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On the welfare implications of nominal GDP targeting

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ABSTRACT

This paper examines the welfare implications of a nominal GDP growth targeting rule, a nominal GDP level targeting rule, and inflation targeting regime in a New Keynesian model featuring positive trend inflation, two measures of welfare, and both high and low growth environments. The paper finds that (i) in general, nominal GDP growth targeting dominates other rules with changes in all dimensions; (ii) nominal GDP growth targeting framework is superior to the level targeting regime for most scenarios; (iii) inflation targeting is preferred to nominal GDP level targeting regime, but to minimize short-run fluctuations, the latter is advantageous; (iv) nominal GDP level targeting may be desirable only in a low growth environment with both low inflation indexation and consumption equivalence criteria. The simulation results provide solid evidence to policy makers on the desirability of nominal GDP growth targeting.

1. Introduction

Prior to the normalization of the federal funds rate, the past economic crisis and the nominal interest rate at the zero lower bound revived economists' interest in the targeting of nominal GDP (or nominal income) as an attractive policy option. Since 2016, the Federal Reserve has been gradually raising the federal funds rate from the zero lower bound, with the expectation of restoring it to the normal range when the unprecedented COVID-19 pandemic broke the pace. Lawmakers passed the relief package of 2.2 trillion dollars, financed by a new round of quantitative easing — open market purchase of treasury bonds. The federal funds rate was brought back to the zero lower bound. In an environment with constrained policy interest rates and a weak global economy, a natural question on what monetary policy a central bank should adopt rises. The current study is motivated by the constraint of the traditional monetary policy rules in the foreseeable future due to the narrow operation room at the zero lower bound, the normalization of the federal rates, and the traditional Taylor rule's congenital defects in requiring the measurement of the potential output, real economic activity and core inflation.

This paper examines a nominal GDP growth targeting (NGDP-GT) rule, a nominal GDP level targeting (NGDP-LT) rule, and inflation targeting regime in a New Keynesian model with the features of trend growth of productivity, partial indexation to inflation and a positive rate of trend inflation. The simulation results provide evidence to U.S. policy makers that nominal GDP growth targeting is desirable relative to alternative regimes with changes of all dimension standards. The paper contributes to the literature on nominal GDP targeting in the following aspects. First, this is the first paper that adopts two welfare measures to comprehensively examine welfare properties of nominal GDP targeting. Although the paper presents different policy rankings in terms of welfare measures, in general, nominal GDP growth targeting produces less welfare loss. Garín et al. (2016) adopt consumption equivalence as the welfare measure and focuses on the desirability of nominal GDP level targeting rule in a New Keynesian model.

Second, this is the first paper to evaluate both the nominal GDP growth and level targeting rules in the same framework with the features of positive trend inflation and trend growth of productivity, and it finds that nominal GDP growth targeting dominates

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level targeting for most scenarios. The paper shows that although the consumption-equivalence-welfare loss associated with the level targeting is smaller conditional on low productivity growth and partial inflation indexation with non-separable utility function, nominal GDP growth targeting outperforms level targeting for all other scenarios. The above conclusion is contingent upon applying consumption equivalence as the welfare measure. When using the weighted sum of variances of inflation and output gap as the welfare standard, nominal GDP growth targeting is always preferable to the level targeting rule.

There is research focusing on either nominal GDP growth targeting rule or level targeting rule in the literature. Beckworth and Hendrickson (2015) amend a standard New Keynesian model and their simulations show that a nominal GDP growth targeting rule produces lower volatility in both inflation and output gap in comparison with the Taylor rule under imperfect information. Chen (2020) examines a nominal GDP growth targeting rule in a New Keynesian model and finds that nominal GDP growth targeting either outperforms Taylor type of rules and inflation targeting or is weakly dominated by a desirable policy. Billi (2017) compares nominal GDP level targeting with strict price level targeting in a small New Keynesian model, with the central bank operating under optimal discretion and facing the zero lower bound on nominal interest rates, and shows that, if the economy is only buffeted by temporary inflation shocks, nominal GDP level targeting may be preferable.

Third, the model of the paper incorporates both demand and supply shocks to thoroughly examine policy performance. When trend growth is greater than one or equal to one, the most likely scenario for the U.S., nominal GDP growth targeting regime is the most desirable framework, generating the least consumption variation while level targeting produces the most consumption variation; when both the trend growth and inflation indexation are less than one with the non-separable utility function, nominal GDP level targeting yields the least consumption-equivalence-welfare loss, regardless of the type of shock, while nominal GDP growth targeting, takes the second place. When using the weighted sum of variances of inflation and output gap as the welfare standard, the paper draws consistent conclusions for both the productivity shock and government spending shock and demonstrates that nominal GDP growth targeting rule dominates all other policy regimes, creating the least fluctuations, and nominal GDP level targeting policy is proved to be the second preferable regime. By adopting nominal GDP growth rate targeting, not only the growth rate of output is stabilized but so is the inflation rate.

Fourth, inflation targeting generally performs better with consumption-equivalence criteria. On average, inflation targeting is superior to the nominal GDP level targeting framework, but to minimize short-run fluctuations, nominal GDP level targeting shows its advantage.

The essential intuition for why nominal GDP growth targeting is desirable is that it puts equal weight on inflation and output growth path, effectively weighting real economic activity more than alternative rules. Nominal GDP growth targeting allows output growth and inflation to accommodate a shock and assists in finding the point where the relative levels of output growth and inflation lead to lower economic fluctuations. Thus, this regime generates higher output and consumption levels and lower volatilities in output and inflation, resulting in relatively low utility loss.

The baseline setup of this paper is characterized by three sectors of the economy: households, monopolistically-competitive firms that face adjustment costs, and a monetary authority. The private-sector equilibrium is constituted by optimal paths of consumption, labor, interest rate, real marginal cost, output, and inflation. For the nominal GDP growth targeting rule, I keep the growth rate of nominal output between two consecutive periods constant. In the benchmark model, the growth rate of nominal GDP is set to the U.S. historical level.

The rest of this paper is organized in the following structure: Section 2 outlines the model and defines the private-sector equilibrium, Section 3 provides a description of the policy rules, Section 4 defines equilibrium, Section 5 presents the quantitative results with consumption equivalence as the welfare measure, Section 6 shows the policy rankings with weighted sum of variances of inflation and output gap as the welfare measure and compares findings under the two measures. Section 7 presents some robustness with a separable utility function. Section 8 concludes.

