Optimal Long-Run Fiscal Policy with Heterogeneous Agents

Adrien Auclert Stanford
Michael Cai Northwestern
Matt Rognlie Northwestern
Ludwig Straub Harvard

Ramsey with heterogeneous agents

- Many successes of heterogeneous-agent models à la Bewley-Aiyagari-Huggett
  - precautionary saving, MPCs, income & wealth inequality; banks, countries, …

Ramsey with heterogeneous agents

- Many successes of heterogeneous-agent models à la Bewley-Aiyagari-Huggett
  - precautionary saving, MPCs, income & wealth inequality; banks, countries, …
- All of these: **positive** properties of these models

Ramsey with heterogeneous agents

- Many successes of heterogeneous-agent models à la Bewley-Aiyagari-Huggett
  - precautionary saving, MPCs, income & wealth inequality; banks, countries, …
- All of these: **positive** properties of these models
- Much less work on **normative** implications (hard!)
  - optimal capital & labor taxation? optimal level of public debt?

Ramsey with heterogeneous agents

- Many successes of heterogeneous-agent models à la Bewley-Aiyagari-Huggett
  - precautionary saving, MPCs, income & wealth inequality; banks, countries, …
- All of these: **positive** properties of these models
- Much less work on **normative** implications (hard!)
  - optimal capital & labor taxation? optimal level of public debt?
- **Today:** systematic exploration of **Ramsey steady state (RSS)** of Aiyagari models
  - propose **new, general "sequence-space" method** to compute Ramsey steady states

What has been done on this question?

- Aiyagari (1995), Chien Wen (2023): some theoretical results
- Dyrda Pedroni (2022): focus on transition, not RSS
- Acikgöz et al (2022): first paper to compute RSS *(with GHH)*
- Le Grand Ragot (2024): also compute RSS *(with GHH)*

What has been done on this question?

- Aiyagari (1995), Chien Wen (2023): some theoretical results
- Dyrda Pedroni (2022): focus on transition, not RSS
- Acikgöz et al (2022): first paper to compute RSS *(with GHH)*
- Le Grand Ragot (2024): also compute RSS *(with GHH)*

Large literature computes "optimal steady state" (OSS) instead of RSS

[e.g. Aiyagari McGrattan 1998 …]

What has been done on this question?

- Aiyagari (1995), Chien Wen (2023): some theoretical results
- Dyrda Pedroni (2022): focus on transition, not RSS
- Acikgöz et al (2022): first paper to compute RSS *(with GHH)*
- Le Grand Ragot (2024): also compute RSS *(with GHH)*

Large literature computes "optimal steady state" (OSS) instead of RSS

[e.g. Aiyagari McGrattan 1998 …]

- issue: OSS assumes infinitely patient planner, ignores transitional dynamics

Today: Sequence-space approach to RSS

- Get new, interpretable and fast-to-evaluate **RSS optimality condition**

Today: Sequence-space approach to RSS

- Get new, interpretable and fast-to-evaluate **RSS optimality condition**
- **Main result:** RSS is extreme in many standard Aiyagari models!
    - (near-) immiseration: $\tau^l \to 100\,\%$, $C \to 0$
    - in some cases (e.g. GHH), RSS reasonable, but modified golden rule may fail

Today: Sequence-space approach to RSS

- Get new, interpretable and fast-to-evaluate **RSS optimality condition**
- **Main result:** RSS is <u>extreme</u> in many standard Aiyagari models!
  - (near-) immiseration: $\tau^l \to 100\,\%$, $C \to 0$
  - in some cases (e.g. GHH), RSS reasonable, but modified golden rule may fail
- **Why?** insatiable need for liquidity + no Laffer curve for labor supply:
  - present value of labor supply ↑ in response to rising labor taxes

Standard heterogeneous-agent model

Households

$$\max_{\{c_{it}, n_{it}, a_{it}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_{it}, n_{it})$$

$$c_{it} + a_{it} = (1 + r_t)a_{it-1} + (1 - \tau_t)e_{it}n_{it} \qquad a_{it} \geq 0$$

Households

$$\max_{\{c_{it}, n_{it}, a_{it}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_{it}, n_{it})$$

$$c_{it} + a_{it} = (1 + r_t)a_{it-1} + (1 - \tau_t)e_{it}n_{it} \qquad a_{it} \geq 0$$

standard Markov process

Households

$$\max_{\{c_{it}, n_{it}, a_{it}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_{it}, n_{it})$$

$$c_{it} + a_{it} = (1 + r_t) a_{it-1} + (1 - \tau_t) e_{it} n_{it} \qquad a_{it} \geq 0$$

Interest rate and labor tax

standard Markov process

Households

$$\max_{\{c_{it}, n_{it}, a_{it}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_{it}, n_{it})$$

$$c_{it} + a_{it} = (1 + r_t) a_{it-1} + (1 - \tau_t) e_{it} n_{it} \qquad a_{it} \geq 0$$

Interest rate and labor tax

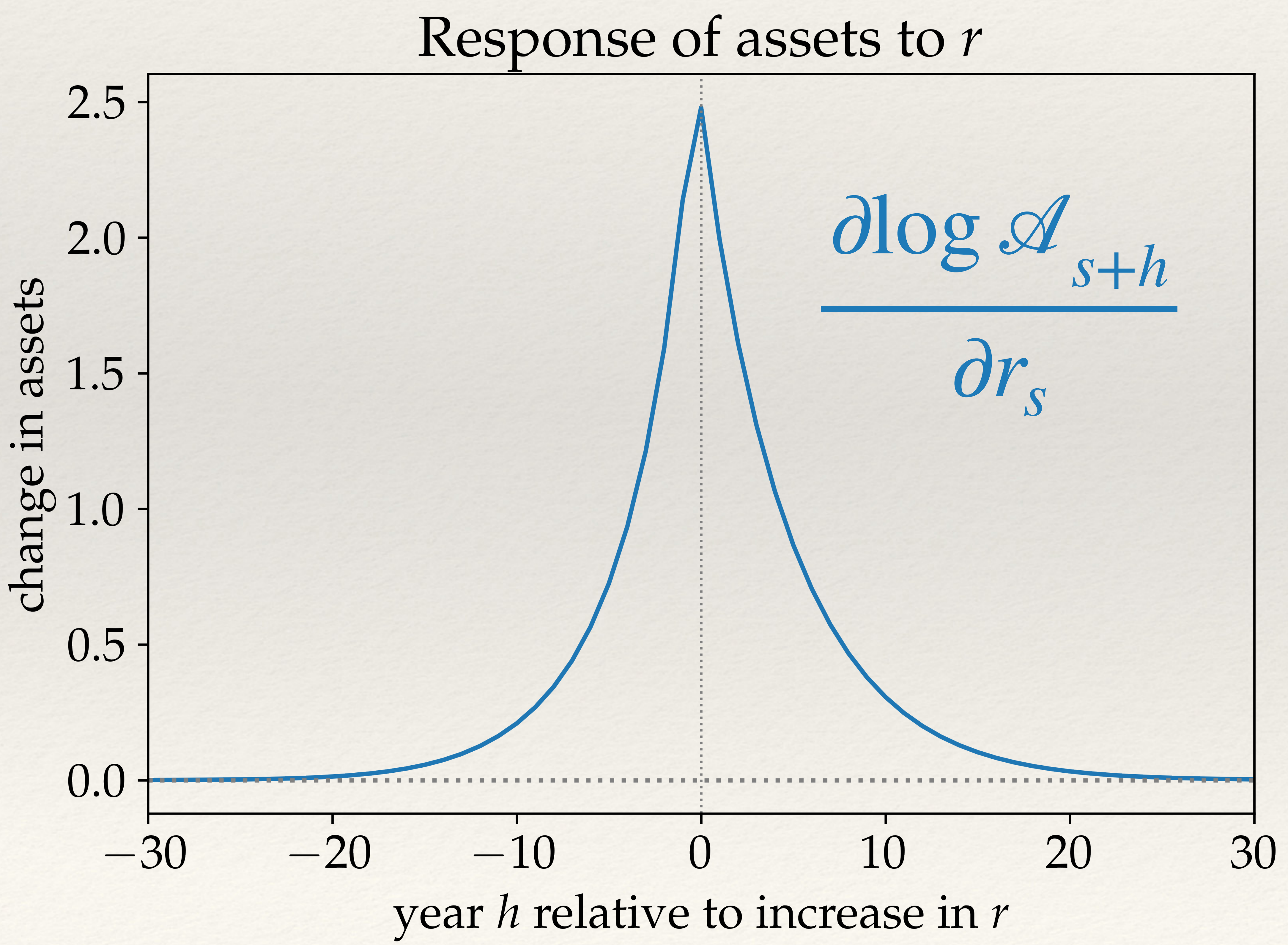
standard Markov process

Given $\{r_t\}$, $\{\tau_t\}$, can again aggregate household behavior using **sequence-space functions**:

Assets	$\mathscr{A}_t(\{r_s, \tau_s\}) = \int a_t dD_t$
Effective labor	$\mathscr{N}_t(\{r_s, \tau_s\}) = \int e n_t dD_t$
Utility	$\mathscr{U}_t(\{r_s, \tau_s\}) = \int u(c_t, n_t) dD_t$

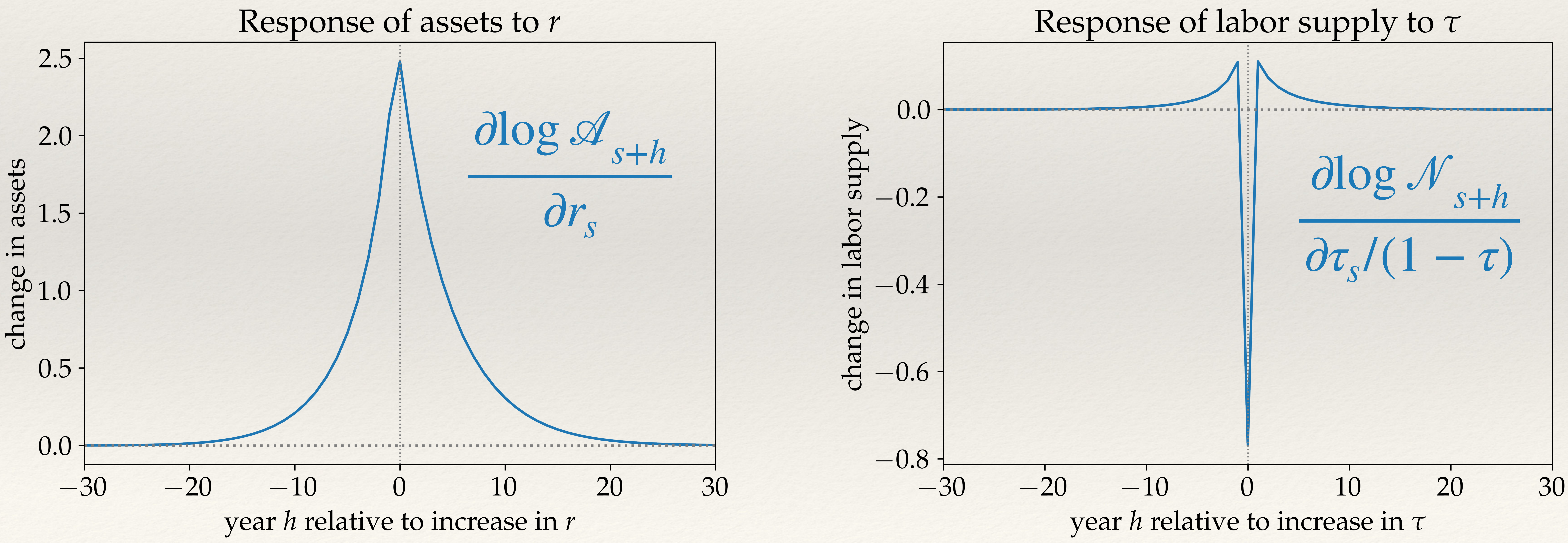
Infinitely anticipated shocks

- Consider **anticipated one-time** shock at some far-out future date s



Infinitely anticipated shocks

- Consider **anticipated one-time** shock at some far-out future date s



δ-discounted elasticities

- Define useful "discounted" version of these derivatives:

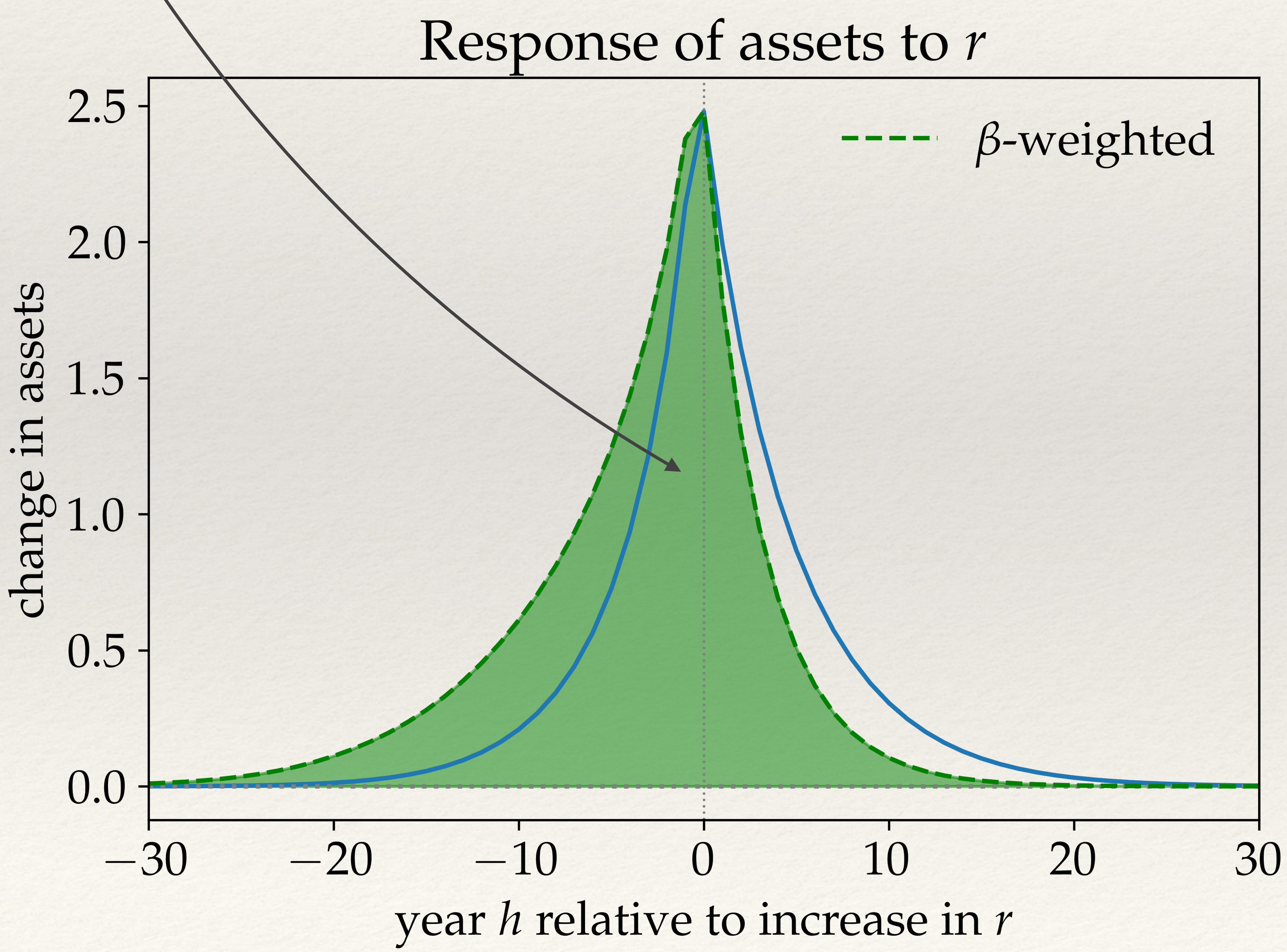
$$\epsilon^{A,r} \equiv \lim_{s\to\infty} \sum_{h=-\infty}^{\infty} \delta^h \frac{\partial \log \mathcal{A}_{s+h}}{\partial r_s} \qquad \epsilon^{N,\tau} \equiv \lim_{s\to\infty} \sum_{h=-\infty}^{\infty} \delta^h \frac{\partial \log \mathcal{N}_{s+h}}{\partial \tau_s/(1-\tau)}$$

