Debt into Growth: How Government Borrowing Accelerated the First Industrial Revolution

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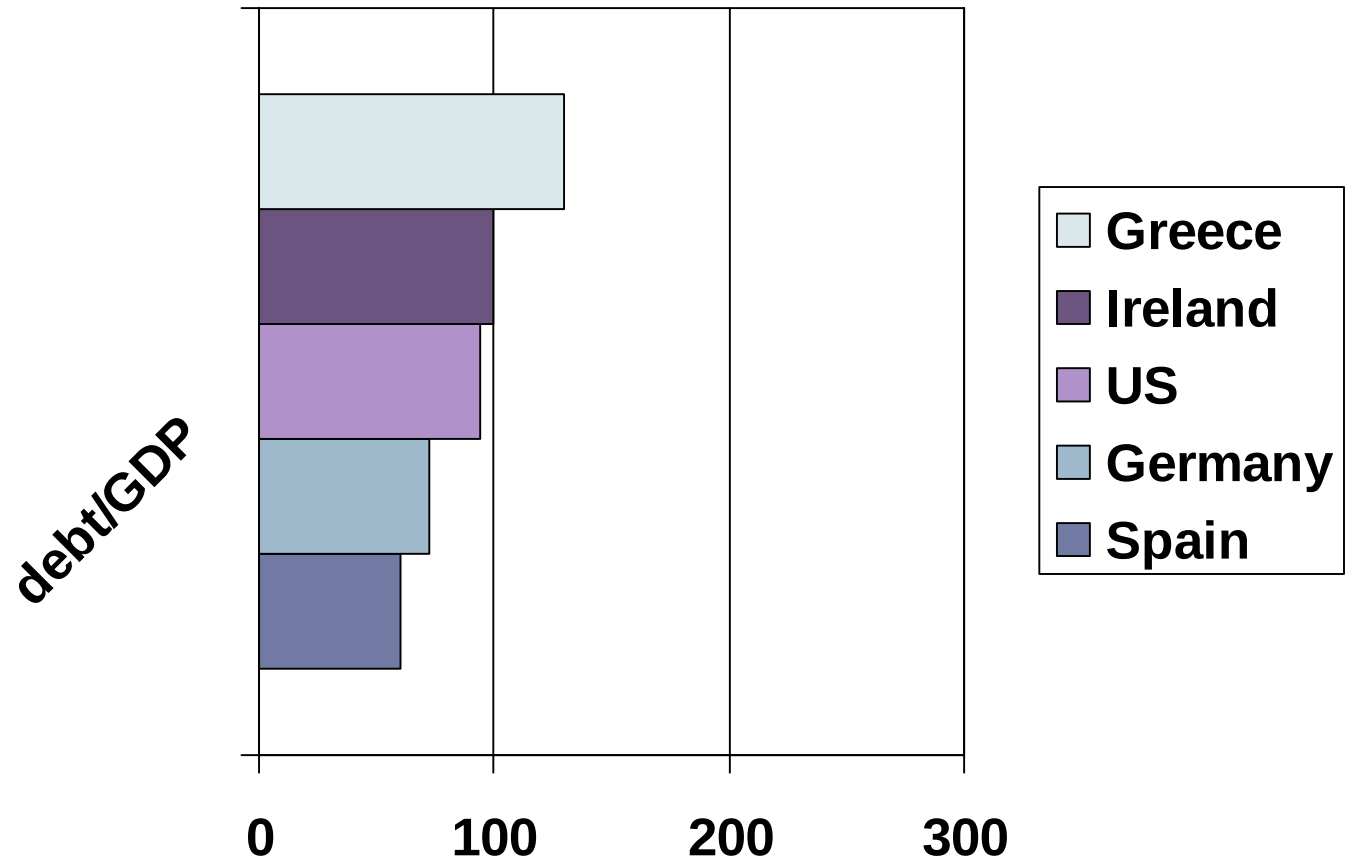
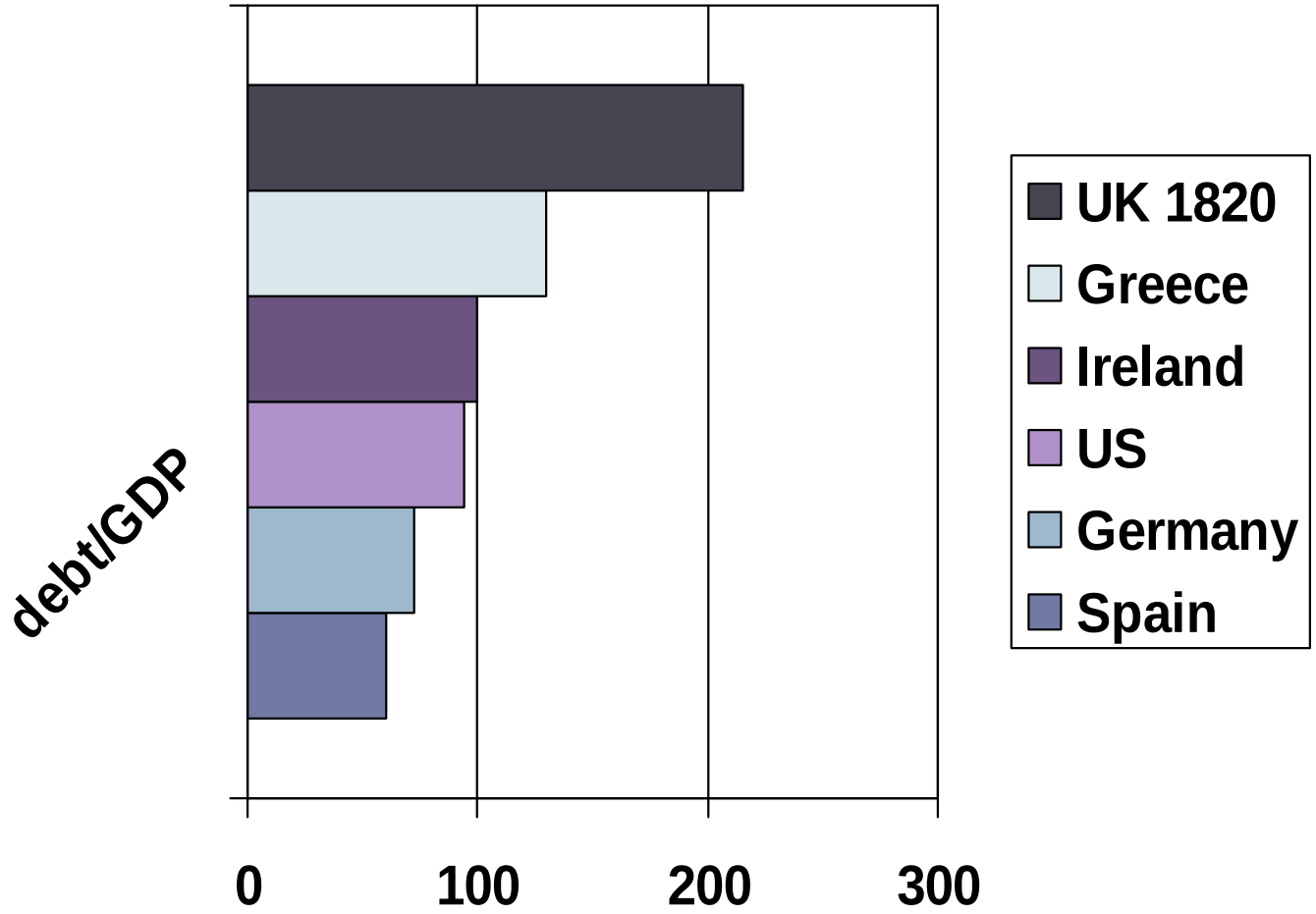
What's the role of debt in the British Industrial Revolution?

- Traditional interpretation
  - debt bad ("crowding out")
    - Britain accumulates more than 200% of GDP within a century
    - Spends it all on wars ("thrown into the sea")
    - Seen as an explanation for slow growth
  - neutral ("Ricardian equivalence")
    - Financed by forward-looking agent
    - Small reactions of interest rates
- This paper – beneficial effect
  - Exogenous shock = Glorious Revolution; massive increase in warfare
  - Massive government borrowing increases the speed of IR
  - Does not explain why there is an IR in the first place
  - Explains why living standards fail to increase for the first century of the IR

Debt “now”



… and “then”


debt/GDP
0
100
200
300
UK 1820
Greece
Ireland
US
Germany
Spain

Related literature

- Role of borrowing in the IR
  - Negative: Williamson 1984, 1987; Temin and Voth 2005
  - Impossible to find: Heim and Mirowski 1987, 1989; Clark 2002; Quinn 2001
  - Neutral for a reason: Barro 1989 [Aschauer 1988]
- Resource allocation and development
  - Hsieh and Klenow 2009; Caselli and Coleman 2001; Gancia and Zilibotti 2009
  - + role of financial frictions: Song, Storesletten, and Zilibotti 2011
- The effects of government debt:
  - Diamond 1965, Barro 197, Barro 1979, Holmstrom-Tirole 1998
- Bubbles and financial frictions
  - Woodford (1990), Azariadis and Smith (1993), Woodford and Santos (1997),
  - Caballero and Krishnamurthy (2006), Farhi and Tirole (2010), Miao and Wang (2011)
  - Kraay and Ventura (2007), Kocherlakota (2010), Martin and Ventura (2011, 2012)
  - Ventura (2011): cost of capital

Two views of the IR

Old view

- Rapid technological change
- Massive increases in TFP
- Investment ratio doubles within a few decades (from 8 to 16%)
- Rapid wage growth

