

Interest Rate Determination & the Taylor Rule

JARED BERRY & JAIME MARQUEZ

JOHNS HOPKINS SCHOOL OF ADVANCED INTERNATIONAL STUDIES

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Monetary Policy Rules

- Policy rules form part of the “modern” approach to monetary policy where the goal is to stabilize the economy
- Definition: systematic decision process using information consistently and predictably
- Desirable properties
 - Rule must recognize that individuals anticipate decisions by the Central Bank
 - Rule must be explicit about how information is used
 - Rule should not be changed without a lot of forethought
 - Rule must be easily understood: complicated rules come across as capricious

Taylor Rule

- The Taylor rule determines a benchmark for the short-term policy rate:

$$i = r + \pi + \beta \cdot (\pi - \pi^*) + (1 - \beta) \cdot (y - y^*)$$

- Where
 - i is the federal funds rate predicted by the Taylor rule
 - r is the real interest rate
 - π is the current value of inflation
 - π^* is the target inflation rate
 - y is the measure of economic activity
 - y^* is the measure of “full employment” economic activity
 - $\beta > 0$ importance of inflation for monetary policy

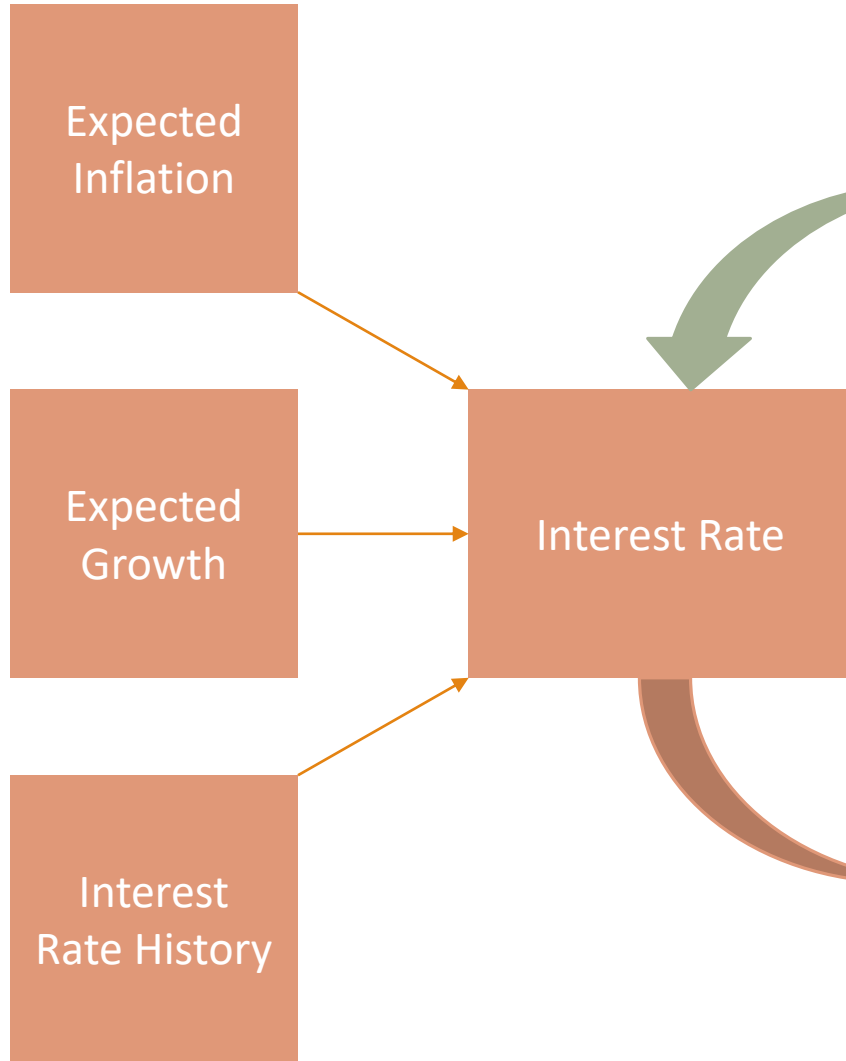
Properties of the Taylor Rule

- If $\pi > \pi^*$ then $i \uparrow$: If the inflation rate exceeds the target rate, then monetary policy raises the short term rate
- If $y > y^*$ then $i \uparrow$: If the economic activity exceeds its full employment level, then monetary policy should raise the short-term rate
- If $\pi > \pi^*$ and $y > y^*$, then $i = r + \pi$, which is the Fisher equation
- The “money” of monetary policy follows the interest rate

