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Article

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Synchronisation of Quantitative Easing and Fiscal Expansion: Macroeconomic Effects in Times of Crises

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Abstract

The purpose of the paper is to capture macroeconomic responses of quantitative easing in times of financial and non-financial crisis and to confront the extent of the output responses with the synchronisation of quantitative easing and expansionary fiscal policy. Several methodological approaches have been implemented to achieve this aim. Firstly, bibliometric analysis of scientific papers in the field shows the existence of liaisons between quantitative easing and fiscal policy (government debt) in scientific research. Secondly, cross-correlations and Granger causality tests uncover the effects on GDP, industrial production, inflation, and nominal effective exchange rate in the US, the euro area, and the UK (during the period 2007 - 2022) and Japan (during the period 2000 - 2022). The macroeconomic effects of quantitative easing are the most important in the UK and Japan during the financial crisis and in the US during the non-financial crisis. The findings confirm the idea that quantitative easing has a generally higher causal effect on output (or industrial production) if it is accompanied and supported by fiscal expansion, i.e., after the pandemic (non-financial crisis). The scientific value of the paper is that it fills the gap in current research by demonstrating the macroeconomic effects of the pandemic quantitative easing in Japan and the UK and taking the results in the context of fiscal policy and quantitative easing synchronisation.

Keywords

Quantitative easing, Financial crisis, Non-financial crisis, Cross-correlations, Granger causality

JEL Classification

E31, E51, E52, E58, E62

Introduction

Recently, central banks have been resorting to non-standard monetary policy tools, mainly quantitative easing, to deal with the negative consequences of crises emerging in the financial sector, such as the debt crisis in 2009 or the recent outbreak of the global pandemic known as COVID-19. During these periods, governments have also resorted to various support and compensation packages for economic subjects to prevent a deeper crisis. These central bank and government interventions open questions: (1) Is there a difference between the macroeconomic effects of quantitative easing in times of non-financial and financial crises? (2) Does support in the form of fiscal expansion lead to a higher effectiveness of quantitative easing? (3) In which countries has quantitative easing had the most important effect on output?

Our paper focuses on the macroeconomic effects of quantitative easing in the context of the monetary and fiscal policy nexus for the economies of Japan, the UK, the USA, and the Euro area. Our ideas are inspired by Reichlin (2021), who outlines the link between fiscal policy and quantitative easing. According to the author, the insufficient fiscal support in 2012–2014 is the reason for the limited effectiveness of the asset purchase program implemented in 2010–2011. This fact showed the scope for filling the gap in empirical research on the effects of quantitative easing, and this specifically led to the idea of investigating the macroeconomic effects of quantitative easing under

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the condition of synchronisation or non-synchronisation between monetary and fiscal policy. Furthermore, we divide the observed sample of seasonally adjusted monthly and quarterly data for the financial crisis period (for Japan 2000-2018 and other economies 2007-2018) and the non-financial "pandemic crisis" from 2019 to mid-2022. We search for macroeconomic effects by applying cross-correlations and Granger causality for the following variables: monetary aggregate M3, nominal effective exchange rate, GDP, industrial production, and inflation. We analyse the fiscal policy settings to identify their synchronisation with quantitative easing based on cross-correlations between the public debt (general government consolidated gross debt) and broad money growth.

The first chapter focuses on a theoretical analysis of the issue, complemented by a chronological development of non-standard monetary policy tools and an overview of the existing empirical research on quantitative easing effects. The second chapter explains the methodology, i.e., the choice of the period, economies, variables, and econometric methods. We report and interpret the results in detail in the third chapter and conclude with specific recommendations based on a comprehensive comparison of the findings in our paper.

The overall purpose of the paper is to test macroeconomic effects of quantitative easing and to compare them in terms of synchronisation and non-synchronisation of quantitative easing with fiscal policy. We aim to solve the problem whether the positive macroeconomic effects of quantitative easing are higher if quantitative easing is supported by fiscal expansion.

Theoretical Background and Literature Review

Since quantitative easing (QE) has been applied, many scientific papers aimed to test and quantify its macroeconomic effects on different variables, mainly on real output and inflation. The researchers used different methods and uncovered different macroeconomic responses in terms of studied countries and analysed period. After a short look at the theory of quantitative easing and a chronological overview of its application, we present results of the studies showing the effects of QE on real economy.

Quantitative easing is an unconventional monetary policy tool that increases the monetary base through massive open market operations (Gern, et al. 2015). It is a monetary policy instrument that increases the money supply, which brings us to one of the most controversial economic questions: are monetary policies effective at the level of real variables? The classical economists based their arguments on the quantity theory of money, and concluded, according to Iranmanesh and Jalaei (2021) and Habiman (2019), that a change in the quantity of money in circulation in the long run change nominal variables without any change in real variables. According to Classical economics, their theory is the so-called neutrality of money, so "money does not matter". The counterpart to their approach is the Keynesian one based on the theory of liquidity preference and the trinity of motives for the demand for money. Summarizing the findings of Iranmanesh and Jalaei (2021), Habiman (2019), and Bibow (2021), we conclude that, according to Keynesians, in the short run, an increase in the money supply causes a fall in the interest rate, which in turn affects economic activity, output, employment, and capital accumulation through portfolio decisions and the liquidity provided by the financial system.

In recent years, authors have also been confronting the macroeconomic effects of standard and non-standard monetary policy. For example, Hauenberger, Pfarrhofer, and Stelzer (2021) use Bayesian smooth-transition VAR results to assess the effectiveness of the ECB's standard and non-standard instruments as a function of the prevailing level of uncertainty. The authors reach the following empirical findings:

- (1) Transmission channels are distorted in times of heightened uncertainty, in particular: changes in the effectiveness of transmission channels related to industry and consumer expectations.
- (2) Standard monetary policy may be ineffective in times of uncertainty, but quantitative easing works well.
- (3) To achieve better outcomes, standard and non-standard tools should be combined: standard monetary policy with forward guidance will ensure more durable and robust outcomes in times of uncertainty, and QE will contribute to changes of the target rate through portfolio rebalancing and the signalling channel, helping to compensate for the transmission shortcomings of standard monetary policy in times of uncertainty.

The Bank of Japan was the first to introduce quantitative easing back in 2001 to solve the problem of falling inflation. Subsequently, other central banks also resorted to non-standard instruments after the economic crisis: the Federal Reserve System in 2007, the European Central Bank in 2008, and the Bank of England in 2009. In 2009, Japan also resorted to QE again. A detailed chronological overview of the specific decisions to introduce quantitative easing in Japan, the UK, the US, and the Euro area is presented in Table 1.

Table 1. The chronological overview of the quantitative easing.