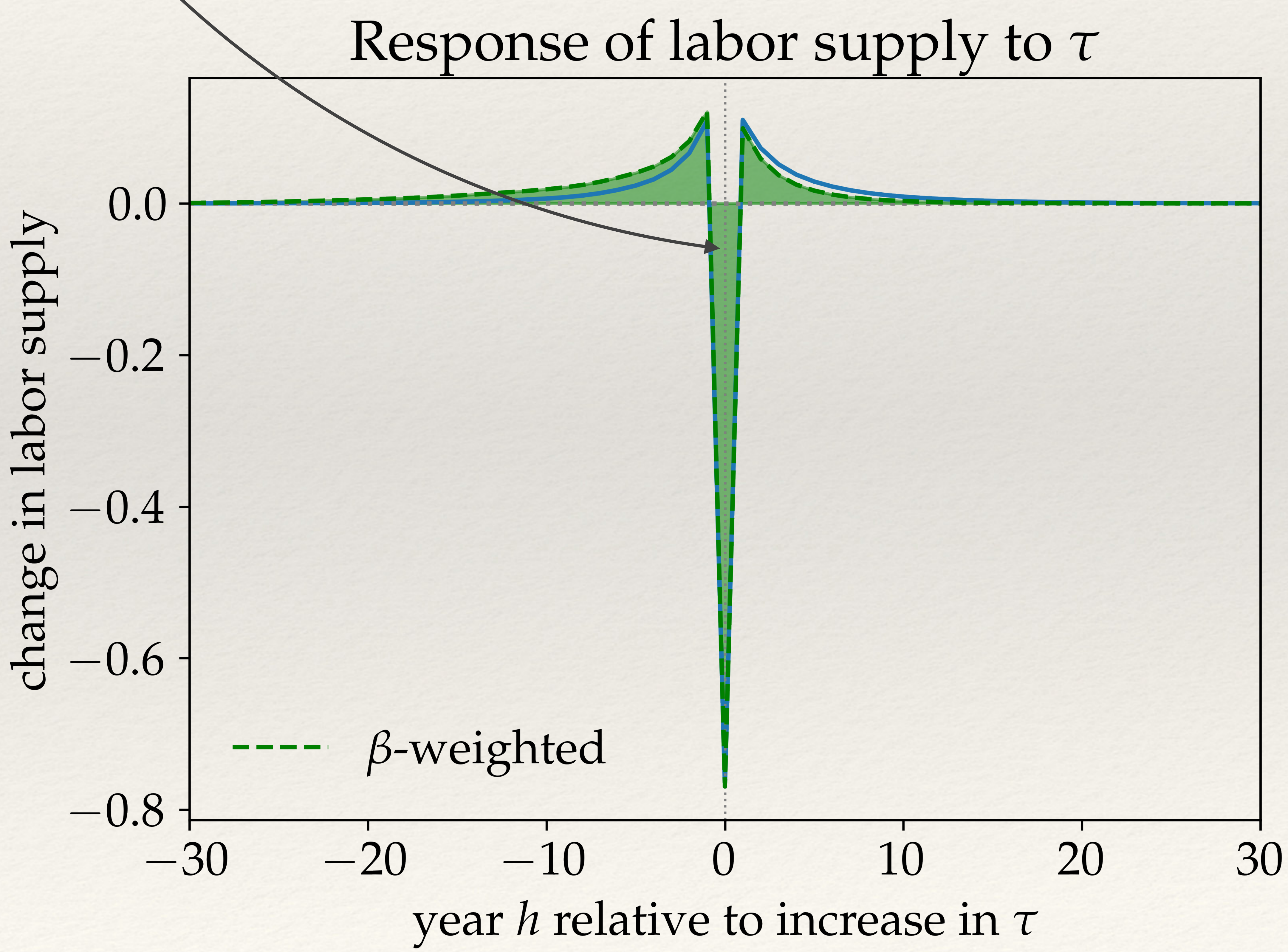
- These elasticities are discounted with some δ (later social discount factor)
- Define all the other elasticities similarly, e.g. $\epsilon^{N,r}$, $\epsilon^{A,\tau}$, $\epsilon^{U,r}$ etc
- Generalize similar elasticities in Piketty Saez (2013), Straub Werning (2020)

β-discounted elasticities

$$\epsilon^{A,r} \equiv \lim_{s\to\infty} \sum_{h=-\infty}^{\infty} \beta^h \frac{\partial \log \mathscr{A}_{s+h}}{\partial r_s} \approx 25$$

$$\epsilon^{N,\tau} \equiv \lim_{s\to\infty} \sum_{h=-\infty}^{\infty} \beta^h \frac{\partial \log \mathscr{N}_{s+h}}{\partial \tau_s/(1-\tau)} \approx 0.15$$





Production and government policy

- Representative firm: $Y_t = \mathcal{N}_t$, pre-tax wage = 1 (similar results with capital)
- Government: spends fixed $G > 0$ (can relax)
  - controls labor taxes and debt
  - subject to budget constraint: $G + (1 + r_t) B_{t-1} = B_t + \tau_t N_t$

Production and government policy

- Representative firm: $Y_t = \mathcal{N}_t$, pre-tax wage = 1 (similar results with capital)
- Government: spends fixed $G > 0$ (can relax)
  - controls labor taxes and debt
  - subject to budget constraint: $G + (1 + r_t) B_{t-1} = B_t + \tau_t N_t$
- **Implementability in the sequence space:** $\{r_s\}, \{\tau_s\}$ part of an equilibrium if

$$G + (1 + r_t) \mathcal{A}_{t-1}\left(\{r_s, \tau_s\}\right) = \mathcal{A}_t\left(\{r_s, \tau_s\}\right) + \tau_t \mathcal{N}_t\left(\{r_s, \tau_s\}\right)$$

Ramsey steady state

Ramsey problem

Full-commitment Ramsey problem, with arbitrary social discount factor δ

$$\max_{\{r_s, \tau_s\}_{s=0}^{\infty}} \quad \sum_{t=0}^{\infty} \delta^t \mathcal{U}_t(\{r_s, \tau_s\})$$

$$G + (1 + r_t)\, \mathcal{A}_{t-1}\left(\{r_s, \tau_s\}\right) = \mathcal{A}_t\left(\{r_s, \tau_s\}\right) + \tau_t \mathcal{N}_t\left(\{r_s, \tau_s\}\right)$$

Ramsey problem

Full-commitment Ramsey problem, with arbitrary social discount factor δ

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathcal{U}_t(\{r_s, \tau_s\})$$

$$G + (1 + r_t)\, \mathcal{A}_{t-1}\left(\{r_s, \tau_s\}\right) = \mathcal{A}_t\left(\{r_s, \tau_s\}\right) + \tau_t \mathcal{N}_t\left(\{r_s, \tau_s\}\right)$$

- If solution converges to well-defined steady state $(r_s \to r < 1/\beta - 1, \quad \tau_s \to \tau < 1)$ we call this steady state a **Ramsey steady state (RSS).**

Ramsey problem

Full-commitment Ramsey problem, with arbitrary social discount factor δ

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathcal{U}_t(\{r_s, \tau_s\})$$

$$G + (1 + r_t)\,\mathcal{A}_{t-1}\left(\{r_s, \tau_s\}\right) = \mathcal{A}_t\left(\{r_s, \tau_s\}\right) + \tau_t \mathcal{N}_t\left(\{r_s, \tau_s\}\right)$$

- If solution converges to well-defined steady state $(r_s \to r < 1/\beta - 1, \quad \tau_s \to \tau < 1)$ we call this steady state a **Ramsey steady state (RSS).**
- Multiplier on the constraint λ_t may or may not converge!
  - For today, assume it does, $\lambda_t \to \lambda$. Relax this in the paper.

Characterizing the Ramsey steady state

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathcal{U}_t(\{r_s, \tau_s\}) \qquad G + (1 + r_t)\,\mathcal{A}_{t-1}\left(\{r_s, \tau_s\}\right) = \mathcal{A}_t\left(\{r_s, \tau_s\}\right) + \tau_t \mathcal{N}_t\left(\{r_s, \tau_s\}\right)$$

Characterizing the Ramsey steady state

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathcal{U}_t(\{r_s, \tau_s\}) \qquad G + (1 + r_t)\,\mathcal{A}_{t-1}\left(\{r_s, \tau_s\}\right) = \mathcal{A}_t\left(\{r_s, \tau_s\}\right) + \tau_t \mathcal{N}_t\left(\{r_s, \tau_s\}\right)$$

- Begin with the FOCs with respect to r_s:

Characterizing the Ramsey steady state

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathscr{U}_t(\{r_s,\tau_s\}) \qquad G + (1+r_t)\,\mathscr{A}_{t-1}\left(\{r_s,\tau_s\}\right) = \mathscr{A}_t\left(\{r_s,\tau_s\}\right) + \tau_t \mathscr{N}_t\left(\{r_s,\tau_s\}\right)$$

- Begin with the FOCs with respect to r_s:

$$\sum_{h=-s}^{\infty} \delta^h \frac{\partial \mathscr{U}_{s+h}}{\partial r_s} + \sum_{h=-s}^{\infty} \delta^h \lambda_{s+h} \left(\frac{\partial \mathscr{A}_{s+h}}{\partial r_s} + \tau_t \frac{\partial \mathscr{N}_{s+h}}{\partial r_s} - (1+r_t)\frac{\partial \mathscr{A}_{s+h-1}}{\partial r_s} \right) - \lambda_s \mathscr{A}_{s-1} = 0$$

Characterizing the Ramsey steady state

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathscr{U}_t(\{r_s,\tau_s\}) \qquad G + (1+r_t)\mathscr{A}_{t-1}\left(\{r_s,\tau_s\}\right) = \mathscr{A}_t\left(\{r_s,\tau_s\}\right) + \tau_t \mathscr{N}_t\left(\{r_s,\tau_s\}\right)$$

- Begin with the FOCs with respect to r_s:

$$\sum_{h=-s}^{\infty} \delta^h \frac{\partial \mathscr{U}_{s+h}}{\partial r_s} + \sum_{h=-s}^{\infty} \delta^h \lambda_{s+h}\left(\frac{\partial \mathscr{A}_{s+h}}{\partial r_s} + \tau_t \frac{\partial \mathscr{N}_{s+h}}{\partial r_s} - (1+r_t)\frac{\partial \mathscr{A}_{s+h-1}}{\partial r_s}\right) - \lambda_s \mathscr{A}_{s-1} = 0$$

Characterizing the Ramsey steady state

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathscr{U}_t(\{r_s,\tau_s\}) \qquad G + (1+r_t)\,\mathscr{A}_{t-1}\left(\{r_s,\tau_s\}\right) = \mathscr{A}_t\left(\{r_s,\tau_s\}\right) + \tau_t \mathscr{N}_t\left(\{r_s,\tau_s\}\right)$$

- Begin with the FOCs with respect to r_s:

$\epsilon^{U,r}$ ← as $s \to \infty$

$$\sum_{h=-s}^{\infty} \delta^h \frac{\partial \mathscr{U}_{s+h}}{\partial r_s} + \sum_{h=-s}^{\infty} \delta^h \lambda_{s+h} \left(\frac{\partial \mathscr{A}_{s+h}}{\partial r_s} + \tau_t \frac{\partial \mathscr{N}_{s+h}}{\partial r_s} - (1+r_t) \frac{\partial \mathscr{A}_{s+h-1}}{\partial r_s} \right) - \lambda_s \mathscr{A}_{s-1} = 0$$

Characterizing the Ramsey steady state

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathcal{U}_t(\{r_s, \tau_s\}) \qquad G + (1+r_t)\,\mathcal{A}_{t-1}\left(\{r_s, \tau_s\}\right) = \mathcal{A}_t\left(\{r_s, \tau_s\}\right) + \tau_t \mathcal{N}_t\left(\{r_s, \tau_s\}\right)$$

- Begin with the FOCs with respect to r_s:

$\epsilon^{U,r}$ (as $s \to \infty$) $\qquad A\lambda \cdot \epsilon^{A,r}$

$$\sum_{h=-s}^{\infty} \delta^h \frac{\partial \mathcal{U}_{s+h}}{\partial r_s} + \sum_{h=-s}^{\infty} \delta^h \lambda_{s+h} \left(\frac{\partial \mathcal{A}_{s+h}}{\partial r_s} + \tau_t \frac{\partial \mathcal{N}_{s+h}}{\partial r_s} - (1+r_t) \frac{\partial \mathcal{A}_{s+h-1}}{\partial r_s} \right) - \lambda_s \mathcal{A}_{s-1} = 0$$

Characterizing the Ramsey steady state

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathcal{U}_t(\{r_s, \tau_s\}) \qquad G + (1 + r_t)\, \mathcal{A}_{t-1}\left(\{r_s, \tau_s\}\right) = \mathcal{A}_t\left(\{r_s, \tau_s\}\right) + \tau_t \mathcal{N}_t\left(\{r_s, \tau_s\}\right)$$

- Begin with the FOCs with respect to r_s:

$\epsilon^{U,r}$ (as $s \to \infty$) $\qquad A\lambda \cdot \epsilon^{A,r} \qquad \tau N \lambda \cdot \epsilon^{N,r}$

$$\sum_{h=-s}^{\infty} \delta^h \frac{\partial \mathcal{U}_{s+h}}{\partial r_s} + \sum_{h=-s}^{\infty} \delta^h \lambda_{s+h} \left(\frac{\partial \mathcal{A}_{s+h}}{\partial r_s} + \tau_t \frac{\partial \mathcal{N}_{s+h}}{\partial r_s} - (1 + r_t) \frac{\partial \mathcal{A}_{s+h-1}}{\partial r_s} \right) - \lambda_s \mathcal{A}_{s-1} = 0$$

Characterizing the Ramsey steady state

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathscr{U}_t(\{r_s, \tau_s\}) \qquad G + (1 + r_t)\,\mathscr{A}_{t-1}\left(\{r_s, \tau_s\}\right) = \mathscr{A}_t\left(\{r_s, \tau_s\}\right) + \tau_t \mathscr{N}_t\left(\{r_s, \tau_s\}\right)$$

- Begin with the FOCs with respect to r_s:

$\epsilon^{U,r}$ (as $s \to \infty$) $\qquad A\lambda \cdot \epsilon^{A,r} \qquad \tau N \lambda \cdot \epsilon^{N,r} \qquad A\lambda(1 + r)\delta \cdot \epsilon^{A,r}$

$$\sum_{h=-s}^{\infty} \delta^h \frac{\partial \mathscr{U}_{s+h}}{\partial r_s} + \sum_{h=-s}^{\infty} \delta^h \lambda_{s+h} \left(\frac{\partial \mathscr{A}_{s+h}}{\partial r_s} + \tau_t \frac{\partial \mathscr{N}_{s+h}}{\partial r_s} - (1 + r_t)\, \frac{\partial \mathscr{A}_{s+h-1}}{\partial r_s} \right) - \lambda_s \mathscr{A}_{s-1} = 0$$

Characterizing the Ramsey steady state

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathscr{U}_t(\{r_s, \tau_s\}) \qquad G + (1 + r_t)\, \mathscr{A}_{t-1}\left(\{r_s, \tau_s\}\right) = \mathscr{A}_t\left(\{r_s, \tau_s\}\right) + \tau_t \mathscr{N}_t\left(\{r_s, \tau_s\}\right)$$

- Begin with the FOCs with respect to r_s:

$$\epsilon^{U,r} \qquad A\lambda \cdot \epsilon^{A,r} \qquad \tau N \lambda \cdot \epsilon^{N,r} \qquad A\lambda(1+r)\delta \cdot \epsilon^{A,r} \qquad \lambda A$$

as $s \to \infty$

$$\sum_{h=-s}^{\infty} \delta^h \frac{\partial \mathscr{U}_{s+h}}{\partial r_s} + \sum_{h=-s}^{\infty} \delta^h \lambda_{s+h} \left(\frac{\partial \mathscr{A}_{s+h}}{\partial r_s} + \tau_t \frac{\partial \mathscr{N}_{s+h}}{\partial r_s} - (1 + r_t) \frac{\partial \mathscr{A}_{s+h-1}}{\partial r_s} \right) - \lambda_s \mathscr{A}_{s-1} = 0$$

Characterizing the Ramsey steady state

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathscr{U}_t(\{r_s,\tau_s\}) \qquad G + (1+r_t)\,\mathscr{A}_{t-1}\left(\{r_s,\tau_s\}\right) = \mathscr{A}_t\left(\{r_s,\tau_s\}\right) + \tau_t \mathscr{N}_t\left(\{r_s,\tau_s\}\right)$$

- From the r_s derivative around the (unknown) RSS:

$$\lambda^{-1}\epsilon^{U,r} = A - \left(1 - \delta\,(1+r)\right) A\epsilon^{A,r} - \tau N \epsilon^{N,r}$$

Characterizing the Ramsey steady state

$$\max_{\{r_s,\tau_s\}_{s=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \mathcal{U}_t(\{r_s, \tau_s\}) \qquad G + (1 + r_t)\, \mathcal{A}_{t-1}\left(\{r_s, \tau_s\}\right) = \mathcal{A}_t\left(\{r_s, \tau_s\}\right) + \tau_t \mathcal{N}_t\left(\{r_s, \tau_s\}\right)$$

- From the r_s derivative around the (unknown) RSS:

$$\lambda^{-1}\epsilon^{U,r} = A - \left(1 - \delta\left(1 + r\right)\right) A\epsilon^{A,r} - \tau N\epsilon^{N,r}$$

- Same procedure applied to the τ_s derivative:

$$\lambda^{-1}\epsilon^{U,\tau} = (1 - \tau)\, N - \left(1 - \delta\left(1 + r\right)\right) A\epsilon^{A,\tau} - \tau N\epsilon^{N,\tau}$$