New view

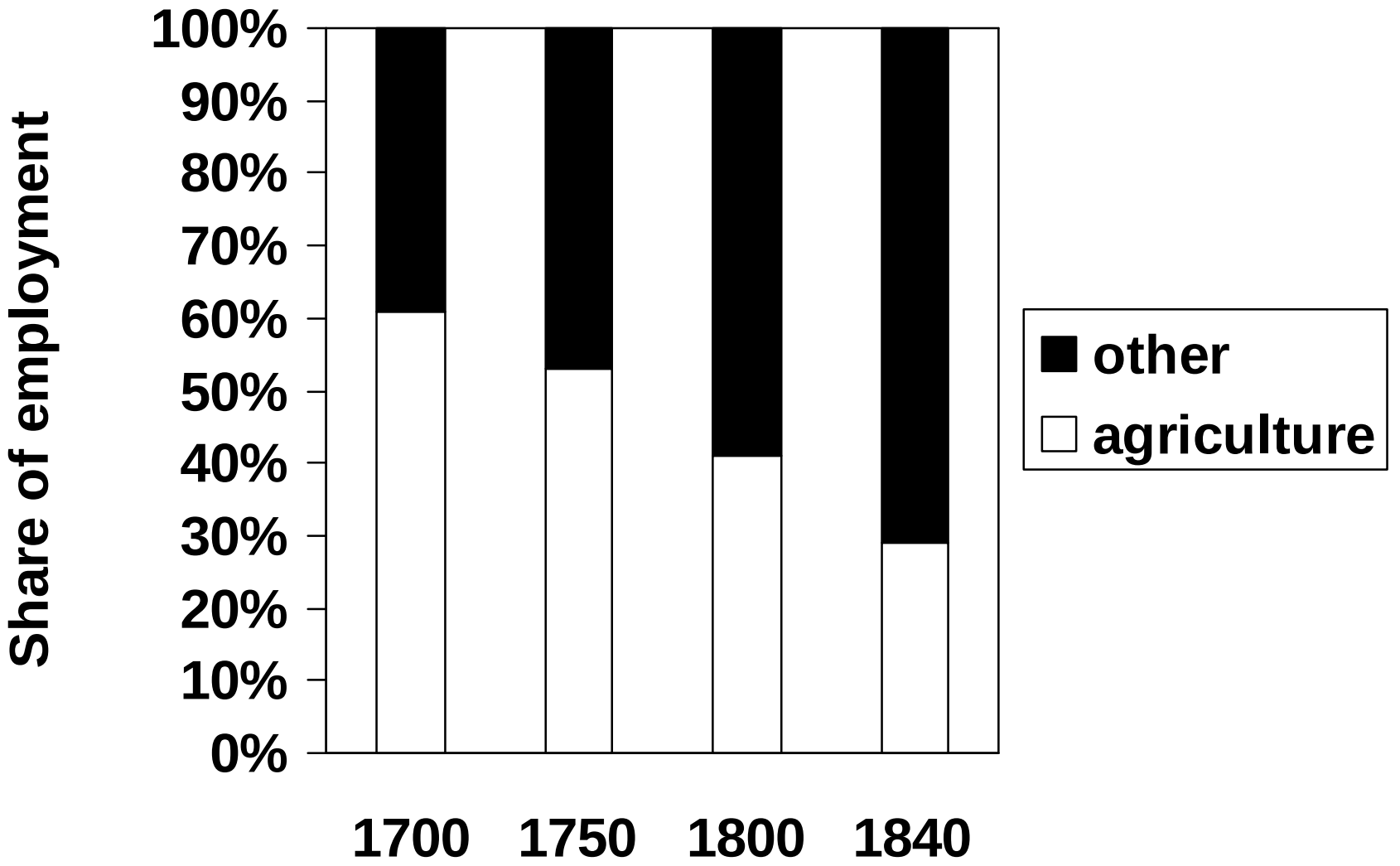
- Slow TFP growth
- Investment grows slowly
- Main feature: structural change
- Minimal wage growth

Growth was slow

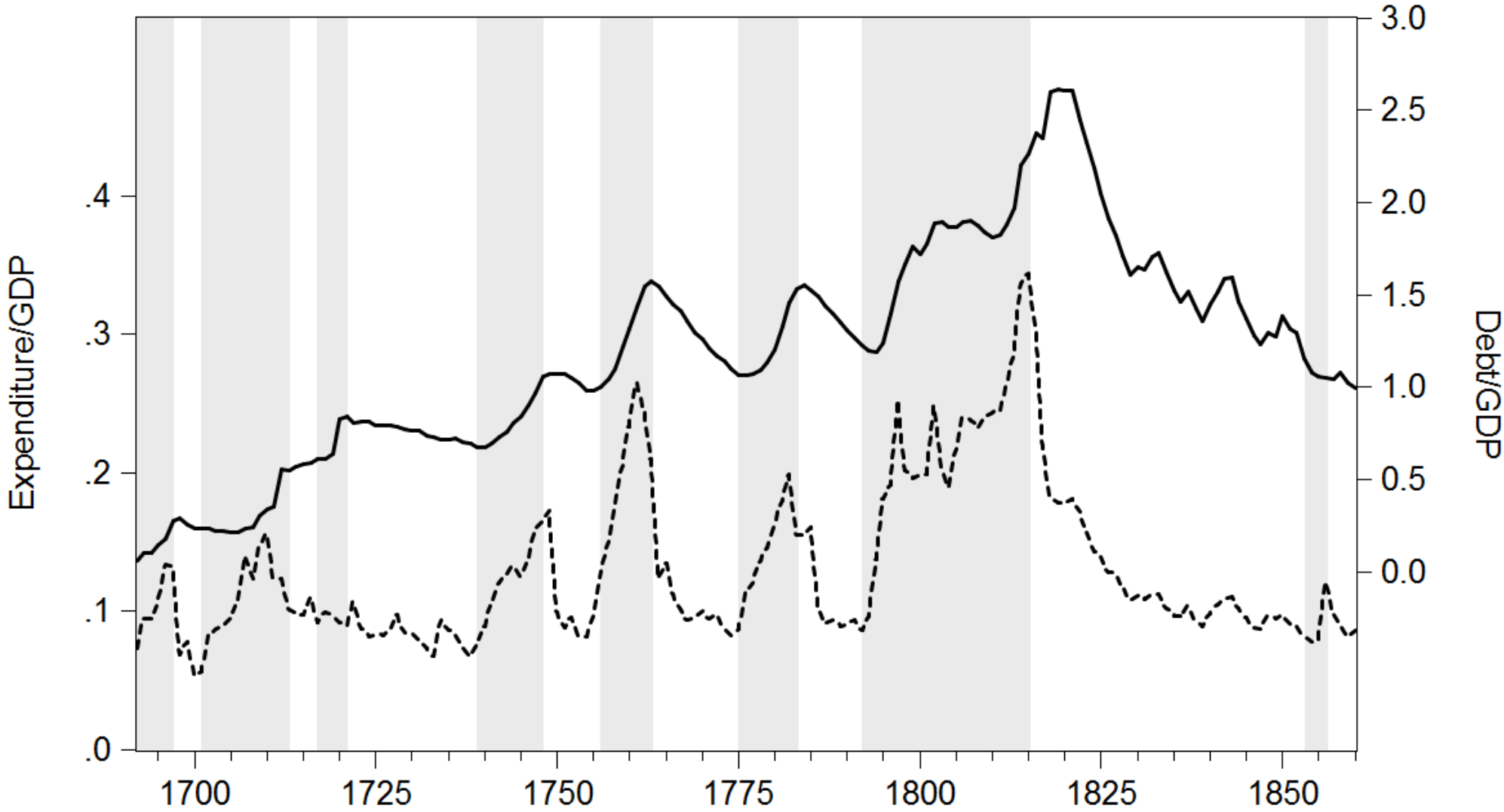
TABLE 1. Estimates of Productivity Growth in England, 1770-1860

	change in % p.a.				
	r	**w**	**q**		**TFP**
Antràs and Voth (2001)					
1770-1801	-0.28	0.40	0.13		0.12
1801-1831	0.83	0.34	0.20		0.49
1831-1860	0.74	0.56	0.11		0.56
	Y	**K**	**L**	**T**	**TFP**
Harley (1999)					
1760-1800	1.0	1.0	0.8	0.2	0.19
1801-1831	1.9	1.7	1.4	0.4	0.50
1831-1860*	2.5	2.0	1.4	0.6	1.00

Structural Change



Wars drive debt accumulation



From North+Weingast 1989:

TABLE 3
GROWTH OF GOVERNMENT DEBT, 1618–1740
(£ million)

Year	Governmental Expenditure[1]	Debt[2]	Prices[3] (1701 = 100)
Stuart England			
1618[4]	£0.5	£0.8	
mid-1630s[5]	1.0	1.0	
1680[6]	1.4		113
1688[6]	1.8	1.0[7]	99
Post Glorious Revolution			
1695	6.2	8.4	116
1697	7.9	16.7	122
1700	3.2	14.2	115
1710	9.8	21.4	122
1714	6.2	36.2	103
1720	6.0	54.0	102
1730	5.6	51.4	95
1740	6.2	47.4	100
1750	7.2	78.0	95

Logic of our argument

- Initial situation
  - All funds in the hands of nobility
  - Agriculture the main form of production
- IR=appearance of new technology in hands of entrepreneurs (cotton manufacturers, etc.)
- Financial friction (+cultural preference) ensures that there is no transfer of resources from old elites to entrepreneurs – growth restrained by profits in new sector (reinvested)
- Emergence of liquid government debt=alternative store of value for old elites
- Investment in agriculture declines
- Profits in the new sector go up
- Effectively, government borrowing acts like a “benign bubble”, ie draining the swamp of inefficient investment that uses factors of production previously
- Result is **faster** growth

A stylized model of the Industrial Revolution

- The Industrial Revolution consists of the arrival of a class of capitalists with a new industrial investment
- technology and an arbitrarily small initial stock of capital.
- Like the nobles, capitalists save a fraction β of their income and invest it.
- But the capitalists produce capital that is $\pi > 1$ times more efficient that the capital produced by nobles.
- That is, for each unit of goods they invest, they obtain π units of capital.
- Government finances expenditure with taxes and debt. Revenue is entirely useless ("thrown in the sea").

Pre-industrial state

- Production function

$$F(l_t, k_t, n_t) = l_t^{\lambda} \cdot k_t^{\alpha} \cdot n_t^{1-\lambda-\alpha}$$

where l_t, k_t and n_t are land, capital and labor; and $\lambda > 0$, $\alpha > 0$ and $\lambda + \alpha < 1$.

- Two groups – nobles and masses
- Nobles save share of incorβe
- Masses do not save
- Crown fights foreign wars, cost x, financed by a proportional tax (reduces income by x)

Evolution of capital stock

- Capital evolves according to

$$k_{t+1} = (1-\delta) \cdot k_t + \beta \cdot (\lambda + \alpha) \cdot (1-x) \cdot k_t^{\alpha}$$

- And the steady state is

$$k^* = \left[\frac{\beta \cdot (\lambda+\alpha) \cdot (1-x)}{\delta} \right]^{\frac{1}{1-\alpha}}$$

