Quantity Theory of Money Around the Globe: Money Growth, Money Velocity and Inflation Subject to Different Monetary Policies

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Abstract

Diverse monetary policies taken by leading central banks did have different effects on inflation during and especially after the COVID-19 pandemic. While certain countries such as Switzerland and Japan registered moderate annual inflation rates under 3.5% (as measured by their respective Consumer Price Index), that was not the case for other monetary areas such as the United States, the euro area, or the United Kingdom. In the last years, theoretical approaches have been used in academia to explain the origins of inflation, including the quantity theory of money, the new Keynesian framework, the modern monetary theory, and the fiscal theory of the price level. Since the leading banks from the aforementioned monetary areas and countries implemented policies with remarkable differences in terms of broad money aggregates correlating with diverse inflation results, the «broad» quantitative theory of money can be a suitable theoretical framework to analyze the effect of broad monetary aggregates on inflation. Therefore, an empirical analysis such as the one to be presented in this publication can lead to relevant conclusions about the possibility of using changes in monetary aggregates and money velocity in order to establish a link to inflation. A regime-switching model (Markov-switching model) is used to test the impact of the monetary variables (changes in money quantity and money velocity) on inflation for Switzerland, Japan, the United States, the euro area, and the United Kingdom. The fact that different monetary areas are used for the present analysis allows for a multi-region, multi-currency study of relationships between monetary aggregates, money velocity, and inflation.

Keywords: inflation, money velocity, money growth, regime switching model.

JEL classification: E31, E41, E50, E52, E58

1. Introduction

Expansive monetary policies have traditionally been a tool used by central banks in order to alleviate difficult economic conditions, such as the global economic situation during the COVID-19 pandemic. Starting at the beginning of 2020, some of the world's most influential central banks started implementing such policies having as a result a broad money growth as high as 25% year-on-year in the United States.

Most central banks, however, were confident about such money growth not having a significant effect on inflation. Federal Reserve Chairman Jerome Powell notably replied to a republican U.S. senator during the "Semiannual Monetary Policy Report to the Congress" in the Committee on Banking, Housing, and Urban Affairs:

> Well, when you and I studied economics a million years ago, M2 and monetary aggregates generally seemed to have a relationship to economic growth. . . that classic relationship between monetary aggregates and economic growth and the size of the economy, it just no longer holds. . . so something we have to unlearn, I guess. (Powell, 2021b).

Furthermore, Powell added later that year at the House of Representatives' Committee of Financial Services:

> Now, we think more of just the imbalances between supply and demand in the real economy rather than monetary aggregates… It's been a different economy and a different financial system for some time. (Powell, 2021a).

Nonetheless, as Figure 1 shows, while certain countries and monetary areas such as the United States, the euro area and the United Kingdom registered remarkably high annual changes in money supply, others did not, such as Switzerland or Japan.