The RSS optimality condition

The RSS optimality condition

Result: If RSS exists & λ_t converges, it satisfies gov. budget and:

$$\underbrace{(1-\delta(1+r))\,\ell\left(m\epsilon^{A,r}+\epsilon^{A,\tau}\right)}_{\text{liquidity benefit of greater debt}} - \underbrace{\frac{\tau}{1-\tau}\left(-\epsilon^{N,\tau}-m\epsilon^{N,r}\right)}_{\text{cost (?) lower labor supply}} - \underbrace{(\ell\, m-1)}_{\text{cost: redistribution from workers to savers}} = 0$$

liquidity **benefit** of greater debt

cost (?) lower labor supply

cost: redistribution from workers to savers

- $\ell \equiv \dfrac{A}{(1-\tau)N}$ is measure of *liquidity* (assets to after-tax income), $m \equiv -\epsilon^{U,\tau}/\epsilon^{U,r}$

The RSS optimality condition

<u>Result:</u> If RSS exists & λ_t converges, it satisfies gov. budget and:

$$\left(1-\delta\left(1+r\right)\right)\ell\left(m\epsilon^{A,r}+\epsilon^{A,\tau}\right)-\frac{\tau}{1-\tau}\left(-\epsilon^{N,\tau}-m\epsilon^{N,r}\right)-\left(\ell m-1\right)=0$$

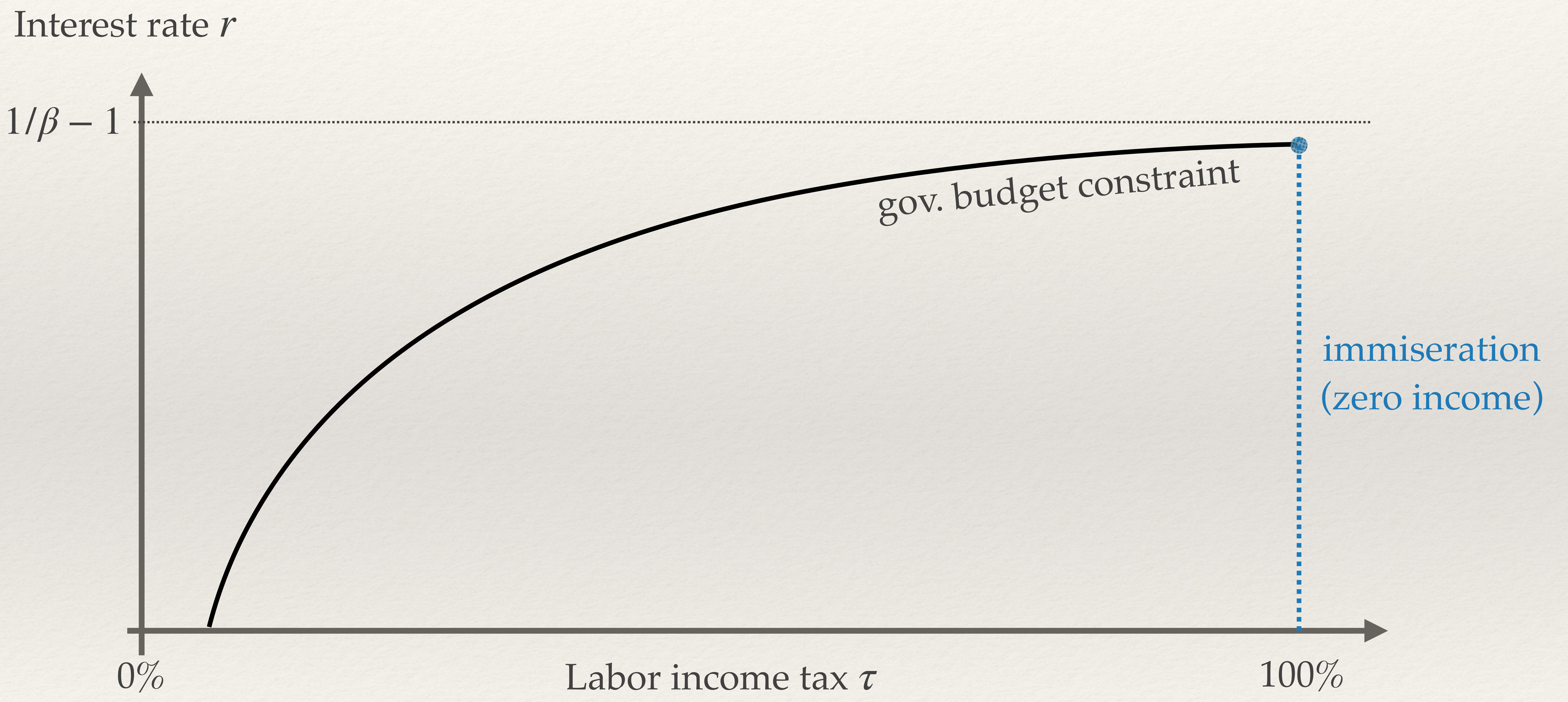
liquidity **benefit** of greater debt

cost (?) lower labor supply

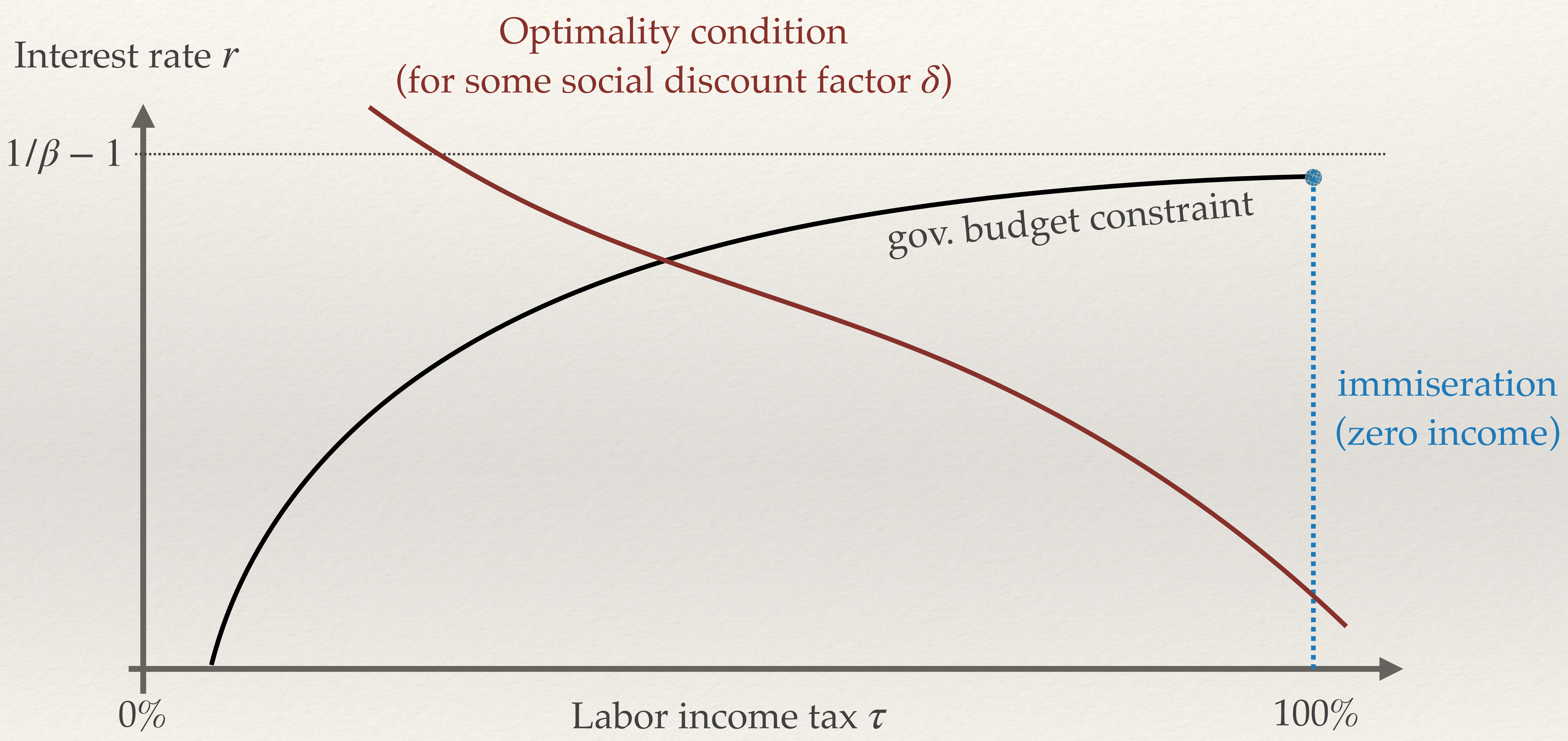
cost: redistribution from workers to savers

- $\ell \equiv \dfrac{A}{(1-\tau)N}$ is measure of *liquidity* (assets to after-tax income), $m \equiv -\epsilon^{U,\tau}/\epsilon^{U,r}$

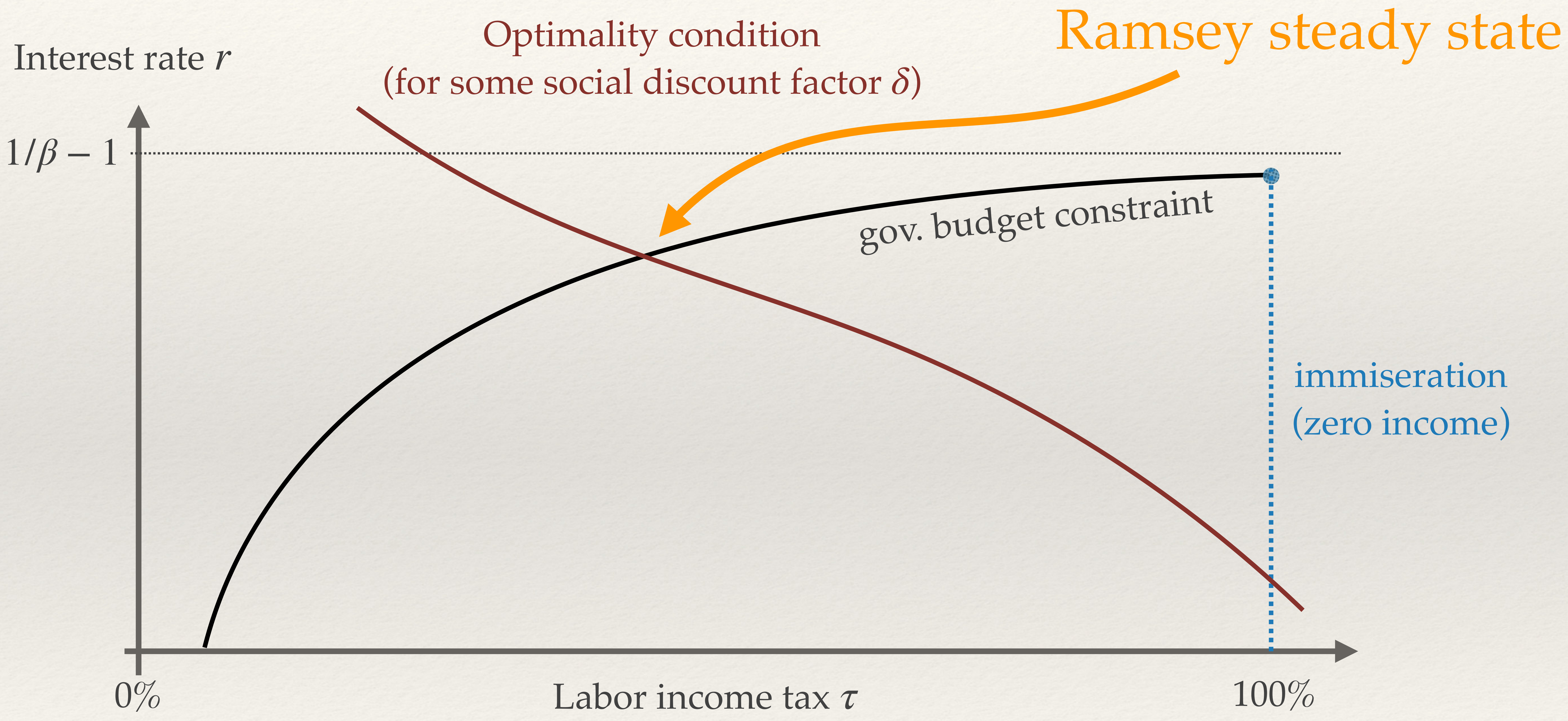
The RSS first order condition



The RSS first order condition



The RSS first order condition



The case of the missing RSS

Utility functions

- What does the RSS look like? Turns out to depend on the utility function $u(c, n)$
- Begin with $u(c, n) = \log c - v(n)$ with constant Frisch elasticity = 1
- Standard calibration:
  - AR(1) income process, initial debt = 100%, $G = 20\%$, initial $r = 2\,\%$
- Later: explore robustness

The missing RSS

- Assume "correct" social discount factor, $\delta = \beta$. Left hand side of FOC:

liquidity **benefit** of greater debt

$$\left(1 - \beta\left(1 + r\right)\right) \ell \left(m\epsilon^{A,r} + \epsilon^{A,\tau}\right)$$

$$-\frac{\tau}{1 - \tau}\left(-\epsilon^{N,\tau} - m\epsilon^{N,r}\right) - \left(\ell\, m - 1\right)$$

cost: lower labor supply **cost**: redistribution

The missing RSS

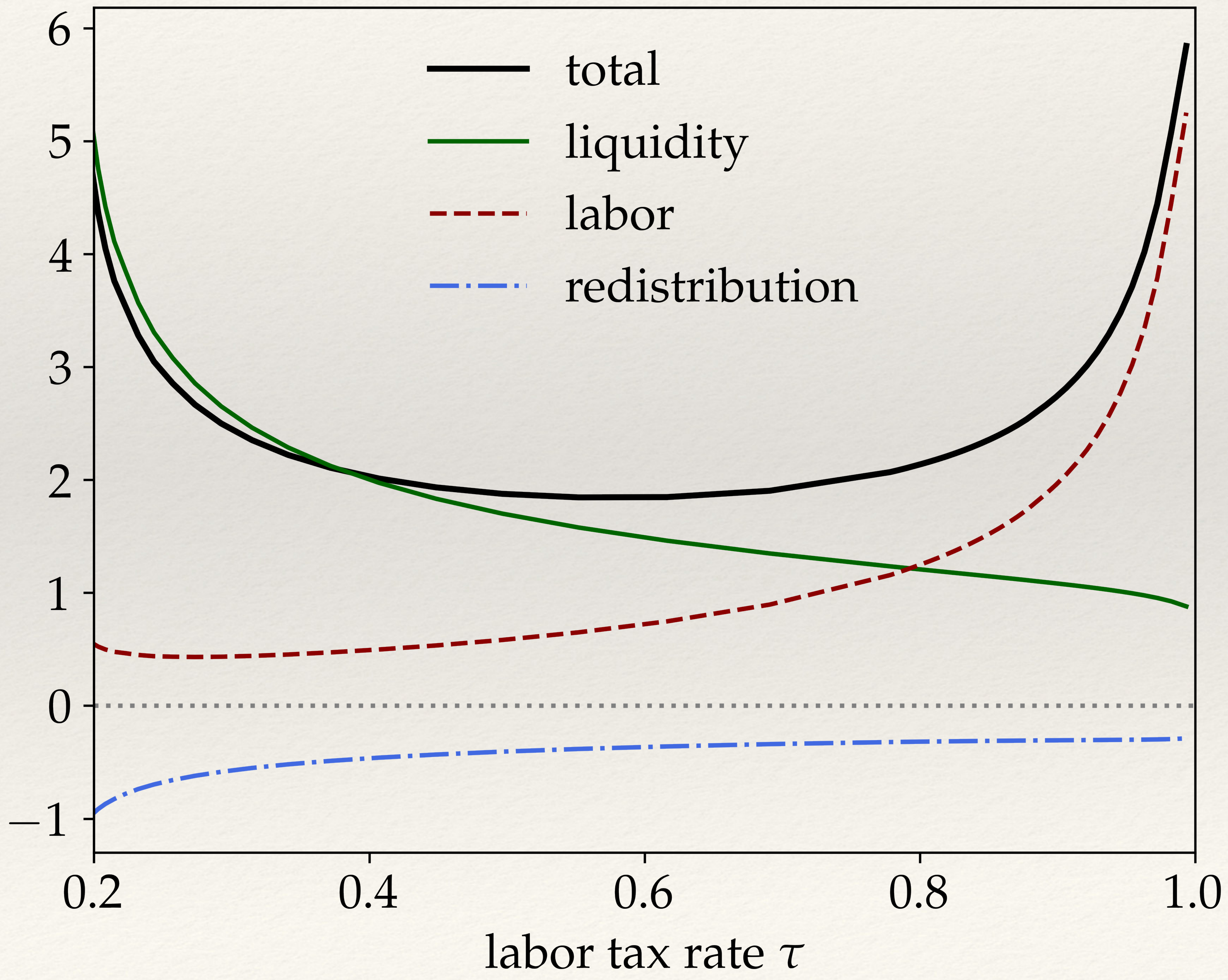
- Assume "correct" social discount factor, $\delta = \beta$. Left hand side of FOC:

liquidity **benefit** of greater debt

$$\left(1-\beta(1+r)\right)\ell\left(m\epsilon^{A,r}+\epsilon^{A,\tau}\right)$$

$$-\frac{\tau}{1-\tau}\left(-\epsilon^{N,\tau}-m\epsilon^{N,r}\right)-\left(\ell\,m-1\right)$$

cost: lower labor supply **cost**: redistribution



The missing RSS

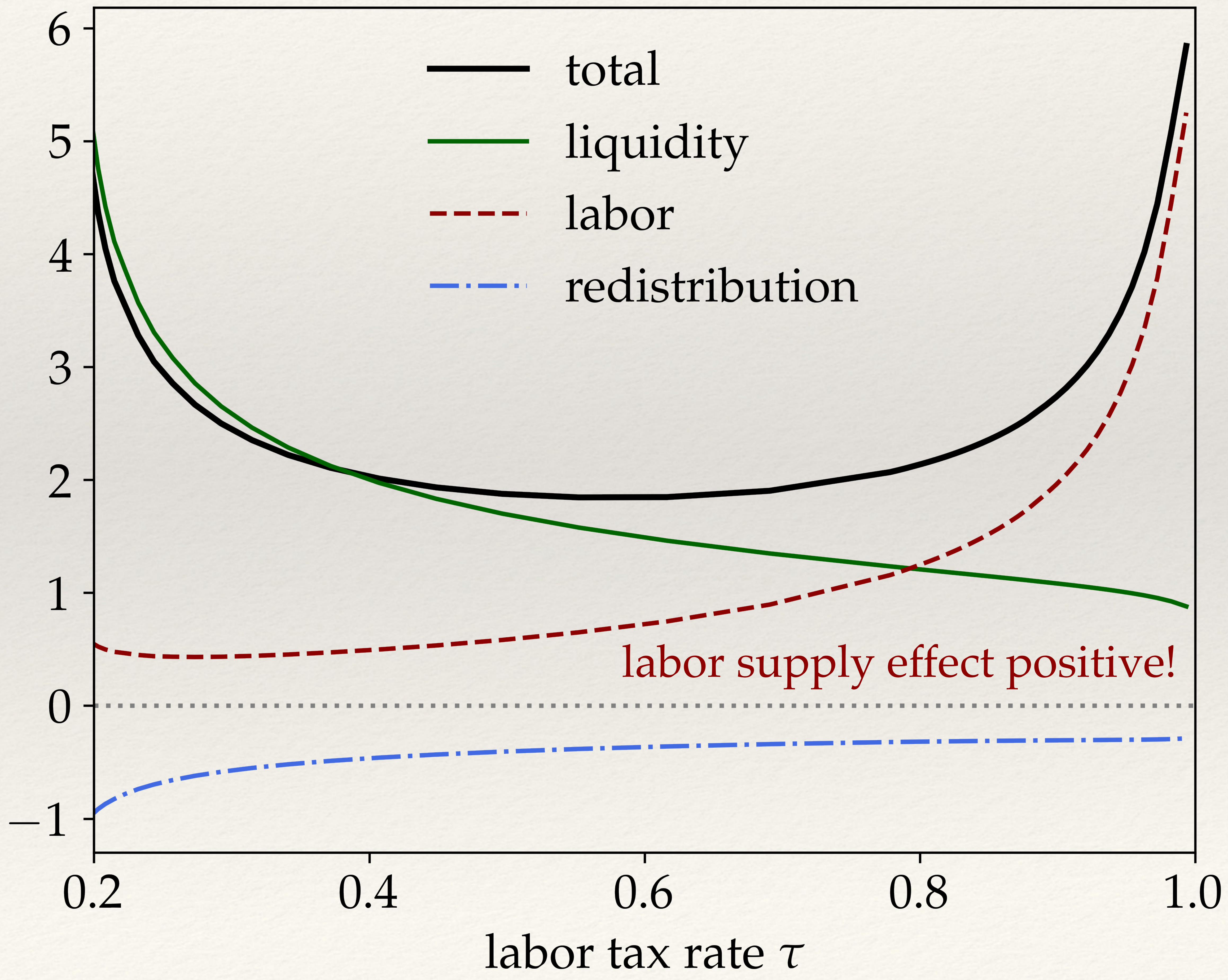
- Assume "correct" social discount factor, $\delta = \beta$. Left hand side of FOC:

liquidity **benefit** of greater debt

$$\left(1-\beta(1+r)\right)\ell\left(m\epsilon^{A,r}+\epsilon^{A,\tau}\right)$$

$$-\frac{\tau}{1-\tau}\left(-\epsilon^{N,\tau}-m\epsilon^{N,r}\right)-\left(\ell\, m-1\right)$$

cost: lower labor supply **cost**: redistribution



The missing RSS

- Assume "correct" social discount factor, $\delta = \beta$. Left hand side of FOC:

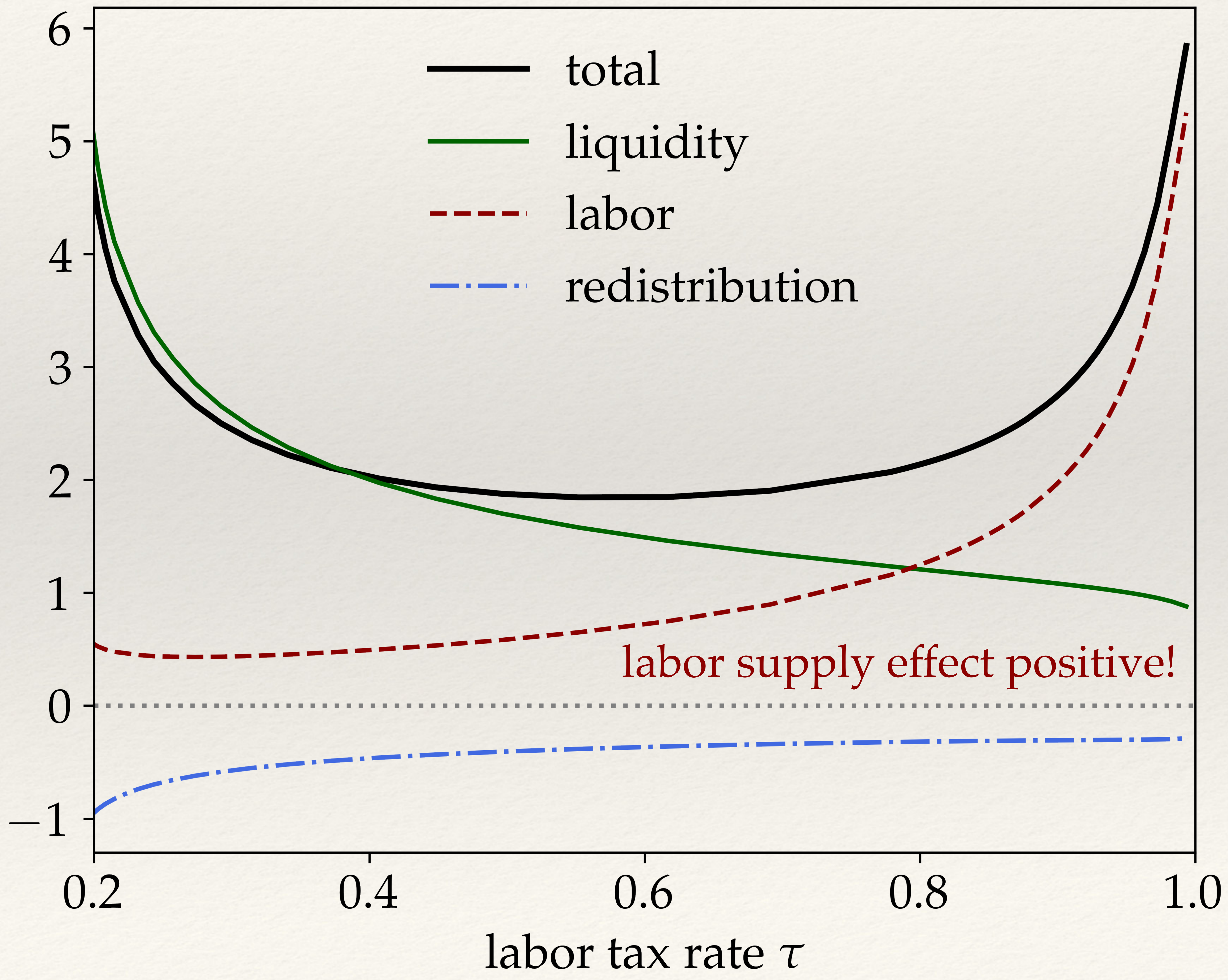
liquidity **benefit** of greater debt

$$\left(1-\beta\left(1+r\right)\right)\ell\left(m\epsilon^{A,r}+\epsilon^{A,\tau}\right)$$

$$-\frac{\tau}{1-\tau}\left(-\epsilon^{N,\tau}-m\epsilon^{N,r}\right)-\left(\ell\, m-1\right)$$

cost: redistribution

benefit: greater labor supply



The missing RSS

- Assume "correct" social discount factor, $\delta = \beta$. Left hand side of FOC:

liquidity **benefit** of greater debt

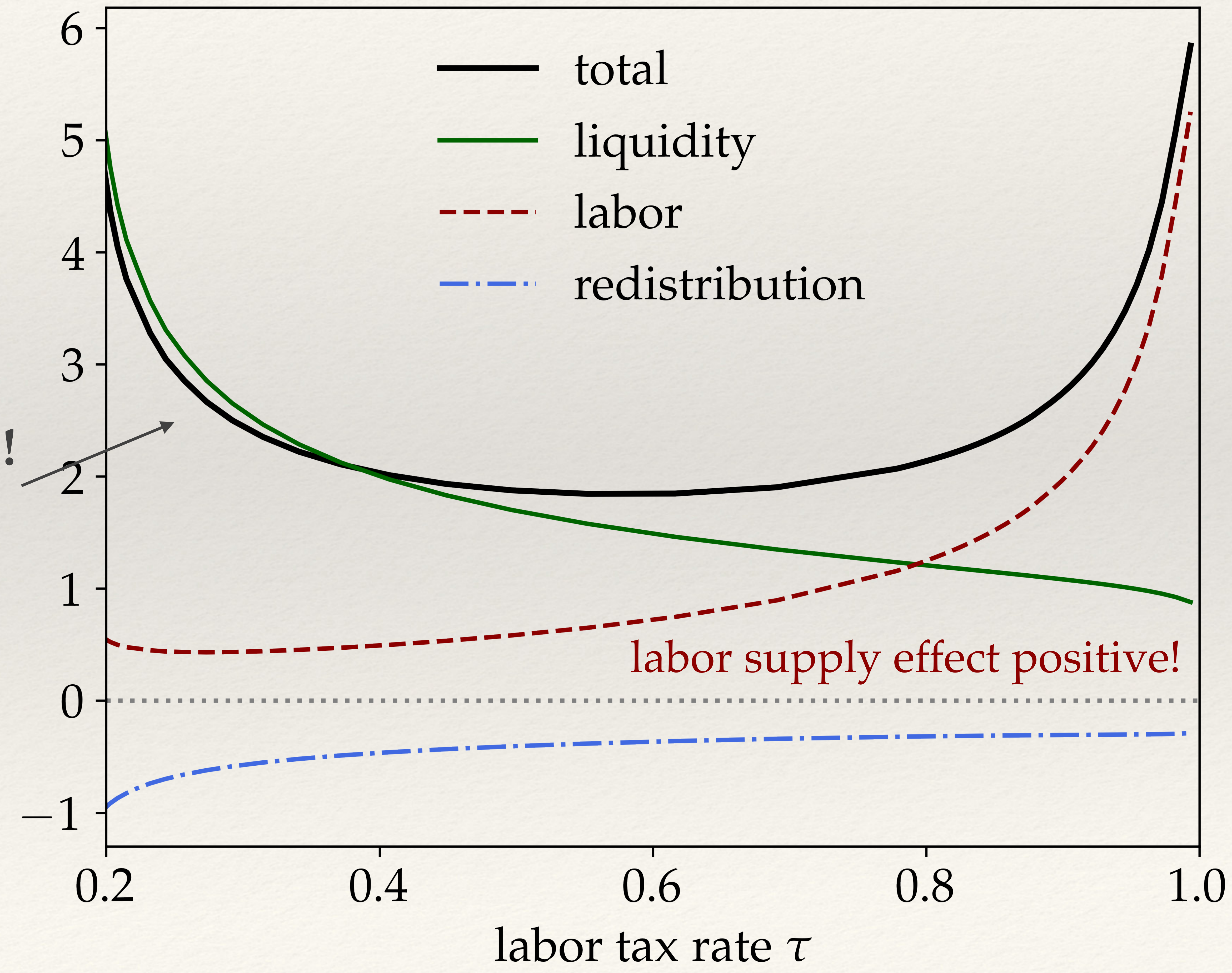
$$\left(1-\beta(1+r)\right)\ell\left(m\epsilon^{A,r}+\epsilon^{A,\tau}\right)$$

$$-\frac{\tau}{1-\tau}\left(-\epsilon^{N,\tau}-m\epsilon^{N,r}\right)-\left(\ell\, m-1\right)$$

cost: redistribution

benefit: greater labor supply

Always > 0 !
No RSS!



Optimal steady state exists

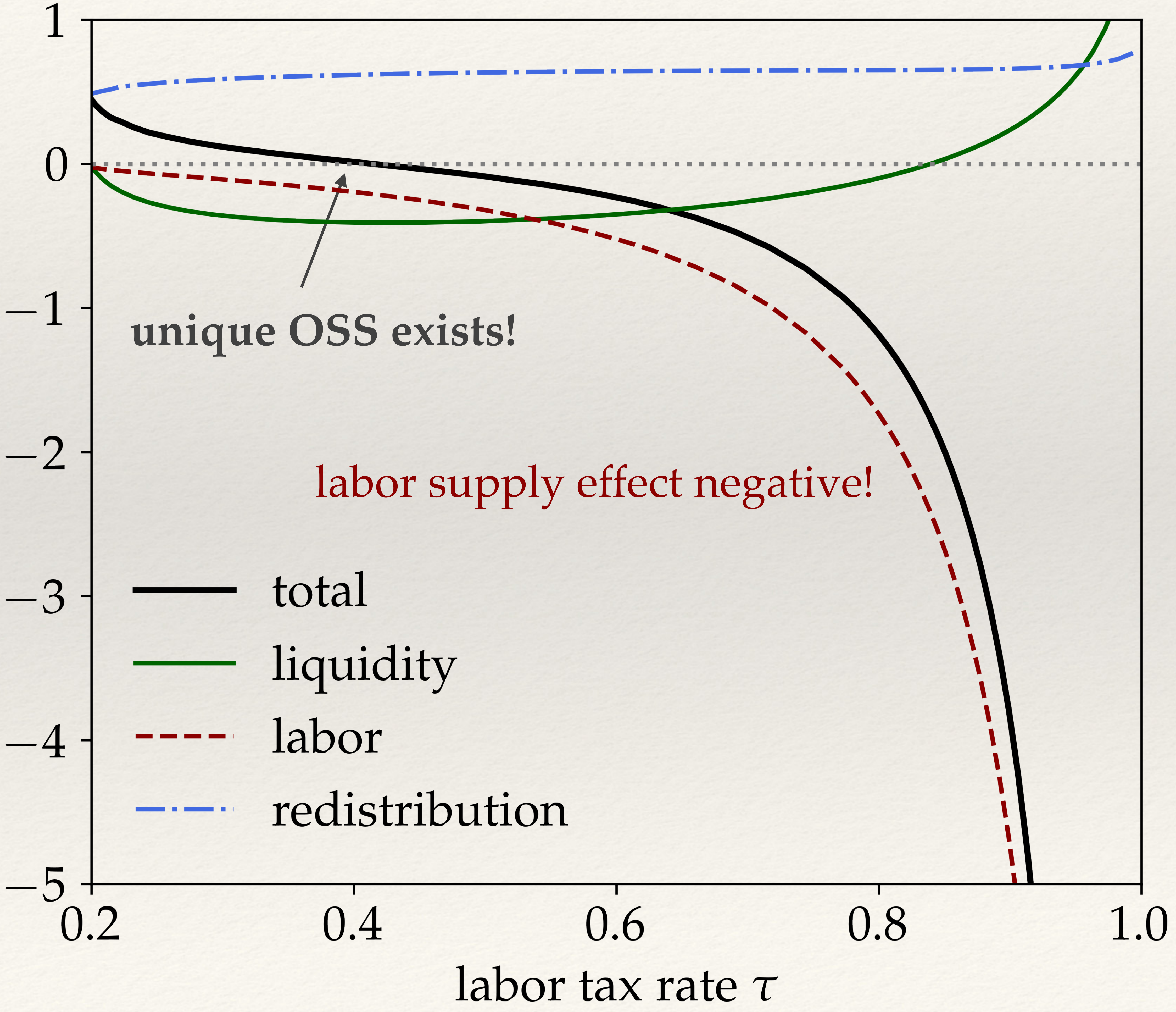
- Same with infinitely patient planner, $\delta = 1$:

liquidity **benefit** of greater debt

$$(1-(1+r))\,\ell\left(m\epsilon^{A,r}+\epsilon^{A,\tau}\right)$$

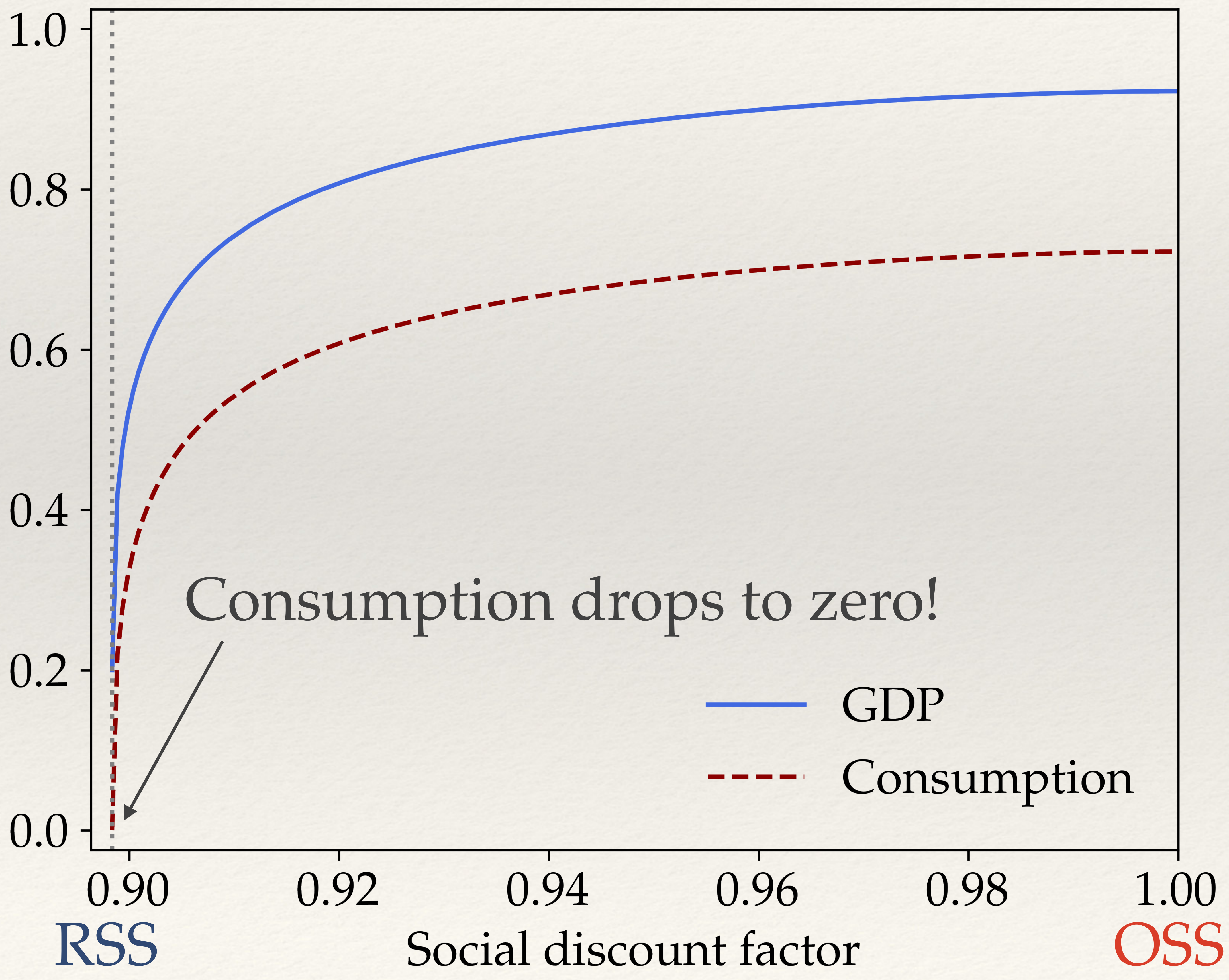
$$-\frac{\tau}{1-\tau}\left(-\epsilon^{N,\tau}-m\epsilon^{N,r}\right)-\left(\ell\, m-1\right)$$

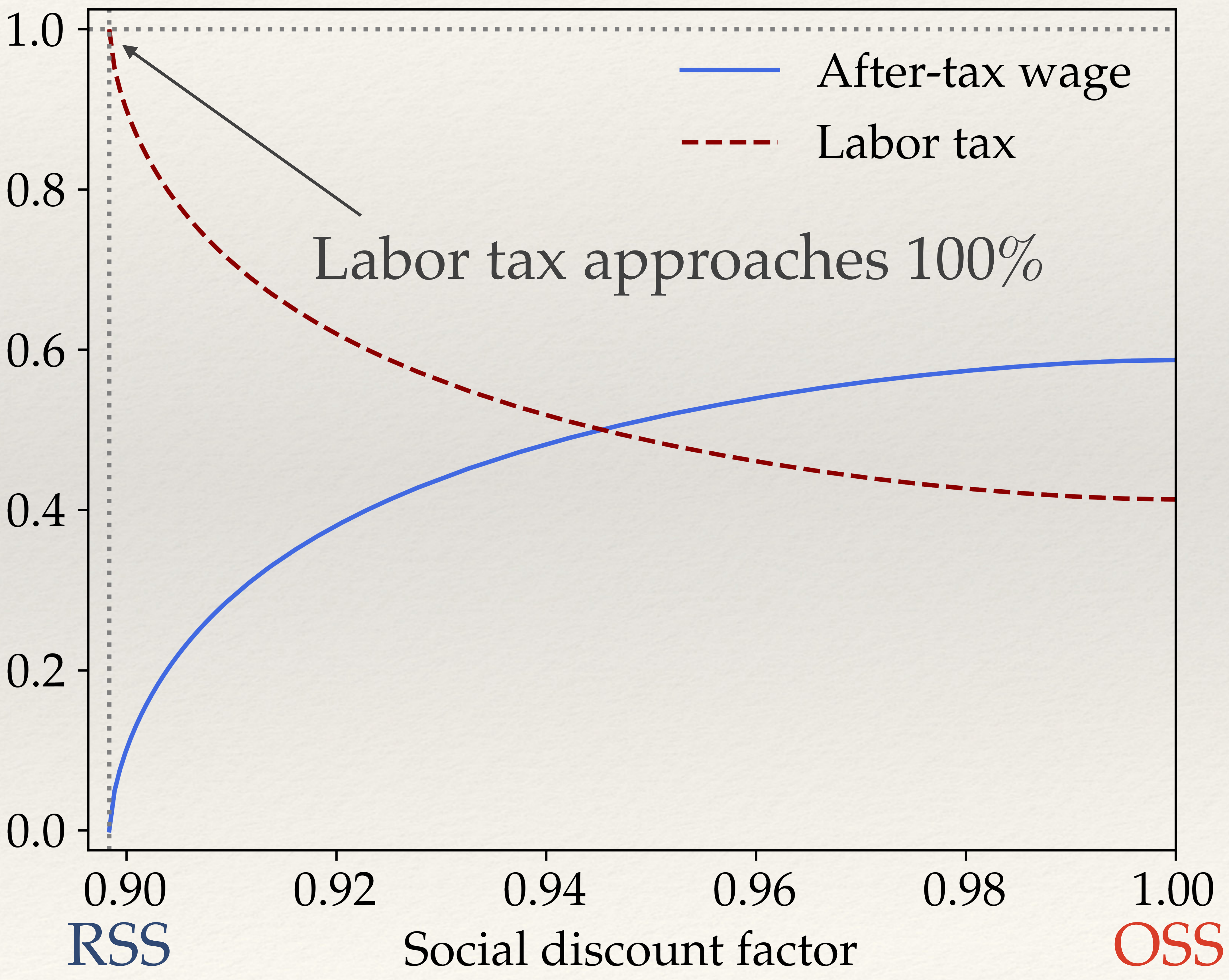
cost: lower labor supply **cost**: redistribution



How the RSS vanishes

- Next, vary social discount factor δ between β and 1:





Standard Aiyagari economy: Why no RSS?

Benefits and **costs** to greater liquidity and higher labor taxes

liquidity benefit

labor supply ↓

redistribution

Standard Aiyagari economy: Why no RSS?

Benefits and **costs** to greater liquidity and higher labor taxes

liquidity benefit

labor supply ↑

~~labor supply ↓~~

redistribution

Standard Aiyagari economy: Why no RSS?

Benefits and **costs** to greater liquidity and higher labor taxes

liquidity benefit

labor supply ↑

~~labor supply ↓~~

redistribution

cost of redistribution is quantitatively small!

What does it take to get an RSS?

What does it take to get an RSS?

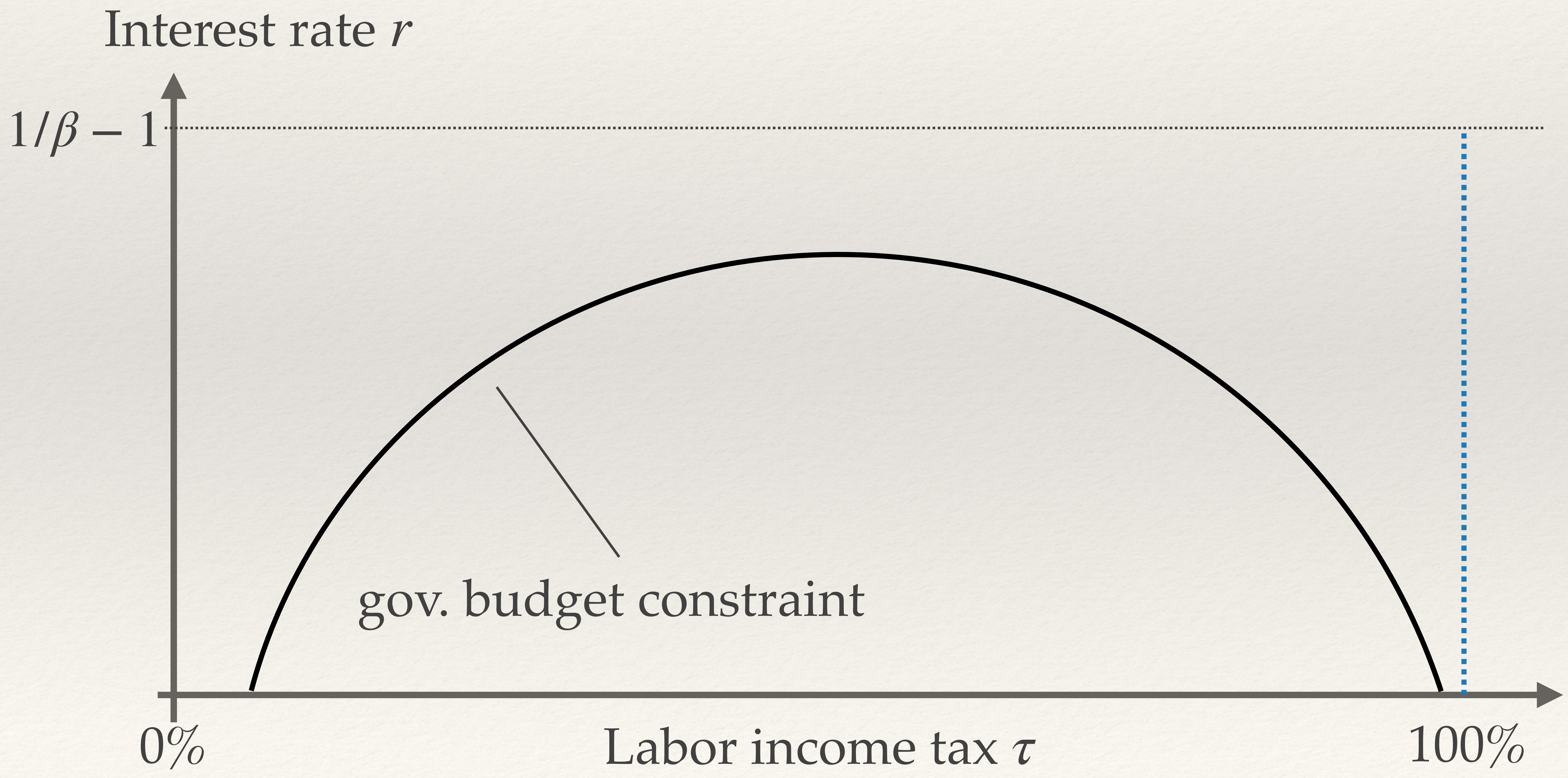
- Paper explores three dimensions of the basic Aiyagari model:
- Role of **inequality**
- Role of **preferences**
- Role of **private liquidity creation (capital)**
- Always find (near-)immiseration unless we sacrifice balanced growth preferences

Non-balanced growth preferences

- GHH preferences $u(c,n) = \dfrac{\left(c - \phi \dfrac{n^{1+\nu}}{1+\nu}\right)^{1-\sigma} - 1}{1-\sigma}$ No wealth effect on labor supply!

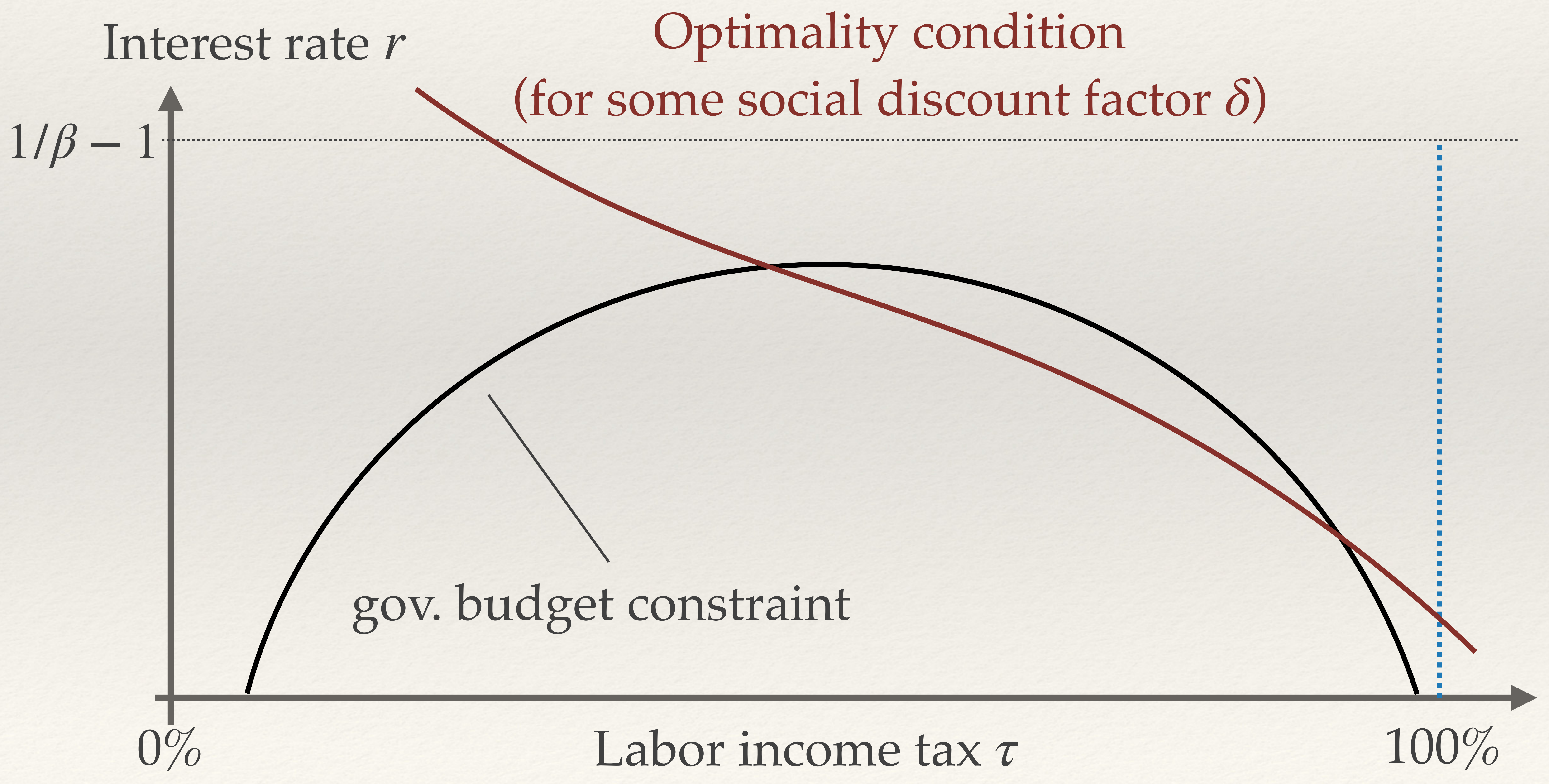
Non-balanced growth preferences

- GHH preferences $u(c,n) = \dfrac{\left(c - \phi \frac{n^{1+\nu}}{1+\nu}\right)^{1-\sigma} - 1}{1-\sigma}$ No wealth effect on labor supply!



