“Can key interest rates decrease output gaps?”

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CAN KEY INTEREST RATES DECREASE OUTPUT GAPS?

Abstract

The difference in the GDP levels is crucial for the macroeconomic forecasting to develop adequate and supportive fiscal and monetary policies. Most mismeasurements under current geoeconomics challenges can be explained by the difficulty in predicting recessions and the overestimation of the economy's potential capacity. The research aims to consider the GDP gap's effectiveness for the possible forecasting of the monetary policy, particularly the central bank's interest rate. The study uses quantitative methods, particularly VAR modeling. The VAR model is chosen as a proven useful tool for describing the dynamic behavior of economic time series and forecasting. The data sample is chosen as Eurozone, the United States, and Japan. The similarity is detected on output gaps implementation in the considered states; however, the variety in the responses to the financial crisis is revealed. This difference is due to the different sensitivity of economies on the impact of monetary instruments. In particular, the Japanese economy has a relatively low level of sensitivity to changes in monetary instruments. In terms of the reactions of central banks to the current economic crisis caused by COVID-19, then due to the global lockdown and the incredible decline in economic activity, almost all countries are in a situation of negative GDP gap according the paper's approach. However, the measures to mitigate it will vary in different states.

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INTRODUCTION

The contemporary economic theory considers governments and central banks' ability to regulate economic growth. An important part is played by fiscal and monetary policy. For a long time, principal tools are under debate on their importance and effectiveness (Chen & Górnicka, 2020). The final answer is still demanded. Both policies are based on the assumption that regulation's task is to achieve a general equilibrium, in which aggregate demand should be equal not only to aggregate supply but also to the potential output of the state. Any deviation from the potential output level is considered a problem that requires government or central bank regulation. In particular, if the market equilibrium is less than the potential output, it indicates underemployment, inefficient attraction of resources, and inflation. On the contrary, if the economy produces more than the potential level, even more terrible deflationary processes have started.

The use of fiscal and monetary instruments allows stimulating or discouraging economic activity. This shifts the equilibrium point towards the potential output level. This response is particularly important in an economic crisis when large-scale stimulus measures are taken. The level of such measures largely depends on the magnitude of the deviation in the potential output level. Obviously, the larger the gap between actual and potential output, the greater the public policy measures to keep the economic situation under control. The magni-

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tude of such measures, their role, and timing are vital right now when the world is experiencing one of the largest economic crises caused by the coronavirus pandemic. Global lockdown, quarantine, some travel restrictions, social contacts, etc. have led to a significant industry collapse in almost all countries, a significant reduction in energy consumption, disruption of logistics, and interstate trade.

The response of the leading central banks and governments of almost all countries in 2020 was almost synchronous: a significant weakening of monetary policy and the introduction of fiscal incentives for the economy. Simultaneously, this response only leads to an increase in government debt and the devaluation of currencies' purchasing power, but does not address the global attempt to reach sustainable economic development. Thus, the question of the effectiveness of fiscal and monetary policy measures arises.

The highlighted challenges are quite broad. Thus, this paper focuses on only one of the tools – monetary tools (particularly, key interest rates which are currently the main instrument of inflation-targeting central banks' monetary policy) to stimulate the economy due to the GDP gap.

1. LITERATURE REVIEW

An important aspect of the analysis is the correct definition of the GDP gap. As a rule, the GDP gap (output gap) means the difference between actual GDP and potential GDP.

Scholars widely discuss the gaps in the tool to forecasts cycles and crises, e.g., Schuler (2020) provides empirical evidence suggesting that the credit-to-GDP gap is subject to spurious medium-term cycles, i.e., artificial boom-bust cycles with a maximum duration of around 40 years. However, most papers are devoted to the regional combating of the GDP gap, e.g., Farrell (2014) tested from a South African perspective how the credit-to-GDP gap can be used as a guide to making decisions regarding the countercyclical capital buffer. This study confirmed that the mechanical application of the credit-to-GDP guide for the region is not advisable. In the same tendency, Kauko and Tölö (2019) considered the trend deviation of the credit-to-GDP ratio ("Basel gap") as an early warning indicator of banking crises. They concluded that the 2008 crisis does not dominate the results while the long sample almost eliminates filter initialization problems. Analysis of fiscal instruments to combat GDP gaps is given in Kharlamova, Stavytskyy, Chernyak, Giedraitis, and Komendant (2019), where the possibility of sustainable economic development in Ukraine by the regulating GDP as it has been experienced in other countries of the world is tested under the limited information and in the concept of the natural level of unemployment. Remarkable, that mostly 90% of studies on GDP gap are based on the Hodrick-Prescott filter (i.e., Kharlamova, Stavytskyy, Chernyak, Giedraitis, & Kome, 2019; Farrell, 2014; Kauko & Tölö, 2019; Kocsis & Sallay, 2018; Jönsson, 2019; Karagedikli & Rummel, 2020).

However, some scholars do not share the view of the importance of the GDP gap (i.e., Orphanides & Van Norden, 2002; Hristov, Vandermeulen, & Raciborski, 2017; Roeger, Mc Morrow, Hristov, & Vandermeulen, 2019). In particular, Tooze (2019) initiated scientific concerns on estimating the benchmark of potential output. The author attempted to explain how a false exactitude in economics has led to terrible politics in the EU. Buti, Carnot, Hristov, Mc Morrow, Roeger, and Vandermeulen (2019) discuss the criticism anxiety and presented some evidence that many of the criticisms are focused to an excessive degree on the role of potential output in EU fiscal surveillance, with the practice of surveillance being much more flexible and less rigid than many commentators tended to suggest. The dispute is still boosting (Heimberger & Kapeller, 2020).

