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MONEY SUPPLY, INFLATION AND ECONOMIC GROWTH: CO-INTEGRATION AND CAUSALITY ANALYSIS

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Abstract. The aim of this paper is to examine the relationship between money supply, inflation rate, and economic growth in the context of Algeria, using various econometric procedures as co-integration without and with structural breaks in addition to three different ways of causality test for the period 1970-2018, the results confirm the long-run relationship between the variables with more than three structural breaks, but with the absence of the effects of money supply and inflation rate on economic growth both in short run and long run terms, on the other hand, the causality results confirmed the existence of hidden causalities among the variables running from the cumulative components not from the natural series, and all the results support the Monetarist view of inflation though the absence of any effect of money supply on economic growth.

JEL classification: C22, E31, E51, F43;

Keywords: Money supply; Inflation; Co-integration; Hidden causality.

1. Introduction

Money supply and inflation rates are one of the most important key determinants of the economic growth, according to Phibian (2010) these two factors can be create employment opportunities and high GDP per capita which leads to poverty reduction (Phibian, 2010) and this what really needs in the Algerian context in last five years, for this reason, several studies have tried to examine the relationship between economic growth, money supply and inflation rate as Kaldor (1959), Moosa (1982), Bessler (1984), Balakrishanan (1991), Moser (1995), Levine (1997), Odedokun (1997), Lucas (2001), Teriba (2005) and many others, according to these studies we can distinguish between two different opinions, the Keynesian opinion which think that money does not matter against the Monetarist opinion which suggest that money does matter, back to Davidson and Weintraub (1973), the Monetarists believes that money supply leads to inflation by raising the general price level in a small manner, this what can stimulate the economy growth but with

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conditions, whereas, if this rise goes behind the limits this will affect negatively the economic growth (Davidson and Weintraub, 1973), on the other extreme, Ball and Romer (1990) showed that the Keynesians suggest that according to the demand in the economy the income can change due the money stock especially for the small flexibility of the prices, so, in their opinion the economy can be controlled by the demand (Ball and Romer, 1990).

On the other hand, Barro (1977, 1978), Mishkin (1982) and Frydman and Rappoport (1987) made a distinction between the expected and unexpected changes in the money supply, in other words, is there a symmetric effect from money supply to economic growth with same relationship between positive and negative changes and shocks with economic growth or there is an asymmetric relationship between the two variables with hidden co-integration and hidden causality.

The relatively fragile Algerian economy especially in last five years according to the deteriorate in oil prices since 2014 is due a high levels of inflation rates and weak monetary policy especially the money supply, but even so, the impact of money supply on the economic growth predominately the GDP per capita has received a very poor attention in the literature of Algerian economy, after the collapse of oil prices in 2014, the Algerian economy entered into a major crisis, for example, the total of government revenues has tumbled from 60 billion dollars in 2014 to 27.5 billion in 2016, and the foreign exchange reserves fell from 193 billion dollars in 2013 to 105 billion in 2017 and then to 50 billion in 2019, this what caused the current account deficit by 27 billion dollars in 2015, 21 billion in 2017 and 15 billion in 2018, and this what promoted the Algerian Central Bank to issue 6555 billion dinars equivalent to 544 million dollars to stimulate the economy and bridge the budget deficit in 2017 and 2018, all of this changes was reflected in the social life with the increase of unemployment rate from 9% in 2013 to 12% in 2017 and the poverty rates from 9.2% in 2013 to 11% in 2018 because the austerity policy that the government has pursued since 2016 by decreasing the government spending and the suspension of many investment projects in addition to the high tax rates.

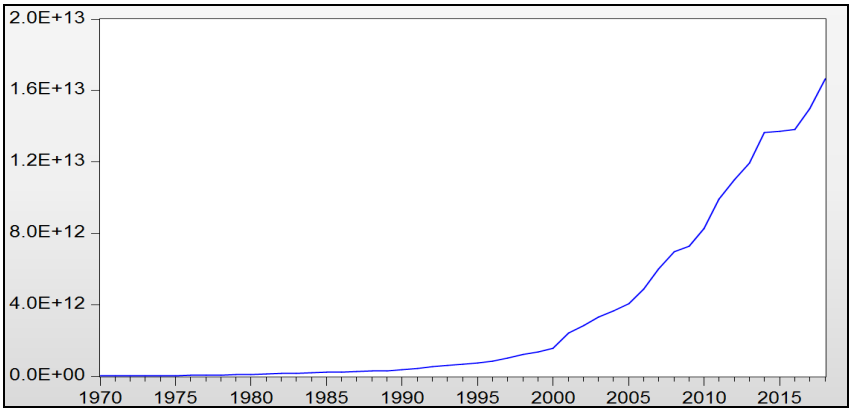

Fig. 1: Money supply in Algeria 1970-2018 in national currency

Source: Authors computation using World Bank databes 2019.

