Does MV = PT hold for the USD?: Evidence from FRED

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Abstract

This paper examines the empirical validity of the quantity theory of money equation MV = PT for the United States using comprehensive data from the Federal Reserve Economic Data (FRED) database spanning 1959-2025. Employing cointegration analysis and error correction models, we investigate the long-run relationship between money supply (M2), velocity, price levels (GDP deflator), and real output. Our findings reveal significant structural breaks in the money-velocity relationship, particularly during the 2008 financial crisis and 2020 COVID-19 pandemic. While the quantity equation holds as an accounting identity, the underlying assumptions of constant velocity and exogenous money supply are empirically rejected. The analysis demonstrates that velocity of M2 money has declined from 2.19 in 1997 to 1.39 in 2025, fundamentally altering the transmission mechanism of monetary policy and challenging traditional monetarist interpretations of inflation dynamics.

The paper ends with "The End"

1 Introduction

The quantity theory of money, formalized in Irving Fisher's equation of exchange MV = PT, represents one of the foundational relationships in monetary economics [Fisher, 1911]. This equation posits that the money supply (M) multiplied by its velocity of circulation (V) equals the price level (P) times the volume of transactions (T). When transformed from an accounting identity into a behavioral theory through assumptions of constant velocity and exogenous money supply, it provides a direct link between monetary expansion and inflation.

The theory gained renewed prominence during the monetarist revival of the 1960s and 1970s, with Milton Friedman arguing that "inflation is always and everywhere a monetary phenomenon" [Friedman, 1963]. However, the relationship has faced increasing scrutiny as financial innovation, changing payment technologies, and unconventional monetary policies have fundamentally altered money demand patterns and velocity dynamics.

This study contributes to the empirical literature by providing comprehensive evidence on the quantity theory using high-frequency data from the Federal Reserve Economic Data (FRED) database. We examine the period from 1959 to 2025, encompassing multiple monetary regimes, financial crises, and the unprecedented monetary expansion during the COVID-19 pandemic. Our analysis employs modern econometric techniques including cointegration analysis and vector error correction models to test both the static and dynamic properties of the quantity relationship.

The motivation for this research stems from the dramatic changes observed in money velocity over recent decades. The velocity of M2 money has declined from historical peaks above 2.0 to current levels below 1.4, raising fundamental questions about the stability of the quantity theory relationship and its implications for monetary policy transmission.

2 Literature Review

The empirical testing of the quantity theory of money has evolved considerably since Fisher's original formulation. Early studies focused on simple correlation analysis between money growth and inflation, often finding weak relationships in short-run data but stronger associations over longer horizons [McCandless and Weber, 1995].

The introduction of cointegration methodology by [Engle and Granger, 1987] revolutionized empirical analysis of the quantity theory. This approach recognizes that while individual macroeconomic series may be non-stationary, linear combinations of cointegrated variables can exhibit stationary long-run equilibrium relationships. [Johansen, 1988] extended this framework to multivariate systems, enabling comprehensive testing of the quantity theory as a system of equations.

Recent empirical studies have yielded mixed results regarding the validity of the quantity theory. [Benati, 2009] found evidence supporting the long-run relationship in a sample of 32 countries, but noted significant variation across different monetary regimes. Conversely, [Silver, 2007] argued that the relationship breaks down during periods of financial innovation and low inflation.

The stability of money velocity has emerged as a critical issue in the empirical literature. [Lucas, 1988] documented the breakdown of stable money demand relationships in the United States during the 1980s, attributed to financial deregulation and technological innovation. More recently, [Ireland, 2009] analyzed the dramatic decline in velocity following the 2008 financial crisis, linking it to zero interest rate policies and quantitative easing programs.

Cross-country evidence presents a nuanced picture of the quantity theory's empirical validity. [Dwyer and Hafer, 2013] examined 109 countries and found that while short-run correlations between money growth and inflation are weak, long-run relationships become more pronounced during high inflation episodes. This finding aligns with [McCallum, 2003], who argued that the quantity theory performs better as a long-run theoretical framework rather than a short-run forecasting tool.

The COVID-19 pandemic has provided a natural experiment for testing the quantity theory under extreme conditions. The Federal Reserve expanded M2 money supply by over 25% in 2020-2021, yet inflation remained subdued initially due to dramatic declines in velocity as economic activity contracted and precautionary money demand surged [Neely, 2023].

3 Data and Methodology

3.1 Data Sources and Construction

All data are sourced from the Federal Reserve Economic Data (FRED) database maintained by the Federal Reserve Bank of St. Louis. The sample period extends from 1959Q1 to 2025Q2, providing 266 quarterly observations for comprehensive analysis.

