R-Star: Natural Rate of Interest

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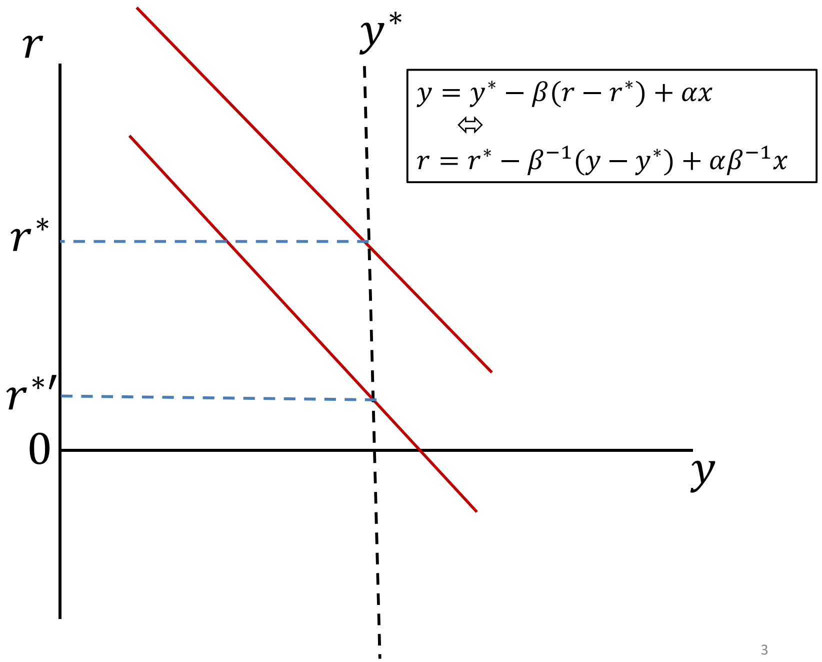
Presentation draws on:

Taylor and Wieland (2016), Finding the equilibrium rate in a fog of policy deviations, *Business Economics*.

Beyer and Wieland (2017), Instability, imprecision and inconsistent use of equilibrium real interest rate estimates, *CEPR DP 11927*.

Wieland and Wolters (2017), Structural estimates of long-run equilibrium real interest rates show little decline.



$$y = y^* - \beta(r - r^*) + \alpha x$$
$$\Leftrightarrow$$
$$r = r^* - \beta^{-1}(y - y^*) + \alpha\beta^{-1}x$$

R-star / natural rate: 3 concepts

(1) Flexible-price real rate in New Keynesian DSGE models.
- Short-run concept.
- Proposed as policy prescription: Fed set fed funds rate s.t. actual real rate = flex-price real rate. (Barsky et al 2014 & others)
- But highly model- and shock-dependent.

Concepts (2) and (3)

(2) Equilibrium rate in AD-Phillips curve model: Laubach & Williams (2003), (2015), Holton, Laubach & Williams (2017).

- ➢ Medium-run concept.
- ➢ Proposed as R-Star in Taylor rule.

(3) Steady-state real rate in DSGE models.

- ➢ Long-run concept.
- ➢ What is used in model-based evaluations of policy rules as R-Star.

Focus on (2) and (3) in the following.