Note that there are differences in the GDP gap calculation due to different understandings of the potential GDP level. On the one hand, the level of GDP should be achieved under the conditions of complete and efficient involvement of resources, technological and demographic development. However, not all of these factors can be fully taken into account, and, therefore, some research-

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ers identify several approaches to potential GDP calculation:

1) institutional approach. Based on the institutional function of Cobb-Douglas, the state output is estimated under the condition of complete utilization of capital and labor, taking into account demographic changes, a constant level of technological improvement (e.g., Gazda & Godziszewski, 2011);

2) regression approach. It is used to calculate a certain long-term trend of actual GDP growth, which continues for the following periods (e.g., Stavytskyy, 2018; Stavytskyy & Martynovych, 2012);

3) the approach is based on unemployment analysis. According to Oaken's law, the deviation from the natural rate of unemployment leads to a change in GDP level depending on the potential level of GDP (e.g., Blázquez-Fernández, Cantarero-Prieto, & Pascual-Sáez, 2018):

$$\%\ Output\ gap = -\beta \cdot \%\ Cyclical\ unemployment, \quad (1)$$

where the coefficient β is determined by regression. This equation can be rewritten as follows:

$$\frac{(Y-Q)}{Q} = -\beta\left(u-u^*\right), \quad (2)$$

where Y is actual output, q is a potential output, u is actual unemployment, u^* is the natural rate of unemployment, β is a constant derived from the regression to show the relationship between deviations from the natural output and natural unemployment.

Each of these approaches has its advantages and disadvantages.

In particular, the first approach can generate the most accurate estimates but is associated with the difficult task of a statistical base maintaining.

Although relatively easy one, the second approach does not indicate which interval to take to assess the long-term trend. The potential GDP assessment behavior will significantly depend on the choice of the initial sample. It is worth mentioning here that in early 2008, the US Federal Reserve estimated potential GDP in this way, expecting continued economic growth. However, the crisis of 2008–2009 has shown that the economy has not yet reached the level of potential GDP, shown by Coibion, Gorodnichenko, and Ulate (2017). Moreover, another disadvantage of this method can be noted (Drehmann & Tsatsaronis, 2014). For example, at the end of the year, the central bank calculates the level of potential GDP to shape policy, but after one quarter, such a forecast becomes inaccurate due to the requirement to recalculate the potential GDP level caused by the changes in the sample, which already contains data for the first quarter. As a result, the GDP gap changes for each subsequent quarter of the year. That leads to a change in monetary policy, representatively (Bank of England, 2014). However, these cases are quite technical and do not significantly affect the accuracy of forecasting.

Finally, the third approach has the right to exist with a constant understanding of who works in the economy. However, the trends of recent decades show that more and more people choose the path of freelance or informal employment, which leads to the impossibility of determining the real unemployment, but also, accordingly, the natural level of employment (Roeger et al., 2019).

2. METHODS

Thus, the GDP gap plays an important role in shaping the fiscal and monetary policy of the state. It can be calculated in several ways, but the most suitable at this stage is a regression approach, taking into account the rules of sampling to determine the long-term trend of economic growth.

The paper aims to determine the interaction of the central bank's main interest rate and the size of the GDP gap in the country. So, the research hypothesis is formulated: the states' central banks can effectively regulate the GDP gap by altering the interest rates. The obtained results are aimed to boost the discourse on the topic by the international community of financiers, both academics and practitioners.

For further analysis, the VAR model tool is used, showing the relationship between the country's main interest rate level and the GDP gap level. This toolkit allows quantifying the impact of interest rates and exploring it in dynamics through the use of impulse functions.

Building a vector autoregression model is one of the most effective methods of analyzing financial and monetary transmission channels' impact on key macroeconomic parameters. The VAR model allows investigating the relationship of each model variable's current values with current and past (lag) values of all variables included in the model. In other words, the model enables us to simultaneously assess many macroeconomic dependencies, taking into account their dynamics and relationships. The general technique for constructing a vector autoregressive model involves selecting inputs based on a cause-and-effect relationship analysis, for which a stationary analysis is then performed. In the case of non-stationary time series, reduction to a stationary form is carried out by taking differences of the corresponding order. It also checks for cointegration to take into account long-term relationships between variables. In this case, the vector autoregressive model will include the so-called error correction mechanism. The last step is to evaluate the unknown parameters of the model and analyze the results.

In general, the VAR model is a system of n equations, which in matrix form can be written as follows:

$$y_t = c + A_1 y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \varepsilon_t,$$

where y_t is a k-measurable vector of endogenous variables, i.e., those estimated using the model; x_t is an m-dimensional vector of exogenous variables that reflect external influences on the model; c is the vector of constants; A_1, ..., A_p and B are matrices of dimensional coefficients (k × k) and (k × m), respectively, to be estimated; ε_t is the error vector, $\varepsilon_t \sim N(0, \sigma^2)$.

VAR is an economic model that reflects the evolution and interdependence between variables of multidimensional time series, generalizing one-dimensional autoregressive models. VARs were first proposed by Sims (1980) as an alternative to structural models, i.e., such models formed based on economic laws of the economic system (for example, the dependence of Phillips for unemployment and inflation or Taylor's rule for the refinancing rate, etc.). Instead, in the VAR model, all variables are considered simultaneously by including for each variable an equation that explains the evolution (dynamics) of the variable based on the previous values of the variable and the lag values of other variables of the model.

This, at first glance, the simple tool allows you to systematically and internally consistently reflect the dynamics of multidimensional time series. So, a long-term trend for the entire observation period from the first quarter of 1999 to the fourth quarter of 2019 is built to determine the GDP gap.

Source: Calculated by the authors.