Non-balanced growth preferences

- GHH preferences $u(c,n) = \dfrac{\left(c - \phi\frac{n^{1+\nu}}{1+\nu}\right)^{1-\sigma} - 1}{1-\sigma}$ No wealth effect on labor supply!



What to do about immiseration?

What to do about immiseration? (if anything)

- **Modify planning problem, e.g. objectives or constraints?**
  - e.g. limited commitment, or greater social discount factor
  - households still want (near-) immiseration but planner does not

What to do about immiseration? (if anything)

- **Modify planning problem, e.g. objectives or constraints?**
  - e.g. limited commitment, or greater social discount factor
  - households still want (near-) immiseration but planner does not
- **Modify household behavior?**
  - different model of labor supply? (human capital? indivisibilities? constraints?)
  - imperfect foresight (e.g. García-Schmidt Woodford, Gabaix) to reduce anticipatory labor supply response of households?

Conclusion

	Stylized models (RA, TA)	Richer models (HA)
Positive	✓ Neoclassical growth model	✓ Aiyagari (1994) …
Normative (Ramsey steady state)	✓ Chamely (1986) Judd (1985) Straub Werning (2020)	This paper

Conclusion

	Stylized models (RA, TA)	Richer models (HA)
Positive	✓ Neoclassical growth model	✓ Aiyagari (1994) …
Normative (Ramsey steady state)	✓ [illegible]mely (1986) Straub [illegible] (2020) Immiseration ?!	This paper

Conclusion

	Stylized models (RA, TA)	Richer models (HA)
Positive	✓ Neoclassical growth model	✓ Aiyagari (1994) …
Normative (Ramsey steady state)	✓ …mely (1986) Straub W… (2020) Immiseration ?!	Immiseration ?!

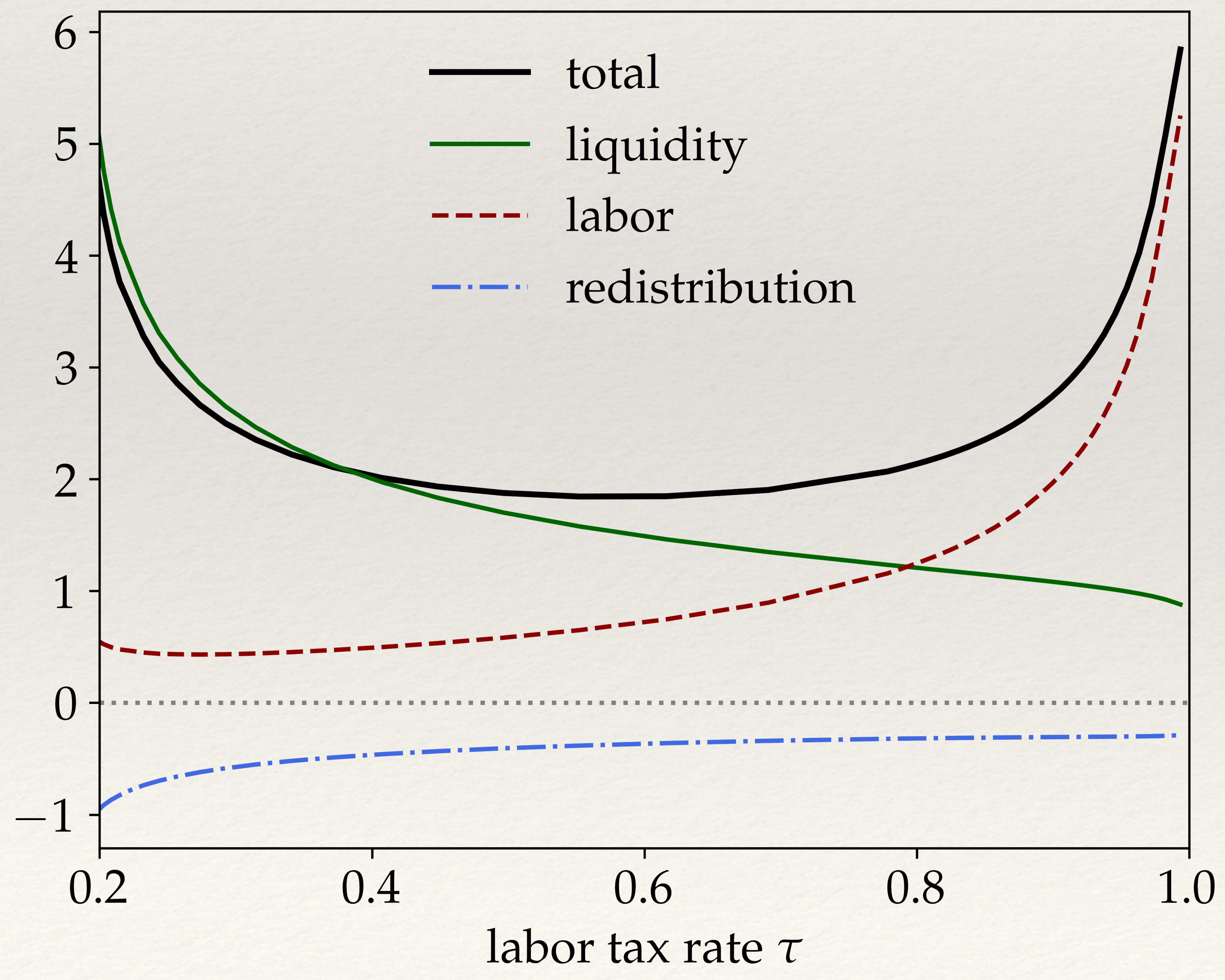
Role of inequality

- Checked many common income processes. All consistent with immiseration.
- What if we add permanent "**poverty state**" in which people earn 1% of avg. income?*

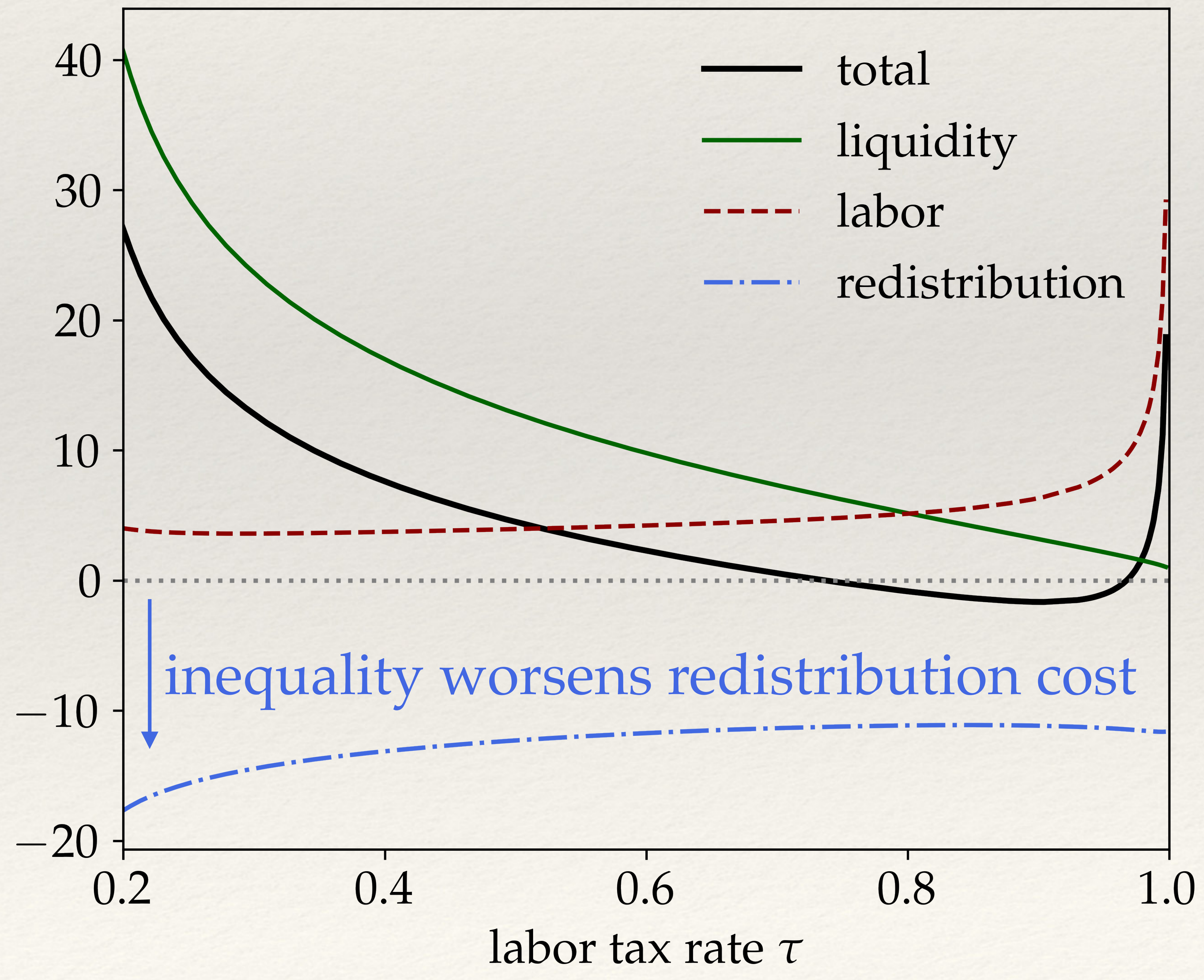
Role of inequality

- Checked many common income processes. All consistent with immiseration.
- What if we add permanent "**poverty state**" in which people earn 1% of avg. income?*

Baseline (nobody in poverty)



90% (!!) of people in poverty

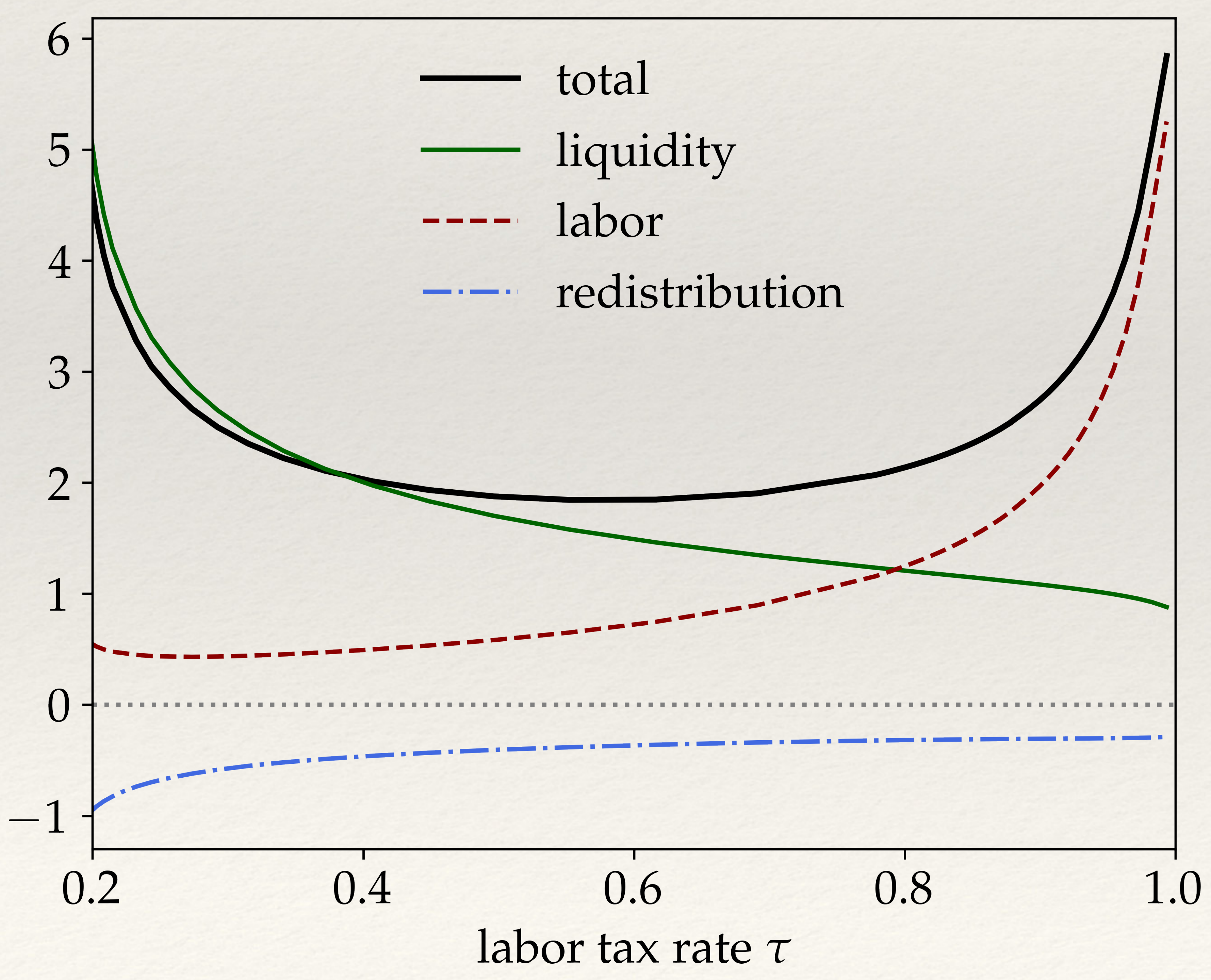


* specifications have higher than calibrated income risk to make the effect more visible.

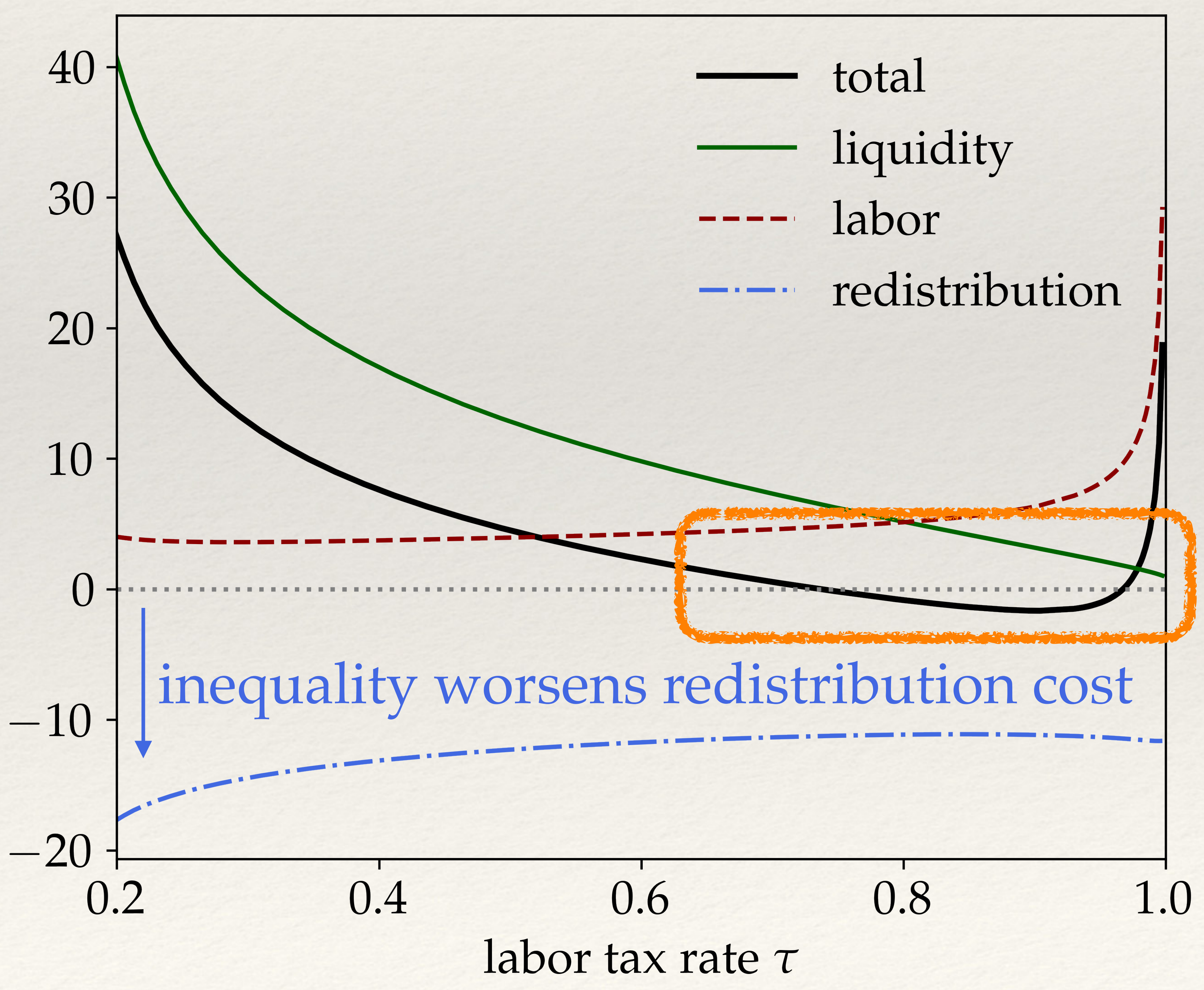
Role of inequality

- Checked many common income processes. All consistent with immiseration.
- What if we add permanent "**poverty state**" in which people earn 1% of avg. income?*

