

Effective Demand, Inflation, and the Persistence of Unemployment: The Limits of Full-Employment Policy

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Effective Demand, Inflation, and the Persistence of Unemployment: The Limits of Full-Employment Policy

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Abstract

This paper examines whether Keynesian demand management can secure full employment once the cumulative path of output and the accompanying price dynamics are taken into account. Building on the principle of effective demand, it develops a reduced-form framework in which public expenditure, the interest rate and taxation determine a policy-induced component of expected output growth, unemployment depends jointly on inflation and output, and inflation evolves through proportional growth factors. Iterating the framework yields a horizon-dependent expression for expected unemployment that separates cumulative output expansion from inflation. Each equation is confronted with quarterly United States data for 1955Q1–2026Q2 using unit-root, cointegration, stability and pseudo out-of-sample forecast tests. Government expenditure relative to GDP is positively associated with subsequent growth, but the policy instruments explain only about 3% of its variance, their association with growth has weakened since the mid-1970s, and they add no predictive content beyond the persistence of output. Unemployment is unrelated to the level of output but closely tied to the output gap (coefficient -0.62), whereas its association with inflation is small and unstable. Conditional projections imply that raising the expenditure ratio by one percentage point lowers unemployment by about 0.15 points after two years. Full employment thus requires demand to outpace productive capacity, not merely sustained growth.

Keywords: Effective demand · Keynesian economic policy · Output growth · Unemployment · Inflation · Full employment

JEL Classification: E12 · E24 · E31 · E52 · E62

1 Introduction

The proposition that the level of employment is governed by effective demand, and not by an automatic tendency of markets towards full employment, lies at the core of Keynesian macroeconomics (Keynes 1936). Its policy corollary—that fiscal and monetary authorities can, and should, sustain aggregate demand whenever private expenditure falls short of the level required to employ the available labour force—was given its sharpest form by Lerner (1943), whose principle of functional finance judges fiscal decisions by their consequences for output and employment rather than by a predetermined budgetary norm. After several decades in which stabilisation was largely delegated to monetary policy, this corollary has regained prominence. The slow recovery from the global financial crisis and prolonged episodes at the effective lower bound revived the case for active demand management (Summers 2014) and prompted a renaissance of empirical research on fiscal policy (Ramey 2019); the scale of the fiscal response to the pandemic has since given the question renewed practical urgency.

Whether an active demand-management strategy can deliver and maintain full employment is, however, a different question from whether it can raise output. Kalecki (1943) argued that the maintenance of full employment through government expenditure is constrained by political and institutional conditions, and not merely by the technical problem of deficient demand. Distributive conflict adds a second constraint: when workers and firms press incompatible claims on output, expansion may be accompanied by inflation that erodes the purchasing power of nominal incomes (Rowthorn 1977; Lavoie 2014). The debate on the trade-off between unemployment and inflation, from Phillips (1958) to the natural-rate critiques of Phelps (1967) and Friedman (1968), recast this constraint as a limit on the rate of unemployment that policy can sustain without accelerating inflation. Post-Keynesian economists have contested both the theoretical foundations of that limit and its independence from the path of demand (Stockhammer 2008; Storm and Naastepad 2012). The empirical trade-off has, moreover, proved unstable. Inflation expectations in the United States have become firmly anchored and the slope of the Phillips curve has declined since the 1980s (Blanchard 2016), while estimates that exploit variation across US states indicate that the slope is small and that the stability of inflation since the 1990s owes more to anchored long-run expectations than to a flattening of the curve (Hazell et al. 2022).

A related literature questions the presumption that the labour-market consequences of demand fluctuations are transitory. Blanchard and Summers (1986) showed that unemployment may display hysteresis, so that adverse shocks raise it persistently. The aftermath of the Great Recession reinforced this view: the recession was followed by large and lasting losses of potential output across OECD economies (Ball 2014), US local labour markets that suffered larger shocks experienced declines in employment rates that persisted for years (Yagan 2019), and a growing body of evidence indicates that recessions, including those driven by demand, leave persistent marks on output (Cerra et al. 2023). Symmetrically, sustained expansions of autonomous demand appear to raise output durably (Girardi et al. 2020). These findings are consistent with the long-standing result that aggregate output is better described as a difference-stationary than as a trend-stationary process (Nelson and Plosser 1982), and they complicate the mapping from output to employment on which

demand management relies. The conventional form of that mapping is Okun's law, which relates unemployment to output relative to its potential level rather than to the level of output itself (Okun 1962). The relation has remained strong and fairly stable over time in most advanced economies (Ball et al. 2017), but it makes the employment effect of any expansion depend on the growth of productive capacity, a quantity that is estimated with considerable uncertainty in real time (Orphanides and van Norden 2002).

Empirical research on macroeconomic policy has, for its part, concentrated on identifying the causal effects of policy on output. For fiscal policy, structural vector autoregressions (Blanchard and Perotti 2002) and narrative measures of tax changes (Romer and Romer 2010) and of anticipated defence spending (Ramey 2011) have produced a wide range of multiplier estimates. Regime-switching models suggest that spending multipliers are considerably larger in recessions than in expansions (Auerbach and Gorodnichenko 2012), although long historical samples for the United States yield little evidence of such state dependence (Ramey and Zubairy 2018). For monetary policy, narrative measures of policy shocks point to large effects of the policy rate on output (Romer and Romer 2004), yet the effects of a given shock appear to have diminished since the early 1980s as policy has responded more systematically to inflation (Boivin and Giannoni 2006). This literature answers a precise causal question—the response of output to an exogenous change in a policy instrument—and its common message is that policy effects are state-dependent and unstable over time.

The question addressed in this paper is different. It concerns the mapping from a policy stance, through the cumulative trajectory of output that this stance implies, to the unemployment outcome once inflation is taken into account. A policy that reliably raises output need not secure full employment if the resulting expansion is matched by the growth of productive capacity, or if its gains are offset by the erosion of real incomes. Answering the question therefore requires a framework that keeps the cumulative expansion of activity and the accompanying price dynamics analytically distinct, and an empirical strategy that confronts each component of that framework with the data, rather than only its final implication.

The paper makes two contributions. First, it develops a compact reduced-form framework in which three policy instruments—public expenditure, the interest rate and the tax rate—determine a policy-induced component of expected output growth, unemployment is related jointly to inflation and output, and inflation evolves through proportional growth factors. Iterating these relationships yields a horizon-dependent expression for expected unemployment, Eq. (9), in which the contribution of cumulative output expansion is separated from that of inflation. The expression makes precise why a sustained expansion of output does not, by itself, guarantee full employment: the outcome depends on the relative contributions of the two components and on how output is mapped into unemployment. Second, the paper takes every equation of the framework to quarterly data for the United States over 1955Q1–2026Q2. Each equation is first estimated exactly as written; deviations are introduced only where unit-root, cointegration and stability diagnostics require them, and both versions are reported throughout. The predictive content of the cumulative framework is then evaluated in a pseudo out-of-sample exercise, and conditional projections translate alternative policy paths into unemployment outcomes.

The evidence supports the central argument of the framework, though not every relationship holds in the form written. Government expenditure relative to GDP is positively associated with subsequent output growth, but the three instruments account for only about 3% of the variance of quarterly growth, and the association has weakened markedly since the mid-1970s, in line with the instability documented by the identification literature. Output is highly persistent, and conditioning its expected path on the policy instruments does not improve on forecasts based on its own history. Written in terms of the level of output, the unemployment relation is spurious; unemployment is instead closely tied to output relative to productive capacity, with a coefficient of -0.62 on the output gap, whereas its association with inflation is small and unstable, turning from a significant trade-off before 1971 to no systematic relationship thereafter. Conditional projections from 2026Q2 imply that raising government expenditure by one percentage point of GDP for four quarters lowers unemployment two years ahead by about 0.15 percentage points. Taken together, these results imply that full employment cannot be inferred from cumulative output growth alone: what matters is whether policy-induced growth outpaces the growth of capacity, and the policy component that could secure this is small and unstable.

The remainder of the paper is organised as follows. Section 2 presents the theoretical framework and derives its testable implications. Section 3 describes the data and Section 4 the econometric methodology. Section 5 reports the results, Section 6 discusses their implications for full-employment policy, and Section 7 concludes.

2 Theoretical framework

2.1 Keynesian policy and the expected growth of output

Consider an economy in which policymakers pursue full employment through active macroeconomic intervention. The evolution of aggregate output is represented by

$$\mathbb{E}_t[Y_{t+1}] = (1 + \hat{g}_t) Y_t, \quad (1)$$

where Y_t denotes aggregate output at time t and $\mathbb{E}_t[\cdot]$ the expectation conditional on the information available at time t . The term $\hat{g}_t$ is the policy-induced component of expected output growth. It depends on three policy instruments—public expenditure G_t , the interest rate r_t and the tax rate τ_t :

$$\hat{g}_t = \delta G_t + \beta r_t + \gamma \tau_t, \quad (2)$$

where δ , β and γ govern the respective contributions of the instruments.

Equation (2) is a reduced-form representation of the relationship between macroeconomic policy and output growth. Public expenditure captures the direct demand-side channel through which government spending supports aggregate demand. The interest rate represents the monetary channel, operating through financing conditions and interest-sensitive expenditure. The tax rate captures the fiscal channel through which taxation affects disposable income, consumption and private demand. The specification reflects the Keynesian proposition that full employment cannot be left to automatic market adjustment: when private expenditure is insufficient to sustain output at its full-employment level, active fiscal and monetary policy may support demand and output. The effectiveness of such intervention depends on the

magnitude of the policy coefficients and on the broader dynamics governing output and employment.

Equation (1) places the dynamics of output within a framework in which production and employment depend on the evolution of aggregate demand. Rather than presuming that market forces bring the economy to full employment, it allows the expected trajectory of output to depend on the stance of policy. This follows the principle of effective demand, according to which employment is determined by the intersection of aggregate demand and aggregate supply expectations (Keynes 1936). It is also consistent with Kalecki (1943), for whom the maintenance of full employment through government expenditure is shaped by the political and institutional conditions governing economic policy. Equation (1) is therefore a reduced-form representation of expected output dynamics, not a structural determination of employment. In particular, a positive policy-induced contribution to growth does not by itself guarantee full employment; that outcome also depends on the initial level of activity, on productive capacity and on the relationship between output and labour demand.

Equation (2) makes this policy dependence explicit. The inclusion of public expenditure reflects the demand-management rationale of functional finance (Lerner 1943), which assesses fiscal decisions by their consequences for output and employment rather than against a balanced-budget norm. The interest-rate term introduces the monetary conditions that affect financing costs and investment, and the tax-rate term the influence of fiscal arrangements on disposable income and private expenditure. These channels are consistent with the post-Keynesian emphasis on the interaction between monetary institutions, income flows and production (Godley and Lavoie 2007). The coefficients δ , β and γ summarise the marginal associations between the instruments and the policy-induced growth component. Their interpretation depends on the units of measurement and on the mechanisms the model represents; in particular, the effects of interest rates and taxation are to be derived from explicit assumptions or evaluated empirically rather than imposed independently of the institutional context. The specification is thus a starting point for examining whether, and under what conditions, an active policy stance can support sustained expansion and the pursuit of full employment.

2.2 Employment, inflation and the limits of demand management

The framework raises a further question about the relationship between output expansion, unemployment and prices. Expansionary policy may support demand and production without bringing a permanent improvement in employment or purchasing power. The outcome depends on the responsiveness of production, on the distribution of income and on the formation of prices and wages. This issue is central to the post-Keynesian critique of the presumption that macroeconomic stabilisation reduces to the attainment of a single equilibrium unemployment rate (Stockhammer 2008; Lavoie 2014). The maintenance of full employment involves institutional and political constraints in addition to demand insufficiency (Kalecki 1943), and the distributive conflict between wages and profits may shape the inflationary consequences of expansion when nominal incomes and prices alter the distribution of real income (Asimakopulos 1975; Rowthorn 1977). The pursuit of full employment must therefore be considered together with the evolution of inflation and its implications for workers' purchasing power.

