Sep. 23, 2009 | FOMC statement              | Fed’s purchases of agency debt and MBS will end in the first quarter of 2010, while its Treasury purchases will end as planned in October. |
| VIII| Nov. 4, 2009  | FOMC statement              | Amount of agency debt capped at $175 billion instead of the $200 billion previously announced. |

**Tab. 1. U.S. Federal Reserve System Key QE Announcements**
*(after Christensen, Rudebusch (2012)).*

**Tab. 2. U.S. Federal Reserve System Important QE Announcements**
*(after Fawley, Neely (2013)).*
Let us briefly summarize the present developments as far as the QE policy implementation is concerned in the U.K in Benford, Berry, Nikolov, Young (2009), Fisher (2010a, 2010b), Joyce, Tong, Woods (2011), Bridges, Rossiter, Thomas (2011), Joyce, Lasaosa, Stevens, Tong (2011). The main completed QE programs by the Bank of England are listed below in Wikipedia (2013):

1. The Bank of England had purchased around £165 billion of assets in 2008 - 2009.
2. The Bank of England had increased the total asset purchases up to £175 billion in 2009 – 2010.
3. The Bank of England had increased the total asset purchases up to £250 billion as of 2011.
4. The Bank of England had increased the total asset purchases up to £375 billion in 2011 - 2012.

Christensen, Rudebusch (2012), Fawley, Neely (2013), Joyce, Tong, Woods (2011) summarized some of the Bank of England QE programs announcements in Tabs. 3, 4 , 5. The Bank of England assets are shown in Fin. 4 in Fawley, Neely (2013).
| No. | Date     | Event                      | Description                                                                                                                                 |
|-----|----------|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| I   | Feb. 11, 2009 | February Inflation Report | Press conference and Inflation Report indicated that asset purchases were likely.                                                          |
| II  | Mar. 5, 2009   | MPC statement             | The MPC announced that it would purchase £75 billion of assets over three months. Gilt purchases would be restricted to the 5-25 year maturity range. |
| III | May 7, 2009   | MPC statement             | The MPC announced that the amount of asset purchases would be extended by a further £50 billion to a total of £125 billion.                    |
| IV  | Aug. 6, 2009  | MPC statement             | The MPC announced that the amount of asset purchases would be extended to £175 billion and that the buying range would be extended to include gilts with residual maturity greater than three years. |
| V   | Nov. 5, 2009  | MPC statement             | The MPC announced that the asset purchases would be extended to £200 billion.                                                              |
| VI  | Feb. 4, 2010  | MPC statement             | The MPC announced that the amount of asset purchases would be maintained at £200 billion.                                                  |
| VII | Oct 6, 2011    | MPC statement             | The MPC announced that the asset purchases would be extended to £275 billion.                                                              |

**Tab. 3. Bank of England key QE announcements (after Christensen, Rudebusch (2012)).**

| Date          | Program | Event                  | Brief description                                                                                                                                                                                                 | Interest rate news                                                                 |
|---------------|---------|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| 1/19/2009     | APF     | HM Treasury statement  | APF established. The BOE will purchase up to £50 billion of ‘high quality private sector assets’ financed by Treasury issuance.                                                                                       | The BOE cuts policy rate from 1% to 0.5%; the ECB cuts policy rate from 2% to 1.5%. |
| 2/11/2009     | APF     | BOE Inflation Report released |                                                                                                          |                                                                                                      |
| 3/5/2009      | APF     | MPC statement          | QE announced: The BOE will purchase up to £75 billion in assets, now financed by reserve issuance; medium- and long-term gilts will comprise the ‘maturity’ of new purchases.  |                                                                                                      |
| 5/7/2009      | APF     | MPC statement          | QE expanded: The BOE will purchase up to £125 billion in assets.                                                                                          |                                                                                                      |
| 8/6/2009      | APF     | MPC statement          | QE expanded: The BOE will purchase up to £175 billion in assets to accommodate the increased size, the BOE will expand purchases into gilts with remaining maturity of 3 years or more. |                                                                                                      |
| 11/5/2009     | APF     | MPC statement          | QE expanded: The BOE will purchase up to £200 billion in assets.                                                                                         |                                                                                                      |
| 2/4/2010      | APF     | MPC statement          | QE maintained: The BOE maintains the stock of asset purchases financed by the issuance of reserves at £200 billion; new purchases of private assets will be financed by Treasury issuance. |                                                                                                      |
| 10/6/2011     | APF     | MPC statement          | QE expanded: The BOE will purchase up to £275 billion in assets financed by reserve issuance; the ceiling on private assets held remains £50 billion.          |                                                                                                      |
| 11/29/2011    | APF     | HM Treasury decision   | Maximum private asset purchases reduced; HM Treasury lowers the ceiling on APF private asset holdings from £50 billion to £10 billion.                                                                 |                                                                                                      |
| 2/9/2012      | APF     | MPC statement          | QE expanded: The BOE will purchase up to £225 billion in assets.                                                                                         |                                                                                                      |
| 7/5/2012      | APF     | MPC statement          | QE expanded: The BOE will purchase up to £375 billion in assets.                                                                                         |                                                                                                      |

*NOTE: MPC, Monetary Policy Committee.*

**Tab. 4. Bank of England important QE announcements (after Fawley, Neely (2013)).**
### Tab. 5. Bank of England key QE announcements (after Joyce, Tong, Woods (2011)).