Year	The central bank	The quantitative easing measures
2001	Bank of Japan	Multiple increases in BOJ current account balance to 10-12 trillion JPY Multiple increases in direct purchases to JPY 800 billion. JPY 9.6 trillion per month (i.e., 9.6 trillion per year)
2002	Bank of Japan	Increase in direct purchases to JPY 1.2 trillion per month Increase in the outstanding balance at the BOJ to JPY 15-20 trillion
2003	Bank of Japan	Multiple increases in the BOJ current account balance to JPY 27-32 trillion
2004	Bank of Japan	An increase in current account balances to JPY 30-35 trillion
2006	Bank of Japan	The outstanding current account balance with the Bank of Japan has been reduced to a level equivalent to the reserve requirement
2007	Federal Reserve System	Term Auction Facility - auction of term funds to depository institutions of USD 20 billion The swap lines with the ECB and the Swiss National Bank (USD 20 billion and USD 4 billion)
2008	Federal Reserve System	Increase of the Term Auction Facility to USD 150 billion Extension of the swap lines to 10 central banks USD 200 billion Term Securities Lending Facility Term Asset-Backed Securities Lending Facility - Federal Reserve Bank of New York to lend up to \$200 billion + 2 additional, \$150 billion each. USD 600 billion Asset Purchase Program
	European Central Bank	Increase in the frequency and scope of long-term refinancing measures Currency swaps - US dollars and Swiss francs
2009	Bank of Japan	The introduction of operations to supply liquidity of JPY 10 trillion
	Federal Reserve System	Expansion of the Term Asset-Backed Securities Loan Facility to USD 1 trillion Expansion of asset purchases by JPY 1 150 billion USD Agency debt purchases will increase from 100 billion to 175 billion USD
	Bank of England	Multiple increases in the GBP 75 billion asset purchase programme funded by central bank issuance of GBP 125 billion
	European Central Bank	Announcement of the purchase of covered bonds denominated in EUR and issued in the Euro area The bond purchases of EUR 60 billion An annual longer-term refinancing operation of EUR 442 billion and EUR 75 billion
2010	Bank of Japan	Delivery of funds against collateral - three-month operations worth JPY 800 billion (total JPY 20 trillion) Six-month operations at a frequency of 1-2 per month, total JPY 10 trillion (JPY 800 billion per operation) Comprehensive monetary easing: reduction of the uncollateralised overnight call rate to 0-0.1% and the introduction of an asset programme (APP) worth JPY 35 trillion
	Federal Reserve System	Intention to purchase \$600 billion in long-term Treasury securities, i. e. approximately \$75 billion per month until the second quarter of 2011
	European Central Bank	A three-month liquidity-providing operation of EUR 75.6 billion A programme for securities markets to withdraw excess liquidity A six-month liquidity-providing operation of EUR 35.7 billion The end of the covered bond purchase programme under which EUR 60 billion of bonds were purchased
2011	Bank of Japan	Increase APP by 20 trillion JPY
	Federal Reserve System	Intention to buy USD 400 billion worth of government bonds with maturities of 6-30 years by the end of June 2012 and to sell an equal amount with maturities of less than 3 years
	Bank of England	An increase in asset purchases by GBP 75 billion
	European Central Bank	A pair of longer-term refinancing operations is announced twice; the first LTRO to credit institutions worth EUR 489.2 billion (replacing the second operation announced earlier) Planning of a second covered bond purchase programme with a total nominal amount of EUR 40 million The announcement of a pair of refinancing operations (LTROs) with a maturity of 3 years
2012	Bank of Japan	Multiple increases in APP by a total of JPY 46 trillion Growth-Supporting Funding Facility of JPY 2 trillion Stimulating Bank Lending Facility of JPY 15 trillion (merged with the Growth-Supporting Facility under the Loan Support Program)
	Federal Reserve System	Additional purchases of MBS at a pace of USD 40 billion per month
	Bank of England	An increase of the asset purchase programme by GBP 100 billion
	European Central Bank	EUR 529,5 billion allocated in the second LTRO
2013	Bank of Japan	An asset purchase programme of JPY 13 trillion per month since January 2014 The quantitative and qualitative easing programme: The BOJ's main objective has changed to increase the monetary base at a pace of 60-70 trillion JPY per year
	Federal Reserve System	Reduction of MBS purchases to USD 35 billion per month and long-term government securities purchases to USD 40 billion per month

Year	The central bank	The quantitative easing measures
2014	Bank of Japan	Growth-Supporting Funding Facility programme: the maximum amount of funds will be doubled to 7 trillion QE: the monetary base grows by 80 trillion JPY annually
	Federal Reserve System	Multiple reductions in the pace of MBS asset purchases to USD 15 billion per month and Treasury bond purchases to USD 20 billion per month Ending the asset purchase programme
	European Central Bank	Announced a third covered bond purchase programme and an asset-backed securities purchase programme A series of targeted longer-term refinancing operations of EUR 82.6 billion and EUR 129.8 billion
2015	Bank of Japan	The Growth-Supporting Funding Facility programme will increase the maximum amount of funds provided to JPY 10 trillion
	European Central Bank	The beginning of asset purchases under the expanded APP with a target of EUR 60 billion per month Targeted longer-term refinancing operations of EUR 97.8 billion; EUR 73.8 billion; EUR 15.5 billion, and EUR 18.3 billion Extension of asset purchases until at least March 2017
2016	Bank of Japan	Increase in Bank Lending Programme to USD 24 billion at a revaluation of JPY 2.5 trillion
	Bank of England	The purchase of GBP 10 billion of corporate bonds Expansion of asset purchases for government bonds by GBP 60 billion
	European Central Bank	A comprehensive package of monetary policy decisions: reduction of all key ECB interest rates; extension of the monthly volumes of the asset purchase programme to EUR 80 billion and the eligibility of such assets; a series of four new targeted longer-term refinancing operations (TLTROs) Balanced TLTROs of EUR 7.3 billion; EUR 399.3 billion; EUR 6.7 billion; EUR 45.3 billion and EUR 62.2 billion
2017	Federal Reserve System	The announcement of a gradual reduction in holdings of securities by reducing the reinvestment of principal payments
	European Central Bank	The fourth TLTRO-II with a value of EUR 233.4 billion, for 474 participants APP of 60 billion per month
2018	European Central Bank	Multiple reductions in the pace of asset purchases up to EUR 15 billion per month
2019	European Central Bank	The reinvestment phase of the APP A restart of net purchases under the Asset Purchase Programme from 1 November
2020	Bank of Japan	Increase in corporate bond purchases by JPY 2 trillion Special operations to facilitate JPY 8 trillion in coronavirus-related corporate financing, increasing to JPY 23 trillion A special programme related to COVID-19 worth JPY 75 trillion Providing funds and eligible loans in the amount of JPY 30 trillion
	Federal Reserve System	An increase in holdings of government bonds by at least EUR 500 billion USD 80 billion per month and mortgage-backed securities (MBS) by at least USD 200 billion at a rate of USD 40 billion per month
	Bank of England	A new forward funding scheme with additional stimulus for small and medium-sized companies should provide at least GBP 100 billion by issuing central bank reserves, an increase of GBP 150 billion A release of the anti-cyclical capital reserve (from 1% to 0%), which will support up to GBP 190 billion of bank lending to companies An increase of GBP 200 billion in government and corporate bond holdings An increase in APP of GBP 100 billion
	European Central Bank	Emergency Pandemic Asset Purchase Programme (PEPP) of EUR 750 billion by the end of 2020 + multiple increases by a total of EUR 1 100 billion Three additional targeted longer-term refinancing operations
	Federal Reserve System	Multiple reductions in the monthly pace of asset purchases totalling USD 30 billion for Treasury bills and USD 15 billion for MBS
2021	European Central Bank	The expectation of an increase in the pace of purchases in the PEPP programme in the second quarter
2022	Federal Reserve System	The size of the balance sheet has increased from USD 4.2 trillion before the pandemic to around USD 8.9 trillion The end of purchases of government securities The beginning of the process of reducing holdings of securities
	European Central Bank	Gradual reduction and end of monthly APP volume

Note 1: If the central bank did not change its monetary policy decision during the year, the central bank is absent from the survey for that year.

Note 2: The chronological overview is processed up to June 2022 in line with the data used for the analysis, where the observed sample ends in the second quarter of 2022. **Source:** according to Bank of Japan 2001-2021, Board of Governors of the Federal Reserve System 2007-2022, Bank of England 2009-2021, and European Central Bank 2008-2022

Many researchers have already demonstrated the macroeconomic effects of the introduced non-standard monetary policy instruments and identify that quantitative easing leads to a decline in the interest rate, which is subsequently reflected in consumption and investment growth (Hohberger, Priftis, and Vogel, 2019), which stimulates GDP growth and inflation. A reduction in interest rates after a shock followed by an investment boom, GDP growth, consumption, and inflation is also observed by Le, Meenagh, and Minford (2016). Neuenkirch (2020) contributes

with the importance in the timing of quantitative easing effects. He reports that the positive effect on GDP reaches its maximum effect after 30 months. Bhattarai, Chatterjee, and Park (2021) found a positive response of monetary shock on domestic GDP, but with a lag of 5 months. This positive effect is confirmed by Ryou, Baak, and Kim (2019) in a time-varying parameter VAR model, but their benchmark Qualitative VAR model does not show a statistically significant response to output. According to Pichova, Cernohorsky, Kacerova, and Zila (2023) quantitative easing in the US helped to avoid an early descent into a severe recession and stabilised the economic cycle in the medium term. Nevertheless, the overall impact of quantitative easing has largely been detrimental.

In the case of inflation, he discusses an initial positive effect of quantitative easing for 12 months, which turns significantly negative after 16 months. Ryou, Baak, and Kim (2019) and Bhattarai, Chatterjee, and Park (2021) show that QE has a positive impact on stock prices and inflation.

In case of internal and external imbalances, Priftis and Vogel (2017) find that non-standard monetary policy had a positive effect on the general government balance (reduction in government debt) and the current account balance. Hohberger, Priftis, and Vogel (2019) observed an improvement in the trade balance and an increase in net exports after the monetary shock. Pastpipatkul, et al. (2015) found a negative impact on Thailand's trade balance, and Ryou, Baak, and Kim (2019) a decline in Korea's net exports. Bhattarai, Chatterjee, and Park (2021) identify a lagged positive effect of foreign non-standard monetary policy on EMEs' net exports only for the more sensitive "Fragile Five".

Monetary shock created by quantitative easing in the domestic economy leads to a depreciation of the domestic currency exchange rate. According to Ryou, Baak, and Kim (2019), this effect is observed for the JPY in both the short and long run. Tillmann (2016) reports that USD depreciation becomes insignificant after 10 months. Examination of the effects of quantitative easing on foreign economies has clearly shown an effect on the appreciation of foreign currencies relative to domestic currencies, although Meszaros and Olson (2020) argue that the effect is insignificant. Most authors find that quantitative easing has led to a boom in the stock markets of foreign economies, also insignificantly according to Meszaros and Olson (2020).

