A Model of Secular Stagnation: Theory and Quantitative Evaluation

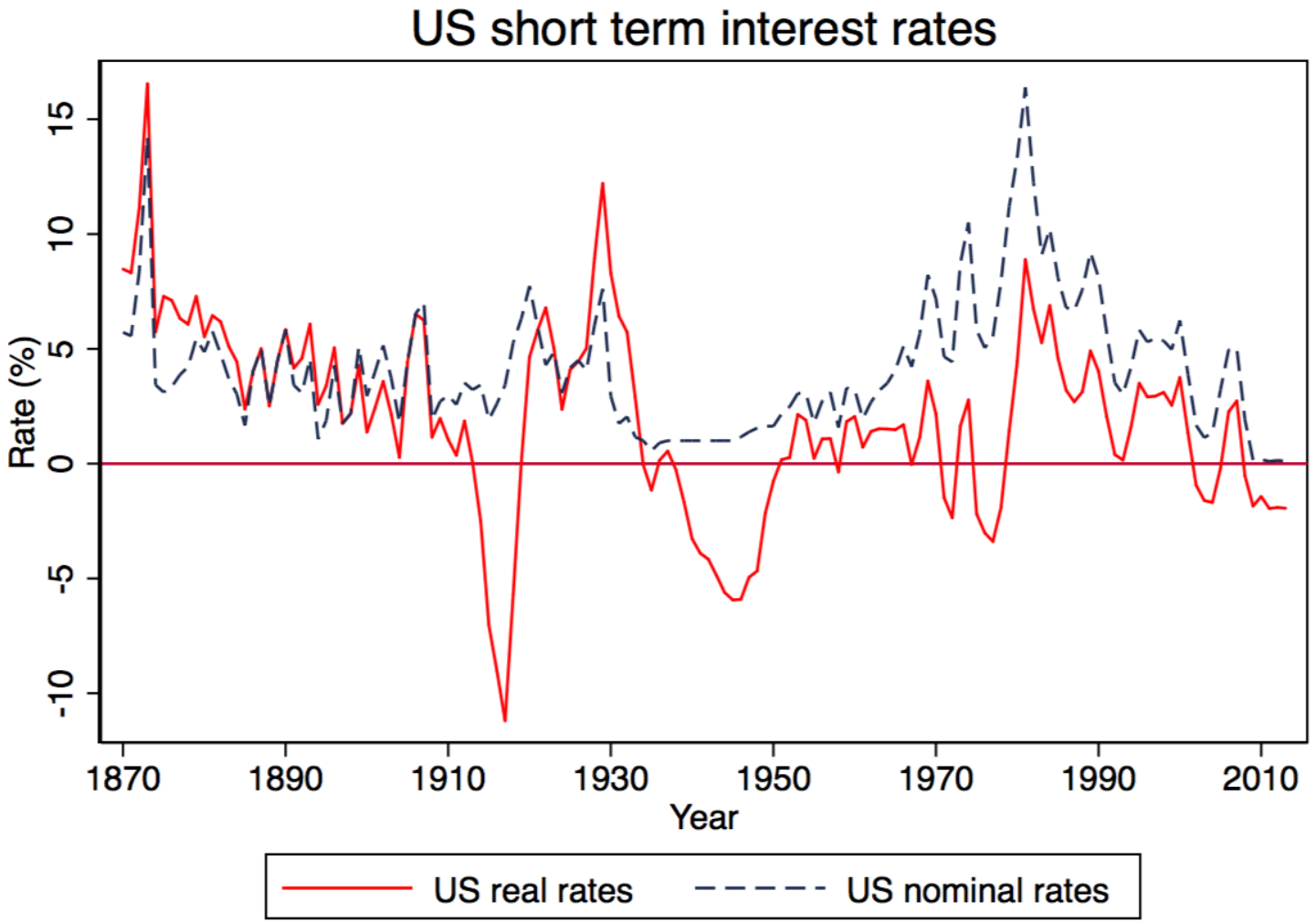
Gauti Eggertsson

Neil Mehrotra

Jacob A. Robbins

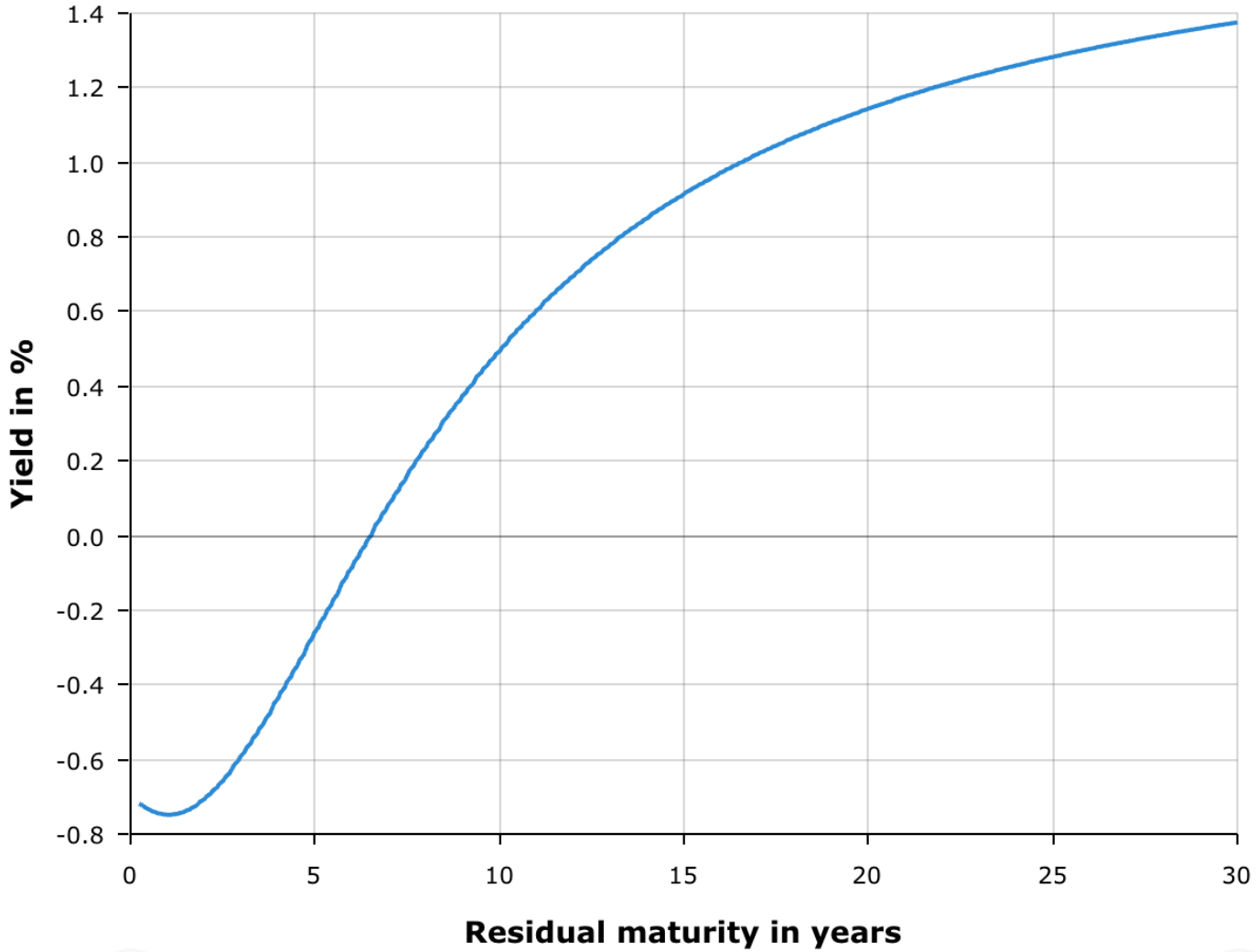
BROWN

Fact 1: Real Interest Rates can be *Negative* For Extended Periods



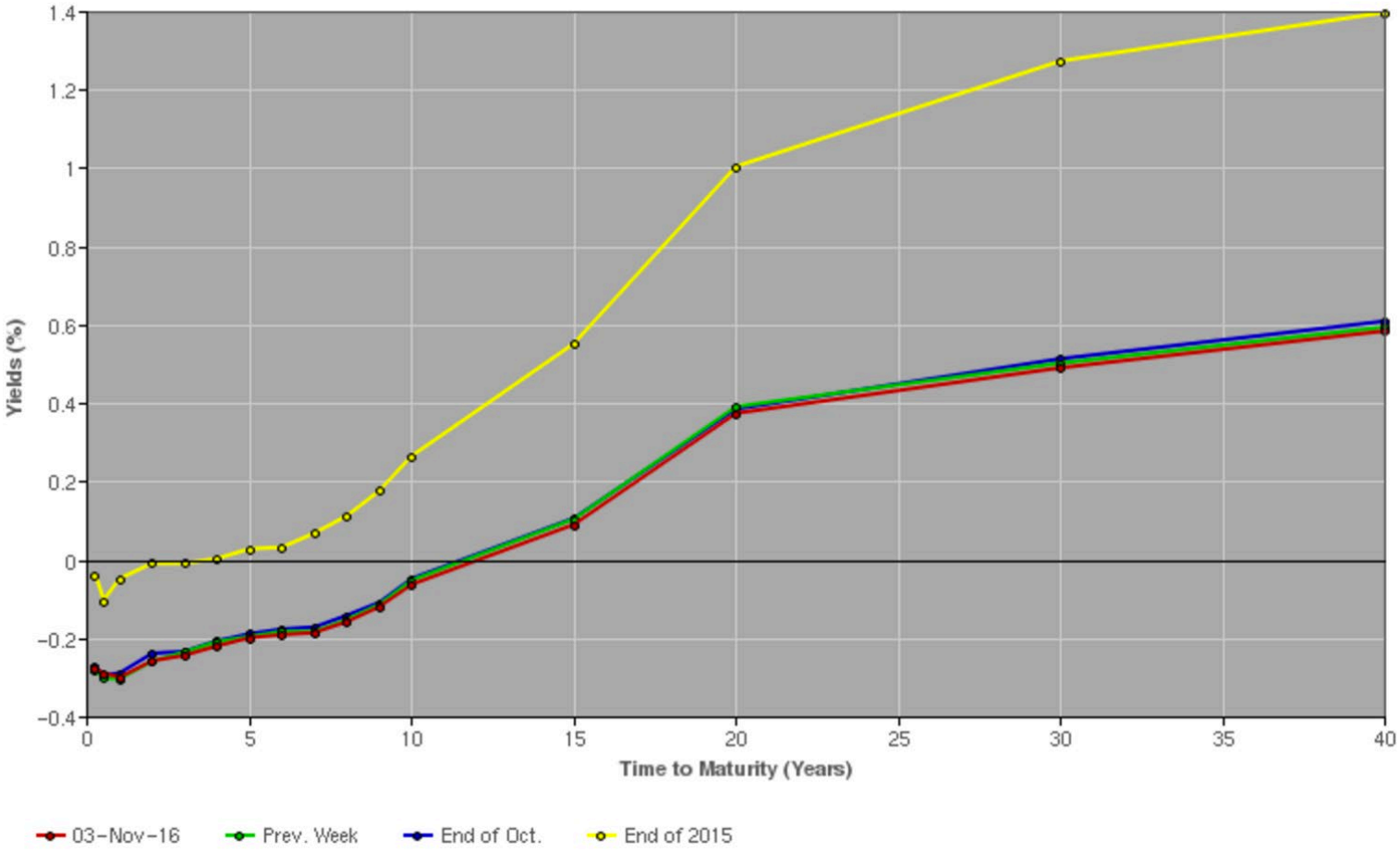
BROWN

Europe: negative rates are here to stay



BROWN

Japan: negative rates are here to stay

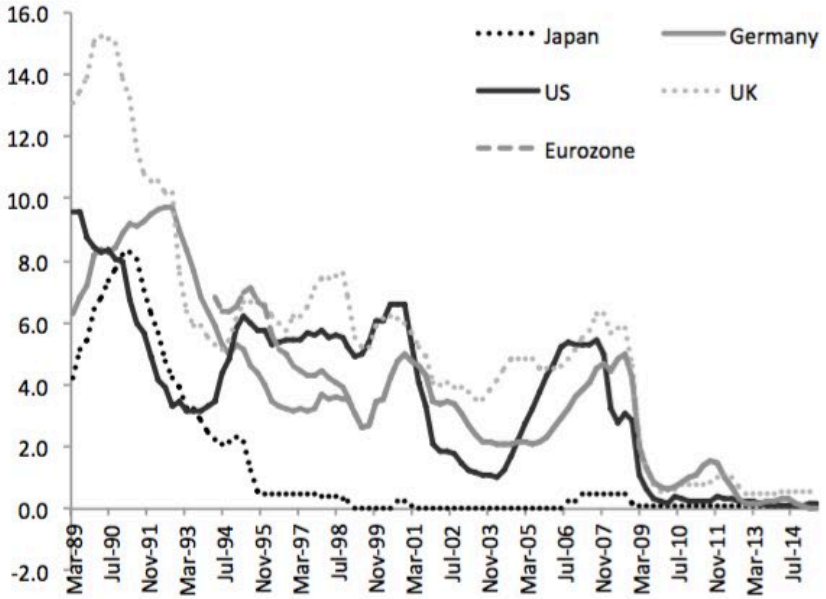


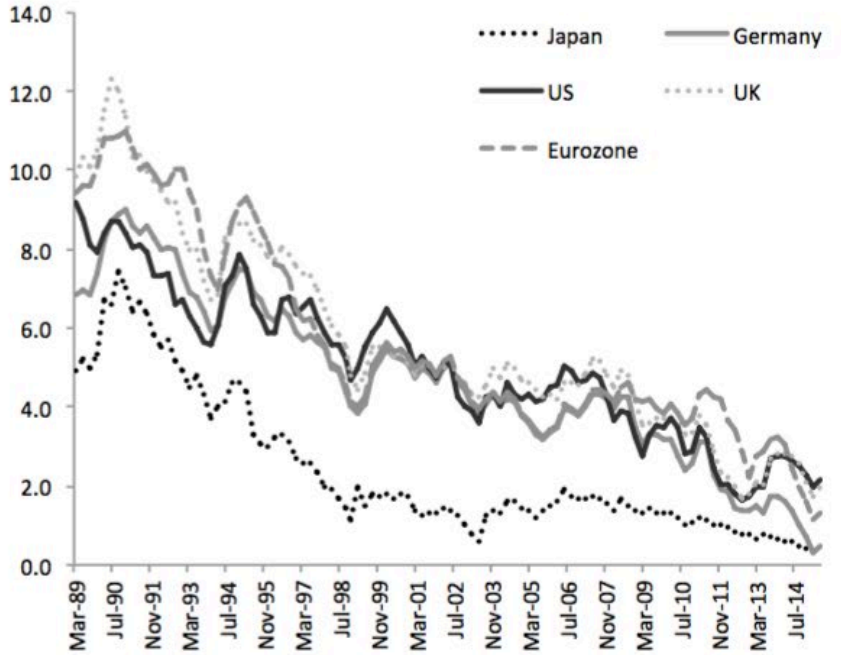
BROWN

Goals of the paper

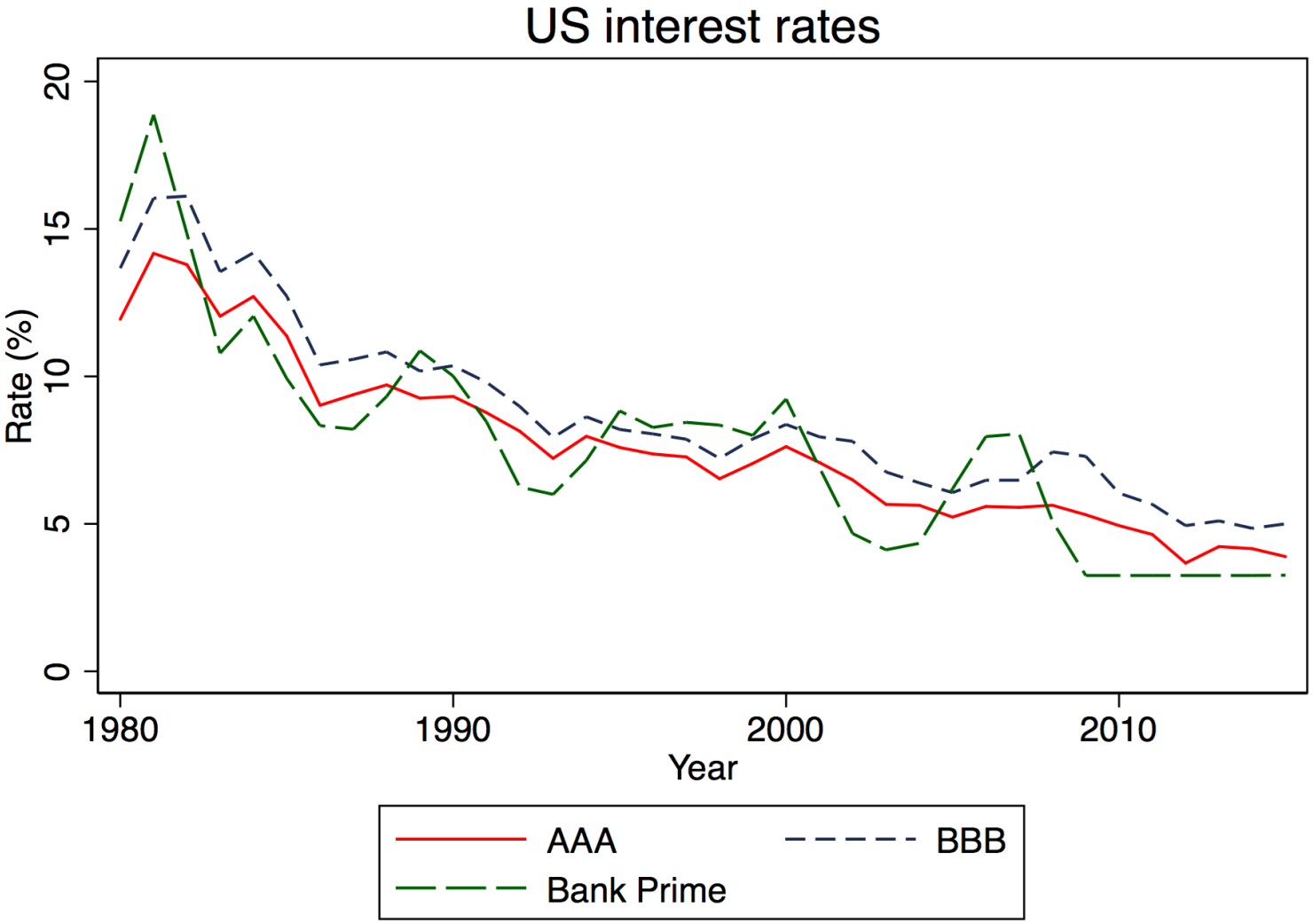
- First goal: create a large scale model of the US economy, explore whether negative interest rates are quantitatively plausible
- Baseline model, calibrated to US economy, has steady state real interest rates of -1.4%
  - Parameters are conservatively calibrated, fall within ranges of literature