The paper makes a contribution to existing literature at first by filling the gap of scarcity and the absence of studies in the context of Algeria where there is no papers in this important relationship especially with modern econometric study, secondly, this paper tries to shed light on the asymmetric shocks (positive and negative shocks and variations) between the three variables unlike the previous studies where they carry out only on the symmetric shocks (the variation on the series), in addition, the paper aims to examine even the structural breaks and its effects in the long run relationship.

Testing the co-integration and causality relationships between money supply, inflation rate and economic growth in the context of Algeria for the period 1970-2018 is the subject of this paper, using various econometric procedures as co-integration with structural breaks based on Gregory Hansen, Hatemi-J and Maki tests, in addition to three different tests of causality (symmetric causality using Hacker Hatemi-J (2010) test, asymmetric causality using Hatemi-J test (2012) and non-linear causality using Dicks Panchenko (2006) test).

This paper is organized as follows, section one is for the introduction where the problematic was raised and the objectives were clarified, section two throws light at the relevant literature, section three describes the data set and explains the econometric tests, section four presents the empirical results and section five concludes the paper with policy recommendations.

2. Literature review

Over the last decades, the studies that care out of the relationship between the money supply, inflation rate and economic growth especially in developing countries under the Monetarists and Keynesians conflict have been very widespread, back to 1963, Friedman suggested that the money supply led to high inflation but just in the long run term nor the short run term this what stimulates the economic growth in the long run term, and this what was confirmed by MeCandless and Weber (1995) where they examined the correlations between the two variables, and the correlation coefficient was between 0.92 and 0.96, the same results was obtained by Tobin (1970), Barro (1978) and many others, on the other hand, Kormendi and Meguire (1984) found the opposite, where they though that there is no evidence of this relationship not just in short run term but also in the long run term, this what makes an important to Cover's study (1992) who distinguish between the positive and negative fluctuations of money supply and he found that only the positive changes can impact the output but by a very small manner, Hussain and Bilquees (1991) found a unidirectional causal relationship running from monetary base to GNP and a bidirectional causality running from money supply and GNP.

Table 1: Some studies for the relationship between money supply, Inflation and Growth

Study	Period and sample	Methodology	Results
Tabi and Ondoa (2011)	Cameroun 1960-2007	VAR model	Increase in money supply increases growth.
Indalmanie (2011)	Jamaica 1961-2006	Causality analysis	Bidirectional causal relationship between

Study	Period and sample	Methodology	Results
			money and growth.
Ahmed and Suliman (2011)	Sudan 1960-2005	Granger causality analysis	Unidirectional causal relationship running from growth to money and inflation.
Sulku (2011)	Turkey 1987:Q3-2006:Q3	Fisher and Seater (1993) ARIMA framework	The long-run money neutrality hypothesis holds in Turkey.
Al-Fawwaz and Al-Sawai'e (2012)	Jordan 1976-2009	Johansen co-integration analysis	No relationship between money and growth neither in short-run nor long run terms.
Muhammadpour et al. (2012)	Malaysia 1991-2011	Co-integration and VEC Model	Long-run influence from M1, M2 and M3 (money supply) to growth.
Wang (2012)	China 1998-2007	Co-integration and causality analysis	No relationship between the variables in the long-run term.
Paun and Topan (2013)	Romania 1st January 1997-31 December 2010	VAR Model	Unidirectional causality from money to inflation.
Sturgill (2014)	OECD countries 1979-1997	Panel data analysis	Causal relationship running from money to growth.
Nguyen (2015)	9 Asian countries 1985-2012	Pooled Men Group and GMM estimations	Positive impact from money to inflation.
Gatawa et al. (2017)	Nigeria 1973-2013	VAR model and Granger causality	No causal relationship from money and inflation to growth.
Hussain and Haque (2017)	Bangladesh 1972-2014	Co-integration and VEC Model	Monetarist view with important effect from money to growth in the long-run term.
Korkmaz (2017)	Mediterranean countries 2008-2014	Panel co-integration analysis	No causal relationship from money and inflation to growth.
Dingela and Kobai (2017)	South Africa 1980-2016	ARDL Model	Statistically positive relationship between money and growth in both short-run and long run.
Mansoor et al. (2018)	Pakistan 1980-2016	ARDL Model	Monetarist view.
Sang (2019)	Vietnam 2009-2018	VAR Model	Positive impact at a high significant level on growth by money supply.
Solina (2019)	Philippines 1986-2017	Johansen co-integration analysis	Significant relationship between money supply, inflation rate and

