

Money Supply and Non-Inflationary Growth: A New Monetary Policy Rule

Patrick Bolton[§], Haizhou Huang^{#1}.

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Preliminary. Comments are welcome.
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Abstract

The paper proposes a new monetary policy rule which is designed to maximize non-inflationary growth, and highlights how inflation targeting, constant money growth, or Taylor rules deviate from this rule. The rule relates to the solution of a dynamic investment problem under a positive NPV standard; it does not directly relate to an inflation target nor to an estimated output gap. In our analysis, the optimal money supply problem is a dynamic optimal investment problem. Therefore our new monetary policy rule connects and integrates two seemingly unrelated literatures, namely the static Philips curve tradeoff and the dynamic macroeconomics of growth. We find that based on our new rule, many inflation-targeting countries could expand their money supply to achieve higher growth while keeping inflation at bay. In turn, many non-inflation-targeting countries could move towards more restrictive money supply (and higher policy rates) to achieve both lower inflation and stronger growth.

[§]: Patrick Bolton: Imperial College London Business School, CEPR and NBER.

[#]: Haizhou Huang, Tsinghua University PBC School of Finance, and External Member of Monetary Policy Committee at the People's Bank of China.

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1. Introduction

The monetary policy rules that are in place today are founded on the rational expectations macroeconomic analysis of the 1990s, which has simultaneously established the importance of time consistency, policy credibility, the resultant benefits of a rule-based monetary policy, and the superiority of reactive rules à la Taylor (1993) over constant money growth rules à la Friedman and Schwartz (1965).² From this macroeconomic research, which affirmed that there is a natural rate of unemployment, that there is no tradeoff between inflation and unemployment (in the long run), emerged the new consensus among central banks that the best prescription for monetary policy is to target low inflation.

By many accounts, the new era of inflation targeting has succeeded in taming inflation: “In recent years, many central banks have adopted inflation-targeting frameworks for the conduct of monetary policy. These have proven in a number of countries to be effective means of first lowering inflation and then maintaining both low and stable inflation and inflation expectations, without negative consequences for the output gap.” This is how Svensson and Woodford (2005), for example, have assessed the record of inflation targeting in the early years of this era.

One may of course wonder whether inflation targeting was necessary to tame inflation. Mervyn King’s answer to this question was: “I do think that inflation targeting made our job easier by reducing the cost of making the right decisions monetary stability, or macroeconomic stability more generally, is a bit like healthy living: you need to find a sustainable way of doing it. There is no point alternating between a crash diet and bingeing. That is the boom/bust syndrome. The key is to find a way of setting policy that can be sustained. I think it is helpful to devise procedures, whether they be thought of as monetary policy rules or whether they are institutions that remove temptation, to help the weaker brethren explain themselves to others.”

Even central banks that did not formally adopt an inflation targeting rule, like the Federal Reserve, benefited from the general switch to inflation targeting through enhanced credibility for maintaining low and stable inflation (Bernanke, 2003). Yet, Bernanke goes on to argue against an entirely rule-based monetary policy, and favors a regime of constrained discretion: “Under constrained discretion, the central bank is free to do its best to stabilize output and employment in the face of short-run disturbances,” and adds “Although constrained discretion acknowledges the crucial role that monetary policy plays in stabilizing the real economy, this policy framework does place heavy weight on the proposition that maintenance of low and stable inflation is a key element—perhaps I should say the key element—of successful monetary policy.” Going one step further, his successor, Kevin Warsh, abandoned forward guidance, which had been introduced to enhance the Fed’s commitment ability, from the Federal Reserve’s policy framework soon after he became the Fed Chairman. Warsh also seems to emphasize the importance of economic growth for the conduct of monetary policy.

So, discretion is seen as necessary to offset the potentially negative effects on output of a rigid inflation target rule, at least in the short run. But could a framework anchored around maintaining low, stable inflation also have detrimental effects on growth in the long run? And if so, are there better rules that are more accommodating of economic growth, while still being non-inflationary? These are the questions we explore in this paper.

² Friedman (1968) further suggested in his presidential address to the American Economic Association in 1967 that deflation is necessary to induce savers to hold the right amount of non-interest bearing money balances. See Mankiw and Reis (2018) for further discussion.

We launch our analysis by going back to the basics, the quantity theory of money equation, $M_t V_t = P_t T_t$. But contrary to the rudimentary monetarist assertion that “longer-period changes in money income produced by a changed secular rate of growth of the money stock are reflected mainly in different price behavior rather than in different rates of growth of output” (Friedman and Schwartz, 1965), we allow for the possibility that the growth of the money stock, if deployed efficiently, could result in higher growth in output rather than a higher growth in prices.

Bolton and Huang (2018, 2024) draw an analogy between fiat money and equity capital. Money supply, or fiat money issuance, is analogous to stock issuance for a company. And the criterion for optimal investment funded by stock issuance in corporate finance—the positive net present value (NPV) rule—is suggested as offering a lead for an optimal money supply policy: the maximization of non-inflationary growth. When the proceeds from an equity issue are used to finance a positive NPV investment then the stock price rises to reflect the addition in net value from the investment. In other words, there is no dilution in share value from the equity issue. Bolton and Huang (2018) make a parallel between the dilution of share value and inflation (or currency debasement), to make the key observation that an increase in money supply to fund an expansion in output may not be inflationary, just as an equity issuance may not be dilutive, provided of course that the expansion in output funded by the increased money supply is sufficiently large.

This perspective fundamentally changes how one thinks about optimal money supply, which becomes a dynamic optimal investment problem. It also changes how one interprets the quantity theory equation $M_t V_t = P_t T_t$, as it allows for the possibility that an increase in M_t could materialize in an increase in T_t , while keeping P_t constant. Accordingly, an optimal monetary policy rule, from a welfare and growth perspective is one that allows for expansions in money supply to fund investment and increase output, as long as this is non-inflationary. The optimal monetary policy rule becomes the solution of a dynamic investment problem under a positive NPV standard, and it naturally connects and integrates two seemingly unrelated macroeconomic literatures, namely monetary economics based on transitory inflation versus output gap episodes and the dynamic long-run macroeconomics of growth.

The monetary policy rule we propose provides a new lens through which to better understand the growth implications of monetary policies. To illustrate what can be learned by looking at the time series through this new lens, we plot two time series for each country: GDP_t/M_t and the slope of GDP_t/M_t , which we denote by the index χ_t (in reference to the word money in Greek, $\chi\rho\acute{\eta}\mu\alpha\tau\alpha$). The index χ_t is the critical variable in our new monetary policy rule. As we will show, it measures how far money supply deviates from the optimal rule in terms of achieving maximum non-inflationary growth. When the index χ_t is strictly positive, this suggests that more money financing of productive investments or expenditures would achieve higher growth. Vice versa, a value of χ_t that is strictly negative suggests that increases in money supply have been wasted on unproductive expenditures, resulting in lower real GDP growth.

We can see clearly from the country plots for the index χ_t , that χ_t fluctuates around a horizontal line $\chi_t = 0$. When χ_t hugs this horizontal line the economy performs well, showing strong growth and low inflation. When χ_t is positive, money supply is too restrictive, and when χ_t is negative, it is too loose. Also, χ_t jumps away from this horizontal line when the economy is hit by a major financial crisis, a huge policy mistake, or a natural disaster.

We propose a concrete way of implementing a reactive rule based on χ_t and show that any failure

to implement it translates into lower growth. We show this both theoretically, which is straightforward, and empirically, by analyzing monetary policy and GDP growth in a sample of 31 countries. Our dataset includes the major advanced economies (G7, Spain, Sweden, Switzerland and South Korea); and several major emerging and developing economies, including China, India, Chile, Mexico, and South Africa. For most of the countries in our sample the data period covers the years 1973 to 2025; but others such as the Euro area have shorter time series.

The main finding in our analysis of the link between money supply and GDP growth is a robust statistical relation between GDP growth and χ_t . As is standard, we address concerns over the collinearity between these macroeconomic variables, by taking a GMM three-stage least squares (3SLS) regression approach (Hansen, 1984).

A key prediction from our theoretical analysis is that deviations of χ_t from $\chi_t = 0$ (positive or negative) are associated with lower GDP growth. We find robust and highly significant empirical support of this fundamental prediction.

Our rule centered around the $\chi_t = 0$ target captures the negative growth implications of both excessively conservative money supply (e.g., under a strict inflation targeting rule) and excessively lax money supply (e.g., as under simple-minded Modern Monetary Theory (MMT)). In both cases, the bigger the deviation from zero the lower is growth. The underlying mechanisms at work are not obvious and have not been explored in the monetary economics literature. There are likely a combination of factors at work, including inefficient investments or expenditures (negative NPV projects), fiscal dominance, and inflation (when χ_t is negative), and credit crunch, financial repression, monetary dominance, and high savings rates (when χ_t is positive) which undermine the efficient operation of the financial sector and consequently lead to lower real GDP.

Our rule focusing on the $\chi_t = 0$ target provides a simple prescription for the direction of money supply changes: if χ_t is positive today the prescribed correction is to finance more investment through faster money growth, and if χ_t is negative the correction is to slow the pace of investment through slower money growth. Thus, the $\chi_t = 0$ target can guide central banks to “keep their eyes on the prize”, which is to maintain growth while containing inflation.