  - Matches key moments of US data

Fact 2: Real Interest Rates have been declining since 1980

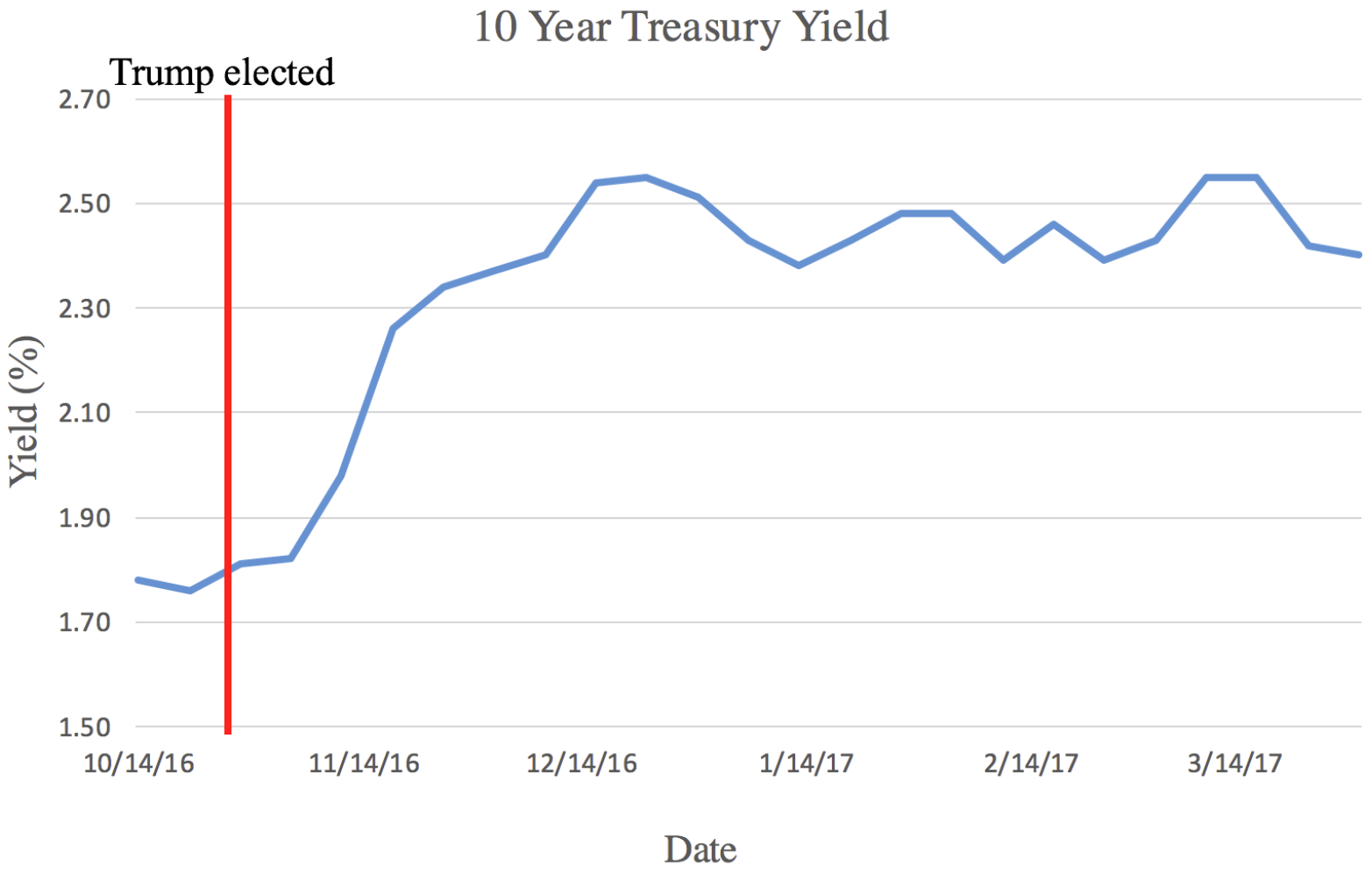




Fact 2: Real Interest Rates have been declining since 1980



BROWN


10 Year Treasury Yield
Trump elected
2.70
2.50
2.30
2.10
1.90
1.70
1.50
Yield (%)
10/14/16
11/14/16
12/14/16
1/14/17
2/14/17
3/14/17
Date

BROWN

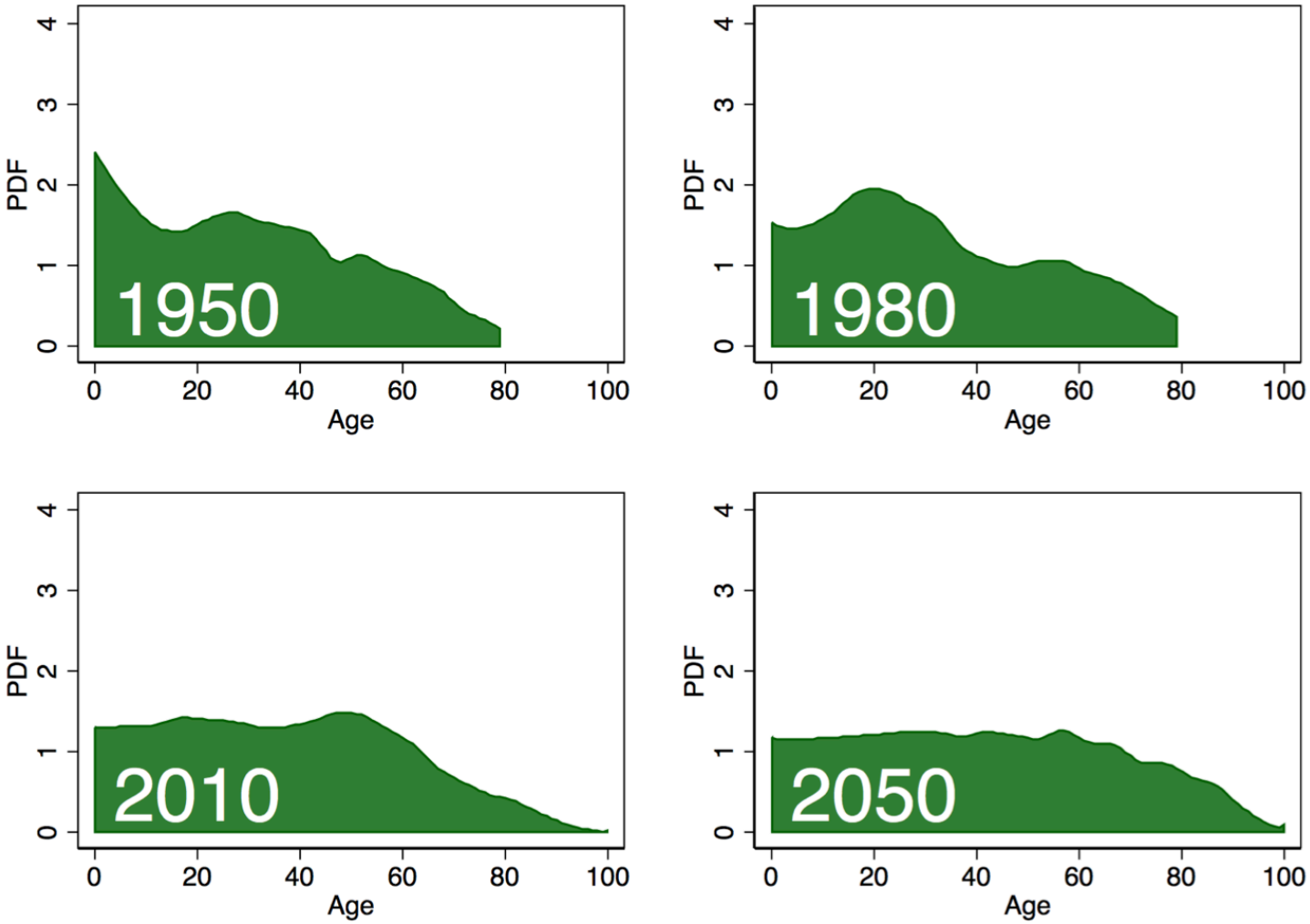

10 Year Treasury Yield
Trump elected
15.50
13.50
11.50
9.50
7.50
5.50
3.50
1.50
Yield (%)
1980
1985
1990
1995
2000
2005
2010
2015
Year

BROWN

Goals of the paper

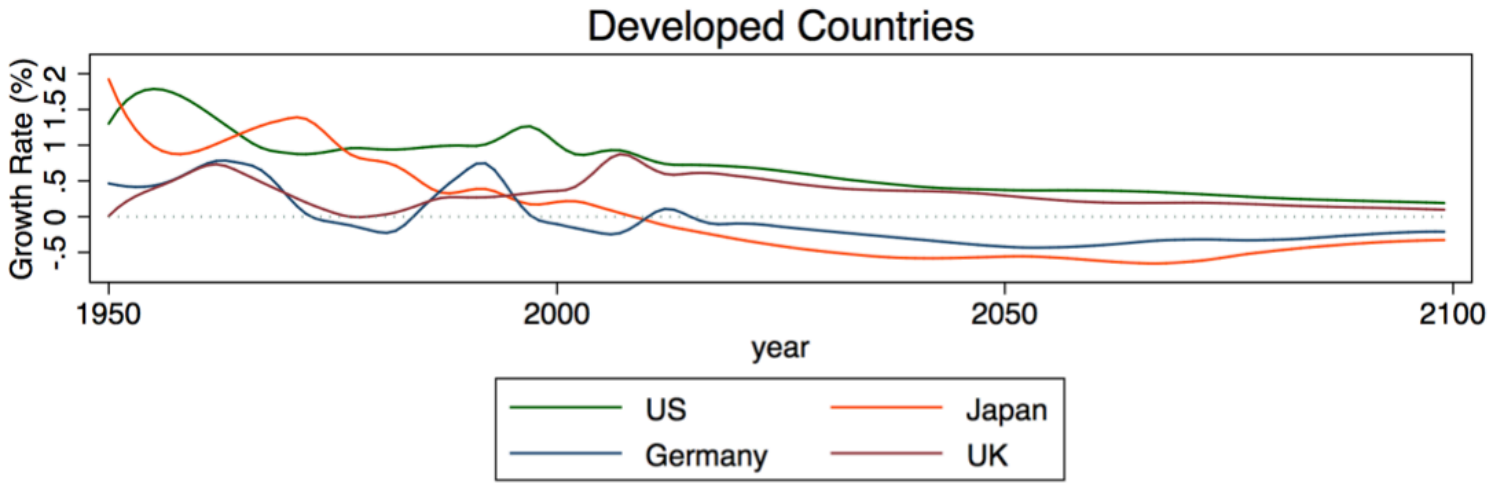
- Second goal: use the model to decompose the factors which have lead to a decline in interest rates from 1970 to the present
- Will show both comparative statics and fully solve transition paths
- The key factors will be changes in fertility, mortality, and productivity growth

