Investigation of potential link between declining CPI inflation and rising asset prices

Adam Henriksson

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Department of economics
Supervised by Fredrik NG. Andersson[1]
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Abstract

This paper examines whether there is a link between missing CPI inflation and asset price inflation. It makes use of the quantity theory of money to establish that increased money growth in relationship to real GDP leads to CPI inflation. The model first tests the period leading up to 1990 then the period after 1990. This is done to establish if the quantity theory of money hold and to obtain parameters to make a forecast. The second part consists of making a forecast with the model leading up to 1990 which is then used to make a forecast for the period after 1990. A forecast error is obtained and used as an explanatory variable to model asset prices. The result show that the relationship theorized in the quantity theory of money holds for the period leading up to 1990 but not for the period after 1990. The paper did not find any evidence that missing CPI inflation leads to increasing asset prices. The paper examines Sweden and USA.

Key words: Quantity theory of money, asset prices, CPI inflation, forecasting, Sweden, USA.

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1. Introduction

The developed world has seen a sharp decline in inflation over the past decades; from 6 to 7 percent during the 1960's and 1970's to close to 2 % since the early 1990s (Worldbank, 2020). This decline has been attributed to factors such as aging population, increased globalization and technological advancements (Broniatowska, 2017; Lv, Liu & Xu, 2019; NBER, 2007). The quantity theory of money (QTM) explains inflation as a function of money stock, real GDP and velocity of money (Fregert & Jonung, 2018, p.237 – p.238). Emerson (2011) found evidence in support of the quantity theory of money using time series data from the United States for period 1959-2004. Sargent and Surico (2010) showed that QTM tends to break down from period to period, they showed that the QTM held valid during 1955-75 and 1960-83 but that it deviated away from the QTM during other periods. Jonung (1976) investigated the relationship between money growth and inflation in Sweden and found strong evidence of an association between inflation and money growth as far back as the 18th century. Moreover, there were evidence regarding the validity of the QTM in the long run, however it was harder to establish a close relationship in the short run (Jonung, 1976). Andersson (2011) used panel data consisting of 8 developed countries and found that money growth affect consumer prices and asset prices at different rates. Housing prices and financial asset prices absorbed new money growth faster than consumer prices (Andersson, 2011). Looking at historical data from the federal reserve over 10-year averages of money stock (M2) and inflation (GNP-deflator & CPI), inflation and money stock growth track each other since the end of the 19th century up until early 1990's. There are some shorter periods of smaller divergence. The data indicate that the relationship between growth in money stock and CPI inflation have been severed since the early 1990's. Increasing financial asset valuations came coupled with the rise in money stock without any subsequent rise in CPI inflation. Rising financial asset valuations like the CAPE may suggest asset price inflation. The CAPE ratio measures CPI inflation adjusted 10 year average of the PE ratio (Shiller, 2016; Multipl, 2021). The CAPE ratio has averaged about 15 since the end of the 19th century up until early 1990's, since then the average has been around 25 (Shiller, 2016; Multipl, 2021). A higher CAPE ratio implies that investors get less company earnings in relationship to the stock price over the long term. That level of stock market valuation has never been sustained in previous history. Another indication of possible asset price inflation is simply historic S&P500 annual average returns, they have gone from about 7.2 % from 1928 – 1989 to 9.1 % from 1990 - 2019 (Macrotrends, 2021).

It is possible that the CPI inflation which appears missing has moved towards financial assets, real estate and other goods which aren't typically measured in the conventional inflation measurements such as CPI or GNP-deflator. This paper examines if growth in money stock in relationship to GDP leads to higher CPI inflation. It is done in two parts by testing if the quantity theory of money holds pre 1990 and post 1990. Then it is investigated whether a link between missed forecasted inflation results in higher financial asset prices. The method to investigate the link differ from previous research, this paper will make use of forecasts and forecast errors to model financial asset price changes. Both USA and Sweden is examined, one large and one small economy. Previous research have focused on the long-run validity of the QTM and haven't specifically focused on the time periods where the money growth seems to deviate from consumer inflation. Moreover, the papers have either consisted of country-specific investigation or used a wide range of countries consisting of panel data. There is also little research for the case of Sweden regarding inflation using QTM in recent time. The results show that money stock growth in relationship to GDP leads to CPI inflation for the years leading up to 1990, but this relationship breaks down after 1990. There is no evidence that the missing forecasted CPI has flowed to asset prices, at least not in the short run with the methods employed in this paper.

Section 2 presents a theoretical overview of the quantity theory of money, a brief overview of theory regarding inflation in the short run and a more specific look at CPI versus asset price inflation. Section 3 presents the data and methods used for this paper. The results are presented and analysed in section 4. Section 5 consists of a general discussion with conclusions.

2. Theory

2.1 Quantity theory of money

2.1.1 General

The quantity theory of money is said to be one of the oldest economic theories which trace back to philosophers like Jean Boudin, John Locke and David Hume who worked on the theory in the 16th, 17th and 18th century (Humphrey, 1974). The classical quantity theory of money studies the relationship between the quantity of money and the price level in the economy (Humphrey, 1974). A simplified version states that if the quantity of money change by a certain rate then the price level will make a proportional change (Humphrey, 1974). If the change in quantity is negative it leads to deflation and if it's positive it leads to inflation (Horwitz, 1996; Fregert & Jonung, 2018, p.135). The classical QTM was the dominating theory for policy making up until the 1930's (Humphrey, 1974). During this period stability policies were stated as equal to monetary policies since at that time stability were believed to be equal to a balanced state budget, the state could only spend as much as it made in income (Fregert & Jonung, 2018, p.135).