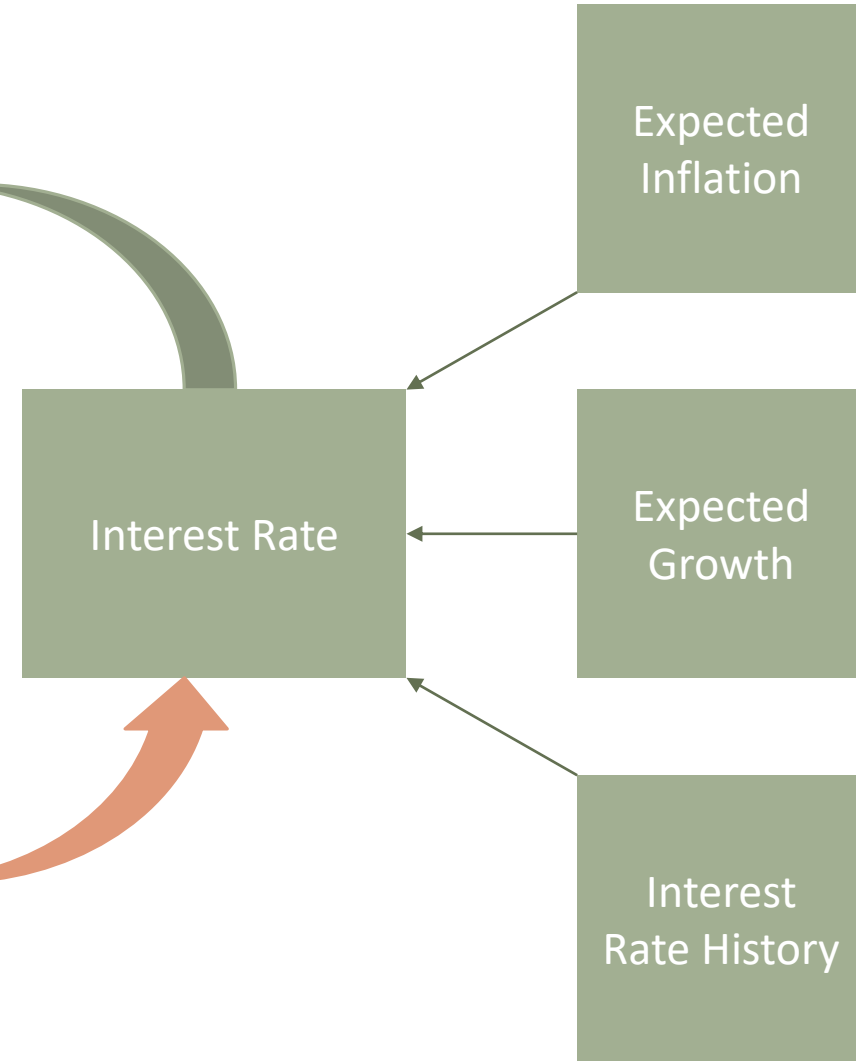
Extensions of the Taylor Rule

- Persistence:
 - Monetary policy seeks to avoid large swings in policy rates
 - History of recent rates plays a role in setting monetary policy
- Expectations:
 - Changes in monetary policy do not materialize instantaneously: there is a lag
 - What matters are expectations of inflation and economic activity
 - If authorities anticipate an event that will disrupt the economy, they must act now to offset the expected disruption
- Interdependencies:
 - Interest rates are not determined in a vacuum
 - Domestic monetary policy potentially depends on foreign monetary policy and vice versa





United
States



Europe



Generic Taylor Rule

	<i>neutral rate</i>	$r + \pi_{t+1}$
	<i>future inflation</i>	$\beta \cdot (\pi_{t+1} - \pi^*)$
	<i>future growth</i>	$(1 - \beta) \cdot (y_{t+1} - y_t^*)$
i_t 	<i>history</i>	$\delta \cdot i_{t-1}$
	<i>interdependence</i>	$\lambda \cdot i_t^e$