The impact of the COVID-19 pandemic on monetary policy transmission in 37 countries by applying the event-study methodology was examined by Wei and Han (2021). The authors find: (1) The emergence of the pandemic significantly weakened the transmission of monetary policy to financial markets, while an increase in the severity of the pandemic did not fundamentally change the results. (2) At the time of the pandemic, neither standard nor non-standard monetary policy means have an impact on financial markets, although non-standard monetary policy is somewhat more effective. (3) Non-standard monetary policy affects stock and foreign exchange markets significantly negatively. (4) A combination of monetary and fiscal policy is recommended to stimulate the economy during a pandemic, which is consistent with conclusions presented by Reichlin (2021).

The link between fiscal policy and quantitative easing studied by Reichlin (2021) uncovers that quantitative easing has a large impact on financial and price stability, but that the effects of this policy also depend on fiscal (political) support for quantitative easing programmes. It is the lack of fiscal support in 2012-2014 that accounts for the limited effectiveness of the asset purchase programme implemented in 2010-2011. Quantitative easing reduces the cost of refinancing public debt, thereby "offers" space for the government's fiscal policy, which can respond to monetary policy by reducing the government budget surplus or, conversely, by increasing it (labelled as a "crosswind"). In the Euro area, we do not observe (except for Germany) an adequate response from the governments of the member countries. Furthermore, the author concludes that the fiscal-monetary interaction is more visible when the level of public debt is high and the central bank balance sheet is large.

Public debt effects in connection with quantitative easing are included by Gambacorta, Hofmann, and Peersman (2014) who analyse the macroeconomic effects of quantitative easing in a robustness framework. Through a panel VAR model, the authors study the dynamic effects of non-standard monetary policy adopted after the financial crisis in eight countries. The analysis showed that an exogenous increase in the central bank's balance sheet (at the ZLB): leads to a temporary increase in output (peak growth after 6 months, return after 18 months) and a temporary increase in the price level (peak after 2 years). The results show that quantitative easing has a greater impact on output and a lower impact on the price level compared to conventional monetary policy. Further, in their extended model, the authors consider the potential overlap between non-standard central bank policy and supportive fiscal policy measures (associated with an increase in public debt) that could contaminate the monetary policy shock.

To conclude, recent empirical studies showed differences in macroeconomic effects of quantitative easing. The purpose of our research is to show the factors, which led to different macroeconomic responses of quantitative easing. Inspired by Reichlin (2021), we suppose that one determinant of different responses of quantitative easing on macroeconomic variables is the fact whether the quantitative easing is synchronised by fiscal policy or not. Therefore, we test the following hypothesis: Quantitative easing is supposed to have stronger positive macroeconomic effect on real output if it is supported by fiscal expansion.

Data and Methods

We analyse the effects of quantitative easing in Japan for the period 2000-2022 and in the UK, US, and Eurozone for the period 2007-2022: (1) based on monthly seasonally adjusted data as in Aßhoff, Belke and Osowski (2021) with lags of 1,3,6 and 12 months, (2) for tracking fiscal and monetary policy synchronisation and macroeconomic effects of quantitative easing, we use quarterly data such as Ryou, Baak, and Kim (2019), Michaelis and Watzka (2017) with lags of 1, 2, 3, and 4 quarters due to the unavailability of public debt data on a monthly frequency.

We ensure an improvement in the estimation early in the observation period before the introduction of the QE programme, as recommended by Meinus and Tillmann (2016) and Aßhoff, Belke, and Osowski (2021). We divide the observation period as in Meszaros and Olson (2020) and Hesse, Hofmann, and Weber (2018). Specifically, we split the period for the financial crisis from January 2000 to December 2018 for Japan and from 2007 to December 2018 for the other economies, and for the non-financial crisis from 2019 as Chen and Yeh (2021) to the latest available data in June 2022.

An overview of the variables examined is presented in the following table (Table 2).

Table 2. Variables included in cross-correlations and the Grange causality testing.

Variable	Abbreviation	Researched by the authors	Source
GDP [%]	GDP	Lyonnet and Werner (2012), Neuenkirch (2020)	OECD, Eurostat
Inflation [index 2015]	CPI /HICP	Ryou, Baak, and Kim (2019), Bhattarai, Chatterjee, and Park (2021)	OECD, Eurostat seasonally adjusted via X-13ARIMA-SEATS
Nominal effective exchange rate, 37 trading partners [index 2015]	NEER	Tillmann (2016), Priftis and Vogel (2017)	Eurostat seasonally adjusted via X-13ARIMA-SEATS
Broad money (M3) [index based on 2015=100]	M3	Gambacorta, Hofmann, and Peersman (2014), Meszaros and Olson (2020)	OECD
General government consolidated gross debt [% GDP]	GGD	Gambacorta, Hofmann, and Peersman (2014)	OECD, Eurostat seasonally adjusted via X-13ARIMA-SEATS
Industrial production index [index 2015]	IPI	Tillmann (2016), Bhattarai, Chatterjee, and Park (2021)	OECD, Eurostat seasonally adjusted via X-13ARIMA-SEATS

Inspired by the authors Kapetanios, et al. (2012) and Aguilar, et al. (2020), we analyse the effects of quantitative easing on macroeconomic variables using several econometric methods. The advantage of investigating the issue with multiple methods is the robustness of the obtained results. The unavailable data for GDP at the monthly level are substituted by the industrial production index (as applied in Aßhoff, Belke, and Osowski (2021), who modelled monthly GDP based on the industrial production index).

(1) *Bibliometric analysis*: Bibliometric analysis focuses on understanding the relationships between journal citations and summarizes the current status of an existing or emerging research topic (Tamala et al., 2022).

Our bibliometric analysis aims to plot the outputs of scientific research in the field of quantitative easing and fiscal policy. The data was obtained from the Web of Science (WoS) database and analysed using VOSviewer software. The bibliometric analysis performed by the VOSviewer software was discussed by Slyvkanyč and Glova (2023).

In the Web of Science search window, we focused on the keyword asset purchase program. The WoS database located a total of 475 publications spanning the period from 2001 to 2023.

We use the following econometric methods for the research:

(2) *Cross-correlation*: Lau and Yip (2019) mention that cross-correlation is a standard method for estimating the degree of correlation between two series. The cross-correlation test is based on the correlation function:

$$c_i = \frac{\sum_{k=1}^N x_{k-i+1} y_{k-i}}{\sqrt{\sum_{k=1}^N x_k^2 \sum_{k=1}^N y_k^2}} \quad (1)$$

which expresses the relationship between two series of time series $x(i)$ and $y(i)$ that have the same length N .

We apply cross-correlations in our analysis (1) to observe the synchronisation of monetary and fiscal policy, which according to Reichlin (2021) is important for increasing the effects of non-standard monetary policy (2) to identify the effect of quantitative easing (monetary aggregate M3) on macroeconomic variables: $\Delta M3 \rightarrow \Delta NEER$, $\Delta M3 \rightarrow \Delta CPI$, $\Delta M3 \rightarrow \Delta IPI$, $\Delta M3 \rightarrow \Delta GDP$ for quarterly and/or monthly data. We use the first differences of time series for

the purpose of cross-correlations to remove deterministic time trends that can lead to false regression (according to Enders, 2015).

Given that we used quarterly data in our analysis (1), we accounted for lag and lead over the course of four quarters. The monetary aggregate M3 of individual countries was denoted as x_{t+h} at time t , while public debt was denoted as y_t . This allowed us to determine whether the monetary aggregate M3 in a given country is catching up, leading, or synchronised with the development of public debt in the same country. The synchronisation between the monetary aggregate M3 of a particular country and public debt was assessed based on the correlation coefficient. If the correlation coefficient was greater than 0.7 at time t , the monetary aggregate M3 (monetary policy) and public debt (fiscal policy) were considered synchronised. If the correlation coefficient was greater than 0.7 from $t - 1$ to $t - 12$, the monetary aggregate M3 of the country was leading the public debt in that country. If the correlation coefficient was greater than 0.7 from $t + 1$ to $t + 12$, the monetary aggregate M3 was lagging behind the public debt in the country. Simultaneous development was demonstrated when the correlation coefficient reached its highest value at time t .

As we used both quarterly and monthly data to identify the impact of quantitative easing (monetary aggregate M3) on NEER, CPI, IPI, and GDP (2), we accounted for lag and lead over the course of four quarters and twelve months. The monetary aggregate M3 of individual countries was denoted as x_{t+h} at time t , while the other variables were denoted as y_t .