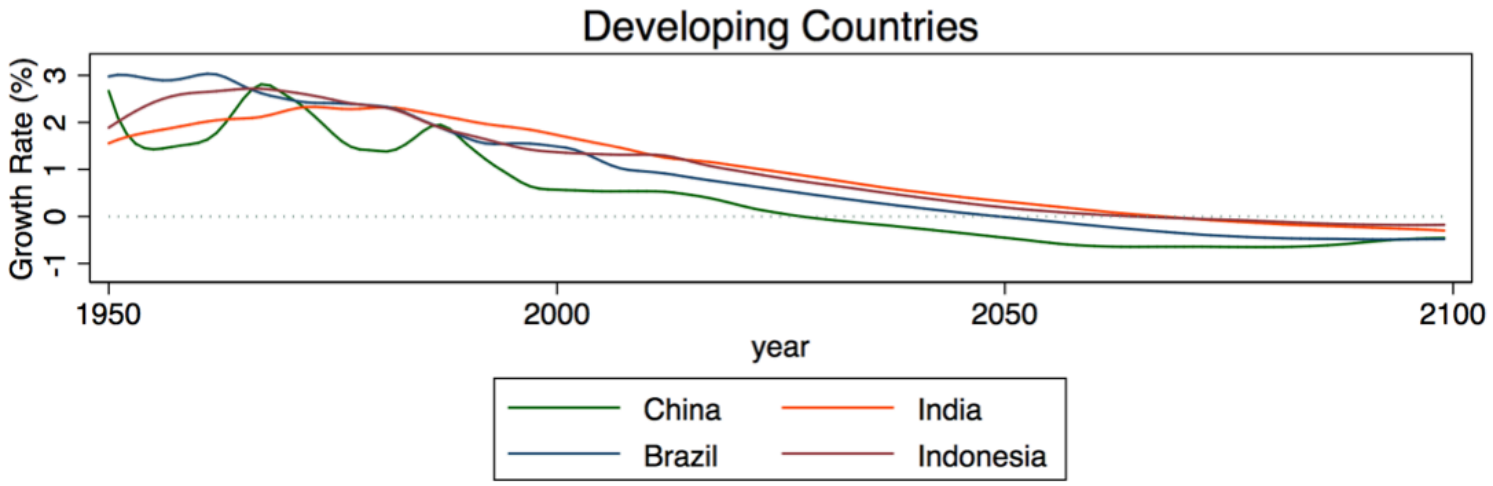
Candidate explanation: Population aging



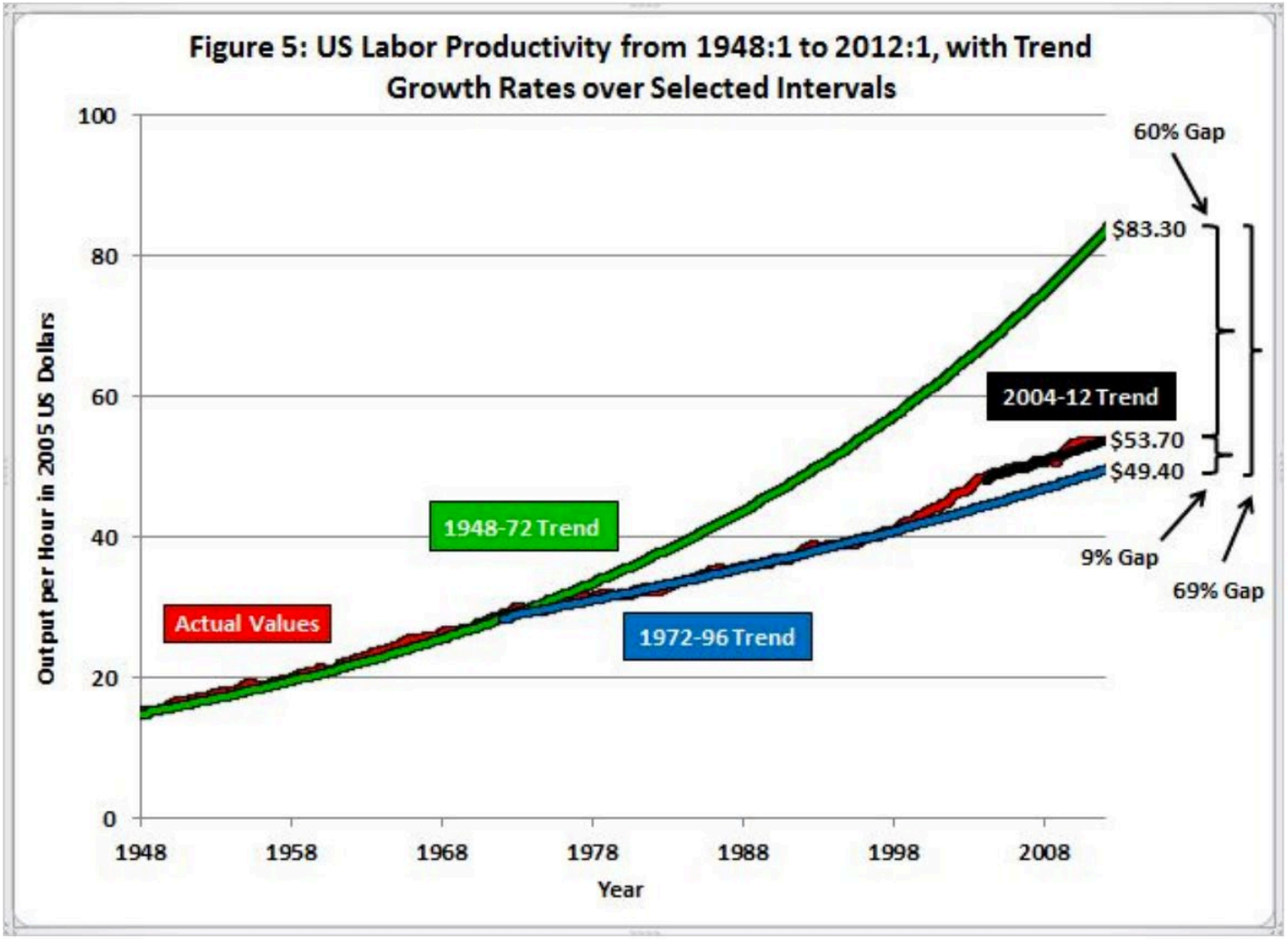
BROWN

Candidate explanation: slower population growth



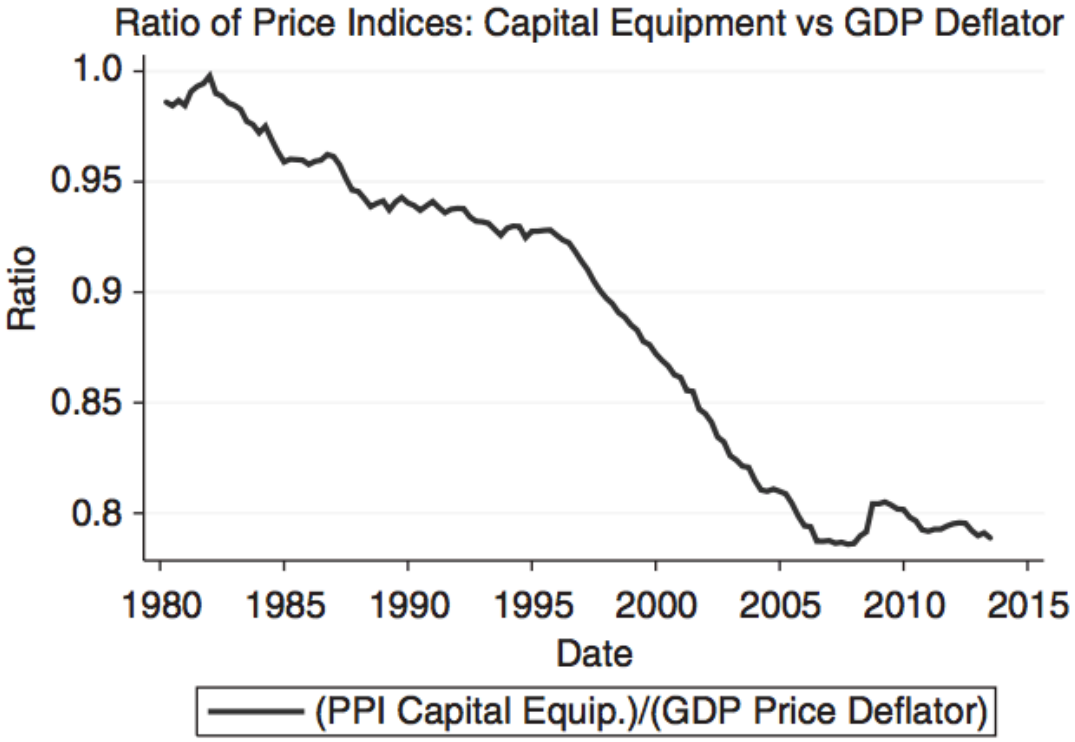


Candidate explanation: productivity growth slowdown



BROWN

Candidate explanation: relative price of capital goods

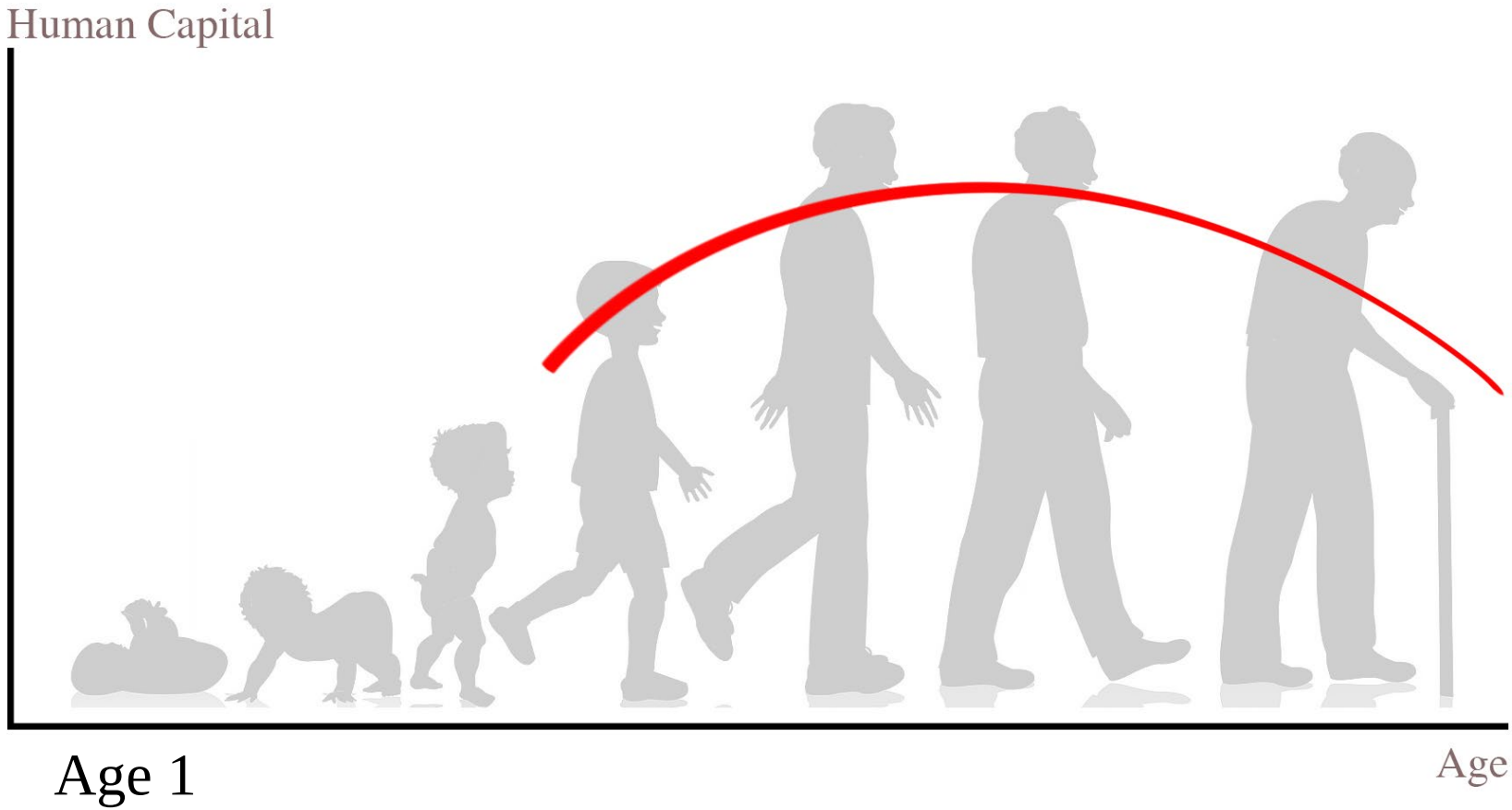


BROWN

Lifecycle Model

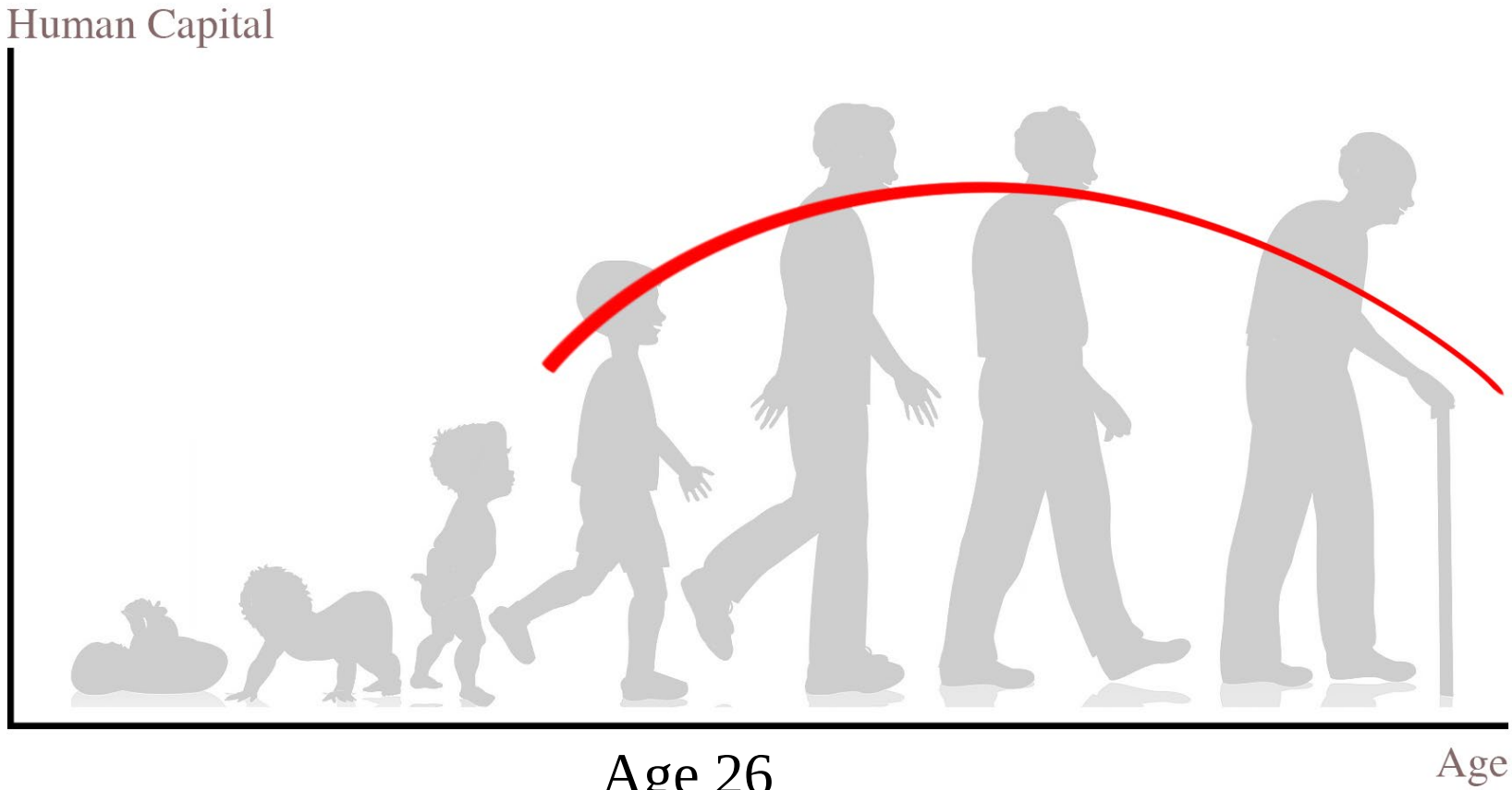