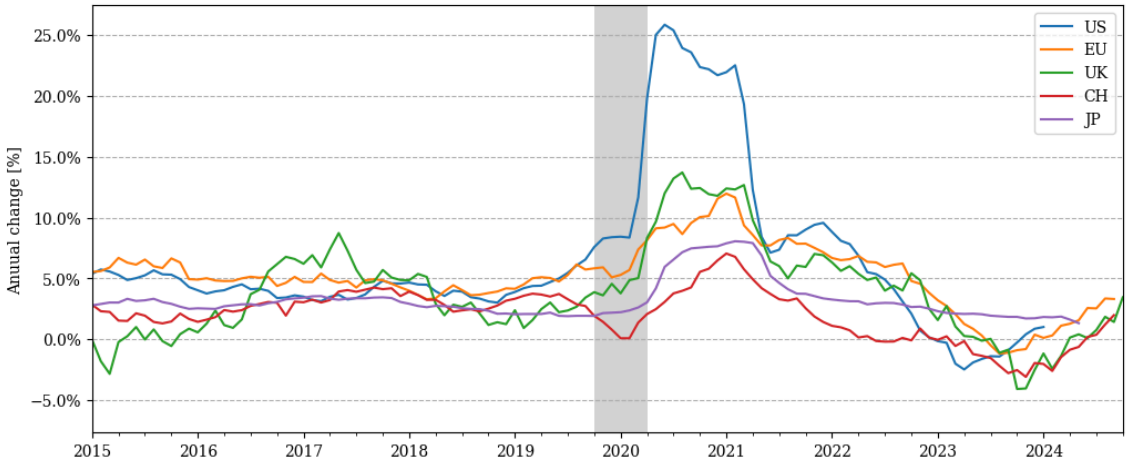


Figure 1: Annual change in broad money supply for the explored monetary areas, monthly.

Following Milton Friedman's now famous claim at the Wincott Memorial Lecture, inflation started to surge:

> Inflation is always and everywhere a monetary phenomenon, in the sense that it is and can be produced only by a more rapid increase in the quantity of money than in output. (Friedman, 1970).

As shown in Figure 2, the countries and monetary areas which implemented such expansive monetary policies resalting in extraordinarily high money supply increases also registered abnormally higher levels of inflation in the aftermath of COVID-19.

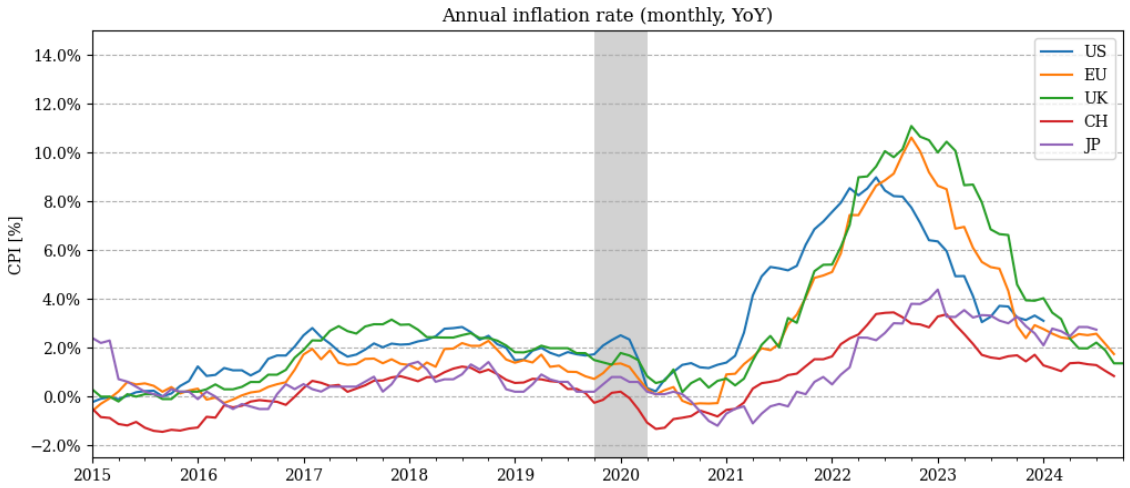


Figure 2: Annual inflation rate for the explored monetary areas, monthly, year-over-year.

The fact that major central banks did not expect such levels of inflation arises the question about whether central banks theoretical framework is indeed correct and if they should pay more attention to broad monetary aggregates in the future.

2. Influence on academia

As a result of the implementation of expansive monetary policies around the globe, several economists alerted about the risk of inflation by analyzing the money supply behavior and the money demand changes during and after the COVID-19 pandemic with works such as Castañeda and Congdon (2020) or Congdon (2020).

However, the connection between money supply changes and inflation was not a new idea: the influence of changes in money supply and the monetary transmission mechanisms has been broadly studied, specially by monetarist economists such as Milton Friedman (1956).

Nonetheless, following COVID-19 the relationship between money supply and inflation has been a research topic for numerous economists:

Borio, Hoffman and Zakrajšek (2023) use a two-regimes model with a regime of low inflation and a regime with high inflation. Although a relationship between these magnitudes is observed, causality cannot be derived from it: countries with high money supply increases also presented higher inflation rates. Greenwood and Hanke (2021) propose two types of explanation for inflation: the ad-hoc explanations and the

monetary explanations; while both types of explanations are analyzed, importance of changes in broad money supply in regard to inflation is highlighted.