(3) *The Granger causality test*: examines whether past changes in one stationary variable X help predict current changes in another stationary variable Y beyond the explanation provided by past changes in Y itself. If not, then X does not cause "Granger cause" Y . The test helps to identify the existence of the relationship as well as measure its direction during the period under consideration (Damle and Basu, 2020).

In the calculations, bivariate regressions are used:

$$x_t = \alpha_0 + \sum_{i=1}^l \alpha_i x_{t-i} + \sum_{i=1}^l \beta_i y_{t-i} + \mu_t \quad (2)$$

$$y_t = \alpha_0 + \sum_{i=1}^l \alpha_i y_{t-i} + \sum_{i=1}^l \beta_i x_{t-i} + \mu_t \quad (3)$$

where

x and y are the analysed time series of the investigated variables with the optimal lag length l .

We test the hypotheses via standard linear F-test and χ^2 distribution (Wald statistic):

H_0 : There is no Granger causality between the variables.

H_1 : There is Granger causality between the variables (Damle a Basu, 2020).

We analyse the relationship: $M3 \rightarrow NEER$, $M3 \rightarrow IPI$, and $M3 \rightarrow CPI/HICP$. The monetary aggregate M3 represents the dependent variable (y), while NEER, IPI, and CPI/HICP are the independent variables (x). In order to meet the stationarity assumption, the data were adjusted via difference (Δ), Hodrick-Prescott filter (HP_t), Beveridge-Nelson decomposition (BN_d), or double difference $\Delta(\Delta)$.

We apply the Granger causality test to monthly data with lags of 1 and 3 months (short-term horizon), 6 months (medium-term horizon), and 12 months (long-term horizon), and to quarterly data with lags of 1, 2, and 4 quarters to maintain the original division into short-term, medium-term, and long-term horizons.

The Euro area economy is analysed in a specific way, where the synchronisation of the ECB's monetary policy with the fiscal policy of the governments of the individual member countries is observed and Granger causality on the macroeconomic variables of individual member countries. The European Central Bank (2022) allocates asset purchases across jurisdictions based on stocks through the capital key, which is used to express the M3 aggregate for each Euro area country shown in Table 3.

Results and Discussion

In this section we present results of each applied method, i.e., bibliographic analysis, cross-correlations, and the Granger causality testing. We present results separately for financial and non-financial crisis and compare the results obtained by cross-correlations and the Granger causality. Finally, our findings are confronted with contemporary research articles.

Bibliographic analysis is useful for exploring new trends in a particular research field (Tamala et al., 2022). The result of this analysis was the motivation for QE and fiscal policy synchronisation.

Table 3. The Eurosystem key for subscription to the European Central Bank's capital

Country	The Eurosystem key for subscription to the ECB's capital [%]					
	from 2/2020	from 1/2019	from 1/2014	from 7/2013	from 1/2009	from 1/2007
Belgium	3.64	3.63	3.54	3.48	3.48	3.55
Germany	26.36	26.38	25.72	26.97	27.13	29.52
Estonia	0.28	0.28	0.28	0.26	-	-
Ireland	1.69	1.69	1.66	1.60	1.59	1.28
Greece	2.47	2.48	2.91	2.80	2.82	2.61
Spain	11.92	11.98	12.63	11.87	11.90	10.86
France	20.42	20.41	20.26	20.32	20.38	20.70
Italy	16.99	16.95	17.59	17.91	17.91	18.03
Cyprus	0.22	0.22	0.22	0.19	0.20	-
Latvia	0.39	0.39	0.40	-	-	-
Lithuania	0.58	0.58	-	-	-	-
Luxemburg	0.33	0.33	0.29	0.25	0.25	0.23
Malta	0.10	0.11	0.09	0.09	0.09	-
The Netherlands	5.86	5.84	5.72	5.70	5.71	5.60
Austria	2.93	2.92	2.81	2.78	2.78	2.90
Portugal	2.34	2.35	2.49	2.54	2.51	2.47
Slovenia	0.48	0.48	0.49	0.47	0.47	0.46
Slovakia	1.15	1.15	1.10	0.99	0.99	-
Finland	1.84	1.83	1.80	1.79	1.80	1.79
Total	100	100	100	100	100	100

Note: „-“ = the country was not part of the Euro area in that year. **Source:** according to ECB 2007-2021

The main keyword of interest in the Web of Science search window was the asset purchase programme. The WoS database retrieved exactly 475 publications from 2001 to 2023. All keywords were analysed using VOSviewer. This software was able to calculate the links, total link strength, and the co-occurrence of the keyword with other keywords.

Bibliometric mapping: co-occurrence mapping refers to the relationships between keywords. In the study, some limitations of the analysis were set, for instance, a minimum of 2 occurrences of a keyword was set as a limiting factor. Out of 217 keywords from 475 articles, only 36 keywords met this threshold. For the sake of clarity, some keywords were excluded from the network.

In the following table (Table 4) we show some of the most frequently occurring keywords. Links refers to the co-occurrence of a keyword with another keyword, occurrences represent the number of articles in which the keyword was found, and cluster number means the number of clusters in which the keyword is found.

Table 4. The most frequently occurring keywords stemming from bibliometric mapping

Keywords	Cluster Number	Occurrences	Links
quantitative easing	4	14	17
interest-rates	1	11	10
unconventional monetary policy	1	8	14
monetary policy	3	7	13
asset purchase programs	1	6	11
fiscal policy	1	2	7
qe	1	3	5

We also used network visualization to illustrate co-occurrences of keywords (see Fig. 1). Each node in the network represents a keyword and the size of this node indicates the number of occurrences of the keyword, the link between nodes indicates the co-occurrences between keywords, and the thickness of the link signals the

occurrences of co-occurrences between keywords. From the selected 23 keywords, 4 clusters were formed, which are color-coded and thematically very closely related to each other. The prominence of the circles in each cluster represents the strength of their co-occurrence with other keywords, and the distance of the items and lines indicates the interconnectedness of the keywords.

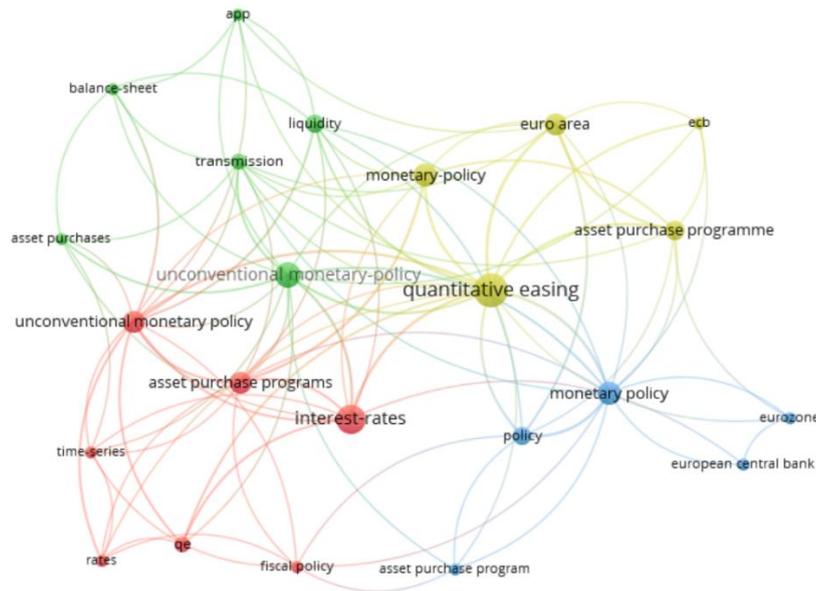


Fig. 1. Bibliometric map of keywords co-occurrence.

Cluster 1 (shown in red), which includes the following keywords, is analysis-worthy: asset purchase programs, fiscal policy, interest-rates, qe, rates, time-series, and unconventional monetary policy.

Unconventional monetary policy and asset purchase programs were the keywords with the highest co-occurrence with 14 and 11 scores. Fiscal policy was the keyword with the highest co-occurrence with a 7 score.

The keyword "fiscal policy" was mentioned in two publications along with seven other keywords such as unconventional monetary policy and asset purchase programs, which led us to our next analysis, which is the synchronisation of unconventional monetary policy (quantitative easing) and fiscal policy. The keyword "qe" (representing quantitative easing) was linked (i.e., co-occurrence) with the keyword unconventional monetary policy, which inspired us to express unconventional monetary policy with this tool.