- Use OLG to capture realistic savings motives
  - Lifecycle
  - Bequest
  - Missing: precautionary savings
- Starting point is Auerbach & Kotlikoff (1987)

Lifecycle Model



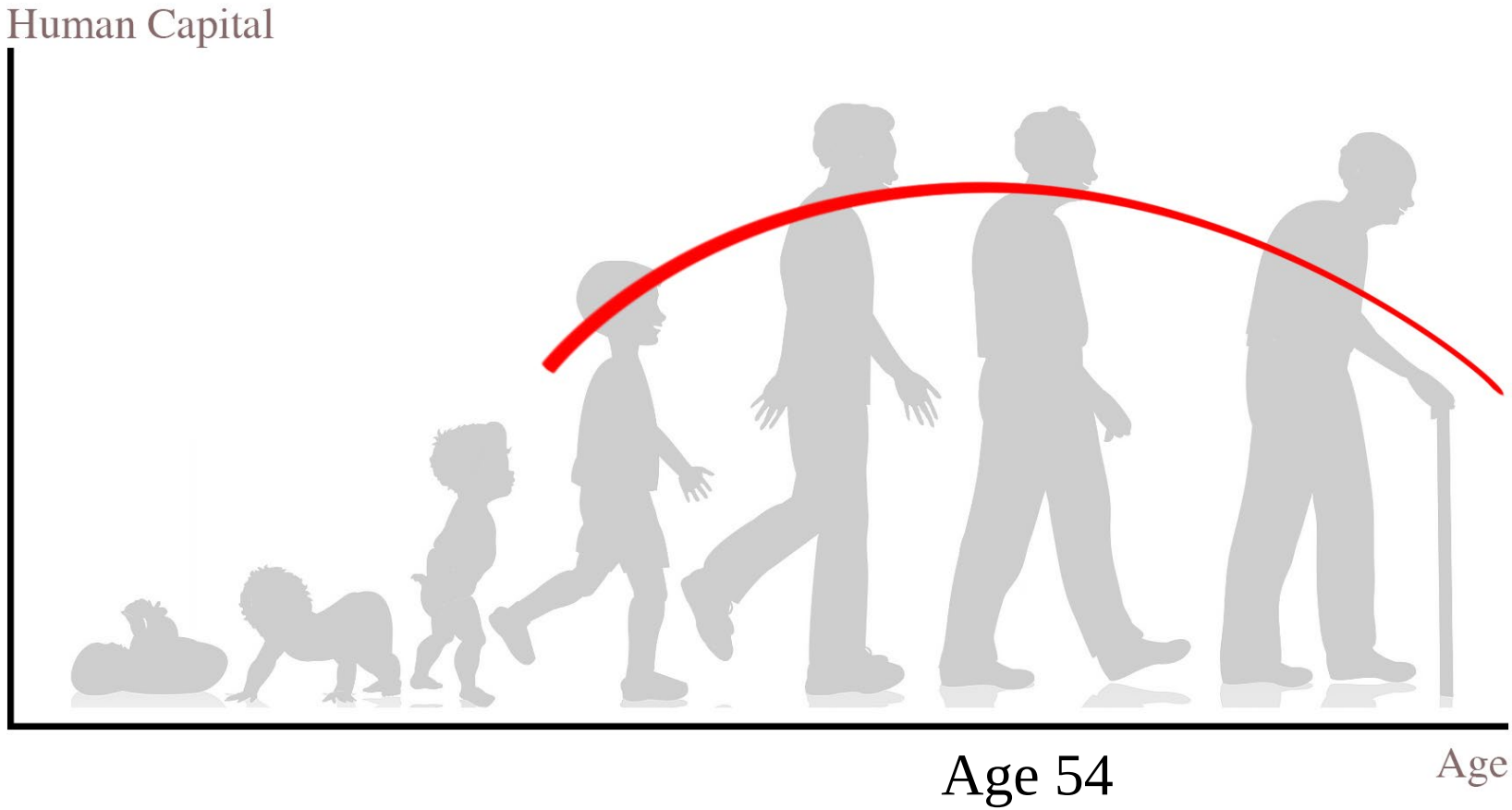
Individuals are born

Lifecycle Model



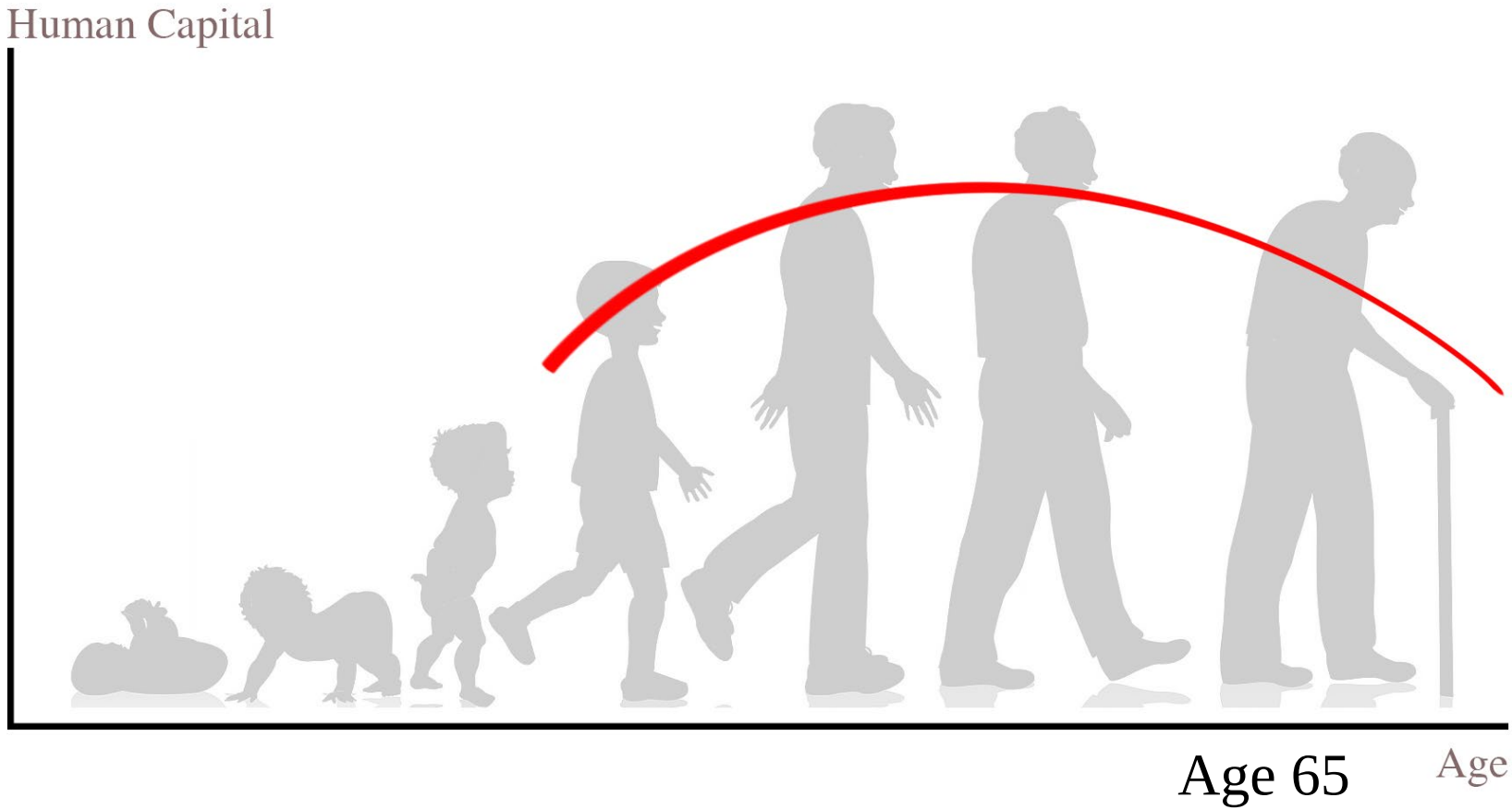
Individuals enter economic maturity, have n children

Lifecycle Model



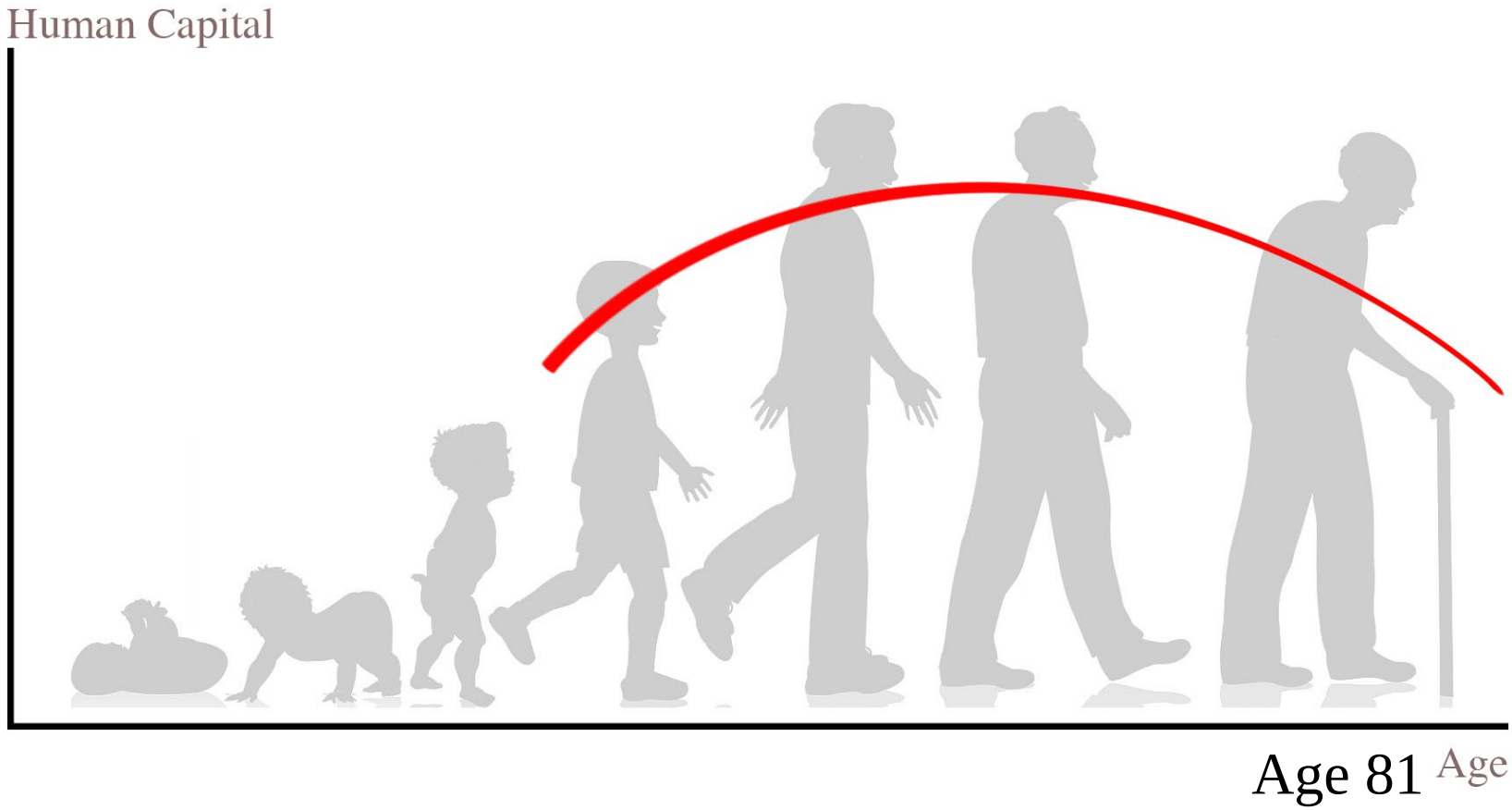
Individuals receive bequests from their parents