To formalise this interaction, let the unemployment-related variable be represented by

$$\hat{u}_t^* = a\hat{\pi}_t + b\hat{Y}_t, \quad (3)$$

where $\hat{u}_t^*$ denotes the unemployment measure, or unemployment-related threshold, of interest, $\hat{\pi}_t$ the inflation variable and $\hat{Y}_t$ the relevant output measure. The parameters a and b capture the relationships between inflation, output and the unemployment-related variable, and their signs depend on the interpretation of the variables. If $\hat{u}_t^*$ is the unemployment rate itself, the relationship between output and unemployment would ordinarily be negative, other things being equal. Equation (3) is accordingly interpreted in the light of the intended definition of the unemployment variable, not as an unrestricted structural relationship.

The inflationary consequences of sustained expansion are introduced through the dynamic specification

$$\hat{\pi}_{t+1} = (1 + f_t)\hat{\pi}_t, \quad (4)$$

where f_t is the rate of change of the inflation variable. When $f_t > 0$ inflation increases from one period to the next; when $f_t = 0$ it is constant; and when $-1 < f_t < 0$ it declines while remaining positive, provided that $\hat{\pi}_t > 0$. Equation (4) captures proportional inflation dynamics but does not, by itself, establish that inflation is caused by expansionary policy. Such a conclusion would require an explicit relationship between f_t and the policy instruments, output, wage formation or other determinants of prices.

The distinction between nominal expansion and real purchasing power is essential to the argument. If prices rise faster than nominal incomes, the purchasing power of those incomes declines, offsetting part of the welfare gains associated with higher output and employment. This does not imply that every expansionary policy generates accelerating inflation, nor that full employment is unattainable. It identifies a limitation of a policy strategy assessed exclusively through nominal output growth: the sustainability of employment gains must also be evaluated in relation to inflation, real wages and the distribution of the additional income generated by expansion. Full employment is thus treated as a policy objective whose achievement and persistence depend on the interaction of demand conditions, price dynamics and distributional processes.

2.3 Output forecasting

To examine the dynamics of output empirically, the framework incorporates a forecasting equation that relates future output to its observed history. Let the h -step-ahead conditional forecast of output be

$$\hat{Y}_{t+h|t} = \mu + \sum_{i=0}^p c_i Y_{t-i}, \quad (5)$$

where $\hat{Y}_{t+h|t}$ is the forecast of output at $t+h$ conditional on information available at t , μ is a constant, p is the maximum lag order and c_i is the coefficient on the observed output value Y_{t-i} . The inclusion of the contemporaneous observation Y_t allows the forecast to incorporate the most recently observed level of output, while the remaining terms capture its dependence on earlier observations.

Equation (5) is a parsimonious autoregressive specification that characterises output persistence and generates forecasts against which the implications of the policy framework can be assessed. Because it contains only the history of output, it is univariate; a multivariate forecasting framework would also include unemployment, inflation, public expenditure, interest rates or taxation. Its role is distinct from that of Eqs. (1)–(2): the latter express the proposed relationship between policy and expected output dynamics, whereas Eq. (5) is a statistical representation of output conditional on its own past. Bringing the two together makes it possible to assess whether the observed persistence of output is consistent with the hypothesised policy dynamics. Forecasts based solely on past output cannot, however, identify the causal effects of fiscal or monetary policy; such identification requires additional restrictions, explanatory variables or a strategy capable of distinguishing policy responses from the conditions that induce them.

2.4 Cumulative output dynamics and the long-run prospects for full employment

The framework makes it possible to examine the long-run implications of Keynesian demand management. Whereas Eqs. (1)–(2) describe the evolution of output under an active policy regime, the central question is the extent to which the resulting expansion translates into a sustained reduction in unemployment. This requires moving beyond the immediate effects of intervention to the cumulative trajectory of output and its interaction with inflation. Iterating Eq. (1) over the interval from t to T yields

$$\mathbb{E}_t[Y_T | g_t] = Y_t \prod_{i=t}^{T-1} (1 + \hat{g}_i), T > t, \quad (6)$$

where $\hat{g}_i$ is the policy-induced growth component in period i , and conditioning on g_t denotes that the expectation is formed for a specified path of growth factors $\{\hat{g}_i\}_{i=t}^{T-1}$. The expression captures the cumulative effect of successive growth factors on output. Under a deterministic policy path, or conditional on a specified sequence of growth factors, it gives a direct representation of the output trajectory associated with the policy regime.

An expanding output trajectory does not imply that full employment will be attained or maintained. The employment consequences of growth depend on the response of labour demand, on productivity and on the distribution of income, while the evolution of prices determines how nominal expansion translates into real purchasing power. To represent the interaction between these dimensions, the unemployment-related variable is specified as

$$\hat{u}_{T+h}^* = a \hat{\pi}_{T+h} + b \hat{Y}_{T+h}, \quad (7)$$

where $\hat{u}_{T+h}^*$ is the unemployment measure under consideration, $\hat{\pi}_{T+h}$ the inflation variable and $\hat{Y}_{T+h}$ the corresponding output measure or forecast. Inflation evolves according to Eq. (4), which can be iterated to obtain

$$\mathbb{E}_t[\hat{\pi}_{T+h} | g_t] = \hat{\pi}_t \prod_{i=t}^{T+h-1} (1 + f_i) \quad (8)$$

for a specified path of inflation growth factors. Combining this expression with the unemployment relationship gives

$$\mathbb{E}_t[\hat{u}_{T+h}^* | g_t] = a \hat{\pi}_t \prod_{i=t}^{T+h-1} (1+f_i) + b \left(\mu + \sum_{i=0}^p c_i \left[\prod_{j=t}^{T-1-i} (1+\hat{g}_j) \right] Y_t \right). \quad (9)$$

Equation (9) brings inflation and output together within a common, horizon-dependent representation of unemployment. It clarifies the analytical distinction between the cumulative expansion of economic activity and the price dynamics accompanying that expansion: the long-run trajectory of unemployment depends on the relative contributions of the two components rather than on output growth considered in isolation.

To characterise the output component, the forecasting specification of Eq. (5) is employed,

$$\hat{Y}_{T+h} = \mu + \sum_{i=0}^p c_i Y_{T-i}, \quad (10)$$

where $\hat{Y}_{T+h}$ is the forecast of output at horizon $T+h$. When the output observations entering Eq. (10) are not yet available at the forecasting origin, their conditional forecasts from Eq. (6) are used; this substitution produces Eq. (9), which holds exactly when $T-p > t$, so that every lagged term is a forecast. Terms with $T-i \leq t$ are observed and enter at their realised values. The specification is univariate in its present form; a multivariate extension would be required to model the joint dynamics of output, inflation and unemployment directly.

The framework thus addresses a central problem of Keynesian policy: whether the expansion of aggregate demand can sustain full employment when inflation and the distribution of real income are also taken into account. If price increases outpace nominal income growth, the purchasing power generated by expansion may be eroded, weakening its benefits for households. Whether this erosion also reverses employment gains depends on the relationship between real demand, production and labour utilisation. Full employment cannot therefore be inferred from cumulative output growth alone; its persistence must be assessed in relation to the interaction between output dynamics, inflation and unemployment.

2.5 Testable implications

The framework yields five implications that can be confronted with the data without imposing signs that the theory leaves open.

- I1. Policy and growth** (Eq. 2). The policy instruments carry information about the expected growth of output: δ , β and γ are not all zero. The conventional Keynesian signs ($\delta > 0$, $\beta < 0$, $\gamma < 0$) serve as a reference, not as a restriction.
- I2. Unemployment, inflation and output** (Eq. 3). With $\hat{u}_t^*$ measured by the unemployment rate, $b < 0$; the sign of a is left open.
- I3. Proportional inflation dynamics** (Eq. 4). The growth factors $1+f_t$ are well defined and display no systematic drift that would by itself generate accelerating inflation.
- I4. Output persistence** (Eq. 5). Output is highly persistent, so that $\sum_i c_i$ is close to one.
- I5. Cumulative dynamics** (Eqs. 6–10). If the policy-induced component carries information about the trajectory of output, conditioning that trajectory on the instruments should improve on forecasts based on the history of output alone, and the composite expression (9) should be informative about future unemployment.

3 Data

The empirical analysis uses quarterly data for the United States from 1955Q1 to 2026Q2 (286 quarters), retrieved from the Federal Reserve Economic Data database (Federal Reserve Bank of St. Louis 2026) on 24 October 2026. Table 1 lists the variables, their definitions and their sources. The sample begins in the first year for which the effective federal funds rate is available for every month, and ends in the last quarter in which all core series are observed; no series is extrapolated.

Table 1 Variables, definitions and sources

Symbol	Definition and units	Source (FRED identifier)
Y_t	Real gross domestic product, billions of chained 2017 dollars, seasonally adjusted annual rate	BEA (GDPC1)
G_t	100× government consumption expenditures and gross investment / nominal GDP (%)	BEA (GCE, GDP)
r_t	Effective federal funds rate, quarterly average of monthly values (% per annum)	Federal Reserve Board (FEDFUNDS)
τ_t	100× government current tax receipts (all levels of government) / nominal GDP (%)	BEA (W054RC1Q027SBEA, GDP)
u_t	Civilian unemployment rate, quarterly average (%)	BLS (UNRATE)
π_t	Year-on-year CPI inflation, 100 ($P_t/P_{t-4}-1$), with P_t the quarterly average of the CPI for all urban consumers (%)	BLS (CPIAUCSL)
Output gap	100 ($Y_t - Y_t^*$)/ Y_t^* , with Y_t^* real potential GDP (% of potential)	BEA, CBO (GDPC1, GDPPOT)
<i>Alternative measures used in robustness checks</i>		
G_t	Federal expenditure/GDP; quarterly growth of real government expenditure	BEA (FGCE; GCEC1)
r_t	3-month Treasury bill rate; 10-year Treasury yield; ex-post real rate $r_t - \pi_t$	Federal Reserve Board (TB3MS; GS10)
τ_t	Federal tax receipts/GDP; personal current taxes/personal income	BEA (W006RC1Q027SBEA; W055RC1Q027SBEA, PI)
π_t	PCE price inflation; GDP-deflator inflation (year on year); annualised quarterly CPI inflation	BEA (PCEPI; GDPDEF); BLS
u_t	Unemployment gap: u_t minus the noncyclical rate of unemployment	BLS, CBO (UNRATE, NROU)

Notes: BEA: U.S. Bureau of Economic Analysis; BLS: U.S. Bureau of Labor Statistics; CBO: Congressional Budget Office. Recession dates for the figures are taken from the NBER-based indicator USRECCQ.

Three measurement choices deserve comment. First, public expenditure and taxation enter as ratios to nominal GDP. This makes the instruments scale-free, gives them units comparable with those of a growth rate, and makes the tax variable an economy-wide average tax rate that captures the disposable-income channel of Eq. (2). Second, inflation is measured year on year. The proportional dynamics of Eq. (4) are defined only when inflation is positive, and the year-on-year rate is positive in all but seven quarters of the sample (1955Q1–Q3, 2009Q1–Q3 and 2015Q1), whereas the annualised quarter-on-quarter rate is non-positive in 16 quarters. Third, the unemployment variable of Eq. (3) is the unemployment rate itself, the interpretation under which the theory expects $b < 0$.

Monthly series are converted to quarterly averages using complete quarters only. All national-accounts and labour-market series are seasonally adjusted at source; regressions of the stationary transforms of the core variables on quarter dummies do not reject the absence of residual seasonality at the 5% level. Missing observations are neither interpolated nor imputed. The only gap within the sample concerns 2025Q4: the October 2025 values of the unemployment rate and the CPI were never collected because of the federal government shutdown of October–November 2025, so that u_t and π_t are unavailable for that quarter.¹

¹ The Bureau of Labor Statistics cancelled the October 2025 employment and CPI releases because data collection could not take place during the shutdown, and household-survey data cannot be collected

Extreme observations, notably those of 2020Q2–Q3, are retained because they correspond to genuine macroeconomic events; their influence is examined through subsample estimates.