Implementation of the Taylor Rule

- Parameters of the Taylor rule are generally unknown
- Practitioners typically assume values for the unknown parameters
- For example:
 - $\beta = 0.5$: Monetary policy is equally concerned with inflation and economic activity
 - $(y_{t+1} - y_t^*)$: output gap from the International Monetary Fund's *World Economic Outlook*
 - Target inflation rate $\pi^* = 2$ set and announced by the Central Bank
 - Real interest rate $r = 2$
- Values for unknown parameters can be estimated from data
- Real interest rate and output gap can be modelled with Monte Carlo analysis

Estimating Parameters: Rationale

- Rather than assuming parameters, estimate them based on past performance
 - United States and Euro Area data from 1995-2015
 - Inflation and output gap from the International Monetary Fund's *World Economic Outlook*
 - Federal funds rate from St. Louis Federal Reserve's *Federal Reserve Economic Data* (FRED)
 - Eonia rate from European Central Bank
- How are the determinants of the interest rate actually weighted?

Empirical Methodology

- The structural model is:

$$i_t^{US} = \varphi_0 + \varphi_1 \cdot (y_t - y_t^*) + \varphi_2 \cdot \pi_t + \varphi_3 \cdot i_{t-1} + \varphi_4 \cdot i_t^{EU}$$

$$i_t^{EU} = \varphi_0^{EU} + \varphi_1^{EU} \cdot (y_t^{EU} - y_t^{EU*}) + \varphi_2^{EU} \cdot \pi_t^{EU} + \varphi_3^{EU} \cdot i_{t-1}^{EU} + \varphi_4^{EU} \cdot i_t^{US}$$

- Estimate using Full Information Maximum Likelihood (FIML) method

Estimating Parameters: Results

Independent Variable	Estimated Parameters for the US	Estimated Parameters for the EU
Economic Activity	$\varphi_1 = 0.3428^{**}$	$\varphi_1^{EU} = 0.1425$
Inflation	$\varphi_2 = 0.1709$	$\varphi_2^{EU} = 0.3951^{**}$
Interest Rate History	$\varphi_3 = 0.6430^{***}$	$\varphi_3^{EU} = 0.5009^{***}$
Foreign Interest Rate (EU/US)	$\varphi_4 = 0.0000^{\wedge}$	$\varphi_4^{EU} = 0.3055^{***}$
*** p<0.01, ** p<0.05, * p<0.1		
[^] We constrain with respect to the EONIA rate because it is statistically insignificant and negative in the unconstrained FIML estimation procedure		

Estimating Parameters: Implications

- For the United States:
 - Interest rate history and economic activity are most important for US rates
 - Inflation is less significant for the US
 - The US interest rate is not impacted by Euro Area rates
- For the Euro Area:
 - Interest rate history and inflation are most important for Euro Area rates
 - Economic activity is less significant for the Euro Area
 - The US interest rate factors heavily in the determination of Euro Area rates

Sensitivity of Results to Changes in Exogenous Variables

- Rather than assuming values for the real interest rate, r , and potential output, y^* , model them with Monte Carlo analysis
 - Federal funds rate from St. Louis Federal Reserve's Federal Reserve Economic Data (FRED)
 - Potential output figures from Congressional Budget Office
 - Determine standard deviation from historic rates and potential output
- Create random drawings for r and y^* to incorporate in Taylor rule
- Incorporate similarly random “shocks” to these drawings
- Generate an empirically robust range of Taylor rules

Empirical Methodology

- Recall the simple Taylor rule,

$$i = r + \pi + \beta \cdot (\pi - \pi^*) + (1 - \beta) \cdot (y - y^*)$$

- Where $r = 2 + \varepsilon_1$ and $y^* = 2 + \varepsilon_2$ such that,
 - $\varepsilon_1 = \sigma_r \cdot \mu_1 + \sigma_{ry} \cdot \mu_2$ and $\varepsilon_2 = \sigma_{ry} \cdot \mu_1 + \sigma_y \cdot \mu_2$
 - σ_r is the historic standard deviation of the federal funds rate
 - σ_y is the historic standard deviation of potential output
 - σ_{ry} is the covariance between the two, chosen exogenously
 - μ_1 and μ_2 are random “shocks” normally distributed with a mean of 0 and standard deviation of 1