R-star in the Taylor rule

$$r = p + .5y + .5(p - 2) + 2 \qquad (1)$$

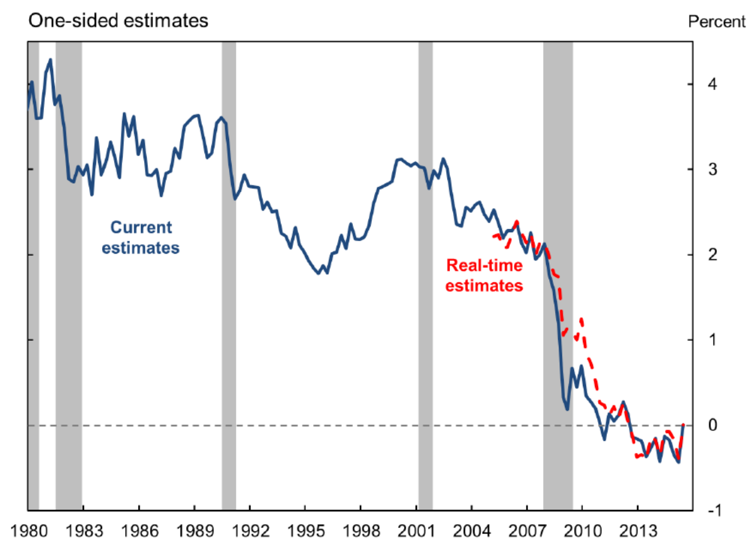
where

r is the federal funds rate,
p is the rate of inflation over the previous four quarters
y is the percent deviation of real GDP from a target.

The 2-percent "equilibrium" real rate is close to the assumed steady-state growth rate of 2.2 percent.

Also, the average real federal funds rate was about 2%.
Now the average 1965.1-2015.12 real funds rate is 2% (5.5-3.5)

Figure 5: Laubach-Williams model estimates of the natural rate of interest



Source: Laubach and Williams (2015)

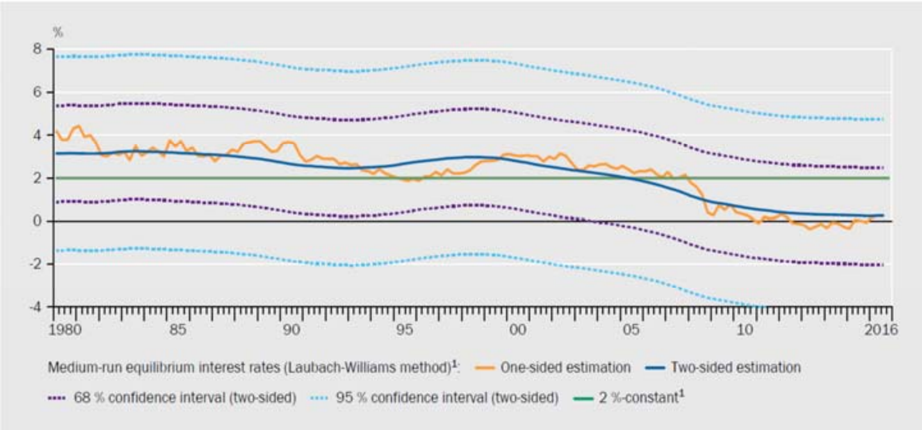
Huge policy impact

L. Summers: 2014, BE, *„The LW methodology demonstrates a very substantial and continuing decline in the (equilibrium) real rate of interest."*

P. Krugman: 2015, NYT, *„the low natural rate is as solid a result as anything in real time can be"* referring to LW.

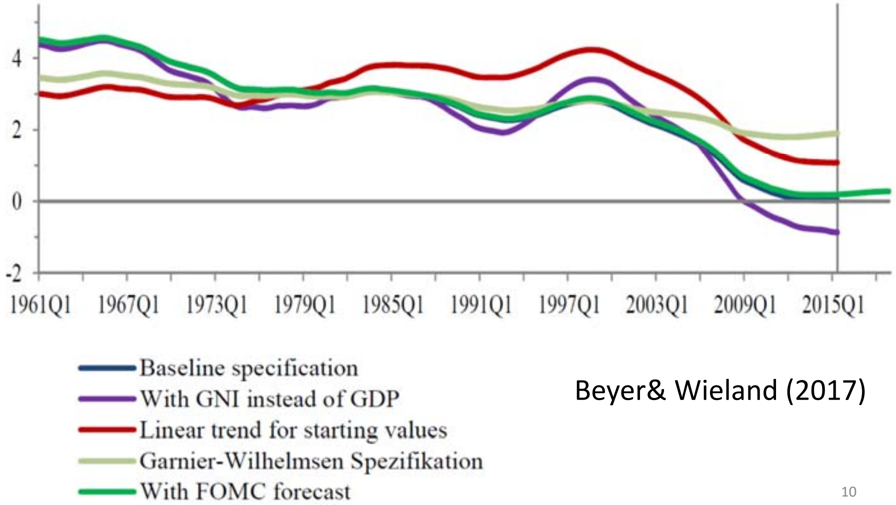
J. Yellen, 2015, *„Under assumptions that I consider more realistic under present circumstances, the Taylor rule calls for the federal funds rate to be close to zero."*

But, huge degree of imprecision.