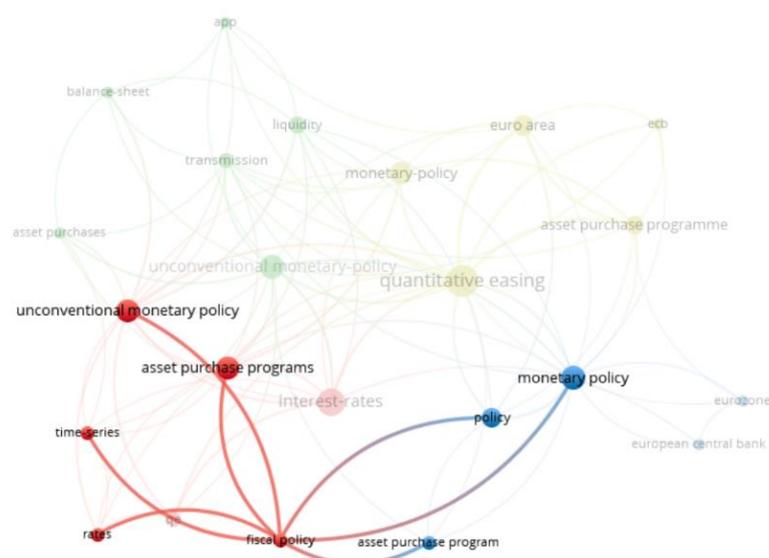


Fig. 2 Bibliometric map signalling the link of the keyword "fiscal policy" to other keywords.

Geographical distribution

475 articles about asset purchase programme were retrieved from 17 countries. The table below (Table 5) shows the 10 countries in which at least 2 articles about asset purchase programme have been published. The USA had

the highest number of publications on the topic with a total of 404 citations.

Table 4. List of countries with the highest number of publications based on bibliometric analysis.

Country	Number of publications	Number of citations
USA	19	404
Germany	13	219
Italy	4	12
England	4	236
Japan	4	11
Switzerland	2	27
Belgium	2	12
France	2	15
Ireland	2	5
Latvia	2	1

The results show that topics related to unconventional monetary policy (or quantitative easing) and fiscal policy have received the attention of researchers from different countries around the world from 2001 to 2023. The most cited research topic in the period was by Chen, Cúrdia, and Ferrero (2012) with a total of 195 citations. These authors dealt with the effects of asset purchase programs on macroeconomic variables (GDP and inflation).

Cross-correlations

The results of the cross-correlations showing the intensity of the synchronisation of quantitative easing and fiscal policy are shown in Table 6.

Table 5. Cross-correlations between monetary aggregate M3 and public debt.

	Financial crisis 2000/2007 Q1 – 2018 Q4					Non-financial crisis 2019 Q1 – 2022 Q2				
	x-lag 0	x-lag 1	x-lag 2	x-lag 3	x-lag 4	x-lag 0	x-lag 1	x-lag 2	x-lag 3	x-lag 4
JAP	0.106	0.175	0.078	0.041	0.097	0.773	0.769	0.092	-0.138	-0.329
GBR	0.333	0.236	0.111	0.102	0.035	0.668	0.072	-0.189	0.021	-0.047
USA	0.006	0.011	-0.213	-0.399	-0.356	0.804	0.287	0.004	0.065	-0.009
Euro area 2007 Q1 – 2022 Q2 (the start of the period for the country at the time of accession)										
AUT	-0.305	-0.389	-0.228	-0.263	-0.252	0.374	0.211	0.022	-0.025	-0.227
BEL	-0.146	-0.523	-0.35	-0.373	-0.379	0.584	0.181	-0.041	0.011	-0.119
CYP	-0.175	0.064	0.281	0.113	-0.025	0.355	0.183	0.174	-0.097	-0.138
DEU	-0.160	-0.212	-0.043	-0.19	-0.129	0.503	0.230	-0.057	-0.023	-0.164
ESP	-0.121	-0.207	-0.205	-0.311	-0.188	0.506	0.234	0.031	-0.045	-0.159
EST	0.398	0.063	-0.009	-0.005	-0.014	0.653	0.153	-0.048	-0.054	-0.026
FIN	-0.328	-0.369	-0.381	-0.342	-0.331	0.496	0.464	-0.178	-0.01	0.023
FRA	-0.36	-0.526	-0.532	-0.486	-0.456	0.592	0.14	-0.007	0.005	-0.091
GRC	0.003	-0.125	-0.128	-0.075	-0.038	0.378	0.214	0.057	-0.061	-0.17
IRL	0.058	0.038	0.019	0.009	-0.044	0.427	0.371	-0.166	-0.097	-0.174
ITA	-0.308	-0.398	-0.404	-0.384	-0.421	0.571	0.136	-0.031	0.002	-0.103
LTU						0.731	-0.123	-0.029	-0.075	-0.061
LUX	-0.056	-0.154	0.237	-0.107	0.052	0.129	0.026	0.297	-0.023	-0.222
LVA	0.266	-0.072	0.001	-0.045	0.567	0.406	0.056	0.08	0.066	-0.191
MLT	-0.468	-0.538	-0.257	-0.423	-0.291	0.415	0.167	0.094	-0.156	-0.246
NLD	0.061	0.138	-0.219	-0.389	-0.357	0.572	0.142	0.031	-0.041	-0.134
PRT	-0.279	-0.233	-0.207	-0.348	-0.19	0.190	0.308	0.068	0.052	-0.254

SVN	-0.127	-0.188	-0.23	-0.018	-0.173	0.576	0.207	-0.059	0.010	-0.102
SVK	0.154	-0.344	-0.298	0.064	0.080	0.492	0.151	0.017	-0.018	-0.119

During the financial crisis, monetary and fiscal policy synchronisation did not occur in Japan, the USA, and the UK. Only the non-financial crisis led to an increase in synchronisation between government and central bank policy in these economies. The strongest correlation is achieved with zero lags, suggesting that central banks and the government started to provide financial support to the population at the same time.

During the period of the financial crisis in the euro area countries, we do not observe, for the most part, a synchronisation of the fiscal policies of the individual member states with the monetary policy of the ECB. Exceptions include (1) Latvia, where we observe a medium-strong positive correlation with a lag of four quarters, indicating moderate synchronisation in the long run; (2) Belgium, Italy, France, and Malta, with a moderately strong negative correlation, suggesting the introduction of contradictory unconventional monetary tools and fiscal policies tools.

The non-financial crisis was characterised by a synchronisation between the ECB's monetary policy and the country's fiscal policy in the short term for most Euro area members. Governments and the European Central Bank introduced support during the pandemic at around the same time (zero lag) or with a lag of one quarter. However, there are exceptions among member states with no synchronisation: Austria, Cyprus, Greece, Luxembourg, and Portugal.

The effects of quantitative easing on countries' macroeconomic variables (Table 7) are initially tracked every quarter.

Table 6. Cross-correlations: macroeconomic effects of monetary aggregate M3, the quarterly data.

Causality		Financial crisis 2000/2007 Q1 – 2018 Q4				Non-financial crisis 2019 Q1 – 2022 Q2			
		x-lag 0	x-lag 1	x-lag 2	x-lag 4	x-lag 0	x-lag 1	x-lag 2	x-lag 4
JAP	M3→NEER	-0.129	-0.022	0.015	0.049	-0.058	0.236	0.075	0.446
	M3→CPI	0.016	0.081	0.155	0.168	-0.377	-0.355	0.077	0.064
	M3→GDP	-0.058	-0.121	-0.112	-0.047	-0.508	-0.161	-0.283	0.073
GBR	M3→NEER	-0.679	-0.445	-0.178	-0.347	-0.295	0.207	0.524	-0.239
	M3→CPI	-0.022	0.072	0.086	-0.335	-0.135	-0.126	-0.151	-0.077
	M3→GDP	-0.229	-0.106	-0.086	-0.26	-0.237	0.211	-0.041	0.096
USA	M3→NEER	0.309	0.306	0.120	-0.033	0.051	0.033	-0.213	0.150
	M3→CPI	-0.272	-0.140	0.140	0.131	-0.666	-0.296	-0.186	-0.281
	M3→GDP	-0.238	0.057	0.341	0.434	-0.205	-0.013	-0.002	-0.025
EA	M3→NEER	0.014	0.061	0.109	0.111	0.536	0.313	-0.025	-0.013
	M3→CPI	0.071	0.146	0.147	-0.02	-0.283	-0.311	-0.155	-0.114
	M3→GDP	0.108	0.309	0.438	0.382	-0.224	-0.059	-0.103	-0.039

During the financial crisis, quantitative easing has manifested itself differently across economies: (1) we do not observe significant macroeconomic effects (i.e., strong correlation) in Japan; (2) there is a medium-strength negative correlation between the change in the monetary aggregate M3 and the nominal effective exchange rate of the British pound sterling. In the short run, the pound depreciates after the introduction of BOE quantitative easing. (3) US GDP increases (medium strong positive correlation) with a lag of four quarters after the introduction of the Fed's non-standard measures; (4) in the medium term (lag of two quarters), European GDP is stimulated by quantitative easing (medium strong positive correlation).