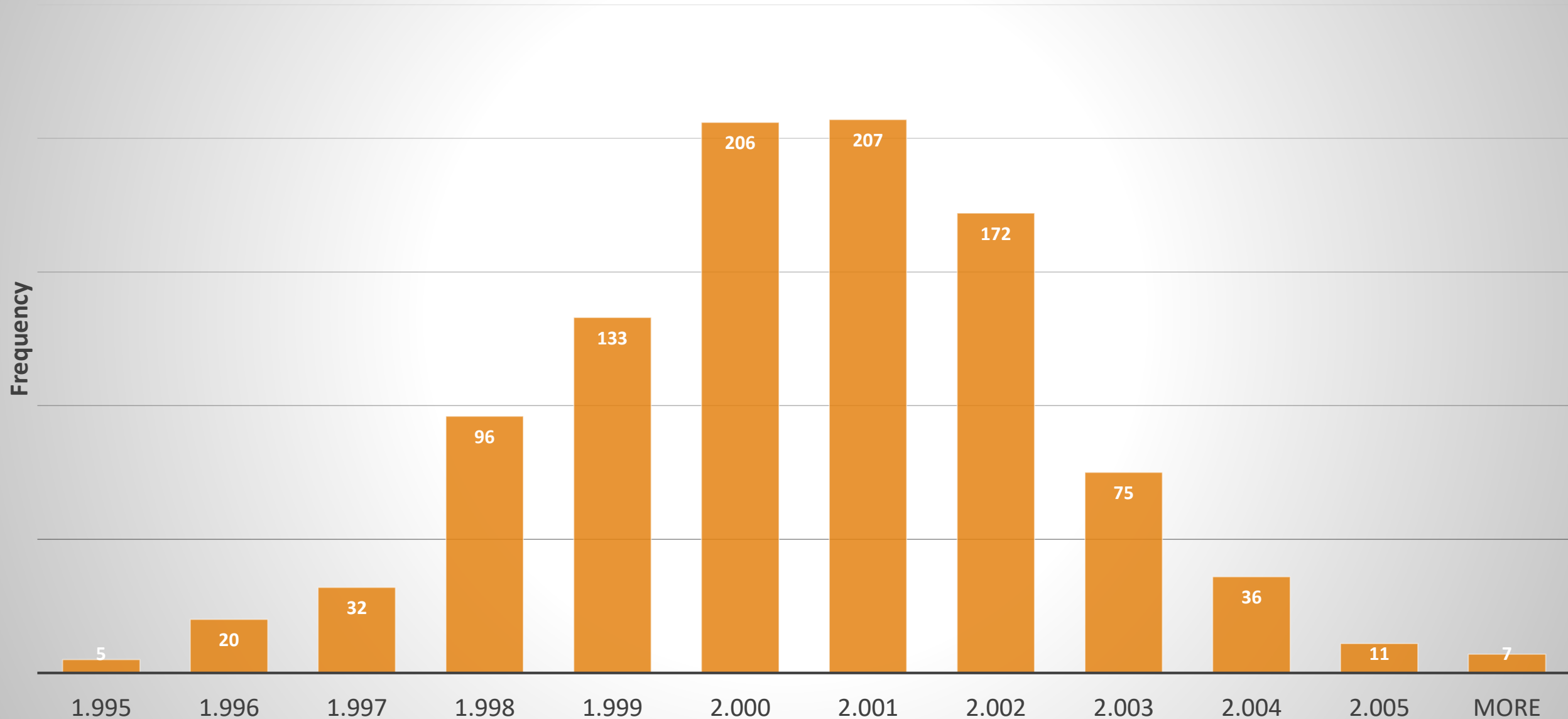
Empirical Methodology

- So, real interest rate and potential output are drawn such that,

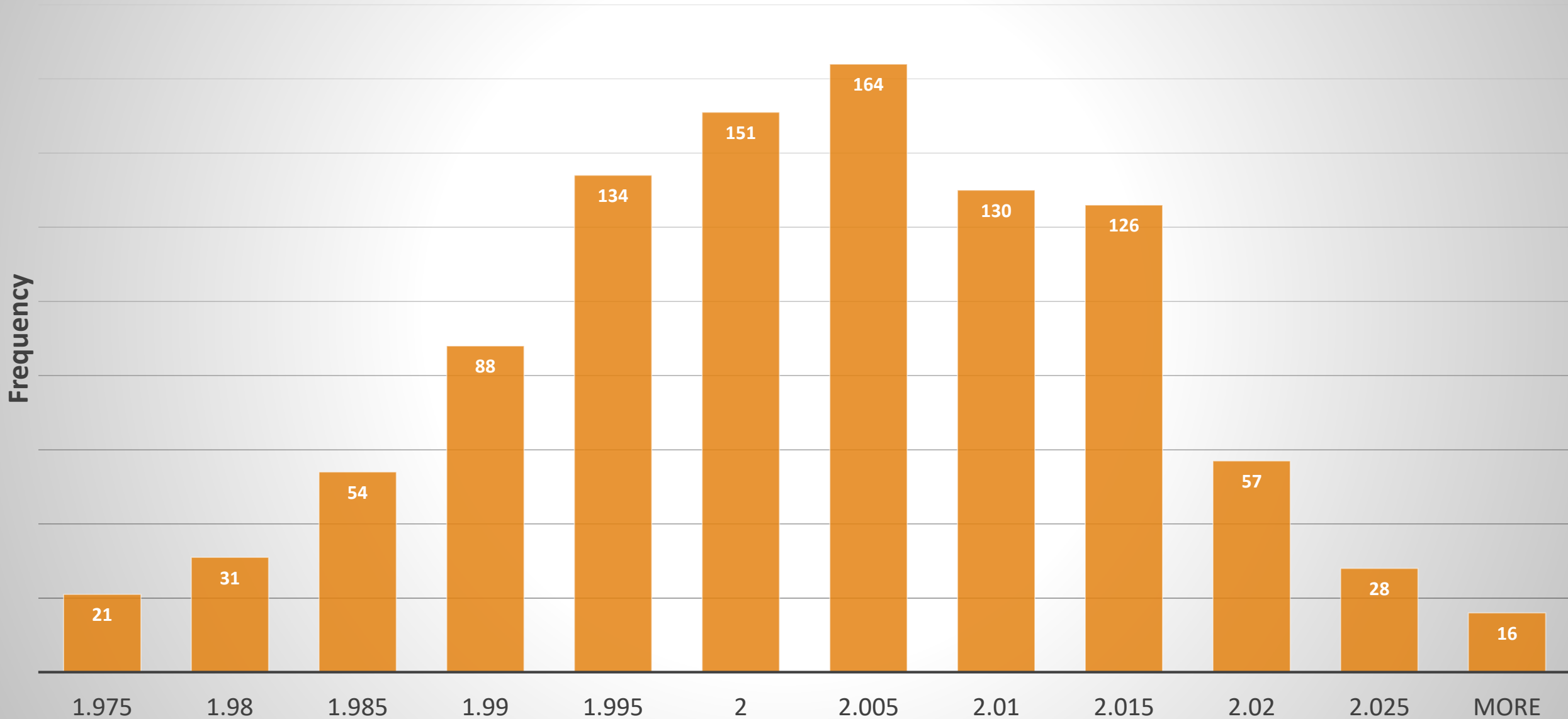
$$\begin{bmatrix} r \\ y \end{bmatrix} = \begin{bmatrix} 2 \\ 2 \end{bmatrix} + \begin{bmatrix} \sigma_r & 0 \\ \sigma_{ry} & \sigma_y \end{bmatrix} \cdot \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix}$$

- Draw 1,000 iterations each of μ_1 and μ_2
- Draw 1,000 subsequent iterations of r and y according to the equation above
- Assume $\sigma_{ry} = 0$