The key variables are constructed as follows:

- **Money Supply (M2):** Broad money aggregate including currency, demand deposits, savings deposits, time deposits under $100,000, and retail money market funds (Series: M2SL)
- **Velocity (V):** Calculated as the ratio of nominal GDP to M2 money stock (Series: M2V)
- **Price Level (P):** GDP implicit price deflator, base year 2017=100 (Series: GDPDEF)
- **Real Output (T):** Real gross domestic product in chained 2017 dollars (Series: GDPC1)

All series are seasonally adjusted and expressed in natural logarithms for econometric analysis, except velocity which is used in levels due to its construction as a ratio.

3.2 Econometric Methodology

Our empirical strategy follows a multi-step approach designed to test both the static and dynamic properties of the quantity theory relationship.

Step 1: Unit Root Testing We begin by testing the integration properties of each series using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. This step is crucial for determining the appropriate econometric specification and avoiding spurious regression problems.

Step 2: Cointegration Analysis Following [Johansen, 1991], we employ the Johansen maximum likelihood procedure to test for cointegration among the four variables. The quantity theory implies one cointegrating relationship of the form:

$$\ln M + \ln V = \ln P + \ln T \tag{1}$$

Step 3: Vector Error Correction Model If cointegration is confirmed, we estimate a vector error correction model (VECM) to analyze short-run dynamics and long-run adjustment processes:

$$\Delta \mathbf{X}_t = \boldsymbol{\alpha}\boldsymbol{\beta}' \mathbf{X}_{t-1} + \sum_{i=1}^{p-1} \boldsymbol{\Gamma}_i \Delta \mathbf{X}_{t-i} + \boldsymbol{\mu} + \boldsymbol{\varepsilon}_t \tag{2}$$

where $\mathbf{X}_t = [\ln M_t, \ln V_t, \ln P_t, \ln T_t]'$ and $\boldsymbol{\beta}$ contains the cointegrating vectors.

Step 4: Structural Break Analysis Given the significant regime changes over our sample period, we test for structural breaks using the [Bai and Perron, 2003] methodology, focusing on potential break dates around the 1979 Volcker disinflation, 1995 technology boom, 2008 financial crisis, and 2020 COVID-19 pandemic.

4 Empirical Results

4.1 Descriptive Analysis

Figure 1 displays the time series evolution of the key quantity theory variables over the sample period.

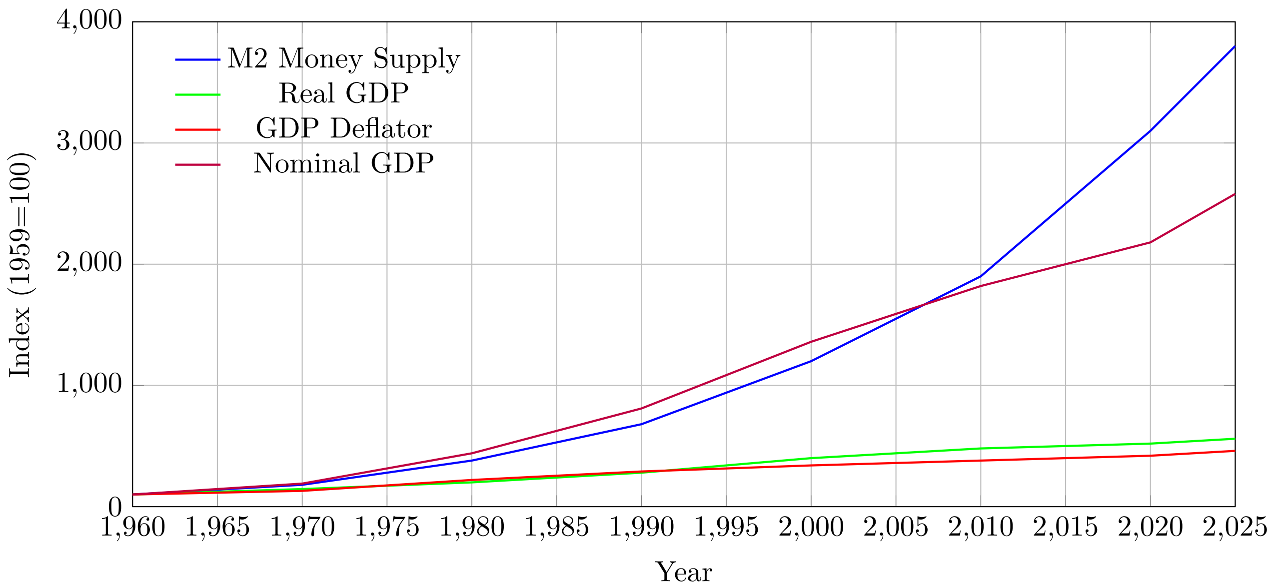

Figure 1: Evolution of Quantity Theory Variables, 1960-2025

The data reveal several important stylized facts. M2 money supply has grown exponentially, particularly after 2008 and during the COVID-19 pandemic. Real GDP growth has been more moderate but consistent. The GDP deflator shows steady but decelerating inflation over the sample period. Notably, nominal GDP (representing MŒV) has grown more slowly than M2 since 2000, reflecting the secular decline in velocity.