The pandemic asset purchase programmes have produced largely different effects compared to the financial crisis: (1) at the time of the introduction of the pandemic asset purchases, domestic currencies appreciated ("medium-strength positive correlation") with a different time lag: the euro contemporaneously with the introduction of quantitative easing, the British pound in the medium term (2 quarters) and the Japanese yen only with a lag of four quarters. (2) Simultaneously with the introduction of quantitative easing, there was a reduction (medium strong negative correlation) in inflation in the US economy and a decline in Japanese GDP. Given the transmission mechanisms needed to transmit the effects of monetary policy to the economy, we suppose that the decrease in inflation and GDP was not the result of the pandemic programs of the Federal Reserve system and the Bank of Japan, but the macroeconomic variables were negatively affected by the government's actions related to preventing the spread of the pandemic.

Further, we proceeded to analyse the macroeconomic effects of quantitative easing monthly to support the robustness of the findings. The results are shown in Table 8.

Table 7. Cross-correlations: macroeconomic effects of monetary aggregate M3, monthly data.

Causality	Financial crisis 2000/2007 M1 – 2018 M12					Non-financial crisis 2019 M1 – 2022 M6					
	x-lag 0	x-lag 1	x-lag 3	x-lag 6	x-lag 12	x-lag 0	x-lag 1	x-lag 3	x-lag 6	x-lag 12	
JAP M3→NEER	-0.132	-0.135	0.032	-0.026	0.039	-0.241	0.053	0.326	-0.011	0.337	
	M3→CPI	0.026	-0.025	0.014	0.090	0.081	-0.164	-0.243	-0.245	0.032	-0.037
	M3→IPI	-0.070	-0.078	-0.03	-0.074	-0.045	0.088	-0.373	-0.195	-0.045	-0.026
GBR M3→NEER	-0.471	-0.272	-0.159	-0.104	-0.082	-0.337	-0.294	0.076	0.374	-0.023	
	M3→CPI	-0.076	-0.004	0.079	0.058	-0.073	-0.026	-0.18	-0.087	-0.094	-0.076
	M3→IPI	-0.057	-0.120	0.038	-0.095	-0.014	-0.531	-0.191	-0.159	0.119	-0.048
USA M3→NEER	0.061	0.141	0.162	-0.008	-0.01	0.084	0.396	-0.062	-0.151	0.093	
	M3→CPI	-0.214	-0.319	0.050	0.058	0.027	-0.573	-0.573	-0.213	-0.131	-0.206
	M3→IPI	-0.172	-0.218	-0.209	-0.076	0.190	-0.536	-0.58	-0.057	-0.046	-0.121
EA M3→NEER	-0.107	0.038	0.015	0.073	0.066	0.297	0.265	0.152	-0.095	0.066	
	M3→CPI	0.012	0.030	0.085	0.118	0.032	-0.135	-0.192	-0.152	-0.053	-0.051
	M3→IPI	-0.104	0.026	-0.081	0.017	0.152	-0.316	-0.323	-0.143	0.083	0.037

Quantitative easing programmes during financial crises did not have a significant effect on the development of macroeconomic fundamentals in the countries under review. The exception is the depreciation of the British pound (moderate negative correlation) accompanied by the introduction of a non-standard monetary policy.

In Japan and the Euro area, we do not observe the macroeconomic effect of the change in "broad money" after the introduction of pandemic quantitative easing. The effects in the UK and US economies were negative in the short run (with a lag of zero to one month) (medium strong negative correlation). The results suggest a fall in the UK inflation rate and a decline in GBR and US industrial production after introducing the pandemic asset purchases. The decline in the IPI and CPI may not be causally caused by the introduction of non-standard monetary policy instruments. Given the delay in transmission, we assume that the negative developments are caused by the spread of the pandemic and the introduction of movement restrictions to reduce the pandemic's momentum.

The Granger causality test

Thereafter, we test the effect of quantitative easing on macroeconomic variables through Granger causality in Table 9.

Table 8. The Granger causality testing in financial and non-financial crisis, monthly data.

Causality	Financial crisis 2000/2007 M1 – 2018 M12				Non-financial crisis 2019 M1 – 2022 M6				
	Lag 1	Lag 3	Lag 6	Lag 12	Lag 1	Lag 3	Lag 6	Lag 12	
JAP M3→NEER	0.8353	0.8697	0.8926	0.0085**	0.4209	0.5164	-	-	
	M3→CPI	0.4613	0.7304	0.3246	0.3195	0.5176	0.2023	-	-
	M3→IPI	0.1902	0.06867	0.02736*	0.03256*	0.09673	0.2533	-	-
GBR M3→NEER	0.3638	0.283	0.7935	0.9153	0.2909	0.4743	0.7428	-	
	M3→CPI	0.2389	0.005347**	0.01988*	0.1167	0.2162	0.7014	0.3256	-
	M3→IPI	0.5192	0.6611	0.2108	0.4344	0.00083***	0.00056***	0.00037***	-
USA M3→NEER	0.5175	0.7772	0.9684	0.9589	0.003**	0.1068	-	-	
	M3→CPI	0.2665	0.7108	0.6847	0.8578	0.6813	0.1373	-	-
	M3→IPI	-	-	0.2474	0.5726	0.8219	0.00015***	-	-
EA M3→NEER	0.0397*	0.05242	-	0.1121	0.3416	0.9255	-	-	
	M3→CPI	0.318	0.6407	-	-	0.897	0.5409	-	-
	M3→IPI	0.0149*	0.2801	-	0.4175	0.02966*	0.00035***	-	-

Note: „-“ not calculated due to not fulfilling assumptions, statistically significant at the significance level $\alpha = 5\%$ (*), 1% (**), 0.1% (***).

The quantitative easing introduced during the financial crisis has had specific effects in each economy. In the case of the United States, there is no statistically significant causal effect on the macroeconomic variables. In the medium term, the Bank of England has had a statistically significant effect on the UK inflation rate. The effect was the strongest three months after the shock and, thereafter, it gradually diminished. With a lag of twelve months, there is no longer statistically significant causality. The changes in "broad money" in Japan and the Euro area had statistically significant effects on the same variables, i.e., the index of industrial production and the exchange rate:

(1) The effect on Japanese industrial production was shown to be significant only with a lag of three months. There is stronger causality in the medium (6 months) and long (12 months) terms (higher statistical significance was found). In addition to output, we observe a strong statistically significant effect on the evolution of the Japanese yen in the long run.

(2) The euro reaction to the shock is statistically significant in the immediate term. The causal effect weakens gradually and is not statistically significant in the long run (lag of 12 months). The response of the industrial production index to the shock was statistically significant only in terms of one month.

Quantitative easing programmes during the non-financial crisis after the outbreak of the COVID-19 pandemic had a statistically significant effect on the evolution of the industrial production index in all studied economies; the effect of the BOJ was statistically significant only in the short term - a period of one month at the level of ten percent. In the euro area, quantitative easing has had causal effects in the short term (1 and 3 months). The increase in statistical significance (from 5% to 0.1%) occurs at a lag of three months. There is strong statistically significant causality in the UK economy (at the 0.1% level) in both the short and medium term. The strong statistically significant effect on the industrial production index (at 0.1%) in the US occurred with a lag of three months. Significantly, the Fed's most extensive quantitative easing also had a causal effect on the US dollar exchange rate (at the 1% significance level) with a lag of one month.

From a comprehensive view of the euro area economy (Table 9), the European Central Bank's quantitative easing has a statistically significant causal effect on the industrial production index and inflation. The causal effect of the ECB's non-standard monetary policy for individual member countries is shown in Table 10. We observe Granger causality on monthly data in euro area member countries, confirming the impact of quantitative easing on the Harmonised Index of Consumer Prices and the Index of Industrial Production.

Table 9. The Granger causality testing - Euro area member countries, monthly data.