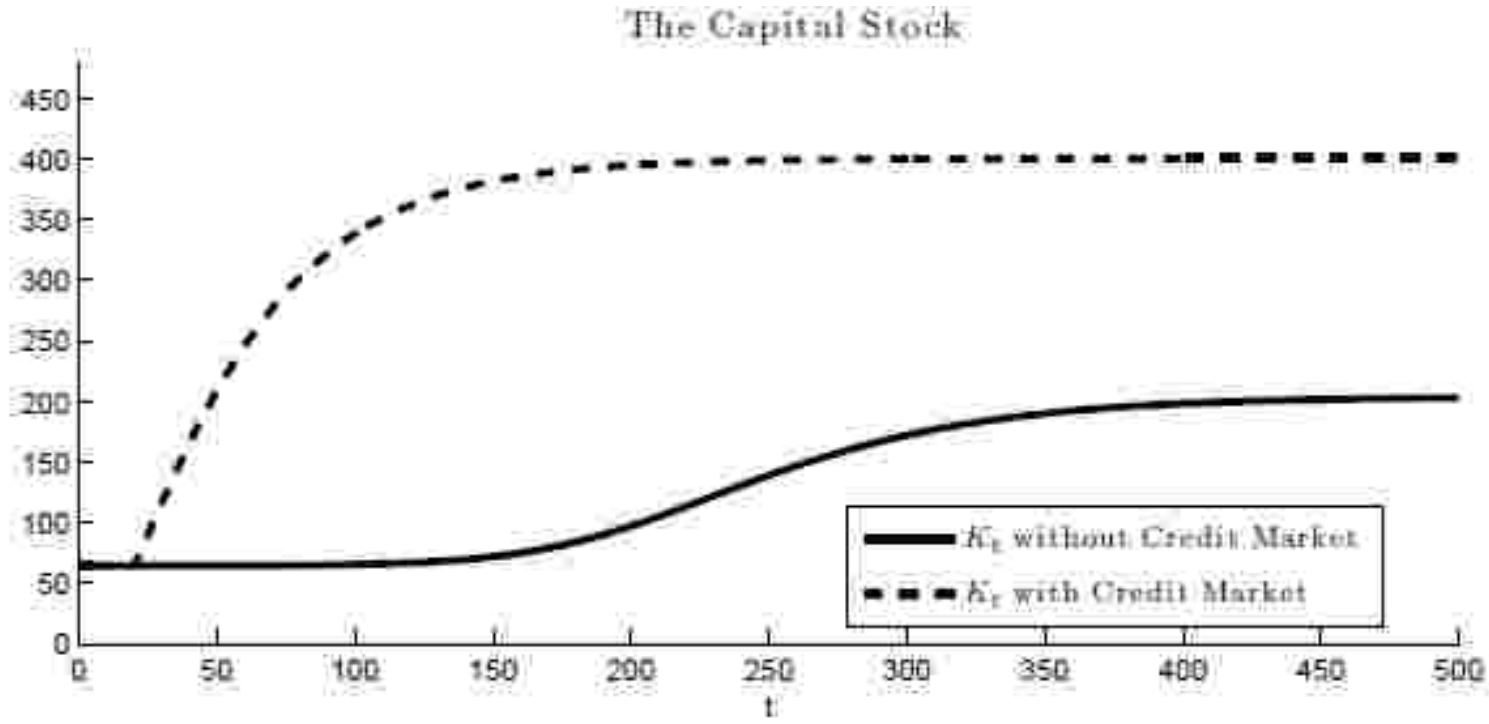
The Industrial Revolution – what **didn't** happen

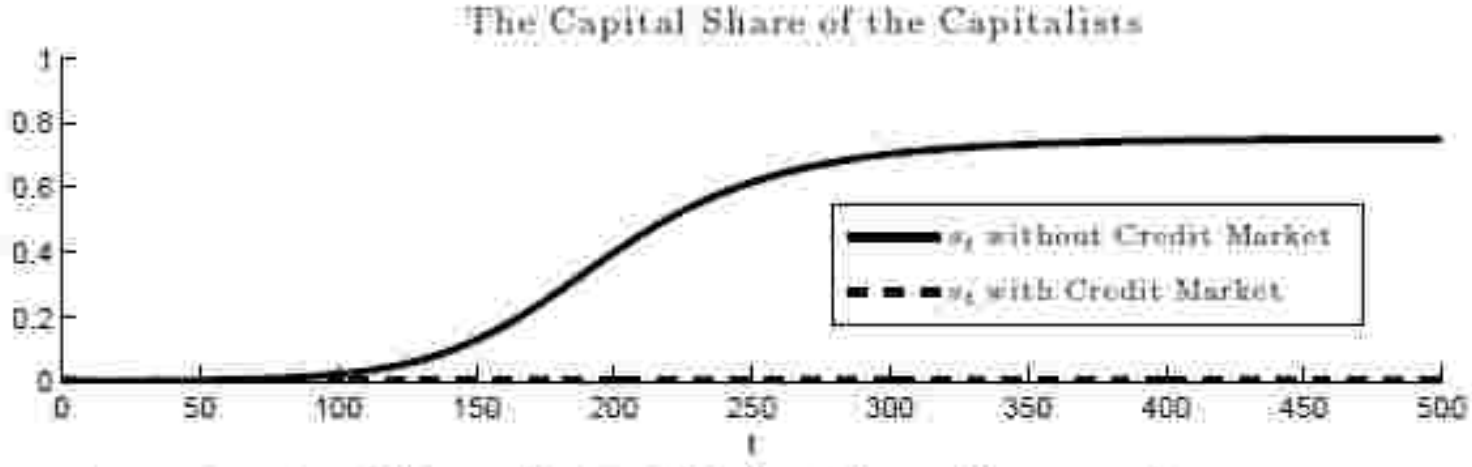
- New group of capitalists appears
- Investment efficiency higher ($\pi>1$)
- These capitalists borrow from nobles
- Capital accumulation:

$$k_{t+1} = (1-\delta)\cdot k_t + \pi \cdot \beta \cdot (\lambda+\alpha)\cdot(1-x)\cdot k_t^{\alpha}$$

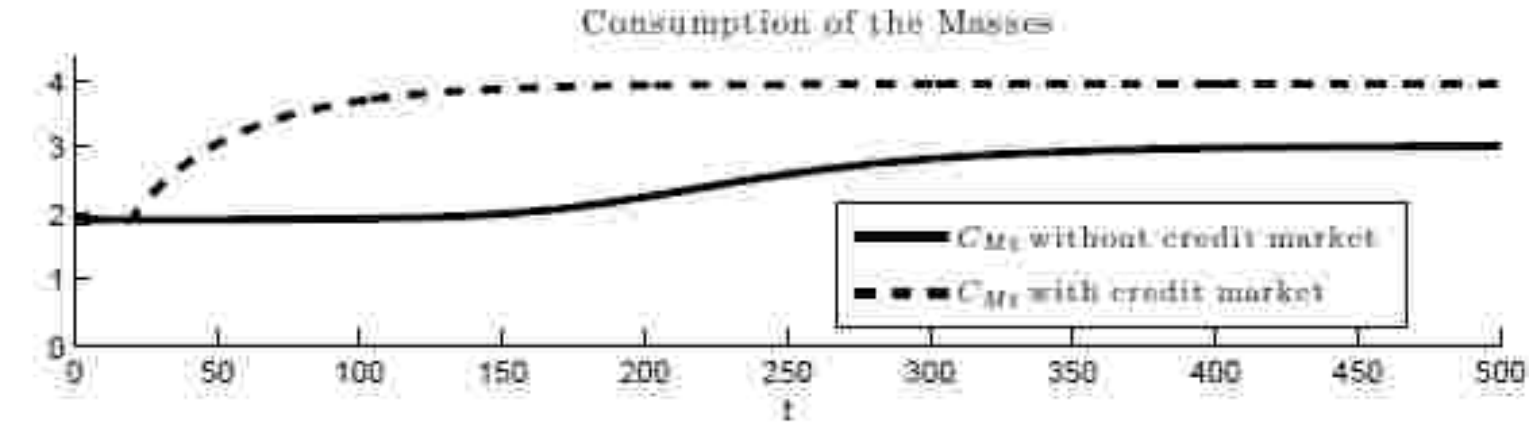
- Share of entrepreneurs:

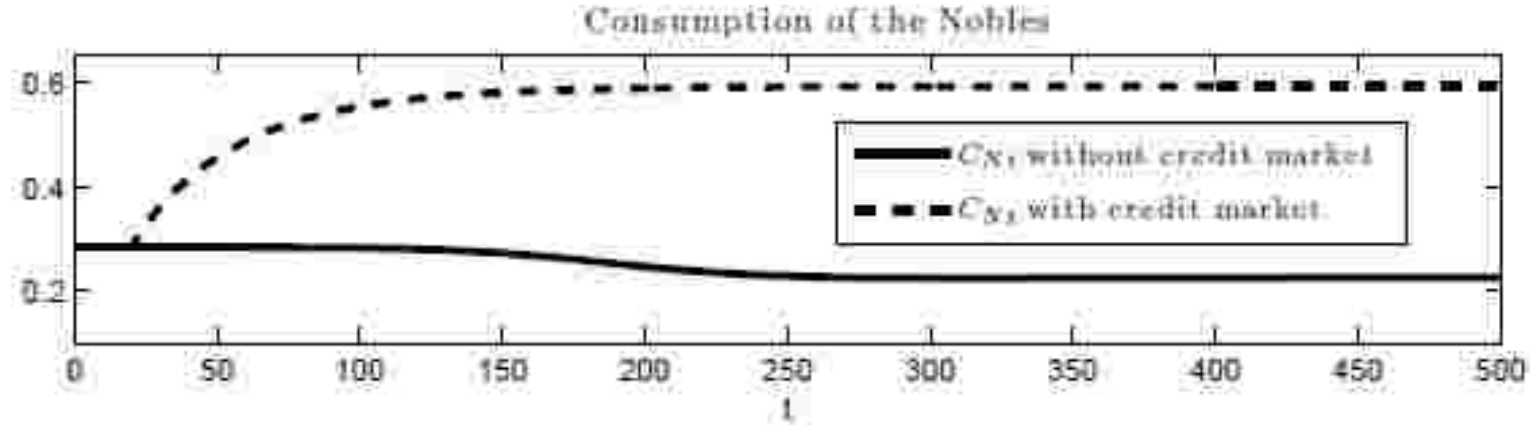
$$s_{t+1} = \frac{(1-\delta)\cdot k_t + \pi\cdot\beta\cdot\alpha\cdot(1-x)\cdot k_t^{\alpha}}{(1-\delta)\cdot k_t + \pi\cdot\beta\cdot(\lambda+\alpha)\cdot(1-x)\cdot k_t^{\alpha}} \cdot s_t$$

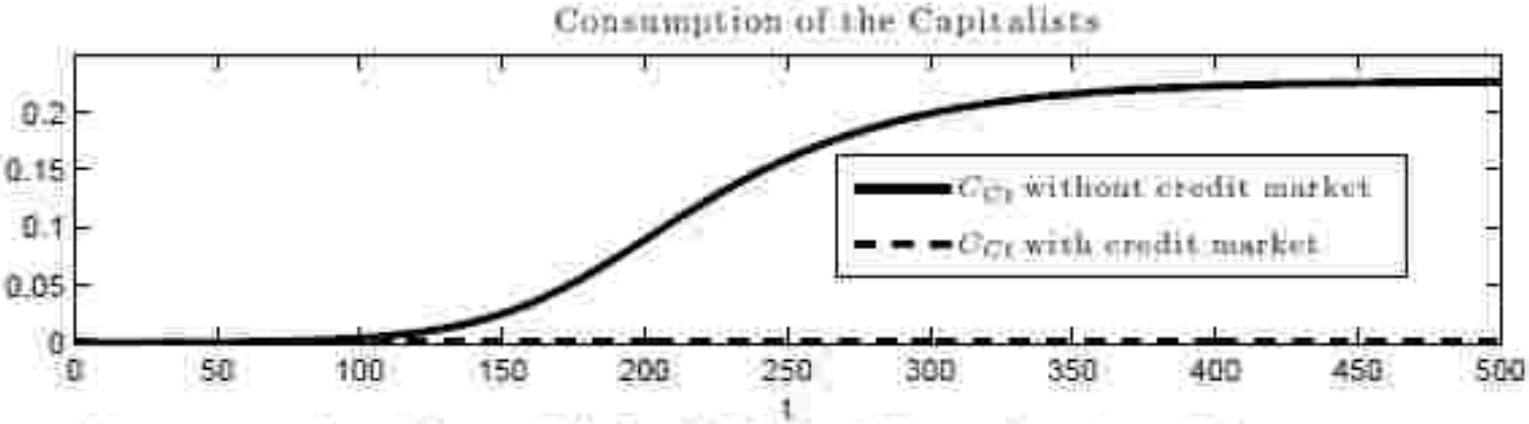




Parameters: $\lambda = 0.2$, $\alpha = 0.4$, $\delta = 0.04$, $\beta = 0.9$, $\pi = 3$ and $x = 0.1$