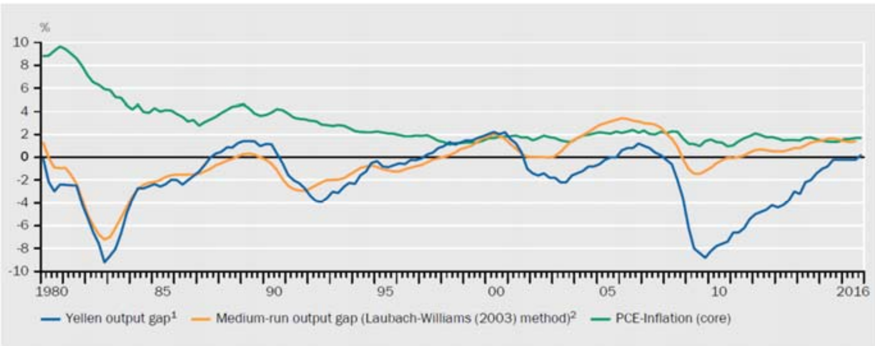
Source: Beyer and Wieland (2017)

Very sensitive to technical assumptions.



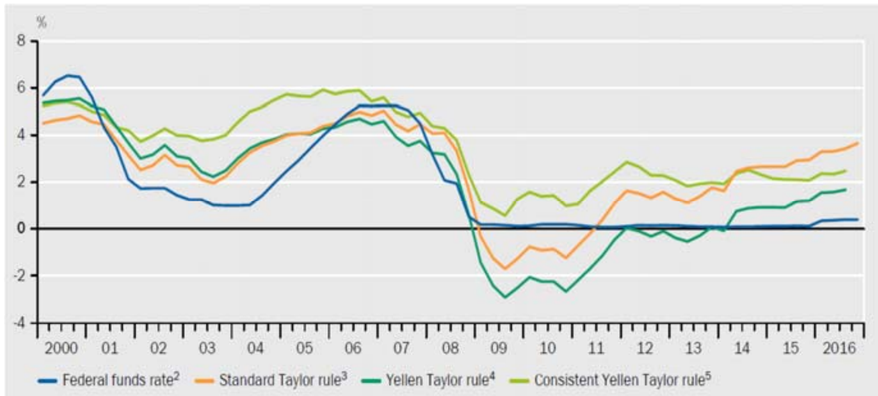
Beyer& Wieland (2017)

Used with inconsistent output gap



1 – Based on the unemployment rate using Okun's law: $Y_t = -2(U_t - U^*)$, where U is the unemployment rate and U^* the natural rate of unemployment. 2 – Based on the two-sided estimation method.

Consistent use ➔ Higher rate prescription



Why r^* estimates decline

(1) $y - y^* = -\beta(r - r^*)$

If $(y - y^*) \neq$ *Predicted* $(y - y^*)$, then adjust r^*

(Example: $(y - y^*) < P(y - y^*)$, lower r^*)

(2) $\pi = \pi_{-1} + \theta(y - y^*)$

If $\pi \neq P\pi$, then adjust y^*

(Example: $\pi \neq P\pi$, so lower y^*)

Omitted variables and trend in policy

(1) $y - y^* = -\beta(r - r^*) - \alpha x^*$

If $(y - y^*) \neq P(y - y^*)$, due to x^*?

Example: $(y - y^*) < P(y - y^*)$, x^* too low? regulation, taxes.

(3) $i = \pi + .5(\pi - 2) + .5y^* + r^* + d^*$

If $i \neq Pi$, then adjust d^*.