| Date       | Event                                                                                           |
|------------|-------------------------------------------------------------------------------------------------|
| 19 January | The Chancellor of the Exchequer announces that the Bank of England will set up an asset purchase programme. |
| 30 January | Asset Purchase Facility Fund established. Exchange of letters between the Chancellor of the Exchequer and the Governor on 29 January 2009. |
| 5 February | Bank rate reduced from 1.5% to 1%.                                                               |
| 11 February| February inflation report and the associated press conference give strong indication that QE asset purchases are likely. |
| 13 February| First purchases of commercial paper begin.                                                       |
| 5 March    | Bank rate reduced from 1% to 0.5%. The MPC announces it will purchase £75 billion of assets over three months funded by central bank money. Conventional bonds likely to constitute the majority of purchases, restricted to bonds with residual maturity between 5 and 25 years. |
| 11 March   | First purchases of gilts begin.                                                                |
| 25 March   | First purchases of corporate bonds begin.                                                       |
| 7 May      | The MPC announces that the amount of QE asset purchases will be extended by a further £50 billion to £75 billion. |
| 3 August   | Secured commercial paper facility launched.                                                       |
| 6 August   | The MPC announces that QE asset purchases will be extended to £75 billion and that the buying range will be extended to gilts with a residual maturity greater than three years. The Bank announces a gilt lending programme, which allows counterparties to borrow gilts from the APS’s portfolio via the DMO in return for a fee and alternative gilts as collateral. |
| 5 November | The MPC announces that QE asset purchases will be extended to £75 billion.                      |
| 22 December| The Bank announces that it will act as a seller, as well as a buyer, of corporate bonds in the secondary market. |

Shading denotes announcements used in the event study analysis by Joyce et al (2011) referred to in the following section.

### Fig. 4. Bank of England assets (after Fawley, Neely (2013)).
Let us take a close look on the QE policy implementation in Japan. The completed QE programs by the Bank of Japan (BOJ) are listed below in Bank of Japan (2001), Hiroshi Fujiki et al (2001), Shirakawa (2002), Wikipedia (2013):

1. The Bank of Japan (BOJ) increased the commercial bank current account balance from ¥5 trillion Yen to ¥35 trillion Yen (approximately US$300 billion) over a 4-year period starting in March, 2001-2004.
2. The Bank of Japan (BOJ) announced that it would purchase of ¥5 trillion Yen (US$60 billion) in assets in early October, 2010.
3. The Bank of Japan (BOJ) announced a unilateral move to increase the amount from ¥40 trillion Yen (US$504 billion) to a total of ¥50 trillion Yen (US$630 billion) on August 4, 2011.
4. The Bank of Japan (BOJ) expanded its asset purchase program by ¥5 trillion Yen (US$66 billion) to a total of ¥55 trillion Yen in October, 2011.

Fawley, Neely (2013) analyzed the Bank of Japan important QE announcements in Tab. 6; and provided information on the Bank of Japan assets in Fig. 5.

| Important Announcements by the Bank of Japan |
|---------------------------------------------|
| **Date** | **Program** | **Event** | **Brief description** | **Interest rate change** |
| 12/2/2008 | SFSOs | Unscheduled monetary policy meeting | The BOJ will operate a facility through the end of April to lend an unlimited amount to banks at the uncollateralized overnight call rate and collateralized by corporate debt. |
| 12/19/2008 | Outright JGB/CFI purchases | Statement on monetary policy | Outright purchases expanded: The BOJ increases monthly JGB purchases (last increased October 2002) from ¥1.2 trillion to ¥1.4 trillion; they will also look into purchasing commercial paper. |
| 1/22/2009 | Outright CFI purchases | Statement on monetary policy | Outright purchases announced: The BOJ will purchase up to ¥3 trillion in commercial paper and ABP and is investigating outright purchases of corporate bonds. |
| 2/19/2009 | Outright CH purchases | Statement on monetary policy | Outright purchases expanded: The BOJ will extend commercial paper purchases and the SFSOs through the end of September (previously end of March) and will purchase up to ¥1 trillion in corporate bonds. |
| 3/18/2009 | Outright JGB purchases | Statement on monetary policy | Outright purchases expanded: The BOJ increases monthly JGB purchases from ¥1.4 trillion to ¥1.8 trillion. |
| 7/15/2009 | Outright CH purchases/SFSOs | Statement on monetary policy | Programs extended: The BOJ extends the FSOS and outright purchases of corporate paper and bonds through the end of the year. |
| 10/30/2009 | Outright CH purchases/SFSOs | Statement on monetary policy | Staus of programs: Outright purchases of corporate and finance instruments will expire at the end of 2009 as expected, but the SFSOs will be extended through 2010Q4; ample liquidity provision post 2010Q1 will occur through funds supplying operations against pooled collateral, which will accept a larger range of collateral. |
| 12/1/2009 | FRIs | Statement on monetary policy | Facility announcement: The BOJ will offer ¥60 trillion in 3-month loans against the full menu of eligible collateral at the uncollateralized overnight call rate. |
| 3/17/2010 | FRIs | Statement on monetary policy | Facility expansion: The BOJ expands the size of the FRIs to ¥10 trillion. |
| 5/21/2010 | GSFF | Statement on monetary policy | GSFF announcement: The BOJ will offer ¥2 trillion in 1-year loans to public financial institutions with project proposals for strengthening the foundations for economic growth. |
| 8/30/2010 | FRIs | Unscheduled monetary policy meeting | Facility expansion: The BOJ adds ¥10 trillion in 6-month loans to the FRIs. |
| 10/5/2010 | CMR | Statement on monetary policy | APP established: The BOJ will purchase ¥4 trillion in assets; ¥1.5 trillion in JGBs and Treasury discount bills, ¥1 trillion in commercial paper and corporate bonds, and ¥1 trillion in equities and JABETs. |
Tab. 6. Bank of Japan important QE announcements (after Fawley, Neely (2013)).