Study	Period and sample	Methodology	Results
			economic output (GDP)
Sean (2019)	Cambodia October 2009- April 2018	Bayesian VAR model	Money supply induces 0.13% to inflation.
Abdullah et al. (2020)	Kuwait 1979-2015	Multiple linear regression analysis	Changes in GDP is responsible for changes in CPI.
Obaid et al. (2020)	6 Asian countries 1993-2017	Panel data analysis	Money supply Granger cause inflation rate.

It's clear from the table above the absence of studies in the case of Algeria and Arabic countries, so in this paper, we shall try to fill this gap using various econometric methods and techniques, on the other extreme, one of the most important results from the literature review is the asymmetric relationship between the three variables (money supply, inflation rate and economic growth) for this reason we use in this paper the asymmetric causality analysis to distinguish between the positive and negative fluctuations and shocks to get more accurate results for the causality named the hidden causality, in addition to the using of the modern co-integration analysis in the presence of structural breaks to avoid any spurious results according the structural changes.

3. Data and Methodology

Back to Westerlund and Edgerton (2006) the existence of structural breaks in non-stationary series can provide biased results using the conventional co-integration tests as Engle-Granger test, Johansen test or Bound test under ARDL model (Shaeri, 2018, p.689), for this reason and to avoid the spurious regression we use different tests of co-integration with regime shifts as follows.

3.1. Gregory-Hansen (1996) test

The Gregory Hansen (1996) procedure can solve this issue (biased results) by accounting for structural breaks in the co-integration equation as follows (Gregory and Hansen, 1996):

1. The level shift model (C):

$$y_t = \mu_0 + \mu_1 \varphi_{t,\tau} + \mu_2 x_t + \varepsilon_t \quad (01)$$

Where $\varphi_{t,\tau}$ is a dummy variable such that $\varphi_{t,\tau}$ = 1 if t >nτ or 0 if r$\leqslant$nτ, and $\tau\in(0,1)$ denotes the relative timing of the break point, the effect of the regime shift in this case in on the intercept μ_0 (before the break) and μ_1 is the change in intercept (at the break time).

2. The level shift with trend model (C/T):
   In this model the break still on the intercept but with the existence of a trend (t) in the series

$$y_t = \mu_0 + \mu_1 \varphi_{t,\tau} + \mu_2 t + \mu_3 x_t + \varepsilon_t \quad (02)$$

3. Regime shift with changes in the intercept and the slope (C/S):
   For this model the structural break is on both intercept and slope coefficient where μ2 is the co-integration slope coefficient before the break where μ3 is the coefficient of co-integration slope at the time of the break.

$$y_t = \mu_0 + \mu_1 \varphi_{t,\tau} + \mu_2 x_t + \mu_3 x_t \varphi_{t,\tau} + \varepsilon_t \quad (03)$$

4. Regime shift with changes in intercept, slope and trend (C/S/T):
   In this case the structural break affects all the components (intercept, slope and the trend).

$$y_t = \mu_0 + \mu_1 \varphi_{t,\tau} + \mu_2 t + \mu_3 t \varphi_{t,\tau} + \mu_4 x_t + \mu_5 x_t \varphi_{t,\tau} + \varepsilon_t \quad (04)$$

   And for each equation, we perform the unit roots tests on the residuals series using three tests ADF, Z_α and Z_t.

