Output Gaps and Robust Monetary Policy Rules

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Should monetary policy focus on output gaps?

- Policy makers often use the **output gap** to guide monetary policy, even though **nominal gross domestic product** (GDP) and **prices** are measured in real time more accurately than the output gap.
- Employing a small New Keynesian model with a **zero lower bound (ZLB) on nominal interest rates**, this article compares the performance of **monetary-policy rules** that are **robust to errors in measuring** the output gap, nominal GDP level, or price level.
- The analysis shows that a robust policy rule that focuses on **stabilizing the price level improves economic performance**, especially when the analysis accounts for **persistent measurement errors** as faced in practice.

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Contacts with ZLB and data uncertainty literature

- **Absent data uncertainty**: Svensson (1999), Eggertsson and Woodford (2003), Svensson (2003), Wolman (2005), Adam and Billi (2006, 2007), Vestin (2006), Nakov (2008), Evans (2012), and Giannoni (2014).
- **Absent the ZLB constraint**: Orphanides et al. (2000), Orphanides (2001, 2003), Rudebusch (2002), Smets (2002), Aoki (2003, 2006), Svensson and Woodford (2003, 2004), Boehm and House (2014), Garín, Lester and Sims (2016).
- **ZLB and purely-temporary measurement errors only**: Gust, Johannsen and Lopez-Salido (2015).
- **Proponents of nominal-GDP-level targets**: Hatzius and Stehn (2011, 2013), Sumner (2011, 2014), Woodford (2012, 2013), Frankel (2013), among others.

Outline

- The model and monetary policy rules
- Noisy equilibrium
- Policy evaluation:
  1. noise absent
  2. white noise
  3. persistent noise
- Conclude

Small New Keynesian model as in Woodford (2010)

- An **Euler equation** describes the household's expenditure decisions

$$y_t = E_t y_{t+1} - \varphi \left(i_t - r - E_t \pi_{t+1} - v_t \right) \tag{1}$$

- A **Phillips curve** describes the optimal price-setting behavior of firms

$$\pi_t = \beta E_t \pi_{t+1} + \kappa \left(y_t - y_t^n \right) + u_t \tag{2}$$

- Where $y_t - y_t^n = x_t$ is the output gap.
- The **structural shocks** (y_t^n, u_t, v_t) follow AR(1) stochastic processes

$$\begin{aligned} y_t^n &= \rho_y y_{t-1}^n + \sigma_{\varepsilon y} \varepsilon_{yt} \\ u_t &= \rho_u u_{t-1} + \sigma_{\varepsilon u} \varepsilon_{ut} \\ v_t &= \rho_v v_{t-1} + \sigma_{\varepsilon v} \varepsilon_{vt} \end{aligned}$$

Policy evaluation based on social welfare function

- Usual approx. of the lifetime utility function of the household

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\pi_t^2 + \lambda x_t^2\right] \tag{3}$$

- The Ramsey plan, the **optimal commitment** policy determined at time zero, used as a benchmark for the policy evaluation.

The simple policy rules I

- **Inertial Taylor rule** along the lines of Taylor and Williams (2010)

$$\begin{aligned} i_t^u &= \phi_i i_{t-1}^u + (1-\phi_i)\left[\left(r + \phi_\pi \pi_t^o + \phi_x x_t^o\right)\right] \\ i_t &= \max\left(0, i_t^u\right) \end{aligned} \quad (4)$$

- Where $\pi_t^o = \pi_t + e_t^\pi$ and $x_t^o = x_t + e_t^x$ are observed.
- e_t^π and e_t^x are **noise shocks** that follow AR(1) stochastic processes.

The simple policy rules II

- **Strict-price-level (SPL) rule**

$$i_t = \max\left(0, r + \phi_p p_t^o\right) \tag{5}$$

- **Nominal-GDP-level (NGDPL) rule**

$$i_t = \max\left(0, r + \phi_n n_t^o\right) \tag{6}$$

- Where $p_t^o = p_t + e_t^p$ and $n_t^o = n_t + e_t^n$ are observed.
- $p_t = p_{t-1} + \pi_t$ and $n_t = p_t + y_t$.
- e_t^p and e_t^n are AR(1) **noise shocks**.