Fig. 5. Bank of Japan assets (after Fawley, Neely (2013)).
Berkmen (2012) analyzed the Bank of Japan current account balance and balance sheet as shown in Figs. 6 and 7.

**Fig. 6.** Bank of Japan current account balance (after Berkmen (2012)).

**Fig. 7.** Bank of Japan balance sheet (after Berkmen (2012)).
Wieland (2010) researched some issues in the QE policy introduction and implementation in Japan, presenting the characteristic dependences in the Figs. 8, 9 and 10.

**Fig. 8.** The Marshallian \( k \) and the money market rate in Japan, 1981–2008, annual observations (after Wieland (2010)).

**Fig. 9.** The base money and M1 relative to nominal income in Japan, 1981–2008, quarterly observations (after Wieland (2010)).
Assenmacher-Wesche, Gerlach, Sekine (2007) also refer to an important remark, made by Governor Mieno in testimony to the Diet in May 1987: “We have paid attention to the developments of the money supply, as history not only in Japan but also in other countries suggests that in the long run a higher money growth rate tends to result in a higher inflation rate. Nevertheless, the relationship between money and inflation is much more complicated than a simple causal relationship implying that a certain rate of money growth will always result in a specified rise of inflation. For this reason, it is very difficult to determine the appropriate level of monetary aggregates and we need to rely on overall judgment based on all available information at the time.”

Assenmacher-Wesche, Gerlach, Sekine (2007) came to the following important conclusion: “the band spectral regressions indicate that money growth is correlated – and output growth is inversely correlated – with inflation in the low frequency band, in particular when that is defined as frequencies of four years or more. Furthermore, that correlation reflects unidirectional Granger causality from money growth to inflation, implying that money growth does contain information about future inflation that is not already embedded in inflation. In the
In Tab. 7, the *Bank of Japan* monetary base target and balance sheet projection are shown in *Bank of Japan* (2013).

|                          | End-2012 (actual) | End-2013 (projected) | End-2014 (projected) |
|--------------------------|-------------------|----------------------|----------------------|
| Monetary base            | 138               | 200                  | 270                  |

**Breakdown of the Bank's Balance Sheet**

|                            | End-2012 | End-2013 | End-2014 |
|---------------------------|----------|----------|----------|
| JGBs                      | 89       | 140      | 190      |
| CP                        | 2.1      | 2.2      | 2.2      |
| Corporate bonds           | 2.9      | 3.2      | 3.2      |
| Exchange-traded funds (ETFs) | 1.5   | 2.5      | 3.5      |
| Japan real estate investment trusts (J-REITs) | 0.11     | 0.14      | 0.17      |
| Loan Support Program      | 3.3      | 13       | 18       |
| Total assets (including others) | 158 | 220      | 290      |

Tab. 7. *Bank of Japan* monetary base target and balance sheet projection (after *Bank of Japan* (2013)).
Fawley, Neely (2013) researched the QE policy implementation by the European Central Bank, presenting the research data in Tab. 8; and showing the European Central Bank assets in Fig. 11.

| Date   | Program | Event                        | Brief description                                                                 | Interest rate news                      |
|--------|---------|-------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------|
| 5/28/2008 | LTR0    | Governing Council press release | LTR0 expanded: 6-month LTROs are announced.                                        |                                         |
| 10/15/2008 | FIRA    | Governing Council press release | Refinancing operations expanded: All refinancing operations will be conducted with fixed rate tenders and full allotment; the list of assets eligible as collateral in credit operations with the Bank is expanded to included lower-rated (with the exception of asset-backed securities) and non-euro-denominated assets. |                                         |
| 5/7/2009  | CBPP/ATRO | Governing Council press release | CBPP announced/LTR0 expanded: The ECB will purchase €60 billion in euro-denominated covered bonds; 12-month LTROs are announced. | ECB lowers the main refinancing rate by 0.25% to 1.25% and the rate on the marginal lending facility by 0.50% to 1.75%. |
| 5/16/2010 | SMP     | Governing Council press release | SMP announced: The ECB will conduct interventions in the euro area public and private debt securities markets; purchases will be sterilized. |                                         |
| 6/30/2010 | CBPP    | Governing Council press release | CBPP finished: Purchases finish on schedule; bonds purchased will be held through maturity. |                                         |
| 10/6/2011 | CBPP2   | Governing Council press release | CBPP2 announced: The ECB will purchase €40 billion in euro-denominated covered bonds. | ECB lowers the main refinancing rate by 0.25% to 1%, and the rate on the marginal lending facility by 0.25% to 1.75%. |
| 12/8/2011 | LTR0    | Governing Council press release | LTR0 expanded: 36-month LTROs are announced, eligible collateral is expanded.        |                                         |
| 8/2/2012  | OMT     | ECB press conference          | ECB President Mario Draghi indicates that the ECB will expand sovereign debt purchases. He proclaims that “the euro is irreversible.” |                                         |
| 9/6/2012  | OMT     | Governing Council press release | OMTs announced: Countries that apply to the European Stabilization Mechanism (ESM) for aid and abide by the ESM’s terms and conditions will be eligible to have their debt purchased in unlimited amounts on the secondary market by the ECB. |                                         |

**Tab. 8. European Central Bank Important QE Announcements (after Fawley, Neely (2013)).**

**ECB Assets**

![ECB Assets chart](chart.jpg)

**Fig. 11. European Central Bank assets (after Fawley, Neely (2013)).**
Fawley, Neely (2013) present a comparative analysis of the monetary base expansion data and M2 data in the USA, European Union, Japan and UK in Fig. 12.