Causality		Financial crisis 2007 M1 – 2018 M12				Non-financial crisis 2019 M1 – 2022 M6			
		Lag 1	Lag 3	Lag 6	Lag 12	Lag 1	Lag 3	Lag 6	Lag 12
AUT	M3→HICP	0.2671	0.1154	0.3028	-	0.6679	0.03016 *	-	-
	M3→IPI	0.4334	0.2234	0.229	-	0.0159*	0.00326**	-	-
BEL	M3→HICP	0.6158	0.8009	0.547	-	0.7463	0.5326	-	-
	M3→IPI	0.936	0.9272	0.002**	-	0.369	0.03196 *	-	-
DEU	M3→HICP	0.4107	0.03331*	0.009**	0.0385*	0.9074	0.9676	-	0.6318
	M3→IPI	0.2009	0.4802	0.4517	0.5888	0.0771.	<0.001***	-	-
ESP	M3→HICP	0.5281	<0.001***	<0.001***	<0.001***	0.8546	0.4231	-	-
	M3→IPI	0.8507	0.2643	0.4036	0.3718	0.1251	<0.001***	-	-
FIN	M3→HICP	0.8877	0.9553	0.9101	-	0.5096	0.1441	-	-
	M3→IPI	0.5308	0.7714	0.4135	-	0.8551	0.1855	-	-
FRA	M3→HICP	0.3548	0.3601	0.6831	-	0.0992.	0.229	-	-
	M3→IPI	0.9637	0.7274	0.2843	-	0.2045	<0.001***	-	-
GRC	M3→HICP	0.8045	0.409	0.6744	-	0.6221	0.1354	-	-
	M3→IPI	0.1252	0.4322	0.8235	-	0.3729	0.06567	-	-
IRL	M3→HICP	0.2588	0.529	0.2515	0.8944	0.4063	0.5283	-	-
	M3→IPI	0.787	0.9167	0.9916	0.9903	0.7036	0.5466	-	-
ITA	M3→HICP	0.5336	0.6103	0.8236	-	0.7406	0.8202	-	-
	M3→IPI	0.4412	0.6434	0.6428	-	0.009**	0.00128**	-	-
LUX	M3→HICP	0.8362	0.6676	0.9583	0.5849	0.3163	0.3394	-	-

	M3→IPI	0.8657	0.3375	0.7164	0.9253	0.1509	0.00177**	-	-
NLD	M3→HICP	0.1026	0.2152	0.009**	-	0.2641	0.9823	-	-
	M3→IPI	0.0261*	0.0013**	0.009**	-	0.1119	0.1472	-	-
PRT	M3→HICP	0.8571	0.9962	0.9012	-	0.871	0.8095	-	-
	M3→IPI	0.0732.	0.2492	0.6043	-	0.0685	<0.001***	-	-
SVN	M3→HICP	0.4292	0.8205	0.8688	0.9785	0.1315	0.09626	-	-
	M3→IPI	0.0922.	0.2841	0.5631	0.874	0.0534.	0.00506**	-	-
CYP	M3→HICP	0.2564	0.5899	0.302	0.3437	0.5348	0.7994	-	-
	M3→IPI	0.4818	0.7938	0.6686	0.7896	0.0729.	<0.001***	-	-
MLT	M3→HICP	0.7461	0.8568	0.5301	0.7328	0.714	0.573	-	-
	M3→IPI	0.3599	0.209	0.3767	0.02327*	0.0977.	0.03956*	-	-
SVK	M3→HICP	0.6781	0.979	0.9908	-	0.9469	0.4953	-	-
	M3→IPI	0.6638	0.5602	0.7996	0.8205	0.8414	0.01134*	-	-
EST	M3→HICP	0.8785	0.9804	0.9233	-	0.3869	0.7865	-	-
	M3→IPI	0.8888	0.7522	0.6042	-	0.0758.	0.1416	-	-
LVA	M3→HICP	0.8227	0.6148	-	-	0.5623	0.8879	-	-
	M3→IPI	0.3764	0.627	0.9334	-	<0.001***	0.008**	-	-
LTU	M3→HICP					0.9237	0.05695	-	-
	M3→IPI					0.0113*	-	-	-

Note: „-“ not counted due to not meeting assumptions, statistically significant at the significance level $\alpha = 5\%$ (*), 1% (**), 0.1% (***).

The macroeconomic variables of the member countries responded differently to the increase in broad money. Based on the results of the Granger causality (Table 10), we can argue that for the financial crisis:

(1) for the EA accession countries, we find a statistically significant effect of the ECB's quantitative easing only on Malta's industrial production in the long run, despite the fact that monetary policy was not supported by Malta's fiscal policy (Table 6 and Table 10);

(2) for euro area countries before the introduction of quantitative easing, where fiscal and monetary policy synchronisation does not occur (Table 6 and Table 10): The effect was strongest in the Dutch economy, where the shock had a causal effect on both the inflation rate and industrial production. The causality increases over time for the industrial production index (from a significance level of 5% with a lag of one month to a significance level of 1% with lags of three and six months). Inflation responds with a lag of six months (in the medium term) at the 5% level of statistical significance. The effect on inflation in Germany is statistically significant, with the largest causality occurring in the medium term - with a lag of six months. A strong statistically significant effect (at the 0.1% significance level) was the change in the M3 monetary aggregate on the HICP in Spain. In the medium term, the ECB's quantitative easing had a significant (at the 1% significance level) impact on Belgium's industrial production index. The production in Portugal and Slovenia reacted to the quantitative easing shock with a lag of one month (the effect is weak, i.e., at the 10% significance level);

(3) in other countries, the causal effect of broad money on HICP and IPI has not been demonstrated.

In the period of the non-financial crisis, the effects of quantitative easing have manifested themselves in several countries (Table 10), which may be supported by the greater coordination of member countries' fiscal policy with the ECB's non-standard monetary policy (which is found in Table 6):

(1) The effects of quantitative easing at the time of the pandemic were causally related to the industrial production index of the euro area member countries as follows: The statistical significance of the quantitative easing effect increases with increasing lags in countries pursuing expansionary fiscal policy, such as Italy, Germany, Malta, Slovenia, and Slovakia. In Latvia, Estonia, and Lithuania, the statistical significance of causality decreases with increasing lags. These countries supported the ECB's quantitative easing with fiscal expansion (Table 6). Further, Belgium, France, and Spain have synchronised their fiscal policies with those of the ECB (Table 6). The causal effect of the pandemic programmes on the industrial output of these countries was found to be statistically significant with a lag of three months. With an increasing lag, the statistical significance of the "broad money" causality on the industrial production of Austria, Cyprus, and Portugal increases. The ECB has successfully stimulated the IPI despite the lack of support from the fiscal policy of these countries (Table 6 and Table 10). Quantitative easing also had a causal effect on the industrial production of other countries, for which, according to cross-correlations, there is no synchronisation of fiscal and monetary policies (Table 6 and Table 10). The effect of

quantitative easing on the output of Luxembourg and Greece becomes statistically significant with a lag of three months.

(2) The change in the monetary aggregate M3 had a causal effect on inflation in the short term (three months) in only four countries - France, Lithuania, Slovenia, and Austria (Table 10). The governments of France and Slovenia have supported the European Central Bank with fiscal expansion (Table 6). In Lithuania and Austria, we do not observe a significant correlation indicating a synchronisation of fiscal policy with the ECB's non-standard monetary policy (Table 6).

(3) In other countries, the European Central Bank's pandemic quantitative easing programmes have not had a statistically significant effect on the economy, despite the identified synchronisation of monetary and fiscal policy (Table 6 and Table 10).

A comprehensive review of our results is presented in Table 11.

Table 10. Cross-correlations and the Grange causality testing – comparison of results.

	Financial crisis						Non-financial crisis					
	Cross-correlations Q/M			The Granger causality			Cross-correlations Q/M			The Granger causality		
	NEER	CPI	GDP/IPI	NEER	CPI/HICP	IPi	NEER	CPI	GDP/IPI	NEER	CPI/HICP	IPi
JAP	X/X	X/X	X/X	**	X	. **	+/X	X/X	-/X	X	X	.
GRB	-/-	X/X	X/X	X	** *	X	+/X	X/X	X/-	X	X	***
USA	X/X	X/X	+/X	X	X	X	X/X	-/-	X/-	**	X	***
EA	X/X	X/X	+/X	* .	X	*	+/X	X/X	X/X	X	X	* ** *
AUT					X	X					*	** *
BEL					X	**					X	*
CYP					X	X					X	***
DEU					** ** *	X					X	***
ESP					***	X					X	***
EST					X	X					X	.
FIN					X	X					X	X
FRA					X	X					.	***
GRC					X	X					X	.
IRL					X	X					X	X
ITA					X	X					X	** ** *
LTU											.	**
LUX					X	X					X	**
LVA					X	X					X	*** **
MLT					X	*					X	.
NLD					**	** ** *					X	X
PRT					X	.					X	***
SVN					X	.					.	**
SVK					X	X					X	*

Note 1: The lightest grey = synchronisation, and the darkest grey = contradictory fiscal and monetary policy settings, medium dark grey = no strong correlation between monetary and fiscal policy found by the analysis. Note 2: "+" = positive, "-" = negative and X = insignificant quantitative easing effect. Note 3: statistically significant causality at the significance level $\alpha = 10\%$ (.), 5% (*), 1% (**), 0.1% (***)

Our results uncover that the quantitative easing was supplemented by the governments after the outbreak of the coronavirus pandemic, i.e., during the period of the non-financial crisis. The comparison of the effects of quantitative easing in these circumstances presents a confrontation of the situation in the economy when fiscal and monetary policies are not synchronised (a financial crisis) and are synchronised (a non-financial crisis). Based on the paper by Reichlin (2021), which argues that fiscal stimulus increases the effectiveness of asset purchases, we expect that the macroeconomic effects of the pandemic quantitative easing should be stronger than the asset purchase programs introduced after the financial crisis.