Distribution of Real Interest Rate Drawings



Distribution of Potential Output Drawings



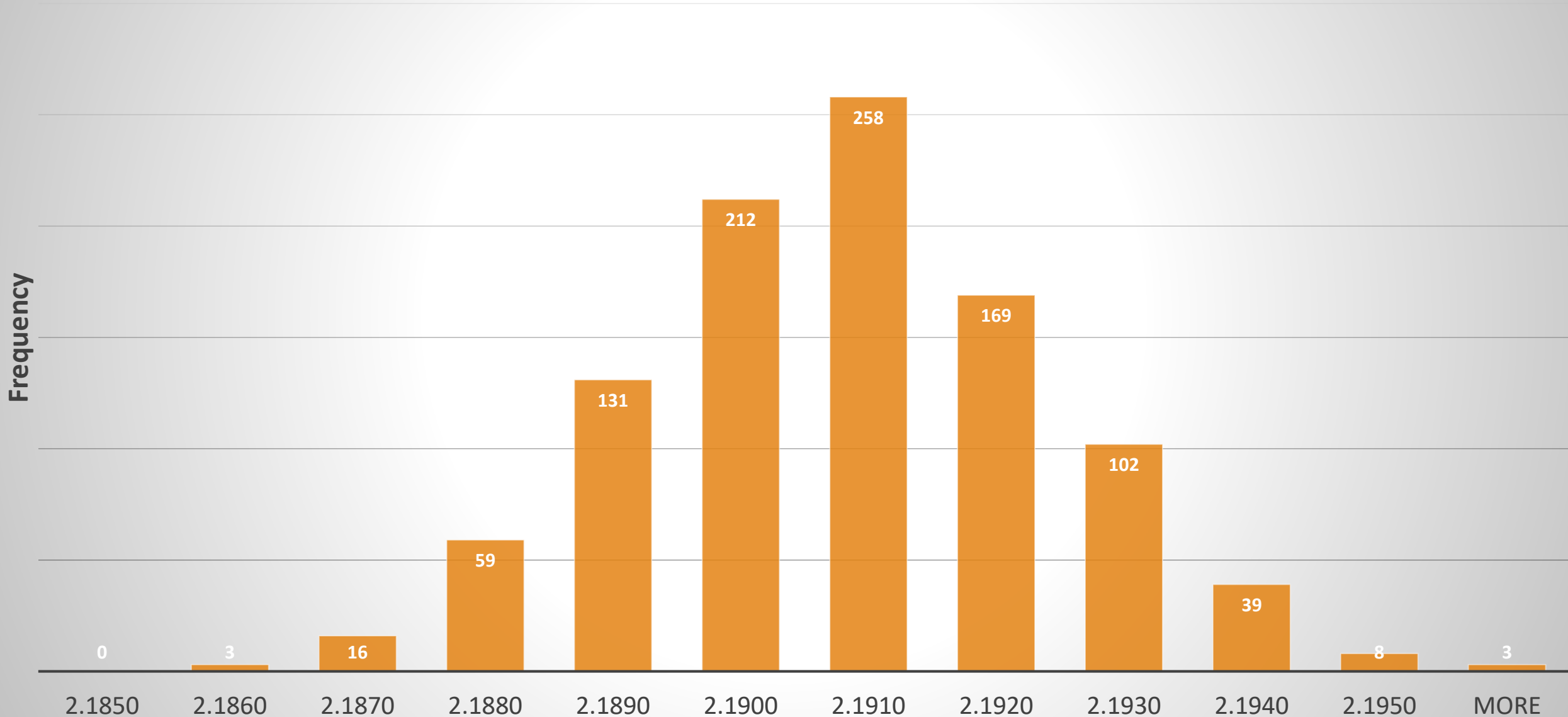
Drawings r and y



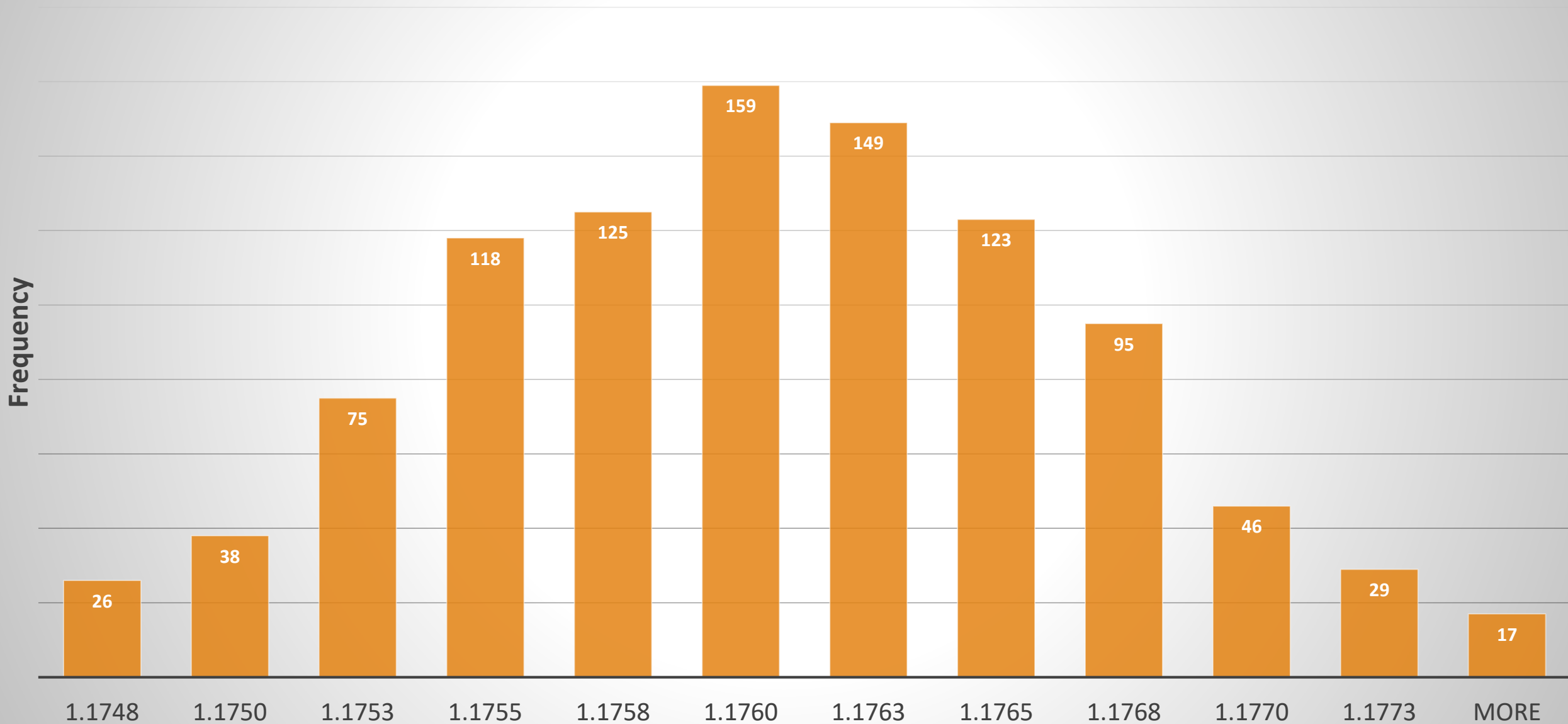
Monte Carlo Taylor Rule: Results

- Using drawings for r and y , establish similar distributions of US Taylor rules
- Forward looking, using estimated parameters
- Forward-looking, using chosen parameters
 - Weight the importance of inflation and growth equally ($\beta = \theta = 0.5$)
 - Weight persistence heavily ($\delta = 0.9$), implying “slow” adjustment of the interest rate
 - No interdependency ($\lambda = 0.0$)

Taylor Rule Distribution (Estimated Parameters)



Taylor Rule Distribution (High Persistence)



Monte Carlo Taylor Rule: Implications

- Should the assumptions of the Taylor rule and projections hold, we can confidently estimate a range of possible interest rates for 2017
- Overall distribution is a reasonably tight range
- Choice parameters can be adjusted accordingly given different assumptions
 - “Slowness” of adjustments (persistence parameter)
 - Expectations vs. current data (forward-looking)
 - Initial value for potential growth and real interest rate
- Changes in parameters more drastically alter the distribution