![Monetary Base and M2 Expansion in USA, European Union, Japan and UK](image)

**Fig. 12.** Monetary Base and M2 Expansion in USA, European Union, Japan and UK (after Fawley, Neely (2013)).

Finally, let us explain that the various problems on the QE policy implementation were comprehensively researched by many other scientists as reviewed in Fawley, Neely (2013): “Academics have already conducted substantial research on recent QE programs. Stroebel and Taylor (2009), Kohn (2009), Meyer and Bomfim (2010), and Gagnon et al. (2011a,b), for example, study the Fed’s 2008-09 QE programs. Gagnon et al.’s (2011a,b) announcement study finds that large-scale asset purchase (LSAP) announcements reduced U.S. long-term yields. Joyce et al. (2011) find that the BOE’s QE program had bond yield effects quantitatively similar to those reported by Gagnon et al. (2011a,b) for the U.S. program. Hamilton and Wu (2011) indirectly calculate the effects of the Fed’s 2008-09 QE programs with a term structure model. Neely (2012) evaluates the effect of the Fed’s 2008-09 QE on international long bond yields and exchange rates, showing that the effects are consistent with a simple portfolio balance model and long-run purchasing power parity.”
Discussion on some aspects of quantitative easing policy implementation

Sibert (2010) made the analytic research on the quantitative easing policy, showing the US Federal Reserve System simplified balance sheet in Tab. 9.

| Assets         | Liabilities                      |
|----------------|----------------------------------|
| Securities     | Currency in circulation          |
| Repos          | Depository institutions’ balances|
| Loans          | Reverse Repos                    |
| Other Assets   | Other Assets                     |
|                | Net worth                        |

Tab. 9. US Federal Reserve System simplified balance sheet (after Sibert (2010)).

Sibert (2010) explains the essence of the monetary policy by the US Federal Reserve System in the normal times: "In normal times it is typical for modern central banks to make monetary policy by choosing a target short-term policy interest rate. The Federal Open Market Committee (FOMC) of the Federal Reserve System targets the federal funds rate, the rate at which private deposit-taking institutions lend balances at the Federal Reserve overnight to each other. The Federal Reserve Bank of New York, acting as agent for the FOMC, conducts open-market operations to attain this targeted rate. In usual times this entails offsetting transitory changes in depository institutions’ reserves. If the central bank wants to increase these reserves it engages in repurchase agreements ("repos"). These operations are equivalent to short-term collateralized loans but technically they are arrangements where the Federal Reserve buys securities in exchange for reserves and agrees to subsequently resell them. As a result, the Federal Reserve’s balance sheet temporarily expands: the monetary base component of its liabilities rises, as does the repo component of its assets. If the Federal Reserve wants to decrease depository institutions’ reserves it engages in reverse repos. These are similar to short-term collateralized borrowing but technically they are an arrangement where the Federal Reserve sells assets in exchange for reserves and agrees to of the Federal Reserve’s liabilities: the monetary base component falls and the reverse repo component rises. To offset more permanent factors that would keep the federal funds rate from its target, the Federal Reserve must make a more permanent change in its balance sheet. To permanently increase liquidity the Federal Reserve expands its balance sheet: purchasing securities and increasing the monetary base. To decrease liquidity it contracts its balance sheet: selling securities and decreasing the monetary base."
Sibert (2010) the essence of the monetary policy by the US Federal Reserve System in the times of crisis: "Unfortunately for the FOMC, as well as other monetary policy committees around the world, by the time the global financial crisis started in earnest in September 2008, policy interest rates were already quite low and there was little scope to reduce them further... As seen in Figure 13 below, the federal funds target rate was 2.0 percent in September 2008; by December of that year it had been reduced to 0 - .25 percent.

Unable to make monetary policy by announcing lower target interest rates and achieving them through open-market operations, central banks have sought alternatives. *A potential idea was that instead of announcing a policy interest rate, the central bank would simply engage in further expansionary open-market operations, selling home-currency denominated securities to increase the monetary base.* This idea, referred to then as *quantitative easing*, was tried in Japan in 2000."

![Fig. 13. US Federal Reserve System target interest rates(after Sibert (2010)).](image)

Sibert (2010) further explains: "In an attempt to free up illiquid markets and deal with failed financial institutions, central banks began to explore more unusual types of monetary policy. In the United States, the Federal Reserve bought the debt of Fannie Mae, Freddie Mac and the Federal Home Loan banks, as well as mortgage-backed obligations guaranteed by Fannie Mae, Freddie Mac and Ginnie Mae. It also engaged in other crisis-related activities such as the creation of the Maiden Lanes I, II and III vehicles. As shown in Figure 14 below, between the end of 2007 and the end of 2008 the assets of the Federal Reserve System mushroomed from about $915 billion to $2,316 billion."
Sibert (2010) attracts some attention to the fact that there are the considerable growing global imbalances between the national economies of various countries as shown in Fig. 15. Sibert (2010) writes: "The consternation undoubtedly reflects some genuine concern that QEII might be effective and that a lower real value of the dollar will threaten the ability of other countries to pursue export-led growth. However, this is probably not the entire reason: the anger, as well as recent the furor over currency wars is a symptom of the dissatisfaction with global imbalances."

