College Education and Income Contingent Loans in Equilibrium

Theory and Quantitative Evaluation

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Motivation

Policy makers support student loan programs to increase equality of opportunity.

- outstanding student debt at \$1.6 trillion in 2019 (2nd after mortgage).

However, investment into college education is risky.

- 50% of college enrollees drop out and have low income.

In 2009, US Congress enacted a program of income-contingent loans (ICLs).

- increasing repayment flexibility + forgiving debt,
- today ≈30% of borrowers use ICLs (≈45% of total student debt).

This paper

Research question:

- What are the welfare implications of income-contingent loans (ICLs)?

What we do

- second-best analysis in simple model with incomplete markets & unobservable effort for graduation,
- build a quant model and examine welfare implications of the US ICLs,
- examine welfare changes if we vary the structure of ICLs.

Preview of results

Theoretically, we show that ICLs:

- can achieve 2nd best in economy with incomplete mkts & moral hazard.
- increase enrollment but decrease graduation.

Quantitatively:

- The current US structure of ICLs improves overall welfare.
- Non-linear structure of ICLs critical to delivering high welfare.

Theoretical Model

Theoretical environment

- Measure 1 of risk-averse agents with hetero taste χ maximizing:

$$\max \left\{ \underbrace{u(c_{HS}),}_{\text{non enrollment}} \quad \underbrace{\max_e p(e)u(c_{CG}) + (1-p(e))u(c_{CD}) - v(e) + \chi}_{\text{enrollment}} \right\}$$

subject to:

$$c_i + (1+r)\,\varphi \cdot 1_{i=CD,CG} \leq w_i.$$

- **Period 1:** Decide enrollment and effort e.
- **Period 2:** *Uninsurable* graduation shock realizes and

$$w_i = \begin{cases} w_{CG} & \text{with } p(e), \text{ if enrolled} \\ w_{CD} & \text{with } 1-p(e), \text{ if enrolled} \\ w_{HS} & \text{if not enrolled} \end{cases}$$

where $w_{CG} > w_{CD} > w_{HS}$.

Theoretical results: Second-best

Consider *a second-best allocation* where the planner:

- maximizes utilitarian welfare,
- can freely redistribute resources between agents,
- respects incentive compatibility for enrollment and effort decisions.

Proposition

1. *A mix of* φ_{CD}, φ_{CG} *(ICLs), and* τ_{HS} *(tax/subsidy for HS) such that*

$$c_{HS} \leq (1 - \tau_{HS}) w_{HS}$$

$$c_i + (1+r)\varphi_i \leq w_i \text{ if } i \in \{CD, CG\}$$

can attain the second-best allocation.

2. *Partial insurance is optimal:* $\varphi_{CD} < \varphi_{CG}$ *and* $c_{CD} < c_{CG}$*.*

Theoretical results: Constrained second-best

Proposition

1. *A mix of ICLs* φ_{CD}, φ_{CG} *with* $\tau_{HS} = 0$ *can attain the second best allocation with constraint* $c_{HS} = w_{HS}$.
2. *Partial insurance is optimal:* $\varphi_{CD} < \varphi_{CG}$ *and* $c_{CD} < c_{CG}$.
3. ***Enrollment increases after the ICLs.***
4. ***Effort decreases after the ICLs.***

Quantitative Model

Quantitive Model Overview

- Hetero agents w.r.t. ability, wealth and labor productivity.
- Life-cycle in OLG (enrollment, college, working, retirement stages).
- GE effects with capital and imperfectly substitutable skill types.
  - Imperfect substitution gives rise to endogenous college wage premium.
- Missing insurance for graduation and labor productivity shocks.

Demography and life-cycle

Population is made of three types of workers, e:

- high school graduates (HS),
- college dropouts (CD),
- college graduates (CG).

Life-cycle: one period = 2 years

- newborns become independent at age 18 and decide to enroll or not,
- college takes 4 years and graduation shock realizes right in the middle,
- transfer assets to their children at age 46,
- retire at age 66 and face stochastic survival probability after that.

Student loan repayment regimes

- Enrollees receive $0.5\underline{A}_c = \$11,500$ for the 1st period of college.
- If they don't drop out, they receive further $0.5\underline{A}_c$ for the 2nd period.