During the 1960's a revised version of the quantity theory of money was developed under the name of monetarism. The new theory used empirical studies to build evidence that fluctuations in the quantity of money was the main driving factor between periods of high inflation or deflation (Friedman & Schwartz, 1963). These extreme periods of high inflation or deflation often resulted in economic crisis (Friedman & Schwartz, 1963). The modern quantity theory of money does not only look at quantity of money stock as a variable but also look at productivity (Hetzel, 2007). Friedman combined elements from the classical QTM and the simple Keynesian model (Fregert & Jonung, 2018, p.146). The effects of monetary policy are believed to affect the price level and productivity under varying time shifts, long and variable lags (Fregert & Jonung, 2018, p.147).
The so called trade equation which is derived from QTM is defined as:

$$M * V \equiv P * T \qquad (1)$$

Where M is the money stock, V its average turnover velocity and P the price level (Humphrey, 1974; McTaggart, Findlay & Parkin, 2013, p.508-509; Fregert & Jonung, 2018, p.235 - 236). T measure all the transactions in the economy but since it's hard to do that in practice, real GDP, Y is used instead where real GDP is assumed to be stable in relationship to the total transactions in the economy:

$$M * V \equiv P * Y \qquad (2)$$

This relationship is an identity, meaning that it is a relationship which is always true by definition given by the fact that money velocity is determined by V = P*Y/M (McTaggart, Findlay & Parkin, 2013, p.508-509; Fregert & Jonung, 2018, p.235 - 236). The identity becomes theoretical in nature once assumptions are made about which quantities should be included, how they should be measured and how they might affect each other (Fregert & Jonung, 2018, p.236). The conclusion from the quantity theory of money is that when the money stock, M change, then then price level, P will change in direct proportion for the relationship $M * V = P * Y$ to hold (McTaggart, Findlay & Parkin, 2013, p.508-509). This is the case due to the assumption that real GDP, Y and money velocity, V is unaffected by a change in the quantity of the money stock, M (McTaggart, Findlay & Parkin, 2013, p.508-509).
By writing the trade equation in relative form:

$$\Delta M/M + \Delta V/V = \Delta P/P + \Delta Y/Y \qquad (3)$$

Then holding money velocity constant, we find that inflation will be equal to:

$$\Delta P/P = \Delta M/M - \Delta Y/Y \qquad (4)$$

Meaning that when money velocity is constant $\Delta V/V = 0$, inflation is equal to the difference in money growth and real GDP growth (McTaggart, Findlay & Parkin, 2013, p.508-509; Fregert & Jonung, 2018, p.237 – p.238). This states that increased money supply should be equal to increased inflation unless productivity also increase. Long term shifts in money velocity are marginal and can be contributed to factors such as less barter trade and increased use of commercial banks with money deposits and medium of exchanges such as banknotes (Jonung, 1978).

2.1.2 Variable specifics in QTM

M represents the money stock in an economy. It's common to use broad money, M2 or M3 when implementing real world measures for money stock into QTM. Wang (2017) showed that broad money is a more robust monetary index to evaluate QTM. This is attributed to the fact that broad money such as M2 has one part which is created by loan issuance, which is the major liability of depositary financial institutions (Wang, 2017). Different countries use different ways to define M2 and M3 which is partly due to practical reasons for policy makers and entities such as financial institutions (Lim & Sriram, 2003). The definition also tends to change over time (Lim & Sriram, 2003). A more general textbook definition looks as following; *M1 = currency in circulation + sight deposits at banks* and *M2 = M1 + time (or savings) deposits at banks with unrestricted access* (Burda & Wyplosz, 2017, p.223). More specifically for the US "M2 consists of M1 plus: (1) savings deposits (which include money market deposit accounts, or MMDAs); (2) small-denomination time deposits (time deposits in amounts of less than $100,000); and (3) balances in retail money market mutual funds (MMMFs)" (Federal reserve, 2020).

Y represents real GDP (or real output) which excludes financial transactions or transactions of goods and assets that already exists (Fregert & Jonung, 2018, p.235). It is a productivity measure, which can be expressed as total value added at constant prices by using a reference year (BEA, 2021; Burda & Wyplosz, 2017, p.576). It is worth stressing that the original definition of the trade equation from the quantity theory of money use T which represent all transactions in the economy. For practical and/or conventional reasons Y is used instead. This is done with the assumption that real GDP is stable in relationship towards total transactions in an economy (Fregert & Jonung, 2018, p.235 - 236).

P is the price level in an economy. Fisher (1911) state that the price level should be derived from a price index containing all purchasable goods in an economy. This would include goods such as financial assets and real estate. One of the conventional ways to measure price level is through a consumer price index (CPI), which is a basket of consumer goods aimed to reflect consumption to uphold a certain level of lifestyle (Fregert & Jonung, 2018, p.121 & p.129). CPI is constructed based upon current prices of consumption (Alchian & Klein, 1973). Goodhart (2001) argue that CPI does not only include prices of current consumption goods and services but also quasi durable and durable goods which is a result of practical conveniency. Alchian and Klein (1973) follows an intertemporal definition of consumption and conclude that a price index must include asset prices to capture inflation.

Furthermore, they argue that inflation measures such as CPI and GNP-deflator are theoretically inappropriate and leads to errors in policy making, research and theory (Alchian & Klein, 1973). Alchian and Klein (1973) argue that the CPI is inadequate as a constant utility money price measure since it focuses on current consumption flows and fails to answer whether present money cost of consumer utility has changed. Another critique of the CPI has been that the way the index is weighted will misrepresent actual inflation for specific sub-groups in the population of an economy (TIME Magazine, 1981). Much of the critiques boils down to that CPI is unable to measure actual inflation since it just captures a subset of all transactions (Heravi & Silver, 2005).