Our empirical analysis also finds that Non-Inflation-Targeting Countries could move towards a steadier and more restrictive monetary stance, through a policy combination of reducing money supply and raising the policy interest rate, so as to avoid too loose a monetary policy that would finance value destroying expenditures, and to achieve stronger growth and lower inflation. Inflation-Targeting Countries, however, could move towards a laxer, more dynamically adjusted, monetary stance, through money supply expansion (but not necessarily through policy interest rate adjustments), so that an easier monetary policy would be able to finance more positive NPV projects and achieve stronger growth while maintaining low inflation.

Our empirical analysis further finds that for Non-Inflation-Targeting Countries, the lower is χ_t , and the higher is the money supply volatility, the higher is the policy rate; for Inflation-Targeting Countries, however, the higher is χ_t and the lower is the volatility of money supply, the lower is the policy rate.

The main limitation of the inflation-target rule commonly used today by central banks is that it is one-dimensional: it focuses only on prices. In contrast, the optimal rule $\chi_t = 0$ is two-dimensional. While the Taylor rule is also two-dimensional, it suffers from other important limitations compared to the

$\chi_t = 0$ rule, primarily its narrow focus on the hard to measure and unstable “output gap”. When a technological revolution like AI shifts potential growth prospects, this is largely left out of the Taylor rule. But under such a technological breakthrough, money supply should play a critical role in providing the needed financing to exploit valuable investment opportunities. By not accounting for this important channel, the implementation of the Taylor rule can result in a structurally restrictive monetary policy, with the consequence of lower long-term growth.

It is important to note that monetarism and monetary theory based on the quantity theory of money equation is fundamentally a static theory, which is orthogonal to the macroeconomics of growth. Indeed, these two literatures have never really overlapped. The notion of output gap is orthogonal to growth and there is no sense in which money supply has something to do with growth. Our theoretical and empirical study in this paper is intended to connect and integrate monetary theory and the macroeconomics of growth, as we have argued in Bolton and Huang (2018, 2024).

The remainder of the paper is structured as follows. Section 2 derives the new monetary policy rule. Section 3 describes the data and empirical methodology. Section 4 illustrates the rule in a series of plots that clearly reveal the power of the new lens rooted in this monetary policy rule. Section 5 provides the main empirical findings. Section 6 concludes.

2. A New Monetary Policy Rule That Supports Non-Inflationary Growth

How should monetary policy balance the objective of containing inflation and the objective of supporting economic growth? Bolton and Huang (2018, 2024) suggest that the optimal money issuance for a nation is akin to the optimal equity issuance to fund investment opportunities in corporate finance: any equity issuance that can fund a positive net present value (NPV) investment adds value to the firm. Analogously any money issuance that funds value creating activity adds to non-inflationary growth.

An optimal monetary policy rule ought to create money to make possible the financing of all positive NPV projects in the economy, but no more. No financing of negative NPV projects. At each optimization point, optimal money creation would provide conditions to finance the last available positive NPV project; the optimal monetary rule should dynamically tighten or loosen monetary policy accordingly in the next decision point.

Monetary policy has often been framed around the quantity theory of money equation:

$$M_t V_t = P_t T_t \tag{1}$$

This can almost be seen as an accounting identity, given that any economic transaction involves money. While the narrow interpretation of this equation by monetarists, which takes V_t and T_t to be constant, is that any change in M_t must be reflected in a proportional change in the price level P_t , a less narrow interpretation of this equation allows for the possibility that both P_t and T_t may respond to changes in M_t . That is, increases in money supply may generate either price increases, output increases, or both.

Also, the quantity theory equation $M_t V_t = P_t T_t$ allows for the possibility that an increase in M_t could materialize in an increase in T_t , while ideally keeping P_t constant. Accordingly, an optimal monetary policy rule, from a welfare and growth perspective is one that allows for expansionary

monetary policy to fund investment (or any other value enhancing expenditures) to increase output, as long as this is non-inflationary.

Price level increases generally cause redistributive costs, when money balance increases are not evenly distributed. These redistributive costs can be understood in similar terms as dilution costs for shareholders following a (seasoned) common share issue, as is explained in Bolton and Huang (2018, 2024). Yet despite the potential for such dilution costs associated with monetary expansions, output increases that result from monetary expansions are generally seen as welfare enhancing, even if the output increase is not necessarily evenly shared.

Allowing for the possibility that monetary expansion may result in higher real GDP, the question then arises as to how one can determine whether money supply changes are welfare enhancing or not. A sufficient condition for a welfare-enhancing monetary expansion is for the increase in money to be non-inflationary, for when that is the case, the effect of the money supply increase must be an increase in real output (keeping V constant).

To see this, note that equation (1) can be rewritten as follows:

$$\frac{T_t}{M_t} = \frac{V}{P_t} \quad (2)$$

Therefore, changing t to $t-1$ we obtain:

$$\frac{T_{t-1}}{M_{t-1}} = \frac{V}{P_{t-1}} \quad (3)$$

Subtracting (3) from (2) and dividing by $\frac{T_{t-1}}{M_{t-1}}$ and using equation (2) we obtain:

$$\frac{\frac{T_t}{M_t} - \frac{T_{t-1}}{M_{t-1}}}{\frac{T_{t-1}}{M_{t-1}}} = \frac{P_{t-1}}{P_t} - 1 \quad (4)$$

If the money increase is non-inflationary then the RHS of (4) is equal to zero. So that a simple test of whether the money supply increase is surely welfare-enhancing is whether the LHS of equation (4) is greater than zero.

Rearranging, this test reduces to whether $(\frac{T_t}{T_{t-1}})/(\frac{M_t}{M_{t-1}}) \geq 1$. That is, a simple test to determine whether a money supply increase is welfare enhancing is to establish whether the change in the real GDP growth rate is higher than the money growth rate. Thus, a monetary authority looking to maximize welfare should increase money supply up to the point where all positive NPV projects are funded, so that inequality (5) holds as an equality.

Without assuming money velocity V is a constant, the slope of T_t/M_t is defined as:

$$\chi_t = \frac{T_t - T_{t-1}}{M_t - M_{t-1}} \quad (5)$$

We will use χ_t as the Index in our study. When χ_t is positive, then some positive NPV projects

have not been funded. That is, higher growth could have been achieved by adopting a more expansionary monetary policy. Similarly, if the index χ_t is negative, then money expansion has been excessive and has funded negative NPV projects at the margin. So intuitively, an optimal monetary policy would imply:

$$\chi_t = 0. \quad (6)$$

In the next two sections, we shall explore how useful this basic policy rule is, and how closely central banks of major economies have (knowingly or not) been able to stick to such a rule.

3. The New Monetary Policy Rule: Empirical Model and Data

3.1 Empirical Model

In our empirical analysis we estimate a joint system for GDP growth, the policy rate, and CPI inflation for each country i . The main regressions use horizons $h = 4, 6$. Let g_{it} denote year-on-year real GDP growth, π_{it} consumer-price inflation, r_{it} the policy rate, and $\sigma_{M,it}$ money-stock volatility. For the cross-country panels define $\mathbf{B}_{it} = (\chi_{it}, (\chi_{it}^+)^2, (\chi_{it}^-)^2)'$, where χ_{it}^+ denotes a positive χ_{it} and χ_{it}^- a negative χ_{it} ; in single-economy systems $\mathbf{B}_{it}$ contains only the linear index χ_{it} .

The Index χ_{it} records the relative evolution of output and money, whereas the policy rate measures a financing cost. Financing costs influence the allocation of purchasing power between consumption and investment and the projects that receive funding. The interaction $r_{it}\chi_{it}$ therefore allows the conditional relationship between the index and future activity to vary with the interest-rate environment. Retaining the standalone r_{it} also allows financing costs to matter independently of the index. The empirical model we estimate is thus:

$$g_{i,t+h} = \alpha_i^{g,h} + \mathbf{B}_{it}'\boldsymbol{\beta}_h^g + a_h^g\sigma_{M,it} + b_h^gr_{it} + d_h^gr_{it}\chi_{it} + \boldsymbol{\gamma}_h^{g'}\mathbf{D}_{g,it} + u_{i,t+h}^g \quad (7)$$

$$r_{it} = \alpha_i^{r,h} + \mathbf{B}_{it}'\boldsymbol{\beta}_h^r + a_h^r\sigma_{M,it} + b_h^rg_{it} + c_h^r\pi_{it} + \boldsymbol{\gamma}_h^{r'}\mathbf{D}_{r,it} + u_{it}^r \quad (8)$$

$$\pi_{i,t+h} = \alpha_i^{\pi,h} + \mathbf{B}_{it}'\boldsymbol{\beta}_h^\pi + a_h^\pi\sigma_{M,it} + b_h^\pi r_{it} + d_h^\pi r_{it}\chi_{it} + \boldsymbol{\gamma}_h^{\pi'}\mathbf{D}_{\pi,it} + u_{i,t+h}^\pi \quad (9)$$

Thus, the policy rate and its interaction with the Index χ_{it} enter both future-outcome equations. Current GDP growth and current inflation enter the policy-rate equation; neither is an explanatory variable in the future-growth or future-inflation equation. Future GDP growth is not a regressor in the inflation equation. Coefficients may differ by horizon and sample window. Equation-specific intercepts represent country fixed effects in the panels and ordinary intercepts in the single-economy systems.

We further add institutional and crisis variables:

$$\begin{aligned} \mathbf{D}_{g,it} &= (D_{IT,it}, D_{GFC,it}, D_{Euro,it})', \\ \mathbf{D}_{r,it} &= (D_{IT,it}, D_{COVID,it})', \\ \mathbf{D}_{\pi,it} &= (D_{IT,it}, D_{GFC,it}, D_{Euro,it}, D_{COVID,it})'. \end{aligned} \quad (10)$$

The inflation target dummy IT follows the existing quarterly inflation-targeting coding. GFC covers 2007Q4–2009Q2; Euro covers 2009Q4–2013Q2 for the applicable European economies; and COVID covers 2020Q1–2022Q4. Indicators without within-sample variation are omitted. No linear time trend or IFC regressor is added. Growth, inflation, interest rates, and money-stock volatility are in percent; the Index χ_{it} is dimensionless.