Fixed (status-quo) loan repayments:

- $\bar{T}$ periods (=20 years) of constant repayments:

$$\bar{\ell}(e)^F = \begin{cases} 0.5\underline{A}^c \frac{(1+r^-)^{\bar{T}}}{(1+r^-)^{\bar{T}}-1} \cdot r^- & \text{if } e = CD \\ \underline{A}^c \frac{(1+r^-)^{\bar{T}}}{(1+r^-)^{\bar{T}}-1} \cdot r^- & \text{if } e = CG \end{cases}$$

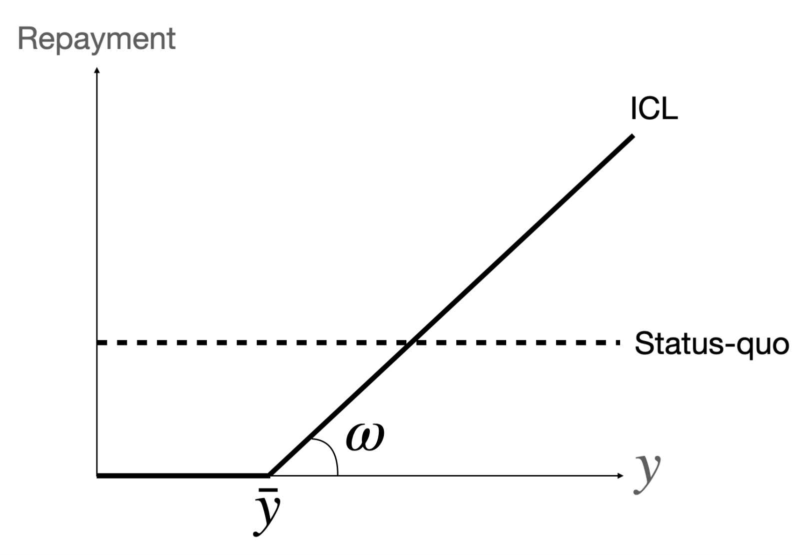
Reform of ICLs:

- repayment of share ω (=10%) of disposable income $y > \bar{y}$ (=\$30,000):

$$\bar{\ell}_j(e,y)^{ICL} = \min\{\omega \cdot \max\{0, y - \bar{y}\}, \bar{\ell}(e)^F\}$$

- debt forgiven if not repaid in $\bar{T}$ periods (=20 years).

ICL vs status-quo



Enrollment stage

$$V_0(a, \theta, \eta, \chi) = \max\{\underbrace{V_1^c(a, \theta, \eta) + \lambda_\chi \chi}_{\text{enrolling}}, \underbrace{V_1(a, HS, \theta, \eta)}_{\text{not enrolling}}\}$$

- a: parental transfer
- θ: innate ability (correlated with parent's)
- η: idiosyn. prod
- χ: college taste

College stage

$$V_1^c(a,\theta,\eta) = \max_{c,h_l,h_e,a'} u(c, 1-h_l-h_e) - \lambda_\theta(\theta)$$
$$+\ \beta\mathbb{E}_{\eta'}(p(h_e;\theta) \underbrace{V_2^c(a',\theta,\eta')}_{\text{proceed to second period}} + (1-p(h_e;\theta)) \underbrace{V_2(a',CD,\theta,\eta')}_{\text{dropout}})$$

subject to:

$$c + a' + 0.5\cdot(\varphi - s) = (1+r)a + 0.5\underline{A}_c + w^{HS}\varepsilon_1^{HS}(\theta,\eta)h_l - T(c, a, w^{HS}\varepsilon_1^{HS}(\theta,\eta)h_l)$$
$$a' \geq 0,\ \ 0 \leq h_l + h_e \leq 1,\ \ h_{l/e} \in [0,1],\ \ c \geq 0,\ \ \eta' \sim \pi^e(\cdot|\eta)$$

- Choose consumption c, assets a', labor hours h_l, study time h_e.
- Study time increases probability of proceeding $p(h_e;\theta)$.
- $\varphi - s$: net tuition
- λ_θ: psychic cost

