Does Inflation Affect the Relationship between Broad Money and Economic Growth? A Threshold Model[1]

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Abstract

This study empirically examines the relationship between broad money (M3) and economic growth according to different level of inflation. The impact is examined on the sample of 17 countries via threshold model for panel data. To ensure the robustness of the results, we apply several alternatives, including single and double threshold model. We conclude that an increase in money supply can be beneficial from the point of view of economic growth only for countries susceptible to maintain their inflation within an optimum interval, which is quantified by our model at around 2% level of inflation in the long run. The model estimation further revealed that countries with inflation over 3.3% should avoid an increase in money supply as they risk negative effects on their output.

Keywords: *broad money, economic growth, inflation, threshold model*

JEL Classification: C24, E32, F44, F45

Introduction

Money supply has been recently in the centre of attention of researchers, monetary authorities and policy makers mainly due to unconventional monetary policy implementation under the form of quantitative easing. The aim of quantitative easing is to increase abruptly money supply by flooding financial institutions with capital, and consequently promote an economic growth in a country. No wonder that this non-standard monetary policy instrument is a matter of argument. Its uncertain results might stem from the concept of money neutrality. Traditional conflict of two opposite opinions regarding economic growth: "*money*

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does not matter" (i.e. irrelevance of money supply impact on economic growth usually represented by monetarists) versus "*money does matter*" (as usually advocated by Keynesians) has again arisen much interest. Economic growth is not possible without sufficient money supply, credit and adequate financial conditions (Walsh, 2010). On the other hand, the new Keynesians claim that in the short-run, price-rigidity (price-stickiness) is crucial. Money supply can affect gross domestic product and other real variables because of price-rigidity and imperfect information in the market (Hussain and Haque, 2017).

The empirical results are ambiguous probably due to various country characteristics, different strength of transmission channels, the choice of monetary policy indicators and applied methodology. Therefore, we decided to identify a key factor between broad money and economic growth, which could alter significantly the relevance of this relationship. These factors can be numerous, such as financial structure of economy, size of financial sector, degree of financial integration, exchange rate regime, etc., and they are responsible for creating conditions for proper transmission. However, we believe that inflation is a crucial intermediary in line with several studies (Manera, 2015). Low and stabilized inflation influences an economic growth in the long run; it creates investment incentives, enhances country competitiveness and encourages efficiency of monetary instruments such as broad money. Therefore, we would like to focus on the fact to which extent the inflation affects the impact of broad money on economic growth. Most studies on this subject employed Vector Autoregressive (VAR) methodology, which can lead to the limitations in empirical results as its results depend on the applied restrictions. To avoid these constrains, we decided to apply a threshold model for panel data.

The paper is structured as it follows. Section 1 briefly outlines theoretical background of this topic and recent relevant research. Section 2 introduces applied data and their descriptive statistics. Section 3 explains employed methods. Section 4 reports empirical results and discussion. Final remarks conclude the paper.

1. Theoretical Background and Relevant Literature

According to the classical theory on money neutrality, changes in the money supply determine exclusively nominal variables (e.g. price level) and no real variables (such as output, employment, etc.). This principle is known as classical dichotomy and can be found already in David Hume's theory (Patinkin, 1989). As relative prices react flexibly and towards equilibrium, changes are proportional and almost simultaneous, a real economy is not affected. Money supply modifications do not change fundamental economic conditions for economic growth. In neo-classical approaches of the money neutrality theory, changes in

the money supply might imply real variables but only in the short run, as price stickiness is obvious phenomenon in each economy.

However, money neutrality still holds in the long run. Some authors even underline importance of so called "*superneutrality of money*", stressing that not only level of money supply has no effect on real economy, but the rate of money supply growth neither (Asako, 1983). On the contrary, Keynesians, post-Keynesians and Austrian school of economics argue in favour of the non-neutrality of money in the most of the countries.

Several current studies confirm a positive link between money supply and economic growth, while others do not find significant relationship between these variables. Hussain and Haque (2017) applied Vector Error Correction Model (VECM) and confirmed that money supply had significant impact on economic growth in Bangladesh. Chaitip et al. (2015) employed Autoregressive Distribution Lag (ARDL) model and attained similar finding that money supply is related to economic growth. Ogunmuyiwa and Ekone (2010) investigated a case of Nigeria using error correction model and proved that money supply positively implies growth rate. The same or similar results were affirmed for Nigeria using ARDL model by Babatude and Shuaibu (2011), Chude and Chude (2016) and for Pakistan using Johansen cointegration model (Mohammad et al., 2009).

Zapodeanu and Cociuba (2010) confirmed statistically significant nexus between money supply and gross domestic product in Romania via Engle-Granger and ARIMA model. Maitra (2011) using cointegration model corroborated that money supply and economic growth were co-integrated in Singapore. Aslam (2016) supported a positive effect of money supply on economic growth through multivariate econometric models in Sri Lanka. Dingela and Khobai (2017) investigated dynamic impact of broad money supply on economic growth by Autoregressive Distribution Lag (ARDL) approach to cointegration in South Africa over the time 1980 – 2016. They used four macroeconomics variables in their model, i.e. gross domestic product per capita, broad money supply (M3), interest rate and inflation rate. They conclude that South African government should maintain consistency and follow the Taylor rule, in other words to allow money supply to increase at a steady rate keeping pace with an economic growth. Review of empirical studies, proving a positive impact of money supply on economic growth, is summarized in the Table 1.