Lifecycle Model



Individuals retire from the workforce

Lifecycle Model



Individuals perish, give bequests to children

Utility Maximization

- Individuals choose consumption and bequest level to maximize utility, subject to budget constraint and borrowing limit:

$$U_t = \sum_{j=1}^{J} s^j \beta^{j-1} u(C_{j,t+j-1}) + s^J \beta^{J-1} \mu v(x_{J,t+J-1})$$

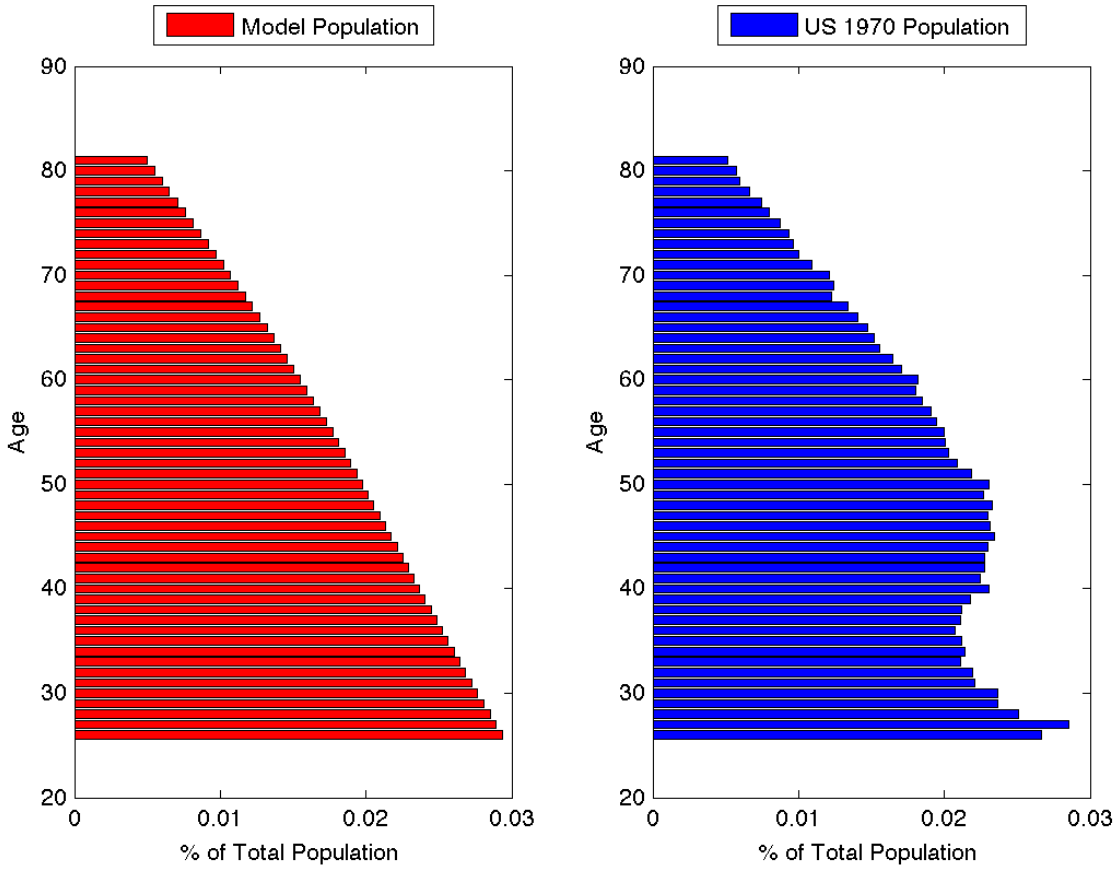
$$t=1$$

$$c_{j,t} + \xi_t a_{j+1,t+1} + TFR \cdot x_{j,t} = (1-\tau^w) w_t h c_j + \Pi_{j,t} + [r_t^k + \xi_t (1-\delta)] \left(a_{j,t} + q_{j,t} + \frac{1-s_j}{s_j} a_{j,t} \right)$$

$$a_{j,t} \geq \frac{D_t}{1+r_t}$$

Demographics

- At any point in time there are 56 generations alive, each at a different age. Stochastic mortality and population growth combine to create a demographic structure



BROWN

Capital Law of Motion

- Capital evolves according to the law of motion

$$K_{t+1} = (1-\delta)K_t + \frac{I_t}{\xi_t}$$

- The real interest rate is given by

$$1 + r_t = \frac{r^k_{t+1} + (1-\delta)\,\xi_{t+1}}{\xi_t}$$

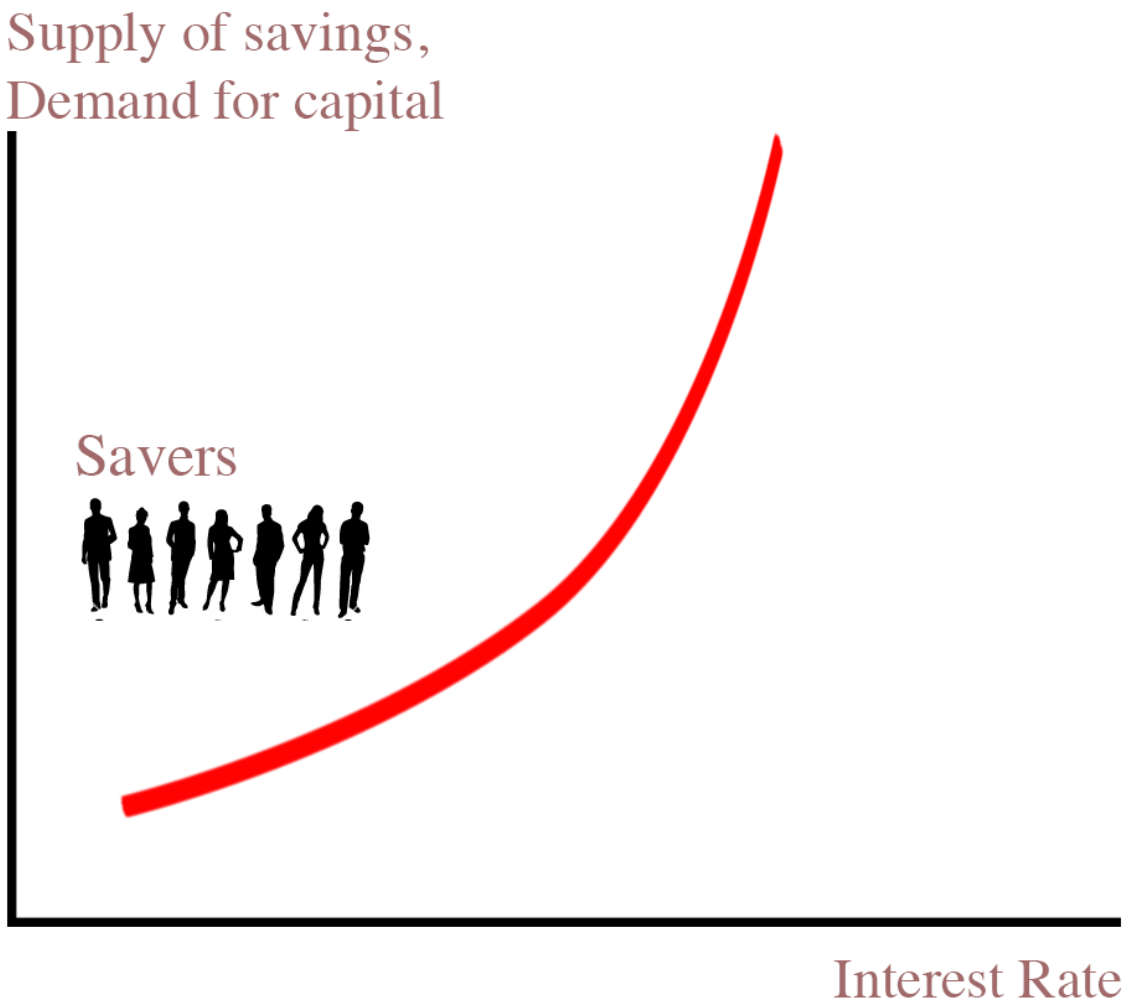
Government

- Governments spends G and pays for it through labor taxes and issuing debt

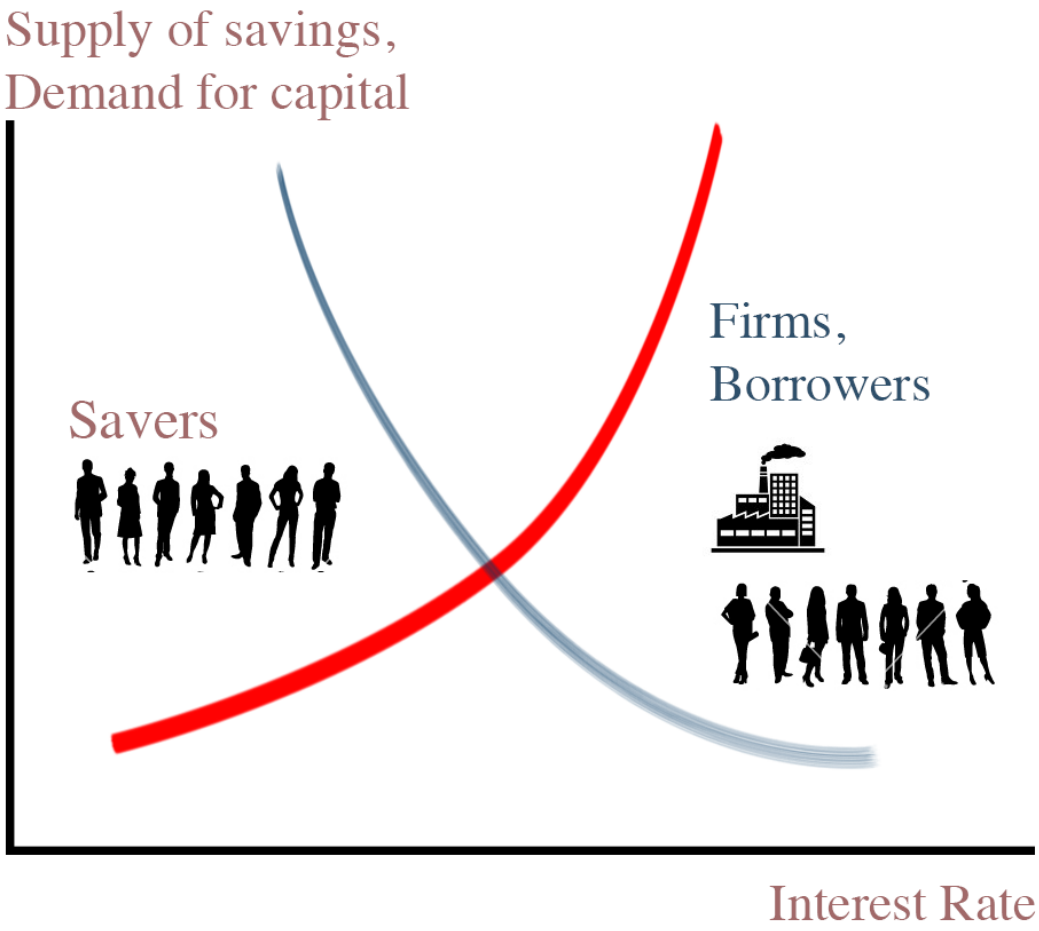
$$b_t = G_t + (1 + r_t)b_{t-1} - T_t$$

- Fiscal policy is specified as a level of government spending (% of GDP) and debt (% of GDP). Wage taxes are then endogenously determined.

Equilibrium



Equilibrium



First thought experiment

- Can a realistically calibrated quantitative model of the US deliver a negative natural rate of interest?

- Calibrate model to US economy in 2015, assuming no output gap

Calibration strategy

- Three sets of parameters
  - Set directly measured in the data (survival rates, productivity growth, etc)
  - Set taken from the literature (IES, production elasticity)
  - Set chosen to match key targets
    - Interest rate in 2015
    - Investment to output and labor share in 2015
    - Data on bequests and unsecured consumer credit

Data and related literature

Table 2: Parameters taken from the data and related literature

Panel A: Data	*Symbol*	*Value*	*Source*
Mortality profile	$s_{j,t}$		US mortality tables, CDC
Income profile	hc_j		Gourinchas and Parker (2002)
Total fertility rate	n	1.88	UN fertility data
Productivity growth	g	0.65%	Fernald (2012)
Government spending (% of GDP)	G	21.3%	CEA
Public debt (% of GDP)	b_g	118%	Flow of Funds
Panel B: Related literature			
Elasticity of intertemporal substitution	ρ	0.75	Gourinchas and Parker (2002)
Capital/labor elasticity of substitution	σ	0.6	Antras (2004)
Depreciation rate	δ	12%	Jorgenson (1996)

Targeted Moments

Table 3: Parameters chosen to match targets

Targets	*Model/Data*	*Source*
Natural rate of interest	−1.47%	Federal Reserve
Investment-to-output ratio	15.9%	NIPA
Consumer-debt-to-output ratio	6.3%	Flow of Funds
Labor share	66.0%	Elsby (2013)
Bequests-to-output ratio	3.0%	Hendricks (2001)

Parameters chosen to match targets	*Symbol*	*Value*
Rate of time preference	β	0.98
Borrowing limit (% of annual income)	D	23.4%
Bequests parameter	μ	21.6
Retailer elasticity of substitution	θ	4.9
Capital share parameter	α	0.24