Table 2 reports descriptive statistics and Fig. 1 plots the series. Real GDP grew on average by 0.75% per quarter, while the policy-induced component of Eq. (2) must be inferred from a realised growth rate that is volatile (standard deviation 1.07 percentage points) and almost serially uncorrelated. Unemployment averaged 5.80% and ranged from 3.4% to 13.0%. It is strongly and negatively correlated with the output gap (correlation -0.85), but it displays no trend while output grows steadily, a contrast that is central to the interpretation of Eq. (3) below. Government expenditure fell from 22.2% of GDP on average before 1984 to 18.4% after 2008, and the federal funds rate averaged 1.44% after 2008, reflecting the long period at the effective lower bound. The ratio of tax receipts to GDP is comparatively stable (standard deviation 1.09 percentage points). The rate of change of inflation, f_t , has a median close to zero but extreme values, because the denominator of f_t approaches zero in a few quarters.

Table 2 Descriptive statistics, United States, 1955Q1–2026Q2

Variable	<i>N</i>	Mean	SD	Min	Max	Skew.	Ex. kurt.	$\rho(1)$
Real GDP, Y_t (trillions)	286	11.294	6.204	3.021	24.408	0.41	-1.08	1.000
Realised growth $100(Y_{t+1}/Y_t - 1)$	285	0.741	1.065	-7.877	7.762	-1.04	20.72	0.060
G_t : government expenditure/GDP (%)	286	20.330	2.022	17.042	24.198	0.05	-1.14	0.990
r_t : federal funds rate (%)	286	4.622	3.513	0.060	17.780	1.02	1.36	0.972
τ_t : tax receipts/GDP (%)	286	19.731	1.088	16.346	22.420	-0.37	0.31	0.924
u_t : unemployment rate (%)	285	5.798	1.668	3.400	13.000	0.93	0.85	0.912
π_t : CPI inflation, y/y (%)	285	3.597	2.751	-1.607	14.426	1.58	2.72	0.965
Output gap (% of potential)	286	-0.130	2.281	-8.831	6.106	-0.38	0.85	0.900
$f_t = \pi_{t+1}/\pi_t - 1$	277	0.064	0.422	-1.115	3.286	3.86	24.90	0.139

Notes: Quarterly data. $\rho(1)$ is the first-order autocorrelation. Realised growth is measured between t and $t+1$ and is therefore unavailable for 2026Q2. f_t is defined only when $\pi_t > 0$; its moments are dominated by quarters in which π_t is close to zero.

retroactively.

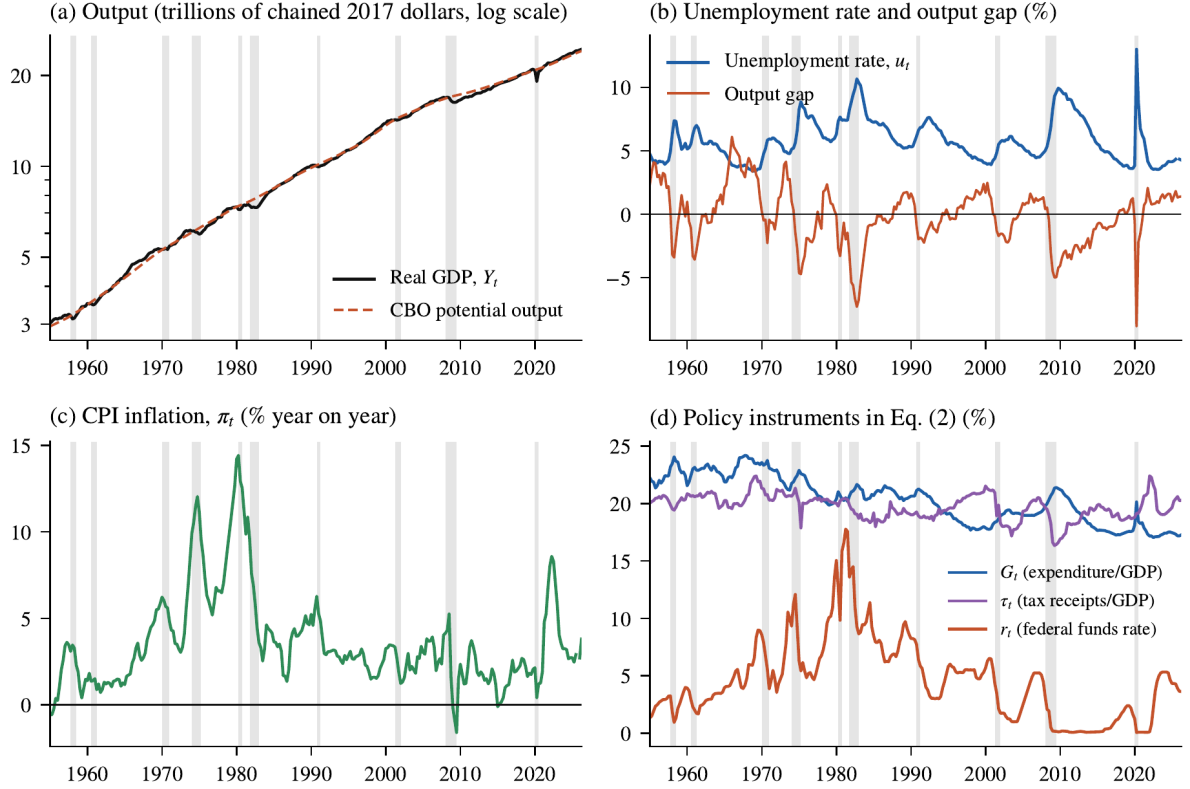


Fig. 1 United States macroeconomic data, 1955Q1–2026Q2. Shaded areas mark NBER recessions. The output gap is measured relative to CBO potential output; the 2025Q4 values of u_t and π_t are missing (see text)

4 Econometric methodology

The empirical strategy evaluates each equation of the framework as written, documents the diagnostics that bear on its validity, and introduces deviations only where these diagnostics require them. Two specifications are therefore carried through the analysis: the specification *as written*, which reproduces Eqs. (2)–(3) exactly, and an *adjusted* specification that departs from them only as far as the evidence demands.

4.1 Empirical counterparts of the framework

Equations (1)–(2) imply that realised growth between t and $t+1$ equals the policy-induced component plus an expectational error. With growth measured in per cent per quarter, so that the growth factor in Eq. (1) is $1+\hat{g}_t/100$, the estimating equation is

$$100 \left(\frac{Y_{t+1}}{Y_t} - 1 \right) = \delta G_t + \beta r_t + \gamma \tau_t + \varepsilon_{t+1}, \mathbb{E}_t[\varepsilon_{t+1}] = 0. \quad (11)$$

Because the instruments are dated t and the dependent variable is realised between t and $t+1$, the regression uses no information that postdates the instruments. Equation (11) contains no constant, as in Eq. (2); the restriction is tested by adding one.

The unemployment relation of Eq. (3) is estimated as

$$u_t = \alpha + a \pi_t + b x_t + v_t, \quad (12)$$

where u_t is the unemployment rate, π_t CPI inflation and x_t the output measure. The specification as written sets $\alpha=0$ and $x_t=Y_t$, real GDP in trillions of chained dollars. The

adjusted specification admits $\alpha \neq 0$ if the zero-intercept restriction is rejected at the 5% level, and replaces the level of output by the output gap if a relationship between u_t and the level of output is unbalanced in its orders of integration or not cointegrated. The output gap is the natural candidate for the “relevant output measure” of Eq. (3), since it relates output to the productive capacity whose utilisation governs labour demand.

The growth factors of Eq. (4) are computed directly as $f_t = \pi_{t+1}/\pi_t - 1$ whenever $\pi_t > 0$. Systematic drift is assessed through the mean of $\ln(\pi_{t+1}/\pi_t)$, which is defined when inflation is positive in both quarters and is less sensitive to near-zero denominators than f_t itself.

The forecasting equation (5) is estimated as a direct h -step projection,

$$Y_{t+h} = \mu_h + \sum_{i=0}^p c_{i,h} Y_{t-i} + e_{t+h}, h \in \{1, 4, 8\}, \quad (13)$$

so that μ and c_i in Eqs. (5) and (10) are specific to the horizon (Marcellino et al. 2006; Jordà 2005). For $h=1$, Eq. (13) is an autoregression in levels with $p+1$ terms. The lag order $p \leq 8$ is selected by the Bayesian information criterion on a common estimation sample.

4.2 Diagnostics and specification

The order of integration of each series is assessed with the augmented Dickey–Fuller (ADF), Phillips–Perron (PP) and DF-GLS tests, which take a unit root as the null hypothesis, and with the KPSS test, which takes stationarity as the null (Dickey and Fuller 1979; Phillips and Perron 1988; Elliott et al. 1996; Kwiatkowski et al. 1992). A series is classified as $I(0)$ if a majority of the three unit-root tests reject at the 5% level, and as $I(1)$ if the majority rejects for its first difference; disagreements with KPSS are reported. Because structural breaks can mask stationarity, the Zivot and Andrews (1992) test with one endogenous break is also applied. Cointegration is examined with the residual-based test of Engle and Granger (1987), using MacKinnon p -values (MacKinnon 2010), and with the trace test of Johansen (1991).

These diagnostics bear directly on the framework. Equation (11) relates a growth rate, which is $I(0)$, to instruments that may be $I(1)$; the regression is balanced only if the instruments are $I(0)$ or cointegrated among themselves. Where it is not, conventional inference is not reliable (Sims et al. 1990), and the evidence is complemented by bootstrap intervals and subsample estimates. Equation (12) with $x_t = Y_t$ relates the unemployment rate to the level of output; unless the two cointegrate, such a regression is spurious in the sense of Granger and Newbold (1974).

4.3 Estimation and inference

All regressions are estimated by ordinary least squares with Newey and West (1987) heteroskedasticity- and autocorrelation-consistent standard errors, using $\lfloor 4(T/100)^{2/9} \rfloor$ lags (Newey and West 1994), that is, five lags in the full sample; for h -step projections the lag length is at least $h-1$. As a complement, 95% percentile intervals are obtained from 999 moving-block bootstrap replications with block length $T^{1/3} \approx 7$ (Künsch 1989). Where an equation is estimated without a constant, the uncentred R^2 is the relevant measure of fit and joint significance tests also restrict the mean of the dependent variable.

Parameter stability is tested with the Andrews (1993) sup-Wald (QLR) test for a break at an unknown date in all coefficients, with 15% trimming and HAC covariance; p -values are

simulated from its asymptotic null distribution. The CUSUM test on OLS residuals (Ploberger and Krämer 1992), HAC Wald tests at four candidate dates (1973Q4, 1984Q1, 2008Q3 and 2020Q1) and coefficients estimated over rolling 60-quarter windows complete the stability analysis. Residuals are examined for autocorrelation, heteroskedasticity, ARCH effects, non-normality and functional-form misspecification.

4.4 Forecast evaluation and conditional projections

The predictive content of the cumulative framework is assessed in a pseudo out-of-sample exercise with forecast origins from 1990Q1 to 2026Q1 and an expanding estimation window. At each origin all parameters, including the lag order p , are re-estimated with information dated t or earlier. Output is forecast at $h=1, 4, 8$ with (i) the direct projection (13); (ii) Eq. (6) with the instruments held at their values at t , so that $\mathbb{E}_t[Y_{t+h}] = Y_t(1 + \hat{g}_t/100)^h$; (iii) Eq. (6) with the realised instrument path, an infeasible benchmark that conditions on actual policy; (iv) a random walk; and (v) a random walk with drift. Unemployment is forecast with the composite expression (9), with $T=t+4$ and $h=4$ so that $T+h=t+8$, $\hat{g}$ held at its value at t , and f_i set either to zero or to the geometric mean of f over the preceding 20 quarters. Because $p=1$ (Sect. 5.1), $T-p > t$ and Eq. (9) applies exactly as written. In the adjusted specification the output forecast $\hat{Y}_{T+h}$ enters as a gap relative to potential output at the target date. Benchmarks are a random walk and a direct autoregression for u_t . Accuracy is compared with the Diebold–Mariano test (Diebold and Mariano 1995) with the small-sample correction of Harvey et al. (1997), and, for the nested comparison of Eq. (13) with the random walk, with the test of Clark and West (2007).