The opposite results (i.e. insignificant or negative relationship) can be found in studies by Adusei (2013) for Ghana using Fully Modified Ordinary Least Squared, by Gatawa, Abdulgafar and Olarinde (2017), Ehigiamusoe (2013) for Nigeria via VECM, and by Ihsan and Anjum (2013) for Pakistan. Review of empirical studies, proving insignificant or negative impact of money supply on economic growth, is summarized in the Table 2.

T a b l e 1

Review of Empirical Studies: Positive Impact of Money Supply on Economic Growth

Author (year)	Analyzed period	Countries	Method
Hussain and Haque (2017)	1972 – 2014	Bangladesh	Vector Error Correction Model (VECM)
Chaitip et al. (2015)	1995 – 2013	AEC* open region	ARDL model
Ogunmuyiwa and Ekone (2010)	1980 – 2006	Nigeria	Error correction model, causality test
Chude and Chude (2016)	1987 – 2010	Nigeria	OLS model, VAR model, Granger causality test
Mohammad et al. (2009)	1977 – 2007	Pakistan	Johansen cointegration model, Granger causality test
Zapodeanu and Cociuba (2010)	1999 – 2010	Romania	ARIMA model, Cointegration analysis
Maitra (2011)	1971 – 2008	Singapore	Cointegration model
Aslam (2016)	1959 – 2013	Sri Lanka	Multivariate econometric method
Dingela and Khobai (2017)	1980 – 2016	South Africa	ARDL model

Notes: AEC* – Arctic Economic Council, i.e. Canada, Finland, Iceland, Denmark, Norway, Russia, Sweden, U.S.

Source: Own elaboration.

Nevertheless, a clear consensus that monetary policy matters for economic growth is defended by many authors, e.g. Woodford (2007) and White (2013). The New Consensus model is based on short-term interest rates as the unique monetary policy instrument for the short-run output evolution (Arestis, 2009).

T a b l e 2

Review of Empirical Studies: Insignificant or Negative Impact of Money Supply on Economic Growth

Author (year)	Analyzed period	Countries	Method
Adusei (2013)	1971 – 2010	Ghana	Fully Modified Ordinary Least Squared model, GMM model
Gatawa et al. (2017)	1973 – 2013	Nigeria	VAR model, Granger causality test
Ehigiamusoe (2013)	1980 – 2012	Nigeria	OLS method, VECM model
Ihsan and Anjum (2013)	2000 – 2011	Pakistan	Regression model

Source: Own elaboration.

2. Data

Our objective is to quantify to which extent the inflation affects the impact of broad money on economic growth. For this purpose, inflation measured by consumer prices index ($INFL_{CP}$, annual %) is used. Robustness of our results is checked by the estimation using the inflation based on GDP deflator (INFLDEF, annual %). An economic growth is measured as annual growth of GDP (GDP_G) and annual growth of GDP per capita ($GDPPC_G$), respectively. Broad money is expressed as annual growth (M_G), as well as an index (M_{INDEX}, SA, index, 2010 = 100).

Further, we use (i) gross fixed capital formation ($GFCF_G$, annual growth, %), (ii) gross domestic savings (SAV, % of GDP), (iii) trade openness (OPEN, exports + imports of goods and services, % of GDP), (iv) age dependency ratio (DEP, % of working-age population) and (v) population growth (POP_G, annual, %) as control variables. In Table 3, we give definition of all variables used in our model. Descriptive statistics for used variables are given in Table 4.

T a b l e 3

Variables Used in the Models and Its Definition

Variable	Description
$INFL_{CP}$	Inflation rate measured by CPI index, annual % change
$INFL_{DEF}$	Inflation rate measured by GDP deflator, annual % change
GDP_G	GDP growth, annual, %
$GDPPC_G$	GDP per capita growth, annual, %
M_G	Broad money (M3) growth, annual, %
M_{INDEX}	Broad money (M3) Index, index, 2010 = 100
$GFCF_G$	Gross fixed capital formation (annual % growth)
SAV	Gross domestic savings (% of GDP)
OPEN	Trade openness (exports + imports of goods and services, % of GDP)
DEP	Age dependency ratio (% of working-age population)
POP_G	Population growth, annual, %

Source: Data from IMF (2016), OECD (2017) and World Bank (2017) databases.

In our model, an independent variable, which depends on regime of inflation, is broad money (M3) growth expressed in %, annual change (M_G). For robustness check, we use the same variable but the variable is expressed as an index with base year 2010, i.e. broad money (M3) index, 2010 = 100 (see M_{index} in Table 3).