2.2 Asset prices vs. CPI inflation

Issing (2003) state that one of the issues that could face the intertemporal consumption approach as presented by Alchian and Klein (1973) is that it would require two vectors of prices, one for present prices and one for future prices. Future prices are not available for most goods and services (Issing, 2003). Furthermore, Gilchrist and Leahy (2002) argue that asset prices can change for a wide variety of reasons that are not related to cost of future consumption.
Issing (2003) also claim that financial assets are not directly related to intertemporal consumption prices faced by households since financial assets are claims on capital owned by firms. Inflation in equity prices can be especially troublesome to measure due to their volatile nature and susceptibility to speculation bubbles (Issing, 2003). Monetary policy may affect asset prices different than consumer prices, the effect on prices might not be as easy to predict or smooth over time. There have been concerns that excessive money growth could cause dry wood needed to cause speculation and rise in asset prices (Baumeister, Durinck & Peersman, 2008; Issing, 2002). It appears as if excessive money growth moved in sympathy with growth rate of New York stock prices during the 1920's (Issing, 2002). Excessive money growth was measured by the quantity relation with real income growing at its potential rate, inflation objective set at central bank and long-term money velocity trend (Issing, 2002). This highlight the importance of the second pillar of monetary policy, where nonmonetary indicators are assessed for price setting over short- to medium term (Issing, 2002). This follows the principle that no information that could guide policy decisions should be lost, including asset prices (Issing, 2003). Baumeister,

Durinck and Peersman (2008) highlight that the first pillar, which base analysis on the long-run link between money growth and inflation may be unreliable. Money growth has been almost continuously above it reference value of 4.5 % but there still has not been any accelerating inflation (Baumeister, Durinck & Peersman, 2008). This stress the need of the second pillar and use of other indicators besides money growth. Issing (2002) do not think that asset prices are suitable goals for monetary policy. Asset prices will mainly be affected by underlying real factors such as technological development and preferences, which is out of the control of monetary policy (Issing, 2002). Even if asset prices and quantities were available it would be hard to interpret changes in asset prices (Alchian & Klein, 1973). A change could be due to a change in price of an unchanged future service flow from the asset, a preference shift in relation to other assets, a shift in preference regarding present consumption over future consumption or a change in forecasted magnitude of service flow from asset (Alchian & Klein, 1973).

2.3 Inflation in the short run

QTM is often said to hold true in the long run with less conclusive evidence of its validity in the short run. There are other theoretical frameworks used to explain inflation in the short run that revolve around aggregate demand and aggregate supply. First thing to note is that classical macroeconomic theory is based on monetary neutrality (Mankiw & Taylor, 2014, p.680-681). Monetary neutrality means that increasing the money supply will change nothing in the long run besides the nominal price level, whereas in the short run it's believed that the nominal and real variables are highly intertwined (Adam, Hudea & Moldovan, 2010; Mankiw & Taylor, 2014, p.680-681). It is believed that increased money supply can push the output from its trend (Mankiw & Taylor, 2014, p.681). Fluctuations in the short run relationship between the price level and output can be represented in the short run aggregate demand / aggregate supply curve (AD/AS) (Farmer, 2007; Mankiw & Taylor, 2014, p.682). Any event which affects how much people want to consume will shift the short run AD curve and thus affect which quantity is sold at a given price level, i.e. if people feel insecure about the future then they start saving and a lower quantity is sold at any given price level (Farmer, 2007; Mankiw & Taylor, 2014, p.684). The short run AS curve slope upwards whereas the long run is vertical (Mankiw & Taylor, 2014, p.689 - 690). This is attributed to slow adjustment of nominal wages and also due to some goods/services adjusting slowly to changes (Mankiw & Taylor, 2014, p.689 - 690).

2.4 Hypothesis 1

Increased money supply in relationship to GDP leads to CPI inflation. This hypothesis can be evaluated by using the theory from the QTM equations, more specifically equation (4) under the assumption of constant money velocity.

2.5 Hypothesis 2

The inflation which does not appear in CPI instead appear as asset price inflation. When inflation as modelled by QTM does not appear in CPI it will flow to other parts of the economy such as asset prices.

3. Methodology and data

3.1 Method

3.1.1 Test if change in money growth in relationship to GDP leads to change in CPI

The first part consists of two tests for each country, four in total.

The tests will see whether change in monetary growth in relationship to real GDP leads to change in CPI. The first period is defined as pre-1990 which model from 1961 – 1989 for USA and for Sweden from 1963 – 1989. The second test is defined as post-1990 which model from 1990 – 2019 for USA and 1990 – 2018 for Sweden. The tests make use of the quantity theory of money equation.

An assumption about constant money velocity is made, due to several reasons. The first reason is that theory claims that money velocity will be close to constant or very small shifts, at least over the long run (Fregert & Jonung, 2018, p.239). However, it is worth to point out that theory also state that advancements in financial technology and financial accessibility could affect money velocity (Fregert & Jonung, 2018, p.237). Secondly, there is a lack of reliable measurable data that could approximate money velocity. Savings rate and consumer confidence are sometimes used as proxies for money velocity. The official money velocity data from Federal reserve (2020) is simply a ratio, calculated as the ratio of quarterly nominal GDP to the quarterly average of M2 money stock. Lastly, Emerson (2011) used a proxy for money velocity which failed to show any significance.