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Problems with this story

- Despite rapid technological change, TFP growth was slow
- Investment increased very slowly too
- The key feature of the Industrial Revolution was structural change with minimal growth
- There was substantial social change, as the wealth of capitalists increased relative to that of nobles
- The masses suffered as wages initially declined and only grew after 1800

IR with frictions

- Without frictions

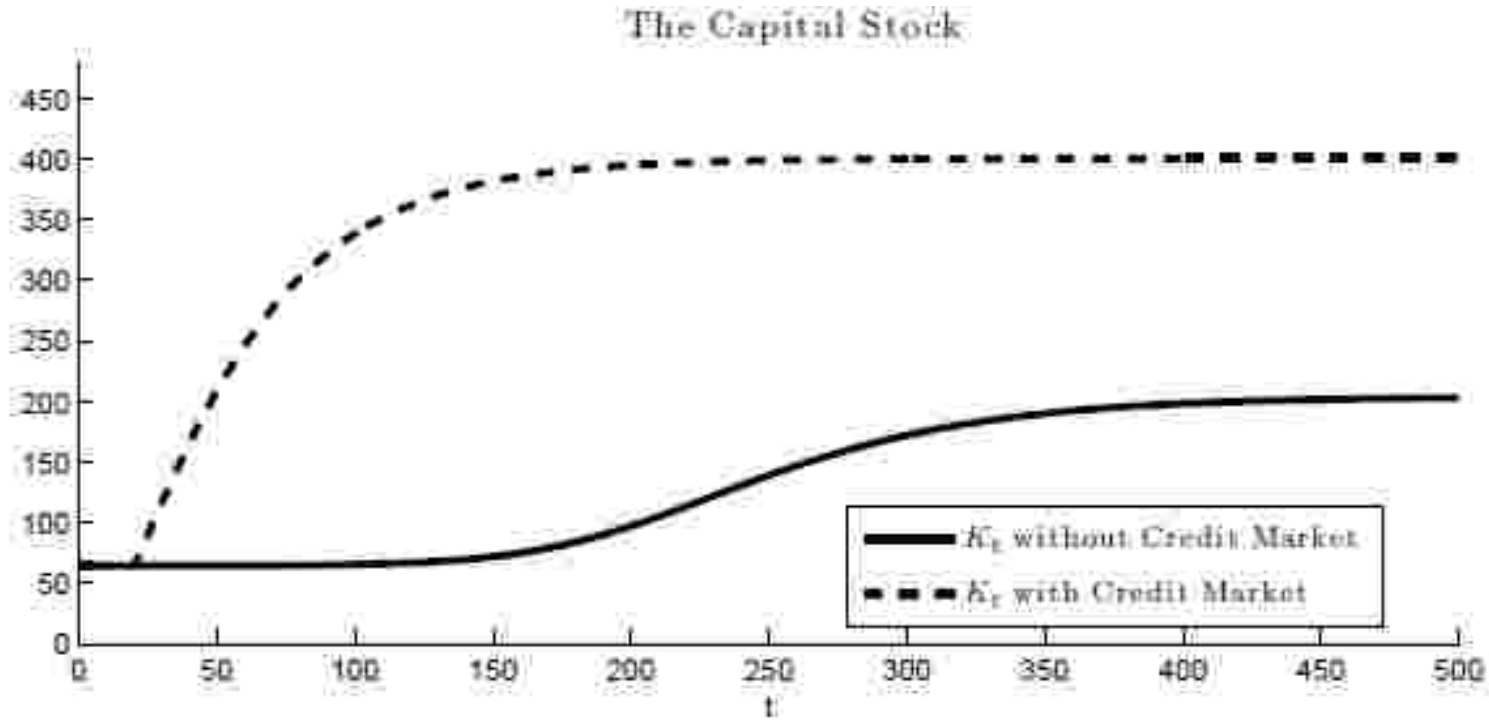
$$k_{t+1} = (1-\delta)\cdot k_t + \pi \cdot \beta \cdot (\lambda + \alpha)\cdot(1-x)\cdot k_t^{\alpha}$$

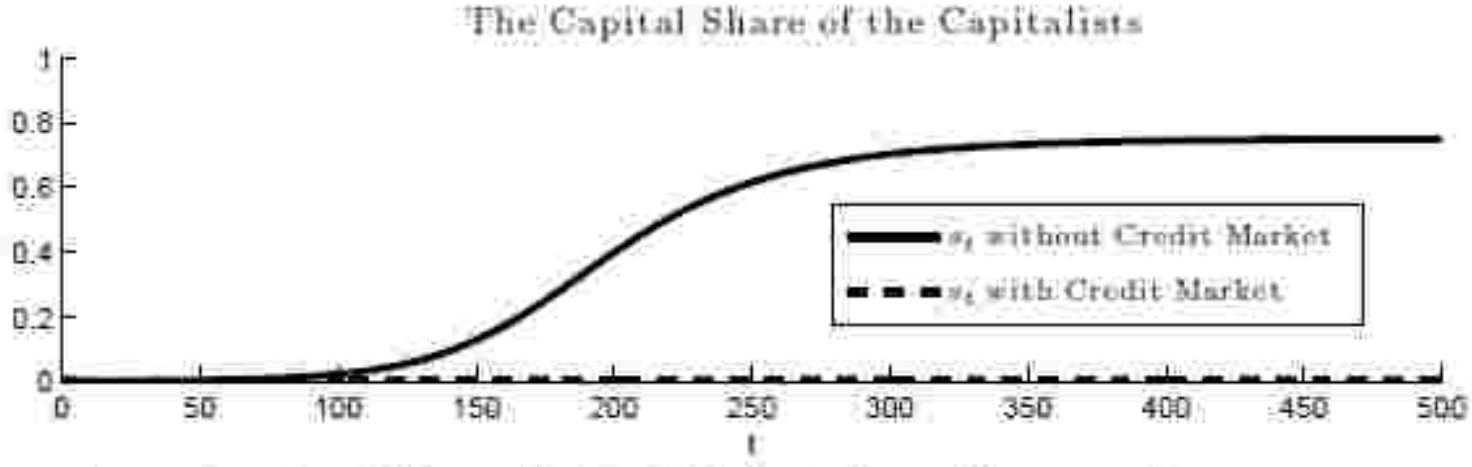
- Now, investment of capitalists only invested with π:

$$k_{t+1} = (1-\delta)\cdot k_t + \beta \cdot [\lambda + \alpha \cdot (1 + (\pi - 1)\cdot s_t)]\cdot(1-x)\cdot k_t^{\alpha}$$

- For industrialization to succeed, we need the capital share of the capitalists to grow: $\pi > 1 + \frac{\lambda}{\alpha}$
- Steady states:

$$k^* = \left[\frac{\pi\cdot\beta\cdot\alpha\cdot(1-x)}{\delta}\right]^{\frac{1}{1-\alpha}} \quad \text{and} \quad s^* = 1 - \frac{\lambda}{\alpha\cdot(\pi-1)}$$