Working stage

Agents decide about labor supply, saving or loan repayments:

$$V_j(a,e,\theta,\eta) = \max_{c,h_l,a'} u\left(\frac{c}{1+\mathbf{1}_{\mathcal{J}_f}\zeta}, 1-h_l\right) + \beta\mathbb{E}_{\eta'|\eta}V_{j+1}(a',e,\theta,\eta')$$

subject to

$$c + \bar{\ell}_j^* + a' = (1+r)a + w^e\varepsilon_j^e(\theta,\eta)h_l - T(c,a,w^e\varepsilon_j^e(\theta,\eta)h_l)$$

$$a' \geq 0, \;\; \eta' \sim \pi^e(\cdot|\eta)$$

$$\mathbf{1}_{\mathcal{J}_f} = 1 \; if \;\; age \in [30,46]$$

- Repayment $\bar{\ell}_j^* \in \{\bar{\ell}_j(e)^F, \bar{\ell}_j(e,y)^{ICL}\}$ depends on the institutional setup (fixed repayments or ICL).
- $\bar{\ell}_j^*$ will be zero from the $\bar{T}+1^{st}$ period after leaving the college.

Further life-cycle stages

- At j_b parents transfer assets to children after observing their ability.

  ▸ Transfer Stage

- After j_r, retire (no labor) and consume their pension and savings.

  ▸ Retirement Stage

Production sector

- A representative firm produces final good from capital K and aggregate labor H:

$$Y = F(K, H) = K^{\alpha} H^{1-\alpha}$$

- H is composed of two skills: skilled labor H^S and unskilled labor H^U:

$$H = (a(H^S)^{\rho} + (1-a)(H^U)^{\rho})^{\frac{1}{\rho}}$$

  where ρ is calibrated to match the elasticity of substitution 1.64.

  - CG work as skilled labor
  - HS and CD work as unskilled labor

Government

The government collects tax revenue using:

$$T(c, a, y) = \tau_c c + \tau_k r a \mathbf{1}_{a \geq 0} + \tau_l y - \psi$$

and spends it on:

- student loan $\underline{A}_c$ net of repayment $\bar{\ell}_j^*$
- college subsidies s,
- other (wasteful) government consumption,
- retirement benefits.

Calibration strategy

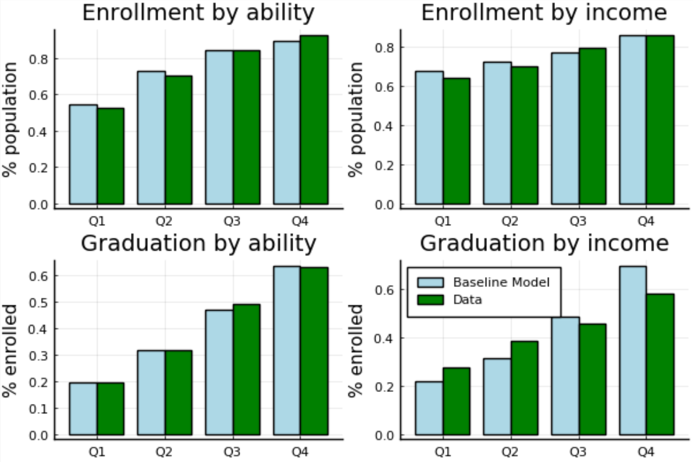
Model is calibrated in stages:

1. set based on literature and institutional setup in the US,
   ▸ Parameter Values
    - loan system, cost of college, production function, government tax system
2. use microdata from PSID and NLSY79, ▸ Labor Productivity
    - labor productivity process over agents' life-cycle for each edu-group
    - intergenerational ability transmission
3. use Simulated Method of Moments for the remaining parameters.
   ▸ Remaining Parameters
    - preferences, grad. probability f-n, lump sum transfer

Calibration fit: SMM targets

Moment	Model	Data
Enrollment rate of ability quartile	(figure)	(figure)
Graduation rate of ability quartile	(figure)	(figure)
Enrollment rate of family income quartile	(figure)	(figure)
Skill premium for CG	89.7%	90.2%
Skill premium for CD	20.0%	19.9%
Hours of work	32.9%	33.3%
Aggregate capital / output	1.338	1.325
Inter-vivo transfer / mean income at 48	73.4%	72.1%
Var log post-tax / var log pre-tax income	0.60	0.61