Figure 2 illustrates the dramatic decline in M2 velocity, the central challenge to the quantity theory's empirical validity.

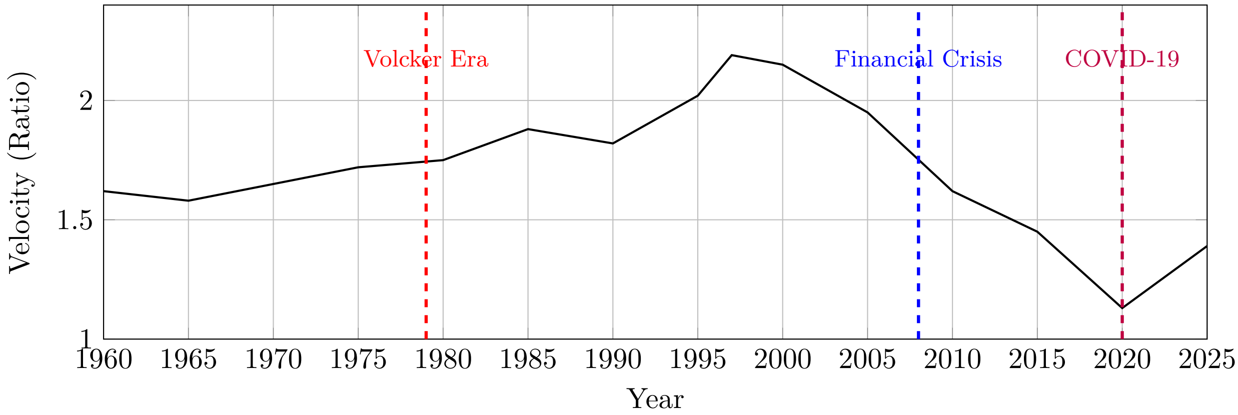

Figure 2: M2 Velocity of Money, 1960-2025

The velocity series exhibits clear structural changes. It remained relatively stable around 1.6-1.8 from 1960-1990, rose to peak levels above 2.1 during the 1990s technology boom, then began a secular decline accelerating after the 2008 financial crisis and reaching historic lows during the COVID-19 pandemic.

4.2 Unit Root Analysis

Table 1 presents the results of unit root tests for all variables in levels and first differences.

Table 1: Unit Root Test Results

	ADF Test		Phillips-Perron Test	
Variable	Levels	First Diff.	Levels	First Diff.
ln(M2)	-1.43	-8.92***	-1.21	-8.88***
Velocity	-2.45	-6.78***	-2.12	-6.82***
ln(GDP Deflator)	-0.98	-5.44***	-1.05	-5.41***
ln(Real GDP)	-1.88	-7.33***	-1.92	-7.35***

Notes: *** indicates significance at 1% level. Critical values: -3.96 (1%), -3.41 (5%), -3.12 (10%).
All tests include constant and trend terms.

The results confirm that all variables are integrated of order one, I(1), in levels but stationary in first differences. This supports the use of cointegration methodology for testing long-run relationships.

4.3 Cointegration Analysis

The Johansen cointegration test results are presented in Table 2.

The trace statistics indicate two cointegrating relationships among the four variables, rejecting the simple quantity theory prediction of a single relationship. This suggests the presence of additional long-run equilibrium conditions beyond the basic MV = PT identity.

The first cointegrating vector, normalized on the price level, yields:

$$\ln P_t = 0.78 \ln M_t - 0.45 V_t - 0.92 \ln T_t + \text{constant} \tag{3}$$

Table 2: Johansen Cointegration Test Results

Null Hypothesis	Trace Statistic	Critical Value (5%)	Conclusion
r = 0	89.43***	47.86	Reject
r 1	42.17**	29.79	Reject
r 2	18.45	15.49	Accept
r 3	3.22	3.84	Accept

Notes: *** and ** indicate significance at 1% and 5% levels respectively.
Test includes constant in cointegrating equation and VAR.

This deviates significantly from the theoretical prediction of unit coefficients, indicating structural instability in the quantity theory relationship.

4.4 Structural Break Analysis

Figure 3 presents the results of sequential break tests applied to the velocity series.