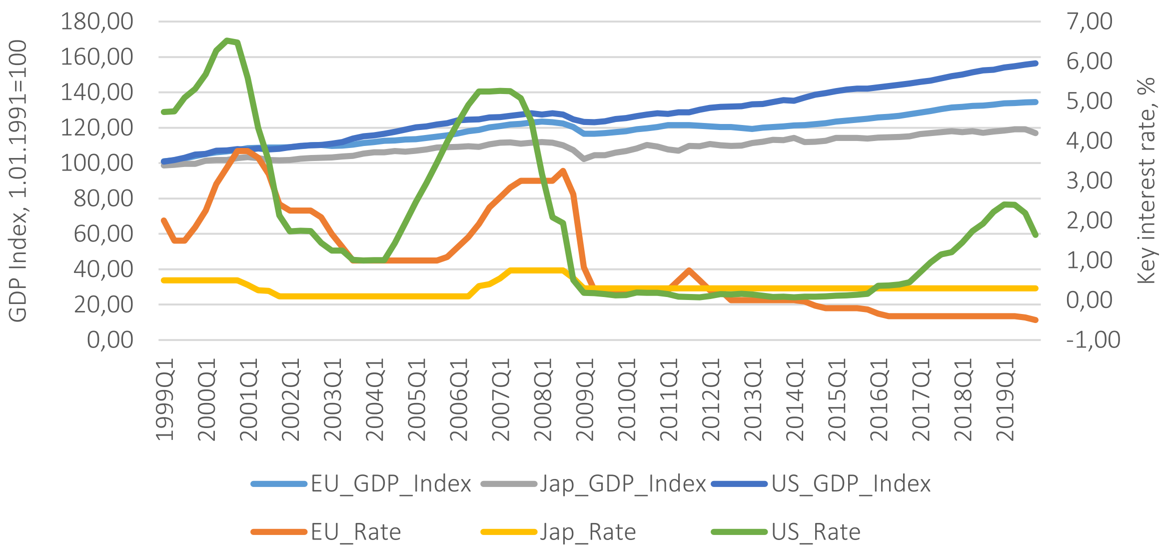

Figure 1. Dynamics of GDP indices and key interest rates of the considered countries

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The states of the Eurozone, the United States, and Japan are selected for the analysis. The analysis is conducted on the data of three major central banks: the Fed, the ECB, the Central Bank of Japan. The same sample is chosen for data comparability. The real GDP index (as of January 1, 1999, equal to 100) and each central bank's key interest rates are used for the analysis. Specific sources of indicators are given in TableA1 in Appendix and Figure1.

The value of actual GDP is used to determine the level of the GDP gap. However, since in all countries GDP calculated with certain methodological differences, in national currencies with volatile exchange rates, it is decided to use the GDP index in constant US dollars instead of actual GDP, according to the country's statistical agency. For greater comparability, all index values are normalized, so that the 4th quarter of 1999 is taken for the basic. These values can be seen in Table A2 in Appendix.

3. RESULTS

According to these data, the long-term trend of the GDP index is estimated. For this purpose, the usual regression is evaluated (Table 1).

All models are adequate with significant coefficients. Thus, it can be concluded that the American economy developed much faster than the European and Japanese. As one can see, Japan has not yet overcome the consequences of the "lost decade". The rate of economic growth in the United States is more than twice bigger than in Japan. Using the obtained coefficients, the GDP gap values were calculated:

$$gap_t = GDP_t - long\_trend_t.$$

The result of calculating the GDP gap for these countries can be seen in Figure 2.

As can be seen from Figure 2, the US, EU, and Japan synchronized economic cycles that led to similar economic problems and reactions to change. The only difference is in the EU's reaction, which has used more fiscal instruments since the 2008 global financial crisis, while the US has used monetary stimulus. However, as can be seen from Figure 2, the difference is not critical. In turn, Japan does not rely on monetary measures at all. The graphs of the dependences of the GDP gap and the key rate dynamics are constructed to illustrate it (Figure 3).

Table 1. Estimation of a long-term trend

Source: Calculated by the authors.

Model criteria	EU	Japan	USA
Slope coefficient	0.323	0.208	0.596
Significance	0.000	0.000	0.000
R^2	0.899	0.857	0.968

Source: Calculated by the authors.

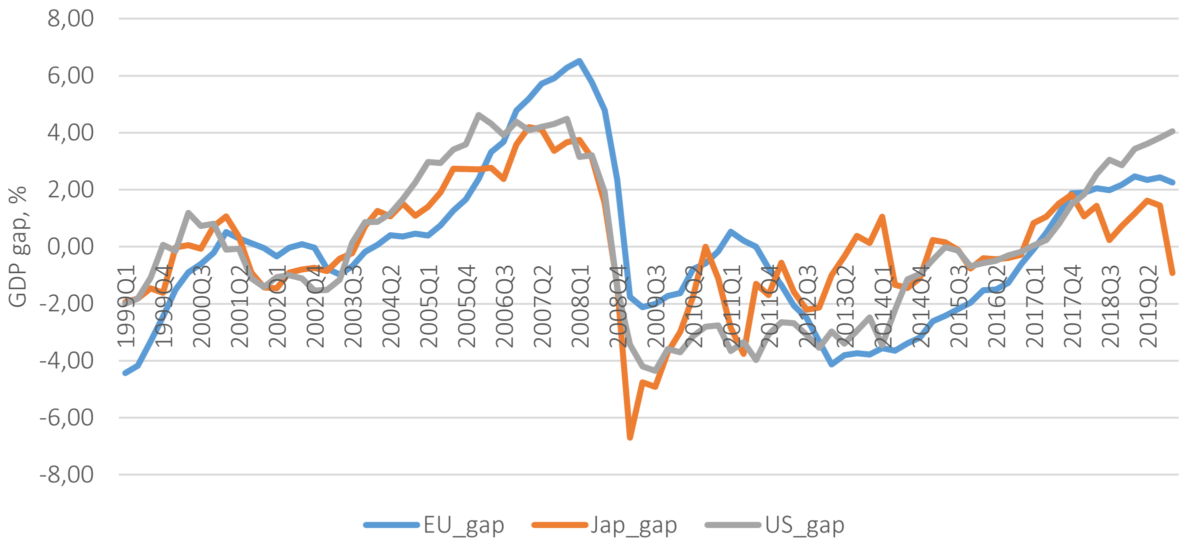

Figure 2. Dynamics of GDP gaps of the considered countries

Source: Calculated by the authors.