Test whether the quantity theory of money holds for the first period, pre-1990:

$$CPI_{pre\text{-}1990} = \beta_1 * M2_t + \beta_2 * M2_{t-1} + \beta_3 * Real\ GDP_t + \beta_4 * Real\ GDP_{t-1} + \varepsilon \quad (5)$$

Test whether the quantity theory of money holds for the second period, post-1990:

$$CPI_{post\text{-}1990} = \beta_1 * M2_t + \beta_2 * M2_{t-1} + \beta_3 * Real\ GDP_t + \beta_4 * Real\ GDP_{t-1} + \varepsilon \quad (6)$$

If the quantity theory of money holds true, we expect that increased money stock will lead to higher CPI and increased real GDP will lead to lower CPI.

Method for model (5) and (6) is simple regression without a constant, using multiple explanatory variables (Dougherty, 2016, p. 160). Model (5) and (6) use lagged explanatory variables. The lagged variable simply is the value at that time period, i.e. real GDP_{t-1} becomes the value of Real GDP at previous time period *t-1* (Dougherty, 2016, p. 413). Models (5) and (6) look for cointegration relationships since we are working with I(1) processes that have been transformed to first differences (Emerson, 2011). If the parameters of the money stock are positively significant and the parameters of of real GDP are negatively significant, then our first hypothesis is correct. Meaning that the quantity theory of money holds true in the short-run, at least to some extent. We can then conclude that an increased money stock will lead to higher CPI and an increased real GDP leads to a lower CPI.

3.1.2 Test if missing CPI inflation leads to asset price inflation

Second part consist of making a forecast of CPI after 1990, one forecast for Sweden from 1990 – 2018 and one for USA from 1990 - 2019.

The forecast is done by t-step-ahead forecasting (Montgomery, Jennings & Kulahci, 2015, p.264). The forecast is done by using the parameters obtained from $CPI_{pre\text{-}1990}$ model:

$$CPI\ Forecast = \hat{\beta}_1 * M2_t + \hat{\beta}_2 * M2_{t-1} + \hat{\beta}_3 * Real\ GDP_t + \hat{\beta}_4 * Real\ GDP_{t-1} + \varepsilon$$

A forecast error is computed by taking the difference between the CPI forecast and the actual CPI (Ragnerstam, 2015). This forecast error is a measurement of how well the $CPI_{pre\text{-}}$

$_{1990}$ model performs on actual data. A large forecast error would indicate a large deviation between actual data and between the forecast values obtained from the $CPI_{pre\text{-}1990}$ model.
Calculation of forecast error:

$$CPI_{forecast\ post\text{-}1990} - CPI_{actual\ post\text{-}1990} = CPI_{forecast\ error} \qquad (7)$$

Lastly the forecast error is used to model the stock index value. This is done two times, one time for USA using S&P500 and one time for Sweden using OMX30.
Test whether $CPI_{forecast\ error}$ can be used as an explanatory variable for increase in financial asset prices:

$$Stock\ index = \alpha_1 + \alpha_1 * CPI_{forecast\ error,\ t} + \alpha_3 * CPI_{forecast\ error,\ t-1} + \alpha_4 * CPI_{forecast\ error,t-2} + \alpha_5 * CPI_{forecast\ error,t-3} + \eta \qquad (8)$$

Model (8) uses a simple regression with constant (Dougherty, 2016, p.85).
Model (8) use lagged explanatory variables, where the lagged variable simply is the value at that time period (Dougherty, 2016, p. 413). If there is a significant positive correlation between the forecast error and the stock index value, that would suggest that missing forecasted CPI is leading to asset price inflation. The second hypothesis would stand without being rejected.

3.2 Data

3.2.1 USA

For USA all the monetary data M2, Real GDP and CPI comes from the federal reserve and is annual time series data (Dougherty, 2016, p. 113). For all the monetary data, the data points in the beginning of the year are used as annual data for previous year, i.e. data from 201901-01 becomes the annual data for 2018. The monetary data for USA is collected from 1959 – 2019 which gives annual growth data for 1960 – 2019.
The data is logged and then the first difference is taken of the logged data such that it represents logged annual growth rates, this is similar data treatment which previous studies such as Andersson (2011) have done.

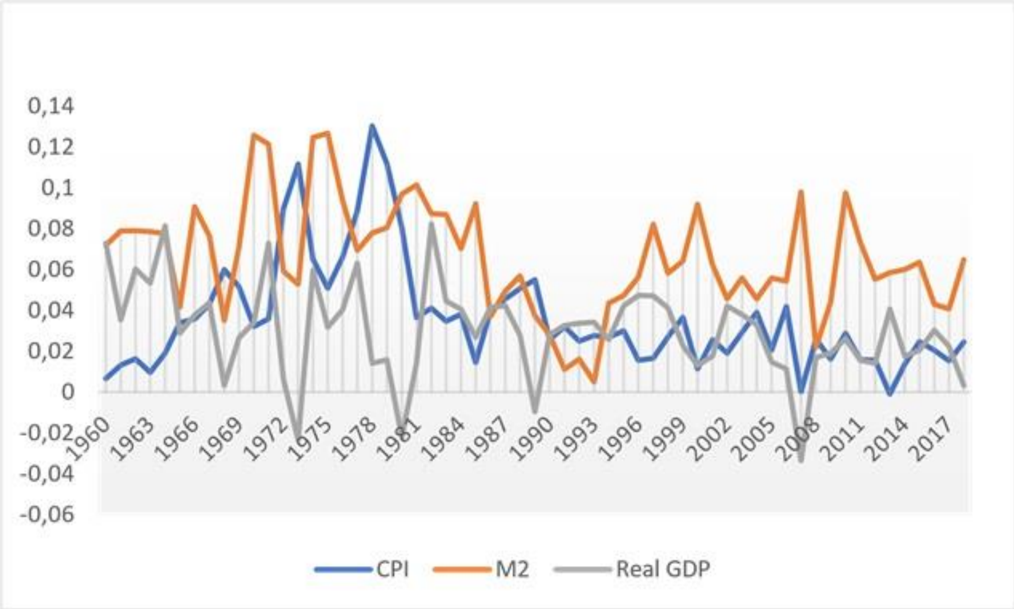

Figure 1: Annual growth of CPI, M2 and Real GDP in USA from 1960-2019.