**Fig. 14.** US Federal Reserve System assets composition (after Sibert (2010)).

**Fig. 15.** Global imbalances, in billions of US dollars (after Sibert (2010)).
Discussing the QE program opportunities, Bank of England (2009) explains: “Normally, central banks do not intervene in private sector asset markets by buying or selling private sector debt. But in exceptional circumstances, such intervention may be warranted – for example, when corporate credit markets became blocked as the financial crisis intensified towards the end of 2008. Bank of England purchases of private sector debt can help to unblock corporate credit markets, by reassuring market participants that there is a ready buyer should they wish to sell. That should help bring down the cost of borrowing, making it easier and cheaper for companies to raise finance which they can then invest in their business.”

In Fig. 16 the Bank of England assets purchases scheme is shown in Bank of England (2009).

**Fig. 16.** Bank of England assets purchases scheme (after Bank of England (2009)).

**Benford, Berry, Nikolov, Young (2009)** write: “The Bank of England is the sole supplier of central bank money in sterling. As well as banknotes, central bank money takes the form of reserve balances held by banks at the Bank of England. These balances are used to make payments between different banks. The Bank can create new money electronically by increasing the balance on a reserve account. So when the Bank purchases an asset from a bank, for example, it simply credits that bank’s reserve account with the additional funds. This generates an expansion in the supply of central bank money.”
Benford, Berry, Nikolov, Young (2009) note: “Asset purchases are a natural extension of the Bank’s conventional monetary policy operations. In normal circumstances, the Bank of England provides reserves according to the demand from banks at the prevailing level of Bank Rate. When conducting asset purchases, the Bank is seeking to influence the quantity of money in the economy by injecting additional reserves. This does not mean though that the Bank no longer has influence over market interest rates. Market interest rates will continue to be affected both by the level of Bank Rate and, in addition, by the amount of reserves that the Bank is injecting as investors react to the additional money that they hold in their portfolios.”

Benford, Berry, Nikolov, Young (2009) explain: “Money is highly liquid because it can easily be used to buy goods and services or other assets. The increase in private sector liquidity will depend on the liquidity of the assets that are being exchanged for money. There are a number of channels through which greater liquidity can have an impact. Three key channels are set out below. The transmission mechanism is also summarized in Figure 17.”

![Fig. 17. Stylized transmission mechanism for asset purchases (after Benford, Berry, Nikolov, Young (2009)).](image)

Benford, Berry, Nikolov, Young (2009) discuss the exit strategy from the QE policy: “Monetary policy could be tightened in a number of ways. It could involve some combination of increases in Bank Rate and sales of assets in order to reduce the supply of money in the economy. Alternatively, the supply of reserves could be reduced without asset sales, through the issuance of short-term Bank of England bills.”

Joyce, Tong, Woods (2011) made the research on the design, operation and impact of the Bank’s asset purchase program that began in 2009 in response to the intensification of the financial crisis. Joyce, Tong, Woods (2011) write: “When financial markets are dysfunctional,
central bank asset purchases can improve market functioning by increasing liquidity through actively encouraging trading. Asset prices may therefore increase through lower premia for illiquidity. The effects of this channel may, however, only persist while the monetary authority is conducting asset purchases.”

In Fig. 18, the **Quantitative Easing (QE) transmission channels** are shown in Joyce, Tong, Woods (2011).

![Quantitative Easing (QE) transmission channels](after Joyce, Tong, Woods (2011)).

**Joyce, Tong, Woods (2011)** mention that the estimates of the macroeconomic impact of **QE** can be done, using the following models:

1. **SVAR approach**: A common approach is to characterize **QE** solely through its effects on longer-maturity government bond yields. The simplest starting point for this kind of analysis is to use a small structural vector auto-regression (SVAR) containing the policy rate, a government bond yield (the ten-year spot rate), real **GDP** growth and **CPI** inflation. A ‘**QE** shock’ can be identified by assuming that a negative shock to bond yields leads to a contemporaneous rise in **GDP** and **CPI** inflation, but has no effect on policy rates (which are constrained at the zero bound). Estimating this model using quarterly **UK** data over a sample period predating the crisis (1992 Q1 to 2007 Q2), and shocking the ten-year gilt yield by 100 basis points, results in a peak impact on the level of real **GDP** of just under 1.5 % and a peak effect on annual **CPI** inflation of about ¾ percentage points. These effects should be taken as illustrative, given the simplicity of the model and the fact that it has been estimated on a sample predating the crisis. Furthermore, in looking at an impulse response, the assumption is that **QE** is similar to a typical one-period shock to bond yields. This implies rather less persistence than might
be expected if QE has operated primarily through a portfolio balance effect. Despite these caveats, the effects on key macro variables appear economically significant.