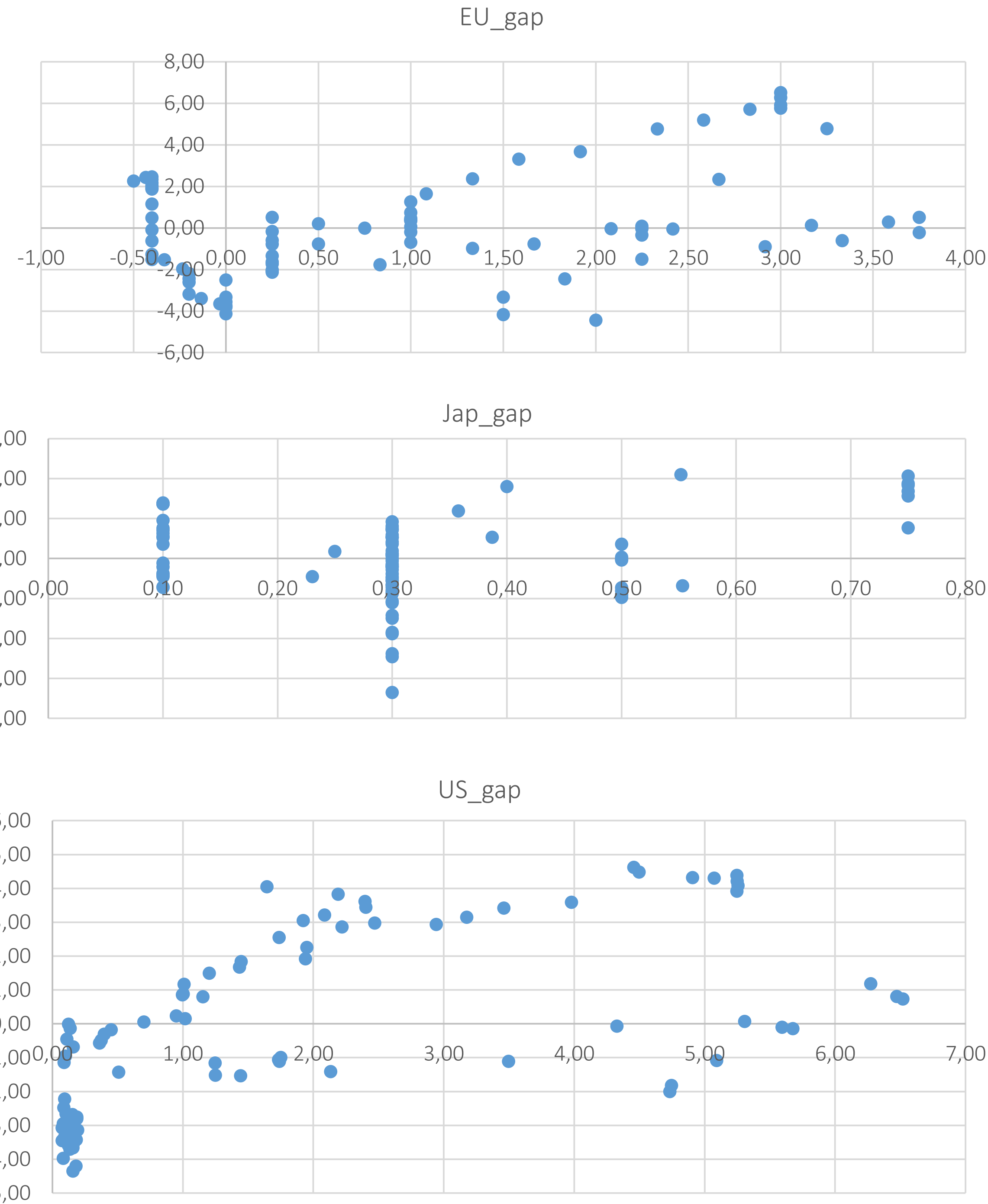

Figure 3. Dependence of the GDP gap and the dynamics of the key rate in selected countries

Thus, the reaction to GDP gaps in these countries differs significantly. In particular, the ECB is trying to respond to the positive gap by raising rates. The Bank of Japan makes insignificant and extremely rare changes in interest rates. In the Fed, the GDP gap response is fairly standard: with a positive gap – rates increase, with a negative – rates approach 0.

However, the correct identification of the VAR model requires that the time series be stationary. The stationarity is understood as the invariance

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in time of mathematical expectation, variance, and covariance of the time series. The stationary requirement is necessary to obtain unbiased estimates of VAR-model coefficients' matrices by the least-squares method. Therefore, the input data are to be checked on stationarity using the augmented Dickey-Fuller test. This test's main essence is to calculate the ADF statistics for the series itself, then for the first, second, etc. differences. The stationary condition is satisfied if the ADF statistics' value does not exceed the corresponding critical value. In this case, a series whose k-th differences are stationary is called an integrated series of k-th order and is denoted by I(k). The stationary series is denoted by I (0).

The Augmented Dickey-Fuller test is performed, which shows that all variables are non-stationary in levels, but stationary in the first differences (see Table A3 in Appendix). Thus, it is appropriate to build a model in the first differences of variables.

The next step is to select the optimal number of lags for the VAR model. The results of the analysis are shown in Table 2.

Table 2. Test results for the length of the lag in models

Source: Calculated by the authors.

Model	LR	FPE	AIC	SC	HQ
EU	2	3	3	2	2
Japan	6	1	1	0	1
USA	1	1	1	1	1

Thus, two lags are chosen for the European model, and one lag for the Japanese and American models. The results of the model evaluation are given in Table A4 in Appendix.

The impulse functions for each country are constructed based on the evaluated models. For the European Union (Figure 4), it can be seen that the shock of the GDP gap plays a significant role for at least 9 quarters, reaching a maximum impact in

Source: Calculated by the authors.