The noisy rational-expectations equilibrium (NREE)

- An equilibrium is given by:
  - a response function $\mathbf{y}(\mathbf{s_t}) = \{y(\mathbf{s}_t), p(\mathbf{s}_t), \pi(\mathbf{s}_t), i(\mathbf{s}_t)\}$
  - and expectations function $\mathbf{E}_t\mathbf{y}(\mathbf{s}_{t+1}) = \int \mathbf{y}(\mathbf{s}_{t+1}) f(\varepsilon_{t+1}) d(\varepsilon_{t+1})$
  - where ε_{t+1} are future innovations of structural and noise shocks

Policy rule	Equilibrium conditions	State vector
Inertial Taylor rule	(1), (2) and (4)	$s_t = (y_t^n, u_t, v_t, e_t^\pi, e_t^x, i_{t-1}^u)$
Strict-price-level rule	(1), (2) and (5)	$s_t = (y_t^n, u_t, v_t, e_t^p, p_{t-1})$
Nominal-GDP-level rule	(1), (2) and (6)	$s_t = (y_t^n, u_t, v_t, e_t^n, p_{t-1})$

Policy evaluation in three distinct economic environments

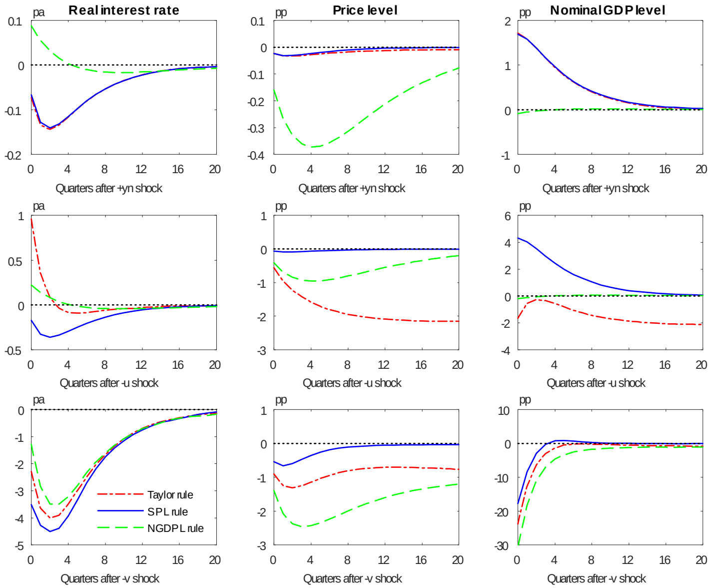
1. Noise absent
2. White noise
3. Persistent noise

Baseline calibration as in Billi (MD, forthcoming), Tab. 1

Definition	Parameter	Numerical value
Discount factor	β	0.99
Interest elasticity of aggregate demand	φ	6.25
Share of firms keeping prices fixed	α	0.66
Price elasticity of demand	θ	7.66
Elasticity of a firms' marginal cost	ω	0.47
Slope of aggregate supply curve	κ	0.024
Weight on output gap	λ	0.003
Taylor rule coefficients	$\phi_{\pi,x,i}$	1.5; 0.25; 0.85
Std. deviation of technology shock	σ_y	0.80%
Std. deviation of mark-up shock	σ_u	0.05%
Std. deviation of demand shock	σ_v	0.80%
AR(1) parameter of shocks	$\rho_{y,u,v}$	0.80

Notes: Because in the model a period is one quarter, shown are parameter values corresponding to inflation and interest rates measured at a quarterly rate. The values of the inertial Taylor rule coefficients are taken from English, Lopez-Salido and Tetlow (IMF Economic Review, 2015).

Fig. 1: Evolution of the economy if no measurement errors



Tab. 1: Economic performance if no measurement errors

	Rule coeff.	ZLB episodes		Welfare loss[b]
	$\phi_{i,p,n}$	Freq.[c]	Duration[d]	Tot.
Inertial Taylor rule				
Techn. shock only	0.87	0.0	0.0	0.0
Mark-up shock only	0.87	0.0	0.0	10.5
Demand shock only	0.87	1.9	3.1	40.7
Strict-price-level rule				
Techn. shock only	1	0.0	0.0	0.0
Mark-up shock only	1	0.0	0.0	4.0
Demand shock only	100	12.5	2.6	5.1
Nominal-GDP-level rule				
Techn. shock only	1	0.0	0.0	1.4
Mark-up shock only	1	0.0	0.0	5.5
Demand shock only	100	15.0	2.4	15.8

a. Baseline calibration but with optimal rule coefficients.

b. Permanent consumption loss (basis points).

c. Expected percent of time at the ZLB.

d. Expected number of consecutive quarters at the ZLB.

