

## ANNUAL RATES

$$\begin{aligned}104/100 &\approx 1.04 \\(104/100)^4 &= 1.17 \\(104/100)^{12} &= 1.60\end{aligned}$$

GDP  $\approx$  20 trillion annual rate  
 $\approx$  5 " per quarter  
seasonally adjusted

## AR4

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \alpha_3 y_{t-3} + \alpha_4 y_{t-4} + u_t$$

$t=1, \dots, T$   
1952.1 - 2020.4

$$\hat{y}_t = \hat{\alpha}_0 + \hat{\alpha}_1 y_{t-1} + \hat{\alpha}_2 y_{t-2} + \hat{\alpha}_3 y_{t-3} + \hat{\alpha}_4 y_{t-4}$$

static  
dynamic

SMP 5-T

$$RMSE = \sqrt{\frac{1}{T-4} \sum_{t=5}^T (y_t - \hat{y}_t)^2}$$

$$MAE = \frac{1}{T-4} \sum_{t=5}^T |y_t - \hat{y}_t|$$

outside sample

$$\hat{\hat{y}}_t = \hat{\alpha}_0 + \hat{\alpha}_1 \hat{y}_{t-1} + \hat{\alpha}_2 y_{t-2} + \hat{\alpha}_3 y_{t-3} + \hat{\alpha}_4 y_{t-4}$$

only  $t-2$  in formation

$$\sqrt{\frac{1}{T-2} \sum_{t=6}^T (y_t - \hat{\hat{y}}_t)^2}$$

# VAR

$$y_t = d_0 + d_1 y_{t-1} + d_2 y_{t-2} + d_3 r_{t-1} + d_4 r_{t-2} + d_5 G_{t-1} + d_6 G_{t-2} + u_{1t}$$

$$r_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \beta_3 r_{t-1} + \beta_4 r_{t-2} + \beta_5 G_{t-1} + \beta_6 G_{t-2} + u_{2t}$$

$$G_t = \gamma_0 + \gamma_1 y_{t-1} + \gamma_2 y_{t-2} + \gamma_3 r_{t-1} + \gamma_4 r_{t-2} + \gamma_5 G_{t-1} + \gamma_6 G_{t-2} + u_{3t}$$

estimate OLS

predict

compare  $\hat{y}_t$  to  $\hat{y}_t$  for AR4.

ENDLESS POSSIBILITIES

## HYBRID (AC MODEL)

$$C_t = d_0 + d_1 C_{t-1} + d_2 C_{t-2} + d_3 C_{t-3} + d_4 C_{t-4} + u_{1t}$$

$$I_t = \beta_0 + \beta_1 I_{t-1} + \dots + u_{2t}$$

$$G_t = \gamma_0 + \gamma_1 G_{t-1} + \dots + u_{3t}$$

$$NX_t = \delta_0 + \delta_1 NX_{t-1} + \dots + u_{4t}$$

$$Y_t = C_t + I_t + G_t + NX_t$$

uses GOP identity