As far as control variables, we suppose that gross fixed capital formation has a positive effect on economic growth (GDP_G) as higher investment are automatically transmitted to higher GDP. Saving are expected to have a negative effect on economic growth – higher savings are accompanied by smaller consumption and investment, so that smaller GDP growth. Higher trade openness is supposed to have a positive effect on economic growth (see e.g. Ulaşan, 2015). Elderly population should slow economic growth so age dependency ratio should have negative effect on economic growth (Santacreu, 2016). Finally, population growth is expected to have positive effect.

Our worldwide data sample consists of 17 economies characterized by different monetary regimes. We included major economies (United States, the euro area aggregate, Japan), BRICS countries (Brazil, Russia, India, China, South Africa) and the European economies, which still implement independent monetary policy (the Czech Republic, Denmark, Hungary, Iceland, Norway, Poland, Switzerland, Sweden, United Kingdom). Data set spans the period 1995 – 2015.[2]

T a b l e 4

Descriptive Statistics, 17 Countries (1995 – 2015)

	Mean	Median	S.D.	Min	Max	Kurtosis	Skewness
$INFL_{CP}$	5.300	2.692	12.915	–1.408	197.471	150.642	10.980
$INFL_{DEF}$	5.461	2.900	11.148	–5.205	144.003	85.108	8.101
GDP_G	3.109	2.900	3.158	–7.821	14.231	1.385	0.098
$GDPPC_G$	2.474	2.128	3.109	–7.849	13.636	1.205	0.148
M_G	11.421	8.765	11.638	–17.239	112.579	18.184	2.778
M_{INDEX}	67.928	64.325	37.329	1.547	185.366	–0.353	0.343
$GFCF_G$	4.170	3.939	8.171	–47.761	31.965	5.290	–0.558
SAV	26.242	25.099	7.845	12.473	51.258	0.869	0.892
OPEN	66.700	65.431	32.977	15.636	170.369	0.530	0.751
DEP	50.075	50.101	6.276	34.493	68.623	0.456	0.146
POP_G	0.612	0.534	0.636	–1.044	2.530	–0.025	0.530

Notes: $INFL_{CP}$ – consumer price index, $INFL_{DEF}$ – GDP deflator, GDP_G – annual growth of gross domestic product, $GDPPC_G$ – annual growth of gross domestic product per capita, M_G – annual growth of broad money (M3 aggregate), M_{INDEX} – index of broad money, $GFCF_G$ – annual growth of gross fixed capital formation, SAV – gross domestic savings, OPEN – trade openness, DEP – age dependency ratio, POP_G – annual growth of population. Data sources: IMF – International Financial Statistics (for $INFL_{CP}$ and M_G), OECD – Monthly Monetary and Financial Statistics (for M_{INDEX}) and World Bank – WDI database (for other variables).

Source: Own calculations, data from IMF (2016), OECD (2017) and World Bank (2017) databases.

3. Methodology

In order to examine the relation between broad money (M3) growth and economic growth, which can differ with different values of inflation, we apply a methodology proposed by Hansen (1999), who elaborated a threshold model for panel data. A threshold model (see Hansen, 1999) solves the situation when the estimated regression functions between dependent and independent variable are not the same in the whole data sample and we expect that they differ depending on the values of other variable, i.e. the so-called threshold variable. Therefore, the estimated regression functions (i.e. relation between broad money and GDP growth in our case) are split into several samples (intervals), which are determined by the estimated values of the threshold variable (i.e. inflation in our case).

3.1. Threshold Model Definition

Hansen (1999) introduces a panel data threshold model taking into account individual country specific fixed effect. The basic threshold model is defined as:

$$y_{it} = \mu_i + \beta'_1 x_{it} I(q_{it} \le \gamma) + \beta'_2 x_{it} I(q_{it} > \gamma) + e_{it} \qquad (1)$$

The data set has a form of balanced panel $\{y_{it},\ q_{it},\ x_{it} : 1 \le i \le n, 1 \le t \le T\}$. The index i determines a country and the index t determines time. The dependent

[2] 1995 – 2014 respectively, due to the data unavailability for several countries.

variable y_{it} is a scalar, the threshold variable q_{it} is a scalar; and the regressor x_{it} is a *k*-item vector. I(.) is indicator of the function.

Hansen (1999) proposes that the model can be rewritten in the following form:

$$y_{it} = \begin{cases} \mu_i + \beta'_1 x_{it} + e_{it}, & q_{it} \le \gamma \\ \mu_i + \beta'_2 x_{it} + e_{it}, & q_{it} > \gamma \end{cases} \tag{2}$$

The estimated value of threshold variable γ (i.e. inflation) divides a panel data set into two regimes: the first one if the real values of threshold variable q_{it} are smaller than the estimated threshold γ and the second one if the real values of threshold variable q_{it} are higher than the estimated threshold γ. These two regimes are described by different estimated regression coefficients β_1 and β_2 (i.e. two different regressions between broad money and GDP growth in our case).