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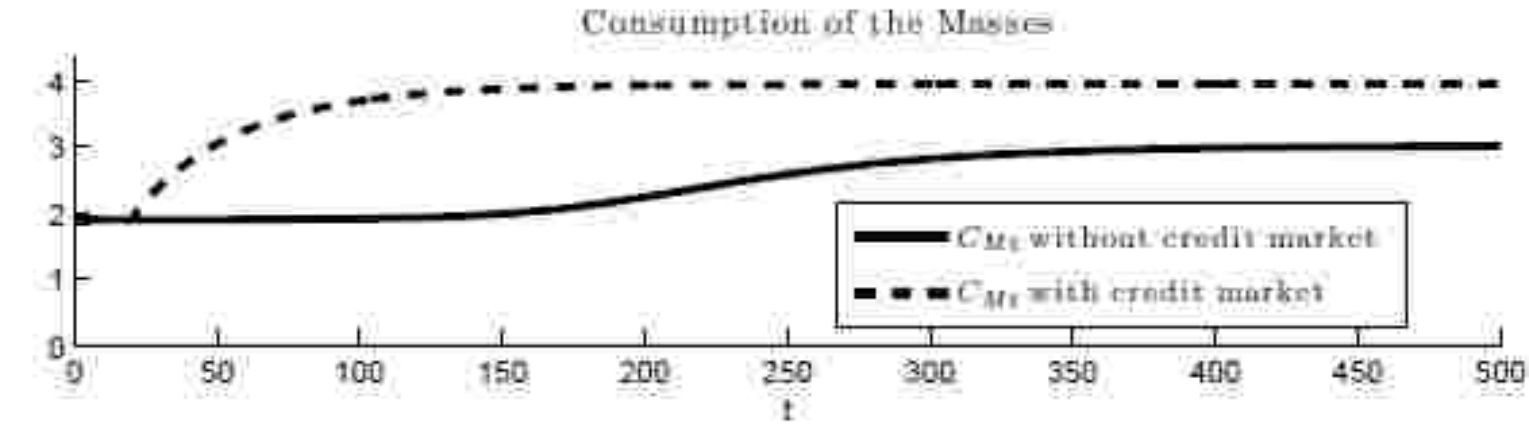
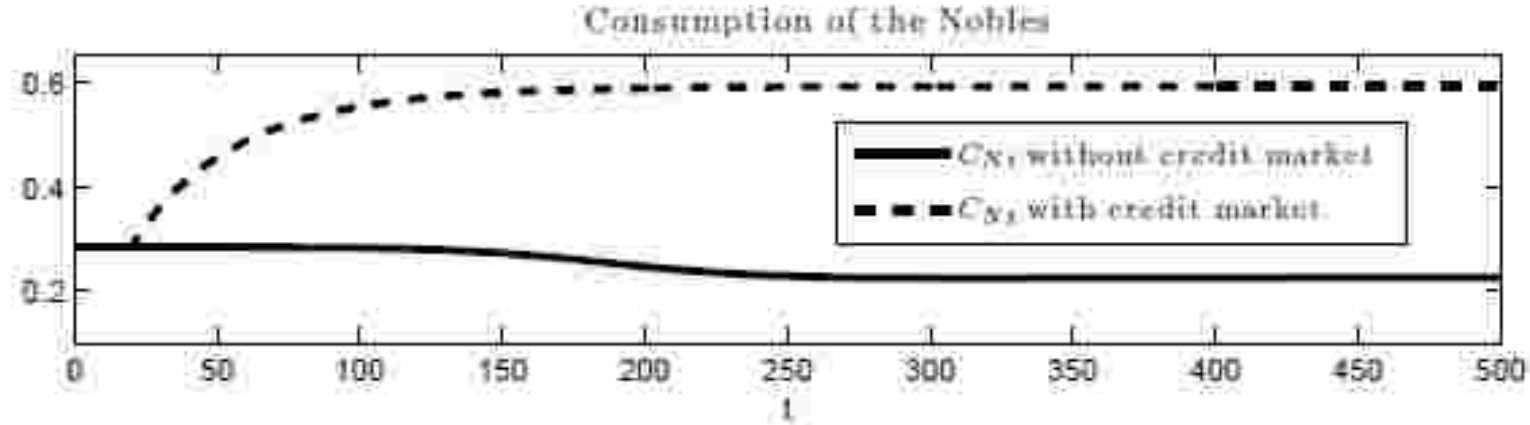
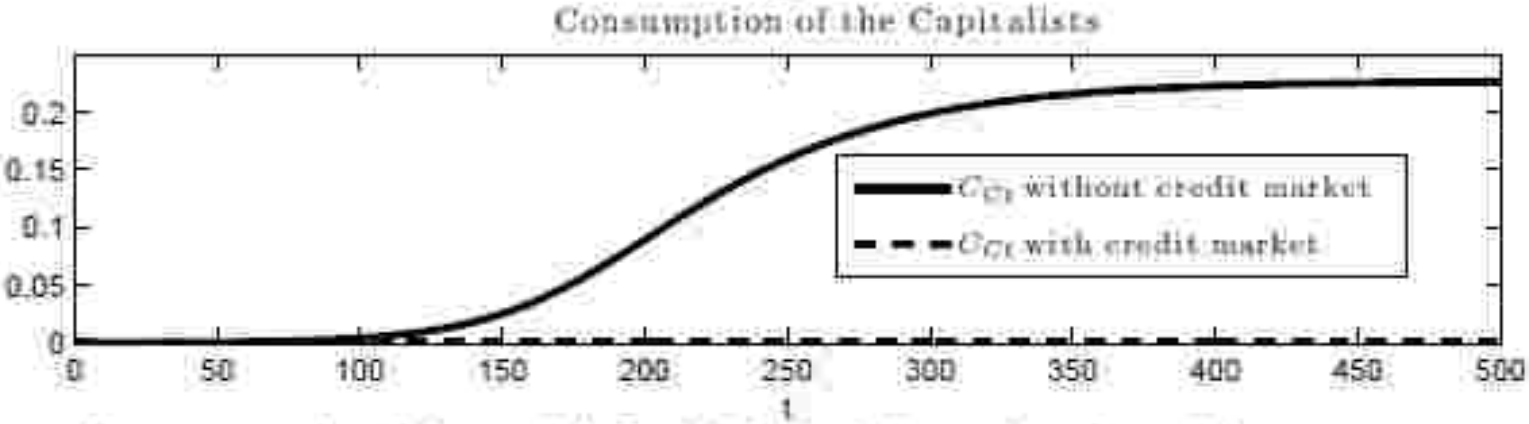






Parameters: $\lambda = 0.2$, $\alpha = 0.4$, $\delta = 0.04$, $\beta = 0.9$, $\pi = 3$ and $x = 0.1$

Crown Borrowing

- Debt accumulation equation

$$d_{t+1} = R_t \cdot d_t + (x - \tau) \cdot k_t^{\alpha}$$

- If debt not greater than savings of nobles, return equal to return to investment of nobles

$$R_t = (1 - \tau) \cdot \alpha \cdot k_t^{\alpha - 1} + 1 - \delta$$

- Capitalists do not buy the debt

$$\pi \cdot (1 - \tau) \cdot \alpha \cdot k_t^{\alpha - 1} + 1 - \delta > R_t$$

IR with Crown Borrowing

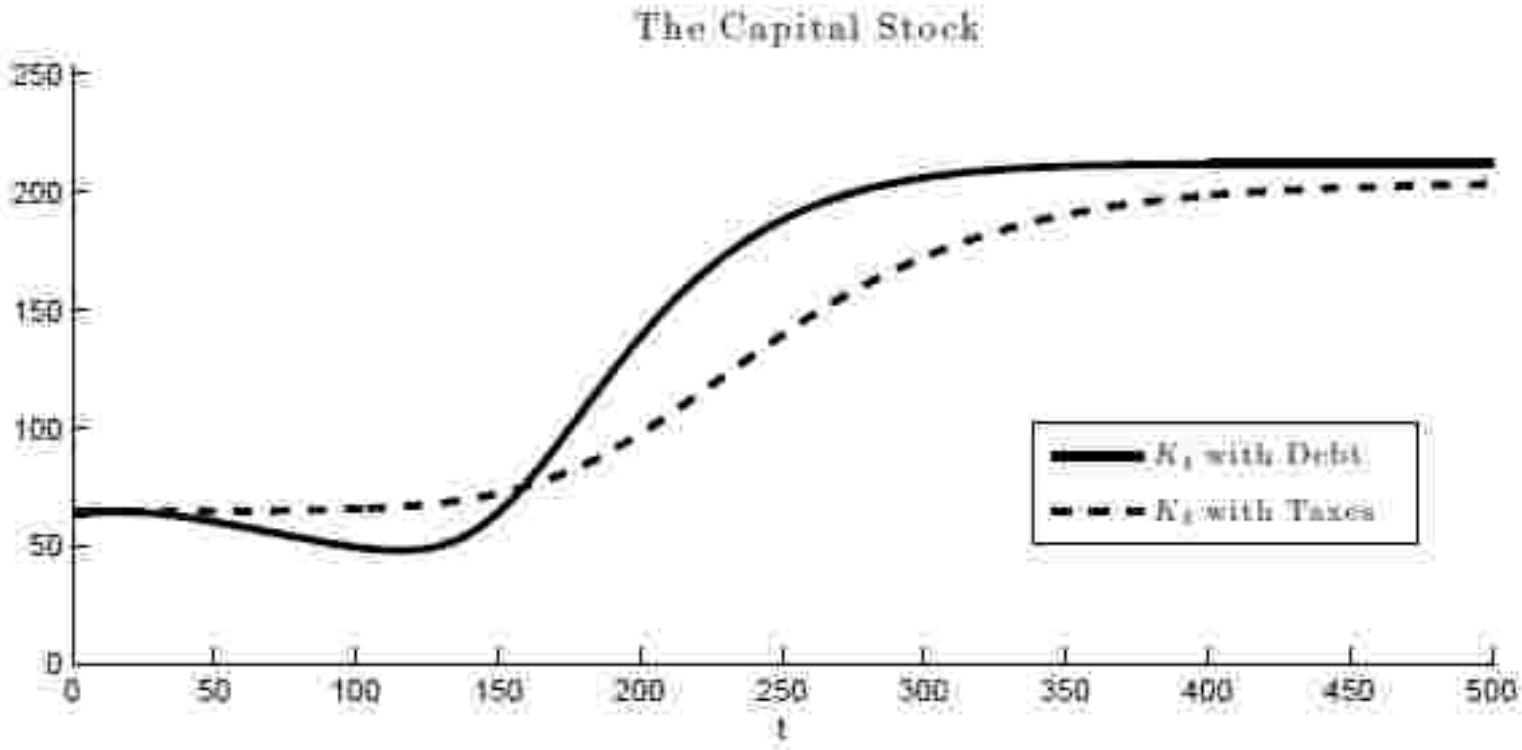
- Capital accumulation

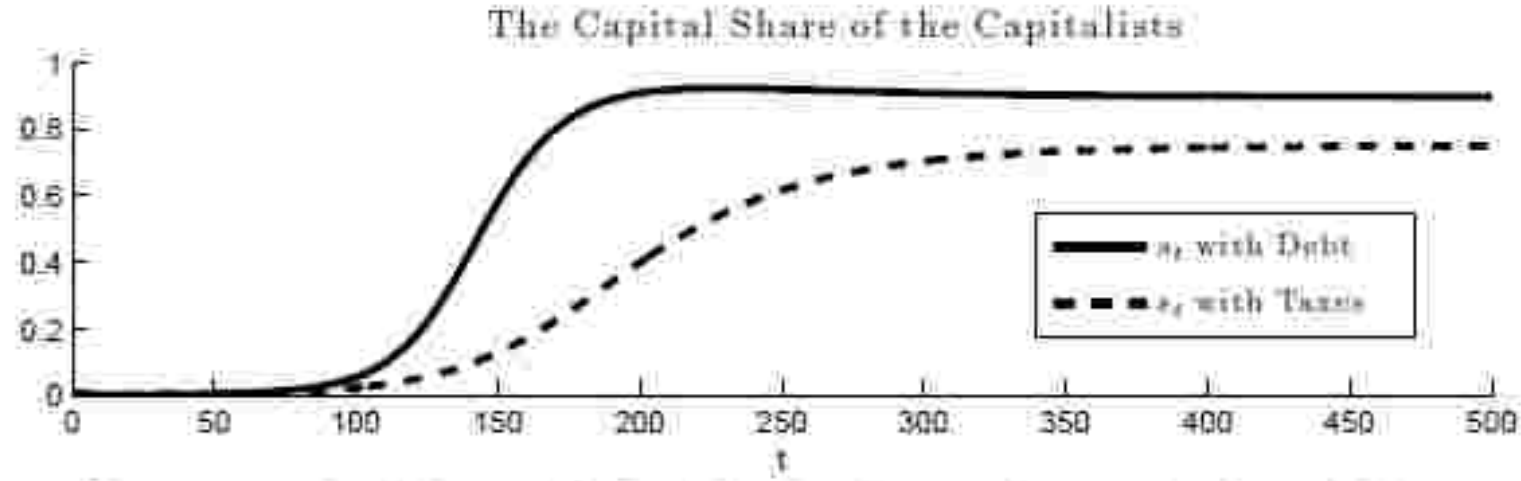
$$k_{t+1} = (1-\delta)\cdot k_t + \beta\cdot\{[\lambda+\alpha\cdot(1+(\pi-1)\cdot s_t)]\cdot(1-\tau)\cdot k_t^{\alpha} + R_t\cdot d_t\} - d_{t+1}$$