3.2 Data and Empirical Methodology

We have 31 countries in our sample. Our dataset includes the major advanced economies, the G7 economies, Spain, Sweden, Switzerland and South Korea. Along with these advanced economies we include major emerging and developing economies, in particular China, India, Chile, Mexico, and South Africa. Most of the countries in our sample cover the period of 1973 to 2025, but the Euro area countries have as their starting point the year of the introduction of the Euro.³

The group of advanced economies comprises 16 countries: Australia, Canada, Czechia, Germany, Iceland, Israel, Italy, Japan, South Korea, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States. The group of developing economies comprises 15 countries: Brazil, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, the Philippines, Poland, Romania, South Africa, Thailand, and Türkiye.

The 31 countries are classified by continent and development group. The aggregate euro-area series is used in the single-economy analysis.

GDP levels are measured at constant prices and use the seasonally adjusted, annualized series recorded in the workbook. Annualization expresses quarterly output on an annual-flow scale: the United States uses the published seasonally adjusted annual rate; series reported as quarterly GDP are multiplied by four. Within each country, GDP and money are expressed in the same local-currency units, such as billions of US dollars for the United States.

Year-on-year real GDP growth, g_{it} , is the percentage change in output from the same quarter a year earlier. The United Kingdom, Switzerland, and certain other worksheets calculate it directly from GDP levels; countries with a recorded growth series retain that series. The calculation is $g_{it} = 100 * (Y_{it}/Y_{i,t-4} - 1)$. GDP levels therefore construct the output–money ratio, while GDP growth measures

³ The underlying data are published by national statistical agencies, central banks, and international financial institutions and assembled through Wind and other channels. GDP and consumer prices come from official national accounts and price statistics. Money stocks and policy rates come from central-bank and international monetary and financial statistics, including the BIS Central Bank Policy Rates database (BIS, 2026). Data are matched by country and calendar quarter. Each row records GDP, GDP growth, inflation, the money stock, and the policy rate for one economy in one quarter; R and the Index are then constructed from these observations.

The cross-country panel covers 1973–2025, with outcome quarters ending no later than 2025Q4. We retain the post-1996 window and the established IMF development classification (IMF, 2026). The pooled regressions report four- and six-quarter horizons. The five individual economies are the United States, the United Kingdom, the euro area, China and Poland. At the six-quarter horizon, the US and UK regressor samples cover 1970Q1–2024Q2, with 218 observations each; the euro area sample covers 1999Q1–2024Q2, with 102 observations. China covers 1994Q1–2024Q2, with 122 observations, and Poland 1997Q2–2024Q2, with 109. The country figures retain the full histories available from the respective national statistical offices or central banks, so their starting dates may differ.

economic growth.

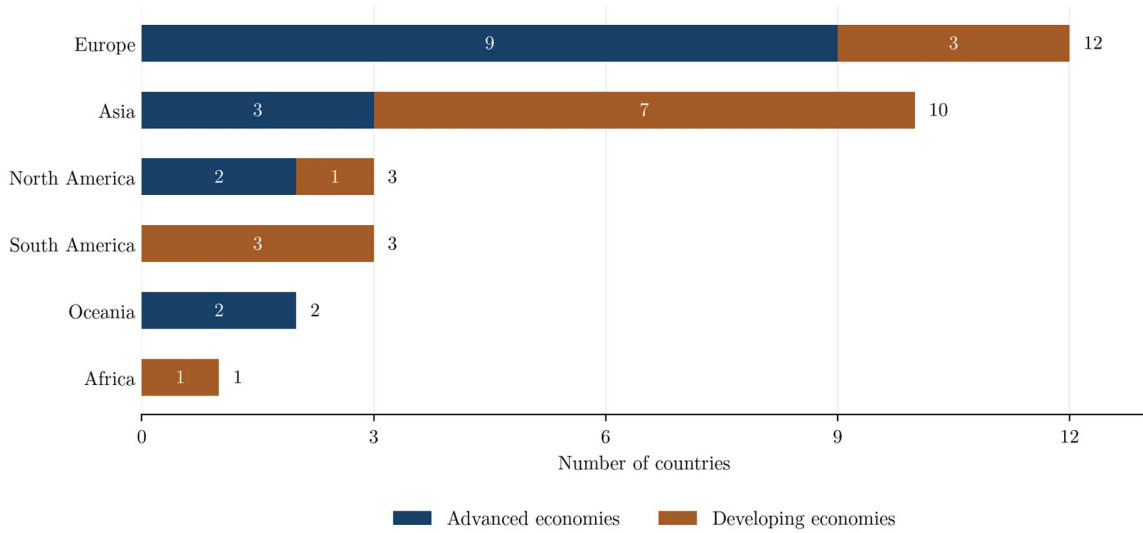


Figure 1. Sample Countries by Continent and Development Group

Inflation, π_{it} , is quarterly year-on-year CPI inflation; Iceland, Norway, and the euro area use HICP inflation. All are expressed in percent and enter the analysis according to the quarterly year-on-year measure recorded in the workbook. Euro-area real GDP uses a fixed 20-country composition (EA20), whereas money and HICP use the membership composition applicable at each date (U2) (Eurostat, 2026; ECB, 2026b; ECB, 2026a).

The money stock, M_{it} , refers to the corresponding quarter. Most countries use M2 and Canada uses M2+. Australia, Chile, Iceland, Romania, Czechia, Poland, Israel, Norway, Hungary, New Zealand, and Colombia use M3. Series retain the seasonal-adjustment conventions recorded in the workbook; some use X-13 and some also incorporate calendar or working-day adjustments. Money is paired with GDP using the quarterly-average or quarter-end convention of the source series. The euro area uses quarterly averages.

UK money uses a backward-linked quarterly series. The original M2 series is retained from 1987Q1. A level-linked M2 bridge covers 1982Q3 through the end of 1986. Earlier observations are extended backward using quarterly growth in seasonally adjusted M1 and aligned with the bridge at the linking quarter. The early series is therefore an M2-type monetary proxy. The linked money series is paired with real GDP in the same quarter to recalculate the χ_{it} index, and four-quarter money-stock volatility, so alternative starting dates draw on the same continuous historical series.

The South Korean series in the cross-country panel uses seasonally adjusted M2 with its 2003 definitional linkage.

The policy rate, r_{it} , measures the current monetary-policy interest-rate level in percent. We use the relevant effective interest rate or central-bank policy rate for each country, following the source series' quarterly average or quarter-end convention.

We define the output–money ratio as $R_{it} = Y_{it}/M_{it}$. Here, Y_{it} corresponds to T_t in equations (1)–(5) above. The slope of R_{it} is therefore χ_t .

$$\chi_t = \frac{Y_{it} - Y_{i,t-1}}{M_{it} - M_{i,t-1}}. \quad (11)$$

The Index χ_t is a relative change expressed as a decimal.

For example, if R rises from 2 a year earlier to 2.1 in the current quarter, the index equals $2.1/2 - 1 = 0.05$. A value of $\chi = 0.01$ means that R is exactly 1 percent above its year-earlier level. Each quarterly index observation is first calculated relative to the same quarter a year earlier; the completed observations are then connected in quarterly order. Connecting quarterly observations neither changes the calculation to quarter-on-quarter growth nor introduces smoothing.

Define the decimal-scale year-on-year growth rates calculated from the same positive level data as $\gamma_{it}^Y = Y_{it}/Y_{i,t-4} - 1$ and $\gamma_{it}^M = M_{it}/M_{i,t-4} - 1$. The exact relationship is

$$\chi_{it} = \frac{1 + \gamma_{it}^Y}{1 + \gamma_{it}^M} - 1 = \frac{\gamma_{it}^Y - \gamma_{it}^M}{1 + \gamma_{it}^M}. \quad (12)$$

The GDP-growth variable g_{it} remains the existing percentage series in the workbook. A positive index indicates that real output grows faster year on year than money; a negative value indicates the reverse. Fixed unit rescalings do not change the index, although changes in statistical definitions may affect comparability.

The quantity relation gives $R = Y/M = V/P$. Consequently,

$$1 + \chi_{it} = \frac{V_{it}/V_{i,t-4}}{P_{it}/P_{i,t-4}}. \quad (13)$$

The cross-country models construct $\chi_{it}^+ = \max(\chi_{it}, 0)$ and $\chi_{it}^- = \max(-\chi_{it}, 0)$ and include their squares alongside the linear index; single-economy models retain only the linear index. The South Korean series uses seasonally adjusted M2 with its 2003 definitional linkage.

Future outcomes are matched within each economy by exact calendar quarter, not by assuming adjacent rows represent consecutive quarters. The main regressions use single-point year-on-year rates four and six quarters ahead:

$$g_{it}^{(h)} = g_{i,t+h}, \pi_{it}^{(h)} = \pi_{i,t+h}, h \in \{4, 6\}. \quad (14)$$

Future GDP growth and future CPI inflation have the same outcome quarter. Every main system uses observations complete for its three equations. Current growth and inflation enter the policy-rate equation, not the future-outcome equations. The local projections reported separately use endpoints $h = 1, \dots, 10$ for the same two year-on-year outcomes; they do not use cumulative growth or averages of intervening quarters.