Need more structure & focus on longer-run

- Wieland-Wolters (2017) estimate long-run equilibrium rates in New Keynesian DSGE models.
  1. Christiano, Eichenbaum, Evans (2005) as estimated by Smets&Wouters (2007), CEE-SW model: Includes demand components, supply-side dynamics & monetary policy.
  2. Del-Negro, Schorfheide (2015), DNGS model: Includes financial accelerator and risk premia data.

CEE-SW: Consumption and R-Star

(1) $\Xi_t = \beta \varepsilon_t^b R_t E_t \left[\frac{\Xi_{t+1}}{\Pi_{t+1}}\right]$

Ξ_t: M.U. of consumption, β : discount factor, ε_t^b risk premium schock, R_t: nominal gross interest rate, Π_{t+1}: inflation.

(2) $\Xi_t = (C_t - \lambda C_{t-1})^{-\sigma_c} exp\left(\frac{\sigma_c - 1}{1+\sigma_l} L_t(j)^{1+\sigma_l}\right)$

C_t: Consumption, λ: habit formation, σ_c inv. Int. elast. of substitution, σ_l Frisch elasticity of labor supply.

Consumption and R-Star

Output grows with γ^t and M.U. of consumption with $\gamma^{-\sigma_c t}$
Detrend Euler equation with $\xi_t = \Xi_t \gamma^{\sigma_c t}$ gives

(3) $$\xi_t = \bar{\beta}\varepsilon_t^b R_t E_t \left[\frac{\xi_{t+1}}{\Pi_{t+1}}\right], \text{ where } \bar{\beta} = \frac{\beta}{\gamma^{\sigma_c}}.$$

In steady state $R^* = \frac{\Pi^*}{\bar{\beta}}$ and

(4) $$r^* = \frac{1}{\bar{\beta}} = \frac{\gamma^{\sigma_c}}{\beta}$$

Long-run r-star in SW model: Original sample 66-04

	Prior distribution			Posterior distribution			
Parameter	Distr.	Mean	Std.	Mode	Mean	5 %	95 %
σ_c	Normal	1.5	0.37	1.39	1.38	1.16	1.59
$\bar{\gamma}$	Normal	0.4	0.10	0.43	0.43	0.40	0.45
$100(\beta^{-1}-1)$	Gamma	0.25	0.1	0.16	0.16	0.07	0.27
implied parameters							
β		0.9975		0.9984	0.9984	0.9993	0.9974
$r^* = \frac{\gamma^{\sigma_c}}{\beta}$		1.0085		1.0075	1.0075	1.0053	1.0099
γ_{ann}		1.60		1.72	1.72	1.60	1.80
r^*_{ann}		3.4436		3.0339	3.0339	2.1369	4.0192

Table 1: Prior and Posterior Distribution of Parameters Relevant for r^*. Notes: γ_{ann} denotes the annualized trend growth rate ($\gamma_{ann} = (\gamma^{*4}-1)*100$). r^*_{ann} denotes the annualized steady state interest rate ($r^*_{ann} = (r^{*4}-1)*100$)

SW r-star: Different sample periods vs means

	Posterior Mean			2.5%	97.5%
Sample, Model	γ_{ann}	β	r^*_{ann}	r^*_{ann}	r^*_{ann}
1966Q1-2016Q4, SW	1.49	0.9984	2.20	1.34	3.30
1966Q1-1979Q2, SW	1.29	0.9981	2.43	1.07	4.25
1984Q1-2016Q4, SW	1.12	0.9984	2.18	1.07	3.60
1966Q1-2004Q4, DNGS	1.61	0.9981	2.17	1.25	3.21

Sample	real interest rate	GDP growth per capita	GDP growth
1966Q1-2004Q4	2.65	1.68	3.12
1966Q1-2016Q4	1.91	1.40	2.76
1966Q1-1979Q2	0.90	1.44	3.36
1984Q1-2016Q4	1.76	1.52	2.64

Table 3: Sample Means of the Real Interest rate and Output Growth.