2. The model

2.1. Modeling trend growth in DSGE models

The paper models productivity growth as characterized by a deterministic linear trend.[1] In particular, the trend-stationary model follows the specification:

$$Z_t = z_t A^t$$

$$\log(z_t) = (1-\rho_z)\log\mu_z + \rho_z \log(z_{t-1}) + \upsilon_t^z \tag{1}$$

in which the trend growth rate A is a primitive parameter and z_t generates stationary fluctuations of Z_t around such trend. μ_z denotes the mean of the productivity term. The innovation terms $\upsilon_t^z \sim N(0, \sigma_z^2)$, and σ_z represents the standard deviation of the innovation term. One of the focuses of the paper is to study the effects that the trend growth rate has on rankings of monetary policies; that is, trend growth allows us to compare monetary policy rules in both high and low growth economies.

The economy is composed of three sectors: a continuum of infinitely-lived households who derive utilities from consumption and leisure, monopolistically-competitive firms that hire labor as the only input to produce differentiated products and face an adjustment cost for changing prices, and the monetary authority. The paper assumes an efficient labor market.

[1] Seen in the work of Perron (1989, 1997) a large body of literature has shown that the linear deterministic trend model can reproduce the serial correlation properties of the data just as well as the random-walk model, provided that the possibility of infrequent structural breaks in the trend is allowed for.

2.2. Households

The representative household seeks to maximize the objective function:

$$E_0\sum_{t=0}^{\infty}\beta^t\frac{c_t^{1-\sigma}}{1-\sigma}(1-l)^{(1-\theta)} \tag{2}$$

where $\beta\in(0,1)$ is the subjective discount factor, E_0 is the mathematical expectation operator conditional on information available in period 0. c_t is the composite consumption index, and l_t is labor. Each household has preference over leisure and consumption, defined by the period utility function $U(c_t,l_t)=\frac{c_t^{1-\sigma}}{1-\sigma}(1-l)^{(1-\theta)}$, which is assumed to be continuous and twice differentiable, satisfying the usual properties: $\frac{\partial U}{\partial c}>0$ $\frac{\partial^2 U}{\partial c^2}\leqslant 0$, $\frac{\partial U}{\partial l}<0$, and $\frac{\partial^2 U}{\partial l^2}\leqslant 0$. In order to have a system of preferences consistent with balanced growth, the paper restrict the parameters value in the utility function to satisfy $\sigma,\theta>1$. For future reference, note that σ denotes the inverse of the intertemporal elasticity of substitution in consumption and $\theta\frac{l}{1-l}$ denotes the inverse of the steady state elasticity of labor supply.

As standard in New Keynesian models, consumption c_t is a Dixit–Stiglitz aggregator of differentiated products $c_{j,t}$, supplied by monopolistically-competitive firms:

$$c_t=\left(\int_0^1 c_{j,t}^{\frac{\epsilon_t-1}{\epsilon_t}}d_{j,t}\right)^{\frac{\epsilon_t}{\epsilon_t-1}} \tag{3}$$

where ϵ_t measures the elasticity of substitution between two varieties of final goods.

The solution to the household's problem of maximizing the consumption bundle c_t for any given level of expenditures yields the set of demand equations:

$$c_{j,t}=\left(\frac{P_{j,t}}{P_t}\right)^{-\epsilon_t}c_t, \tag{4}$$

where $P_t=\left(\int_0^1 P_{j,t}^{1-\epsilon_t}dj\right)^{\frac{\epsilon_t}{\epsilon_t-1}}$ is the Dixit–Stiglitz price index that results from cost minimization. This paper evaluates policy performance when the economy is subject to a productivity shock and government spending shock. Therefore, the study considers a constant elasticity of substitution ϵ.

The consumer seeks to maximize the expected discounted stream of lifetime utility flows subject to the sequence of the budget constraints of the form:

$$c_t+\frac{B_t}{P_t}+\frac{T_t}{P_t}=\frac{R_{t-1}B_{t-1}}{P_t}+\frac{W_t l_t}{P_t}+\frac{Tr_t}{P_t}+\frac{\Pi_t}{P_t} \tag{5}$$

where B_t represents the quantity of one-period nominally riskless bond that is purchased in period t and matures in period $t+1$. Each bond pays one unit of money at maturity. T_t is lump-sum taxes. R_t is the nominal gross policy (or market) interest rate. W_t denotes nominal wage, and w_t denotes the real wage expressed as W_t/P_t. Tr_t is the net nominal transfers, and Π_t stands for nominal profits from the ownership of firms. The household's choices of c_t, l_t and B_t yield the following optimality conditions:

$$(\frac{1-\theta}{1-\sigma})\frac{c_t}{1-l_t}=w_t \tag{6}$$

and

$$(c_t)^{-\sigma}(1-l_t)^{1-\theta}=\beta E_t\{R_t\frac{(c_{t+1})^{-\sigma}(1-l_{t+1})^{1-\theta}}{\pi_{t+1}}\} \tag{7}$$

where $\pi_t=P_t/P_{t-1}$ is the gross inflation rate. Eq. (6) describes the labor supply decisions, and Eq. (7) describes the optimal consumption decisions, which is the Euler equation in consumption.

2.3. Firms

There is a continuum of identical monopolistically-competitive firms indexed by $j\in[0,1]$. Each firm j hires labor as the only input and produces a differentiated product $y_{j,t}$ using the identical technology:

$$y_{j,t}=Z_t l_{j,t}=z_t A^t l_{jt} \tag{8}$$

where z_t is assumed to be common to all firms, and to evolve exogenously over time, which follows the trend-stationary model specified in Eq. (1). $l_{j,t}$ is the labor hired by firm j at time t. First consider the cost minimization problem of firm j, min $W_t l_{j,t}$ s.t. $y_{j,t}=Z_t l_{j,t}$, where by symmetry, it implies

$$mc_t=\frac{w_t}{z_t A^t} \tag{9}$$

where mc_t is the Lagrange multiplier on the output constraint Eq. (8) and also the real marginal cost of production. Eq. (9) specifies the labor demand function.

Moreover, following Rotemberg (1982), the monopolistic firm faces a quadratic cost of adjusting nominal prices, which can be measured in terms of the final-good and given by

$$\frac{\phi}{2}\left(\frac{P_{j,t}}{P_{j,t-1}}-\bar{\pi}^{\eta}\right)^{2} y_t \tag{10}$$

where $\phi > 0$ determines the degree of nominal price rigidity and $\bar{\pi}$ is the gross steady-state inflation rate. As stressed in Rotemberg (1982), the adjustment cost seeks to account for the negative effects of price changes on the customer-firm relationship. These negative effects increase in magnitude with the size of the price change and with the overall scale of economic activity, y_t. The adjustment cost depends on the ratio between the new reset price and the one set during the previous period, adjusted by the steady state inflation with partial indexation $\eta \in [0,1]$. When $\eta = 0$, Eq. (10) would be the more common pricing function. The goal of introducing this parameter is to examine if conclusions are robust to partial indexation and to avoid discussions of which extreme (i.e. $\eta = 0$ versus $\eta = 1$) has better microfoundations.