Finally, conditional projections are computed from the last observation, 2026Q2, with $T=t+4$ and $h=4$, so that the target is 2028Q2. Four deterministic policy paths are considered: the instruments held at their 2026Q2 values, and the same path with government expenditure raised by one percentage point of GDP, the federal funds rate lowered by one percentage point, or the tax rate lowered by one percentage point. Each is combined with three inflation paths: $f_i=0$, and f_i equal to the geometric mean of f over the last 20 quarters or over the full sample. Ninety per cent bands reflect parameter uncertainty and are obtained from 999 joint moving-block bootstrap re-estimations of Eqs. (11), (12) and (13). The computations use Python with the statsmodels (Seabold and Perktold 2010) and arch libraries.

5 Results

5.1 Time-series properties

Table 3 reports the unit-root and stationarity tests. Output is integrated of order one: the unit-root null is not rejected for real GDP in levels or logarithms (ADF $p=0.967$ and $p=0.900$), while all tests reject it for the first differences and KPSS confirms both conclusions. Government expenditure relative to GDP and the federal funds rate are also I(1) (ADF $p=0.637$ and $p=0.209$), and the Zivot–Andrews test does not overturn this classification when a single break is allowed (Table A1). The tax ratio is classified as I(0), since ADF, PP and DF-GLS all reject the unit root, but the KPSS test rejects stationarity, so its order of integration is uncertain. The unemployment rate, the output gap and realised output growth are unambiguously stationary. For inflation, ADF and DF-GLS do not reject the unit root, PP

rejects only at the 10% level and KPSS does not reject stationarity at 5%, so the evidence is inconclusive and the decision rule classifies it as I(1). All three information criteria select $p=1$ in Eq. (13), so the forecasting equation contains Y_t and Y_{t-1} (Table A5).

Table 3 Unit-root and stationarity tests

Variable	Form	ADF	PP	DF-GLS	KPSS	Order
$\ln Y_t$	Level (c,t)	-1.25	-1.27	-0.63	0.53***	I(1)
	Δ (c)	-10.57***	-15.86***	-7.02***	0.39*	
Y_t	Level (c,t)	-0.78	-0.64	0.35	0.61***	I(1)
	Δ (c,t)	-19.53***	-20.25***	-19.49***	0.04	
G_t	Level (c)	-1.28	-1.03	-0.67	2.22***	I(1)
	Δ (c)	-7.79***	-15.22***	-4.46***	0.04	
r_t	Level (c)	-2.19	-2.23	-1.60	0.80***	I(1)
	Δ (c)	-7.55***	-12.31***	-7.11***	0.07	
τ_t	Level (c)	-3.84***	-3.39**	-3.71***	0.76***	I(0)
	Δ (c)	-10.36***	-18.19***	-9.49***	0.03	
u_t	Level (c)	-3.58***	-3.62***	-3.14***	0.17	I(0)
	Δ (c)	-17.40***	-17.96***	-15.13***	0.04	
π_t	Level (c)	-1.67	-2.68*	-0.47	0.38*	I(1)
	Δ (c)	-5.39***	-10.31***	-5.29***	0.05	
Output gap	Level (c)	-4.64***	-3.86***	-3.12***	0.27	I(0)
	Δ (c)	-16.27***	-16.74***	-10.85***	0.03	
Realised growth	Level (c)	-10.57***	-15.88***	-6.99***	0.38*	I(0)
	Δ (c)	-9.23***	-67.85***	-3.52***	0.14	

Notes: ADF (Dickey and Fuller 1979), PP (Phillips and Perron 1988) and DF-GLS (Elliott et al. 1996) test the null of a unit root; KPSS (Kwiatkowski et al. 1992) tests the null of stationarity. (c) constant; (c,t) constant and linear trend. ADF lags selected by AIC. ***, **, *: rejection of the respective null at 1%, 5%, 10%. Integration order: a series is I(0) if a majority of ADF, PP and DF-GLS reject at 5%, and I(1) if the majority rejects for its first difference; KPSS is confirmatory. KPSS contradicts the majority for τ_t and π_t .

These properties have direct implications for the framework (Table 4). Equation (3) as written relates a stationary variable, the unemployment rate, to an I(1) variable, the level of output. Such a relationship cannot be a cointegrating one, and the Engle–Granger test accordingly does not reject the absence of cointegration ($p=0.130$). The relation between unemployment, inflation and the output gap with a constant is, by contrast, balanced and its residuals are stationary ($p=0.003$). For Eq. (11), two of the three instruments are I(1), and the Johansen trace test does not reject the absence of cointegration among them (trace statistic 28.63 against a 5% critical value of 29.80). The growth equation is therefore unbalanced, and its conventional standard errors are treated as indicative and complemented by bootstrap and subsample evidence.

Table 4 Cointegration tests

Relation	Statistic	p -value
<i>Panel A. Engle–Granger residual-based tests (H_0: no cointegration)</i>		
u_t on π_t, Y_t (Eq. 3 as written)	-2.882	0.130
u_t on π_t, Y_t , constant	-3.666	0.061
u_t on π_t , output gap	-3.121	0.077
u_t on π_t , output gap, constant	-4.632	0.003
<i>Panel B. Johansen trace tests (5% critical values in brackets)</i>		
System	Det.	$r = 0$ $r \leq 1$ $r \leq 2$ Rank
(u_t, π_t, Y_t)	none	173.94 [24.28] 20.34 [12.32] 1.19 [4.13] 2
(u_t, π_t, Y_t)	const.	75.03 [29.80] 28.67 [15.49] 10.43 [3.84] 3
$(u_t, \pi_t, \text{gap}_t)$	const.	70.59 [29.80] 31.05 [15.49] 7.18 [3.84] 3
(G_t, r_t, τ_t)	const.	28.63 [29.80] 11.65 [15.49] 0.53 [3.84] 0

Notes: Panel A: Engle and Granger (1987) tests with MacKinnon p -values and BIC lag selection. Panel B: Johansen (1991) trace statistics; VAR lag order in differences by BIC; critical values from Osterwald-Lenum (1992). A rank equal to the number of variables indicates that all variables are stationary, which is the expected outcome when stationary series such as u_t or the output gap enter the system.

5.2 Policy instruments and the growth of output

Table 5 reports the estimates of Eq. (11). In the specification as written (column 1), the coefficient on government expenditure is positive and significant at the 5% level ($\hat{\delta}=0.0618$, standard error 0.0297), the coefficient on the federal funds rate is negative and significant at the 10% level ($\hat{\beta}=-0.0383$, standard error 0.0215), and the coefficient on the tax ratio is small and insignificant ($\hat{\gamma}=-0.0170$). Adding a constant does not change these conclusions (column 2); the constant itself is insignificant ($p=0.329$), so the zero-intercept restriction implicit in Eq. (2) is not rejected and the adjusted specification of the growth equation coincides with the specification as written.

Table 5 Estimates of the policy-induced growth component, Eq. (2)

	(1) Eq. (2) as written	(2) With constant	(3) Eq. (2), pre-break	(4) Eq. (2), post-break
$\delta (G_t)$	0.0618** (0.0297)	0.0749** (0.0320)	0.1281 (0.1298)	0.0443 (0.0364)
$\beta (r_t)$	-0.0383* (0.0215)	-0.0431* (0.0222)	-0.1594*** (0.0406)	-0.0156 (0.0252)
$\gamma (\tau_t)$	-0.0170 (0.0291)	0.0396 (0.0632)	-0.0652 (0.1500)	-0.0044 (0.0337)
Constant		-1.3634 (1.3971)		
Sample	1955Q1–2026Q1	1955Q1–2026Q1	1955Q1–1975Q1	1975Q2–2026Q1
N	285	285	81	204
R^2 (centred)	0.028	0.033	0.170	0.010
R^2 (uncentred)	0.347	0.349	0.497	0.308
Wald $\delta = \beta = \gamma = 0, p$	<0.001	0.058	<0.001	<0.001
MBB 95% CI, δ	[0.003, 0.129]			
MBB 95% CI, β	[-0.078, 0.017]			
MBB 95% CI, γ	[-0.086, 0.042]			

Notes: Dependent variable: realised growth $100(Y_{t+1}/Y_t - 1)$, in per cent per quarter; regressors dated t . G_t and τ_t in per cent of GDP, r_t in per cent per annum. OLS with Newey and West (1987) standard errors in parentheses (5 lags in the full sample). ***, **, *: significant at 1%, 5%, 10% (two-sided). Columns (3)–(4) split the sample at 1975Q2, the break date estimated by the QLR test (Table 8). Without a constant the Wald test also restricts mean growth to zero and is uninformative about the policy channels; the uncentred R^2 is the relevant fit measure for columns (1), (3) and (4). MBB: moving-block bootstrap percentile intervals (999 replications, block length 7; Künsch 1989) for column (1).

The estimated associations are economically modest. A one-standard-deviation increase in government expenditure (2.02 percentage points of GDP) is associated with growth higher by 0.125 percentage points in the following quarter, about half a point at an annual rate, and a one-point increase in the federal funds rate with growth lower by 0.038 points per quarter. More importantly, the instruments explain only 2.8% of the variance of quarterly growth. The fitted policy-induced component varies between 0.23% per quarter (1981Q3) and 1.12% (1958Q2), with a standard deviation of 0.17 percentage points against 1.07 for realised growth (Fig. 2a). Cumulated through Eq. (6), the component tracks the trend of output over long periods but not its deviations: the path started in 1984Q1 falls persistently below actual output during the 1990s, and the path started in 2010Q1 rises above it (Fig. 2b). The fitted component therefore behaves essentially as a slowly moving average growth rate.

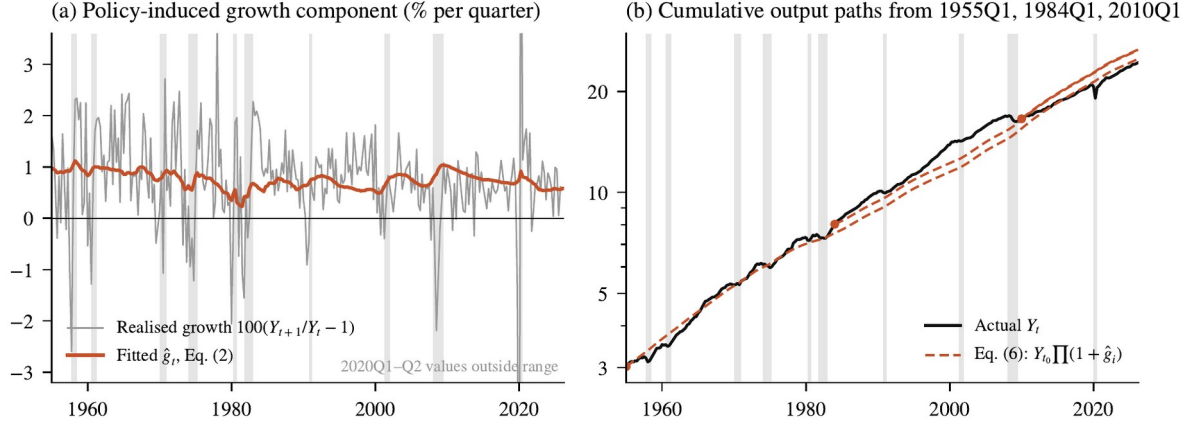


Fig. 2 Policy-induced growth component. Panel (a): realised quarterly growth and the fitted component $\hat{g}_t$ from column (1) of Table 5. Panel (b): actual real GDP and the output paths implied by Eq. (6), cumulating the fitted $\hat{g}_i$ from three starting quarters (dots); trillions of chained 2017 dollars, log scale

The positive association with government expenditure is the most robust feature of the growth equation. The moving-block bootstrap interval for δ excludes zero ($[0.003, 0.129]$), whereas those for β and γ do not (Table 5). Across alternative measures of the instruments, $\hat{\delta}$ lies between 0.052 and 0.077 and is significant at least at the 10% level whenever public expenditure is measured relative to GDP, with one exception, while it vanishes when expenditure enters as the growth rate of real government spending (Table A2). The interest-rate association is more fragile: it is insignificant when the policy rate is replaced by the 3-month Treasury bill rate, the 10-year Treasury yield or the ex-post real rate, and when quarters at the effective lower bound are excluded.