Hansen (1999) defines also a threshold model with two thresholds (the so-called double threshold model), which divides our data sample into three regimes and estimates three different coefficients β_1, β_2, β_3 of regime-dependent variable x_{it}. The model can be written as:

$$y_{it} = \mu_i + \beta'_1 x_{it} I(q_{it} \le \gamma_1) + \beta'_2 x_{it} I(\gamma_1 < q_{it} \le \gamma_2) + \beta'_3 x_{it} I(q_{it} > \gamma_2) + e_{it} \tag{3}$$

where the estimated thresholds $\gamma_1 < \gamma_2$ (Hansen, 1999).

3.2. Threshold Model Describing the Impact of Broad Money on GDP Growth

We estimate the following single and double threshold models, in three variants:

1. The impact of broad money growth (M_G) on GDP growth, which depends on different intervals of inflation measured by consumer prices index ($INFL_{CP}$):

a) Single threshold model:

$$\begin{aligned} GDP_{G\,it} &= \mu_i + \beta_1 M_{G\,i,t-1} I\left(INFL_{CP\,i,t-1} \le \gamma_1\right) + \beta_2 M_{G\,i,t-1} I\left(INFL_{CP\,i,t-1} > \gamma_1\right) + \\ &+ \theta_1 GFCF_{G\,i,t-1} + \theta_2 SAV_{i,t-1} + \theta_3 OPEN_{i,t-1} + \theta_4 DEP_{i,t-1} + \theta_5 POP_{G\,i,t-1} + e_{it} \end{aligned} \tag{4}$$

b) Double threshold model:

$$\begin{aligned} GDP_{G\,it} &= \mu_i + \beta_1 M_{G\,i,t-1} I\left(INFL_{CP\,i,t-1} \le \gamma_1\right) + \beta_2 M_{G\,i,t-1} I\left(\gamma_1 < INFL_{CP\,i,t-1} \le \gamma_2\right) + \\ &+ \beta_3 M_{G\,i,t-1} I\left(INFL_{CP\,i,t-1} > \gamma_2\right) + \theta_1 GFCF_{G\,i,t-1} + \theta_2 SAV_{i,t-1} + \theta_3 OPEN_{i,t-1} + \\ &+ \theta_4 DEP_{i,t-1} + \theta_5 POP_{G\,i,t-1} + e_{it} \end{aligned} \tag{5}$$

where

GDP_G – Gross domestic product (annual growth, %),
M_G – Broad money (M3) growth (annual %) – a regime-dependent variable,
$INFL_{CP}$ – Inflation measured by consumer prices index (annual, %) – a threshold variable,
$GFCF_G$ – Gross fixed capital formation (annual growth, %),
SAV – Gross domestic savings (% of GDP),
OPEN – Trade openness (exports + imports of goods and services, % of GDP),
DEP – Age dependency ratio (% of working-age population),
POP_G – Population growth (annual, %).

2. The impact of broad money growth (M_G) on GDP growth, which depends on different intervals of inflation measured by GDP deflator ($INFL_{DEF}$); i.e. a model where the threshold variable $INFL_{CP}$ is replaced by $INFL_{DEF}$.

3. The impact of broad money index (M_{INDEX}) on GDP growth, which depends on different intervals of inflation measured by consumer prices index ($INFL_{CP}$); i.e. a model where a regime-dependent variable M_G is replaced by M_{INDEX}.

In comparison with general writing of threshold model (see eq. (1) for single threshold model, eq. (3) for double threshold model), a threshold variable $q_{it} = INFL_{CP\,i,t-1}$ and a regime-dependent variable $x_{it} = M_{G\,i,t-1}$. The above defined double threshold model (see eq. (5)) estimates different regime-dependent coefficients (β_1, β_2, β_3 – coefficients of broad money growth M_G), which depend on values (i.e. regime) of threshold variable – inflation $INFL_{CP}$; and the regime-independent coefficients[3] (θ_1, θ_2, θ_3, θ_4, θ_5), which are independent from the regime of inflation $INFL_{CP}$ and are identical for each interval of inflation. With a view to avoid an endogeneity bias, each independent variable is lagged by one year (e.g. according to Baum, Checherita-Westphal and Rother, 2013).

4. Results and Discussion

The estimation results of single and double threshold models (defined by eq. (4) and eq. (5)) in three different variants are given by Tables 5 – 7.

According to the single threshold models, if inflation $INFL_{CP}$ is inferior to 2.1958%, there is a statistically significant positive relation between broad money growth M_G and economic growth ($\beta = 0.088$, $\beta = 0.084$, $\beta = 0.089$, or $\beta = 0.086$; see Table 5).

[3] Coefficients for other control variables (gross fixed capital formation, gross domestic savings, trade openness, age dependency ratio, population growth), which also explain the evolution of GDP growth.