The problem for firm j is then to choose its price to maximize the expected present discounted stream of profits:

$$E_0 \sum_{t=0}^{\infty} \frac{\beta^t U_{c,t}}{U_{c,0}} \left\{ \left(\frac{P_{j,t}}{P_t} - mc_{j,t}\right) y_{j,t} - \frac{\phi}{2}\left(\frac{P_{j,t}}{P_{j,t-1}} - \bar{\pi}^{\eta}\right)^2 y_t \right\} \tag{11}$$

subject to the downward-sloping demand curve that firm j faces:

$$y_{j,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\epsilon} y_t \tag{12}$$

where $\frac{\beta^t U_{c,t}}{U_{c,0}}$ is the stochastic discount factor.

Subject to the adjustment cost, firms can change their prices in each period. Therefore, all the firms face the same problem, and thus will choose the same price and produce the same quantity. In other words, $P_{j,t} = P_t$ and $y_{j,t} = y_t$ for any j. Hence, the first-order condition for a symmetric equilibrium

$$1 - \phi(\pi_t - \bar{\pi}^{\eta})\pi_t + \beta\phi E_t \left[\frac{U_{c,t+1}}{U_{c,t}}(\pi_{t+1} - \bar{\pi}^{\eta})\pi_{t+1}\frac{y_{t+1}}{y_t}\right] = \epsilon(1 - mc_t) \tag{13}$$

is the Rotemberg version of the non-linear Phillips curve, showing that current inflation is a function of future expected inflation, the real marginal cost, and the level of output.

Since all firms will employ the same amount of labor, the aggregate production function is simply given by:

$$y_t = z_t A^t l_t \tag{14}$$

2.4. Market clearing

In equilibrium, the aggregate resource constraint is given by:

$$y_t = c_t + \frac{\phi}{2}(\pi_t - \bar{\pi}^{\eta})^2 y_t + g_t \tag{15}$$

where g_t is the exogenous government spending, financed through lump-sum taxes and is determined by the AR(1) process.

3. Policy regimes

This section outlines the rules that interchangeably describe monetary policy frameworks. Given the model described above, I examine the performance of three policy rules. One rule targets the growth rate of nominal output, one targets the level of nominal output, and one targets the inflation rate. The paper assumes that each monetary policy should be set in a way that ensures that each target is met. Next, the study discusses these three regimes and analyzes their performances following a negative productivity shock and a negative government spending shock with the exogenous processes of z_t and g_t.

3.1. Nominal GDP growth targeting rule

McCallum (1998), Orphanides (1999), and Trehan (1999) suggest that monetary policy should focus on nominal output growth because such a strategy does not rely on uncertain estimates of the level of the output gap. Rudebusch (2002) points out that it automatically takes into account movements in both prices and real output and can serve as a long-run nominal anchor for monetary policy. Such a target linked to a weighted average of inflation and employment will better address the Federal Reserve's dual mandate, according to Sumner (2014). In the NGDP-GT regime, policymakers observe and respond only to the variations of nominal GDP growth rate.

Nominal GDP growth targeting assumes that the monetary authority commits to a certain growth rate of nominal GDP. Letting Y_t be nominal output, this rule reads:

$$\frac{Y_t}{Y_{t-1}} = \bar{k} \tag{16}$$

or, using the definition of nominal output ($Y_t = y_t P_t$), we have:

$$\frac{y_t}{y_{t-1}} \pi_t = \bar{k} \tag{17}$$

where $\bar{k}$ is the growth rate of nominal GDP. The regime of nominal GDP growth rate targeting implies a positive steady state inflation (or zero inflation when $\bar{k}$ is set to 1).

3.2. Nominal GDP level targeting rule

Under the nominal GDP level targeting, nominal GDP (Y_t) is set as follows:

$$Y_t = \bar{Y} \tag{18}$$

with $\bar{Y}$ being the target of nominal output. This condition can also be rewritten as:

$$P_{t-1} \pi_t y_t = \bar{Y} \tag{19}$$

I set the initial price level to 1.

3.3. Inflation targeting rule

Besides the nominal GDP targeting rules, the strict inflation targeting rule receives much attention. As in Svensson (1999), the monetary authority is assumed to have perfect control over the inflation rate. It sets the inflation rate in each period. For simplicity, I assume the inflation rate is set at its steady-state value $\bar{\pi}$ with partial indexation η at any period t. Inflation targeting can be written

$$\pi_t = \bar{\pi}^{\eta} \tag{20}$$

4. The equilibrium

4.1. The stationary equilibrium

Given trend growth, variables like consumption and output inherit a deterministic trend from the productivity index, which prevents the system from converging to a steady state. For a steady-state equilibrium to be definable, therefore, the system needs to be transformed to ensure stationarity. The obvious transformation in this case is to divide the generic trending variable X_t by the time trend, and I denote the transformed variable with a "hat": $\hat{X}_t \equiv X_t / A^t$.

In terms of the transformed variables, the system is described by:

$$\left(\frac{1-\theta}{1-\sigma}\right)\frac{\hat{c}_t}{1-l_t} = mc_t z_t \tag{21}$$

$$(\hat{c}_t)^{-\sigma}(1-l_t)^{1-\theta} = \beta A^{-\sigma} R_t E_t\left[\frac{(\hat{c}_{t+1})^{-\sigma}(1-l_{t+1})^{1-\theta}}{\pi_{t+1}}\right] \tag{22}$$

$$1 - \phi(\pi_t - \bar{\pi}^{\eta})\pi_t + \beta\phi A^{1-\sigma} E_t\left[\left(\frac{\hat{c}_{t+1}}{\hat{c}_t}\right)^{-\sigma}\left(\frac{1-l_{t+1}}{1-l_t}\right)^{1-\theta}(\pi_{t+1} - \bar{\pi}^{\eta})\pi_{t+1}\frac{\hat{y}_{t+1}}{\hat{y}_t}\right] = \epsilon(1 - mc_t) \tag{23}$$

$$\hat{y}_t = z_t l_t \tag{24}$$

$$\hat{y}_t = \hat{c}_t + \frac{\phi}{2}(\pi_t - \bar{\pi}^{\eta})^2 \hat{y}_t + \hat{g}_t \tag{25}$$

Eq. (21) is at the equilibrium where labor demand is equal to the labor supply, Eq. (22) represents the consumption Euler equation, Eq. (23) describes the Philips curve, Eq. (24) denotes the production function and Eq. (25) represents the resource constraint.