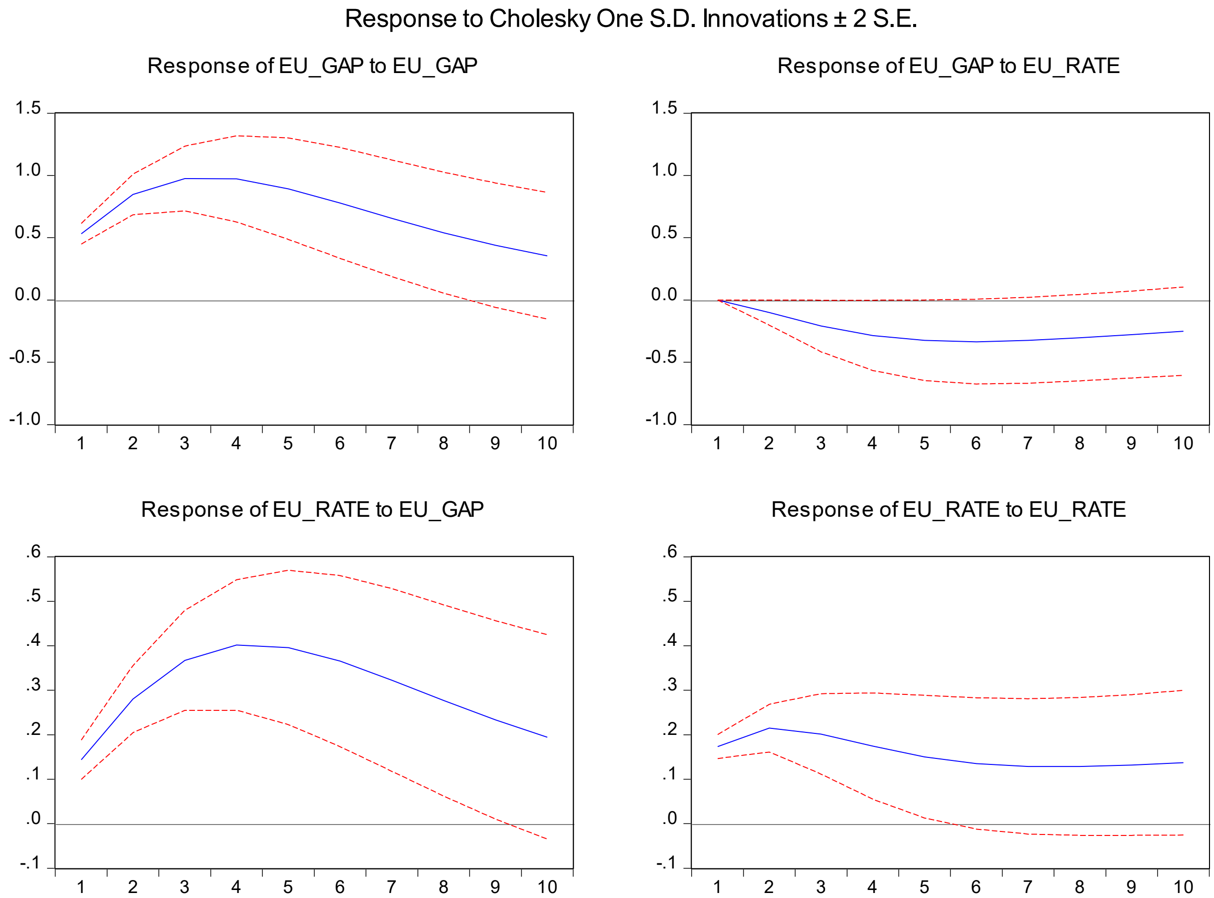

Figure 4. Impulse functions for the EU

Source: Calculated by the authors.

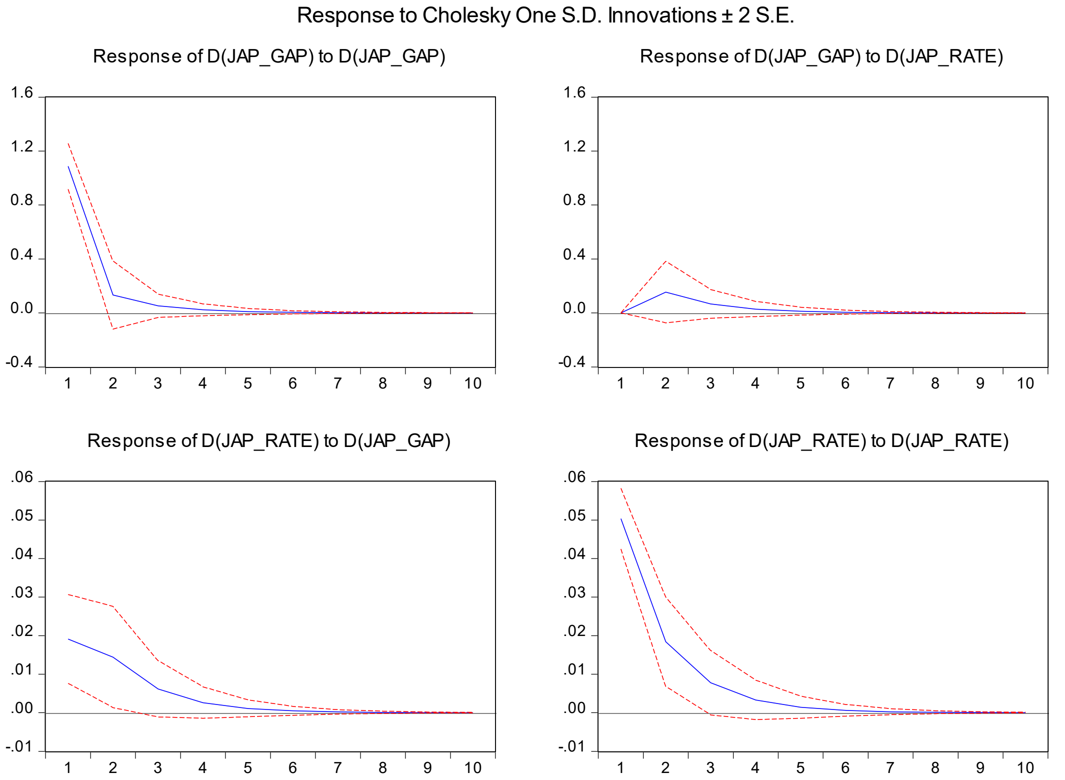

Figure 5. Impulse functions for Japan

Source: Calculated by the authors.