Source: Federal Reserve

The S&P 500 index will be used as a proxy to measure financial asset prices in USA. The data collection is made from Wharton Research Data Services, using CRSP Index File on the S&P 500. The data is logged and then taking the first differences of the logged data, just like with the monetary data. The data is collected from 1989 – 2019, giving growth data for 1990 – 2019.

3.2.2 Sweden

Similar monetary data is collected for Sweden. The time period is slightly different than for USA and M3 is used as broad money instead of M2 as in the case of USA. The Swedish monetary data M3, CPI and Real GDP is collected from Statistics Sweden. The monetary data for Sweden is collected from 1961 – 2018 which gives annual growth data for 1962 – 2018. The data is logged and then the first difference is taken of the logged data such that it represents logged annual growth rates.

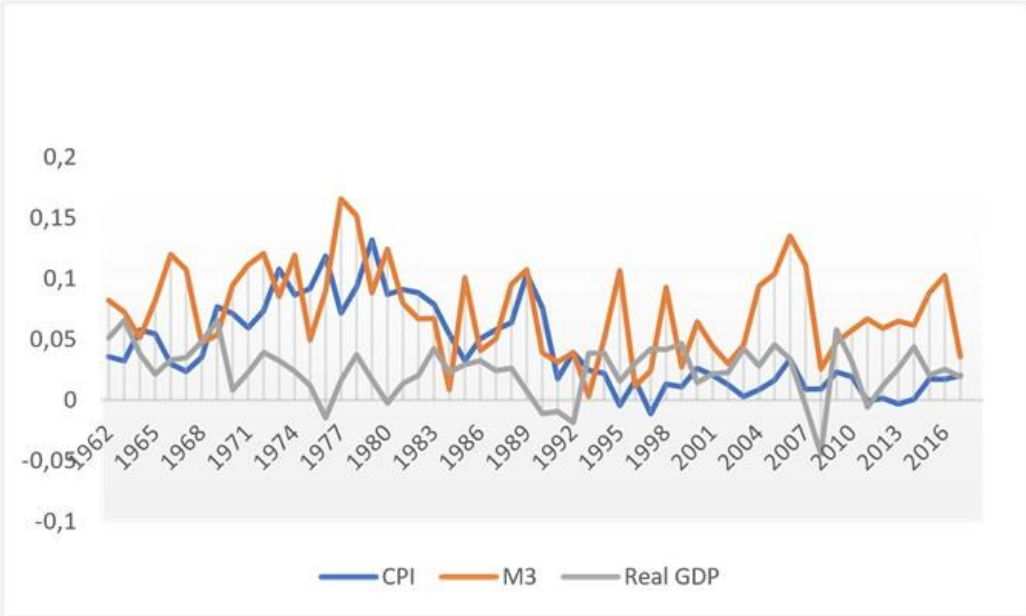

Figure 2: Annual growth of CPI, M3 and Real GDP in Sweden from 1963-2018.
Source: Statistics Sweden

OMX30 is used for Swedish stock market valuation, the data is collected from Nasdaq OMX Nordic. The last observation of the year becomes that year's annual data, i.e. 2018-12-29 becomes the annual data for 2018. The data is logged and then taking the first differences of the logged data, just like with the monetary data. The data is collected from 1989 – 2019, giving growth data for 1990 – 2019.

3.3 Descriptive statistics

Augmented Dickey-Fuller tests with a constant are performed on all the variables to determine that they are stationary (Montgomery, Jennings & Kulahci, 2015, p.367). The null hypothesis is that they are non-stationary with a unit root.

3.3.1 USA

Augmented dickey-fuller test:

Table 1

	1960 – 1989		1990 – 2019	
	Lags included	P-Value	Lags included	P-Value
CPI	1	0.05406	1	0.03337
M2	1	0.0001	0	0.01328
Real GDP	0	0.0001	0	0.01093
SP500			0	0.000247
Forecast error			0	0.05609

3.3.2 Sweden

Augmented dickey-fuller test:

Table 2

	1963 – 1989		1990 – 2018	
	Lags included	P-Value	Lags included	P-Value
CPI	0	0.1734	0	0.06499
M3	0	0.006466	0	0.00377
Real GDP	0	0.02443	0	0.002484
OMX30			0	0.0003457
Forecast error			1	0.001134

4. Results

Money stock growth in relationship to GDP growth leads to CPI inflation both for United States and Sweden in the periods leading up to 1990. Increased money stock increase CPI inflation and increased GDP decrease CPI inflation. For USA both parameters have a positive magnitude for money growth. Only the parameter for the lagged $M2_{t-1}$ is significant at 5 % significance level with value (0.527085). The parameter of Real GDP_t is negative and significant at 5 % significance level with value (−0.611491), the parameter of Real GDP_{t-1} is non-significant and close to zero. In the case of Sweden the relationship is similar but both parameters are positive and significant for money growth. The parameter of $M3_{t-1}$ show significance at 1 % significance level with value (0.491239). The parameters for Real GDP are both significant at 5 % significance level, but perhaps a bit surprisingly the lagged parameter for Real GDP_{t-1} is positive with value (0.663754). The parameter for Real GDP_t is negative with value (-0.726219). The net effect is still negative which indicate that QTM is a good estimate for predicting CPI inflation, meaning that increased money supply leads to higher CPI and increased Real GDP leads to lower CPI.