Reynard (2023) examines central banks' responses, focusing on changes in their balance sheets and inflation. This study proposes a relationship between inflation and broad money supply within the framework of the quantity theory of money, emphasizing the critical choice of monetary aggregates and advocating the use of broad aggregates.

Addressing this point, Bordo and Levy (2021) conclude that the money multiplier associated with the monetary base lacks stability when comparing aggregates such as MB and M2 and their respective inflationary impacts. They also provide a historical overview of various episodes of fiscal expansion, analyzing outcomes in terms of price level changes.

This raises the question of central banks' limitations in designing effective monetary policy tools. In this regard, Congdon (2021) examines these constraints in developing and implementing specific monetary policy instruments without triggering associated inflation.

From a quantitative methodology perspective, a recent study by Castañeda and Cendejas (2023) investigates "whether changes in money velocity and broadly defined monetary growth account for long-term inflation patterns in the United States," concluding that both variables indeed play a significant role in explaining long-term inflation.

Quantitative methods have been extensively applied to explore the link between money supply and inflation. For instance, Amisano and Fagan (2013) employ a regime-switching Markov model, akin to that used by Castañeda and Cendejas, applying it to multiple economies—namely the euro area, Germany, the United States, the United Kingdom, and Canada—from the 1960s onward. Additionally, Anderson, Bordo, and Duca (2017) conduct similar analyses on money velocity in terms of stationarity, using empirical models to capture the demand for broad money in the United States since the Great Depression.

3. Empirical analysis

This work attempts to analyze the relationship between broad money supply changes and inflation by using quantitative methods. In order to achieve this result, the methodology presented in Castañeda and Cendejas (2023) is followed not only for the United States, but also extended to other relevant countries and monetary areas: the euro area, Switzerland, the United Kingdom and Japan.

Within this subset of countries and monetary areas Japan and Switzerland have been chosen as examples of central banks not executing an expansive monetary policy having such a noticeable effect on money supply changes as the United States, the euro area or the United Kingdom in order to present, in a form of a controlled experiment, the results of different monetary policies on inflation. The period analyzed for each country and monetary area has been selected by maximizing the available observation period, varying per monetary area as presented in the results.

The main variables relevant for the analysis are the following: (1) the money supply, as represented by the corresponding available broad money aggregate being M3 for the United States, euro area, Switzerland and Japan, and M4x for the United Kingdom; (2) the velocity of money, computed with the nominal GDP and the money supply; and (3) inflation as a measure of price level variations using CPI data.

The quantity theory of money is used as theoretical background in order to perform the analysis in this work. Thus, the equation of exchange is used to model the aforementioned relationship:

$$M_t v_t = P_t Y_t$$

The variation of the velocity of money is thence computed as follows from available data; nominal GDP being $P_t Y_t$ and money supply the corresponding broad aggregate M_t (M3 or M4x):

$$\Delta \log log\, v_t = \Delta \log log \left(P_t Y_t\right) - \Delta \log log\, M_t$$

One of the most repeated critics to monetarism relates to the non-stationarity of the velocity of money. That is why, following the approach Castañeda and Cendejas (2023) to the United States, the stationarity of the changes (not the magnitude itself) of the velocity of money is scrutinized.

Magnitude	**United States**	**Euro area**	**Switzerland**	**United Kingdom**	**Japan**
μ_v	-0.88 %	-1.71 %	-1.08 %	-1.60 %	-1.79 %
μ_v (until 2019.IV)	-0.81 %	-1.90 %	-1.36 %	-1.48 %	-2.02 %
σ_v	4.48	4.06	3.91	2.97	5.64
σ_v (until 2019.IV)	3.58	2.87	3.65	2.31	4.61
p-value	0.002	0.000	0.001	0.000	0.000
ADF p-value	0.031	0.038	0.012	0.017	0.062

Table 1: Money velocity analysis results for the explored monetary areas: money velocity change mean, standard deviation, p-value for proposed hypothesis test and augmented Dickey-Fuller p-value.