Double threshold model confirms these results and identifies the intervals of inflation more precisely. If inflation $INFL_{CP}$ is inferior to 1.8088%, a double threshold model (Table 5) concludes a positive relationship between the broad money (M3) growth M_G and economic growth. However, if inflation is inferior to 1.8088%, it is weaker (β = 0.063, i.e. an increase of broad money (M_G) by 1% is accompanied by an increase of GDP growth by 0.063%) than in the interval 1.8088% – 2.1958% (β = 0.164, i.e. an increase of broad money (M_G) by 1% is accompanied by an increase of GDP growth by 0.164%). According to the model 3 in Table 5, optimal inflation is superior to approx. 1.8% and inferior to approx. 2.2%, as an increase in broad money growth stimulates here an economic growth.

T a b l e 5

Single and Double Threshold Model Estimation: The Impact of Broad Money Growth (M_G) on GDP Growth (GDP_G) in Different Intervals of Inflation Measured by Consumer Prices Index ($INFL_{CP}$)

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Dependent variable	GDP_G	GDP_G	GDP_G	$GDPPC_G$	$GDPPC_G$
Regime-dependent variables (single threshold)					
Estimated threshold T1	**T1 = 2.1958**	**T1 = 2.1958**		**T1 = 2.1958**	**T1 = 2.1958**
M_G (if $INFL_{CP} \leq$ T1)	0.088 ***	0.084 ***		0.089 ***	0.086 ***
M_G (if $INFL_{CP}$ > T1)	0.013	0.006		0.014	0.008
Regime-dependent variables (double threshold)					
Estimated thresholds T1, T2			**T1 = 1.8088** **T2 = 2.1958**		
M_G (if $INFL_{CP} \leq$ T1)			0.063 **		
M_G (if T1 < $INFL_{CP} \leq$ T2)			0.164 ***		
M_G (if $INFL_{CP}$ > T2)			0.006		
Regime-independent variables					
$GFCF_G$	0.089 ***	0.082 ***	0.082 ***	0.079 ***	0.073 ***
SAV	–0.106			–0.092	
OPEN	–0.035 ***	–0.039 ***	–0.039 ***	–0.036 ***	–0.041 ***
DEP	–0.125 **	–0.071	–0.065	–0.121 **	–0.074 *
POP_G	–1.321 **	–1.293 **	–1.299 **	–2.132 ***	–2.108 ***

Notes: ***, **, * denote statistical significance at 1%, 5%, 10%; time period 1995 – 2014, 17 countries; dependent variable: GDP annual growth (%) – GDP_G (models 1 – 3) or GDP per capita annual growth (%) – $GDPPC_G$ (models 4 – 5); threshold variable: inflation – consumer prices index (annual growth, %) – $INFL_{CP}$; in order to calculate p-values of estimated coefficients, we used heteroscedasticity-consistent (HC) standard errors. According to Levin-Lin-Chu Unit-Root Test (Levin, Lin and Chu, 2002) and Maddala-Wu Unit-Root Test (Maddala and Wu, 1999), our panel is stationary.

Source: Own calculations, output from R.

Our results are in accordance with price stability objective of several central banks included in our data sample (ECB, FED, Bank of England, Bank of Japan, etc.; see appendix for overview of inflation targets), which represents maintaining inflation level close to 2% over the medium term.

T a b l e 6

Single and Double Threshold Model Estimation: The Impact of Broad Money Growth (M_G) on GDP Growth (GDP_G) in Different Intervals of Inflation Measured by GDP Deflator ($INFL_{DEF}$)

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Dependent variable	GDP_G	GDP_G	GDP_G	GDP_G	$GDPPC_G$
Regime-dependent variables (single threshold)					
Estimated threshold T1	**T1 = 1.9616**		**T1 = 1.8421**		
M_G (if $INFL_{DEF} \leq$ T1)	0.068 **		0.068 **		
M_G (if $INFL_{DEF} >$ T1)	0.017		0.010		
Regime-dependent variables (double threshold)					
Estimated thresholds T1, T2		**T1 = 2.0237** **T2 = 3.7157**		**T1 = 2.0237** **T2 = 3.7157**	**T1 = 2.0237** **T2 = 3.7157**
M_G (if $INFL_{DEF} \leq$ T1)		0.053 *		0.051 *	0.052 *
M_G (if T1 < $INFL_{DEF} \leq$ T2)		–0.062 *		–0.063 **	–0.065 **
M_G (if $INFL_{DEF} >$ T2)		0.030		0.019	0.033
Regime-independent variables					
$GFCF_G$	0.094 ***	0.102 ***	0.087 ***	0.093 ***	0.092 ***
SAV	–0.110	–0.138 **			–0.127 **
OPEN	–0.034 ***	–0.029 **	–0.039 ***	–0.036 ***	–0.031 **
DEP	–0.133 ***	–0.156 ***	–0.077 *	–0.085 **	–0.154 ***
POP_G	–1.361 ***	–1.217 **	–1.354 **	–1.195 **	–2.021 ***

Notes: ***, **, * denote statistical significance at 1%, 5%, 10%; time period 1995 – 2014, 17 countries; dependent variable: GDP annual growth (%) – GDP_G (models 1 – 4) or GDP per capita annual growth (%) – $GDPPC_G$ (model 5); threshold variable: inflation – GDP deflator (annual growth, %) – $INFL_{DEF}$; in order to calculate p-values of estimated coefficients, we used heteroscedasticity-consistent (HC) standard errors.