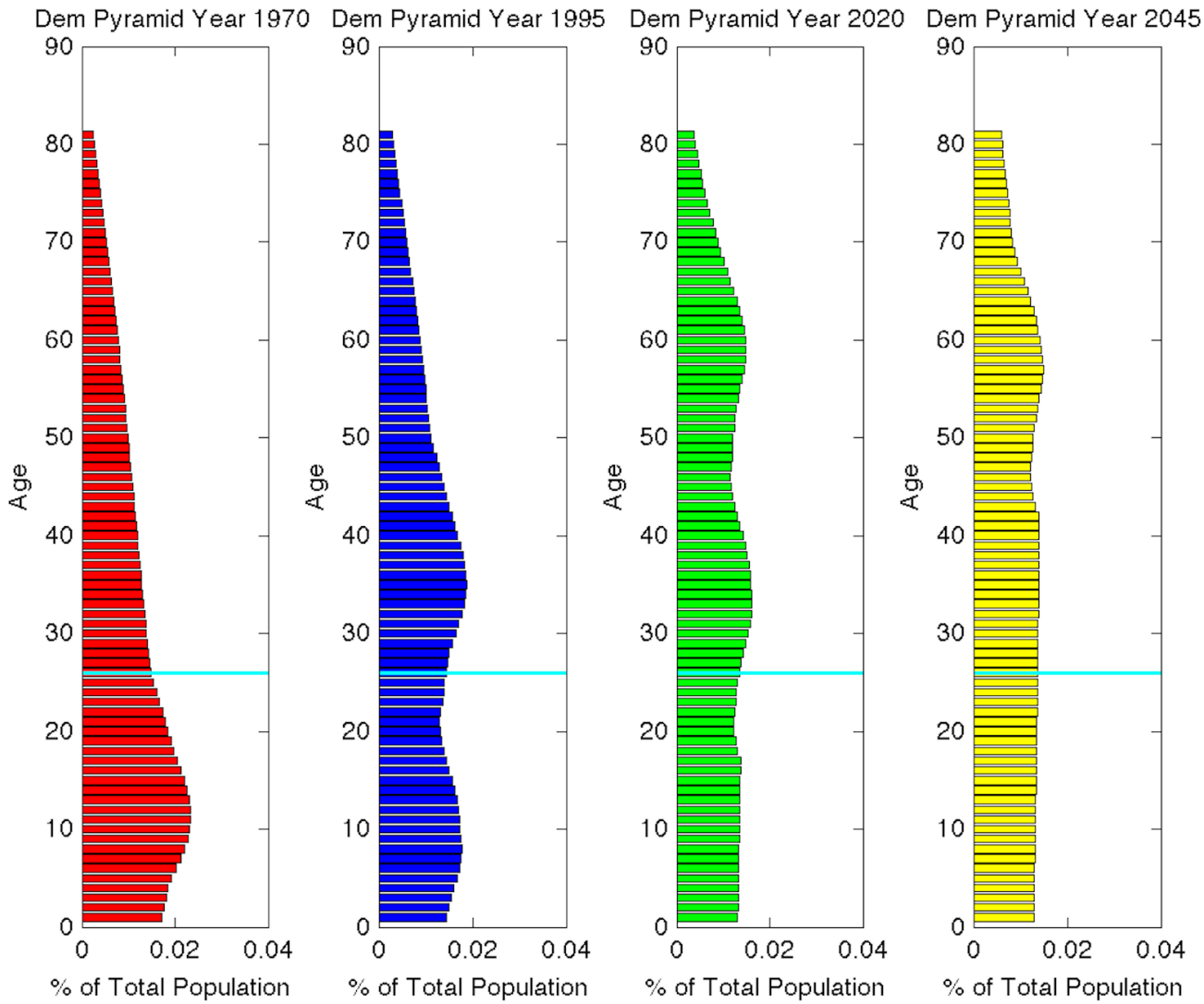
Main results

- Standard, conservatively calibrated OLG can deliver a substantially negative interest rate
- Suggests no reason apriori to expect normalization of interest rates in the US
- Results are robust to a variety of additional specifications

Explaining the decline in interest rates since 1970

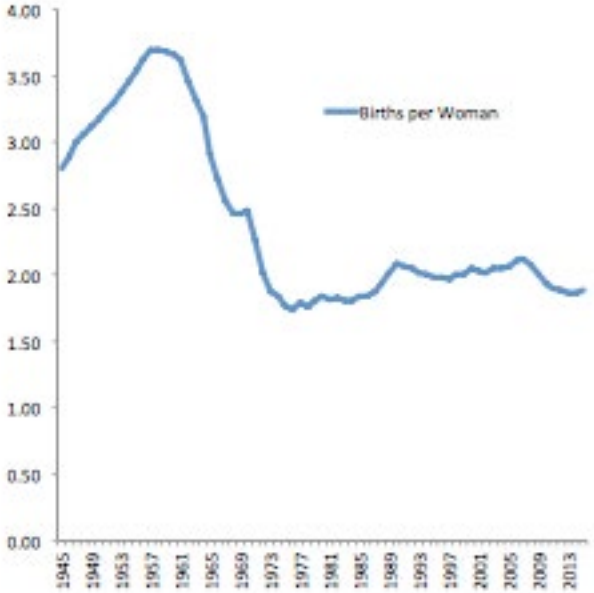
- Assess the contribution of the following factors:
  - **Total fertility rate**
  - Productivity growth
  - **Mortality changes**
  - Relative price of investment goods
  - Changes in the labor share
  - Changes in government debt

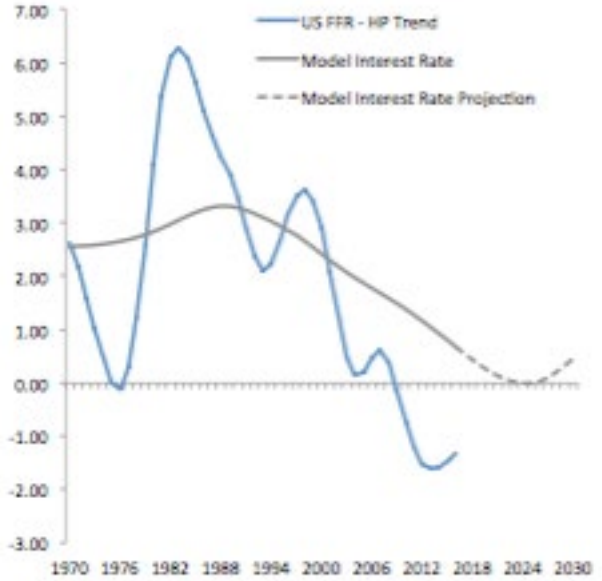
Postwar Baby Boom: Fertility



BROWN

Transition Path: Fertility

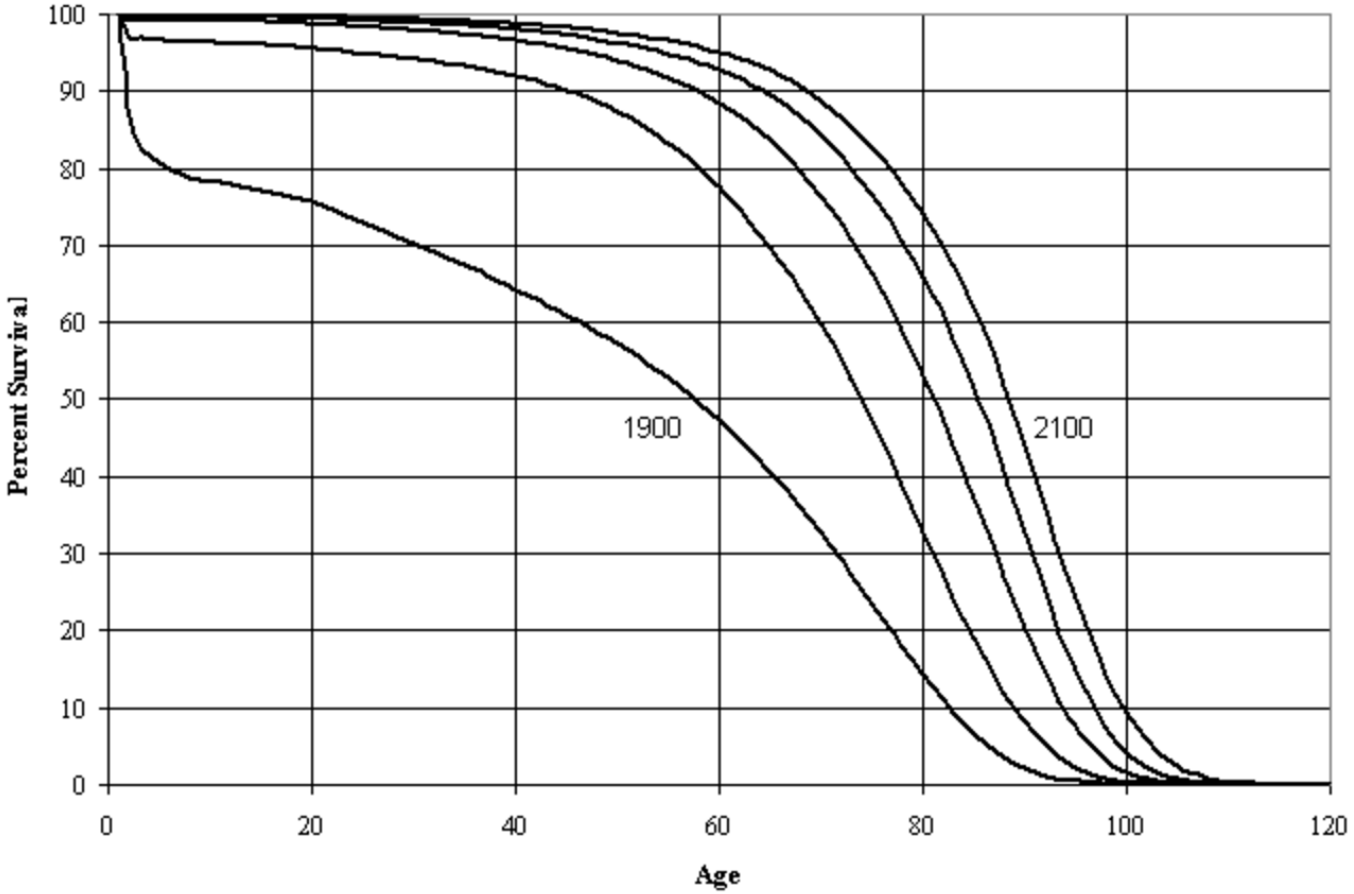




BROWN

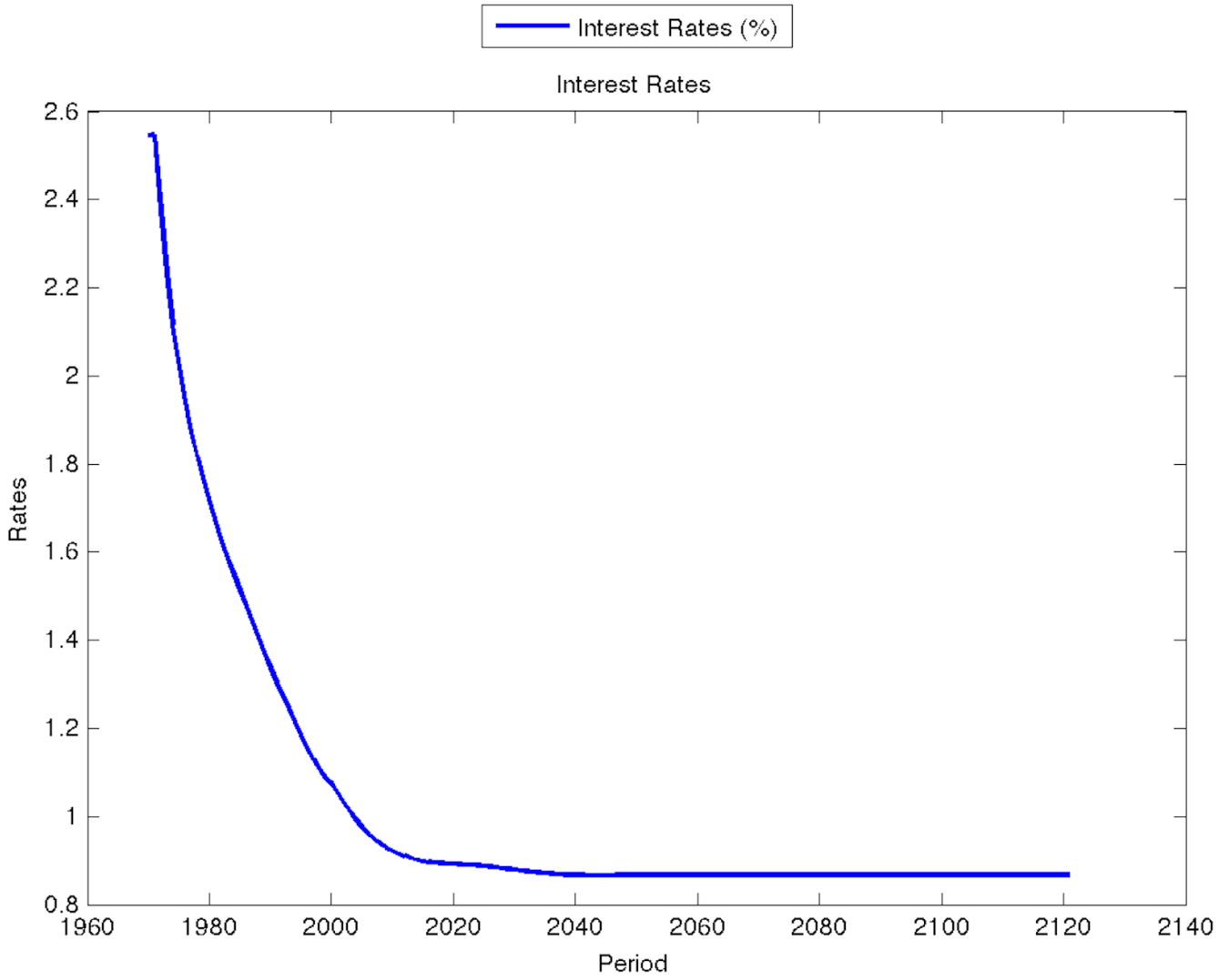
Transition path: mortality

Figure 5—Survival Function for SSA Population
for Selected Calendar Years (1900, 1950, 2000, 2050, 2100)
(Based on Period Tables)



BROWN

Transition path: mortality



BROWN

Mechanism: Asset Supply Composition

BROWN

Mechanism

- Main mechanism – because the elderly hold the largest proportion of wealth, a greater proportion of elderly leads to an increase in the supply of assets
- Because of this composition effect, there is also a decrease in labor supplied, thus the capital supplied per worker increases even more
- Seems to be completely general to multiperiod OLGs