First, a similar decreasing trend in the velocity of money is observed for all the countries and monetary areas is observed with differences in the mean value and standard deviation of $\Delta \log log\, v_t$ due to intrinsic variance in money demand behavior. Furthermore, it is verified with a statistical hypothesis test that the null hypothesis of a zero-mean behavior can be rejected for all the monetary areas with a 99% significance level, as Table 1 shows.

In order to test if the velocity of money time series is stationary, the existence of unit roots in the series is verified with the Augmented Dickey-Fuller (ADF) test, being the null hypothesis the existence of a unit root in the time series. Table 1 shows that the

p-values for the ADF test are under 0.1 and thence the null hypothesis of unit root existence is rejected with a 90% significance level.

Following the analytic approach by Hamilton (1989), and as applied by Castañeda and Cendejas (2023), a regime switching model is used to model two magnitudes: (1) changes in the velocity of money ($\Delta \log log\, v_t$), and (2) inflation ($\Delta \log log\, P_t$). The models proposed present two regimes: a high regime and a low regime for the corresponding magnitude.

Peak quarter	Trough quarter
1857Q2	1858Q4
1860Q3	1861Q3
1865Q1	1867Q1
1869Q2	1870Q4
1873Q3	1879Q1
1882Q1	1885Q2
1887Q2	1888Q1
1890Q3	1891Q2
1893Q1	1894Q2
1895Q4	1897Q2
1899Q3	1900Q4
1902Q4	1904Q3
1907Q2	1908Q2
1910Q1	1911Q4
1913Q1	1914Q4
1918Q3	1919Q1
1920Q1	1921Q3

Peak quarter	Trough quarter
1923Q2	1924Q3
1926Q3	1927Q4
1929Q3	1933Q1
1937Q2	1938Q2
1945Q1	1945Q4
1948Q4	1949Q4
1953Q2	1954Q2
1957Q3	1958Q2
1960Q2	1961Q1
1969Q4	1970Q4
1973Q4	1975Q1
1980Q1	1980Q3
1981Q3	1982Q4
1990Q3	1991Q1
2001Q1	2001Q4
2007Q4	2009Q2
2019Q4	2020Q2

Table 2: U.S. business cycle expansions and contractions according to the National Bureau of Economic Research (NBER 2023).

First, for the changes in the velocity of money, the magnitude is modelled using the U.S. business cycle expansions and recessions as expressed in Table 2 through a dummy variable being set to 1 for the recession periods, and then the corresponding coefficients to each regime, being estimated for every country and monetary region mentioned as follows:

$$\Delta \log log\, v_t = \beta_{recession} d_{recession,t} + \alpha_{S_1} S_t + \alpha_{S_2}\left(1 - S_t\right) + \varepsilon_t$$

The estimated coefficients along with the corresponding p-values are shown at Table 3. It can be concluded that (1), except for Switzerland, expansions and recessions as measured by NBER are significant when modelling changes in the velocity of money; and (2) with the selected independent variables a significant part of the dependent variable can be explained.

Since the Bank of Japan only publishes M3 data from 2003 on, the volume available data for the analysis is considerably lower than for other monetary areas, and thence this particular analysis is skipped for this country.

Magnitude	United States	Euro area	Switzerland	United Kingdom	Japan
α_{S_1}	0.002 (0.513)	0.035 (0.000)	0.030 (0.000)	0.009 (0.028)	-
α_{S_2}	-0.109 (0.000)	-0.023 (0.000)	-0.033 (0.000)	-0.085 (0.000)	-
$\beta_{recession}$	-0.015 (0.025)	-0.057 (0.000)	0.000 (0.960)	-0.069 (0.000)	-
p_{00}	0.988 (0.000)	0.890 (0.000)	0.932 (0.000)	0.961 (0.000)	-
p_{10}	0.164 (0.059)	0.037 (0.092)	0.041 (0.050)	0.140 (0.042)	-
R^2	0.515	0.610	0.668	0.666	-

Table 3: Parameters corresponding to the money velocity change Markov regression model for the explored monetary areas.