Source: Own calculations, output from R.

According to the single threshold model (see Table 6), the inflation inferior to 1.9616% (model 1) or 1.8421% (model 3) encourages an economic growth, as the model concludes here a positive relationship between the broad money growth and GDP growth, analogous to results given in Table 5.

If inflation $INFL_{DEF}$ is inferior to 2.0237%, a double threshold model concludes that broad money growth M_G is in positive relationship with economic growth. On the contrary, if inflation $INFL_{DEF}$ is in the interval 2.0237% – 3.7157%, the broad money growth M_G is even in a negative relationship with the economic growth (see Table 6). Several countries from our data sample have targets concerning inflation from this interval (e.g. Iceland – 2.50%, Norway – 2.50%, Poland – 2.50% +/–1.0% or Hungary – 3.00% +/–1.0%; see Appendix). Higher inflation rate may cause decreased ability of economic agents to make correct long-term financial and economic decisions. However, extremely low level of inflation does not represent optimal condition for economic growth as well; this situation can be associated with increased probability of falling into deflation resulting in negative influence on economic growth, as a stimulation of aggregate demand by use of interest rate is more difficult in a deflationary environment.

T a b l e 7

Single and Double Threshold Model Estimation: The Impact of Broad Money Index (M_{INDEX}) on GDP Growth (GDP_G) in Different Intervals of Inflation Measured by Consumer Prices Index ($INFL_{CP}$)

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Dependent variable	GDP_G	GDP_G	GDP_G	GDP_G	GDP_G
Regime-dependent variables (single threshold)					
Estimated threshold T1	**T1 = 3.2894**		**T1 = 3.2894**		
M_{INDEX} (if $INFL_{CP} \leq T1$)	–0.009		–0.008		
M_{INDEX} (if $INFL_{CP} > T1$)	–0.039 ***		–0.038 ***		
Regime-dependent variables (double threshold)					
Estimated thresholds T1, T2		**T1 = 3.2894** **T2 = 14.112**		**T1 = 3.2894** **T2 = 14.112**	**T1 = 3.3145** **T2 = 14.112**
M_{INDEX} (if $INFL_{CP} \leq T1$)		–0.008		–0.008	–0.009
M_{INDEX} (if $T1 < INFL_{CP} \leq T2$)		–0.038 ***		–0.038 ***	–0.042 ***
M_{INDEX} (if $INFL_{CP} > T2$)		–0.133 **		–0.132 **	–0.144 ***
Regime-independent variables					
$GFCF_G$	0.041 *	0.043 **	0.035	0.044 **	0.065 ***
SAV	–0.042	0.006			
OPEN	–0.004	–0.015	–0.007	–0.014	–0.025 *
DEP	–0.230 ***	–0.200 ***	–0.206 ***	–0.204 ***	–0.265 ***
POP_G	–2.065 ***	–1.975 ***	–2.113 ***	–1.968 ***	–1.424 ***

Notes: ***, **, * denote statistical significance at 1%, 5%, 10%; dependent variable: GDP annual growth (%) – GDP_G; threshold variable: inflation – consumer prices index (annual growth, %) – $INFL_{CP}$; models 1 – 4: time period is 1996 – 2015, 16 countries (Island was excluded due to missing data); model 5: time period is 1996 – 2014, 17 countries; in order to calculate p-values of estimated coefficients, we used heteroscedasticity--consistent (HC) standard errors.

Source: Own calculations, output from R.

According to the single threshold model in Table 7, broad money index M_{INDEX} is in a statistically significant negative relationship with GDP growth if inflation is higher than 3.2894%. Double threshold model confirms this negative relationship and identifies the regimes of inflation more precisely. If inflation is in the interval 3.2894% – 14.112%, there is a negative relation between broad money index and economic growth (here, $\beta = –0.038$; or $\beta = –0.042$). The negative relationship between the broad money index and economic growth is also confirmed if inflation is higher than 14.112%, however this relationship becomes relatively stronger ($\beta = –0.132$; $\beta = –0.132$; or $\beta = –0.144$).

Once we estimated threshold models in three variants (see Tables 5 – 7), we chose one representative model from each variant. Thereafter, we identified the percentage of countries corresponding to the particular regimes of inflation, which are determined by the estimated threshold values of inflation. Results are presented in Tables 8 – 10. These tables permit to identify a division of countries in three intervals according to the estimated threshold values of inflation. In other words, if for instance, country has inflation smaller than 1.8088%, it is classified

in the first interval for the corresponding year. If its inflation is between 1.8088% and 2.1958%, it is classified in the second interval (see e.g., Table 8). Thereafter, the model estimates a regression in each interval using only data of countries, which correspond to this interval. Tables 8 – 10 allow to see a percentage of countries classified in each of these intervals for each corresponding year. This permits us to see how the countries have been moving between the estimated intervals. Furthermore, when we look at our data, we can even identify concrete countries according to their values of inflation.