Baseline (nobody in poverty)



90% (!!) of people in poverty



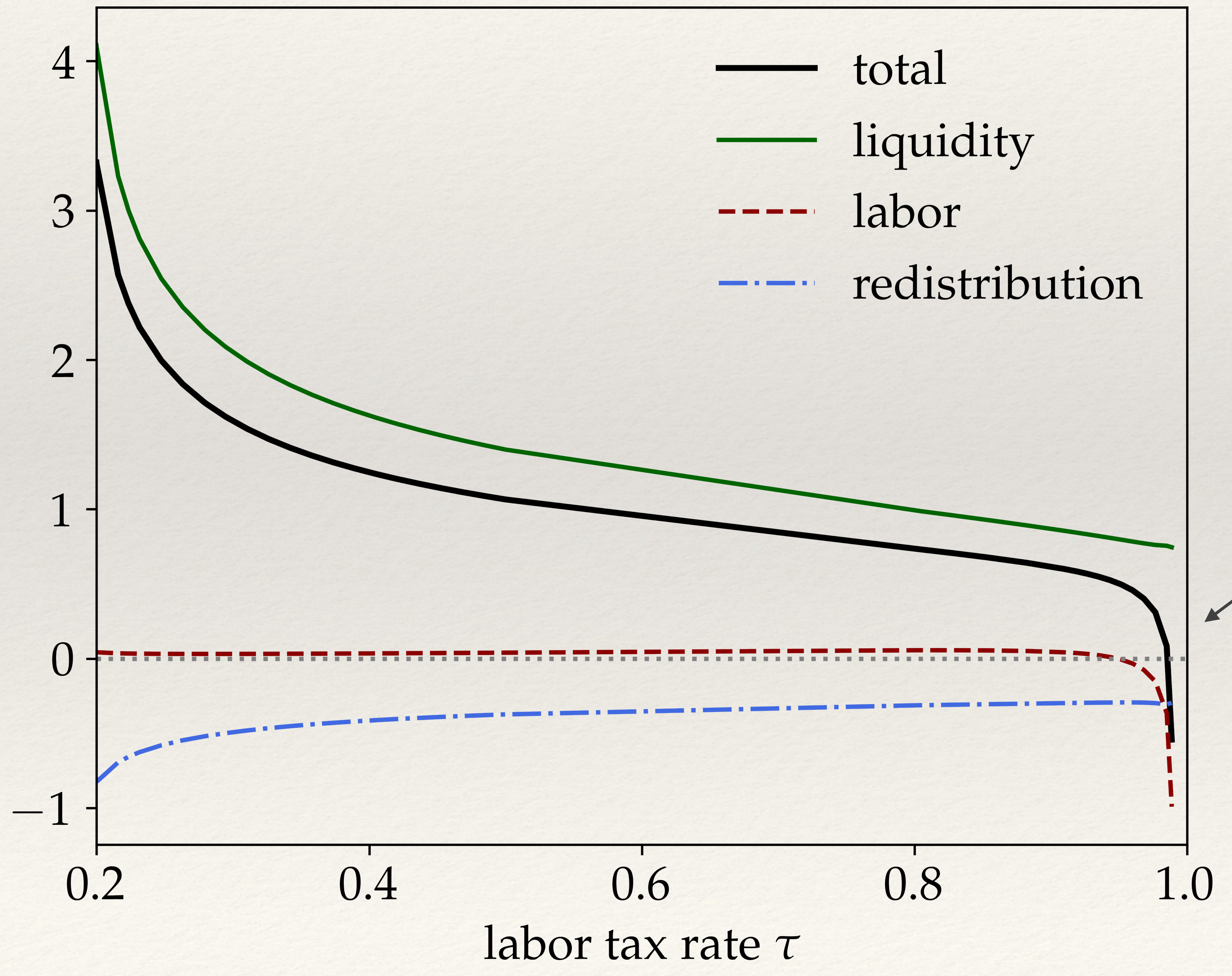
* specifications have higher than calibrated income risk to make the effect more visible.

Role of preferences: Frisch elasticity

- For normal Frisch elasticities, find immiseration. What if Frisch = 0.05 ?

Role of preferences: Frisch elasticity

- For normal Frisch elasticities, find immiseration. What if Frisch = 0.05 ?



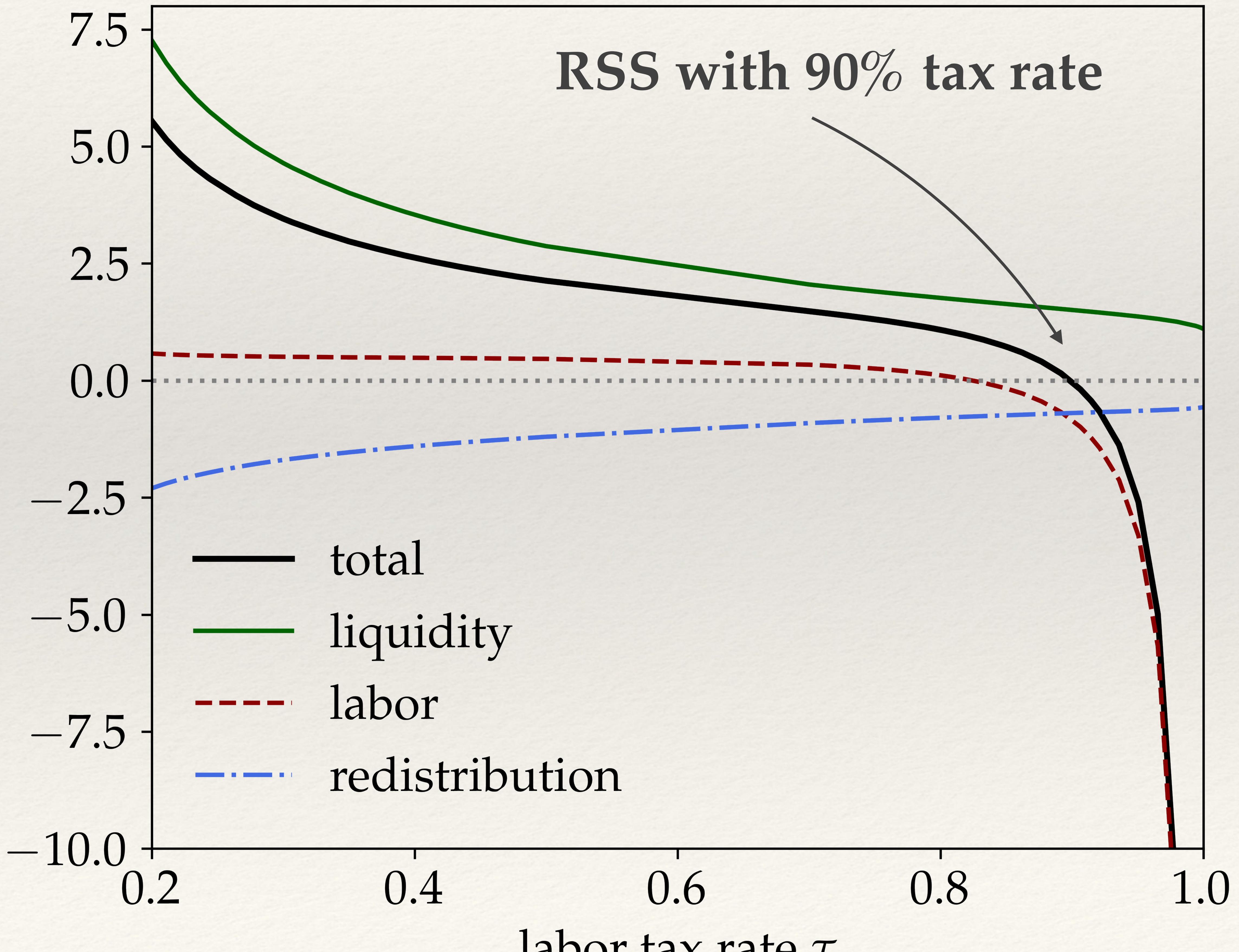
RSS! But tax rate = 99%…

Role of preferences: EIS

- Find immiseration with King-Plosser-Rebelo (KPR) preferences and EIS > 1.
- What if KPR with EIS = 0.5?

Role of preferences: EIS

- Find immiseration with King-Plosser-Rebelo (KPR) preferences and EIS > 1.
- What if KPR with EIS = 0.5?

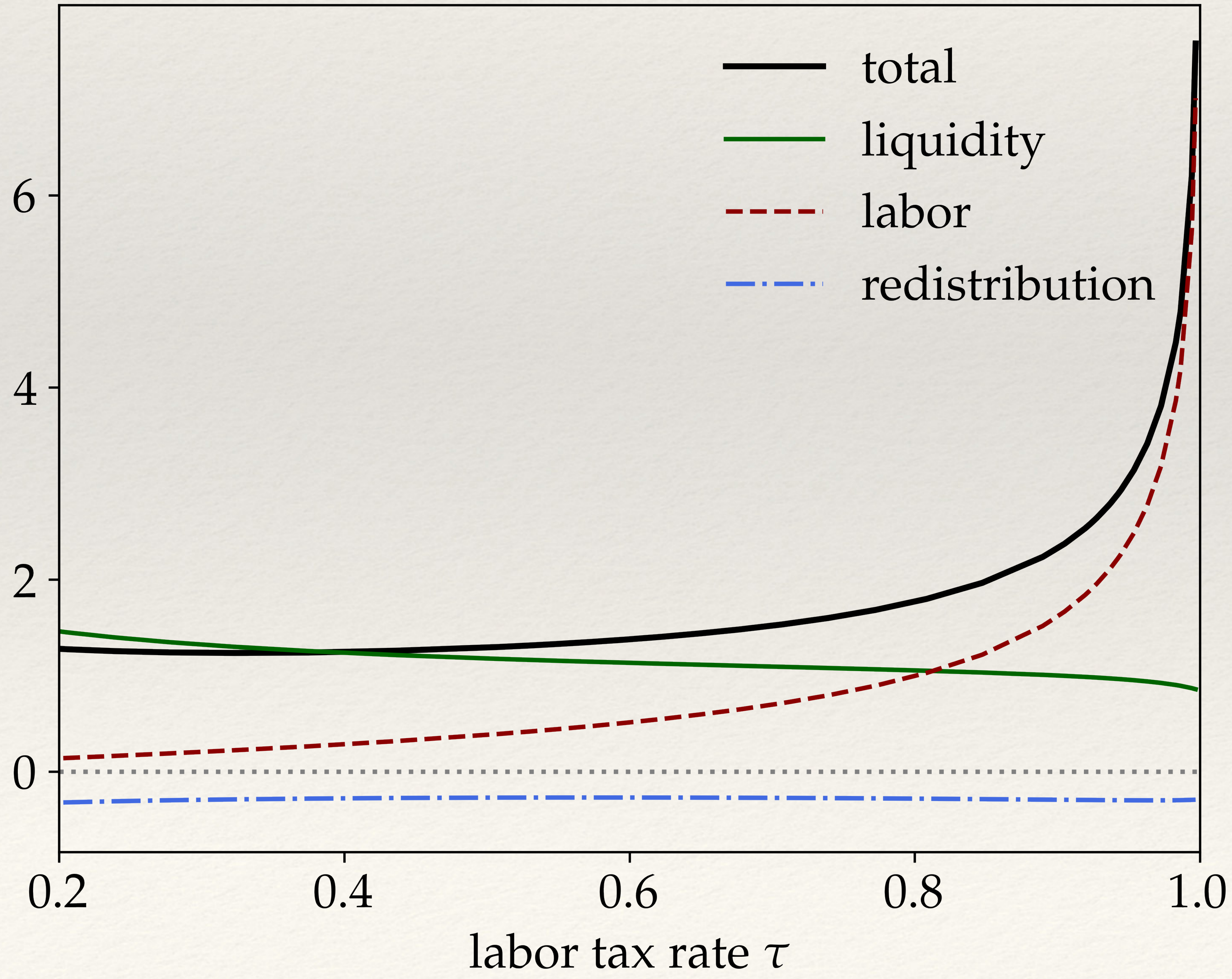


Role of private liquidity

- CRS production function with capital, $Y = F(K, N)$ and capital taxes
- Same RSS condition still works, but need to change gov budget constraint

Role of private liquidity

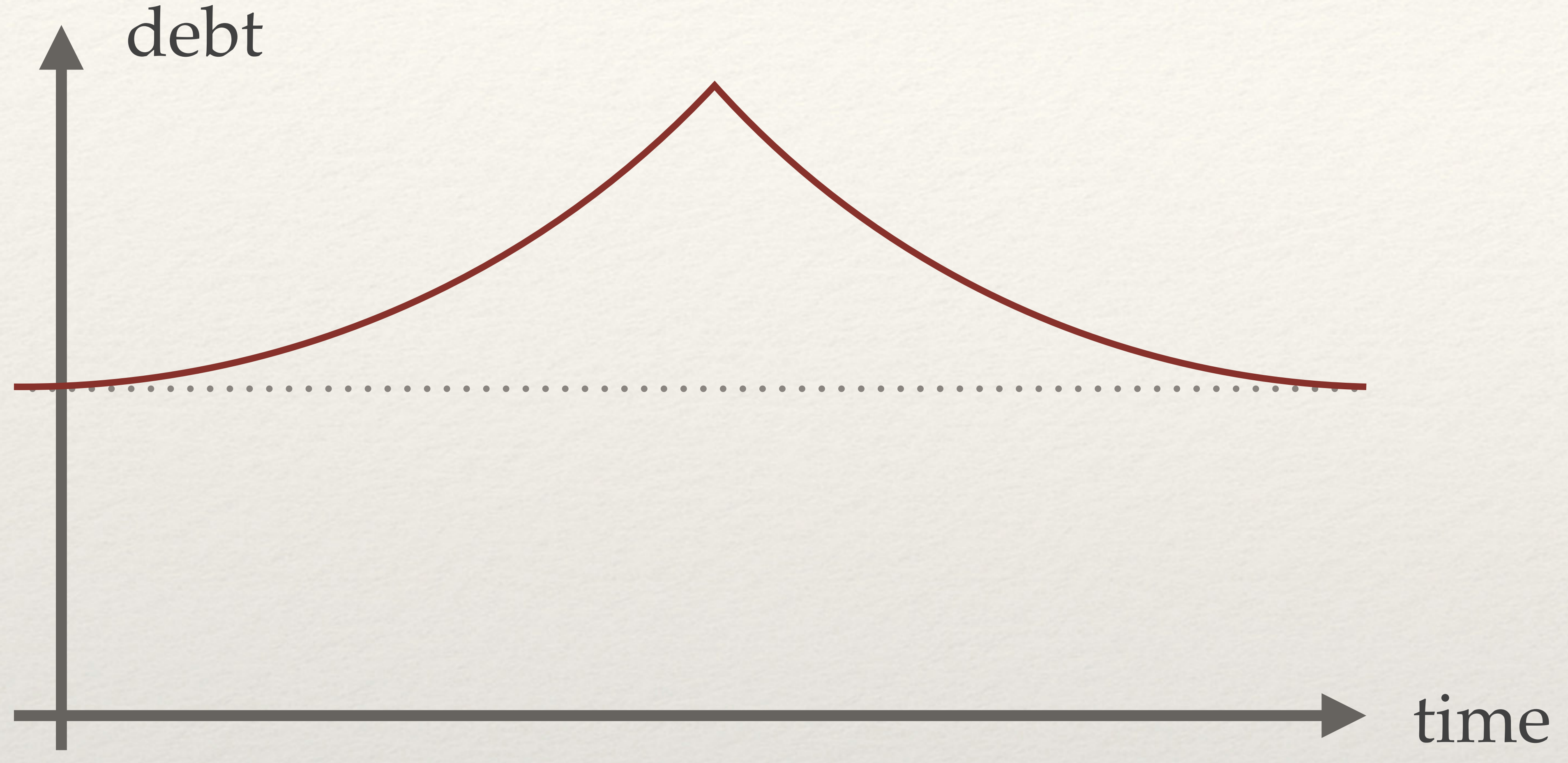
- CRS production function with capital, $Y = F(K, N)$ and capital taxes
- Same RSS condition still works, but need to change gov budget constraint