Second, for the changes in the price level, inflation is modelled with the changes in past and present broad money supply changes and velocity of money changes as follows:

$$\Delta \log log\, P_t = \left[c_{S_1} + \alpha_{S_1}(L)\Delta \log log\, M_t\right]S_t + \left[c_{S_2} + \alpha_{S_2}(L)\Delta \log log\, M_t\right]\left(1 - S_t\right) + \gamma(L)\Delta \log log\, v_t$$

where, for simplicity, the lag operator (L) is used:

$$L^m x_t = x_{t-m}$$

and expressions with delays and thence expressed for the corresponding coefficients:

$$\gamma(L) = \gamma_0 + \gamma_1 L + \gamma_2 L^2 + \ldots$$

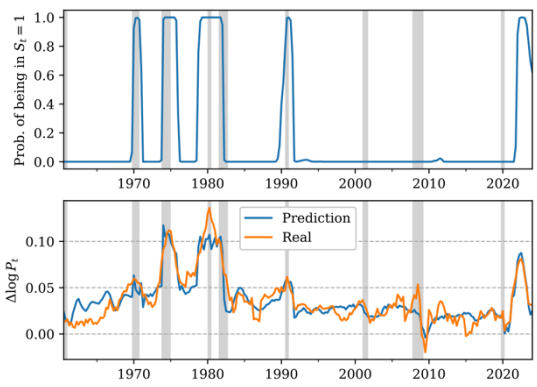
$$\alpha_{S_k}(L) = \alpha_{0,S_k} + \alpha_{1,S_k} L + \alpha_{2,S_k} L^2 + \ldots$$

Results, estimated coefficients and corresponding p-values are expressed at Table 4. From these results it can be derived that both past and present broad money supply changes are significative to model present inflation. Furthermore, all regime switching probabilities are significative at 90% significance level except for Switzerland, and from the R^2 values it can be concluded that this model establishes a significant relationship between past and present values of broad money supply, changes of velocity of money and inflation.

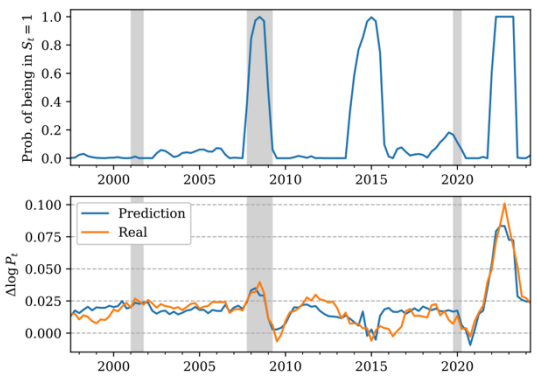
Magnitude	United States	Euro area	Switzerland	United Kingdom	Japan
c_{S_1}	0.003 (0.153)	0.014 (0.000)	0.005 (0.001)	0.003 (0.223)	0.001 (0.651)

α_{0,S_1}	0.191 (0.001)	0.130 (0.000)	0.071 (0.089)	0.098 (0.008)	0.162 (0.001)
α_{1,S_1}	0.273 (0.074)	0.215 (0.118)	0.106 (0.245)	0.147 (0.143)	0.252 (0.362)
α_{2,S_1}	0.154 (0.103)	-0.003 (0.977)	-0.023 (0.729)	0.120 (0.125)	-0.129 (0.375)
c_{S_2}	0.053 (0.000)	-0.017 (0.001)	0.044 (0.000)	0.018 (0.000)	0.017 (0.022)
α_{0,S_2}	-0.444 (0.004)	1.020 (0.000)	0.133 (0.058)	0.435 (0.000)	0.014 (0.882)
α_{1,S_2}	0.217 (0.361)	-0.502 (0.034)	0.053 (0.756)	-0.069 (0.443)	-0.992 (0.501)
α_{2,S_2}	0.262 (0.244)	1.642 (0.000)	-0.251 (0.085)	0.642 (0.000)	1.361 (0.345)
γ_0	0.100 (0.095)	0.034 (0.376)	0.076 (0.063)	0.051 (0.168)	-0.002 (0.958)
γ_1	-0.002 (0.982)	-0.061 (0.495)	0.039 (0.566)	0.027 (0.702)	0.025 (0.900)
γ_2	0.096 (0.201)	0.054 (0.213)	0.083 (0.113)	0.035 (0.371)	0.028 (0.665)
p_{00}	0.977 (0.000)	0.957 (0.000)	0.993 (0.000)	0.972 (0.000)	0.955 (0.000)
p_{10}	0.116 (0.029)	0.218 (0.040)	0.043 (0.255)	0.060 (0.105)	0.150 (0.107)
R^2	0.819	0.836	0.789	0.811	0.817