This relationship breaks down after 1990. In the case of United States, increased money stock still leads to higher CPI inflation. The parameter for $M2_{t-1}$ is still significant with value (0.297392). However, increased GDP now seems to lead to a higher CPI inflation which go against what the QTM equation states. The parameter for Real GDP_{t-1} is significant at 5 % significance level and positive with value (0.369564). For Sweden there is still evidence that money stock growth led to increased CPI inflation after 1990, at least at 10 % significance level. There is no longer a significant relationship between GDP and CPI inflation.

There is no evidence that the missing CPI is leading to increased asset prices for USA or Sweden. The forecast error at period *t* has a significant relationship for USA, but in the opposite direction than what the hypothesis predicts. This is likely due to the fact that the forecast error correlates with GDP which in turn correlates with S&P500, see appendix A. The forecast error show no significant relationship for Sweden. Both constants show significant relationship for USA and Sweden when predicting S&P500 and OMX30, this is simply due to average trend growth in the indices.

4.1 USA

Table 3

Dependent variable:	$CPI_{1961-1989}$	$CPI_{1990-2019}$	$S\&P500_{1994-2019}$
$M2_{t}$	0.328266	−0.100166	
	(0.221630)	(0.125396)	
$M2_{t-1}$	0.527085**	0.297392**	
	(0.247545)	(0.113669)	
Real GDP_{t}	−0.611491**	0.0883741	
	(0.232699)	(0.155112)	
Real GDP_{t-1}	0.0202314	0.369564**	
	(0.230650)	(0.176446)	
Constant			0.113505***
			(0.0362894)
Forecast $error_{t}$			−4.28708***
			(1.46906)
Forecast $error_{t-1}$			2.41202
			(1.54402)
Forecast $error_{t-2}$			−0.321569
			(1.52648)
Forecast $error_{t-3}$			−1.20546
			(1.36451)
Uncentered R^2	0.746952	0.758363	
Adjusted R^2			0.197759

* denotes significance at 10%; ** significance at 5%; and *** significance at 1%

Model 3 (forecast):

$$CPI_{forecast\ 1991\text{-}2019} - CPI_{actual\ 1991\text{-}2019} = CPI_{forecast\ error}$$

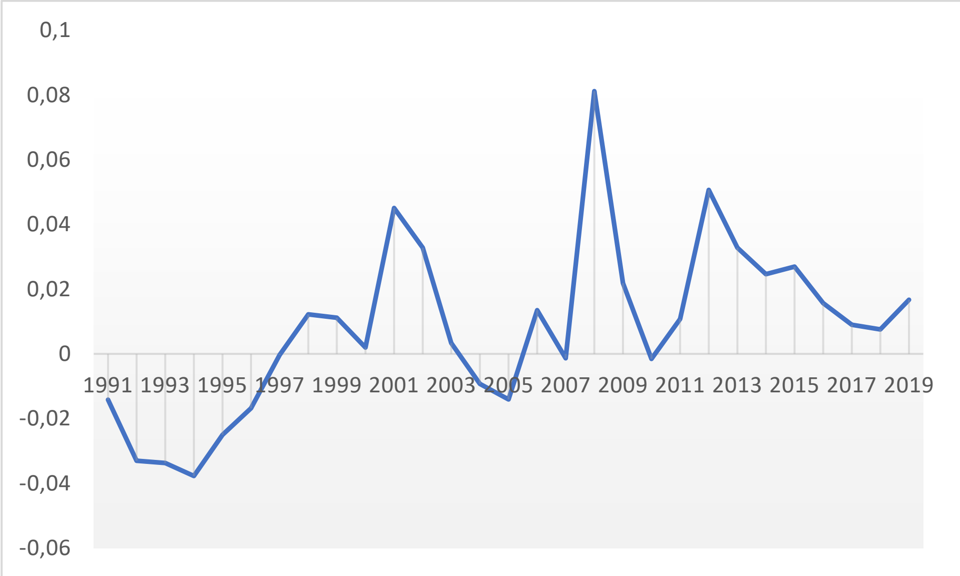

Figure 3: Forecast error in USA from 1991-2019

Source: Derived using data from Federal Reserve

4.2 Sweden

Table 4

Dependent variable:	$CPI_{1963-1989}$	$CPI_{1990-2018}$	$OMX30_{1993-2018}$
$M3_t$	0.289326** (0.130241)	0.162938 (0.141551)	
$M3_{t-1}$	0.491239*** (0.145712)	0.200644* (0.107861)	
Real GDP $_t$	−0.726219** (0.329955)	−0.0651223 (0.179888)	
Real GDP $_{t-1}$	0.663754** (0.295745)	−0.175918 (0.220327)	
Constant			0.180166* (0.0874476)

Forecast error $_t$			−2.13236 (1.51475)
Forecast error $_{t-1}$			1.12315 (1.54566)
Forecast error $_{t-2}$			−2.09325 (1.55664)
Forecast error $_{t-3}$			−0.234273 (1.47892)
Uncentered R^2	0.879686	0.464382	
Adjusted R^2			0.013444

* denotes significance at 10%; ** significance at 5%; and *** significance at 1%

Model 3 (forecast):

$$CPI_{forecast\ 1990\text{-}2019} - CPI_{actual\ 1990\text{-}2019} = CPI_{forecast\ error}$$