While the model economy grows indefinitely over time, the stationary system above converges to a non-zero inflation steady state, in which the average rate of growth A enters the Euler equation for consumption and the pricing equation of consumption goods.

Definition 1. Given the exogenous processes of z_t and $\hat{g}_t$, the private sector equilibrium is a state-contingent sequence of allocations of $\{\hat{c}_t, l_t, \hat{y}_t, R_t, mc_t, \pi_t\}$ that satisfies the equilibrium conditions of (21)–(25).

4.2. The transformed monetary policy rules

The NGDP-GT rule, Eq. (17), can be rewritten as

$$\frac{\hat{y}_t}{\hat{y}_{t-1}} A\pi_t = \bar{k} \tag{26}$$

The NGDP-LT regime can be written as

$$P_{t-1}\pi_t \hat{y}_t = \bar{\pi}\bar{y} \tag{27}$$

The inflation targeting, Eq. (20), does not change its form.

Table 1
Values of the parameters.

Parameter	Description	Value
β	Households' discount factor	0.990
σ	Risk aversion	2.000
A	trend growth rate of technology	1.000
θ	determines the IES of labor supply	4.919
ϕ	Price adjustment cost parameter	18.473
η	partial indexation to steady state inflation	1.000
μ_z	Mean of productivity index	1.000
ϵ	Elasticity of substitution between goods	6.000
$\bar{k}$	Nominal GDP growth rate(gross)	1.016
$\bar{R}$	Steady-state gross interest rate	1.026
$\bar{\pi}$	Steady-state gross inflation	1.016
$\bar{\hat{y}}$	Steady-state output	0.210
$\bar{\hat{g}}$	Steady-state government spending	0.042
ρ_r	Smoothing coefficient of the interest rate	0.900
ρ_z	AR(1) coefficient of TFP	0.950
ρ_g	AR(1) coefficient of government spending	0.900
σ_z	Standard deviation of the innovation term in TFP	0.008
σ_g	Standard deviation of the innovation term in government spending	0.008

Note: TFP denotes total factor productivity.

4.3. Exogenous processes

There are two exogenous variables in the model, the total factor productivity shock and the government spending shock. The total factor productivity is shown in the beginning of the paper, and the government spending is assumed to follow the stationary AR(1) process as well:

$$\log(\frac{\hat{g}_t}{\bar{\hat{g}}}) = \rho_g \log(\frac{\hat{g}_{t-1}}{\bar{\hat{g}}}) + v_t^g \tag{28}$$

$\bar{\hat{g}}$ denotes the steady-state government spending, the innovation terms $v_t^g \sim N(0, \sigma_g^2)$, and σ_g represents the standard deviation of the innovation term.

5. Quantitative results

5.1. Parameterization

Table 1 lists the baseline parameter values. These parameters are set to widely accepted values based on U.S. data. Assuming a time unit of one quarter, the discount factor β is set to 0.99, implying a 4% annual interest rate. The risk aversion parameter σ is set to 2, so that the deterministic steady-state value of l is 0.21, implying an average workweek of 35 hours, which is in line with the empirical average of weekly hours over the period of 1964:Q1–2014:Q1, as in Abo-Zaid (2015). The underling theory introduced in Faia and Monacelli (2007) and Abo-Zaid (2015) implies the adjustment cost parameter $\phi = \frac{\lambda(\lambda-1)(\epsilon-1)}{\lambda-\beta(\lambda-1)}$, with λ being the quarterly price duration. Following Christiano et al. (2005) and Abo-Zaid (2015), the price duration is set to 2.5 quarters. ϵ is set to 6, so that the net steady-state markup is 20%, consistent with the literature.

In the benchmark calibration, I assume the monetary authority targets the nominal GDP growth rate $\bar{k}$ at 1.016, based on the historical quarterly GDP growth rate over the period of 1947:Q1–2019:Q4. The value of $\bar{R}$ can be easily derived from the consumption Euler equation: $\bar{R} = \bar{\pi} A^{\sigma}/\beta$. The benchmark model sets $A = 1$, $\eta = 1$, indicating that firms adjust prices in terms of positive trend inflation as η appears in the quadratic adjustment cost. The steady-state output level $\bar{y}$ is determined by the aggregate production function. ρ_z and ρ_g are the AR(1) coefficients of these processes, with μ_z and $\bar{\hat{g}}$ being the deterministic steady state values of z_t and $\hat{g}_t$. μ_z is normalized to 1, and $\bar{\hat{g}}$ is set so that $\bar{\hat{g}}/\ \bar{\hat{y}}$=0.2. The innovation terms are $v_t^z \sim N(0, \sigma_z^2)$ and $v_t^g \sim N(0, \sigma_g^2)$. Following Faia (2008), σ_z and σ_g are set to 0.008.

5.2. Benchmark results with consumption equivalence

5.2.1. The optimal monetary policy problem

This paper adopts a Ramsey-type approach to study the optimal monetary policy; the monetary authority chooses allocations to maximize the life time utility of households subject to the resource constraint and the private sector equilibrium conditions. This formulation also assumes commitment in the solution to the optimal policy problem.

Definition 2. Given the exogenous process of z_t and $\hat{g}_t$, the monetary authority chooses a sequence of allocations of $\{\hat{y}_t, \pi_t, \hat{c}_t, l_t, mc_t, R_t\}$ to maximize (2) subject to the equilibrium conditions of (21)–(25) and the monetary composite.

This section and the following section present welfare analysis to assess the optimal monetary policy relative to ad-hoc monetary rules by using two welfare measures: consumption equivalence and weighted sum of variances of inflation and output gap.

Table 2
Consumption equivalent welfare losses (×100) from different policy rules, only productivity shocks (HP filter, lambda = 1600).