2. **Multiple time-series models approach:** It is also possible to use more sophisticated econometric models to look at this issue. Kapetanios et al (2011) use three different time-series models of varying complexity to conduct counterfactual forecasts of the effects of QE. The approach (broadly similar in spirit to Lenza, Pill and Reichlin (2010)) is to use these models to conduct conditional forecasts under ‘policy’ and ‘no policy’ scenarios and then to attribute the difference in the resulting forecasts to the effects of the policy. In the no policy scenario, it is assumed that without QE five and ten-year gilt yields would have been 100 basis points higher, although a variety of alternative scenarios are also examined. Averaging across the models suggests that QE had a peak effect on the level of GDP of around 1 ½% and a peak effect on annual CPI inflation of about 1 ¼% percentage points. These estimates vary considerably across the individual model specifications, and with the assumptions made to generate the counterfactual forecasts, suggesting they are subject to considerable uncertainty.

3. **Monetary approach:** An alternative method of estimating the effects of QE is to focus on its impact on the money supply. Bridges and Thomas (2011) first calculate the impact of QE on the money supply, allowing for the various other influences on broad money over the period. They then apply their estimates to two econometric models — an aggregate SVAR model and a linked set of sectoral money demand systems — that allow them to calculate how asset prices and spending need to adjust to make money demand consistent with the increase in broad money supply. Their preferred model estimates suggest that the higher money supply resulting from QE may have boosted the level of GDP by around 2% and CPI inflation by about 1%, though again these estimates are subject to a lot of uncertainty.

4. **Bottom-up approach:** Ideally one would want to make an assessment using a properly specified structural model. But no such model embodying all the relevant transmission channels discussed earlier appears to exist. The forecasting model used by the Bank of England, in common with most large-scale macroeconomic models, does not explain risk premia and therefore does not embody a portfolio balance channel. But, to make a rough calculation, one can take a more bottom-up approach. More specifically, the effects of the QE policy can be broken down into two main elements: (1) the impact of asset purchases on gilt prices and other asset prices and (2) the effect of asset prices on demand and hence inflation.
A number of ways of estimating (1) were already discussed above. The analysis of the QE announcement effects suggested that asset purchases pushed down medium to long-term gilt yields by about 100 basis points. The effect of QE on a broader range of asset prices is much more uncertain, but there was an immediate 70 basis points fall in investment-grade corporate bond yields and a 150 basis points fall in sub-investment grade yields. There is considerable uncertainty about the effect on equity prices and the immediate market reaction is unlikely to provide an accurate guide, but an estimated portfolio balance model would suggest an impact of around 20%. Combining these effects on government and corporate bonds and equity prices suggests an overall boost to households’ net financial wealth of about 16%.

To quantify the next leg in the transmission mechanism, between asset prices and demand, a range of simple models may be used. To calculate the impact on consumer spending, it is necessary to calculate the wealth elasticity of consumption. One way of doing this is to make an annuity calculation, assuming that households perceive the policy’s effects as long-lasting and want to spend their extra wealth evenly over their lifetimes. To calculate the effects on business and dwellings investment, one can use Q models, where the incentive to invest depends on the market value of capital relative to its replacement cost. Higher asset prices should raise the market value of capital and reduce the cost of finance, boosting investment spending. Allowing for reasonable uncertainty about the initial impact on asset prices, the result of these sorts of calculations would suggest a peak impact on the level of real GDP of between ¾ % and 2 ½ %.

Tab. 10 shows the estimates of the macroeconomic impact of QE, peak impact on the level of output and inflation in Joyce, Tong, Woods (2011).

| Method                  | Level of GDP (per cent) | CPI inflation (percentage points) |
|-------------------------|-------------------------|----------------------------------|
| SVAR                    | 1½                      | ½                               |
| Multiple time-series models average impact(a) | 1½                      | 1½                              |
| Monetary approach(b)    | 2                       | 1                               |
| Bottom-up approach      | 1½–2½                   | ¾–2½                            |
| Range across methods(c) | 1½–2                    | ¾–1½                            |

Tab. 10. Estimates of the macroeconomic impact of QE, peak impact on the level of output and inflation (after Joyce, Tong, Woods (2011)).
Joyce, Tong, Woods (2011) conclude: “These estimates are clearly highly uncertain, particularly as none of the methods used to produce them fully capture all the likely transmission channels set out earlier, but they do suggest that the effects of QE were economically significant.”

Krogstrup, Reynard, Sutter (2012) make a research supposition that the expansion in reserves following recent quantitative easing programs of the Federal Reserve may have affected the long-term interest rates through liquidity effects. Krogstrup, Reynard, Sutter (2012) define the liquidity effect as: “The liquidity effect is the impact of an expansion of the central bank’s liabilities on bond yields, irrespective of the type of asset the central bank buys.” The estimates suggest that between January 2009 and 2011, 10-year US Treasury yields fell 46-85 basis points as a result of liquidity effects in Krogstrup, Reynard, Sutter (2012). Finally, Krogstrup, Reynard, Sutter (2012) come to the conclusion: “… the large scale asset purchases carried out by the Federal Reserve may have had liquidity effects due to increases in reserves as well as portfolio balance effects of the changes in the supply of Treasury outstanding to the public. Failing to take into account such liquidity effects could lead to an underestimation of the impact of the large scale asset purchase programs on long-term government bond yields. While correlation is not causality, preliminary evidence suggests that reserves and yields were indeed correlated during the ZLB period, and that this correlation points to economically important effects. Thus, liquidity effects may have reduced long-term yields by 46 to 85 basis points due to the increase in reserves of about 2.5 percentage points of GDP between January 2009 and January 2011.”