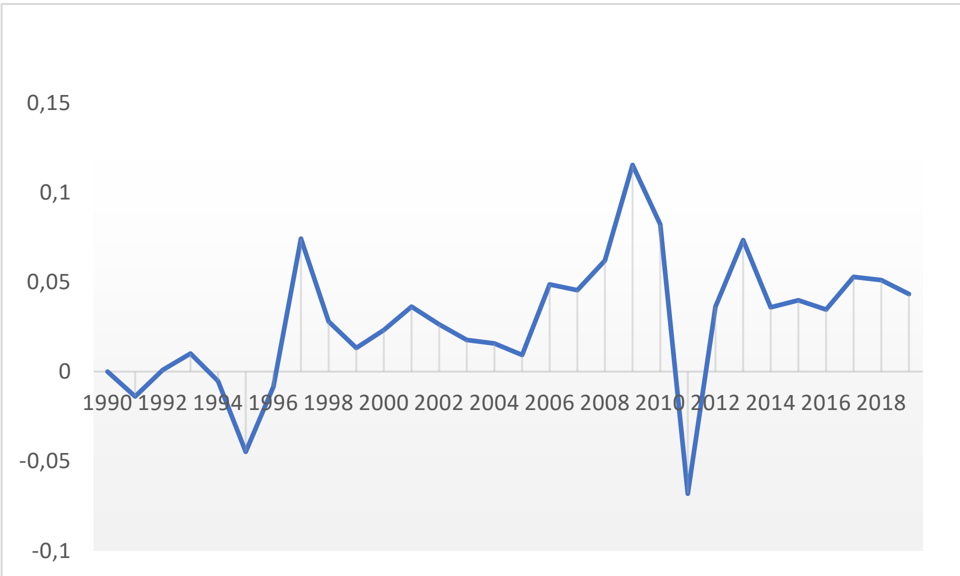

Figure 4: Forecast error in Sweden from 1990-2018.

Source: Derived using data from Statistics Sweden

5. Discussion

The CPI inflation in the period leading up to 1990 tends towards the long-term theoretical trend according to QTM, which is 1 for the effect of M2 and -1 for the effect of Real GDP (Fregert & Jonung, 2018, p.238 - 239). The negative effect of real GDP on CPI inflation is weaker in the case of Sweden than for USA. The relationship breaks down after 1990, both for USA and Sweden. From the period of 1990 – 2019 in USA when the QTM relationship breaks down, the effect of M2 is relatively low and perhaps more surprisingly the effect of Real GDP is in opposite direction than what theory would suggest it should be. The opposite direction of effect from Real GDP is particularly interesting, it may be due to saved money which have created a sort of inflation potential which then starts to release once the economy accelerates (Real GDP increase) which increase inflation.

One way to think about it is that there might be a build-up of money stock due to actions by the Federal reserve. Whenever there is a recession, there is build-up of money stock. Either by direct injection of monetary base or continued build-up of credit when the interest rate is cut which in turn cause higher money stock. Once the economy gets going then real GDP increase and so will money velocity. Money velocity is partly a function of GDP by definition. The relationship could be non-linear *(∂Money velocity (real GDP)/ ∂real GDP) > 0.* This is likely an effect of a levered economy. The more levered the economy, the higher the breaks in money velocity in a downturn due to need of deleveraging. The level of leverage in the economy is partly due to what type of policies a central bank is enacting.

Sargent and Surico (2010) showed that one explanation of why the QTM could break down from one period to another has to do with what type of policies the central banks are pursuing, i.e. whether the central banks pursue an inflation-targeting policy or an unemployment targeting policy will affect QTM's validity. This breakdown could also be the initial reason for money stock build up, lower interest rates and higher debt levels.

The results found no evidence of asset price inflation from missing CPI inflation, not for Sweden or USA. Perhaps the simplest explanation for the elevated stock market valuations the past decades is the relative value investors see in stocks as they experience lower interest rates with falling yields on bonds and savings accounts (Burda & Wyplosz, 2017, p.260). If the yields have been falling due to increased demand of bonds and savings account and not due to interest rate suppression by central banks, then it is likely that there is some increased demand by specific groups. It could be by increased demand from the oldest deciles in the economy seniors or the wealthiest deciles. Mechanism behind increased inflation within financial assets could be the following: (1) Interest rate goes down (2) Companies increase their debt level, which (3) increase M2 supply. (3) Companies use this leverage to buy back stocks. (4) Increase financial assets price levels. It creates a debt driven asset bubble (Fregert & Jonung, 2018, p. 514 – 515; Dalio, 2019). QE is another related mechanism, which also often affects yields. QE can be seen as an asset swap (Business insider, 2010). This asset swap would benefit those who own the assets swapped with QE and the relative value arbitrage which appear. This could push up prices on assets owned by the wealthier deciles in society. It is worth stressing that even though the results in this paper do not find any evidence of missing CPI inflation leading to asset price inflation, the effect may still be there when using other methods or looking at longer term price developments. Future research could employ alternative methods to look at longer term effects, such as using moving averages in the models.

Analysis of CPI inflation and asset price inflation could be improved by expanding understanding of inflation for specific groups. An alternative explanation regarding the divergence of M2 and CPI inflation is that the wealthy are getting wealthier (Bricker et al., 2020). Wealthier people likely spend a larger proportion of their money on assets instead of consumer goods. This would give rise to a long-term shift. They are not necessarily just being acted upon by monetary forces such as lower interest rates or easier credit, but it might actually be they as a group who drive up stock prices. As stated in the theory chapter, the original QTM is defined as $M * V \equiv P * T$ but usually a proxy is used $M * V \equiv P * Y$. $Y \subset T$ and Y is assumed to be stable in relationship to T over time. CPI is an even more imperfect proxy of total inflation in T since; Total transactions captured by CPI $\subset Y \subset T$. If the wealth gap increase and wealthier people spend a larger proportion on assets over consumer goods, then the relationship between Y and T would no longer be stable and alternative methods to CPI or GNP-deflator would have to be employed to capture total inflation in an economy. See appendix B for suggestion.