The relationship is also unstable over time. The QLR test rejects parameter constancy ($p=0.017$) and dates the break in 1975Q2; tests at fixed dates also reject a break in 1984Q1 ($p=0.020$) and 2008Q3 ($p=0.036$) (Table 8). Before 1975Q2 the interest-rate coefficient is large and highly significant ($\hat{\beta} = -0.159$), whereas from 1975Q2 onwards none of the three coefficients is significant (Table 5, columns 3–4). Rolling estimates confirm the picture (Fig. 3a–c): the interest-rate coefficient is clearly negative in windows ending in the 1970s and early 1980s and close to zero thereafter, apart from a transient dip in windows that include the pandemic, while the expenditure coefficient is positive in windows ending between the mid-1980s and the late 1990s and close to zero since. The residuals of Eq. (11) show no serial correlation (Ljung–Box $Q(4)$, $p=0.508$), consistent with their interpretation as expectational errors, but strong ARCH effects and non-normality, which motivate the robust inference used here.

Implication I1 thus receives qualified support. Public expenditure carries information about the subsequent growth of output, the monetary channel did so mainly before the mid-1970s, and the average tax rate carries none. The policy-induced component is, however, small relative to the fluctuations of growth and has weakened over time.

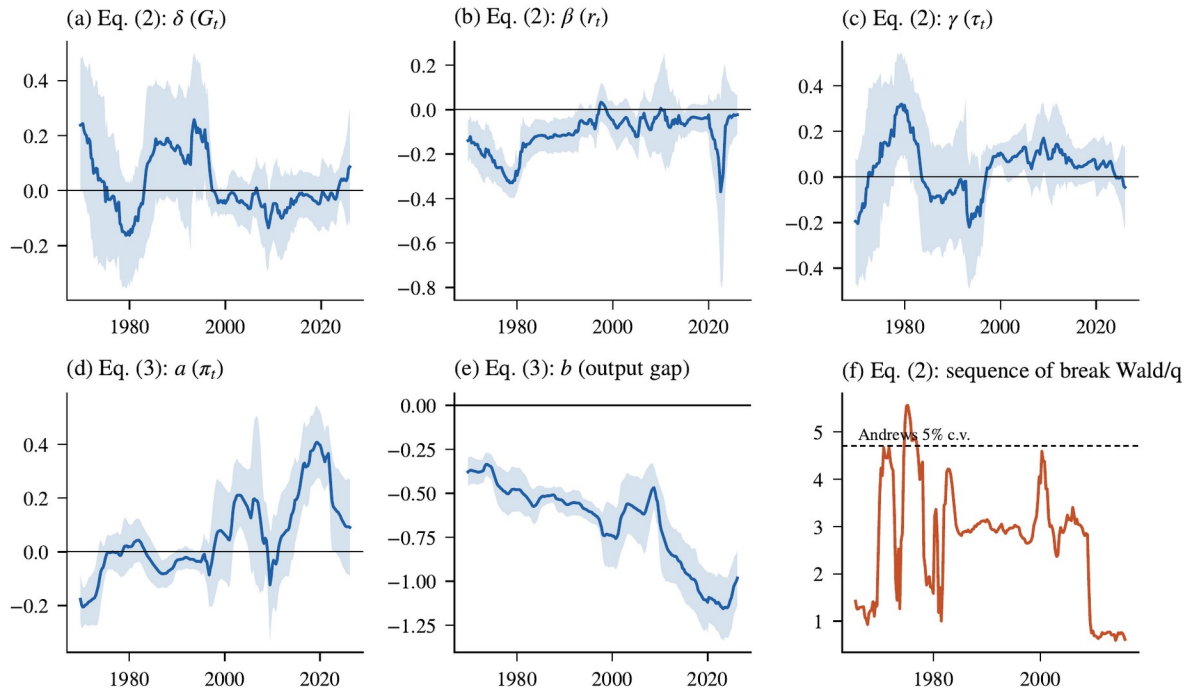


Fig. 3 Parameter instability. Panels (a)–(e): coefficients of Eq. (11) and of the adjusted Eq. (12) estimated over rolling 60-quarter windows, plotted at the end of each window, with 95% Newey–West bands. Panel (f): sequence of Wald statistics (divided by the number of restrictions) for a break in all coefficients of Eq. (11); the dashed line is the 5% critical value of Andrews (1993)

5.3 Unemployment, inflation and output

Table 6 reports the estimates of the unemployment relation. Estimated exactly as written (column 1), Eq. (3) yields positive and highly significant coefficients on both inflation ($\hat{a}=0.561$) and the level of output ($\hat{b}=0.264$), so that higher output appears to be associated with higher unemployment. This result should not be interpreted. The regression combines a stationary dependent variable with a trending regressor and no constant, its residuals are highly autocorrelated ($p<0.001$), its centred R^2 is -1.703 , and the Engle–Granger test finds no cointegration. These are the signatures of a spurious regression: the positive coefficient on output arises because a regression through the origin uses the trending level of output to reproduce the positive mean of unemployment. Once a constant is admitted (column 2), neither coefficient is significant and the joint test does not reject that both are zero ($p=0.598$). The level of output carries no information about unemployment.

Table 6 Estimates of the unemployment relation, Eq. (3)

	(1) Eq. (3) as written	(2) With constant	(3) Output gap	(4) Gap and constant	(5) Col. (4), pre-break	(6) Col. (4), post-break
a (π_t)	0.561*** (0.082)	0.050 (0.063)	1.016*** (0.126)	0.034 (0.032)	-0.182*** (0.032)	0.056 (0.035)
b (output measure)	0.264*** (0.036)	-0.022 (0.035)	-0.614*** (0.214)	-0.619*** (0.050)	-0.379*** (0.036)	-0.715*** (0.054)
Constant		5.860*** (0.490)		5.592*** (0.170)	5.810*** (0.102)	5.437*** (0.194)
Output measure	Y_t	Y_t	Gap	Gap	Gap	Gap
Sample	1955–2026	1955–2026	1955–2026	1955–2026	1955Q1–1970Q4	1971Q1–2026Q2
N	285	285	285	285	64	221
R^2 (centred)	-1.703	0.016	-3.426	0.726	0.892	0.734
Engle–Granger p	0.130	0.061	0.077	0.003		
Ljung–Box $Q(4) p$	<0.001			<0.001		

Notes: Dependent variable: civilian unemployment rate u_t (%). π_t : CPI inflation, year on year (%). Output measure: real GDP in trillions of chained 2017 dollars, or the CBO output gap in per cent of potential. Newey–West standard errors in parentheses. Column (4) is the adjusted specification used in the projections. Columns (5)–(6) split the sample at 1971Q1, the QLR break date (Table 8). Engle–Granger: p -value of the residual-based test for the same relation (Table 4). A negative centred R^2 arises because the regressions in columns (1) and (3) omit the constant. ***, **, *: 1%, 5%, 10%.

Measured relative to productive capacity, output is closely related to unemployment. In the adjusted specification (column 4), which uses the output gap and a constant, the coefficient on the gap is $\hat{b} = -0.619$ (standard error 0.050) and the regression explains 72.6% of the variance of unemployment. A gap of one per cent of potential output is associated with an unemployment rate lower by 0.62 percentage points, a coefficient almost twice the value of about one third implied by the original statement of Okun’s law (Okun 1962). The constant implies an unemployment rate of 5.59% at a zero gap and zero inflation. The coefficient on inflation is small and insignificant ($\hat{a} = 0.034$, standard error 0.032), and the bootstrap interval includes zero (Table A4). The coefficient on the output gap is robust to the measure of inflation, ranging from -0.619 to -0.634 , and to the use of the unemployment gap as the dependent variable (-0.617). The inflation coefficient, by contrast, is marginally positive with PCE or quarterly CPI inflation and significantly negative when the dependent variable is the unemployment gap (Table A3).

Both coefficients of the adjusted relation have shifted over time. The QLR test rejects constancy decisively and dates the break in 1971Q1, and the Chow-type tests reject a break at every candidate date (Table 8). Before 1971 unemployment was negatively related to inflation ($\hat{a} = -0.182$), the trade-off emphasised by Phillips (1958); after 1971 the inflation coefficient is positive and insignificant (Table 6, columns 5–6). At the same time the response of unemployment to the output gap has become stronger: the rolling estimate of b falls from -0.38 in the window ending in 1969Q4 to -0.74 in the window ending in 2000 and reaches -1.16 in the window ending in 2023Q2 (Fig. 3e). The residuals of the adjusted relation remain strongly autocorrelated, and the RESET test rejects the static functional form (Table 8). Deviations of unemployment from the level implied by current capacity utilisation are therefore persistent, which is consistent with the persistence of unemployment emphasised by Blanchard and Summers (1986).

Implication I2 is thus supported when output is measured relative to capacity and rejected when it is measured in levels. This distinction is the empirical counterpart of the central theoretical claim: unemployment is not governed by the level of output that the cumulative dynamics of Eq. (6) deliver, but by output relative to productive capacity.

5.4 Inflation dynamics and output persistence

Panel A of Table 7 summarises the proportional inflation dynamics of Eq. (4). The growth factor is undefined in the seven quarters with non-positive inflation, and inflation turns from positive to non-positive twice. Where it is defined, f_t is positive in 52.7% of quarters and has a median of 0.008, but a mean of 0.064 that is driven by quarters in which inflation is close to zero. Its logarithmic counterpart has a mean of 0.021 that is not significantly different from zero ($p=0.282$). There is, therefore, no systematic proportional drift that would by itself generate accelerating inflation, in line with implication I3. The proportional representation is nevertheless fragile near zero inflation. It also extrapolates aggressively when a recent growth factor is compounded: the geometric mean of f_t over the last 20 quarters, 0.034, compounded over eight quarters raises inflation by 31%. In the pseudo out-of-sample exercise, holding inflation constant ($f_t=0$) yields a root mean squared error of 2.20 percentage points at the two-year horizon, against 3.58 when the recent growth factor is compounded (Table 9, Panel C).

Table 7 Inflation dynamics, Eq. (4), and output persistence, Eq. (5)

	Value
<i>Panel A. Proportional inflation dynamics, Eq. (4)</i>	
Quarters with $\pi_t \leq 0$ (f_t undefined)	7
Quarters with f_t defined	277
Quarters with $ \pi_t < 0.5$	7
Share of quarters with $f_t > 0$	0.527
Median f_t	0.0081
Mean f_t (all / $ \pi_t \geq 0.5$)	0.0638 / 0.0188
Geometric mean f_t (full sample / last 20 quarters)	0.0214 / 0.0340
Mean $\ln(\pi_{t+1}/\pi_t)$ [HAC t ; p]	0.0211 [1.08; 0.282]
<i>Panel B. Output forecasting equation, Eq. (5), $p = 1$</i>	
	<div> $h = 1$ $h = 4$ $h = 8$ </div>
μ	<div> 27.07* 98.66** 197.26*** </div> <div> (14.00) (43.27) (71.34) </div>
c_0 (Y_t)	<div> 0.853*** 0.782*** 0.792*** </div> <div> (0.158) (0.276) (0.272) </div>
c_1 (Y_{t-1})	<div> 0.152 0.237 0.246 </div> <div> (0.159) (0.278) (0.276) </div>
$\Sigma_i c_i$	<div> 1.0053 1.0197 1.0385 </div>
Wald $\Sigma_i c_i = 1$ [p]	<div> 7.80 [0.005] 15.13 [<0.001] 20.52 [<0.001] </div>
N	<div> 284 281 277 </div>
R^2	<div> 0.999 0.998 0.997 </div>

Notes: Panel A: $f_t = \pi_{t+1}/\pi_t - 1$ with π_t the year-on-year CPI inflation rate; the geometric mean uses quarters with $\pi_t > 0$ and $\pi_{t+1} > 0$; the t -test uses Newey–West standard errors. Panel B: direct h -step projections of real GDP (billions of chained 2017 dollars) on Y_t and Y_{t-1} ; $p = 1$ is selected by AIC, BIC and HQIC (Table A5). Newey–West standard errors with $\max(5, h-1)$ lags in parentheses. The Wald statistic for $\Sigma_i c_i = 1$ has a non-standard distribution under a unit root and is reported descriptively.