The cross-correlation method shows the existence of relationships between the development of the monetary

aggregate M3 and other macroeconomic variables to a greater extent during non-financial crisis. The effects of quantitative easing identified by this method are contradictory in times of financial and non-financial crisis:

- (1) The exchange rate of the British pound depreciated during the financial crisis,
- (2) For the period of pandemic programmes, domestic currencies have tended to appreciate against the currencies of their major trading partners,
- (3) after the introduction of QE, in response to the outbreak of the financial sector crisis, the gross domestic product of the US and the Euro area was stimulated to grow,
- (4) Industrial production and GDP declined during the pandemic despite the non-standard monetary policy measures introduced.

Granger causality testing does not provide information about the specific (positive or negative) effect of quantitative easing. However, the conclusions of the test are important in assessing the causal effect of non-standard monetary policy on macroeconomic variables:

- (1) when QE is not supported by fiscal expansion, asset purchases have a causal relationship with the nominal effective exchange rate, industrial production, and the inflation rate, but the statistical significance of these relationships is largely not high,
- (2) the synchronisation of non-standard monetary and fiscal policy significantly increases the significance of broad money causality on industrial production. The increase in the monetary aggregate M3 is insignificant as far as the development of the nominal effective exchange rate (except for the US dollar) and the inflation rate.

The different responses to the evolution of macroeconomic indicators and the significance of the causal effect of quantitative easing among the economies may be due to asset purchases in different volumes and the economic situation in the economy when non-standard monetary policy measures are introduced. Based on the results summarised in Table 11 we conclude that:

- (1) Each economy responds specifically to the introduction of quantitative easing,
- (2) during the financial crisis, the Bank of England and the Bank of Japan had the most significant impact on their economies; the effects of the Federal Reserve system's quantitative easing were insignificant,
- (3) on the contrary, during the non-financial crisis, the Federal Reserve system's pandemic purchases were the most effective, and Japan's non-standard monetary policy did not cause significant reactions on macroeconomic indicators.

Consequently, we confront our obtained results with contemporary empirical research.

When examining the impact of quantitative easing during the financial crisis on domestic macroeconomic variables, analysis, and empirical research the following effects were identified:

- According to several articles, quantitative easing has a positive effect on industrial production and GDP. Exceptions include Michaelis and Watzka (2017), Ryou, Baak, and Kim (2019), Aßhoff, Belke, and Osowski (2021), and Bhattarai, Chatterjee, and Park (2021), who consider the effect on production in the observed economies to be insignificant.
 - In our study, the stimulation of GDP and production was confirmed by cross-correlations in the analysis of the US and Eurozone economies. Cross-correlations confirmed the insignificant effect of quantitative easing in the attempt by the Japanese central bank to increase GDP. According to this method, no significant effect was found in the economy of the United Kingdom either. Using the Granger causality test, we confirm a positive impact of QE on IPI in Japan and the Eurozone, Belgium, the Netherlands, Slovenia, Portugal, and Malta.
- Based on available literature, we assert that the reaction of inflation is the most frequently examined effect of QE. After increasing the amount of monetary aggregate M3 in the economy, inflation rises. Exceptions are the results of Aßhoff, Belke, and Osowski (2021) and Hauzenberger, Pfarrhofer, and Stelzer (2021), who consider the effect in the Eurozone to be insignificant.
 - According to our results, the insignificant effect of quantitative easing was confirmed by the method of cross-correlations in all observed economies. The Granger causality test confirmed a positive effect of QE on inflation in the United Kingdom.
- The exchange rate is the least frequently analysed in connection with quantitative easing. According to the authors, unconventional monetary policy predominantly has depreciation effects on the domestic currency. Hausken and Ncube (2013) report an appreciation of the currency in Japan and the United Kingdom.
 - Our results of cross-correlations analysis confirmed the insignificant effect of asset purchases on the exchange rates of the US dollar, Japanese yen, and euro. Cross-correlations in the UK economy

identified a depreciation of the domestic currency in response to the implementation of QE. Using the Granger causality test, we observe an appreciation of the Japanese yen and the euro.

When examining the non-financial crisis, we rely on other empirical research articles. The effects of pandemic quantitative easing programs on macroeconomic variables have so far been studied to a limited extent. This study expands the existing research by monitoring the impacts of unconventional monetary policy measures taken to prevent the negative impacts of the pandemic in the economies of Japan and the United Kingdom.

Authors have mostly focused on the Eurozone economy. The examination of macroeconomic effects yielded the following findings:

- GDP was studied by Aguilar et al. (2020) in the Eurozone and Spain. The lack of research on this variable is likely due to the unavailability of data at a frequency lower than quarterly. The authors claim that pandemic asset purchases have a stimulative effect on GDP.
 - Via the cross-correlation method we do not observe a significant effect of changes in "broad money" on GDP growth. The Granger causality test indicates a positive effect of QE on IPI in Japan, the United Kingdom, the USA, the Eurozone, Austria, France, Slovenia, and Lithuania.
- Aguilar et al. (2020) observe rising inflation following the implementation of PEPP.
 - In our case, cross-correlations did not reveal a significant effect of quantitative easing on inflation. On the other hand, the Granger causality test revealed a positive effect in Austria, France, Slovenia, and Lithuania.
- The exchange rate development was studied by Wei and Han (2021) through an event study, showing depreciation effects.
 - Based on cross-correlations, we confirmed that quantitative easing has appreciation effects on the domestic currency. The exception is the US economy, where the effect of pandemic asset purchases is insignificant. The Granger causality test indicated opposite results.

The different effects of quantitative easing found in empirical research across various economies may be conditioned by the set interval of the observed period, the choice of method, and the specific economic and financial situation in the observed country. Both supportive and contrasting findings are important for a comprehensive understanding of the consequences of unconventional monetary policy tools and their proper use in the future.

To conclude our findings, we confirm set hypothesis that quantitative easing has stronger positive macroeconomic effect on real output if it is supported by fiscal expansion. More specifically, the results of applied methods in our study uncover that quantitative easing has a higher causal effect on output and industrial production if it is accompanied by expansionary fiscal policy – as it was applied after the pandemic (non-financial) crisis.

Conclusion

The purpose of the paper is to study the macroeconomic effects of quantitative easing for the financial and non-financial crisis in the context of the monetary and fiscal policy nexus in the economies of Japan, the UK, the US, and the Euro area. The aim of our study is to reveal whether the positive macroeconomic effects of quantitative easing are higher if quantitative easing is accompanied by fiscal expansion.

To reach our objective we applied several methods. Synchronisation of fiscal policy and quantitative easing is demonstrated through cross-correlations of public debt and monetary aggregate M3. Subsequently, cross-correlations are applied to study the macroeconomic effects of quantitative easing on the nominal effective exchange rate, GDP, industrial production, and inflation. Further, the Granger causality testing showed the causal effect of quantitative easing programs on these macroeconomic variables. The paper also fills a gap in existing research by extending the research to study the effects of pandemic quantitative easing in the Japanese and UK economies.

Our results point to several key findings: (1) quantitative easing was supported by fiscal expansion, especially after the pandemic (i.e., in times of non-financial crisis), (2) the effect of QE supported by fiscal expansion on industrial production is statistically more significant. (3) QE was the most significant on the UK and Japanese economies during the financial crisis and on the US during the non-financial crisis, (4) the effects of quantitative easing are proved to be insignificant during the financial crisis in the US economy and during the non-financial crisis in Japan.

Our findings confirmed the expectations - the introduction of quantitative easing had a higher causal effect on the development of industry (or GDP) in a situation when fiscal and monetary policies are synchronised, i.e., in a period of non-financial crisis. Therefore, based on our results, we recommend that the central bank should evaluate the situation of the economy at the time if it decides to apply quantitative easing and take decisions in confrontation with fiscal policy. It would be advisable to time and synchronise asset purchases with fiscal support packages so that the effects of quantitative easing would be more effective. It is crucial for policymakers to collaborate with

economists and independent fiscal policy experts. Their expertise can enrich analyses and recommendations based on the latest research and empirical evidence. Efficient fiscal policy requires a combination of theoretical knowledge, practical experience, and the ability to communicate and implement complex decisions. Collaboration with experts, continuous education, and sufficient level of transparency are key elements for achieving success in this area.

Moreover, it is imperative to respect conclusions of existing fiscal committees and councils to ensure the compliance with the fiscal responsibility and fiscal transparency rules as well as to guarantee their enforceability.

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