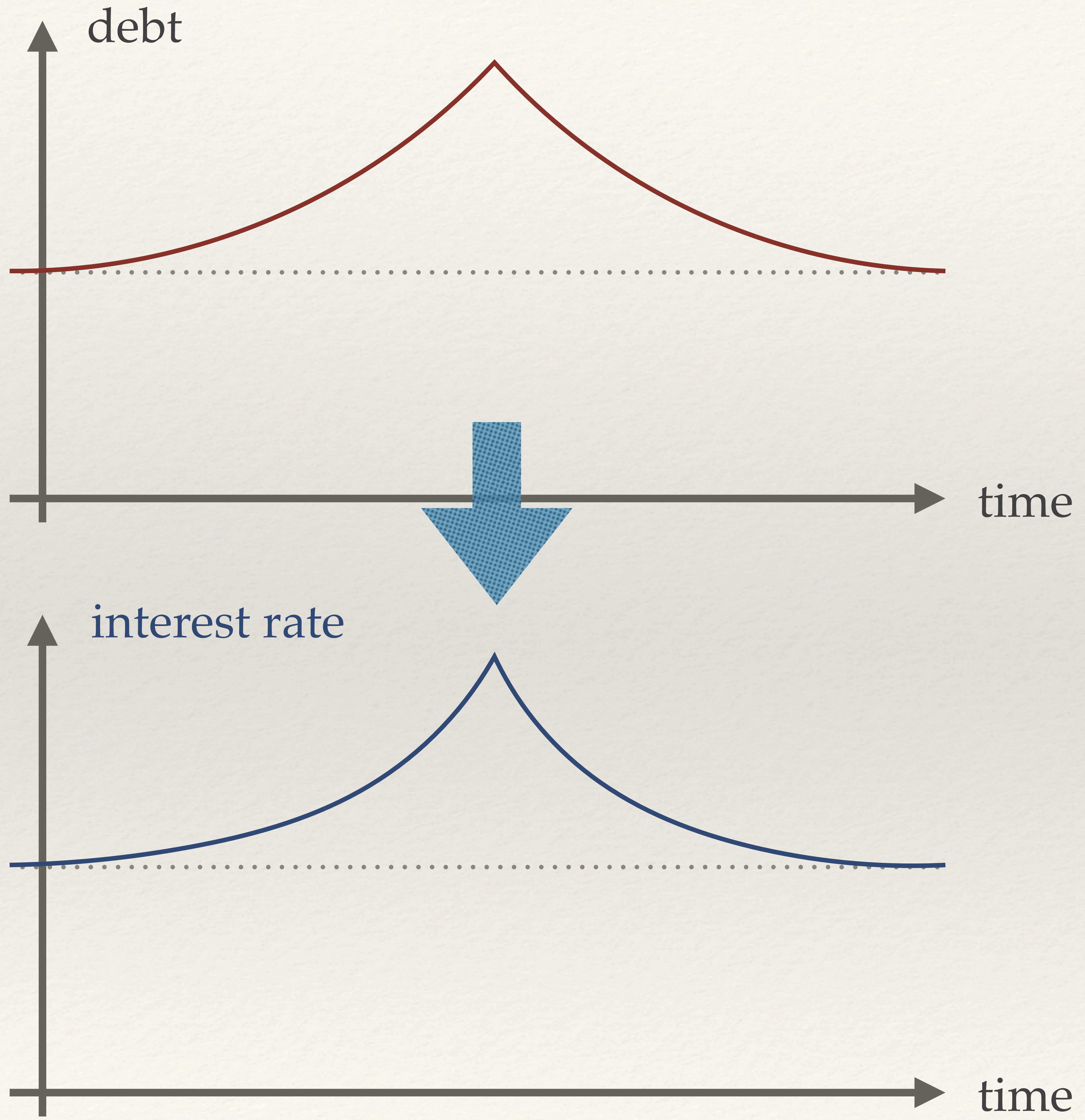
No RSS in log-separable economy with capital

Intuition

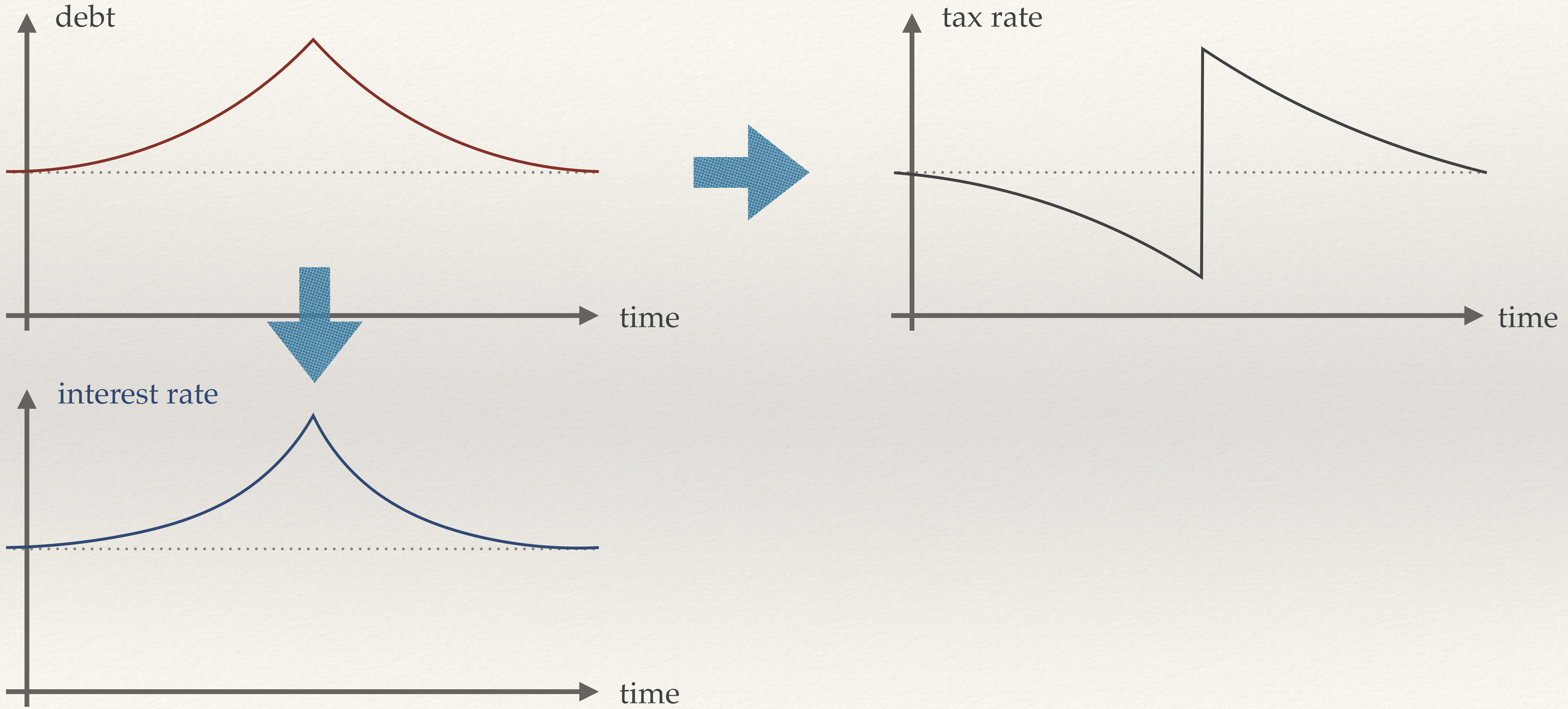
Intuition



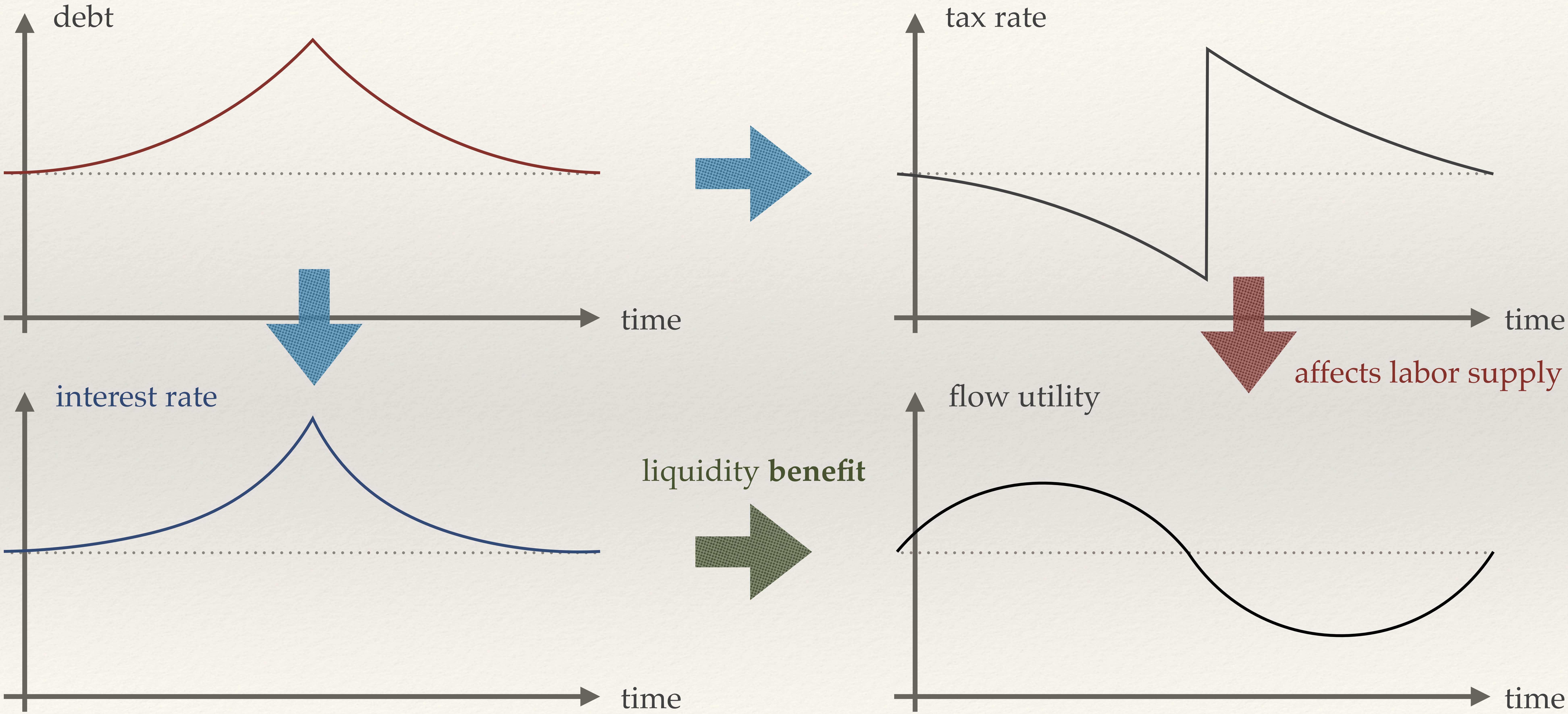
Intuition



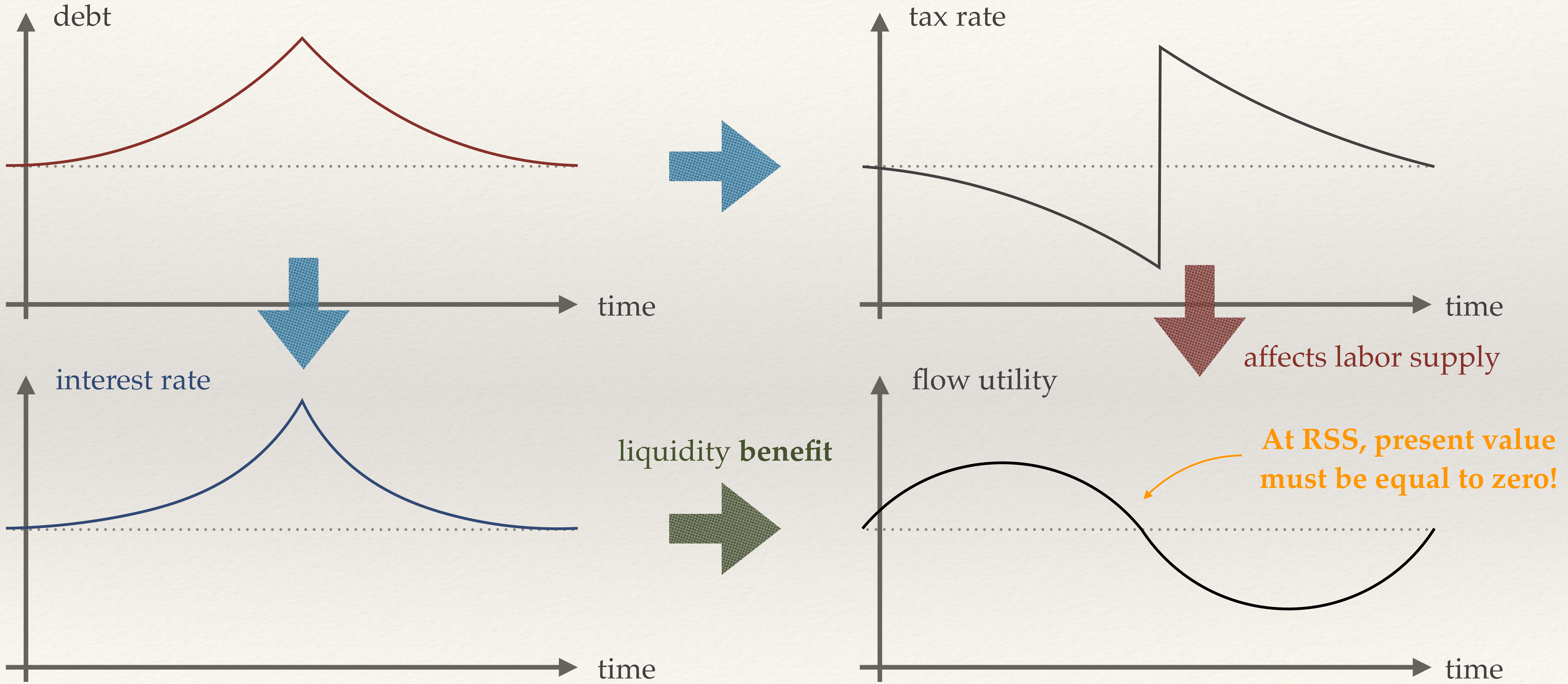
Intuition



Intuition


debt
time
tax rate
time
affects labor supply
interest rate
time
flow utility
liquidity **benefit**
time

Intuition


debt
time
tax rate
time
interest rate
time
liquidity **benefit**
affects labor supply
flow utility
At RSS, present value
must be equal to zero!
time

One-period deviation

- Imagine Ramsey plan settles at some steady state in the long run, with r, τ
  - **Ramsey steady state (RSS)**

One-period deviation

- Imagine Ramsey plan settles at some steady state in the long run, with r, τ
  - **Ramsey steady state (RSS)**
- Contemplate one-period deviation, in some period s, by some dr and $d\tau$
- Effect on utility: $$d\sum_{t=0}^{\infty}\delta^t\mathcal{U}_t = \delta^s\sum_{h=-s}^{\infty}\delta^h\frac{d\mathcal{U}_{s+h}}{dr_s}dr + \delta^s\sum_{h=-s}^{\infty}\delta^h\frac{d\mathcal{U}_{s+h}}{d\tau_s/(1-\tau)}\frac{d\tau}{1-\tau}$$

One-period deviation

- Imagine Ramsey plan settles at some steady state in the long run, with r, τ
  - **Ramsey steady state (RSS)**
- Contemplate one-period deviation, in some period s, by some dr and $d\tau$
- Effect on utility: $$d \sum_{t=0}^{\infty} \delta^t \mathcal{U}_t = \delta^s \sum_{h=-s}^{\infty} \delta^h \frac{d\mathcal{U}_{s+h}}{dr_s} dr + \delta^s \sum_{h=-s}^{\infty} \delta^h \frac{d\mathcal{U}_{s+h}}{d\tau_s/(1-\tau)} \frac{d\tau}{1-\tau}$$

$\rightarrow \epsilon^{U,r}$

One-period deviation

- Imagine Ramsey plan settles at some steady state in the long run, with r, τ
  - **Ramsey steady state (RSS)**
- Contemplate one-period deviation, in some period s, by some dr and $d\tau$
- Effect on utility: $$d\sum_{t=0}^{\infty}\delta^t \mathcal{U}_t = \delta^s \sum_{h=-s}^{\infty}\delta^h \frac{d\mathcal{U}_{s+h}}{dr_s}dr + \delta^s \sum_{h=-s}^{\infty}\delta^h \frac{d\mathcal{U}_{s+h}}{d\tau_s/(1-\tau)}\frac{d\tau}{1-\tau}$$

$\rightarrow \epsilon^{U,r}$ $\rightarrow \epsilon^{U,\tau}$

One-period deviation

- Imagine Ramsey plan settles at some steady state in the long run, with r, τ
  - **Ramsey steady state (RSS)**
- Contemplate one-period deviation, in some period s, by some dr and $d\tau$
- Effect on utility: $$d\sum_{t=0}^{\infty}\delta^t\mathcal{U}_t = \delta^s\sum_{h=-s}^{\infty}\delta^h\frac{d\mathcal{U}_{s+h}}{dr_s}dr + \delta^s\sum_{h=-s}^{\infty}\delta^h\frac{d\mathcal{U}_{s+h}}{d\tau_s/(1-\tau)}\frac{d\tau}{1-\tau}$$
  $\rightarrow \epsilon^{U,r}$ $\qquad \rightarrow \epsilon^{U,\tau}$
- To keep utility unchanged: $$dr = \frac{-\epsilon^{U,\tau}}{\epsilon^{U,r}}\frac{d\tau}{1-\tau} \equiv m\frac{d\tau}{1-\tau}$$

How the RSS vanishes

- Gov. debt explodes relative to after-tax income, however …

… in absolute terms,
gov. debt goes to zero!