Panel B reports the forecasting equation. At $h=1$ the coefficients on Y_t and Y_{t-1} are 0.853 and 0.152, and their sum is 1.0053; the sums at $h=4$ and $h=8$ are 1.020 and 1.038. Output thus behaves as a near-unit-root process with drift, in line with the unit-root tests and with implication I4. This persistence is stable across lag orders, subsamples and the logarithmic specification, with sums between 0.998 and 1.006 (Table A5). The forecasting relation nevertheless shifted around the global financial crisis and the pandemic: the Chow-type tests reject constancy at 2008Q3 ($p=0.003$) and 2020Q1 ($p<0.001$).

Table 8 Parameter stability and residual diagnostics

<i>Panel A. Parameter stability</i>								
	QLR	p	Break	CUSUM p	1973Q4	1984Q1	2008Q3	2020Q1
Eq. (2)	5.56	0.017	1975Q2	0.126	0.284	0.020	0.036	0.537
Eq. (3) as written	78.38	<0.001	1965Q3	<0.001	<0.001	<0.001	<0.001	<0.001
Eq. (3) adjusted	19.64	<0.001	1971Q1	<0.001	<0.001	<0.001	<0.001	<0.001
Eq. (5), $h = 1$	7.30	0.002	2009Q3	0.366	0.303	0.047	0.003	<0.001
<i>Panel B. Residual diagnostics (p-values)</i>								
	LB Q(4)	LB Q(8)	BG(4)	BP	ARCH(4)	JB	RESET	
Eq. (2)	0.508	0.910	0.396	0.795	<0.001	<0.001	0.813	
Eq. (3) as written	<0.001	<0.001	<0.001	0.143	<0.001	0.085	<0.001	
Eq. (3) adjusted	<0.001	<0.001	<0.001	0.194	<0.001	0.381	<0.001	
Eq. (5), $h = 1$	0.814	0.914	0.798	<0.001	<0.001	<0.001	0.741	

Notes: Panel A: QLR is the Andrews (1993) sup-Wald statistic (F form, 15% trimming, Newey–West covariance) for a break in all coefficients at an unknown date; p -values are simulated from its asymptotic null distribution. CUSUM: Ploberger and Krämer (1992) test on OLS residuals. The last four columns report p -values of HAC Wald tests for a break in all coefficients at the stated quarter. For Eq. (5) the regressors are trending and the QLR asymptotics are non-standard. Panel B: LB Ljung–Box; BG Breusch–Godfrey; BP Breusch–Pagan; ARCH Engle’s LM test; JB Jarque–Bera; RESET with squared and cubed fitted values. Rejections motivate the HAC inference used throughout.

5.5 Predictive content of the cumulative framework

Table 9 and Fig. 4 report the pseudo out-of-sample evaluation. For output (Panel A), the direct projection (13) is significantly more accurate than the random walk at four and eight quarters, with root mean squared errors 29% and 45% lower ($p=0.010$ and $p=0.005$), but not at one quarter. The policy-conditional path of Eq. (6) improves on the random walk by 26% and 36% at four and eight quarters, a gain that is borderline significant ($p=0.052$ and $p=0.048$) and close to that of a random walk with drift. Against the history of output, however, conditioning on the instruments brings no significant gain at any horizon: the Diebold–Mariano statistics comparing Eq. (6) with Eq. (13) are -0.79 , 0.27 and 1.21 ($p=0.429$, 0.791 and 0.228), and the point estimates favour Eq. (13) at four and eight quarters. Conditioning on the realised path of the instruments, which would be infeasible in real time, does not help either: it raises the root mean squared error at four and eight quarters relative to holding the instruments at their values at the origin. The policy-conditional path also over-predicts output on average after 1990, by 0.80% at four quarters and 1.59% at eight. Implication I5 is therefore not supported in its forecasting form. The information that the instruments carry about future output adds nothing that the persistence of output does not already capture.

Table 9 Pseudo out-of-sample forecast evaluation, origins 1990Q1–2026Q1

	<i>N</i>	ME	RMSE	Rel. RMSE	DM vs RW	DM vs Eq. (5)/AR
<i>Panel A. Real GDP (errors in per cent of the outcome)</i>						
<i>h = 1</i>						
Eq. (5)	145	−0.054	1.431	1.137	0.55 [0.582]	
Eq. (6), instruments held at <i>t</i>	145	0.203	1.149	0.913	−1.73 [0.085]	−0.79 [0.429]
Eq. (6), realised instruments	145	0.203	1.149	0.913	−1.73 [0.085]	−0.79 [0.429]
Random walk with drift	145	0.186	1.129	0.897	−2.18 [0.031]	
Random walk	145	−0.604	1.258	1.000		
<i>h = 4</i>						
Eq. (5)	142	0.033	2.219	0.713	−2.61 [0.010]	
Eq. (6), instruments held at <i>t</i>	142	0.803	2.299	0.739	−1.96 [0.052]	0.27 [0.791]
Eq. (6), realised instruments	142	0.803	2.398	0.771	−1.62 [0.109]	0.58 [0.563]
Random walk with drift	142	0.717	2.135	0.686	−2.45 [0.016]	
Random walk	142	−2.428	3.110	1.000		
<i>h = 8</i>						
Eq. (5)	138	0.134	3.031	0.550	−2.83 [0.005]	
Eq. (6), instruments held at <i>t</i>	138	1.594	3.547	0.643	−1.99 [0.048]	1.21 [0.228]
Eq. (6), realised instruments	138	1.576	3.923	0.711	−1.44 [0.152]	1.56 [0.120]
Random walk with drift	138	1.369	3.073	0.557	−2.41 [0.017]	
Random walk	138	−4.875	5.515	1.000		
<i>Panel B. Unemployment rate, $T+h = t+8$ (errors in percentage points)</i>						
Eq. (9) as written, $f_i = 0$	137	2.950	3.659	1.787	2.59 [0.011]	2.77 [0.006]
Eq. (9) as written, $f_i = \bar{f}$	137	3.532	4.409	2.154	2.60 [0.010]	2.83 [0.005]
Eq. (9) adjusted, $f_i = 0$	137	−0.068	2.259	1.104	0.61 [0.540]	0.45 [0.656]
Eq. (9) adjusted, $f_i = \bar{f}$	137	−0.016	2.252	1.100	0.60 [0.551]	0.43 [0.666]
Direct autoregression for <i>u</i>	137	0.299	2.046	0.999	−0.01 [0.996]	
Random walk	137	0.120	2.047	1.000		
<i>Panel C. Inflation path of Eq. (8), $T+h = t+8$ (percentage points)</i>						
$f_i = 0$ (constant inflation)	137	0.112	2.198			
$f_i = \bar{f}$ (recent geometric mean)	137	1.217	3.584			

Notes: Expanding estimation window; every parameter, including the lag order p , is re-estimated at each origin with information dated t or earlier (final-vintage data). ME: mean error (forecast minus outcome). Rel. RMSE: ratio to the random walk. DM: Diebold–Mariano statistic with the Harvey et al. (1997) correction under squared loss, p -value in brackets; a negative statistic favours the model in the row. In Panel A the last column compares with Eq. (5); in Panel B with the direct autoregression for u . The Clark–West test of Eq. (5) against the nested random walk gives $t = -0.16$ ($h = 1$), 6.20 ($h = 4$) and 8.54 ($h = 8$). In Panel B, $T = t+4$ and $h = 4$; $\bar{f}$ is the geometric mean of f_i over the 20 quarters before the origin. One target quarter (2025Q4) is excluded because the October 2025 unemployment rate was not published.

For unemployment (Panel B), the composite expression (9) built on Eq. (3) as written over-predicts unemployment by 2.95 percentage points on average and is significantly less accurate than a random walk ($p=0.011$). Built on the adjusted relation, it is unbiased, with a mean error of -0.07 points, and its accuracy is statistically indistinguishable from both the random walk ($p=0.540$) and a direct autoregression for unemployment ($p=0.656$). The choice of inflation path is immaterial in the adjusted specification (root mean squared errors of 2.259 and 2.252), because the estimated inflation coefficient is close to zero. Like the benchmarks, the composite forecast misses the turning points of 2008–09 and 2020 (Fig. 4a).

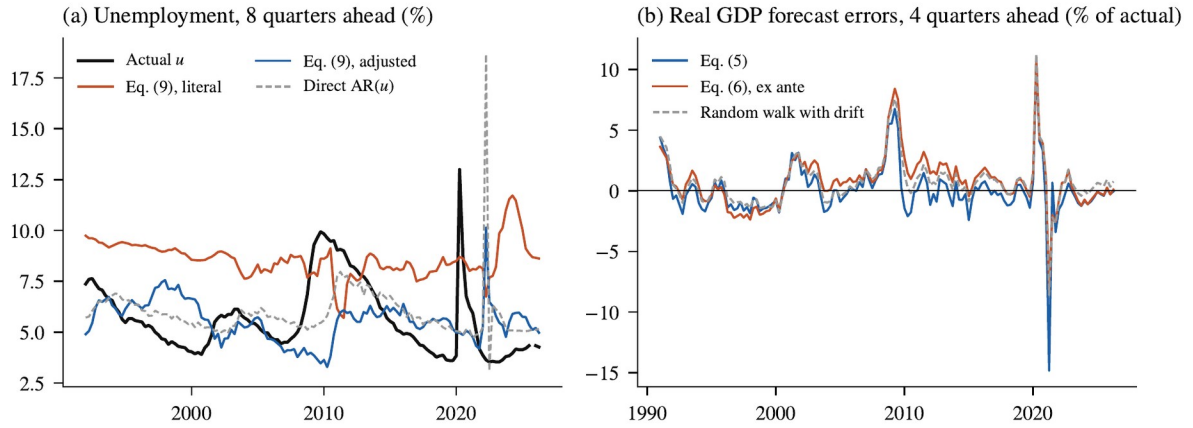


Fig. 4 Pseudo out-of-sample forecasts, origins 1990Q1–2026Q1, plotted at the target quarter. Panel (a): unemployment rate eight quarters ahead from Eq. (9) with $f_i = 0$, built on Eq. (3) as written and on the adjusted specification, and from a direct autoregression. Panel (b): errors of real GDP forecasts four quarters ahead, in per cent of the outcome

5.6 Conditional projections

Table 10 and Fig. 5 report projections from 2026Q2, when unemployment stood at 4.27%, inflation at 3.80% and the output gap at 1.40%. With the instruments held at their 2026Q2 values, the policy-induced component is 0.584% per quarter, or 2.36% at an annual rate. This exceeds the growth of CBO potential output over the projection horizon (2.13% a year), so that the projected output gap widens to 1.72% in 2028Q2. The adjusted specification decomposes the resulting unemployment projection of 4.66% into a constant of 5.59, an inflation term of 0.13 and an output term of -1.06 percentage points. Compounding the recent inflation growth factor raises projected inflation from 3.80% to 4.97% but projected unemployment only from 4.66% to 4.70%, because the inflation term is small.