The result found in this paper suggest that small and large developed economies follow similar trends, although it is noteworthy that the effect of Real GDP was comparatively small for Sweden during the period leading up to 1990. It is also hard to make any strong conclusions since this paper only studies one large economy and one small economy.
It is still likely that most developed countries face similar effects like those observed in the US and Sweden. Largely since there are efforts to harmonize policy and policy convergence through institutions such as the Bank of International Settlement (White, 1994).
There are several potential effects on CPI inflation and asset price inflation which has not been accounted for in this research such as change in commodity prices due to shift in scarcity, change in labour costs, globalization, technological advancements or an aging population. Other less obvious sources of inflation could be decreased quality of public services per tax dollar spent or increased externalities such as air pollution or information pollution.

6. Conclusion

Increased money supply in relation to real GDP does not lead to increased CPI inflation after 1990. There is no evidence that missing CPI inflation has led to asset price inflation, at least not with the methodology applied in this paper. The quantity theory of money holds in the period leading up to 1990 and the parameters move towards their long-term prediction. For USA there is an interesting shift in how the Real GDP variable in the QTM model behave for the period 1990 – 2019. Real GDP had a positive correlation with inflation during this period. The forecast error from QTM for period 1990 – 2019 did not have any explanatory power. There is evidence pointing at a breakdown of the QTM model after 1990, this breakdown might be explained by different central bank policy approaches yielding different reliability of the QTM. Furthermore, the breakdown in the QTM could be because of a break in the initial assumption of stable Y against total transactions in an economy. It's not unlikely that different policies will shift incentives, some which incentives increased ownership of financial assets which increase wealth disparities which in turn further dislocate money spent in consumer economy versus financial economy.

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Appendix A.

Table A

Dependent variable:	S&P500$_{1992\text{-}2019}$
Constant	−0.0358372
	(0.0819220)
Forecast error $_{t}$	−1.03034
	(1.77426)
Forecast error $_{t-1}$	0.827448
	(1.76198)
Real GDP $_{t}$	5.9146**
	(2.69058)
Real GDP $_{t-1}$	−1.33663
	(2.72965)
Adjusted R^2	0.278162

* denotes significance at 10%; ** significance at 5%; and *** significance at 1%

Appendix B.

The alternative way could be captured by shifting focus a little bit. Away from a vector of transactions and towards a matrix of individuals and goods. This could be done in practice with sampling and anonymization of data or perhaps by government with access to ledger of full transactions, i.e. similar to the digital Yuan under development which tracks user to user transactions. A rough formal definition could look like this;

Buy-side:

$ps_{m,n}$ is vector prices for particular transactions spent on good/service m by person/entity n.

$ps_{m,n} \subset p$ where p is representative of P

$qs_{m,n}$ is quantity for particular transaction on good m by person/entity n.

$qs_{m,n} \subset q$ where q is approximation for T

$$A = \begin{bmatrix} ps_{1,1} \times qs_{1,1} & ps_{1,2} \times qs_{1,2} & \cdots & ps_{1,n} \times qs_{1,n} \\ \vdots & \vdots & \ddots & \vdots \\ ps_{m,1} \times qs_{m,1} & ps_{m,2} \times qs_{m,2} & \cdots & ps_{m,n} \times qs_{m,n} \end{bmatrix}$$

Sell-side:
$pb_{m,n}$ is vector prices for particular transactions spent on good/service m by person/entity n.
$pb_{m,n} \subset p$ where p is representative of P
$qb_{m,n}$ is quantity for particular transaction on good/service m by person/entity n.
$qb_{m,n} \subset q$ where q is approximation for T

$$B = \begin{bmatrix} pb_{1,1} \times qb_{1,1} & pb_{1,2} \times qb_{1,2} & \cdots & pb_{1,n} \times qb_{1,n} \\ \vdots & \vdots & \ddots & \vdots \\ pb_{m,1} \times qb_{m,1} & pb_{m,2} \times qb_{m,2} & \cdots & pb_{m,n} \times qb_{m,n} \end{bmatrix}$$

Total sum spent on each good:

C = A – B =

$$\begin{bmatrix} ps_{1,1} \times qs_{1,1} - pb_{1,1} \times qb_{1,1} & ps_{1,2} \times qs_{1,2} - pb_{1,2} \times qb_{1,2} & \cdots & ps_{1,n} \times qs_{1,n} - pb_{1,n} \times qb_{1,n} \\ \vdots & \vdots & \ddots & \vdots \\ ps_{m,1} \times qs_{m,1} - pb_{m,1} \times qb_{m,1} & ps_{m,2} \times qs_{m,2} - pb_{m,2} \times qb_{m,2} & \cdots & ps_{m,n} \times qs_{m,n} - pb_{m,n} \times qb_{m,n} \end{bmatrix}$$

From these matrices it would now be easy to find average price on particular good by dividing total amount spent (or made) on each good/service with the total quantity bought (or sold), as well as finding weights for each good for each person by simply summing total spent and then divide each amount spent on particular good with the total. Inflation could be calculated by looking at sum of average price (either positive or negative) then multiply quantity and divide by sum for each good, then you compare average price from time period to time period and adjust weighting, this will make up inflation. Lastly one could associate each person (m, row in matrix) with other attributes such as age, income or wealth as well as associations for each good/service, i.e. if it's a consumption good or a financial asset which makes it possible to analyze group specific inflation. The associated attributes could be sorted and formed into deciles. As an example, it wouldn't be a surprise if the top decile for income or wealth is using a larger proportion of their money on financial assets than the rest of the population. Therefore, if the rich are getting richer you could expect "more money, chasing fewer goods" for that specific wealth-decile. This will in turn break the initial assumption in the quantity theory of money, that the relationship between Y and T is stable.