All future outcomes must occur no later than 2025Q4. The formal regressions do not interpolate, winsorize or exclude crisis periods, and Mexico remains in the panel. Growth and inflation retain the workbook's existing year-on-year percentage series. Figure-specific processing, where used, is stated separately and does not change the main regressions.

Money-stock volatility uses the money stock in quarter t and the preceding three consecutive quarters. We calculate their mean and sample standard deviation, divide the standard deviation by the mean, and multiply by 100. This expresses volatility relative to the average money stock:

$$\bar{M}_{it}^{(4)} = \frac{1}{4} \sum_{j=0}^3 M_{i,t-j}. \quad (15)$$

$$\sigma_{M,it} = 100 \sqrt{\frac{\frac{1}{3} \sum_{j=0}^3 (M_{i,t-j} - \bar{M}_{it}^{(4)})^2}{\bar{M}_{it}^{(4)}}}. \quad (16)$$

The measure is calculated only when money is positive and observed in all four quarters. All lags and leads are matched by within-country quarterly dates. The euro area's supporting lag observations are used to calculate year-on-year changes, the χ_{it} Index, and money-stock volatility. Each regression then selects observations complete for its own regressors and outcomes.

Table **Error! Reference source not found.** summarizes the 3,708 observations in the common estimation sample of the full-panel four-quarter system. It reports the distribution of the original relative-change index, the current variables and their rate–index interaction, including the P10 and P90 percentiles. The sample is the same as in the corresponding main regression.

Table 1—Descriptive Statistics: Full-Panel Four-Quarter Estimation Sample

Variable	Mean	SD	Min	P10	P90	Max	N
χ	-0.05	0.06	-0.51	-0.12	0.01	0.19	3,708
$(\chi^+)^2$	0.0003	0.002	0.00	0.00	0.00003	0.04	3,708
$(\chi^-)^2$	0.01	0.01	0.00	0.00	0.01	0.26	3,708
g_t	2.89	3.51	-22.78	-0.58	6.54	25.48	3,708
π_t	3.94	5.08	-3.03	0.37	8.29	81.10	3,708
r_t	5.21	5.20	-0.75	0.15	11.75	55.50	3,708
$r_t \chi_t$	-0.41	0.96	-15.78	-1.07	0.01	3.22	3,708
$\sigma_{M,t}$	2.94	2.07	0.05	0.99	5.21	32.47	3,708

Note: Statistics use the exact common sample of the full-panel $h = 4$ three-equation system, with 3,708 observations from 31 countries. The euro-area aggregate is excluded from the panel. No winsorization or crisis-period exclusion is applied. g_t and π_t are current year-on-year rates; growth, inflation, policy rates and money-stock volatility are in percent. The Index and its squares are dimensionless. $r_t \chi_t$ is the uncentered product of the policy rate in percent and the dimensionless Index, with no additional scaling. SD denotes the sample standard deviation; P10 and P90 are the 10th and 90th percentiles; N is the number of non-missing observations.

R_t records the accumulated relationship between production and the money stock; χ_t shows when that relationship changes. We read the two panels together for the United States, the United Kingdom, the euro area, China and Poland. Each economy retains its full available history through 2025Q4, with no smoothing of the plotted indicators. Monetary definitions and statistical coverage continue to differ across economies.

The left panel in each figure below records the long-run decline in a country's output–money ratio, R_t ; the right panel in each figure reveals the movements χ_t obscured by that trend.

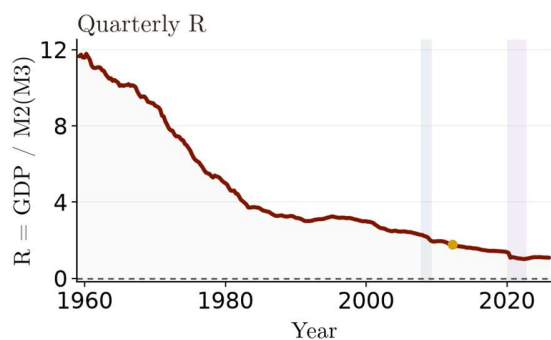


Figure 2.1—United States: Output–Money Ratio R

Left: $R = Y/M$, 1959Q1–2025Q4; right: $\chi_t = R_t/R_{t-4} - 1$, 1960Q1–2025Q4. Shading denotes applicable crisis periods. Markers retain the recorded inflation-targeting dates. Sources: US Bureau of Economic Analysis (real GDP) and Board of Governors of the Federal Reserve System (M2), accessed through FRED.

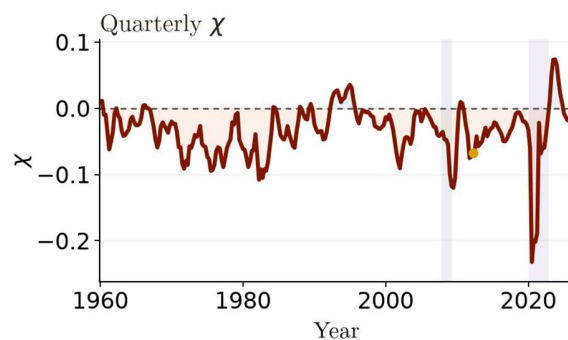


Figure 2.2—United States: Index (χ)

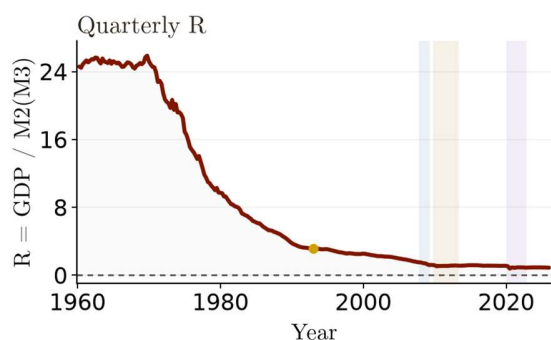


Figure 3.1—United Kingdom: Output–Money Ratio R

Left: $R = Y/M$, 1960Q1–2025Q4; right: $\chi_t = R_t/R_{t-4} - 1$, 1961Q1–2025Q4. Shading denotes applicable crisis periods. Markers retain the recorded inflation-targeting dates. Sources: IMF International Financial Statistics; Bank of England and OECD. The historical monetary series is extended backwards using an M2 bridge series and, for earlier periods, M1 growth rates.

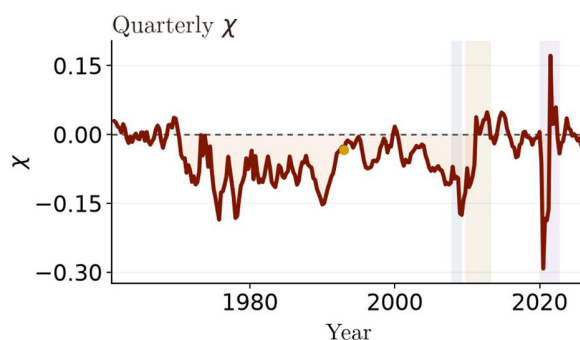


Figure 3.2—United Kingdom: Index (χ)

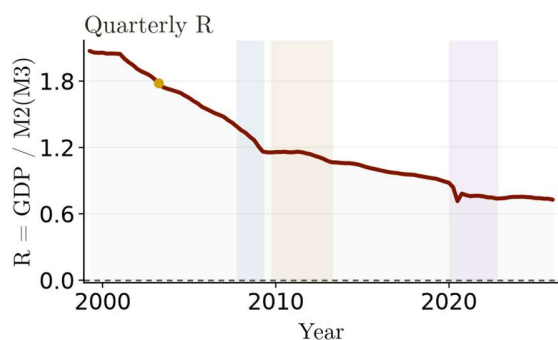


Figure 4.1—Euro Area: Output–Money Ratio R

Left: $R = Y/M$, 1999Q1–2025Q4; right: $\chi_t = R_t/R_{t-4} - 1$, 2000Q1–2025Q4. Shading denotes applicable crisis periods. Markers retain the recorded inflation-targeting dates. Sources: Eurostat and the European Central Bank.

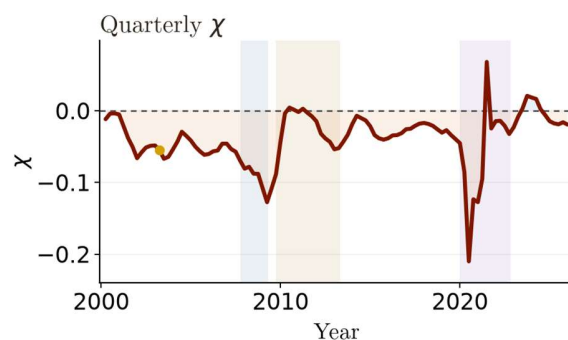


Figure 4.2—Euro Area: Index (χ)

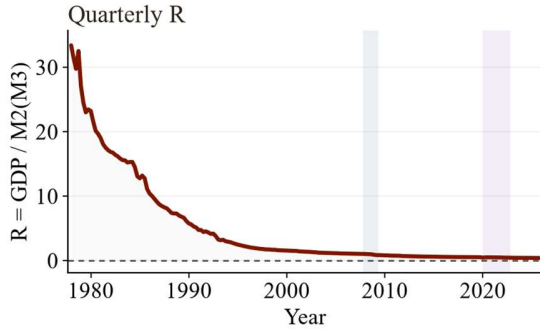


Figure 5.1—China: Output–Money Ratio R

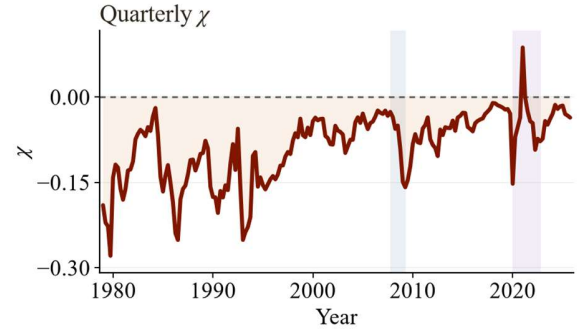


Figure 5.2—China: Index (χ)

Left: $R = Y/M$, 1978Q1–2025Q4; right: $\chi_t = R_t/R_{t-4} - 1$, 1979Q1–2025Q4. Shading denotes applicable crisis periods. Sources: National Bureau of Statistics of China (underlying GDP data), Abeyasinghe and Rajaguru (historical GDP), IMF International Financial Statistics and the People's Bank of China (money). GDP is adjusted using X-13; money is measured using official seasonally adjusted levels.