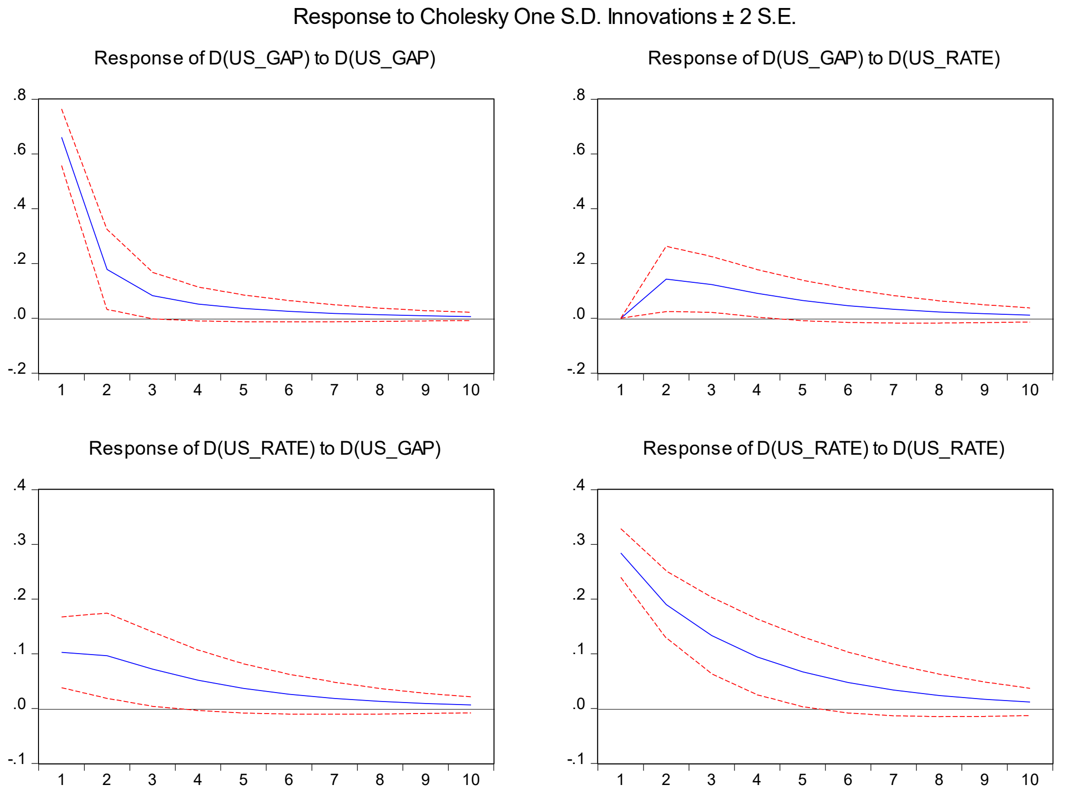

Figure 6. Impulse functions for the USA

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the 4th quarter. Therefore, avoiding such shocks is an important task of the ECB. Simultaneously, the impact of changes in interest rates reaches a maximum in a year, gradually decreasing over 2.5 years.

For Japan, the situation is significantly different (Figure 5). The impact of the GDP gap shock is observed only for 1 period, and the impact of interest rate changes – for 2 quarters. Thus, the intervention of the Central Bank of Japan has a very short-term effect.

The USA occupies an intermediate position between the considered states (Figure 6). The shocks have an obvious effect for 2 quarters, and the Fed rate's impact – for at least 3 quarters. Simultaneously, in contrast to Japan, the new rate determines the change itself for a long time (up to 6 quarters); meanwhile, this effect ends after two quarters in Japan.

The variance decomposition in these models turns out that EU_RATE variance due to EU_GAP is from 40% in the first period to 80% after 9 periods. In the US and Japan, this percentage is between 10 and 20%, indicating that the rate remains a fairly effective mean of combating GDP gaps in the EU.

4. DISCUSSION

Of course, several important aspects of this paper are not fully considered. In particular, the effect of other monetary policy channels is not enough disclosed, e.g., changes in the money supply and various operations to maintain liquidity in financial markets through the government bonds issued. The impact of monetary channels on other aspects of the economy, particularly inflation and unemployment, is not considered. Another unresolved issue is the study of the asymmetric effects of positive and negative GDP gaps. Monetary policy may differ during periods of economic boom and bust (e.g., Kangur, Kirabaeva, Natal, & Voigts, 2019). However, additional analysis is needed to determine the level of these differences.

Another discussable aspect is supposed to be in studying the changing role of interest rates in many countries. So far, almost all countries have faced either lower interest rates (Eastern European countries) or the lowest possible values (Switzerland, Denmark, etc.). It is shown in the research that this situation leads to limited opportunities for the state to stabilize the economy and increase fiscal influence, which only complicates the problems with debt payments. Also, since low rates have persisted for a long time, it leads to a change in the economy and investments structure. In particular, at low-interest rates, incentives to keep deposits in banks are lost (Lumsden, 1990), and, accordingly, there is an accumulation of money from people who do not work in the economy. However, after some time, in the event of a revival of economic activity, these funds will be directed to the real economy, which will result in a surge in inflation.

Another aspect of low rates in developed countries is also worth to be noted. Due to the policy of cheap money and the actual impossibility of investing within developed countries, there is a demand for risky transactions abroad. Thus, significant speculative capital is formed, which significantly increases the volatility of emerging markets and increases losses from the upcoming financial crisis.

The results are obtained for developed countries (USA, Japan, EU countries) and are slightly different from those obtained for developing countries. In particular, Brandao-Marques, Gelos, Harjes, Sahay, and Xue (2020) showed that there are significant transmission changes in monetary rates to output and prices. However, it should be mentioned that other studies claim that the stabilization of short-term interest rates is the main operational goal of central banks, i.e., changes in rates generally negatively affect the country's economic performance (Mahle, 2020). Thus, it is obvious that there is currently no clear economic opinion on the feasibility of actively changing interest rates, and therefore banks are using traditional tools to combat GDP gaps.

Thus, there is currently no clear economic opinion on the feasibility of actively changing interest rates, and therefore banks are using traditional tools to combat GDP gaps.