T a b l e 8

Percentage of Countries Corresponding to the Particular Regime of Inflation, Model 3 from Table 5 (in %)

	Percentage of countries in 3 intervals Estimated thresholds: 1.8088; 2.1958		
Inflation (consumer price index):	≤ 1.8088%	1.8088% – 2.1958%	> 2.1958%
Relation between M_G and GDP_G:	positive	positive	not significant
Year			
1996	18	6 (DK)	76
1997	24	6 (DK)	71
1998	29	12 (DK, EA)	59
1999	41	6 (DK)	53
2000	35	12 (US, CZ)	53
2001	29	0	71
2002	24	0	76
2003	41	12 (PL, SE)	47
2004	35	24 (DK, EA, IS, SE)	41
2005	41	0	59
2006	29	24 (CHN, CZ, PL, UK)	47
2007	29	6 (DK)	65
2008	24	0	76
2009	6	0	94
2010	47	12 (NO,UK)	41
2011	35	0	65
2012	18	6 (CZ)	76
2013	24	6 (US)	71
2014	53	6 (NO)	41

Notes: In our model, data are lagged by one period, i.e. year 1996 corresponds to values of inflation in 1995; DK – Denmark, EA – the euro area, US – United States, CZ – the Czech Republic, PL – Poland, SE – Sweden, UK – United Kingdom, CHN – China, NO – Norway

Source: Own calculations, output from R.

If inflation $INFL_{CP}$ is in the interval 1.8088 % – 2.1958 %, a panel data threshold model estimated positive and statistically significant relationship between broad money (M3) growth and economic growth (see Table 5, model 3). Here, an increase of broad money promotes a higher economic growth.[4]

[4] Positive and statistically significant relationship between the broad money and the economic growth is approved also in regime of inflation smaller than 1.8088% (β = 0.063), but it is relatively weaker if inflation is in the interval 1.8088% – 2.1958% (β = 0.164); see Table 2.

When we look at our data sample, this was a case of Denmark, Sweden, Norway, the euro area, United States or United Kingdom in several years of examined period (Table 8). Statistically significant positive relationship in 1996 – 1999 for Denmark raises from stable level of inflation close to 2%, which contributed to average 3% economic growth in this period. The euro area, United States, United Kingdom and Sweden target inflation at 2% level,[5] Norway's inflation target represents 2.50% – results suggest that this inflation target setting may support economic growth. Denmark does not have precise level of inflation target, however, objective of the monetary policy is to keep the krone stable vis-à-vis the euro.

T a b l e 9

Percentage of Countries Corresponding to the Particular Regime of Inflation, Model 2 from Table 6 (in %)

	Percentage of countries in 3 intervals Estimated thresholds: 2.0237; 3.7157		
Inflation (GDP deflator):	≤ 2.0237%	2.0237% – 3.7157%	> 3.7157%
Relation between M_G and GDP_G:	positive	negative	not significant
Year			
1996	18	24	59
1997	29	12	59
1998	41	12	47
1999	47	6	47
2000	41	24	35
2001	29	29	41
2002	24	41	35
2003	41	29	29
2004	47	24	29
2005	18	29	53
2006	24	41	35
2007	29	29	41
2008	6	59	35
2009	24	18	59
2010	53	12	35
2011	47	12	41
2012	41	24	35
2013	41	35	24
2014	59	18	24

Notes: In our model, data are lagged by one period, i.e. year 1996 corresponds to the values of inflation in 1995.

Source: Own calculations, output from R.

When we look at the relationship between the broad money growth and economic growth in three regimes of inflation $INFL_{DEF}$, which are determined by threshold model (see Table 6, model 2), countries are rather equally divided into three estimated intervals of inflation (see Table 9).

[5] The euro area's inflation target is close to 2%.

The positive relationship between the broad money (M3) growth and economic growth is proved if inflation $INFL_{DEF}$ is ≤ 2.0237%, however this coefficient turns to negative if inflation is in the interval 2.0237% – 3.7157% (see Table 6). Inflation rate in this interval is observed mostly in time series of United States and the euro area before 2008, which signalled overheating of these economies and it was followed by rapid decrease of economic growth. Poland was the only EU country with positive economic growth in 2009 (the highest economic growth in 2009 from our data sample can be observed in case of China – 9.40%).

T a b l e 10
Percentage of Countries Corresponding to the Particular Regime of Inflation, Model 4 from Table 7 (in %)

	Percentage of countries in 3 intervals Estimated thresholds: 3.2894; 14.112		
Inflation (consumer price index):	≤ 3.2894%	3.2894% – 14.112%	> 14.112%
Relation between M_{INDEX} and GDP_G:	not significant	negative	negative
Year			
1997	50	25	25 (BR, RU, HU, PL)
1998	56	25	19 (RU,HU,PL)
1999	62	25	12 (RU, HU)
2000	62	31	6 (RU)
2001	50	44	6 (RU)
2002	56	38	6 (RU)
2003	69	25	6 (RU)
2004	69	25	6 (BR)
2005	62	38	0
2006	62	38	0
2007	69	31	0
2008	62	38	0
2009	12	81	6 (RU)
2010	62	38	0
2011	62	38	0
2012	50	50	0
2013	56	44	0
2014	75	25	0
2015	75	25	0

Notes: In our model, data are lagged by one period, i.e. year 1997 corresponds to values of inflation in 1996. BR – Brazil, RU – Russia, HU – Hungary, PL – Poland.