Calibration of the measurement errors

- **Noise shocks** in the model are fit to **historical revisions** of U.S. data for the period 1991Q1-2015Q4:
  - **Output gap** (x) from Congressional Budget Office
  - **Prices** (π, p) measured by core personal consumption expenditures
  - **Nominal GDP** (n) from Bureau of Economic Analysis

	Historical revisions			
	x	π	p	n
Std. deviation	1.7	0.3	0.3	1.1
Autocorrelation	0.85	0.7	0.8	0.8

Fig. 2: Evolution after white-noise shock

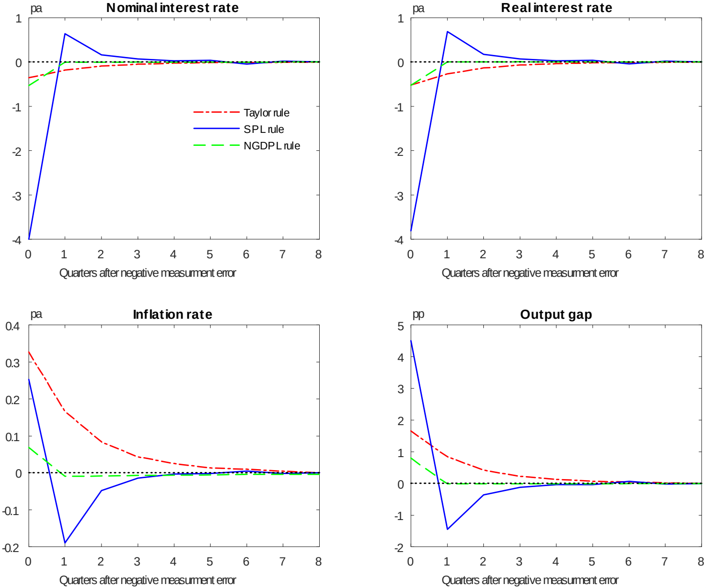
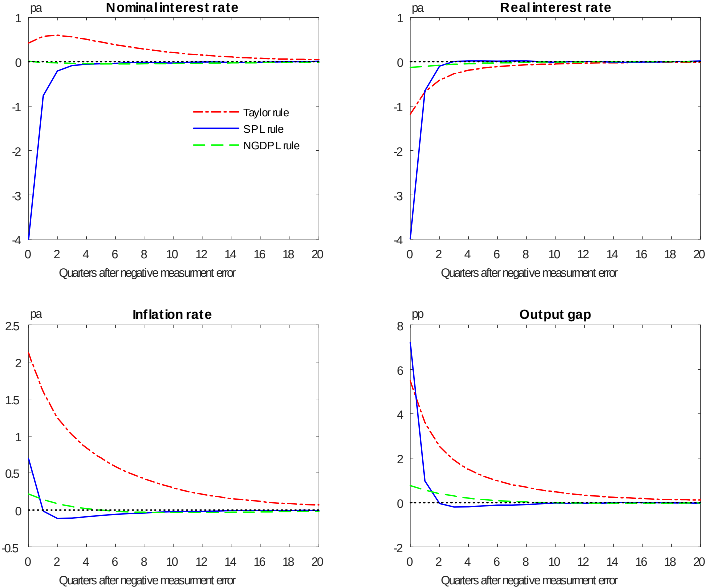


Fig. 3: Evolution after persistent-noise shock



Tab. 6: Effects of noise on economic performance

	Rule coeff.	ZLB episodes		Welfare loss[b]
	$\phi_{i,p,n}$	Freq.[c]	Duration[d]	Tot.
Without measurement errors				
Inertial Taylor rule	0.87	1.5	2.9	52.8
Strict-price-level rule	100	10.7	2.6	10.2
Nominal-GDP-level rule	100	11.0	2.1	22.6
Purely-temporary measurement errors				
Inertial Taylor rule	0.88	0.7	2.1	54.1
Strict-price-level rule	10	8.6	2.2	18.1
Nominal-GDP-level rule	20	10.6	2.0	23.0
Persistent measurement errors				
Inertial Taylor rule	0.88	0.9	2.3	66.9
Strict-price-level rule	20	6.4	2.6	14.0
Nominal-GDP-level rule	20	11.0	2.1	22.7

a. Baseline calibration but with optimal rule coefficients.

b. Permanent consumption loss (basis points).

c. Expected percent of time at the ZLB.

d. Expected number of consecutive quarters at the ZLB.

Monetary policy should focus on the price level

- Some argue that monetary-policy rules should ignore the **output gap** and seek to stabilize the **level of nominal GDP** because:
  - monetary policy would be more robust to measurement errors;
  - and would ensure greater stimulus during ZLB episodes.
- However, because prices are measured in real time more accurately than nominal GDP, **why not stabilize the price level?**
- Still, as the analysis is conducted in a **stylized model**, further study is needed to extend the results to a broader class of models.