CONCLUSION

This paper examines the impact of monetary instruments, particularly the key rate of central banks on the size of the GDP gap. The GDP gap is considered the deviation from the level of potential GDP, which is determined by the long-term GDP trend. For correct assessments of the long-term trend, the GDP value is normalized to the corresponding deflator level and translated all values into constant US dollars for comparability, which allowed calculating comparable GDP indices. The GDP gaps for the European Union, Japan, and the United States were calculated based on this. It showed that the size and direction of GDP gaps are quite similar for the countries considered. The only difference is the response to the global financial crisis of 2008–2009. This difference is due to the different sensitivity of economies on the impact of monetary instruments. In particular, the Japanese economy has a relatively low level of sensitivity to changes in monetary instruments.

The VAR models investigate how the interest rate channel is related to the shock GDP gaps in the analyzed countries. It has been shown that this channel has the greatest and most significant influence in the European Union. Despite the current negative rates, the economy's response to changes in rates remains active, accounting for 80% of the GDP gap changes. This explains the so-called quantitative easing in these countries, as the main channel is no longer operational.

This study attempts to be valuable in terms of studying the reactions of central banks to the current economic crisis caused by COVID-19. Due to the global lockdown and the incredible decline in economic activity, almost all countries face a negative GDP gap. It was found out from the considered models, a simple reduction in rates may not help all countries. In particular, if in the EU such a policy seems promising, in Japan its effect will be very low, and in the USA– short-lived one. Thus, given the huge GDP gap, other channels should be expected to be used, which will create the preconditions for the strengthening of the euro.

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APPENDIX A

Table A1. Variables for the models

Source: Authors.

Country	Data	Transformation	Link
USA	Effective Federal Funds Rate, Percent, Monthly, Not Seasonally Adjusted	Average between a month to get quarterly data	https://fred.stlouisfed.org
USA	Real Gross Domestic Product, Chained Dollars [Billions of chained (2012) dollars] Seasonally adjusted at annual rates	Normalization to level (1996Q4 = 100)	https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey
EU	Gross domestic product at market prices – Euro area 19 (fixed composition) – Domestic (home or reference area), Total economy, Index, Chain linked volume (rebased), Non-transformed data, Calendar and seasonally adjusted data	Normalization to level (1996Q4 = 100)	http://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=320.MNA.Q.Y.I8.W2.S1.S1.B.B1GQ._Z._Z._Z.IX.LR.N
EU	ECB's deposit facility rate/End of the month	The average level for the quarter	https://www.bundesbank.de/statistic-rmi/StatisticDownload?tsId=BBK01.SU0200&its_csvFormat=en&its_fileFormat=csv&mode=its
Japan	The Basic Discount Rate and Basic Loan Rate	The average level for the quarter	https://www.stat-search.boj.or.jp/ssi/mtshtml/ir01_d_1_en.html
Japan	Gross Domestic Product by Expenditure in Constant Prices, Index 2015 = 100, Seasonally Adjusted	Normalization to level (1996Q4 = 100)	https://fred.stlouisfed.org/series/NAEXKP01JPQ661S

Table A2. Data set for the models

Period	EU_GDP_Index	EU_Rate	Jap_GDP_Index	Jap_Rate	US_GDP_Index	US_Rate
1999Q1	100.97	2.00	98.73	0.50	100.95	4.73
1999Q2	101.55	1.50	99.07	0.50	101.72	4.75
1999Q3	102.72	1.50	99.63	0.50	103.06	5.09
1999Q4	103.93	1.83	99.69	0.50	104.81	5.31
2000Q1	105.19	2.25	101.49	0.50	105.19	5.68
2000Q2	106.11	2.92	101.77	0.50	107.11	6.27
2000Q3	106.74	3.33	101.85	0.50	107.25	6.52
2000Q4	107.44	3.75	102.84	0.50	107.92	6.47
2001Q1	108.50	3.75	103.40	0.39	107.62	5.59
2001Q2	108.60	3.58	102.89	0.25	108.24	4.33
2001Q3	108.76	3.17	101.85	0.23	107.80	3.50
2001Q4	108.91	2.42	101.53	0.10	108.09	2.13
2002Q1	108.95	2.25	101.71	0.10	109.03	1.73
2002Q2	109.57	2.25	102.46	0.10	109.69	1.75
2002Q3	110.02	2.25	102.79	0.10	110.18	1.74
2002Q4	110.21	2.08	103.05	0.10	110.35	1.44
2003Q1	109.80	1.67	103.14	0.10	110.97	1.25
2003Q2	109.92	1.33	103.79	0.10	111.92	1.25
2003Q3	110.54	1.00	104.19	0.10	113.82	1.02
2003Q4	111.36	1.00	105.34	0.10	115.13	1.00
2004Q1	111.93	1.00	106.09	0.10	115.74	1.00
2004Q2	112.59	1.00	106.10	0.10	116.62	1.01
2004Q3	112.87	1.00	106.76	0.10	117.73	1.43
2004Q4	113.30	1.00	106.54	0.10	118.91	1.95
2005Q1	113.55	1.00	107.06	0.10	120.22	2.47
2005Q2	114.23	1.00	107.77	0.10	120.78	2.94
2005Q3	115.07	1.00	108.81	0.10	121.85	3.46
2005Q4	115.78	1.08	109.00	0.10	122.62	3.98
2006Q1	116.83	1.33	109.21	0.10	124.25	4.46
2006Q2	118.09	1.58	109.47	0.10	124.54	4.91
2006Q3	118.78	1.92	109.28	0.36	124.74	5.25

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Table A2 (cont.). Data set for the models