3.2. Hatemi-J (2008) test

As pointed by Hatemi-J (2008) the traditional co-integration tests are based on the assumption that the co-integrating vector remained the same during the period of study (Hatemi, 2008), but the presence of economic crises, technological shocks, policy and regime changes can cause big changes in this co-integrating vectors in the long run term, for this reason Hatemi (2008) propose the following procedure based on Gregory-Hansen (1996) test to examine the co-integration relationship in the presence of two different structural breaks:

To account for the effect of two structural breaks on the intercept and the slopes, we have the following equation:

$$y_t = \alpha_0 + \alpha_1 D_{1t} + \alpha_2 D_{2t} + \beta_0' x_t + \beta_1' D_{1t} x_t + \beta_2' D_{2t} x_t + \mu_t \quad (05)$$

Where D_{1t} and D_{2t} are dummy variables defined as:

$$D_{1t} = \begin{cases} 0 & if\ t \leq [n\tau_1] \\ 1 & if\ t > [n\tau_1] \end{cases}$$

And

$$D_{2t} = \begin{cases} 0 & if\ t \leq [n\tau_2] \\ 1 & if\ t > [n\tau_2] \end{cases}$$

With the unknown parameter $\tau_1 \in (0,1)$ and $\tau_2 \in (0,1)$ signifying the relative timing of the regime change point and the bracket denotes the integer part.

3.3. Maki (2012) test

When the number of breaks are more than three, the tests of Gregory Hansen (1996) and Hatemi-J (2008) would perform poorly (Maki, 2012), for this reason, Maki suggested four equations to test the co-integration relationship under maximum of five structural breaks as follows:

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta' x_t + \varepsilon_t \quad (06)$$

$$y_t = \mu + \sum_{t=1}^{k} \mu_t D_{t,t} + \beta' x_t + \sum_{t=1}^{k} \beta_t' x_t D_{t,t} + \varepsilon_t \quad (07)$$

$$y_t = \mu + \sum_{t=1}^{k} \mu_t D_{t,t} + \gamma_t + \beta' x_t + \sum_{t=1}^{k} \beta_t' x_t D_{t,t} + \varepsilon_t \quad (08)$$

$$y_t = \mu + \sum_{t=1}^{k} \mu_t D_{t,t} + \gamma_t + \sum_{t=1}^{k} \gamma_t t D_{t,t} + \beta' x_t + \sum_{t=1}^{k} \beta_t' x_t D_{t,t} + \varepsilon_t \quad (09)$$

Where equation (06) is the model with level shifts, eq. (07) called the regime shifts model, eq. (08) is model (07) with a trend and eq. (09) constitutes structural breaks of levels, trends and regressors; $D_{1,t}$ takes a value 1 if $t>T_{B1}$ (i=1,…,k) and 0 otherwise, where k is the maximum number of breaks and T_{B1} denotes the time period of the break.

3.4. Asymmetric causality (Hatemi-J (2012) test)

The term causality is one of the most important terms in economics and econometrics with the co-integration concept, the first appearances of the causality term was in 1969 according to Cleve Granger work, in simple words, a causal relationship running from variable X to other variable Y means that we can use the actual values of variable X to predict the futures values of the variable Y, there is a massive literature since Granger (1969) on causality analysis like Sims (1972) and Geweke (1983) and many others both in time domain analysis or frequency domain analysis like Breitung-Caldelon (2006) procedure, but the problem with this traditional causality tests as said by Hatemi-J (2011) is the assumption that the impact of positive shock is the same as the impact of a negative shock with no separation between them under the symmetric causality, and this might be a too restrictive assumption because in many cases there is no symmetric relationship between the variables like the response of people to the positive and negative shocks in the financial markets, Granger and Yoon (2002) tried to transform the variables into cumulative positive and negative changes to test co-integration relationship which named the hidden co-integration, and this what open the door to the hidden causality between the variables and the cumulative positive and negative changes under the hidden causality (Granger and Yoon, 2002).

Assuming that we are tried to test the causal relationship between two integrated variables Y and X defined as the following random walk processes:

$$y_t = y_{t-1} + \varepsilon_{1t} = y_0 + \sum_{l=1}^{t} \varepsilon_{1t} \quad (10)$$

$$x_t = x_{t-1} + \varepsilon_{2t} = x_0 + \sum_{l=1}^{t} \varepsilon_{2t} \quad (11)$$