Calibration fit: enrollment and graduation



Calibration fit: non-targeted moments

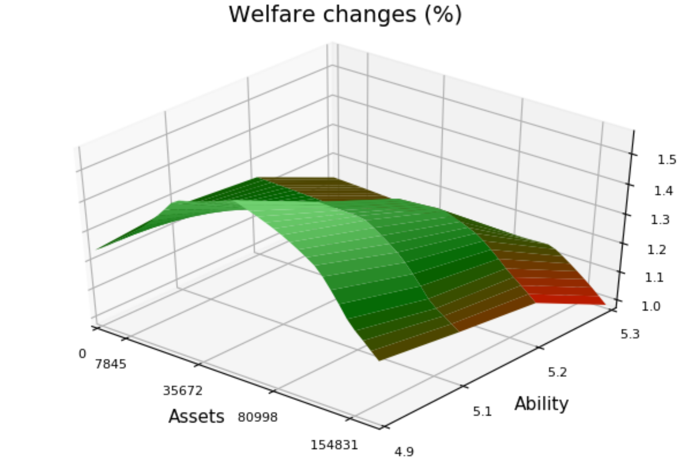
- Graduation patterns along income quartiles matched well.
- Life-cycle decision patterns in line with literature.
- Tax progressivity in line with Heathcote et al [2017]. ▸ Tax progressivity
- In line with micro-evidence, upon a $1,000 subsidy:
  - Enrollment increases by 1.8 p.p.
  - Graduation increases by 2.59 p.p.

Quantitative Results

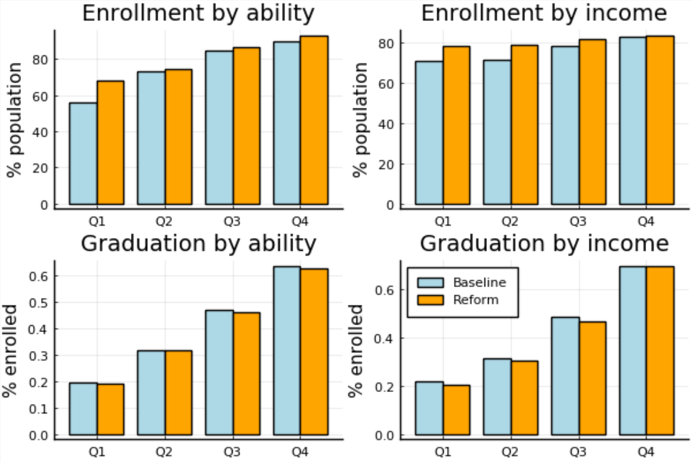
Result 1: US ICLs improve welfare of everyone

Statistic	Fixed	ICL
Average cons.-eq. welfare gain		+1.16%
Average cons.-eq. welfare gain for HS		+0.27%
Average cons.-eq. welfare gain for CD		+1.95%
Average cons.-eq. welfare gain for CG		+1.26%
Consumption inequality (Gini)	28.3%	27.5%
Share of college enrollees	74.6%	80.0%
Share of college graduates	31.4%	32.4%
Skill premium	89.7%	83.6%
Mean effort	23.0%	21.9%
Take-up of ICLs	N/A	79.9%
Mean repayment by CG	\$2,097	\$1,457
Mean repayment by CD	\$992	\$621
Labor income tax rate	35.7%	35.9%
Aggregate output	0.284	0.285

Low ability & middle income benefit most



Heterogenous enrollment and graduation impact of ICLs



- ICLs increase enrollment and decrease graduation rate.