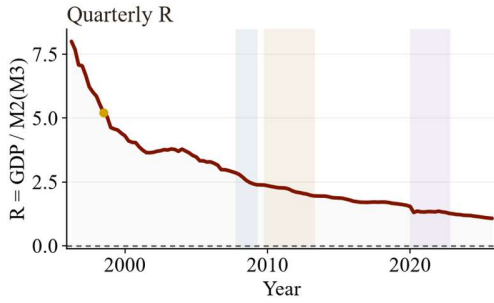


Figure 6.1—Poland: Output–Money Ratio R

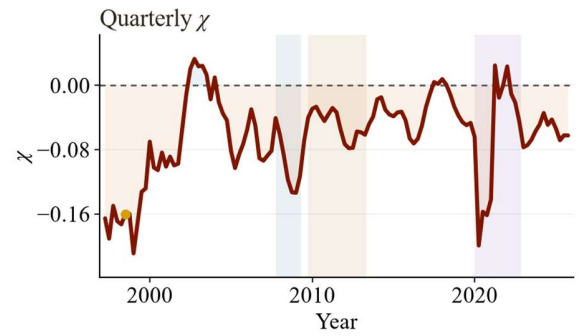


Figure 6.2—Poland: Index (χ)

Left: $R = Y/M$, 1996Q2–2025Q4; right: $\chi_t = R_t/R_{t-4} - 1$, 1997Q2–2025Q4. Shading denotes applicable crisis periods. Markers indicate inflation-targeting dates. Sources: World Bank Global Economic Monitor and OECD.

3.3 Empirical Methodology

3.3.1 Joint Estimation by 3SLS

We jointly estimate future growth and inflation, with the current policy-rate equation capturing the financing environment and its response to economic activity and prices. Growth and inflation are the outcomes against which we assess the rule. Each horizon is estimated separately, using the sample windows described above. Each system uses a common complete-case sample, with both t and $t + h$ falling within the stated window.

3SLS combines equation-level instrumental-variable estimation with information on the covariance of the system's disturbances. First, the endogenous regressors are projected onto the exogenous instruments. Preliminary residuals are then used to construct the cross-equation covariance matrix for generalized least-squares weighting. All three equations are estimated on the same complete-case sample, allowing their disturbances to be correlated. Estimating each horizon separately allows these relationships to vary across horizons rather than imposing the coefficients from one horizon on another (Zellner and Theil, 1962).

3.3.2 Endogenous Regressors and Three-Stage Estimation

Placing CPI on the left-hand side does not resolve the endogeneity of policy rates on the right-hand side. A single equation can also be estimated by IV or 2SLS when valid instruments are available. We retain 3SLS to estimate inflation jointly with the growth–policy-rate system, not because joint estimation itself supplies an additional source of identification.

The current policy rate and $r\chi$ are treated as endogenous regressors. The common instrument set contains the union of included exogenous regressors, current GDP growth and inflation, equation-specific excluded controls, intercepts, and country indicators in the panels. It adds no historical lags or external instruments. The maintained orthogonality conditions apply to all three disturbances:

$$E[Z_{it}u_{i,t+h}^g] = 0, \quad E[Z_{it}u_{it}^r] = 0, \quad E[Z_{it}u_{i,t+h}^\pi] = 0. \quad (17)$$

Satisfying the numerical rank condition is necessary for estimation but does not establish instrument strength or the exclusion restrictions. We therefore report conditional predictive relationships within the system, rather than interpreting coefficients directly as causal effects of exogenous policy shocks.

Cross-country inference uses country-clustered standard errors and $t(G-1)$ tests, allowing dependence across quarters within each country. Single-economy inference uses system Bartlett HAC, retaining both cross-equation and quarterly serial dependence. At horizon h , the weights are $1 - j/h$, $j = 1, \dots, h-1$, with the finite-sample correction $N/(N - K_{\max})$ and $t(N - K_{\max})$ tests; $K_{\max}$ is the largest number of parameters in an equation, including the intercept. Tables report coefficients with significance stars and standard errors beneath them. The policy-rate equation is estimated jointly but is not tabulated. Each single-economy outcome column also reports the overall Wald F -test p -value.

The interaction term represents the Index at a zero policy rate. We therefore interpret it jointly with $r\chi$ and, in the panel specifications, the two squared terms. Fitted comparisons retain all these terms and hold the policy rate at the relevant sample mean. The local projections separately trace average marginal slopes over time. This distinction keeps the economic interpretation focused on growth and prices under the financing conditions being examined.

4. Empirical Results

4.1 Pooled Estimates and GDP–CPI Relationships

The pooled regression connects the output–money balance to the growth objective of our rule. A higher χ Index means that output has grown faster relative to money; it does not by itself show that all productive financing opportunities have been met. The linear growth coefficients are -15.66 ($t = -2.41$) four quarters ahead and -13.40 ($t = -4.85$) six quarters ahead (Table 2). At the four-quarter mean policy rate of 5.21%, moving χ from zero to 0.01 corresponds to 0.14 percentage points lower fitted growth after allowing for the interaction and curvature. On the positive side of zero, this is the relationship our financing argument brings into focus: money falling further behind real activity is associated with weaker subsequent growth, rather than a costless improvement in monetary discipline.

The inflation results further demonstrate why the two outcomes must be evaluated together. The four-quarter linear index coefficient for inflation is 29.57 ($t = 3.79$), while the interest-rate interaction is -4.61 ($t = -2.99$). Together with the nonlinear terms, these estimates imply that the same increase in

the index corresponds to an inflation change of just 0.04 percentage points at the mean policy rate; the corresponding change at six quarters is -0.05 . Thus, the negative growth relationship is not simply the counterpart of a large reduction in inflation.

Table 2—All economies, 1973–2025: Growth and Inflation at 4 and 6 Quarters

Variable	$h = 4$		$h = 6$	
	$g_{i,t+4}$	$\pi_{i,t+4}$	$g_{i,t+6}$	$\pi_{i,t+6}$
χ_{it}	-15.66^{**} (6.49)	29.57^{***} (7.80)	-13.40^{***} (2.76)	19.93^{***} (6.09)
$(\chi_{it}^+)^2$	210.52^{***} (75.28)	-116.25 (130.51)	82.98 (58.68)	33.92 (104.70)
$(\chi_{it}^-)^2$	19.81 (35.43)	-57.43 (43.84)	15.85 (24.82)	-60.80 (47.82)
r_{it}	-0.32^{**} (0.14)	0.26 (0.31)	0.01 (0.12)	0.02 (0.31)
$r_{it}\chi_{it}$	0.003 (0.75)	-4.61^{***} (1.54)	1.08 (0.79)	-4.80^{***} (1.68)
$\sigma_{M,it}$	-0.06 (0.12)	0.49^{**} (0.21)	-0.06 (0.10)	0.38^{**} (0.15)
$D_{IT,it}$	-2.11^{***} (0.46)	1.28 (1.10)	-0.90^{**} (0.37)	0.35 (1.12)
$D_{GFC,it}$	-3.80^{***} (0.52)	-0.55 (0.34)	-1.90^{***} (0.45)	-1.17^{***} (0.35)
$D_{Euro,it}$	-0.81^{**} (0.33)	-0.13 (0.31)	-0.72^{**} (0.29)	-0.50 (0.31)
$D_{COVID,it}$	—	6.03^{***} (1.29)	—	5.69^{***} (1.57)
Constant	5.79^{***} (0.94)	-0.50 (2.07)	3.41^{***} (0.71)	1.40 (2.02)
Observations	3,708	3,708	3,646	3,646
Economies	31	31	31	31
R^2	0.231	0.227	0.182	0.216
Country FE	Yes	Yes	Yes	Yes

Note: Three-equation 3SLS; the policy-rate equation is estimated jointly. Parentheses contain standard errors. Country-clustered inference uses $t(G - 1)$. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ (two-sided).

The later sample shows that the growth pattern is not confined to the earliest monetary regimes in our data. Even when the window is restricted to 1996–2025, the linear coefficients remain negative at four and six quarters: -17.99 ($t = -2.62$) and -14.27 ($t = -5.10$), respectively (Table 3). At the lower mean policy rate of 4.55%, the full four-quarter comparison again implies a 0.14 percentage-point decline in growth as χ rises from zero to 0.01. This economically interpretable comparison remains similar across windows: the association between relatively slow money growth and weaker subsequent activity persists under different financing conditions.