- Share of capitalists

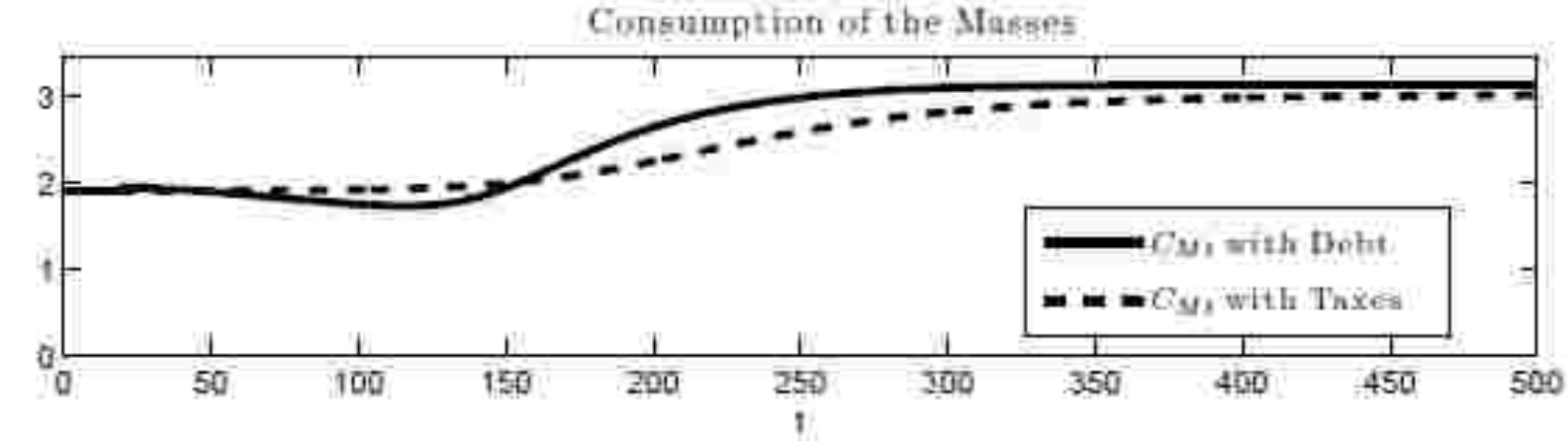
$$s_{t+1} = \frac{(1-\delta)\cdot k_t+\pi\cdot\beta\cdot\alpha\cdot(1-\tau)\cdot k_t^{\alpha}}{(1-\delta)\cdot k_t+\beta\cdot\{[\lambda+\alpha\cdot(1+(\pi-1)\cdot s_t)]\cdot(1-\tau)\cdot k_t^{\alpha}+R_t\cdot d_t\}-d_{t+1}}\cdot s_t$$

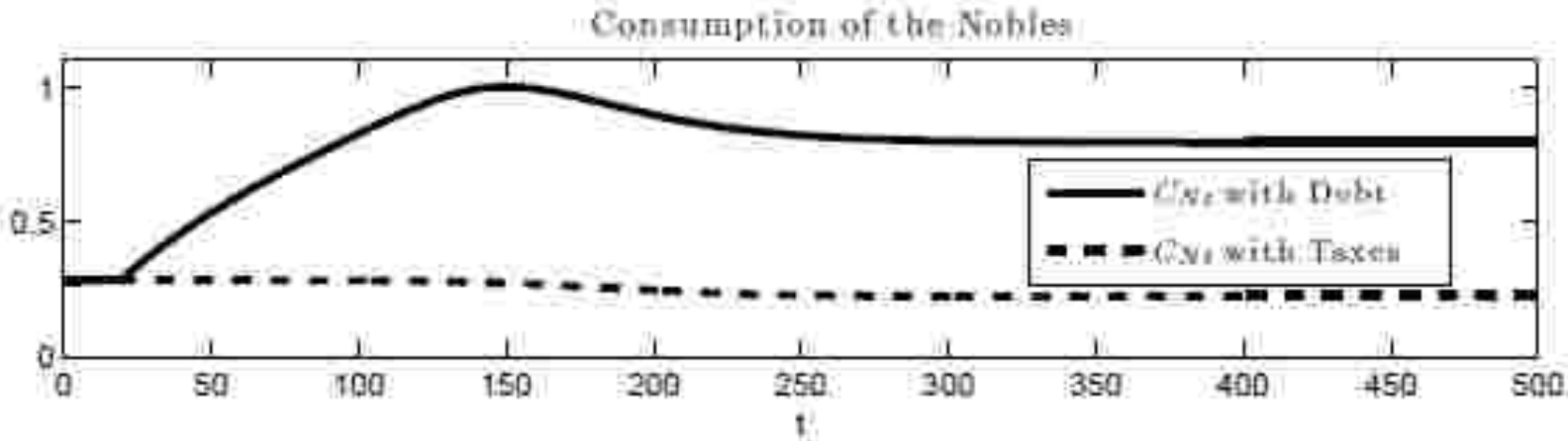
- Debt crowds out investment BUT raises share of capitalists

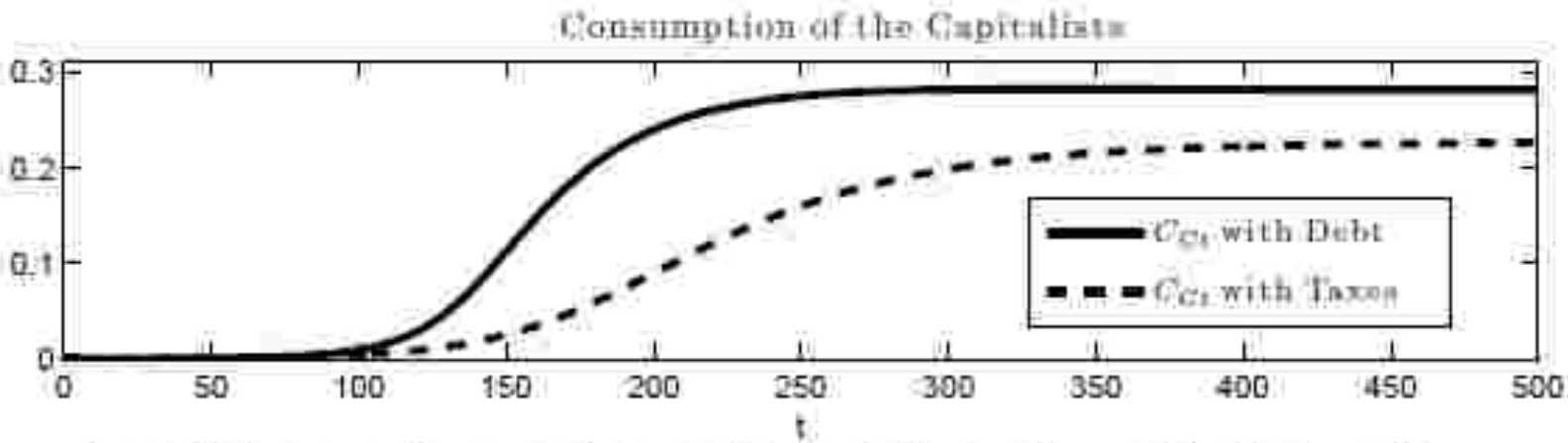




Parameters: $\lambda = 0.2$, $\alpha = 0.4$, $\delta = 0.04$, $\beta = 0.9$, $\pi = 3$, $x = 0.1$ and $\tau = 0.08$



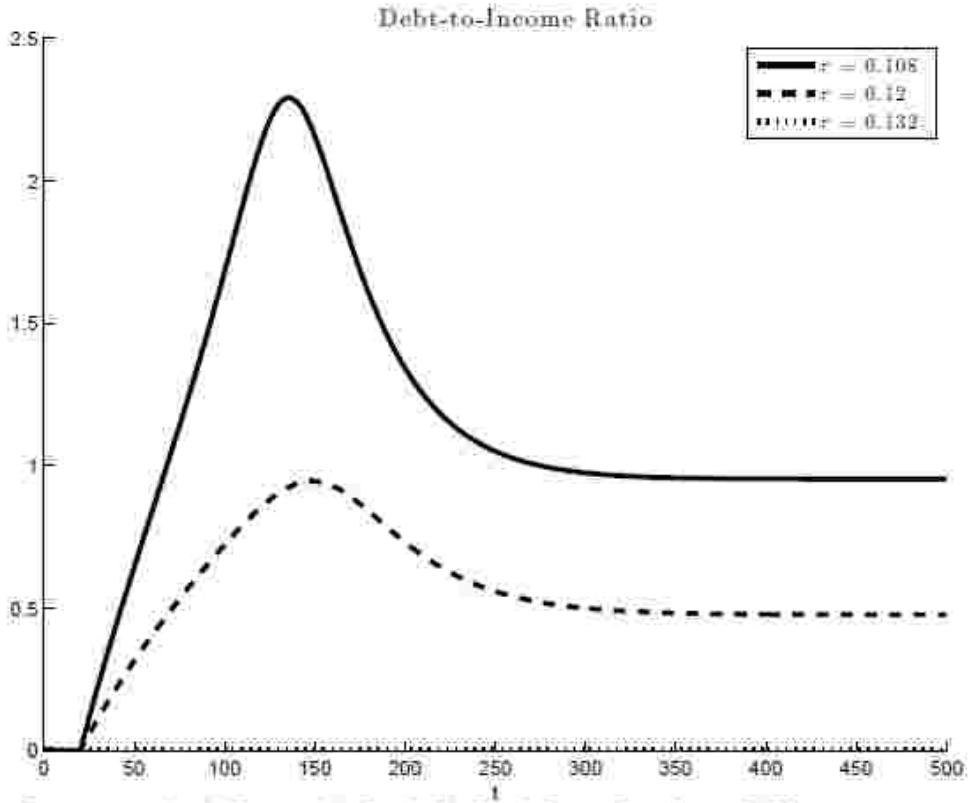




Parameters: $\lambda \equiv 0.2$, $\alpha \equiv 0.4$, $\delta = 0.04$, $\beta = 0.9$, $\pi = 3$, $x \equiv 0.1$ and $r \equiv 0.08$