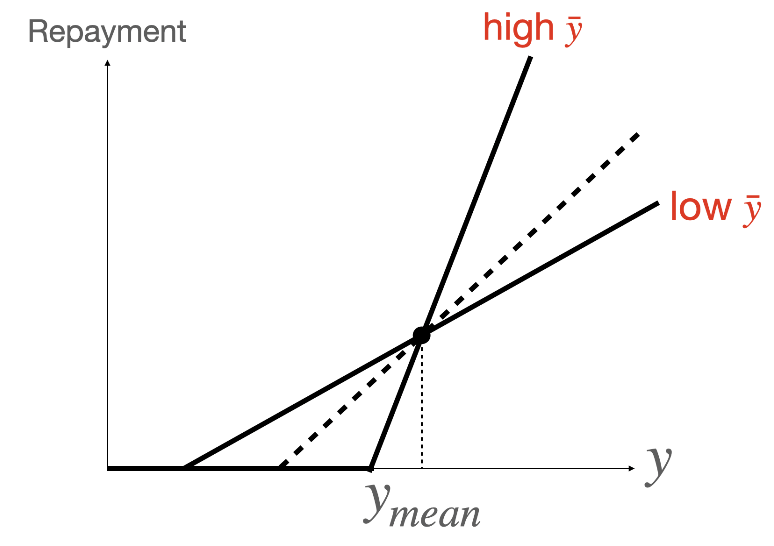
Result 2: Varying the ICL structure

- Examine welfare changes if we vary the structure of ICLs.
- Varying the threshold $\bar{y}'$ and find ω' balancing budget in expectation:

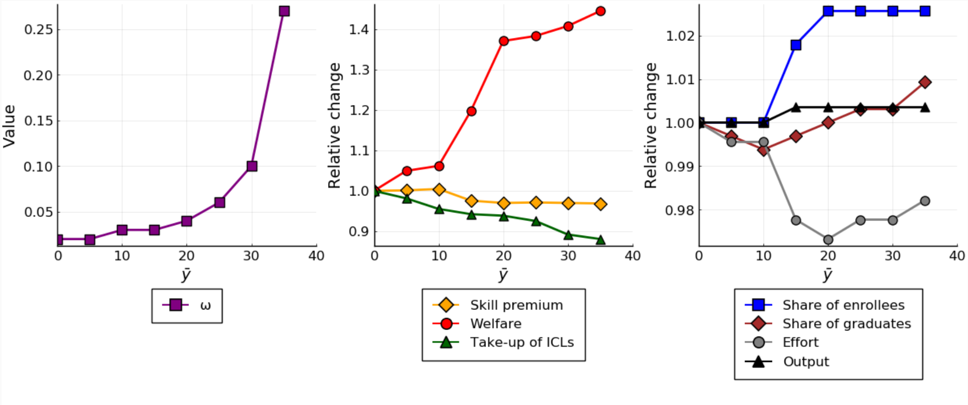
$$\omega'(y_{mean} - \bar{y}') = \omega(y_{mean} - \bar{y})$$

where y_{mean} is the mean income of repayers under current ICLs in US.

Tradeoff between ω and $\bar{y}$



Importance of poverty threshold for welfare



Wrapping up

- ICLs can implement Second Best in a model with incomplete markets and moral hazard.
- ICLs increase enrollment, but decrease graduation.
- Calibrated framework shows ICLs improve welfare of everyone (in long-run).
- The current structure of ICLs in the US seems optimal.

Thank you!

Every feedback highly appreciated:

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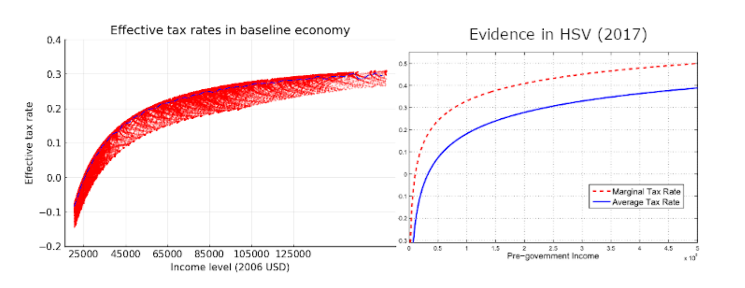
Tax progressivity: model and empirics



▸ Back

Transfer stage

$$V_{j_b}(a, e, \theta, \theta', \eta) = \max_{c \geq 0, h_l \in [0,1], a', b} u(c, 1 - h_l) + \beta \mathbb{E}_{\eta' | \eta} V_{j_b+1}(a' - b, e, \theta, \eta') + \nu \mathbb{E}_{\eta'', \chi} V_0(b, \theta', \eta'', \chi)$$

subject to:

$$c + a' = w^e \varepsilon_j^e(\theta, \eta) h_l + (1 + r)a - T(c, a, y)$$

$$a' \geq 0$$

$$\eta' \sim \pi^e(\cdot | \eta), \;\; \eta'' \sim \Pi^{HS}, \;\; \chi \sim N(0, 1)$$