The later inflation equation retains the same offsetting structure. The four-quarter index coefficient is 29.12 ($t = 3.28$), and the interaction is -5.17 ($t = -4.11$). The full inflation comparisons at the mean policy rate are 0.05 percentage points at four quarters and -0.04 at six quarters.

Table 3—All economies, 1996–2025: Growth and Inflation at 4 and 6 Quarters

Variable	$h = 4$		$h = 6$	
	$g_{i,t+4}$	$\pi_{i,t+4}$	$g_{i,t+6}$	$\pi_{i,t+6}$
χ_{it}	-17.99** (6.86)	29.12*** (8.89)	-14.27*** (2.80)	18.12** (6.96)
$(\chi_{it}^+)^2$	234.12** (85.32)	-106.82 (129.07)	106.71* (55.30)	44.14 (94.86)
$(\chi_{it}^-)^2$	31.18 (35.85)	-62.88* (36.86)	21.59 (23.24)	-54.37 (40.58)
r_{it}	-0.23 (0.14)	-0.02 (0.22)	0.07 (0.13)	-0.19 (0.22)
$r_{it}\chi_{it}$	0.38 (0.63)	-5.17*** (1.26)	1.30* (0.75)	-4.91*** (1.39)
$\sigma_{M,it}$	-0.13 (0.13)	0.47** (0.22)	-0.08 (0.10)	0.32** (0.16)
$D_{IT,it}$	-1.78*** (0.34)	2.19 (1.52)	-0.98*** (0.28)	1.67 (1.63)
$D_{GFC,it}$	-3.86*** (0.53)	-0.31 (0.35)	-1.93*** (0.45)	-0.96*** (0.34)
$D_{Euro,it}$	-0.78** (0.33)	-0.30 (0.36)	-0.69** (0.29)	-0.66* (0.35)
$D_{COVID,it}$	—	5.47*** (1.34)	—	5.16*** (1.66)
Constant	5.22*** (0.67)	-0.67 (1.93)	3.42*** (0.56)	0.46 (2.01)
Observations	3,129	3,129	3,067	3,067
Economies	31	31	31	31
R^2	0.269	0.283	0.198	0.290
Country FE	Yes	Yes	Yes	Yes

Note: Three-equation 3SLS; the policy-rate equation is estimated jointly. Parentheses contain standard errors. Country-clustered inference uses $t(G - 1)$. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ (two-sided).

4.2 Descriptive GDP and CPI Relationships

Figure 7 brings the two sides of the economic problem into view. At strongly negative values of χ , money expands much faster than output, and fitted inflation is high relative to fitted growth. As the index approaches zero, inflation falls substantially while growth changes much less. On the positive side, growth declines and inflation eventually turns upward. This distinction is central to our rule: neither money creation detached from production nor monetary restraint pursued for its own sake during stagflation constitutes sound policy. A meaningful comparison must bring real activity and prices into the same picture.

At both horizons, the GDP and CPI curves intersect on either side of zero, at approximately $\chi = -0.05$ and 0.05 (Table 4). Between the intersections, fitted growth exceeds fitted inflation. The left-hand intersections correspond to rates of about 2.92%; the right-hand intersections correspond to 2.18% at four quarters and 2.15% at six quarters.

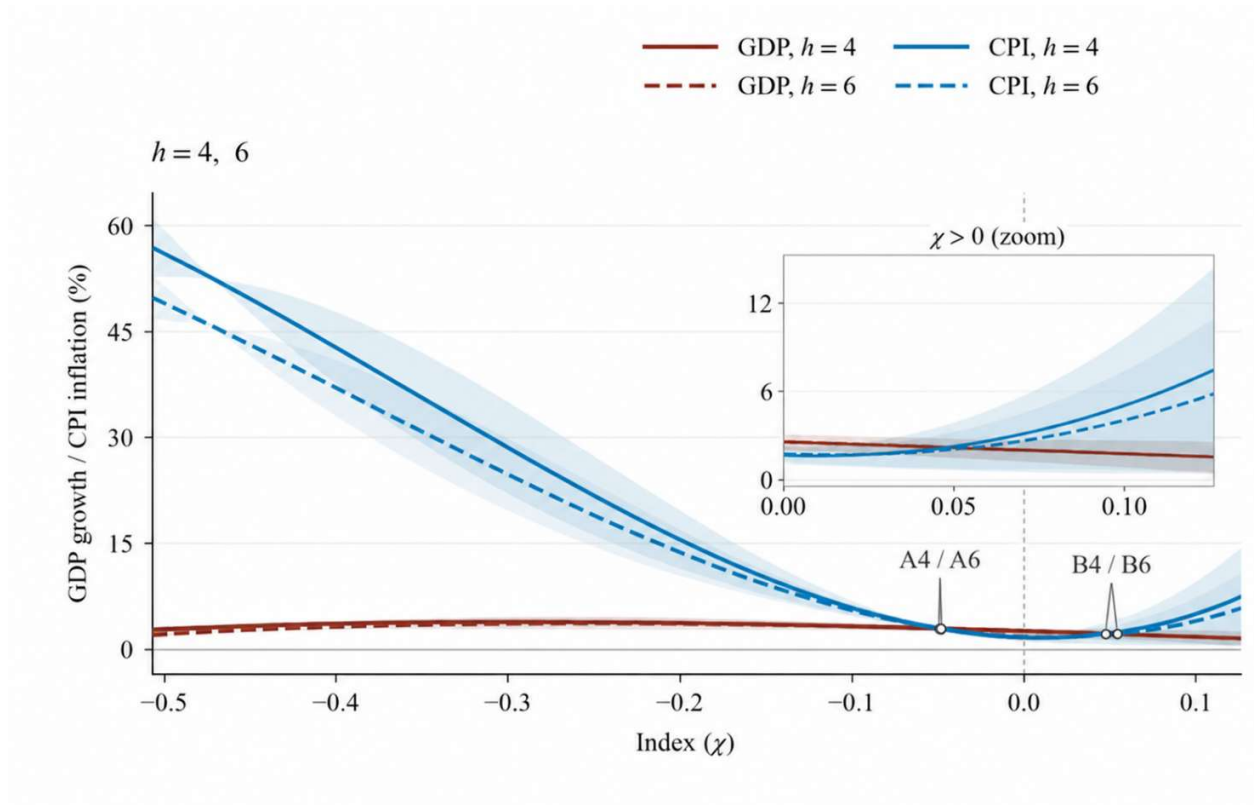


Figure 7—Descriptive Spline Relationships: GDP Growth and CPI Inflation

GDP is shown in red-brown and CPI in blue. Solid lines denote $h = 4$ and dashed lines $h = 6$. The 31-country panel provides 3,008 and 2,952 common observations, respectively. For this descriptive figure only, quarters in which the regressors fall within a crisis period are excluded; observations whose future outcome falls within a crisis period are retained. Shading shows approximate 95% pointwise confidence intervals for the mean, based on country-clustered sandwich covariance.

Table 4—Intersections of the Descriptive GDP and CPI Curves

Horizon	Point	Index (χ)	GDP (%)	CPI (%)
$h = 4$	A4	-0.05	2.92	2.92
$h = 4$	B4	0.05	2.18	2.18
$h = 6$	A6	-0.05	2.92	2.92
$h = 6$	B6	0.05	2.15	2.15

Note: All intersections within observed support are shown. These are descriptive coordinates, not policy optima; the CSV retains full precision.

4.3 Local Projections

We use local projections with country fixed effects (Jordà, 2005) to trace the relationships between χ_{it} and GDP growth and CPI inflation over $h = 1, \dots, 10$. The sample covers 31 countries, with both regressor and outcome quarters falling within 1973–2025.

Both equations include χ , its positive- and negative-side squared terms, monetary volatility, the current policy rate, current GDP growth, and the IT, GFC and Euro indicators. The CPI equation additionally controls for current CPI inflation and COVID. We report the average marginal slope evaluated over a fixed reference sample:

$$\text{AME}_{k,h} = \beta_{1,k,h} + 2\beta_{+,k,h}\bar{\chi}^+ - 2\beta_{-,k,h}\bar{\chi}^-. \quad (18)$$

Reference means use 3,832 equally weighted country–quarter observations from 31 countries with all current candidate controls observed, fixed across outcomes and horizons. Standard errors use the complete coefficient covariance matrix.

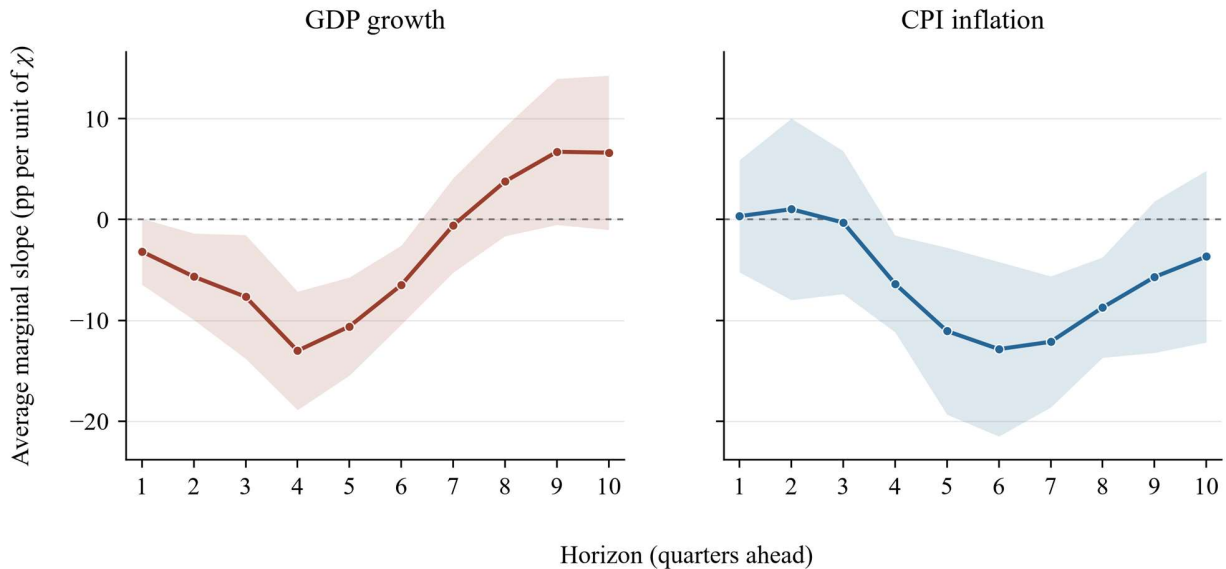


Figure 8—Local Projections: GDP Growth and CPI Inflation

Shading: country-clustered 95% pointwise confidence intervals using $t(G - 1) = t(30)$. Slopes are percentage points per unit of original χ ; a 0.01 increment is one hundredth of this unit.