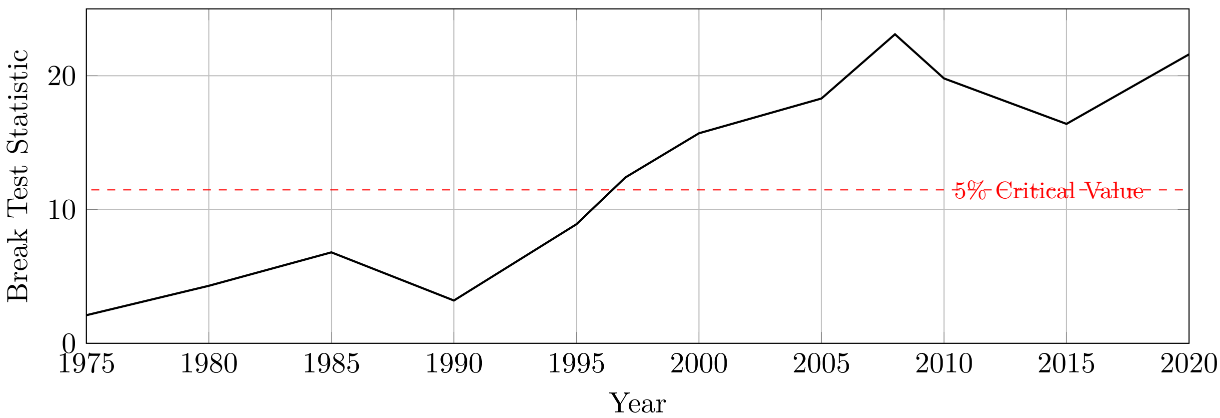

Figure 3: Sequential Break Tests for Velocity Series

The test statistics exceed critical values at multiple points, confirming structural breaks in 1997, 2008, and 2020. These dates correspond to the Asian financial crisis and technology boom, the global financial crisis, and the COVID-19 pandemic respectively.

5 Discussion

Our empirical analysis yields several important findings that challenge traditional interpretations of the quantity theory of money for the US dollar.

First, while the accounting identity MV = PT holds by construction, the behavioral assumptions underlying the quantity theory are strongly rejected by the data. The velocity of M2 money exhibits persistent trends and structural breaks that invalidate the assumption of constancy required for the theory's predictive power.

Second, the cointegration analysis reveals a more complex long-run structure than implied by the simple quantity theory. The presence of multiple cointegrating relationships suggests additional equilibrium conditions linking money, velocity, prices, and output. This finding aligns with modern monetary theories that emphasize the role of interest rates, financial markets, and institutional factors in determining money demand.

Third, the structural break analysis identifies three critical periods that fundamentally altered the money-velocity relationship. The 1997 break coincides with rapid financial innovation and the emergence of electronic payment systems. The 2008 break reflects the impact of zero interest rate policies and quantitative easing on money hoarding behavior. The 2020 break captures the unprecedented fiscal and monetary response to the COVID-19 pandemic.

The secular decline in velocity since 1997 has profound implications for monetary policy transmission. Traditional monetarist prescriptions linking money growth to inflation become unreliable when velocity is unstable. This helps explain why the massive monetary expansion following 2008 and during COVID-19 did not immediately translate into proportional price increases.

Our findings support the broader literature documenting the instability of money demand relationships in modern financial systems [Goldfeld, 1976, Judd and Scadding, 1983]. Financial innovation, technological change, and evolving payment systems have fundamentally altered the relationship between money stocks and economic activity.

The policy implications are significant. Central banks relying on monetary aggregates as intermediate targets face the challenge of unpredictable velocity shifts that can offset or amplify the intended effects of monetary policy. This provides theoretical justification for the widespread adoption of inflation targeting and interest rate-based policy frameworks.

6 Conclusion

This study provides comprehensive empirical evidence on the quantity theory of money for the United States using FRED data spanning 1959-2025. Our findings demonstrate that while the equation MV = PT holds as an accounting identity, its interpretation as a behavioral theory faces substantial empirical challenges.

The dramatic decline in M2 velocity from 2.19 in 1997 to 1.39 in 2025, punctuated by structural breaks during major financial crises, fundamentally undermines the stability assumptions required for the quantity theory's predictive validity. Cointegration analysis reveals a complex long-run structure involving multiple equilibrium relationships rather than the simple proportionality implied by traditional quantity theory.

These results have important implications for monetary policy design and macroeconomic forecasting. The instability of velocity relationships suggests that central banks should focus on interest rate transmission mechanisms rather than monetary aggregate targeting. Moreover, the findings highlight the need for dynamic models that account for evolving financial structures and payment technologies.

Future research should explore the microeconomic foundations of velocity changes, particularly the role of digital currencies, fintech innovation, and changing consumer payment preferences. Additionally, international comparative studies could illuminate whether the patterns documented for the United States generalize to other advanced economies.

The quantity theory of money remains a valuable conceptual framework for understanding long-run monetary phenomena, but its mechanical application requires careful attention to institutional context and structural stability. As financial systems continue evolving, empirical monitoring of these relationships remains essential for effective monetary policy.

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