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Retirement stage

$$V_j(a, e, \theta) = \max_{c, a'} u(c, 1) + \beta \zeta_j V_{j+1}(a', e, \theta)$$

subject to:

$$c + a' = (1 + r)\zeta_{j-1}^{-1} a + P(e, \theta) - T(c, \zeta_{j-1}^{-1} a, 0)$$

$$a' \geq 0 \;\; c \geq 0.$$

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Parameter values

parameter	interpretation	value	target/source
		externally determined	
γ	coefficient of relative risk aversion	4	modelling choice, CRRA=2
ζ	adult equivalence scale	0.3	literature
α	capital share of GDP	33.3%	literature
δ	depreciation (annual)	7%	Kruger and Ludwig (2016)
ρ	elasticity of substitution in production	0.39	elast.=1.64, Katz and Murphy (1992)
$\epsilon^{CG}, \epsilon^{HS}$	prod. intercept for CG, HS	1	normalization
ψ_j^e	labor prod. at age j for $e \in \{HS, CD, CG\}$	Estimates	Appendix E, PSID
ϵ_θ^e	e-specific effect of ability on prod.	(0.58,0.65,1.08)	Appendix E, NLSY 79
ρ^e	e-specific persistence of idiosyn. shocks	(0.94,0.96,0.94)	Appendix E, PSID
$\sigma_\eta^{2,e}$	e-specific variance of idiosyn. shocks	(0.02,0.02,0.03)	Appendix E, PSID
ι	Stafford interest premium (annual)	2.3%	US Department of Education
$\underline{A}^c$	Stafford borrowing constraint	\$23,000	US Department of Education
$\bar{y}$	ICL poverty threshold	\$30,000	150% of 2000 fed poverty level, CBO (2020)
ω	ICL minimum repayment rate	10%	CBO (2020)
$\bar{T}$	student loan repayment period	20 years	CBO (2020), Scherschel (1998)
φ	net tuition fee (annual)	\$11,018	College Board, US Dept. of Education
s	government college subsidies (annual)	\$1,183	US Dept. of Education
τ_c	consumption tax rate	8%	McDaniel (2007)
τ_k	capital income tax rate	29%	McDaniel (2007)
g	gov cons.+investment-edu./GDP	17%	BEA, OECD

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The Remaining Parameters

	internally determined (jointly using SMM)		
$p_\theta(\theta)$	θ-dependent slope of graduation prob. f-n	(1.17, 0.855, 0.927, 1.24)	grad. profile, Fig. ??/NLSY97
$\lambda_\theta(\theta)$	θ-dependent psychic cost	(-5.72, -14.6, -21.5, -24.4)	enrol. profile, Fig. ??/NLSY97
λ_χ	college taste-slope	33.0	enrol. profile, Fig. ??/NLSY97
a^S	productivity of skilled labor	0.499	CG-HS skill premium, CPS
ϵ^{CD}	productivity intercept of CD	1.09	CD-HS skill premium, CPS
μ	consumption share of preference	0.404	7.5 hours of work per day
β	time discount rate	0.953	capital/output ratio, F.-V. and K. (2011)
ν	altruism parameter	0.116	transfer/mean income at 48, Daruich (2018)
ψ	lump-sum transfer	0.0341	log pre-tax/post-tax income, HPV (2010)

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Labor Productivity

- We assume labor productivity

$$\ln \epsilon_j^e(\theta, \eta) = \ln \epsilon^e + \ln \psi_j^e + \epsilon_\theta^e \theta + \ln \eta$$

- Normalize $\epsilon^{HS} = \epsilon^{CG} = 1$ and calibrate ϵ^{CD} to match the college dropout premium.

- ψ_j^e is the age profile of workers at age j estimated from PSID.

	HS	CD	CG
Age	.0530181	.0684129	.0955783
	(.0030501)	(.0040353)	(.0036997)
Age^2	-.0005314	-.0006872	-.0009521
	(.0000356)	(.0000474)	(.0000429)

- We assume $\pi_\eta^e(\eta'|\eta)$ is a two-state Markov chain approximating

$$\ln \eta' = \rho^e \ln \eta + \epsilon_\eta^e, \quad \epsilon_\eta^e \sim N(0, \sigma_\eta^{e2})$$