Table 10 Conditional projections from 2026Q2: decomposition of Eq. (9)

Policy path	f_i	$\hat{g}$	$\mathbb{E}_t[Y_T]$	$\hat{Y}_{T+h}$	$\mathbb{E}_t[\pi_{T+h}]$	Const.	$a\pi$	$b\hat{Y}$	$\mathbb{E}_t[u_{T+h}]$
<i>Adjusted specification (output gap, constant)</i>									
Instruments at 2026Q2 values	0	0.584	24.983	25.540	3.80	5.592	0.129	-1.063	4.66
Instruments at 2026Q2 values	$\bar{f}_{20}$	0.584	24.983	25.540	4.97	5.592	0.169	-1.063	4.70
$G_t + 1$ pp	0	0.646	25.045	25.599	3.80	5.592	0.129	-1.208	4.51
$G_t + 1$ pp	$\bar{f}_{20}$	0.646	25.045	25.599	4.97	5.592	0.169	-1.208	4.55
$r_t - 1$ pp	0	0.622	25.021	25.576	3.80	5.592	0.129	-1.153	4.57
$r_t - 1$ pp	$\bar{f}_{20}$	0.622	25.021	25.576	4.97	5.592	0.169	-1.153	4.61
$\tau_t - 1$ pp	0	0.601	25.000	25.556	3.80	5.592	0.129	-1.103	4.62
$\tau_t - 1$ pp	$\bar{f}_{20}$	0.601	25.000	25.556	4.97	5.592	0.169	-1.103	4.66
<i>Eq. (3) as written (output level)</i>									
Instruments at 2026Q2 values	0	0.584	24.983	25.540	3.80	0.000	2.134	6.734	8.87
Instruments at 2026Q2 values	$\bar{f}_{20}$	0.584	24.983	25.540	4.97	0.000	2.788	6.734	9.52
Instruments at 2026Q2 values	$\bar{f}_{all}$	0.584	24.983	25.540	4.50	0.000	2.527	6.734	9.26

Notes: Origin $t = 2026Q2$ ($u_t = 4.27\%$, $\pi_t = 3.80\%$, $Y_t = 24.408$ trillion); $T = t+4 = 2027Q2$, $h = 4$, target 2028Q2. $\hat{g}$ in per cent per quarter from Eq. (2) with the instruments held at the stated values over $[t, T-1]$; Y in trillions of chained 2017 dollars. f_i : 0 holds inflation at its 2026Q2 value; $\bar{f}_{20}$ and $\bar{f}_{all}$ compound the geometric mean of f_i over the last 20 quarters and the full sample. The last four columns decompose $\mathbb{E}_t[u_{T+h}]$ into the constant, the inflation term $a\mathbb{E}_t[\pi_{T+h}]$ and the output term $b\hat{Y}_{T+h}$ of Eq. (9); in the adjusted specification $\hat{Y}_{T+h}$ enters as a gap relative to CBO potential output for 2028Q2. Projections are conditional on estimated associations and are not causal policy effects.

The policy paths move the projection by small amounts. Raising government expenditure by one percentage point of GDP increases the policy-induced component to 0.646% per quarter and lowers projected unemployment in 2028Q2 by 0.15 percentage points, to 4.51%. Lowering the policy rate by one point lowers it by 0.09 points, and lowering the tax rate by one point by 0.04 points. Under unchanged policy, projected unemployment declines gradually from 4.77% in 2027Q3 to 4.27% in 2030Q2, because policy-induced growth exceeds the growth of capacity throughout; parameter uncertainty alone widens the 90% band to $[2.77, 5.89]$ by 2030Q2 (Fig. 5a). The specification as written projects an unemployment rate of 8.87%, rising to 9.19% by 2030Q2, because it relates unemployment positively to the level of output. These implausible values reflect the spurious level relationship documented in Sect. 5.3.

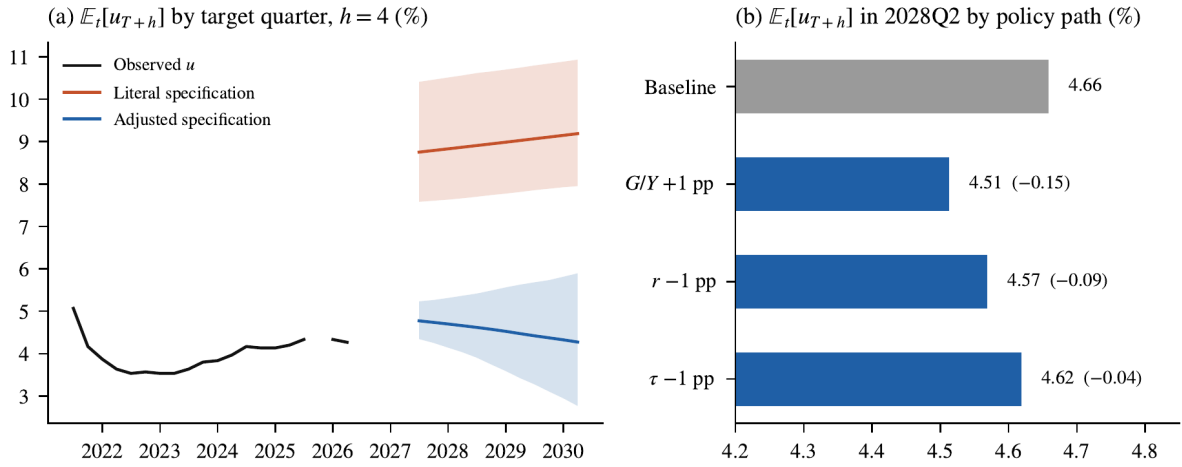


Fig. 5 Conditional projections of unemployment from 2026Q2. Panel (a): $E_t[u_{T+h}]$ from Eq. (9) with $h = 4$ and $T = t+1, \dots, t+12$, instruments held at their 2026Q2 values and $f_i = 0$, with 90% moving-block bootstrap bands reflecting parameter uncertainty; observed unemployment since 2021Q3 (the 2025Q4 value is missing). Panel (b): adjusted specification, target 2028Q2, by policy path; changes relative to the baseline in parentheses

6 Discussion: the limits of full-employment policy

6.1 Growth is not employment

The central theoretical claim of the framework is that full employment cannot be inferred from cumulative output growth alone. The empirical results give this claim a precise form. In Eq. (9) the output component enters through the cumulative product of growth factors applied to the level of output, and the unemployment relation (3) then translates that level into unemployment. Estimated with the level of output, this relation is spurious; the level of output carries no information about unemployment once a constant is admitted. What is associated with unemployment is output relative to productive capacity. When this measure is used, the output term of Eq. (9) lowers unemployment only to the extent that the cumulative policy-induced growth of output exceeds the cumulative growth of capacity over the horizon. A policy stance that sustains growth at the rate of potential output leaves the unemployment projection unchanged however long the expansion lasts. Conversely, the gradual decline in the projected unemployment rate after 2026 (Fig. 5a) arises only because policy-induced growth at 2.36% a year exceeds CBO potential growth of 2.13%.

This reading connects the framework with the principle of effective demand in a specific way. Demand determines output, but the employment consequences of a given expansion depend on the growth of productive capacity, on productivity and on labour demand—precisely the conditions that the framework lists as determining whether a positive policy-induced contribution translates into full employment. The persistence of the residuals of the unemployment relation adds a further element: deviations of unemployment from the level implied by current utilisation are long-lived, so that the labour-market consequences of past shortfalls in demand are not undone quickly when demand recovers (Blanchard and Summers 1986).

6.2 The size and stability of the policy lever

The estimated policy-induced component is small. The three instruments together account for about 3% of the variance of quarterly growth, and conditioning the output path on them does not improve on forecasts based on the history of output. In the projections, an increase in government expenditure of one percentage point of GDP, sustained for a year, lowers the unemployment rate two years ahead by 0.15 percentage points; changes of one point in the policy rate or the tax rate have smaller effects. The positive association between public expenditure and subsequent growth is nevertheless the most robust policy relationship in the data, which is consistent with the emphasis of functional finance on expenditure as the instrument of demand management (Lerner 1943).

The instability of the policy coefficients is equally relevant. The interest-rate association is concentrated before the mid-1970s, and neither instrument displays a significant association with growth after 1975Q2. Such instability is what the institutional reading of Kalecki (1943) would lead one to expect: the effectiveness of policy depends on the regime within which it operates, including the monetary framework, the composition of public expenditure and the political conditions that govern its use. A reduced-form coefficient estimated over seven decades averages over several such regimes.

These magnitudes must be read with the endogeneity of policy in mind. Expenditure, tax receipts and the policy rate all respond to the state of the economy, through automatic stabilisers, discretionary fiscal action and systematic monetary reaction (Taylor 1993). Counter-cyclical responses of this kind tend to weaken, or reverse, the reduced-form association between an instrument and subsequent growth, and they are one reason why studies that isolate exogenous policy variation obtain different, and state-dependent, estimates of policy effects (Blanchard and Perotti 2002; Romer and Romer 2010; Ramey 2011; Ramey and Zubairy 2018). The coefficients reported here measure the information that the stance of policy carries about the subsequent growth of output, not the causal effect of a policy change.

6.3 Inflation and purchasing power

The framework treats inflation as the second determinant of the unemployment outcome. In the data, the inflation term contributes little: the association between inflation and unemployment conditional on the output gap is small, and it has changed sign over time, from a significant trade-off before 1971 to no systematic relationship afterwards. Compounding plausible inflation paths through Eq. (8) therefore changes projected unemployment by only a few hundredths of a point. The proportional dynamics of Eq. (4) display no systematic drift,

but compounding a recent growth factor extrapolates transitory inflation dynamics and produces poor forecasts.

These results do not imply that inflation is irrelevant to the sustainability of full employment. They imply that, in these data, the constraint does not operate through a stable statistical relationship between inflation and unemployment. The channel emphasised by the framework is purchasing power: if prices rise faster than nominal incomes, the real gains from expansion are eroded (Rowthorn 1977; Lavoie 2014). Equations (4) and (8) record the price side of this channel, but neither equation, nor the unemployment relation, contains the nominal-income side. An empirical assessment of the purchasing-power constraint therefore requires extending the framework to real wages and the functional distribution of income (Asimakopulos 1975).

6.4 Association, causation and limitations

All results describe conditional associations within a reduced-form framework; none identifies the causal effect of fiscal or monetary policy, as the framework itself acknowledges for the forecasting equation. Several limitations qualify the evidence further. The growth equation is unbalanced, since two of its instruments are integrated and not cointegrated, so its conventional inference is indicative only; the bootstrap and subsample evidence point in the same direction but cannot fully resolve the issue. The analysis uses final-vintage data, and the output gap relies on a current estimate of potential output that embeds information unavailable at early forecast origins (Orphanides and van Norden 2002). The policy rate is an imperfect measure of the monetary stance at the effective lower bound, and the average tax rate moves mechanically with the cycle. The unemployment relation is static and leaves highly persistent residuals, which points to a dynamic extension. Finally, the evidence concerns a single economy, whose institutions differ from those of the economies in which full-employment policy has historically been pursued most explicitly.

7 Conclusion

This paper has asked whether the expansion of aggregate demand through fiscal and monetary policy can sustain full employment once inflation is taken into account. Building on the principle of effective demand, it has developed a reduced-form framework in which policy instruments determine a policy-induced component of expected output growth, unemployment is related jointly to inflation and output, and inflation evolves through proportional growth factors. Iterating the framework yields a horizon-dependent expression for expected unemployment that separates the cumulative expansion of activity from the accompanying price dynamics.

Confronted with quarterly United States data for 1955Q1–2026Q2, the framework yields four main findings. First, public expenditure relative to GDP is positively associated with subsequent output growth, but the policy instruments explain only a small share of growth fluctuations, and their association with growth has weakened since the mid-1970s. Second, output is highly persistent, and conditioning its expected path on the policy instruments does not improve on forecasts based on its own history. Third, unemployment is unrelated to the level of output but closely related to output relative to productive capacity, while its association with inflation is small and unstable. Fourth, conditional projections from 2026Q2

imply that raising government expenditure by one percentage point of GDP for four quarters lowers unemployment two years ahead by about 0.15 percentage points.

These findings support the proposition that full employment cannot be inferred from cumulative output growth alone. A demand-management strategy reduces unemployment only to the extent that it raises the growth of output above that of productive capacity, and the policy-induced component that could achieve this is small, unstable and difficult to distinguish from the persistence of output itself. The limits of full-employment policy identified by the framework are therefore not only a matter of inflation, but of the relationship between demand, capacity and labour utilisation.

Three extensions follow naturally. A multivariate version of the forecasting equation would model the joint dynamics of output, inflation and unemployment directly. An explicit treatment of nominal wages and income distribution would allow the purchasing-power constraint emphasised by the framework to be measured rather than inferred. And an identification strategy that isolates exogenous variation in the policy instruments would make it possible to distinguish the effects of policy from the conditions to which policy responds.

Declarations

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Competing interests [To be completed by the author, e.g. “The author declares no competing interests.”]

Data availability All data are publicly available from the Federal Reserve Economic Data (FRED) database of the Federal Reserve Bank of St. Louis under the identifiers listed in Table 1; the series used here were retrieved on 24 October 2026.