SW and DNGS r-star estimates

	Posterior Mean			2.5%	97.5%
Sample, Model	γ_{ann}	β	r^*_{ann}	r^*_{ann}	r^*_{ann}
1966Q1-2016Q4, SW	1.49	0.9984	2.20	1.34	3.30
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1966Q1-2004Q4, DNGS	1.61	0.9981	2.17	1.25	3.21
1966Q1-2016Q4, DNGS	1.33	0.9989	1.75	1.06	2.51
1966Q1-1979Q2, DNGS	1.37	0.9985	2.09	0.91	3.63
1984Q1-2016Q4, DNGS	0.72	0.9988	1.43	0.64	2.40

Un-modeled trends

- DSGE models distinguish structural factors not considered by LW AD-Phillips curve model: demand compoments, technology shocks, investment shocks, risk premia, monetary policy rule and deviations.
- Yet, model constants/steady assumptions may ignore certain un-modeled trends, which LW aim to capture with time-series methods.
- Simple approach to un-modeled trends and breaks: Rolling window estimation, 20-year-length.

SW: 20-year real-time rolling window r-star estimates

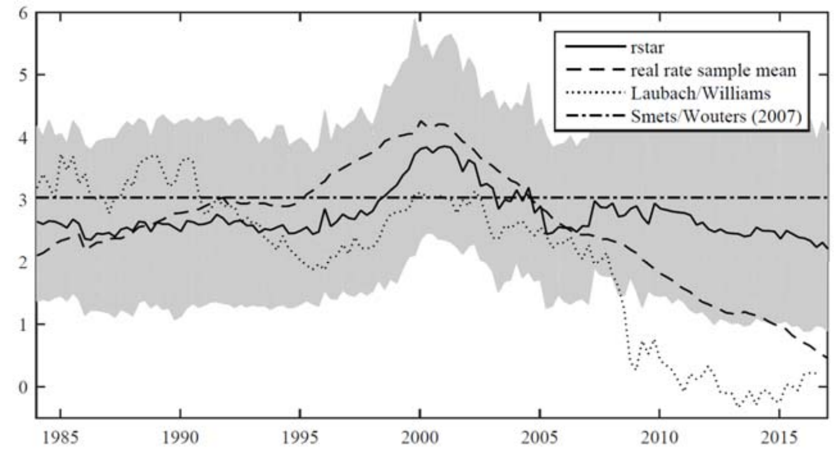

Figure 1: Realtime estimates of rstar with the Smets and Wouters model. Shaded areas show 95% probability bands. The dashed line shows the sample mean of the real interest rate.

SW: Structural parameters influence r-star

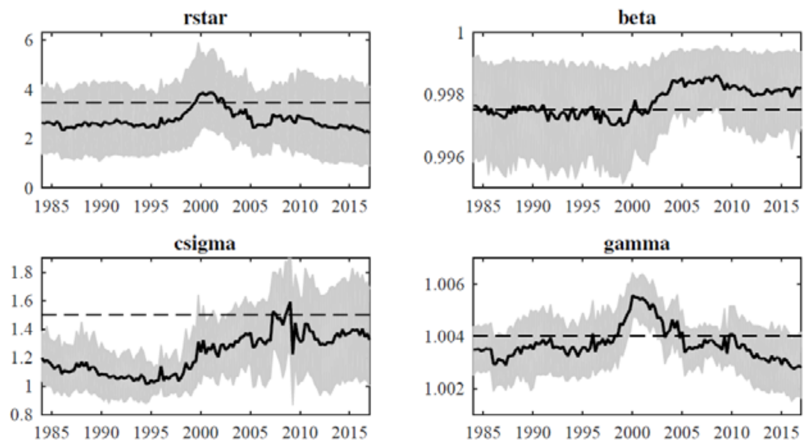

Figure 2: Structural parameters relevant for rstar. Shaded areas show 95% probability bands. The dashed line shows the implicit prior means (the parameters are not estimated directly, but functions of them). The dashed line for rstar shows the combination of prior means of $\gamma^{-\sigma_c}/\beta$.

SW: Which factors are driving mean below r-star (most recent window)?