In addition, let us explain that Iino, Iyetomi (2012) researched the Japanese transaction network consisting of about 800 thousand firms (nodes) and four million business relations (links) with focus on its modular structure in Fig. 19. Iino, Iyetomi (2012) write: “Networks formed by firms through their mutual transactions are a manifestation of economic activities. This is a new way to study economic phenomena emphasizing importance of interaction between economic agents. A number of researches on complex networks have been carried out from a physical point of view. The endeavors encompass development of statistical mechanics methods for quantifying network structure, construction of theoretical models for network formation and visualization of networks based on a physical model.” We believe that the capital flows propagation in the transaction networks channels, created by the complex interconnected transaction networks between the firms, banks and the US Federal Reserve System, may have an influence on the QE policy implementation in the US financial system.

Let us summarize the above research findings by saying that, in our opinion, the Quantitative Easing (QE) transmission channels together with the transaction networks channels
play an important role during the QE policy implementation in the US financial system. Therefore, the nonlinearity, originated in the Quantitative Easing (QE) transmission channels and the transaction networks channels in the financial system, need to be investigated properly.

![Image](image.png)

**Fig. 19.** The Japanese transaction network drawn in three-dimensional space by a spring-electrical model. Dots in these images represent nodes (firms) whose communities are distinguished by colors. The image (a) shows the whole network. The images (b) and (c) illuminate only the first and second largest communities, respectively. And those communities are further decomposed into sub-communities as displayed with different colors. The first and second largest sub-communities in the largest community are selected in (d) and (e), respectively (after Iino, Iyetomi (2012)).

**Nonlinear dynamic chaos generation by turbulent capital flows in QE transmission channels and transactions network channels in US financial system**

The modeling of the USA economy can be completed with the application of the VAR model with the Smets-Wouters model, making it possible to provide the reasonably accurate forecasts for the economic series in the selected model Del Negro, Schorfheide, Smets, Wouters (2007), FRED (2013), Kimball (1995), Lutkepohl (2006), NBER (2013), Smets-Wouters (2002, 2004, 2007). The Smets-Wouters model is a nonlinear system of equations in the form of a Dynamic Stochastic General Equilibrium (DSGE) model that seeks to characterize an economy derived from the economic first principles in Smets-Wouters (2002, 2004, 2007). The considered model works with the eight time series: output, prices, wages, hours worked, interest rates, consumption, investment, unemployment in Matlab (2012).
Let us consider the results on the modeling of the USA economy, which are shown in Figs. 20 - 26 in Matlab (2012).

**Fig. 20.** Plots of time series with shaded bands that identify periods of economic recession as determined by NBER (after Matlab (2012)).

**Fig. 21.** "Optimal" number of autoregressive lags based on the Akaike Information Criterion (AIC) (after Matlab (2012)).
Fig. 22. Forecast accuracy of model for 1-year horizon (after Matlab (2012)).

Fig. 23. Model calibration to December 31, 2008 (after Matlab (2012)).
Fig. 24. Model calibration to March 31, 2009 (after Matlab (2012)).

Fig. 25. Projected dynamic responses of each time series along each column in reaction to a 1 standard deviation impulse along each row. The units for each plot are percentage deviations from the initial state for each time series (after Matlab (2012)).
We would like to comment that the general approach to the modeling of the US economy can be based on both:

1) the "large" empirically-motivated regression model, and
2) the Value at Risk (VAR) model with the incorporated Smets-Wouters model.

Let us note that the above two approaches don’t take to the account an origination of the nonlinear dynamic chaos during the capital flow in the quantitative easing transmission channels and the transaction networks channels in the US financial system at the time of the QE policy implementation by the US Federal Reserve System.

Therefore, we completed the computer modeling, using both the Nonlinear Dynamic Stochastic General Equilibrium Theory (NDSGET) and the Hydrodynamics Theory (HT), to accurately characterize the US economy in the conditions of the QE policy implementation by the US Federal Reserve, because, in our opinion, the nonlinear dynamic chaos can be generated by the turbulent capital flows in the QE transmission channels in the US financial system in Kolmogorov (1941), Landau (1944, 2001), Feigenbaum (1979, 1980). In this connection, we focused our attention on a set of the important financial questions in (see the book on the nonlinearities in microwave superconductivity in D O Ledenyov, V O Ledenyov (2012)):

1. How does the laminar – turbulent transition in the QE transmission channels and the transaction networks channels in the US financial system occur?
2. How does the inflow of capital with the turbulent spectrum in the QE transmission channels and the transaction networks channels impact the macroeconomics situations in the US economy?
3. How does the inflow of capital with the turbulent spectrum influence the business cycle’s characteristics during the business cycle’s propagation in and interaction with the US financial and economic systems?

4. Will the degree of nonlinearity of the US financial and economic systems increase as a result of the increase of capital flows with the turbulent spectrum in the QE transmission channels during the QE policy introduction and implementation by the US Federal Reserve System?

Aiming to clarify the above research problems, we developed the two complex recursive algorithms and applied the parallel computing techniques to complete the computer modeling with the goal to accurately characterize the impulse responses by the US financial and economic systems to the changing levels of liquidity due to the QE program implementation. For example, we completed the following computer simulations:

1) the dependence of the capital flows propagation in the quantitative easing transmission channels in the US financial system over the specified time period, and

2) the dependence of the capital flows propagation in the transaction networks channels, created by the complex interconnected transaction networks between the firms, banks and the US Federal Reserve System, in the US financial system over the certain time period.