Quantitative Exploration

- α=0.4, λ=0.2
- π=3
- β=0.9
- δ=0.04
- $S_1 = 0.001$
- x=0.132, τ=0.108



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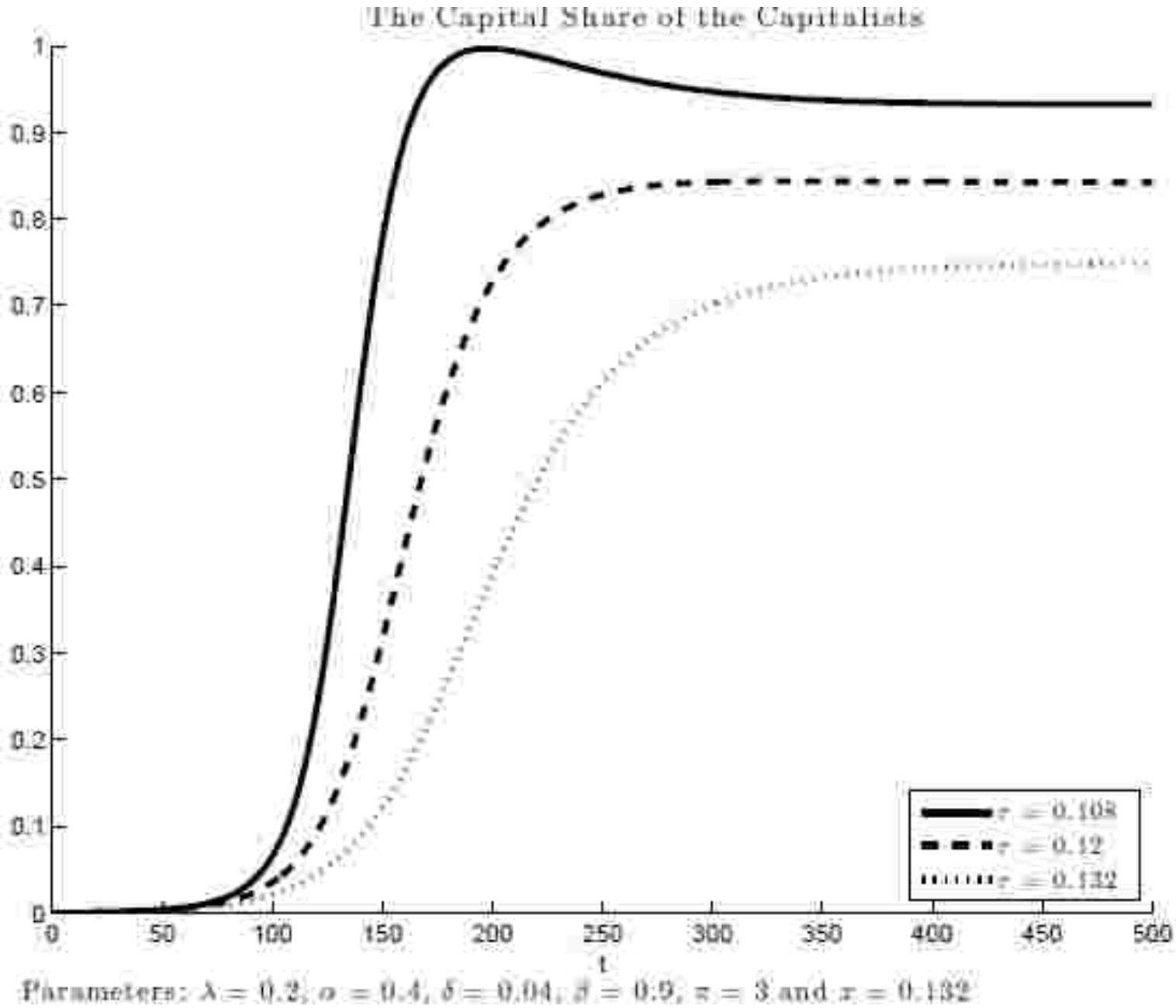

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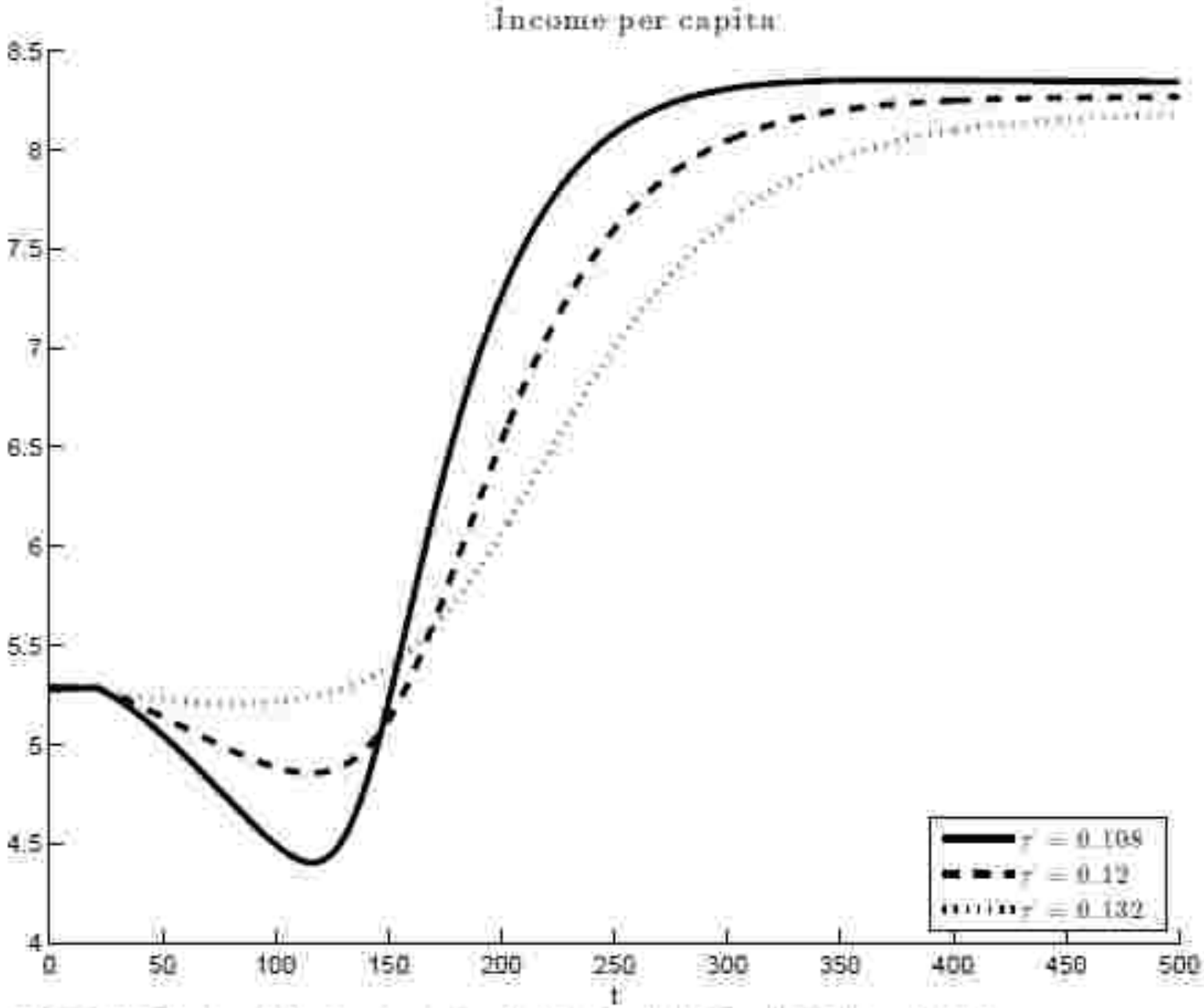


Parameters: $\lambda = 0.2$, $\alpha = 0.4$, $\delta = 0.04$, $\beta = 0.9$, $\pi = 3$ and $x = 0.132$

Magnitude of Effects

- Time to travel 50% (75%) of distance from first to second steady state
  - 171 (200) – baseline with debt
  - 196 (234) – half the actual deficit
  - 225 (274) – no debt

Building blocks for an explanation

- Financial friction = useless financial sector
- Ample evidence for crowding out
- Big differences in productivity growth between sectors