Where y_0 and x_0 are the initial values, and the variables ε_{1t} and ε_{2t} signify white noise disturbance terms, and the cumulative positive and negative components (shocks) are defined as $\varepsilon_{1t}^{+} = max\ (\varepsilon_{1t}, 0)$ and $\varepsilon_{2t}^{+} = max(\varepsilon_{2t}, 0)$ for positives shocks or $\varepsilon_{1t}^{-} = min(\varepsilon_{1t}, 0)$ and $\varepsilon_{1t}^{+} = min(\varepsilon_{1t}, 0)$ for negative shocks, therefore $\varepsilon_{1t} = \varepsilon_{1t}^{+} + \varepsilon_{1t}^{-}$ and $\varepsilon_{2t} = \varepsilon_{2t}^{+} + \varepsilon_{2t}^{-}$, therefore the random walk processes will be as follows:

$$y_t = y_{t-1} + \varepsilon_{1t} = y_0 + \sum_{l=1}^{t} \varepsilon_{1t}^{+} + \sum_{l=1}^{t} \varepsilon_{1t}^{-} \quad (12)$$

$$x_t = x_{t-1} + \varepsilon_{2t} = x_0 + \sum_{l=1}^{t} \varepsilon_{2t}^{+} + \sum_{l=1}^{t} \varepsilon_{2t}^{-} \quad (13)$$

And we can write the positive and negative shocks of each variable as $y_t^+ = \sum_{t=1}^{t} \varepsilon_{1t}^+$ and $y_t^- = \sum_{t=1}^{t} \varepsilon_{1t}^-$ for Y variable and $x_t^+ = \sum_{t=1}^{t} \varepsilon_{2t}^+$ and $x_t^- = \sum_{t=1}^{t} \varepsilon_{2t}^-$ for X variable, and then process is ready to test the causal relationship between these components under VAR model or any other form of its transformations.

The series employed in this study are annual observations covering the period 1970-2018 of Gross Domestic Product per capita (GDP per capita) as a proxy of economic growth, the Broad money supply (M2) as a proxy for money supply and the consumer price index (CPI) as a proxy of inflation rate, and all the variables were derived from the World Bank's database September 2019.

4. Results of study

4.1. Unit root tests

As usual the first step in time series analysis is the unit root test to get the order of integration for each variable, for this purpose, we use the modern test of NG-Perron (2001) without structural breaks to test the stationary processes of the series, in addition to both Zivot-Andrews (1992) to test the possibility of the existence of one structural break in the series and Lumsdaine-Papell (2003) test to examine the existence of two structural breaks to avoid any spurious regression according the co-integration relationship or the structural changes, and it's clear from the results inspired from table 2 that all the variables are I(1) variables which means that they are not stationary at their levels but stationary at the first differences for GN-Perron test, and by passing to unit root tests with structural breaks we assume that in 5% significance level all the variables doesn't have any structural breaks for both the two tests.

Table 2: Unit root tests results

Variables	NG-Perron test				
	MZa	MZt	MSB	MPT	
GDP	-4.898	-1.560	0.318	18.580	
M2	-4.938	-1.525	0.308	18.209	
CPI	-8.339	-2.036	0.244	10.945	
D(GDP)	-23.308***	-3.410	0.146	3.931	
D(M2)	-22.836***	-3.375	0.147	4.012	
D(CPI)	-23.213***	-3.403	0.146	3.946	
	Zivot-Andrewe test				
	t-statistic	Break	1% c-value	5%c-value	10%c-value
GDP	-2.610	1988	-5.57	-5.08	-4.82
M2	-4.521	1990	-5.57	-5.08	-4.82
CPI	-4.624	1996	-5.57	-5.08	-4.82

	Lumsdaine-Papell test					
	t-statistic	1st break	2nd break	1% c-v	5% c-v	10% c-v
GDP	-3.118	1991	2010	-7.190	-6.750	-6.840
M2	-6.261	1987	1995	-7.190	-6.750	-6.840
CPI	-5.604	1977	1996	-7.190	-6.750	-6.840
*** denotes the significance at 1%, 5% and 10% significance level; D denotes the first differences.						

Source: Our data processing in Eviews 10, Stata 16 and Rats 9.2 programs.

4.2. Co-integration tests results

After determining all variables are I(1) series, we shall continue with the co-integration analysis to detect the long run relationship between the three variables with two different types of co-integration test, Johansen-Juselius (1994) test without structural breaks and three co-integration tests with structural breaks (Gregory-Hansen (1996) test for one structural break , Hatemi-J (2008) test for two structural breaks and Maki (2012) test for more than two structural breaks), and the results are reported in table 3 and 4.