Policy rule	$A = 1.00$ $\eta = 1.00$	Ranking	$A = 1.00$ $\eta = 0.50$	Ranking	$A = 0.98$ $\eta = 1.00$	Ranking	$A = 0.98$ $\eta = 0.50$	Ranking	$A = 1.01$ $\eta = 1$	Ranking	$A = 1.01$ $\eta = 0.5$	Ranking
NGDP-GT	1.4288	1	0.2976	1	1.4288	1	2.5036	2	7.3820	1	5.7737	1
IT	1.5479	2	0.3572	2	1.5479	2	2.56323	3	7.5012	2	5.8928	2
NGDP-LT	11.5013	3	5.1813	3	17.7099	3	0.00000	1	11.7330	3	9.3484	3

Note: IT denotes inflation targeting. Table 2 presents the benchmark model results: consumption equivalence and policy rankings for combinations of trend growth rate and the partial indexation to steady state inflation subject to a negative productivity shock. When $A > 1 and/or A = 1$, NGDP-GT produces the least consumption-equivalence welfare loss. On the other hand, the inflation targeting dominates NGDP-LT. When both the trend growth and the partial indexation level are less than 1, NGDP-LT outperforms alternative frameworks. NGDP-GT takes the second place.

Table 3
Consumption equivalent welfare losses (×100) from different policy rules, only government spending shocks (HP filter, lambda = 1600).

Policy rule	$A = 1.00$ $\eta = 1.00$	Ranking	$A = 1.00$ $\eta = 0.50$	Ranking	$A = 0.98$ $\eta = 1.00$	Ranking	$A = 0.98$ $\eta = 0.50$	Ranking	$A = 1.01$ $\eta = 1.00$	Ranking	$A = 1.01$ $\eta = 0.50$	Ranking
NGDP-GT	2.2024	1	0.0005	1	0.0010	1	1.0132	2	5.8928	1	4.2850	1
IT	2.2024	1	0.0601	2	0.0010	1	1.0132	2	5.8928	1	4.2850	1
NGDP-LT	12.2742	2	4.9428	3	2.7310	2	0.0000	1	10.1829	2	7.8586	2

Table 3 shows benchmark model results: consumption equivalence and policy rankings for combinations of trend growth rate and the partial indexation to steady state inflation subject to a negative government spending shock. When $A > 1$ and/or $A = 1$, NGDP-GT co-favorites with inflation targeting, dominating NGDP-LT framework. When both the trend growth and the partial indexation are less than one, NGDP-LT performs almost as well as the optimal monetary policy. NGDP-GT is shown to be the second superior regime, producing a compensating variation of one percent.

5.2.2. Benchmark results with consumption equivalence

Using the consumption equivalence as a measure of welfare, the results are shown in Tables 2 and 3. The numbers are the percentage difference of consumption under the particular policy rule from its value under the optimal policy. For example, the first entry in column I suggests that consumption under the NGDP-GT rule should be increased by nearly 1.43 percent so that welfare under the NGDP-GT rule is equivalent to the welfare under the optimal policy.

The policy rankings in this paper are tested under both high and low growth environment. When the economy is subject to a negative productivity shock, Table 2 presents consumption equivalence of policy regimes for different combinations of trend growth rate and the level of partial index to steady state inflation. When $A \geqq 1$, which is the most likely scenario,[2] the results consistently demonstrate that NGDP-GT outperforms alternative policies, generating the least consumption-equivalence-welfare loss. The NGDP-LT performs very poorly, found to be the least desirable regime.

The intuition behind the findings is that NGDP-GT allows the output growth path and price path (inflation) to absorb the shock, thus creating a stable environment and generating the highest output and consumption levels compared to the other two frameworks. Meanwhile, the trend growth rate in the policy equation serves as a cushion, mitigating the downward pressure on output and inflation when the economy is subject to a negative supply shock. Inflation targeting, however, stabilizes inflation at the cost of output stabilization, so it is dominated by the NGDP-GT rule. Nominal GDP level targeting puts all the shock burden equally on the overall price level and real economic activities, and is likely to create more volatilities in output, inflation and consumption.

When both the trend growth and the partial indexation level are less than 1, NGDP-LT produces the least consumption-equivalent utility loss. NGDP-GT, however, is shown to be the second superior rule, and inflation targeting produces the most consumption variation. Compared to NGDP-LT, the low trend growth rate in the NGDP-GT may aggravate the downward pressure for NGDP-GT to hit the target. For inflation targeting, a negative supply shock causes inflation to rise. Therefore, it calls for contractionary practices to hit the inflation target, resulting in low output and consumption. In summary, NGDP-GT is either the most desirable policy or is weakly dominated, in a low growth environment, by NGDP-LT regime when the economy is buffeted by negative supply shock.

Table 3 repeats the exercises in Table 2 conditional on a negative government spending shock. When $A > 1$ and/or $A = 1$, NGDP-GT co-favorites with inflation targeting, dominating the NGDP-LT rule. When both the trend growth and the partial indexation are less than one, NGDP-LT performs almost as well as the optimal monetary policy, producing the lowest consumption-equivalence welfare loss. When the economy is hit by a negative demand shock, both output growth and inflation tend to decrease, while a low trend growth in NGDP-GT imposes a downward pressure, calling for aggressive practices in order to hit the target rate.

6. Welfare analysis with weighted sum of variances of inflation and output gap

6.1. Some robustness with consumption equivalence

Tables 4 and 5 present welfare rankings of alternative combinations of trend growth of productivity and partial indexation to inflation. It shows the cases when trend growth is greater than 1 and inflation indexation is equal to 1, trend growth is equal to 1 and inflation indexation is less than 1, and trend growth is less than 1 and inflation indexation is less than 1. The findings suggest

[2] Mattesini and Nisticò (2010) show that the estimated average trend growth rate of the United States is about 1.01.

Table 4
Consumption equivalent welfare losses (×100) with alternative combinations of trend growth and inflation indexation, only productivity shocks (HP filter, lambda = 1600).

Policy rule	$A = 1.00$ $\eta = 0.60$	Ranking	$A = 1.00$ $\eta = 0.40$	Ranking	$A = 1.008$ $\eta = 1.00$	Ranking	$A = 0.99$ $\eta = 0.50$	Ranking	$A = 0.98$ $\eta = 0.60$	Ranking	$A = 0.98$ $\eta = 0.4$	Ranking
NGDP-GT	1.4286	1	1.4881	1	1.4288	1	1.4889	2	1.4301	2	1.4909	2
IT	1.5477	2	1.5477	2	1.5479	2	1.5484	3	1.4897	3	1.5505	3
NGDP-LT	7.3260	3	5.3594	3	7.0288	3	1.3697	1	0.0000	1	0.0000	1

Table 4 shows the robustness results, namely, consumption variations and welfare rankings for alternative combinations of trend growth and partial indexation to inflation under a negative productivity shock. The findings suggest consistent results with the benchmark models. When $A > 1$ and/or $A = 1$, NGDP-GT is the best policy, and inflation targeting is found to be the second-most superior framework. When both the above parameters are less than one, NGDP-LT emerges as the desirable regime with NGDP-GT being the second-best policy rule.