Period	EU_GDP_Index	EU_Rate	Jap_GDP_Index	Jap_Rate	US_GDP_Index	US_Rate
2006Q4	120.19	2.33	110.70	0.40	125.80	5.25
2007Q1	120.94	2.58	111.52	0.55	126.10	5.26
2007Q2	121.78	2.83	111.65	0.75	126.82	5.25
2007Q3	122.31	3.00	111.09	0.75	127.51	5.07
2007Q4	122.99	3.00	111.61	0.75	128.28	4.50
2008Q1	123.55	3.00	111.90	0.75	127.54	3.18
2008Q2	123.13	3.00	111.48	0.75	128.20	2.09
2008Q3	122.47	3.25	110.09	0.75	127.51	1.94
2008Q4	120.36	2.67	107.41	0.55	124.75	0.51
2009Q1	116.57	0.83	102.28	0.30	123.35	0.18
2009Q2	116.53	0.25	104.42	0.30	123.17	0.18
2009Q3	116.96	0.25	104.48	0.30	123.62	0.16
2009Q4	117.57	0.25	105.90	0.30	124.98	0.12
2010Q1	117.99	0.25	106.82	0.30	125.46	0.13
2010Q2	119.16	0.25	108.27	0.30	126.62	0.19
2010Q3	119.68	0.25	110.22	0.30	127.55	0.19
2010Q4	120.43	0.25	109.31	0.30	128.19	0.19
2011Q1	121.44	0.25	107.79	0.30	127.88	0.16
2011Q2	121.45	0.50	107.09	0.30	128.80	0.09
2011Q3	121.56	0.75	109.75	0.30	128.76	0.08
2011Q4	121.13	0.50	109.57	0.30	130.25	0.07
2012Q1	120.86	0.25	110.90	0.30	131.27	0.10
2012Q2	120.47	0.25	110.10	0.30	131.84	0.15
2012Q3	120.36	0.00	109.67	0.30	132.02	0.14
2012Q4	119.86	0.00	109.96	0.30	132.16	0.16
2013Q1	119.37	0.00	111.31	0.30	133.34	0.14
2013Q2	120.02	0.00	112.17	0.30	133.50	0.12
2013Q3	120.41	0.00	113.10	0.30	134.55	0.08
2013Q4	120.69	0.00	113.06	0.30	135.62	0.09
2014Q1	121.24	0.00	114.19	0.30	135.24	0.07
2014Q2	121.47	–0.03	112.00	0.30	137.07	0.09
2014Q3	122.05	–0.13	112.10	0.30	138.74	0.09
2014Q4	122.58	–0.20	112.65	0.30	139.52	0.10
2015Q1	123.47	–0.20	114.20	0.30	140.62	0.11
2015Q2	123.98	–0.20	114.33	0.30	141.66	0.12
2015Q3	124.54	–0.20	114.26	0.30	142.13	0.14
2015Q4	125.09	–0.23	113.82	0.30	142.17	0.16
2016Q1	125.85	–0.33	114.39	0.30	142.89	0.36
2016Q2	126.20	–0.40	114.56	0.30	143.56	0.37
2016Q3	126.76	–0.40	114.81	0.30	144.34	0.40
2016Q4	127.72	–0.40	115.13	0.30	145.07	0.45
2017Q1	128.58	–0.40	116.45	0.30	145.89	0.70
2017Q2	129.49	–0.40	116.89	0.30	146.67	0.95
2017Q3	130.47	–0.40	117.55	0.30	147.83	1.15
2017Q4	131.51	–0.40	118.07	0.30	149.12	1.20
2018Q1	131.86	–0.40	117.52	0.30	150.06	1.45
2018Q2	132.34	–0.40	118.10	0.30	151.36	1.74
2018Q3	132.60	–0.40	117.10	0.30	152.46	1.92
2018Q4	133.11	–0.40	117.80	0.30	152.87	2.22
2019Q1	133.73	–0.40	118.45	0.30	154.04	2.40
2019Q2	133.93	–0.40	119.11	0.30	154.81	2.40
2019Q3	134.34	–0.43	119.15	0.30	155.62	2.19
2019Q4	134.48	–0.50	116.99	0.30	156.44	1.64

Table A3. The stationarity test

Source: Authors' calculations.

Variable	Level		First differences	
	t-statistic	Prob.*	t-statistic	Prob.*
EU_gap	–2.781188	0.0654	–4.370005	0.0007
EU_rate	–1.409995	0.5735	–5.447000	0.0000
Jap_gap	–2.527211	0.1128	–7.548362	0.0000
Jap_rate	–2.638481	0.0895	–5.737876	0.0000
US_gap	–1.498962	0.5293	–6.279947	0.0000
US_rate	–2.553206	0.1070	–3.643646	0.0068

Note: *MacKinnon (1996) one-sided *p*-values.

Table A4.1. VAR model assessed for the EU

Variable	EU_GAP	EU_RATE
EU_GAP(–1)	1.751175	0.191572
	(0.12539)	(0.05304)
	[13.9657]	[3.61191]
EU_GAP(–2)	–0.795508	–0.197678
	(0.12147)	(0.05138)
	[–6.54892]	[–3.84730]
EU_RATE(–1)	–0.587124	1.239420
	(0.28783)	(0.12175)
	[–2.03980]	[10.1800]
EU_RATE(–2)	0.549395	–0.259447
	(0.28966)	(0.12252)
	[1.89670]	[–2.11756]
C	0.033648	–0.013457
	(0.08150)	(0.03447)
	[0.41288]	[–0.39037]
R-squared	0.959688	0.970796

Table A4.2. VAR model assessed for Japan

Variable	D(JAP_GAP)	D(JAP_RATE)
D(JAP_GAP(–1))	0.067510	0.006854
	(0.12480)	(0.00618)
	[0.54096]	[1.10840]
D(JAP_RATE(–1))	3.067120	0.365727
	(2.25011)	(0.11149)
	[1.36310]	[3.28049]
C	0.015616	–0.001831
	(0.12040)	(0.00597)
	[0.12970]	[–0.30688]
R-squared	0.040478	0.186451

Table A4.3. VAR model assessed for the USA

Variable	D(JAP_GAP)	D(JAP_RATE)
D(US_GAP(–1))	0.191283	0.041937
	(0.11857)	(0.05418)
	[1.61326]	[0.77410]
D(US_RATE(–1))	0.504182	0.669288
	(0.20552)	(0.09390)
	[2.45324]	[7.12748]
C	0.073653	–0.020067
	(0.07415)	(0.03388)
	[0.99328]	[–0.59229]
R-squared	0.177841	0.493616

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