Conditional projections of $t + h$ year-on-year outcomes, not cumulative changes or identified policy-shock responses.

4.4 Advanced and Developing Economies

The growth relationship extends across economies at different stages of development. The linear index coefficients are -18.29 ($t = -4.12$) for advanced economies and -15.73 ($t = -3.61$) for developing economies (Table 5). At each group's mean policy rate, the full comparison from $\chi = 0$ to 0.01 , including the interaction and curvature, corresponds to changes in growth of -0.06 and -0.11 percentage points, respectively.

Table 5—Advanced and Developing Economies: Six-Quarter Growth and Inflation (1973–2025 Window)

Variable	Advanced		Developing	
	g_{t+6}	π_{t+6}	g_{t+6}	π_{t+6}
χ_{it}	-18.29*** (4.44)	21.96*** (7.22)	-15.73*** (4.36)	31.78** (11.14)
$(\chi_{it}^+)^2$	80.26 (93.82)	27.74 (104.98)	129.57* (63.28)	14.97 (134.56)
$(\chi_{it}^-)^2$	18.36 (32.47)	-12.39 (48.96)	-8.73 (30.64)	-83.01 (98.21)
r_{it}	0.05 (0.16)	-0.03 (0.48)	-0.04 (0.15)	-0.16 (0.49)
$r_{it}\chi_{it}$	2.78* (1.40)	-5.62 (3.43)	0.41 (0.89)	-5.69* (2.87)
$\sigma_{M,it}$	-0.05 (0.10)	0.36** (0.16)	-0.03 (0.14)	0.53 (0.38)
$D_{IT,it}$	-1.03** (0.41)	-0.78 (1.20)	-1.97*** (0.58)	7.97* (4.35)
$D_{GFC,it}$	-2.24*** (0.40)	-1.03** (0.41)	-1.27 (0.75)	-1.57** (0.55)
$D_{Euro,it}$	-0.88** (0.36)	0.13 (0.58)	-0.28 (0.45)	-0.51 (1.07)
$D_{COVID,it}$	—	4.37*** (0.57)	—	7.03** (2.95)
Constant	3.79*** (0.88)	1.98 (2.88)	4.07*** (1.06)	-5.45 (4.22)
Observations	2,327	2,327	1,319	1,319
Economies	16	16	15	15
R^2	0.120	0.393	0.207	0.165
Country fixed effects	Yes	Yes	Yes	Yes

Notes: A three-equation 3SLS system, including a policy-rate equation and country fixed effects, is estimated separately for each group. Country-clustered standard errors are in parentheses. χ is dimensionless; growth and interest rates are expressed in percent. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ (two-sided). An em dash indicates a term not included.

Restricting the analysis to the later window preserves the same growth relationship in both groups. The coefficients for advanced and developing economies are -16.00 ($t = -4.34$) and -15.75 ($t = -3.62$), respectively. Inflation remains more sensitive to the conditioning environment.

Table 6—Advanced and Developing Economies: Six-Quarter Growth and Inflation (1996–2025 Window)

Variable	Advanced		Developing	
	g_{t+6}	π_{t+6}	g_{t+6}	π_{t+6}
χ_{it}	-16.00*** (3.68)	21.59*** (4.90)	-15.75*** (4.34)	31.24** (10.93)
$(\chi_{it}^+)^2$	90.92 (60.47)	41.85 (52.89)	127.89* (63.89)	33.80 (127.00)
$(\chi_{it}^-)^2$	36.98 (23.10)	14.86 (35.98)	-8.34 (30.76)	-87.77 (100.61)
r_{it}	0.003 (0.17)	-0.64*** (0.11)	-0.04 (0.15)	-0.20 (0.51)
$r_{it}\chi_{it}$	3.65** (1.44)	-6.54*** (1.61)	0.43 (0.90)	-5.85* (2.92)
$\sigma_{M,it}$	-0.07 (0.06)	0.39* (0.22)	-0.03 (0.14)	0.52 (0.39)
$D_{IT,it}$	-0.74** (0.35)	-1.16** (0.49)	-1.99*** (0.62)	8.74* (4.50)
$D_{GFC,it}$	-1.78*** (0.35)	-0.79* (0.41)	-1.27 (0.75)	-1.57** (0.55)
$D_{Euro,it}$	-0.92** (0.39)	0.07 (0.45)	-0.28 (0.45)	-0.53 (1.07)
$D_{COVID,it}$	—	3.13*** (0.49)	—	6.98** (2.93)
Constant	3.75*** (0.86)	4.64*** (0.77)	4.05*** (1.07)	-5.91 (4.38)
Observations	1,756	1,756	1,311	1,311
Economies	16	16	15	15
R^2	0.143	0.268	0.207	0.166
Country fixed effects	Yes	Yes	Yes	Yes

Notes: A three-equation 3SLS system, including a policy-rate equation and country fixed effects, is estimated separately for each group. Country-clustered standard errors are in parentheses. χ is dimensionless; growth and interest rates are expressed in percent. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ (two-sided). An em dash indicates a term not included.

4.5 Growth and Inflation across Five Economies

The country systems show how the common economic question plays out in distinct monetary settings. We fix the horizon at six quarters and report growth and inflation together. Estimates of the Index relationship are imprecise in the full US sample.

Table 7—The United Kingdom, United States and Euro Area: Six-Quarter Growth and Inflation

Variable	United Kingdom		United States		Euro area	
	g_{t+6}	π_{t+6}	g_{t+6}	π_{t+6}	g_{t+6}	π_{t+6}
χ_{it}	-28.16** (13.38)	-154.10 (323.37)	-19.34 (30.35)	180.38 (273.71)	-28.59*** (9.50)	11.70 (9.49)
r_{it}	0.05 (0.48)	20.58 (34.78)	-0.04 (0.34)	-1.45 (2.89)	-0.14 (0.28)	-0.37 (0.51)
$r_{it}\chi_{it}$	5.67 (4.37)	101.18 (163.00)	1.97 (5.03)	-31.75 (46.23)	11.02** (5.48)	1.72 (9.49)
$\sigma_{M,it}$	0.10 (0.30)	7.65 (10.38)	-0.005 (0.53)	2.88 (3.16)	0.33 (0.47)	0.97 (0.76)
$D_{IT,it}$	-2.58 (2.30)	80.27 (146.07)	-1.23 (0.75)	-2.29 (4.05)	-1.41 (0.98)	-0.74 (0.97)
$D_{GFC,it}$	-4.06*** (1.12)	-5.32 (12.86)	-3.47*** (1.16)	2.16 (5.08)	-1.24 (1.54)	-0.42 (1.47)
$D_{Euro,it}$	-0.17 (1.67)	39.96 (105.90)	—	—	—	—
$D_{COVID,it}$	—	45.11 (80.26)	—	7.36 (8.40)	—	3.47** (1.63)
Constant	4.15 (3.58)	-161.14 (285.89)	3.01** (1.19)	5.74 (9.49)	1.81 (1.34)	2.03 (1.51)
Observations	218	218	218	218	102	102
Overall p -value (Wald F)	0.001	0.531	0.062	0.139	< 0.001	< 0.001

*Notes: A three-equation 3SLS system is estimated separately for each economy, with the policy-rate equation estimated jointly. Standard errors are in parentheses. Inference uses system Bartlett HAC(5) and the established $N/(N - K_{\max})$ adjustment. The overall p -value is based on a Wald $F(q, N - K_{\max})$ test of the joint null that all non-intercept coefficients in the displayed equation are zero. Regressor quarters are 1970Q1–2024Q2 for the United Kingdom and United States, and 1999Q1–2024Q2 for the euro area; dependent variables are year-on-year rates at $t + 6$, ending in 2025Q4. Country fixed effects, IFC and a time trend are not included. χ is dimensionless; growth and interest rates are expressed in percent. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ (two-sided). An em dash indicates a term not included.*