Table 5
Consumption equivalent welfare losses (×100) with alternative combinations of trend growth and inflation indexation, only government spending shocks (HP filter, lambda = 1600).

Policy rule	$A = 1.00$ $\eta = 0.60$	Ranking	$A = 1.00$ $\eta = 0.40$	Ranking	$A = 1.008$ $\eta = 1.00$	Ranking	$A = 0.98$ $\eta = 0.60$	Ranking	$A = 0.98$ $\eta = 0.50$	Ranking	$A = 0.98$ $\eta = 0.40$	Ranking
NGDP-GT	0.0006	1	0.0005	1	2.5428	1	3.2768	2	1.0132	2	17.4704	2
IT	0.0006	1	0.0005	1	2.5428	1	3.2768	2	1.0132	2	17.4704	2
NGDP-LT	5.8962	2	3.8706	2	8.1426	2	0.0000	1	0.0000	1	0.0000	1

Table 5 presents the robustness results, namely, welfare rankings for alternative combinations of trend growth and partial indexation to inflation when a negative government spending shock hits the economy. The results are in line with the benchmark model. First, NGDP-GT and inflation targeting perform equally well. Two, inflation targeting is preferred to the NGDP-LT framework. However, NGDP-LT is desirable when both productivity growth and inflation indexation are less than one.

roughly consistent results with the benchmark models. Subject to a productivity shock, when the trend growth is greater than 1 or equal to 1, NGDP-GT is the best policy, and NGDP-LT is the least desirable regime. When both the above parameters are less than 1, NGDP-LT emerges as the preferable policy with NGDP-GT being the second superior rule.

When the economy is subject to a negative government spending shock, the results deliver the same message from the benchmark model, albeit robustness shows that NGDP-GT and inflation targeting regimes perform equally well for all combinations of parameters. Moreover, the results suggest that on average, inflation targeting is preferred to the NGDP-LT framework when the economy is buffeted by either shock. However, NGDP-LT is desirable conditional on low productivity growth and inflation indexation.

6.2. Weighted sum of variances of inflation and output gap

As shown in Woodford (2011), the period utility losses resulting from deviations from the flexible price allocation can be approximated by means of the period loss function:

$$L_t = \frac{U_c c}{2}\left((\sigma+\theta)E_t\{x_t^2\} + \frac{\epsilon\phi}{(1-\phi)(1-\beta\phi)}E_t\{\pi_t^2\}\right) \tag{29}$$

where c is the steady state consumption, and x_t denotes the output gap.

$$\frac{1}{2}\left((\sigma+\theta)var\{x_t\} + \frac{\epsilon\phi}{(1-\phi)(1-\beta\phi)}var(\pi_t)\right) \tag{30}$$

According to Gali (2002), the expected loss of utility resulting from departures from the optimal allocation, expressed as a fraction of steady state consumption, is given approximately by Eq. (30).

This measure of welfare delivers different results from the consumption equivalence. Tables 6 and 7 present the weighted sum of variances of inflation and output gap. Under any combination of trend growth and the level of partial indexation to inflation, Tables 6 and 7 present the conclusive rankings of policy regimes when a supply shock and/or a demand-side shock (government spending shock) hit the economy. The two tables show that NGDP-GT is the best rule to follow, producing the least utility loss for all combinations of productivity growth and inflation indexation. Targeting the level of nominal GDP yields intermediate results in this respect while the inflation targeting generates the most fluctuations in output gap and inflation.

The observation that NGDP-GT stabilizes inflation and real economic activity is novel to what economic intuition would suggest. According to Tables 8 and 9, targeting nominal GDP growth rate yields a more stable path of inflation and output than alternative frameworks. By adopting nominal GDP growth rate targeting, not only the growth rate of real GDP is stabilized but so is the inflation rate. The intuition is that NGDP-GT allows both output growth and inflation to absorb the shock, resulting in mild variations of the two variables. Therefore, the weighted sum of variances of inflation and output gap is lower under NGDP-GT than under alternative rules.

Two welfare measures deliver some different results. First, inflation targeting generally performs better with consumption-equivalence criteria than with the weighted sum of variances of inflation and output gap. According to the above utility loss function, if the second moment generates higher deviations of inflation and output from their steady state values, then the welfare loss will

Table 6
Welfare losses-weighted sum of variances of inflation and output gap (×10^5^), only productivity shocks (HP filter, lambda = 1600).

Policy regimes	$A = 1.00$ $\eta = 1.00$	Ranking	$A = 1.00$ $\eta = 0.50$	Ranking	$A = 0.98$ $\eta = 1.00$	Ranking	$A = 0.98$ $\eta = 0.50$	Ranking	$A = 1.01$ $\eta = 1.00$	Ranking	$A = 1.01$ $\eta = 0.50$	Ranking
NGDP-GT	6.6475	1	6.6020	1	6.6059	1	6.4995	1	6.66661	1	6.6495	1
IT	6.6955	3	6.9472	3	6.9259	3	6.8826	3	6.9825	3	6.9472	3
NGDP-LT	6.7114	2	6.6640	2	6.7556	2	6.6457	2	6.6893	2	6.6640	2

Table 7
Welfare losses-weighted sum of variances of inflation and output gap (×10^5^), only government spending shocks (HP filter, lambda = 1600).

Policy regimes	$A = 1.00$ $\eta = 1.00$	Ranking	$A = 1.00$ $\eta = 0.50$	Ranking	$A = 0.98$ $\eta = 1.00$	Ranking	$A = 0.98$ $\eta = 0.50$	Ranking	$A = 1.01$ $\eta = 1.00$	Ranking	$A = 1.01$ $\eta = 0.50$	Ranking
NGDP-GT	0.1258	1	0.1259	1	0.1149	1	0.1254	1	0.1267	1	0.1263	1
IT	0.1415	3	0.1427	3	0.1308	3	0.1439	3	0.1422	3	0.1422	3
NGDP-LT	0.1271	2	0.1273	2	0.1176	2	0.1283	2	0.1272	2	0.1269	2

Tables 6 and 7 indicate the welfare loss and policy rankings with the second welfare measure subject to only a productivity shock or a government spending shock. The two tables show that NGDP-GT is the best rule to follow, producing the least utility loss. Targeting the level of nominal GDP yields intermediate results in this respect while the inflation targeting generates the most fluctuations in output gap and inflation.

Table 8
Standard deviations of inflation and output (×100), only productivity Shocks (HP filter, lambda = 1600).