Table 3: Johansen co-integration test results

Johansen and Juselius (1994) test results (trace test)				
Hypothesized No. of CE(s)		Trace test	Critical value 5%	Probability
r = 0	r = 1	28.675	29.797	0.066
r ≤ 1	r = 2	11.286	15.494	0.194
r ≤ 2	r = 3	1.937	3.841	0.163
Johansen and Juselius (1994) test results (max-eigenvalue test)				
r = 0	r = 1	17.388	21.131	0.154
r ≤ 1	r = 2	9.348	14.264	0.258
r ≤ 2	r = 3	1.937	3.841	0.163

Source: Our data processing in Eviews 10 program.

The results from the table above clarified that the null hypothesis of no co-integration relationship cannot be rejected in 5% significance level for the two tests (trace test and max-eigenvalue test), whereas, there is no evidence of any co-integrating vector between the series which means there is no long run relationship between the three variables, this result corresponds to the results of Al-Fawwaz and Al-Sawaoi'e (2012) in Jordan, but is only relevant with the co-integration test without structural breaks, and to avoid any spurious results we must deal with the co-integration tests with structural breaks.

The next step in this study is to test the co-integration relationship with structural breaks to avoid any spurious results from co-integration test without structural breaks, Gregory-Hansen with its four equations and Hatemi-J in addition to Maki test are employed to deal with 1 to 5 structural breaks, and the results are reported in table 4.

Table 4: Co-integration with structural breaks tests results

Gregory-Hansen test					
Equations	Tests	t-statistic	Break	1% c-value	5% c-value
Equation (C)	ADF	-3.93	1992	-5.44	-4.92
	Zt	-3.94	1994	-5.44	-4.92
	Za	-22.91	1994	-57.01	-46.98
Equation (C/T)	ADF	-3.79	2005	-5.80	-5.29
	Zt	-3.67	2005	-5.80	-5.29
	Za	-21.40	2005	-64.77	-48.94
Equation (C/S)	ADF	-2.80	2005	-5.97	-5.50
	Zt	-3.85	1996	-5.97	-5.50
	Za	-22.52	1966	-68.21	-58.33
Equation (C/S/T)	ADF	-4.16	2010	-6.45	-5.72
	Zt	-4.32	2005	-6.45	-5.72
	Za	-24.04	2005	-79.65	-63.10
Hatemi-J test					
Tests	t-statistic	1st break	2nd break	1% c-value	5% c-value
Modified ADF	-10.692**	1978	2004	-6.928	-6.458
Modified Zt	-10.638**	1978	2004	-6.928	-6.458
Modified Za	-70.952	1978	2005	-99.458	-83.644
Maki test					
N of breaks	Equations	t-statistic	Breaks		5% c-value
3 breaks	Equation 6	-10.3**	1982-1992-2002		-5.392
	Equation 7	-9.36**	1984-2002-2007		-5.961
	Equation 8	-9.61**	1976-1991-1997		-6.516
	Equation 9	-9.58**	1991-1997-2008		-7.145
4breaks	Equation 6	-10.3**	1982-1992-2000-2012		-5.550
	Equation 7	-9.36**	1994-2002-2007-2013		-5.831
	Equation 8	-9.61**	1976-1984-1991-1997		-6.872
	Equation 9	-9.58**	1991-1997-2008-2014		-7.636
5 breaks	Equation 6	-10.3**	1976-1982-1992-2000-2012		-5.760
	Equation 7	-9.36**	1988-1994-2002-2007-2013		-5.993
	Equation 8	-9.61**	1976-1984-1991-1997-2014		-7.288
	Equation 9	-9.58**	1991-1997-2003-2008-2014		-8.129
** denote the significance at 1 and 5% significance level.					

Source: Our data processing in Stata 16 and Gauss 16 programs.

The results obtained from the table shows that there is no co-integration relationship between the variables with one structural break under Gregory-Hansen test for the three tests and four all the equations at 10% significance level, but in Hatemi-J test with two structural breaks, two of the three tests accept the null hypotheses in 5% significance level which means the existence the long run

relationship between the variables with two structural breaks, and the same result is obtained from Maki test in all the equations and for 3, 4 and 5 structural breaks, subsequently, we conclude that there is a long run relationship among money supply, inflation rate and economic growth in Algeria over the period 1970-2018 with at least two structural breaks.

4.3. Short run estimation results

As declared by Engle and Granger (1987) the best solution to estimate the short run effects in case of co-integrated variables is the Error Correction Model (ECM), according to the results in table 5, the estimated coefficient of error term (ECT) is negative and significant at 5% significance level (-0.49), therefore, the results states that the ECM corrects its previous period's level of disequilibrium by 49% each year (after two years the model back to its equilibrium stat after any shock), according the parameters of both inflation and money supply in the ECM, it's clear that there is no effect from both the variables on economic growth in 5% significance level, this result confirm the previous studies which suggests that there is no relationship between the three variables in the short run terms.