Source: Own calculations, output from R.

When examining the relationship between the broad money index and economic growth in different regimes of inflation (see Table 7), majority of countries in our sample are classified in the interval of inflation inferior to 3.2894% (see Table 10). However, in 2008, 81% countries of our sample increased their inflation and moved to the second interval of inflation (3.2894% – 14.112%), for which a threshold model shows a negative relationship between the broad money

index and economic growth. The highest value of inflation in 2008 is reached in Russia (14.11%), followed by Iceland (12.68%) and South Africa (11.54%). High level of inflation can be mainly observed at the beginning of selected period, when transformation process of transitive economies was present. Further, Table 7 releases that the percentage of countries classified in this interval of inflation varies from 25% to 50%, which can be explained especially by the financial and economic crisis occurrence and its impact.

A negative relationship between broad money index and economic growth is estimated also if inflation is higher than 14.112%. This negative relationship (β = –0.132, see Table 7) is even stronger if inflation is in the interval 3.2894% – 14.112% (β = –0.038, see Table 7). In our data sample, inflation higher than 14.112% was observed mainly in Russia (Table 10). In 1999, inflation measured by consumer prices index in Russia reached 85.74%. This situation can be explained by currency crisis in 1998 – a decline in economic growth was accompanied with extremely high inflation rate. Similarly, higher level of inflation at the beginning of period is observed in Poland and Hungary (see Table 10). Polish liberalization and stabilization program was put into effect in 1990 and Hungarian inflation rate was in early 90s affected by a loosening of monetary conditions, changes in indirect taxes (e.g. VAT) and others factors. The period 1990 – 1999 is for these former communist and transitive countries in general significantly marked by fundamental structural changes in economies (e.g. privatization, liberalization), which were reflected in baseline macroeconomic indicators such as inflation or economic growth. Finally, Table 10 shows that we observe an inflation convergence in recent years as majority of countries are situated in the first interval with inflation smaller than 3.2894%.

Conclusion

The paper examines effects of increasing money supply on economic growth in countries under different inflation conditions. We conclude that an increase in broad money supply is generally favourable for output but only if inflation is maintained with certain boundaries. Especially double threshold model enables to identify more precisely these optimum inflation levels. On the sample of 17 countries it seems that the most appropriate inflation limits are between 1.80% and 2.19%, which is in line with several countries' central bank inflation targets (the euro area, US, Japan, etc.). As far as political implications, a reasonable rate of money supply growth (possibly even under the unconventional form of quantitative easing) in times of crisis can be rather beneficial for inflation disciplined countries.

However, countries targeting and achieving inflation above 2.19% will probably find neither positive nor negative results of increase in broad money in circulation. Consequently, their monetary policies can be relatively useless. Finally, our political implication resulting from our model estimation is that monetary authorities of countries with inflation over 3.28% should completely avoid rise of money supply as they risk negative effects on their output, which can lead to even deeper output decline in case of dangerously high inflation over 14.11%.

Our empirical findings show that non-neutrality of money holds for our sample of countries. Nevertheless, it is questionable if time span from 1995 – 2015 is sufficiently long to make this conclusion valid in the long run. Most of examined countries underwent various transformations over this period (transition process in post-communist countries, monetary integration in European countries, currency crises in 1990's, financial and economic crisis later on, deflation trap, etc.). Even though turbulences are integral part of the world economy, future economic evolution might contest our findings valid in previous turbulent times.

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Appendix

Central Bank Inflation Targets

Country	Central Bank	Target
Brazil	Central Bank of Brazil	4.50% +/–1.50%
China	People's Bank of China	around 3.00%
Czech Republic	Czech National Bank	2.00% +/–1.0%
Denmark	Danmarks Nationalbank	(a fixed-exchange-rate policy, keeping krone stable vis-à-vis euro)
Euro Area	European Central Bank	below 2.00%
Hungary	Central Bank of Hungary	3.00% +/–1.0%
Iceland	Central Bank of Iceland	2.50%
India	Reserve Bank of India	4.00% +/–2.0%
Japan	Bank of Japan	2.00%
Norway	Norges Bank	2.50%
Poland	National Bank of Poland	2.50% +/–1.0%
Russia	Bank of Russia	4.00%
South Africa	South African Reserve Bank	3.00% – 6.0%
Sweden	The Riksbank	2.00%
Switzerland	Swiss National Bank	<2.00%
United Kingdom	Bank of England	2.00%
United States	Federal Reserve	2.00%

Source: CentralBankNews.info (2017).