Policy regimes	$A = 1.00$ $\eta = 1.00$		$A = 1.00$ $\eta = 0.50$		$A = 0.98$ $\eta = 1.00$		$A = 0.98$ $\eta = 0.50$		$A = 1.01$ $\eta = 1.00$		$A = 1.01$ $\eta = 0.50$	
	$std(\hat{y})$	$std(\pi)$	$std(\hat{y})$	$std(\pi)$	$std(\hat{y})$	$std(\pi)$	$std(\hat{y})$	$std(\pi)$	$std(\hat{y})$	$std(\pi)$	$std(\hat{y})$	$std(\pi)$
NGDP-GT	0.1385	0.3182	0.1367	0.3083	0.1378	0.3222	0.1335	0.2989	0.1389	0.3163	0.1367	0.3127
IT	0.1837	0.0000	0.1836	0.0000	0.1837	0.0000	0.1834	0.0000	0.1867	0.0000	0.1837	0.0000
NGDP-LT	0.1429	0.3358	0.1410	0.3261	0.1480	0.3612	0.1437	0.3402	0.1405	0.3229	0.1398	0.3193

Table 9
Standard deviations of Inflation and Output (×100), only government spending shocks (HP filter, lambda = 1600).

Policy regimes	$A = 1.00$ $\eta = 1.00$		$A = 1.00$ $\eta = 0.50$		$A = 0.98$ $\eta = 1.00$		$A = 0.98$ $\eta = 0.50$		$A = 1.01$ $\eta = 1.00$		$A = 1.01$ $\eta = 0.50$	
	$std(\hat{y})$	$std(\pi)$	$std(\hat{y})$	$std(\pi)$	$std(\hat{y})$	$std(\pi)$	$std(\hat{y})$	$std(\pi)$	$std(\hat{y})$	$std(\pi)$	$std(\hat{y})$	$std(\pi)$
NGDP-GT	0.0252	0.0602	0.0250	0.0588	0.0025	0.0608	0.0247	0.0575	0.0253	0.0600	0.0252	0.0594
IT	0.0358	0.0000	0.0360	0.0000	0.0358	0.0000	0.0363	0.0000	0.0358	0.0000	0.0358	0.0000
NGDP-LT	0.0256	0.0627	0.0255	0.0614	0.0259	0.0656	0.0256	0.0631	0.0255	0.0609	0.0254	0.0604

Tables 8 and 9 show the standard deviations of output (gap) and inflation for combinations of trend productivity and inflation indexation subject to only productivity shocks or government spending shocks. According to Tables 8 and 9, targeting nominal GDP growth rate yields a more stable path of inflation and output than alternative frameworks.

be higher. Inflation targeting's low ranking under the second welfare measure implies that this policy regime has caused more volatility in inflation and output than the NGDP-LT, shown in Tables 8 and 9. Second, with the consumption equivalence criteria, which emphasizes only the value of consumption with the first moment, consumption under the inflation targeting is greater than under the NGDP-LT, especially in a high growth environment. It implies that on average inflation targeting is superior than the NGDP-LT, but to minimize short-run fluctuations, the latter shows its advantage over the former. Three, NGDP-LT is preferable in a low growth environment with low partial indexation to inflation under the consumption equivalence criteria, but not with the second measure.

6.3. Some robustness with weighted sum of variances of inflation and output gap

Tables 10 and 11 present results of policy performance under alternative combinations of trend growth and inflation indexation. The results show conclusive policy rankings. Nominal GDP growth targeting is the best policy to follow and level targeting takes the second place, echoing the results of the benchmark model under the second welfare measure.

7. Some robustness with a separable utility function

This section is to examine if the results hold with other specifications. This robustness analysis adopts a separable utility function:

$$U(c_t, l_t) = \ln c_t - \chi \frac{l_t^{1+\gamma}}{1+\gamma} \tag{31}$$

Table 10
Welfare losses-weighted sum of variances of inflation and output gap (×10[5]) with alternative combinations of trend growth and inflation indexation, only productivity Shocks (HP filter, lambda = 1600) (HP filter, lambda = 1600).

Policy regimes	$A = 1.00$ $\eta = 0.60$	Ranking	$A = 1.00$ $\eta = 0.40$	Ranking	$A = 1.008$ $\eta = 1.00$	Ranking	$A = 0.99$ $\eta = 0.50$	Ranking	$A = 0.98$ $\eta = 0.60$	Ranking	$A = 0.98$ $\eta = 0.40$	Ranking
NGDP-GT	6.6108	1	6.5931	1	6.6628	1	6.5507	1	6.5176	1	6.4815	1
IT	6.9501	3	6.9444	3	6.9797	3	6.9149	3	6.8883	3	6.8770	3
NGDP-LT	6.6731	2	6.6560	2	6.6934	2	6.6541	2	6.6648	2	6.6257	2

Table 11
Welfare losses-weighted sum of variances of inflation and output gap (×10[5]) with alternative combinations of trend growth and inflation indexation, only government spending shocks (HP filter, lambda = 1600) (HP filter, lambda = 1600).

Policy regimes	$A = 1.00$ $\eta = 0.60$	Ranking	$A = 1.00$ $\eta = 0.40$	Ranking	$A = 1.008$ $\eta = 1.00$	Ranking	$A = 0.99$ $\eta = 0.50$	Ranking	$A = 0.98$ $\eta = 0.60$	Ranking	$A = 0.98$ $\eta = 0.40$	Ranking
NGDP-GT	0.1261	1	0.1262	1	0.1263	1	0.1259	1	0.1252	1	0.1255	1
IT	0.1425	3	0.1431	3	0.1419	3	0.1434	3	0.1432	3	0.1445	3
NGDP-LT	0.1274	2	0.1276	2	0.1269	2	0.1281	2	0.1282	2	0.1285	2

Tables 10 and 11 present the robustness results with the second welfare measure, namely, the welfare loss and policy rankings with alternative parameter values subject to only a productivity shock or a government spending shock. Nominal GDP growth targeting is the best policy to follow and level targeting takes the second place, echoing the results of the benchmark model under the second welfare measure.

Table 12
Consumption equivalent welfare losses (×10[4]) with a separable utility function, only productivity shocks (HP filter, lambda = 1600).