Mechanism – Even larger in the data than in models

BROWN

Key parameter: EIS

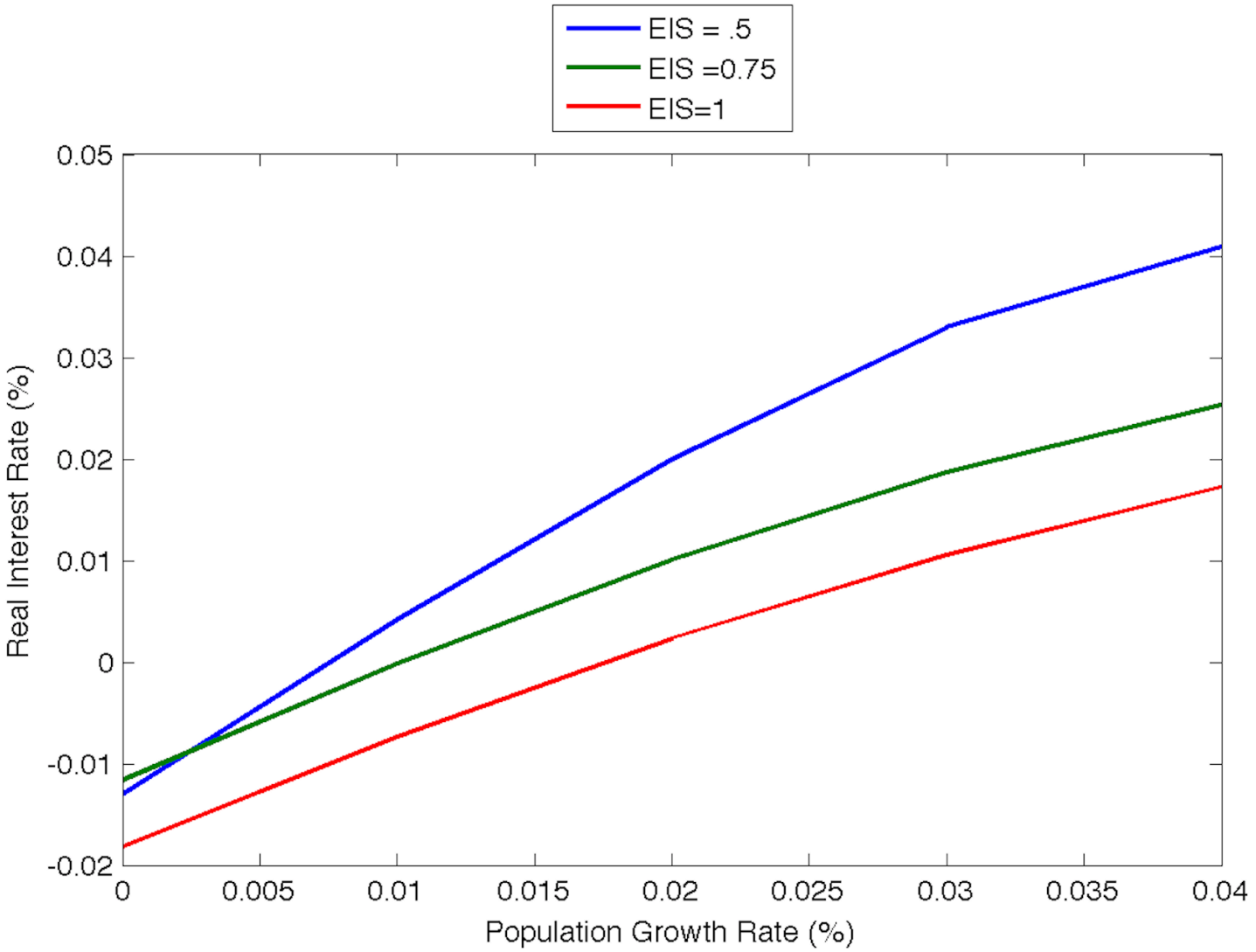


Table 4: Change in parameters from 1970 to 2015

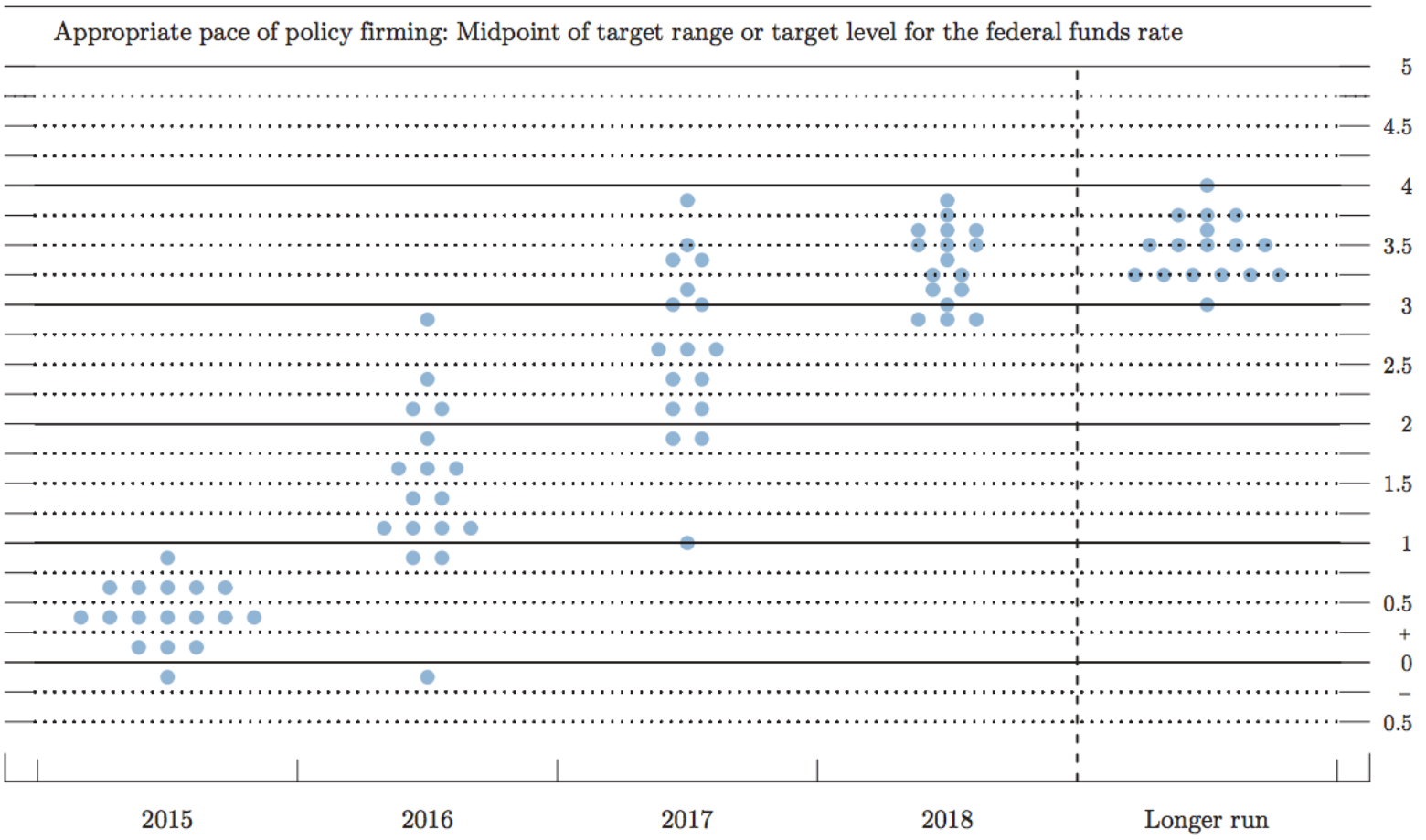
Panel A: Data	*1970*	*2015*
Life expectancy	70.7	78.7
Total fertility rate	2.8	1.9
Productivity growth	2.02%	0.65%
Government debt (% of GDP)	42%	118%
Panel B: Relative price of investment		
Relative price of investment (index 100=2015)	130	100
Panel C: Change in targets		
Consumer-debt-to-output ratio	4.2%	6.3%
Labor share	72.4%	66.0%

Results

Table 6: Decomposition of the decline in the natural rate of interest: 1970-2015

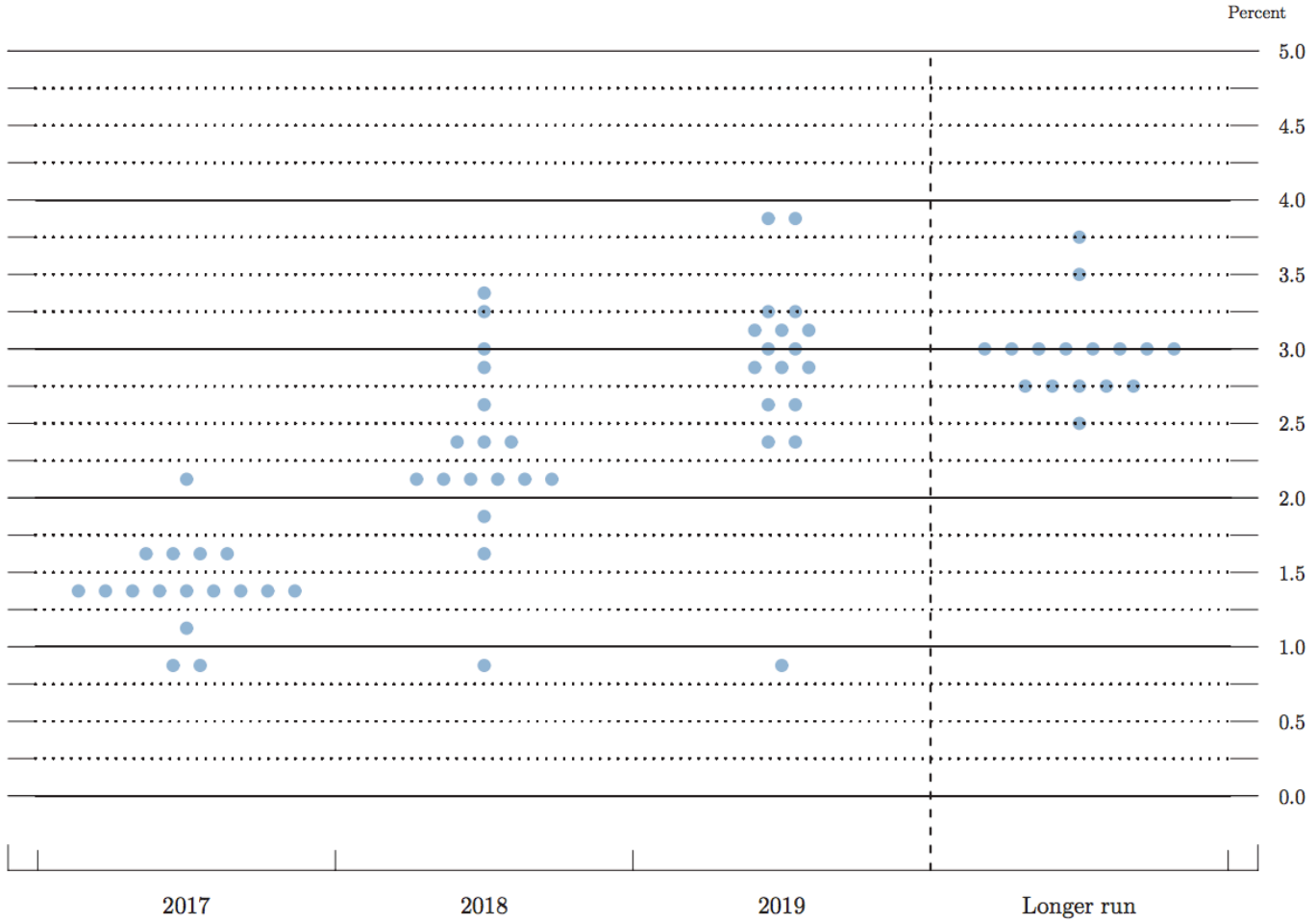
Forcing variable	Δ in r	% of total Δ
Total interest rate change	-4.02%	100%
Mortality rate	−1.82	43%
Total fertility rate	−1.84	43%
Productivity growth	−1.90	44%
Government debt (% of GDP)	+2.11	−49%
Labor share	−.52	12%
Relative price of investment goods	−0.44	10%
Change in debt limit	+.13	-3%

The Fed's View -- 2015



BROWN

The Fed's View -- 2017

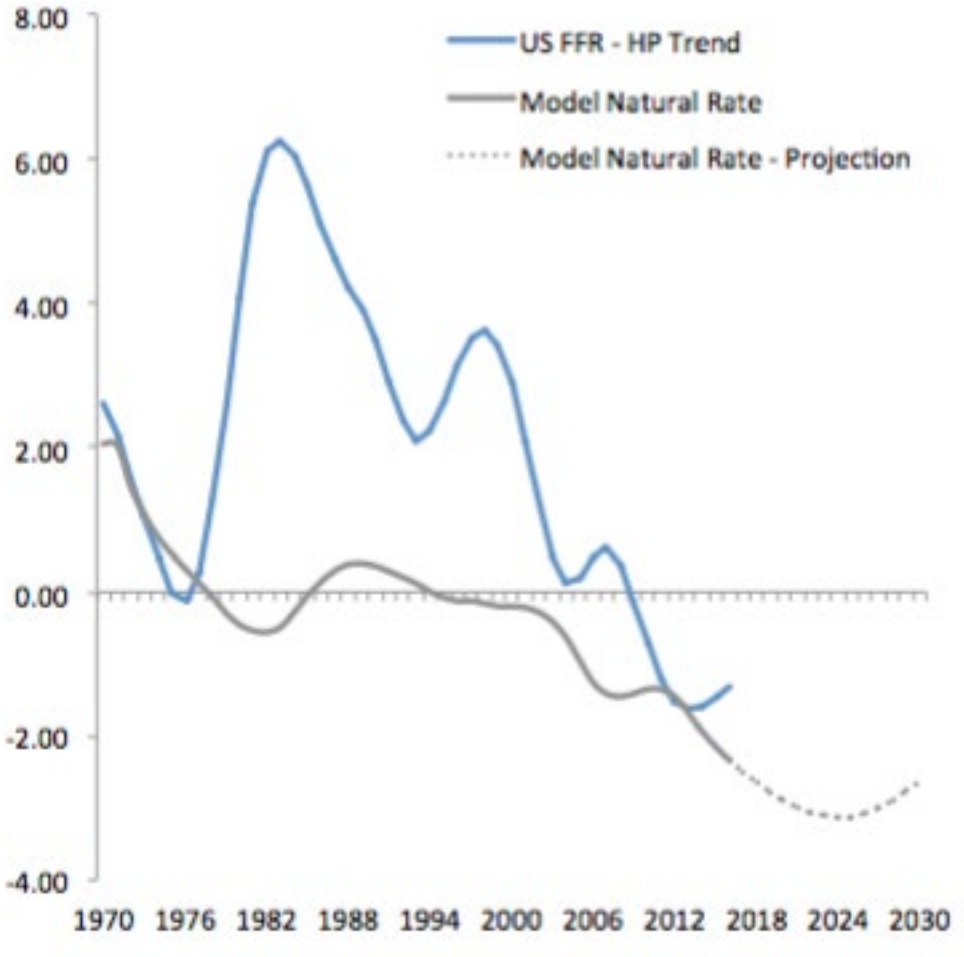


BROWN

Yellen, March 2017:

- “In the Committee's most recent projections last December, most FOMC participants assessed the longer-run value of the neutral real federal funds rate to be in the vicinity of 1 percent. This level is quite low by historical standards, reflecting, in part, slow productivity growth and an aging population not only in the United States…”

Full Transition Path



BROWN

Conclusion

- Our model suggests the US may be in a "new normal", with a permanently lower neutral rate of interest

- This has business cycle implications with the ZLB going forward

Restoring a positive natural rate

- FOMC anticipates a long-run neutral rate of 1%
- What changes are needed to raise the natural rate to that level?