Shock	Contribution to $Mean(r_t) - r^*$ 0.45% − 2.20%	Share of Overall Difference
technology	−0.09%	5%
risk premium	−0.48%	27%
government spending	−0.04%	2%
investment spec. techn.	−0.24%	14%
monetary policy	−0.83%	47%
price markup	0.15%	−9%
wage markup	−0.01%	1%
initial values	−0.22%	13%

Table 5: Contribution of Shocks to Difference Between r^* and the Real Interest Rate.

SW: Role of priors

	Posterior Mean				2.5%	97.5%
Specification	σ_c	γ_{ann}	β	r^*_{ann}	r^*_{ann}	r^*_{ann}
Baseline	1.32	1.12	0.9982	2.20	0.89	4.06
Wide prior σ_c	1.30	1.12	0.9982	2.17	0.91	4.03
Wide prior $\bar{\gamma}$	1.30	0.88	0.9983	1.83	0.67	3.47
Wide prior $100(\beta^{-1}-1)$	1.37	1.12	0.9999	1.60	0.78	2.76
Wide prior σ_c, $\bar{\gamma}$, $100(\beta^{-1}-1)$	1.30	0.76	0.9999	1.03	0.46	2.02

Table 6: Robustness checks with wider priors for parameters determining r^* for data vintage 2017Q.

SW: Shadow interest rates for z.l.b.

	Posterior Mean				2.5%	97.5%
Specification	σ_c	γ_{ann}	β	r^*	r^*	r^*
Baseline	1.32	1.12	0.9982	2.20	0.89	4.06
Shadow interest rate (Wu,Xia)	1.33	1.08	0.9982	2.20	0.82	4.03
Shadow int. + wide prior σ_c, $\bar{\gamma}$, β	1.37	0.96	0.9999	1.38	0.53	2.84
Shadow interest rate (Krippner)	1.30	1.21	0.9981	2.32	0.98	4.13
Shadow int. + wide prior σ_c, $\bar{\gamma}$, β	1.27	1.04	0.9999	1.35	0.52	2.65

Table 7: Robustness checks with shadow interest rate for data vintage 2017Q.

Model uncertainty: 4 different variants

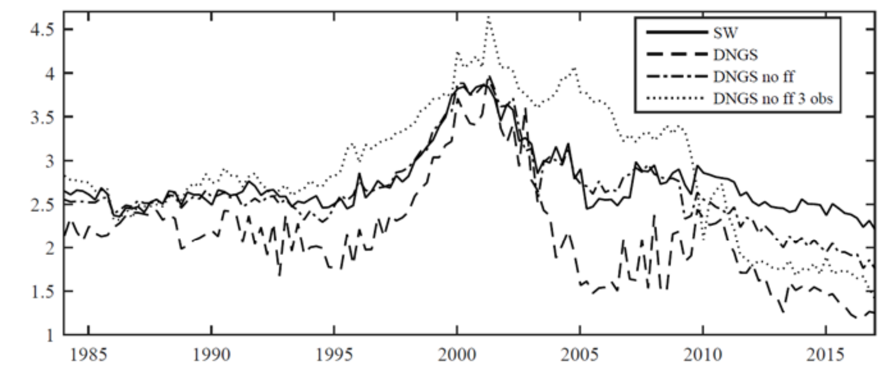

Figure 3: Posterior Mean Estimates of r^* from four different models. Notes: SW: Smets and Wouters, DNGS: Del Negro, Gianonni and Schorfheide, DNGS no ff: DNGS without financial frictions, DNGS no ff 3 obs: DNGS without financial frictions and three observables.

Conclusions

- Popular medium-run LW estimates of real-rate highly uncertain, very sensitive to technical assumptions, possible omitted variable bias, sometimes inconsistent use in assessing monetary policy (ignoring associated output gap).
- Structural model estimates of equilibrium rates between 1,5 and 2,5%. Significantly positive and above the decline in mean real rate. Moderate changes due to un-modeled trends. Difference from mean due to monetary policy and risk premia.

Conclusions

- Economic policy and R-star.   Treat with great caution.
- Avoid model- and shock-dependent (average) natural rate targeting.
- Take into account uncertainty in designing policies.
- Preferably use simple rules that need no equilibrium rate or use long-run equilibrium rate as reference points for monetry policies.