Table 5: Short run estimation results

Parameters	Coefficients	Student statistic	Probability
ECT	-0.491**	-4.690	0.000
D(GDP)	0.068	0.436	0.850
D(M2)	4.673	0.354	0.872
D(CPI)	-1.857	-0.173	0.932
Constant	79.532	1.297	0.625
** denote significance at 1% and 5% levels; D denote the first difference; ECT denote the error correction term.			

Source: Our data processing in Eviews 10 program.

4.4. Long run estimation results

After the short run estimation, we analyses the co-integration estimators to get the long run coefficients using the Fully Modified Ordinary Least Squares estimation (FMOLS), according to Maki co-integration test, we estimate two models with five structural breaks, the regime shift with trend model and the level shift with trend model.

Table 6: Long run estimation results (the regime shift with trend model)

Parameters	Coefficients	Student statistic	Probability
M2	6.499	0.597	0.554
CPI	15.866	0.860	0.396
D1	-2813.264	-1.965	0.058
D2	1406.914	1.336	0.191
D3	-7579.158*	-2.131	0.041
D4	14552.44**	3.378	0.002

Parameters	Coefficients	Student statistic	Probability
D5	-2804.620	-0.316	0.754
CPI*D1	-31.158	-0.994	0.328
CPI*D2	41.226	0.621	0.538
CPI*D3	-689.960**	-2.827	0.008
CPI*D4	685.557**	2.785	0.009
CPI*D5	-538.369**	-4.364	0.000
M2*D1	39.149	1.740	0.092
M2*D2	-58.446*	-2.661	0.012
M2*D3	177.960*	2.524	0.017
M2*D4	-247.533**	-3.177	0.003
M2*D5	61.604	0.549	0.587
Constant	-152.302	-0.238	0.812
Trend	126.598**	6.759	0.000
** denote significance at 1% and 5% levels. D_i denotes the dummy variables for each structural break.			

Source: Our data processing in Eviews 10 program.

Table 7: Long run estimation results (the level shift with trend model)

Parameters	Coefficients	Student statistic	Probability
M2	6.499	0.597	0.554
CPI	15.866	0.860	0.396
D1	-2813.264	-1.965	0.058
D2	1406.914	1.336	0.191
D3	-7579.158*	-2.131	0.041
D4	14552.44**	3.378	0.002
D5	-2804.620	-0.316	0.754
Constant	-152.302	-0.238	0.812
Trend	126.598**	6.759	0.000
** denote significance at 1% and 5% levels. D_i denotes the dummy variables for each structural break.			

Source: Our data processing in Eviews 10 program.

According to both of the two models, the effect of money supply and inflation rate on economic growth still insignificant at 5% significance level, which means that there is no long run effect from money supply and inflation rate on economic growth, and all the efforts from the Algerian Bank is still very limited to impulse the economic growth, especially the latest unconventional financing in 2015 and 2016 from the insignificant dummy variable M2*D5, this results confirm the Komendi and Meguire (1984) results as is the Keynesian view.

4.5. Causality analysis results

The last step in this study is the test of causal relationship between the three variables, and as mentioned before we use three different tests, the Hacker-

Hatemi-J (2010) test for symmetric linear causality, Dicks Panchenko (2006) test for symmetric non-linear causality and the asymmetric causality proposed by Hatemi-J (2012), and the results are reported in table 8.