Policy rule	$A = 1.00$ $\eta = 1.00$	Ranking	$A = 1.00$ $\eta = 0.50$	Ranking	$A = 0.98$ $\eta = 1.00$	Ranking	$A = 0.98$ $\eta = 0.50$	Ranking	$A = 1.01$ $\eta = 1.00$	Ranking	$A = 1.01$ $\eta = 0.50$	Ranking
NGDP-GT	1.5479	1	1.5480	1	1.5479	1	9.7120	1	1.5479	1	1.1311	1
IT	1.6074	2	1.6075	2	1.6074	2	9.7717	2	1.6074	2	1.1906	2
NGDP-LT	15.2019	3	5.4795	3	62.1107	3	18.5467	3	4.3472	3	2.6198	3

Table 12 presents the robustness results, namely, consumption variations and policy rankings with a separable utility function subject to a negative productivity shock. The findings suggest consistent results with the benchmark models. When $A > 1$ and/or $A = 1$, NGDP-GT is the best policy, and inflation targeting is found to be the second-most superior framework. However, the only result that differs from the benchmark model is that NGDP-LT has never emerged as the best regime.

Table 13
Consumption equivalent welfare losses (×10[4]) with a separable utility function, only government spending shocks (HP filter, lambda = 1600).

Policy rule	$A = 1.00$ $\eta = 1.00$	Ranking	$A = 1.00$ $\eta = 0.50$	Ranking	$A = 0.98$ $\eta = 1.00$	Ranking	$A = 0.98$ $\eta = 0.50$	Ranking	$A = 1.01$ $\eta = 1.00$	Ranking	$A = 1.01$ $\eta = 0.50$	Ranking
NGDP-GT	0.0059	1	0.3572	1	0.0059	1	8.1020	1	0.0059	1	0.0004	1
IT	0.0059	1	0.3572	1	0.0059	1	8.1020	1	0.0059	1	0.0004	1
NGDP-LT	13.5901	2	4.3472	2	60.5440	2	16.9338	2	2.7389	2	1.0120	2

Table 13 indicates the robustness results, namely, consumption variations and policy rankings with a separable utility function when a negative government spending shock hits the economy. The results echo the benchmark model findings. First, NGDP-GT and inflation targeting perform equally well. Two, inflation targeting is preferred to the NGDP-LT framework. However, the only result that differs from the benchmark model is that NGDP-LT has never emerged as the desirable regime.

where χ is the scaling parameter and γ is the inverse of the intertemporal elasticity of substitution for labor supply. χ is set at a value so that steady state output level is 0.21. γ is set according to the labor demand and labor supply equations in the steady state, which is a function of ϵ, $\bar{l}$ and χ.

The simulation results are shown in Tables 12 and 13. Tables 14 and 15 are the policy rankings for alternative combinations of parameter values. The major findings of the benchmark model carry to the scenario with a separable utility function. When the economy is subject to a productivity shock, again, NGDP-GT dominates alternative polices, producing the least consumption variation. Inflation targeting rule is the second-best policy, and NGDP-LT is shown to be the least desirable framework. When the economy is buffeted by a government spending shock, NGDP-GT and inflation targeting are equally preferable as in the benchmark model. However, the only result that differs from the benchmark model is that NGDP-LT has never emerged as the best regime.

8. Conclusion

In this paper, I examine the welfare implications of a nominal GDP growth targeting rule, a level targeting rule, and a strict inflation targeting regime in a New Keynesian model with trend productivity growth and incomplete inflation indexation. The paper finds that rankings of policy rules depend on the measure of welfare, the trend growth rate, the level of inflation indexation, the type of shock and the specification of the utility function. In general, nominal GDP growth targeting is the best policy.

With the non-separable utility function, when both the trend growth and inflation indexation are less than one, nominal GDP level targeting generates the least consumption variation, while growth targeting takes the second place, and inflation targeting is

Table 14
Consumption equivalent welfare losses ($\times 10^4$) with alternative combinations of trend growth and inflation indexation, only productivity shocks (HP filter, lambda = 1600).

Policy rule	$A = 1.00$ $\eta = 0.60$	Ranking	$A = 1.00$ $\eta = 0.40$	Ranking	$A = 1.008$ $\eta = 1.00$	Ranking	$A = 0.98$ $\eta = 0.60$	Ranking	$A = 0.98$ $\eta = 0.50$	Ranking	$A = 0.99$ $\eta = 0.40$	Ranking
NGDP-GT	1.4883	1	2.6198	1	1.5479	1	6.0752	1	9.7120	1	6.9693	1
IT	1.5479	2	2.6793	2	1.6075	2	6.1348	2	9.7717	2	7.0885	2
NGDP-LT	7.3865	3	4.6451	3	5.4795	3	25.1229	3	18.5467	3	8.2212	3

Table 14 presents the policy rankings for alternative combinations of trend growth and partial inflation indexation under a separable utility function subject to a negative productivity shock.

Table 15
Consumption equivalent welfare losses ($\times 10^4$) with alternative combinations of trend growth and inflation indexation, only government spending shocks (HP filter, lambda = 1600).

Policy rule	$A = 1.00$ $\eta = 0.60$	Ranking	$A = 1.00$ $\eta = 0.40$	Ranking	$A = 1.008$ $\eta = 1.00$	Ranking	$A = 0.98$ $\eta = 0.60$	Ranking	$A = 0.98$ $\eta = 0.50$	Ranking	$A = 0.99$ $\eta = 0.40$	Ranking
NGDP-GT	0.0119	1	1.0120	1	0.0059	1	4.4664	1	8.1020	1	5.4197	1
IT	0.0119	1	1.0120	1	0.0059	1	4.4664	1	8.1020	1	5.4197	1
NGDP-LT	5.7773	2	3.0367	2	2.7389	2	23.5079	2	16.9338	2	6.6116	2

Table 15 shows the policy rankings for alternative combinations of trend growth and partial inflation indexation under a separable utility function when a negative government spending shock hits the economy.

the least desirable regime. For all other scenarios (including the most likely scenario for the U.S. economy when $A > 1$), nominal GDP growth targeting dominates alternative frameworks, and inflation targeting outperforms nominal GDP level targeting.

When using the weighted sum of variances of inflation and output gap as the welfare measure, the paper finds consistent policy rankings, that is, nominal GDP growth targeting is preferred to the other two regimes, with the level targeting framework shown to be the second superior policy. Therefore, the paper demonstrates that inflation targeting is superior to the nominal GDP level targeting regime, but to minimize short-run fluctuations, the latter is advantageous.

With the separable utility function, the policy ranking is consistent with the non-separable utility function scenario. The only difference is that nominal GDP level targeting never emerges as the best regime.

Nominal GDP growth targeting produces high welfare and low fluctuations in output and inflation across the dimensions of trend productivity growth, incomplete inflation indexation, two welfare measures, both demand and supply shocks, and different specifications of utility function, suggesting that this regime has broadly desirable stability properties.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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