Code availability The Python code that downloads the data and reproduces every table and figure is available from the author on request [or: deposited at [repository and DOI]].

Author contributions H. Boughabi is the sole author and is responsible for the conception, analysis and writing of the manuscript.

Use of AI tools [To be completed by the author in accordance with the journal’s policy on the documentation of large language model assistance in preparing the manuscript and code.]

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Appendix A: Supplementary results

This appendix reports the break-sensitive unit-root tests (Table A1), the estimates of Eqs. (2) and (3) under alternative measures and samples (Tables A2 and A3), the bootstrap confidence intervals (Table A4) and the sensitivity of Eq. (5) to the lag order (Table A5).

Table A1 Zivot–Andrews unit-root tests with one endogenous break

Variable	Break in	Statistic	<i>p</i> -value	5% c.v.	Break date
$\ln Y_t$	intercept	−3.36	0.761	−4.81	2007Q4
$\ln Y_t$	intercept and trend	−3.02	0.962	−5.07	2007Q4
Y_t	intercept	−1.84	0.999	−4.81	1973Q2
Y_t	intercept and trend	−2.58	0.993	−5.07	1980Q1
G_t	intercept	−4.67	0.076	−4.81	2000Q4
G_t	intercept and trend	−4.76	0.120	−5.07	2006Q3
r_t	intercept	−3.51	0.671	−4.81	1971Q1
r_t	intercept and trend	−4.46	0.230	−5.07	1984Q3
τ_t	intercept	−4.67	0.077	−4.81	1981Q3
τ_t	intercept and trend	−5.03	0.058	−5.07	2008Q2
u_t	intercept	−4.27	0.204	−4.81	1973Q4
u_t	intercept and trend	−4.41	0.256	−5.07	2008Q2
π_t	intercept	−2.77	0.959	−4.81	1984Q1
π_t	intercept and trend	−3.96	0.534	−5.07	1982Q3
Output gap	intercept	−5.21	0.014	−4.81	1973Q2
Realised growth	intercept	−16.12	<0.001	−4.81	1982Q3

Notes: Zivot and Andrews (1992); H_0 : unit root without break; 15% trimming; lags by AIC.

Table A2 Eq. (2) under alternative measures and samples

Specification	Const.	δ	β	γ	<i>N</i>	Wald <i>p</i>
Baseline	No	0.0618** (0.0297)	−0.0383* (0.0215)	−0.0170 (0.0291)	285	<0.001
Baseline	Yes	0.0749** (0.0320)	−0.0431* (0.0222)	0.0396 (0.0632)	285	0.058
<i>r</i> : 3-month T-bill	No	0.0604** (0.0292)	−0.0312 (0.0262)	−0.0178 (0.0285)	285	<0.001
<i>r</i> : 3-month T-bill	Yes	0.0716** (0.0323)	−0.0360 (0.0269)	0.0307 (0.0628)	285	0.137
<i>r</i> : 10-year Treasury yield	No	0.0614** (0.0305)	−0.0164 (0.0310)	−0.0209 (0.0281)	285	<0.001
<i>r</i> : 10-year Treasury yield	Yes	0.0680** (0.0335)	−0.0169 (0.0313)	0.0087 (0.0588)	285	0.242
<i>r</i> : ex-post real rate ($r - \pi$)	No	0.0524* (0.0280)	0.0188 (0.0288)	−0.0174 (0.0278)	284	<0.001
<i>r</i> : ex-post real rate ($r - \pi$)	Yes	0.0581* (0.0319)	0.0175 (0.0288)	0.0073 (0.0553)	284	0.198
τ : federal tax receipts / GDP	No	0.0522* (0.0290)	−0.0384* (0.0215)	−0.0120 (0.0491)	285	<0.001
τ : federal tax receipts / GDP	Yes	0.0772** (0.0368)	−0.0404* (0.0216)	0.0026 (0.0542)	285	0.066
τ : personal taxes / personal income	No	0.0769*** (0.0213)	−0.0353 (0.0224)	−0.0540 (0.0357)	269	<0.001
τ : personal taxes / personal income	Yes	0.0571 (0.0358)	−0.0288 (0.0252)	−0.0929 (0.0765)	269	0.037
G : federal G / GDP	No	0.0530** (0.0261)	−0.0390* (0.0210)	0.0213* (0.0125)	285	<0.001
G : federal G / GDP	Yes	0.0529** (0.0259)	−0.0392* (0.0215)	0.0247 (0.0619)	285	0.081
G : real G growth (% q/q)	No	0.0034 (0.0558)	−0.0347 (0.0220)	0.0457*** (0.0057)	285	<0.001
G : real G growth (% q/q)	Yes	0.0044 (0.0559)	−0.0356 (0.0228)	0.0607 (0.0628)	285	0.445
Pre-1984 (to 1983Q4)	No	0.1167 (0.1067)	−0.0768** (0.0343)	−0.0628 (0.1232)	116	<0.001
Pre-1984 (to 1983Q4)	Yes	−0.0194 (0.1002)	−0.1075*** (0.0343)	−0.2874* (0.1518)	116	<0.001
1984Q1–2007Q4	No	0.0138 (0.0365)	−0.0097 (0.0265)	0.0287 (0.0380)	96	<0.001
1984Q1–2007Q4	Yes	−0.0741 (0.0872)	0.0140 (0.0298)	−0.0675 (0.0899)	96	0.853
Pre-COVID (to 2019Q4)	No	0.0526 (0.0320)	−0.0352 (0.0218)	−0.0084 (0.0322)	260	<0.001
Pre-COVID (to 2019Q4)	Yes	0.0629** (0.0320)	−0.0397* (0.0229)	0.0396 (0.0676)	260	0.109
excluding ZLB quarters	No	0.0741** (0.0324)	−0.0393 (0.0275)	−0.0293 (0.0343)	249	<0.001
excluding ZLB quarters	Yes	0.0783** (0.0345)	−0.0402 (0.0272)	0.0057 (0.0792)	249	0.047

Notes: Newey–West standard errors in parentheses. Alternative instruments replace one baseline measure at a time: the 3-month Treasury bill rate, the 10-year Treasury yield or the ex-post real rate $r_t - \pi_t$ for r_t ; federal tax receipts/GDP or personal current taxes/personal income for τ_t ; federal expenditure/GDP or the quarterly growth of real government expenditure for G_t . ZLB: quarters with a federal funds rate below 0.25% excluded. Wald *p*: joint test of $\delta = \beta = \gamma = 0$. ***, **, *: 1%, 5%, 10%.

Table A3 Eq. (3) under alternative measures and samples

Specification	Output	Const.	<i>a</i>	<i>b</i>	<i>N</i>	<i>R</i> ²
As written baseline (Y level, no intercept)	Y_t	No	0.561*** (0.082)	0.264*** (0.036)	285	-1.703
Adjusted baseline	Gap	Yes	0.034 (0.032)	-0.619*** (0.050)	285	0.726
Output measure: q/q growth	Growth	Yes	0.050 (0.066)	-0.157 (0.130)	285	0.020
π : PCE inflation	Gap	Yes	0.067* (0.039)	-0.634*** (0.052)	265	0.727
π : GDP deflator inflation	Gap	Yes	0.054 (0.044)	-0.619*** (0.050)	285	0.728
π : CPI q/q annualised	Gap	Yes	0.045* (0.024)	-0.626*** (0.049)	284	0.730
<i>u</i> : unemployment gap (<i>u</i> – NROU)	Gap	Yes	-0.070*** (0.026)	-0.617*** (0.045)	285	0.790
<i>u</i> : unemployment gap, Y level (literal form)	Y_t	No	-0.029 (0.053)	0.045** (0.022)	285	0.040
Adjusted, sample: Pre-1984 (to 1983Q4)	Gap	Yes	0.040 (0.027)	-0.520*** (0.047)	116	0.844
As written, sample: Pre-1984 (to 1983Q4)	Y_t	No	-0.207*** (0.077)	1.279*** (0.092)	116	0.242
Adjusted, sample: 1984Q1-2007Q4	Gap	Yes	0.214** (0.092)	-0.657*** (0.091)	96	0.611
As written, sample: 1984Q1-2007Q4	Y_t	No	0.920*** (0.164)	0.218*** (0.042)	96	-1.251
Adjusted, sample: Pre-COVID (to 2019Q4)	Gap	Yes	0.056* (0.029)	-0.585*** (0.047)	260	0.729
As written, sample: Pre-COVID (to 2019Q4)	Y_t	No	0.558*** (0.081)	0.320*** (0.035)	260	-1.298

Notes: Newey–West standard errors in parentheses. Alternative inflation measures: PCE price index and GDP deflator (year on year) and annualised quarter-on-quarter CPI inflation. Unemployment gap: u_t minus the CBO noncyclical rate of unemployment. ***, **, *: 1%, 5%, 10%.

Table A4 Newey–West and moving-block bootstrap 95% confidence intervals

Equation	Parameter	Estimate	Newey–West	Moving-block bootstrap
Eq. (2)	δ	0.0618	[0.0037, 0.1200]	[0.0027, 0.1292]
Eq. (2)	β	-0.0383	[-0.0805, 0.0039]	[-0.0784, 0.0166]
Eq. (2)	γ	-0.0170	[-0.0740, 0.0399]	[-0.0861, 0.0417]
Eq. (3) as written	<i>a</i>	0.5612	[0.4003, 0.7220]	[0.4239, 0.7930]
Eq. (3) as written	<i>b</i>	0.2637	[0.1938, 0.3335]	[0.1953, 0.3527]
Eq. (3) adjusted	Constant	5.5919	[5.2579, 5.9259]	[5.1775, 5.9348]
Eq. (3) adjusted	<i>a</i>	0.0340	[-0.0281, 0.0961]	[-0.0354, 0.1063]
Eq. (3) adjusted	<i>b</i>	-0.6192	[-0.7166, -0.5218]	[-0.7309, -0.5042]

Notes: 999 moving-block bootstrap replications (Künsch 1989); block length $T^{1/3} \approx 7$; pairs (y_t, x_t) resampled in blocks; percentile intervals.

Table A5 Lag order and persistence in Eq. (5)

Panel A. Information criteria for <i>p</i> (common sample, <i>n</i> = 277)					
<i>p</i>	AIC	BIC	HQIC		
0	10.1182	10.1443	10.1287		
1	10.1021	10.1413	10.1178		
2	10.1066	10.1590	10.1276		
3	10.1134	10.1788	10.1396		
4	10.1176	10.1961	10.1491		
5	10.1247	10.2162	10.1614		
6	10.1268	10.2315	10.1688		
7	10.1338	10.2515	10.1810		
8	10.1405	10.2714	10.1930		
Panel B. Persistence, <i>h</i> = 1					
Specification	μ	c_0	Σc_i	<i>N</i>	
<i>p</i> = 1 (BIC = AIC, baseline)	27.071	0.8530	1.00527	284	
<i>p</i> = 0 (fixed)	24.561	1.0045	1.00449	285	
<i>p</i> = 2 (fixed)	28.084	0.8452	1.00557	283	
<i>p</i> = 4 (fixed)	30.660	0.8427	1.00600	281	
<i>p</i> = 8 (fixed)	32.963	0.8432	1.00628	277	
Log level ln <i>Y</i> , <i>p</i> = 1	0.025	1.0461	0.99798	284	
Pre-1984 (to 1983Q4), <i>p</i> = 1	17.733	1.2784	1.00251	114	
1984Q1-2007Q4, <i>p</i> = 1	24.711	1.2011	1.00412	94	
Pre-COVID (to 2019Q4), <i>p</i> = 1	16.301	1.3473	1.00289	258	
Panel C. Out-of-sample RMSE (% of outcome) for fixed <i>p</i>					
<i>h</i>	<i>p</i> = 0	<i>p</i> = 1	<i>p</i> = 2	<i>p</i> = 4	<i>p</i> = 8
1	1.118	1.430	1.449	1.507	1.552
4	2.059	2.218	2.205	2.215	2.249
8	2.906	3.027	3.031	3.066	3.121

Notes: Panel A: criteria computed on a common estimation sample for all *p*. Panel B: Newey–West inference in the main text. Panel C: expanding-window forecasts as in Table 9.