In our research, the cross-sections of both the quantitative easing transmission channels and the transaction networks channels have the complex dependencies on a number of the financial and economic variables in the US financial system. Using the knowledge base in the econophysics, we assumed that the nonlinear dynamic chaos can be generated by the turbulent capital flows in both the quantitative easing transmission channels and the transaction networks channels in the US financial system, when there are the laminar - turbulent capital flows transitions. We demonstrated that the capital flows in the quantitative easing transmission channels and the transaction networks channels in the US financial system can be accurately characterized by the Reynolds numbers in Reynolds (1883):

\[ \text{Re} = \frac{v d}{\nu}, \]

where \( d \) is the characteristic geometric dimension of researched system, \( \nu \) is the coefficient of kinematic viscosity, \( \nu \) is the characteristic velocity of capital flow. We think that the transition to the nonlinear dynamic chaos regime of the US financial system operation can be realized through the cascade of the Landau – Hopf bifurcations in the turbulent capital flows in both the quantitative easing transmission channels and the transaction networks channels in the US financial system in Landau (1944, 2001), Hopf (1948). We found that the ability of the US
financial system to adjust to the different levels of liquidity strongly depends on the nonlinearities appearance in the \(QE\) transmission channels, and it is limited by the laminar–turbulent capital flows transitions in the \(QE\) transmission channels and the transaction networks channels in the US financial system. In our opinion, one of the interesting modeling results is that the main purpose of liquidity adding into the US financial system is to stabilize the US financial system; however, we found that the instabilities may appear at the certain levels of added liquidity in the \(QE\) transmission channels in the US financial system, because of the laminar–turbulent capital flows transitions, resulting in the switching to the nonlinear dynamic chaos regime of the US financial system operation. Therefore, we made an important conclusion that the \(QE\) program implementation may stabilize or destabilize the US financial system, depending on the level of added liquidity in the US financial system over some time period.

**Conclusion**

The central banks introduced a series of quantitative easing programs and decreased the long term interest rates to near zero with the aim to ease the credit conditions and provide the liquidity into the financial systems, responding to the 2007-2013 financial crisis in the USA, UK, Western Europe, and Japan. We reviewed the U.S. Federal Reserve System, European Central bank, Bank of England and Bank of Japan monetary and financial policies with the particular focus on the quantitative easing policy implementation in the USA. Discussing some aspects of the quantitative easing policy implementation, we highlighted the fact that the levels of capital may change quickly in the quantitative easing transmission channels and in the transaction networks channels during the quantitative easing policy implementation, when the liquidity is added to the financial system. In agreement with the recent research findings in the econophysics, we propose that the nonlinear dynamic chaos can be generated by the turbulent capital flows in quantitative easing transmission channels and in the transaction networks channels, when the laminar capital flows transform to the turbulent capital flows in the US financial system. We demonstrated that the capital flows in both the quantitative easing transmission channels and the transaction networks channels in the US financial system can be accurately characterized by the Reynolds numbers. We explained that the transition to the nonlinear dynamic chaos regime can be realized through the cascade of the Landau–Hopf bifurcations during the turbulent capital flows in both the quantitative easing transmission channels and the transaction networks channels in the US financial system. Finally, we clarify that the general approach to the modeling of the US economy is based on both 1) the "large"
empirically-motivated regression model, and 2) the Value at Risk (VAR) model with the incorporated Smets-Wouters model, which don’t take to the account the origination of the nonlinear dynamic chaos regime during the capital flow in the quantitative easing transmission channels and in the transaction networks channels in the US financial system. Therefore, we completed the computer modeling, using both the Nonlinear Dynamic Stochastic General Equilibrium Theory (NDSGET) and the Hydrodynamics Theory (HT), to accurately characterize the US economy in the conditions of the QE policy implementation by the US Federal Reserve System. We found that the ability of the US financial system to adjust to the different levels of liquidity strongly depends on the nonlinearities appearance in the QE transmission channels, and is limited by the laminar – turbulent capital flow transitions in the QE transmission channels at the US financial system operation. The developed computer model allows us to make the very accurate long- and short-time forecasts of the US economy performance in the cases, when the different levels of liquidity are added into the US financial system.

Acknowledgement

This research article outlines the existing problems and provides some insightful ideas on the possible solutions to the US financial system problems, appearing during the quantitative easing policy implementation by the US Federal Reserve System. Authors would like to thank Dr. Ben Shalom Bernanke, Chairman of the Board of Governors of the Federal Reserve System for his brilliant thoughts, interesting scientific discussions and valuable practical advices on the quantitative easing policy implementation by the US Federal Reserve System in the U.S.A. It makes sense to highlight the fact that our research proposal that the financial system is dynamic, hence the financial variables, characterizing the stability of the US financial system, have to be taken to the account during the US financial system stability monitoring and its vulnerabilities evaluation (see the research article: “On the accurate characterization of business cycles in nonlinear dynamic financial and economic systems” by Dimitri O. Ledenyov and Viktor O. Ledenyov 1304.4807.pdf www.arxiv.org on April 13, 2013) was fully supported in the speech: “Monitoring the Financial System” by Dr. Ben Shalom Beranke at the 49th Annual Conference on Bank Structure and Competition in Chicago, Illinois in the U.S.A. on May 10, 2013. In addition, we thank the Federal Reserve System for giving us an opportunity to analyse the requested research articles, reports, reviews and financial data on the QE policy implementation in the USA. Authors have a strategic vision that more advanced research on the quantitative easing policy implementation is required to improve our understanding of the problem, taking to
the consideration the complexity of conducted computer modeling and the novelty of obtained research results.

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