Table 7: Raising the natural rate of interest to 1%

Forcing variable	*2015* Value	*Counterfactual value*
Total fertility rate	1.88	3.28
Government debt (% of GDP)	118%	215%
Productivity growth	0.65%	2.43%
Relative price of investment goods	1.00	2.43

Secular stagnation equilibrium

- Pose the question: what happens if natural rate is -3%, and inflation target by central bank is 2%?
- Now, add two elements to the model:
  - Monetary policy rule (Taylor rule)
  - Downward nominal wage rigidity

Wage Rigidity

- Tractable way of implementing wage rigidity: wage norm.
- Household will never accept wage below norm

$$\tilde{W}_t = \gamma W_{t-1} + (1-\gamma) W_t^{flex}$$

- Then wages are given by

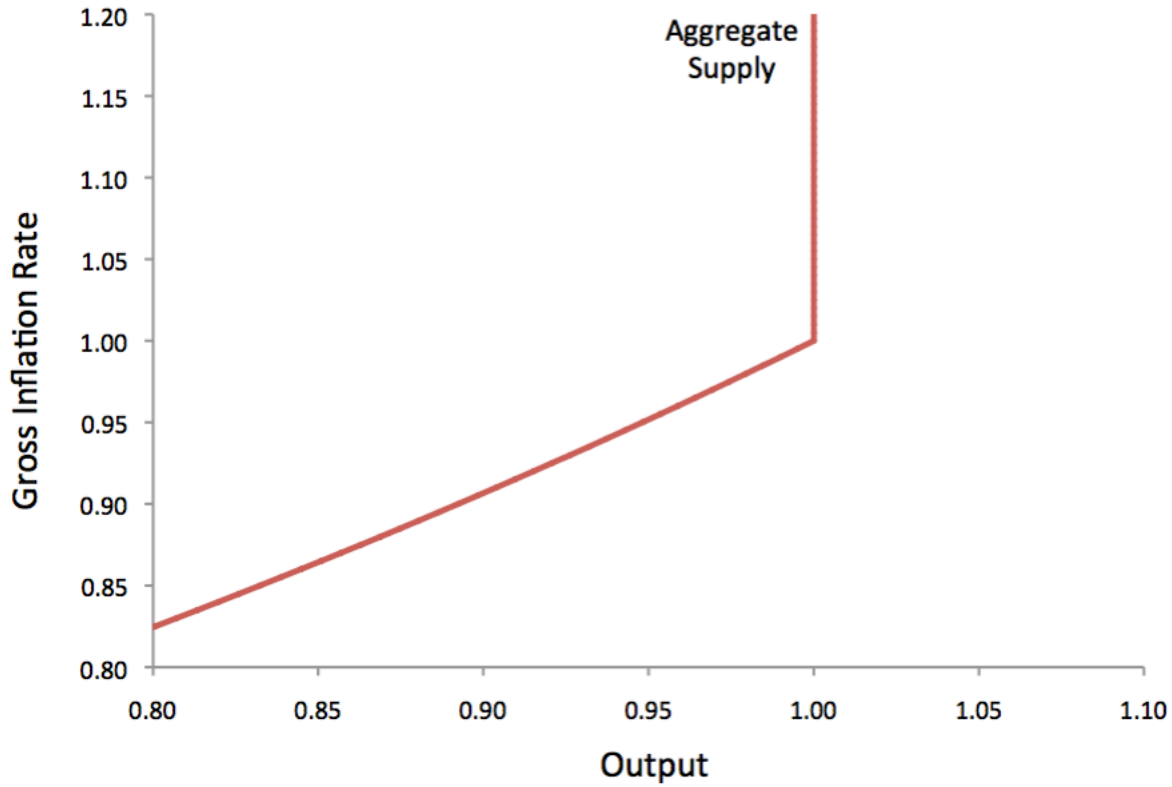
$$W_t = \max\left\{\tilde{W}_t, W_t^{flex}\right\} \text{ where } \tilde{W}_t = \gamma W_{t-1} + (1-\gamma) W_t^{flex}$$

Wage rigidity

- If there is deflation in the steady state ($\Pi < 1$), leads to upward sloping aggregate supply curve

$$\frac{\gamma}{\Pi} = 1 - (1-\gamma)\left(\frac{Y}{Yf}\right)^{\frac{1-\alpha}{\alpha}} \quad \text{for } \Pi < 1.$$

Wage rigidity



BROWN

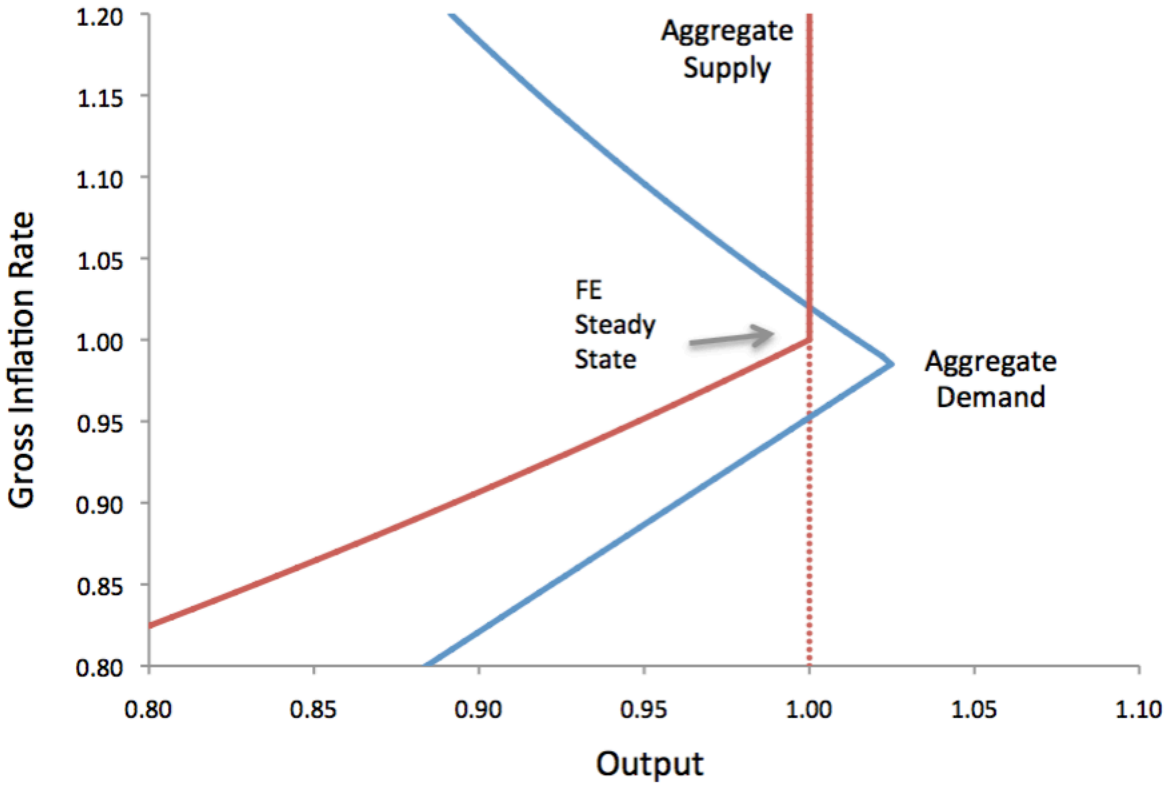
Monetary Policy

- Standard Taylor Rule

$$1 + i_t = \max\left(1, (1 + i^*)\left(\frac{\Pi_t}{\Pi^*}\right)^{\phi_\pi}\right)$$

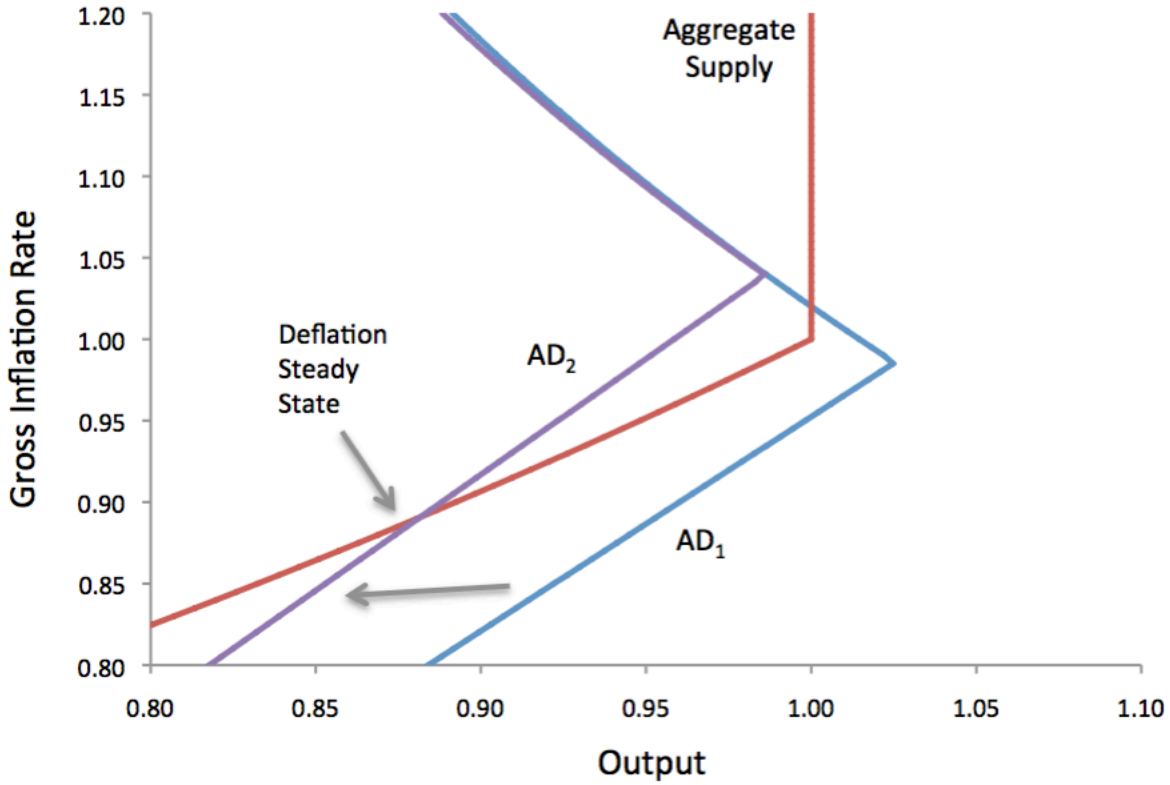
- Where i* and Π* are parameters of monetary policy rule

Result: Kinked AD curve



BROWN

In a secular stagnation

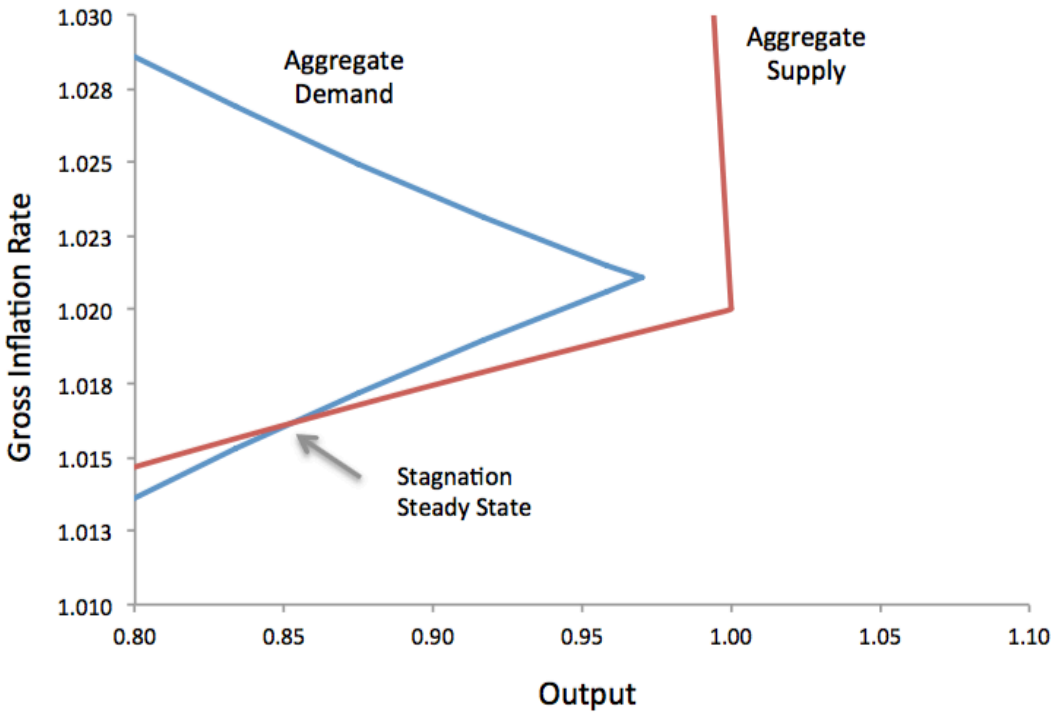


BROWN

Quantitative secular stagnation

- Calibrate the model to the US in 2015, to match
  - Output gap of 15% (Hall 2016)
  - Inflation below target at 1.62%, to match data

Secular stagnation results



BROWN