Table 8: Causality analysis results

Direction of causality	Statistic	Critical values with 10000 repetitions		
		1%	5%	10%
Symmetric linear causality				
M2 to GDP	0.426	10.466	6.456	4.975
CPI to GDP	1.850	12.651	7.167	5.282
GDP to M2	2.529	10.200	6.390	4.917
GDP to CPI	0.924	12.872	7.109	5.126
CPI to M2	0.386	11.122	6.804	5.031
M2 to CPI	1.358	10.559	6.555	4.937
Symmetric non-linear causality				
Direction of causality	t-statistic		P-value	
M2 to GDP	0.759		0.223	
CPI to GDP	1.109		0.133	
GDP to M2	1.102		0.135	
GDP to CPI	1.367		0.085	
CPI to M2	0.660		0.254	
M2 to CPI	0.675		0.249	
Asymmetric causality (Hidden causality)				
GDP^+ to M2	0.349	9.109	4.551	3.150
GDP^- to M2	6.838	12.546	7.337	5.389
INF^+ to M2	2.951	9.896	6.408	4.878
INF^- to M2	1610.918***	9.809	6.318	4.868
$M2^+$ to GDP	0.501	10.719	6.497	4.977
$M2^-$ to GDP	16672.017***	10.247	6.427	4.824
INF^+ to GDP	9.984	9.410	6.182	4.856
INF^- to GDP	729369.596***	10.029	6.369	4.804
GDP^+ to INF	40.371***	15.657	7.267	4.809
GDP^- to INF	42.781***	15.319	7.015	4.776
$M2^+$ to INF	59.161***	10.481	6.464	4.863
$M2^-$ to INF	64.658***	10.419	6.220	4.711
*** denote significance at 1%, 5% and 10% levels.				

Source: Our data processing in Gauss 16 and Panchenko for non-linear causality programs.

Based on table 8, the null hypothesis in both linear and non-linear causalities is that the first variable do not Granger-cause the second variable cannot be rejected at any critical values, this implies there is no symmetrical causality (linear nor non-linear) between the original series of the three variables, this result is the same of Getawa et al (2017) and Korkmaz (2017) studies with no causal relationship between the three variables, especially when we know that the first study was on a similar economy for the Algerian economy (the Nigerian

economy both are oil exporter countries), and the second study focused on the Mediterranean countries where Algeria is one of theme, on the other hand, there is a hidden causalities (asymmetric causalities) running from negative shocks of Money supply to growth and inflation rate, negative shocks of inflation to money supply and economic growth and from both negative and positive shocks of growth to inflation rate, these results confirm the Cover (1992) who distinguish between the positive and negative shocks, according to these results, the money supply in Algeria have a hidden causality running from just its negative shocks to economic growth which means that the Algerian economy doesn't react to the rising in the money supply as the decreasing of it according to the inflation rate which react to both positive and negative changes in money supply.

5. Conclusion

This study analyze the co-integration and causal relationships between money supply, inflation rate and economic growth in Algeria by using data covering the period 1970-2018, the investigation of the three variables for the long-run relationship is determined by both the co-integration without structural breaks (Johansen-Juselius (1994) test) and the co-integration with structural breaks (Gregory-Hansen (1996) test, Hatmi-J (2008) test and Maki (2012) test), and the causal relationships are obtained from Hacker-Hatemi-J (2010) test and Dicks-Panchenko (2006) for the symmetric causality both linear and non-linear respectively, in addition to the Hatemi-J (2012) procedure for the asymmetric causality following the Cover (1994) work to distinguish between the positive and negative shocks in order to detect the hidden causality, the co-integration approach confirmed the absence of co-integration relationship in the absence of structural breaks in contrast of the presence of the breaks when we found a strong evidence of co-integration relationship especially with more than 3 breaks, which means the existence of long-run relationship between the variables when the economic growth served as the dependent variable, on the same extreme, both the short run and long run estimations revealed a non-effect from the money supply and inflation rate on economic growth, on the other hand, the causality results confirmed the previous results, whereas, there is no evidence of symmetric causal relationship between all the variables neither linear relationship nor non-linear, this result under Cover (1994) believe doesn't mean the total absence of the causalities, but there is a possibility of the existence of hidden causalities running from only the cumulative components not the naturel series, this what was confirmed by Hatemi-J (2012) test, when we had causal relationships running from negative shocks of money supply to economic growth and from both negative and positive shocks of money supply to inflation rate in addition to both positive and negative shocks of economic growth to inflation rate.

Our results confirmed the Monetarist view of inflation because the hidden causalities running from both money supply and economic growth to inflation rate, this what consist the applying of the Taylor rule in Algerian economy to allow the money supply to increase the economic growth especially the positive changes which still very limited to impulse the outputs, but with a steady rate to avoid any shocks from inflation rates, in addition to this, the monetary policy based on money

supply must be pursued if the economy is to produce tradable goods to eliminate the inflation shocks, and this may occurred by encourage the investments both domestic and FDI, since in an inflationary environment the money supply can increase when the nominal expenditures increases, and based in our results, it's clear that the inflation rates must be accommodated by the expansion in the money supply, and this is necessary with the non-effect of money supply in economic growth neither in short run nor long run terms.

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