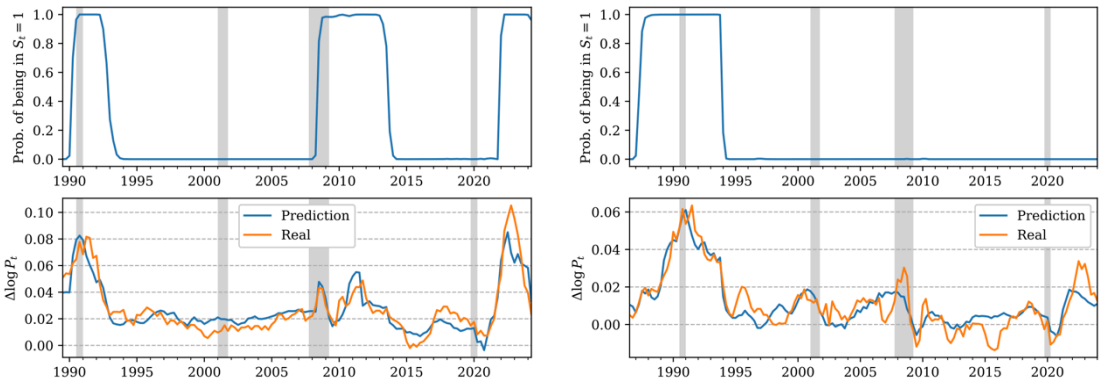
Table 4: Parameters corresponding to the inflation Markov regression model for the explored monetary areas.



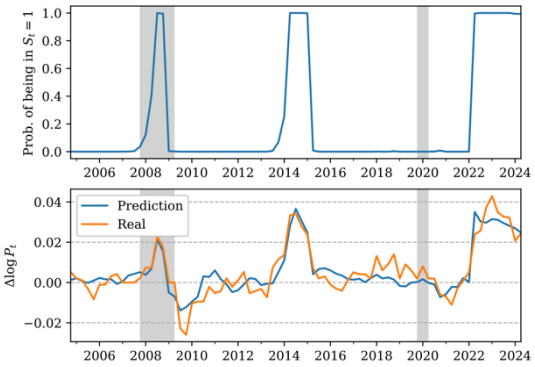
(a) United States



(b) Euro area



(c) United Kingdom (d) Switzerland



(d) Japan

Figure 3: Probability of being in the high regime, observed value of change in logarithm of price level and model prediction.

4. Conclusions

This work generalizes the conclusions presented by Castañeda and Cendejas (2023) for the United States to other countries and monetary areas with intrinsic differences and profoundly differing monetary policies during the COVID-19 pandemic: the euro area, the United Kingdom, Switzerland and Japan.

The empirical analysis shows a consistent behavior of velocity of money across the analyzed monetary areas with a decreasing trend on its changes, being stationary for the periods of analysis.

Finally, the presented analysis highlights the importance of present and past broad money supply changes in its relationship with inflation. Since money supply changes were not at the core of the analytical framework of certain central banks when responding to the COVID-19 situation, from this analysis it can be concluded that central banks shall not underestimate the influence of monetary aggregates on price level changes and consider their importance in their theoretical frameworks both to predict inflation and to review their role in monetary transmission mechanisms.

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