Table 8—China and Poland: Six-Quarter Growth and Inflation

Variable	China (from 1994Q1)		Poland	
	g_{t+6}	π_{t+6}	g_{t+6}	π_{t+6}
χ_{it}	-121.73** (56.32)	180.31 (207.83)	-40.53*** (12.57)	35.76* (18.24)
r_{it}	3.49*** (1.03)	-2.67 (5.18)	0.19 (0.46)	-0.96 (0.79)
$r_{it}\chi_{it}$	24.79*** (8.44)	-25.94 (36.86)	4.03 (3.97)	-9.86 (7.13)
$\sigma_{M,it}$	0.37 (0.53)	1.15 (0.91)	-0.08 (0.50)	-0.03 (0.90)
$D_{IT,it}$	—	—	-7.74* (4.41)	9.99 (7.95)
$D_{GFC,it}$	-1.47 (1.24)	0.94 (3.55)	-1.53** (0.61)	1.20 (1.40)
$D_{Euro,it}$	—	—	-1.47 (1.00)	0.01 (1.14)
$D_{COVID,it}$	—	-1.50 (4.45)	—	8.12*** (2.39)
Constant	-11.44** (4.52)	12.97 (24.63)	10.27*** (3.10)	-4.11 (5.54)
Observations	122	122	109	109
Overall p -value (Wald F)	< 0.001	0.256	< 0.001	< 0.001

Note: Separate three-equation 3SLS systems; the policy-rate equation is estimated jointly. Standard errors are in parentheses. System Bartlett HAC(5), with the existing $N/(N - K_{\max})$ adjustment; coefficient tests use $t(115)$ for China and $t(100)$ for Poland. Overall p -values test all non-intercept coefficients in each displayed equation jointly using Wald $F(q, N - K_{\max})$. Predictor quarters: China, 1994Q1–2024Q2; Poland, 1997Q2–2024Q2. Outcomes are year-on-year rates at $t + 6$, through 2025Q4. China uses the supplementary seasonally adjusted money series, with R , χ , $r\chi$ and money volatility rebuilt consistently. Poland was selected from 13 developing economies by the smallest growth- χ p -value; China's start comes from the existing start-date scan. Reported p -values are nominal and unadjusted for selection. No country fixed effects, IFC or trend. χ is dimensionless; rates are in percent. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ (two-sided). — denotes an excluded term.

5. Discussion and Policy Implications

The analysis in the preceding sections highlights the central role that χ_t plays in our model, as it measures how far money supply deviates from the optimum. When χ_t is positive, money supply is too restrictive; when χ_t is negative, it is too loose. As reported in Tables 2 to 7, our first major finding is that the coefficient of χ_t is negative and statistically significant. Indeed, the coefficient β_1 on χ_t is highly significant, at the 1% level, in both non-inflation-targeting and inflation-targeting countries. This establishes a link between GDP growth, the monetary policy stance, and the policy rate.

This finding captures the growth implications of both excessively conservative money supply under inflation targeting, and excessively loose money supply. In both cases, the greater the deviation from zero, the lower the growth rate. In other words, the more inefficiently restrictive money supply is—the larger the deviation from below—the greater the increment in GDP generated by each additional unit of money supply. Conversely, the more inefficiently loose money supply is—the larger the deviation from above—the greater the decline in GDP.

The underlying mechanism is not apparent and is likely to involve a set of factors combining inefficient investment or expenditure on negative-NPV projects with higher inflation, undermining the efficient operation of a monetary economy and thereby reducing real GDP. The key point is that inefficient money supply does affect growth whether it is excessively restrictive or excessively loose.

Neither prediction is consistent with the strict quantity theory of money. That theory holds that economic activity is largely independent of money supply, whether money supply is excessive and raises prices or insufficient and lowers them. Friedman's 2% money-growth rule is presented as an appropriate rule for achieving low and stable inflation. It implicitly assumes no link between money supply and growth.

Our rule, centered on the target $\chi_t = 0$, makes this link explicit to guide monetary policy under changing circumstances and growth opportunities. The direction of monetary adjustment is determined by the sign of χ_t : if it is currently positive, the prescribed correction is to finance more investment through faster money growth; if it is negative, the correction is to slow investment through slower money growth. The $\chi_t = 0$ target can therefore help central banks to “keep their eyes on the prize”: maintaining growth while containing inflation.

The principal limitation of the inflation-targeting rule commonly used by central banks today is that it is one-dimensional: it focuses only on prices. By contrast, the $\chi_t = 0$ target is two-dimensional.

Although the Taylor rule— $r = a + p + 0.5(y - y^*) + 0.5(p - p^*)$ —is also two-dimensional, it has two important limitations relative to the $\chi_t = 0$ rule. First, as has been widely noted, both y^* and p^* evolve dynamically. This undermines the conception of monetary policy as a corrective mechanism that returns the economy to stable long-run macroeconomic conditions, which is the premise of the rule, especially during financial crises or technological revolutions. Second, the rule does not account for the possibility that money supply also affects y^* . During technological revolutions that shift y^* upward, money supply is crucial to financing the investment needed to bring about that shift. Ignoring this important channel can make the implementation of the Taylor rule structurally too restrictive, reducing long-run growth. Ironically, implementing the Taylor rule may then confirm, in a self-fulfilling manner, that money

growth has no bearing on changes in y^* .

As shown in Table 2, inflation targeting adversely affects growth, with coefficients of -2.11 and -0.9 at lags of four and six quarters, respectively. It also lowers policy rates, with corresponding coefficients of -4.05 and -4.18 . Its effect on containing inflation, however, is not particularly strong statistically, or at least not as statistically strong as its adverse effect on growth.

This suggests that inflation-targeting countries have generally faced an excessively restrictive monetary policy stance, preventing them from financing valuable investment projects. Some positive-NPV projects consequently remained unfunded, resulting in lower growth and perhaps somewhat lower inflation. By contrast, non-inflation-targeting countries have generally experienced an excessively loose monetary policy stance, allowing too much investment financing, including funding for negative-NPV projects, and thereby producing lower real GDP growth and perhaps somewhat higher inflation.

Neither group appears to have found the right policy mix. By our rule, non-inflation-targeting countries should move toward a somewhat more restrictive stance and reduce money supply, thereby reducing financing of inefficient activities in the economy. This would help them achieve stronger growth and lower inflation. Inflation-targeting countries, in contrast, could have adopted an easier monetary stance and expanded money supply, leaving fewer positive-NPV projects unfunded. This would have helped them achieve stronger growth without risking higher inflation.

This is an overall average assessment. Some countries in some periods have indeed found the right policy mix, with χ_t fluctuating closely around the horizontal zero line, as the preceding figures show.

Our second major empirical finding concerning GDP growth is that, across all countries, the coefficient for the standard deviation of money supply on GDP growth and policy rates, is highly significant. The coefficient of $(\chi_{it}^+)^2$ is significant at the 1% level for both growth and policy rates at lags of four and six quarters. The coefficient of $(\chi_{it}^-)^2$ is also significant for growth and policy rates at both lags, although its statistical significance is weaker. This establishes a nonlinear link between GDP growth and policy rates, on the one hand, and the monetary policy stance as measured by money-supply volatility, on the other.

Our regression results also show that, unsurprisingly, the global financial crisis had a strong negative effect on growth, whereas the euro-area debt crisis had a much weaker negative effect. COVID has had a strong negative effect on policy rates.

6. Concluding Remarks

The beauty of the inflation targeting rule is its simplicity. It has also been effective in containing inflation and in maintaining lower policy rates. However, our evidence shows that this has come at the cost of lower growth. Price stability is important both economically and politically. Yet, achieving a full growth potential is arguably just as important economically and politically, if only to be able to better support welfare programs in a sustainable way without structural fiscal deficits.

As we have argued, maximizing GDP growth does not mean giving up on price stability. Higher non-inflationary growth can be achieved if a new rule for money supply is followed than a rigid inflation target. This new rule also involves a simple target, but instead of targeting CPI it targets χ_t , with the target being $\chi_t = 0$. It is a reactive rule, and just as the Taylor rule, it is two-dimensional. However, a key difference with the Taylor rule is that it targets GDP growth rather than an elusive “output gap”. Any measure of output gap is fundamentally backward looking and therefore is ill-suited to capture new growth opportunities.

In our framework, money growth beyond the $\chi_t = 0$ rule will lead to higher inflation but lower growth, as many negative NPV projects are financed in the economy; money growth below the $\chi_t = 0$ rule will lead to lower inflation and lower growth, as positive NPV projects are left unfunded. Therefore, our new rule does not imply a tradeoff relationship between growth and inflation.

A fundamental micro-foundation behind the $\chi_t = 0$ target is the positive NPV rule. Money creation through the funding of positive NPV investments is both non-inflationary and growth enhancing. In contrast, a money injection in the form of the textbook metaphor of a helicopter drop is fundamentally inflationary and wasteful. Accordingly, what is important is not just to move to a new macroeconomic rule for money supply but also to implement more robust microeconomic criteria on how to inject money in the economy and how to ensure that money creation goes to value enhancing investments or expenditures.

In policy implementation, as shown in our analysis, it seems wise to lean slightly below $\chi_t = 0$, although $\chi_t = 0$ is the theoretically optimal target that is consistent with the positive-NPV rule. The intuition is that leaning slightly below $\chi_t = 0$ supports higher growth without much inflation, while leaning slightly above $\chi_t = 0$ depresses growth and inflation, which risks attaining too low growth, too low inflation, and possibly even deflation. A rigid inflation target similarly risks too low growth, too low inflation, and possibly deflation.

From theoretical perspectives, it is interesting to note that the two literatures on monetarism and monetary theory and on the macroeconomics of growth have never

really overlapped. This is because the quantity theory of money equation is fundamentally a static theory, which is orthogonal to the macroeconomics of growth. The notion of output gap is orthogonal to growth and there is no sense in which money supply has something to do with growth. The new framework we have developed (Bolton and Huang, 2018, 2024) informs the theoretical and empirical analysis in this paper that connects and integrates monetary theory and the macroeconomics of growth.

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