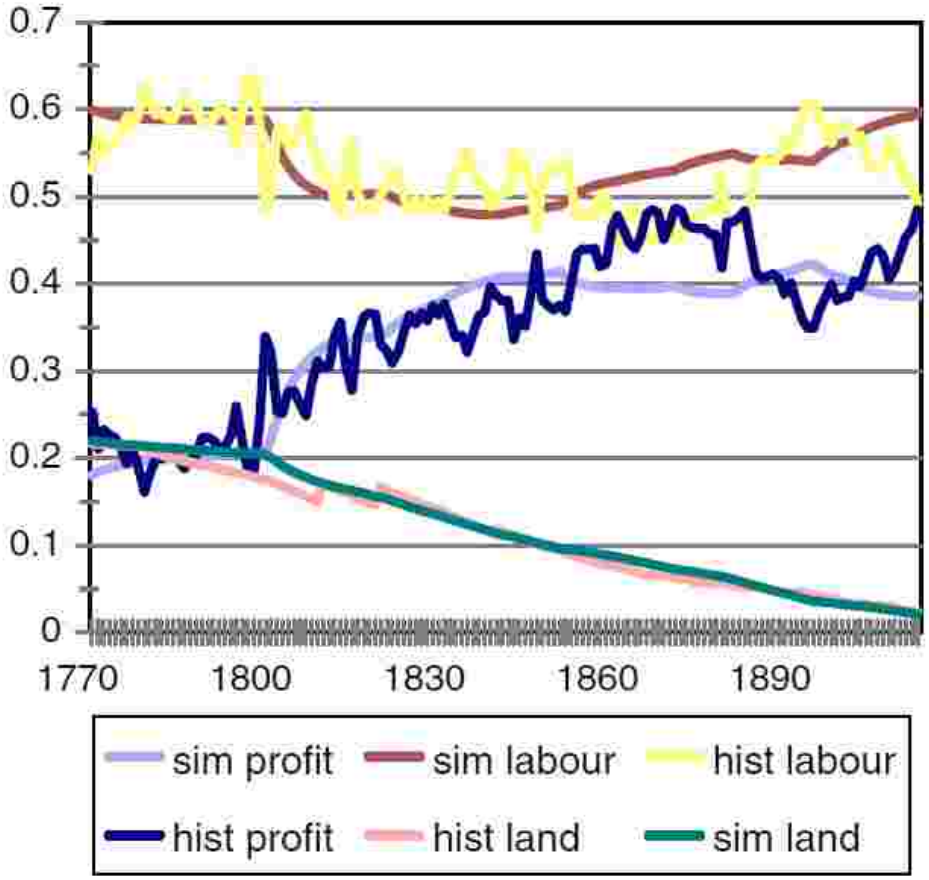
Highly uneven productivity growth

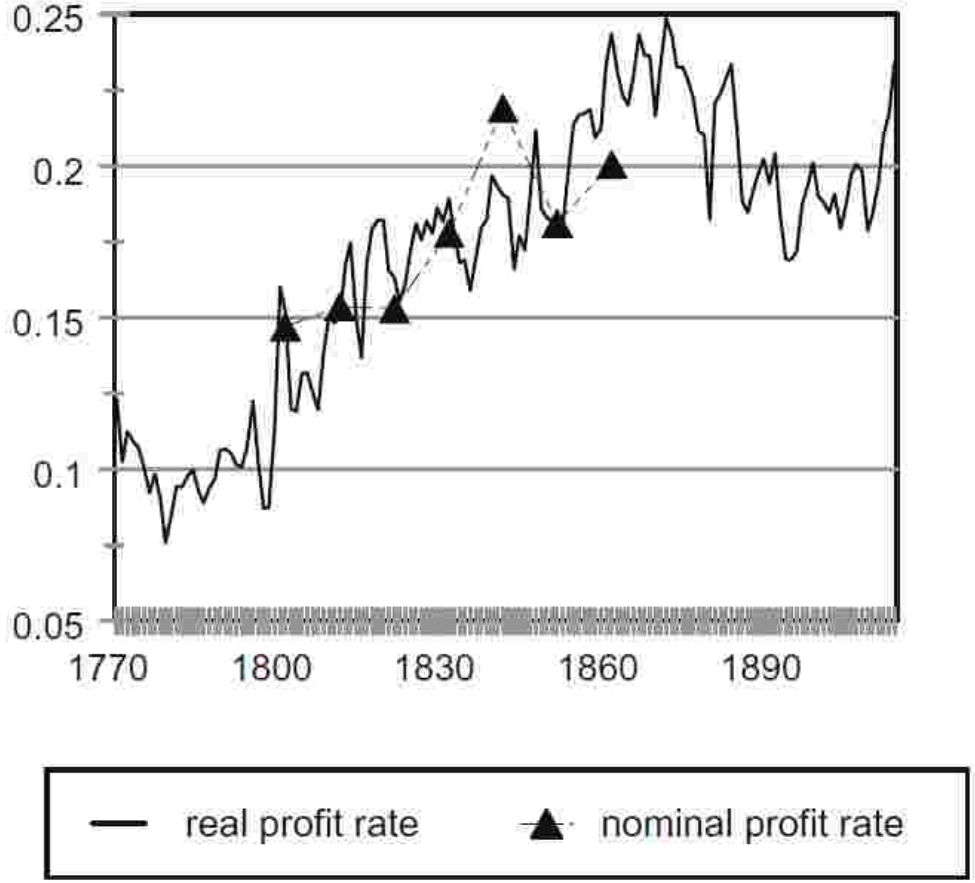
TABLE 1
CONTRIBUTIONS TO NATIONAL PRODUCTIVITY GROWTH, 1780–1860
(percentage per annum)

Sector	McCloskey	Crafts	Harley
Cotton	0.18	0.18	0.13
Worsteds	0.06	0.06	0.05
Woolens	0.03	0.03	0.02
Iron	0.02	0.02	0.02
Canals and railroads	0.09	0.09	0.09
Shipping	0.14	0.14	0.03
Sum of modernized	0.52	0.52	0.34
Agriculture	0.12	0.12	0.19
All others	0.55	0.07	0.02
Total	1.19	0.71	0.55

Sources: McCloskey, "Industrial Revolution," p. 114; Crafts, *British Economic Growth*, p. 86; and Harley, "Reassessing the Industrial Revolution," p. 200.

Rising returns to capital (and shift in factor shares)





Financial system

- No effective transfer of resources from rich nobles to poor entrepreneurs

  "the reservoirs of savings were full enough, but conduits to connect them with the wheels of industry were few and meagre ... surprisingly little of [Britain's] wealth found its way into the new industrial enterprises ..." – Postan 1935

- Banks hamstrung by usury laws [legal constraints on duration of loans] and the six partner rule [limits size of banks]
- No new joint stock companies [Bubble Act]
- Restrictions revoked from the 1820s

Lending rate on loans, 1700-22

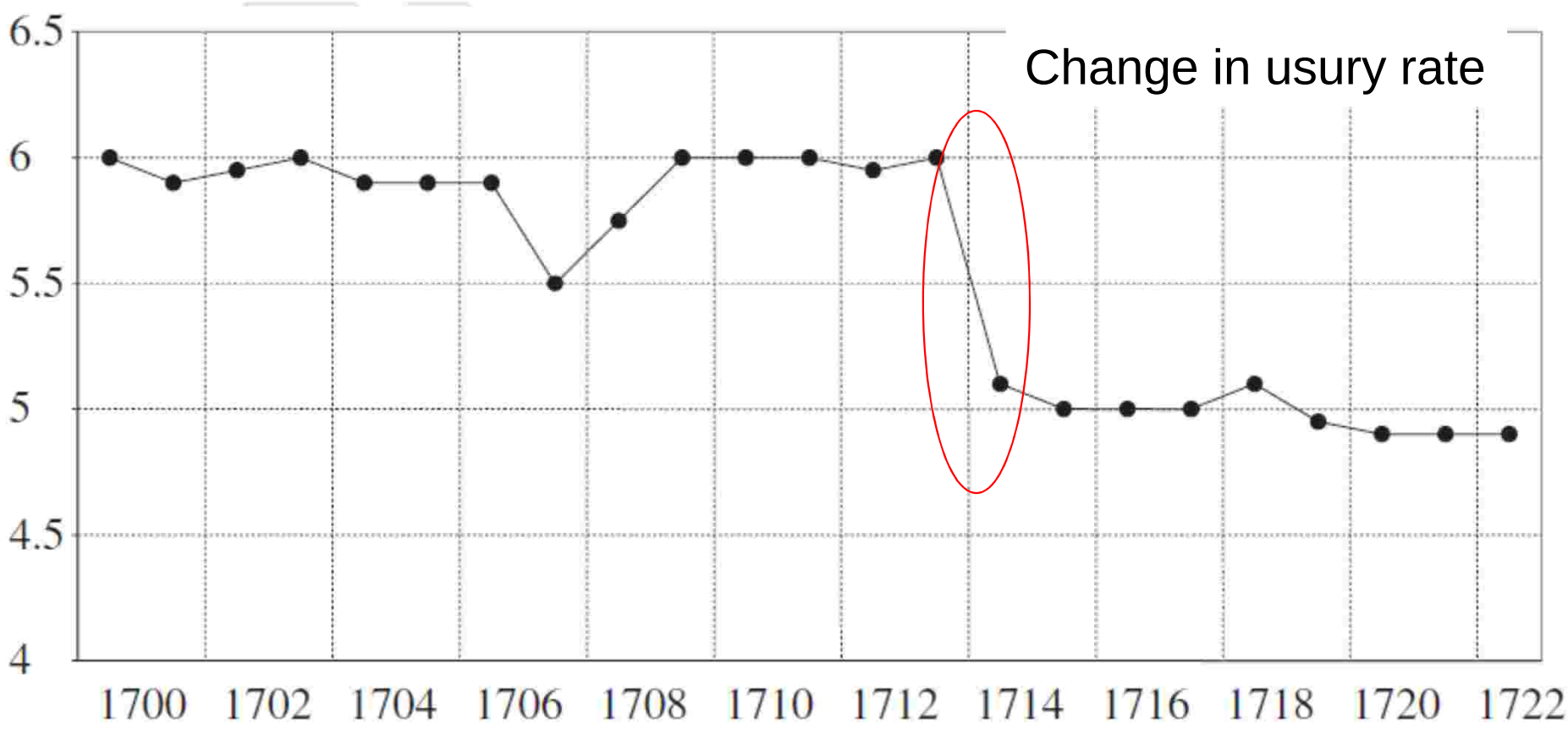


Fig. 1. *Median Interest Rate on Loans against Interest, Hoare's* 1702–1725

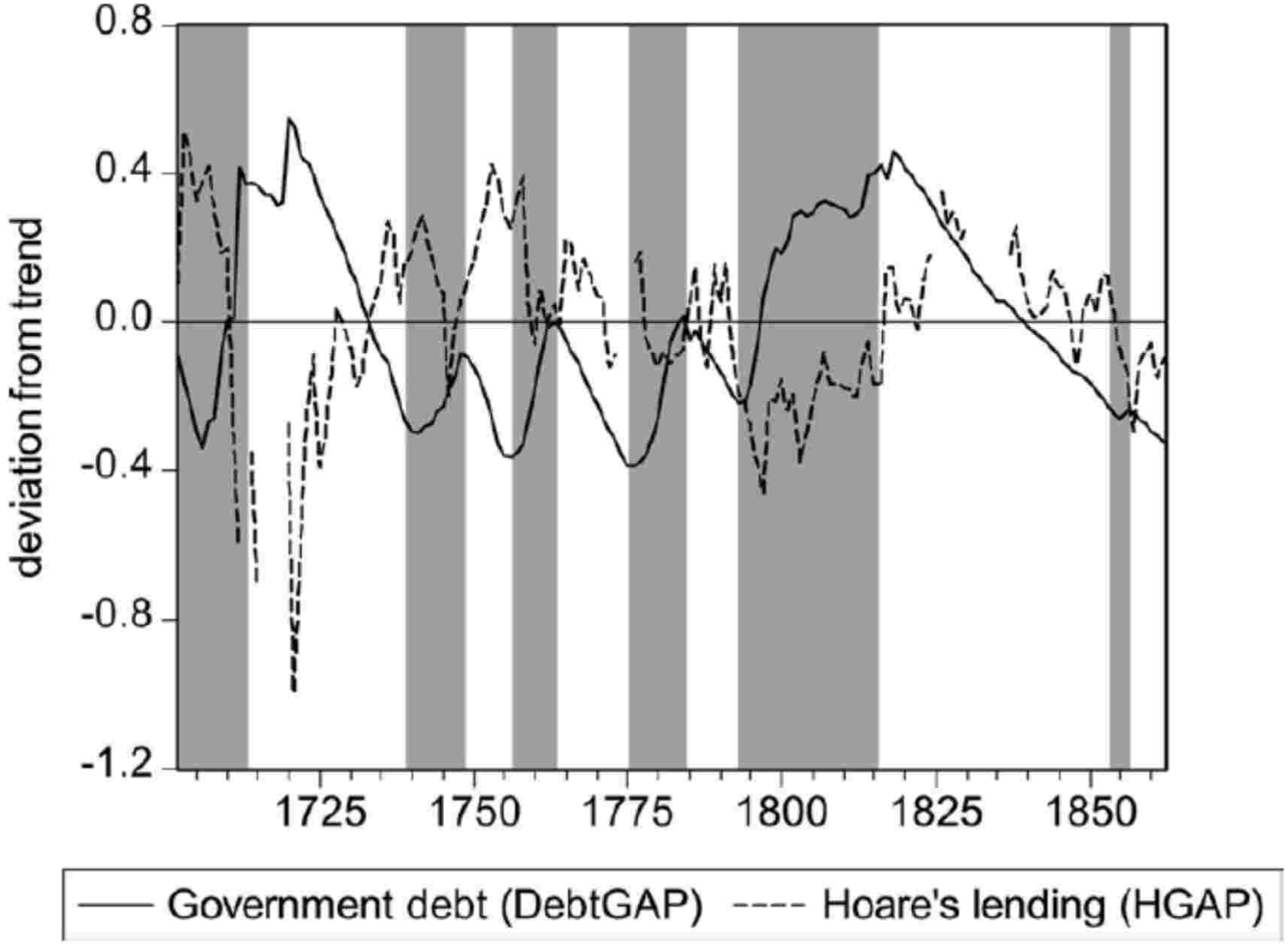
Crowding out

- Consols overwhelmingly held by English nobility
- Deposits at the most blue-blooded banks collapse when war breaks out → shift into bonds

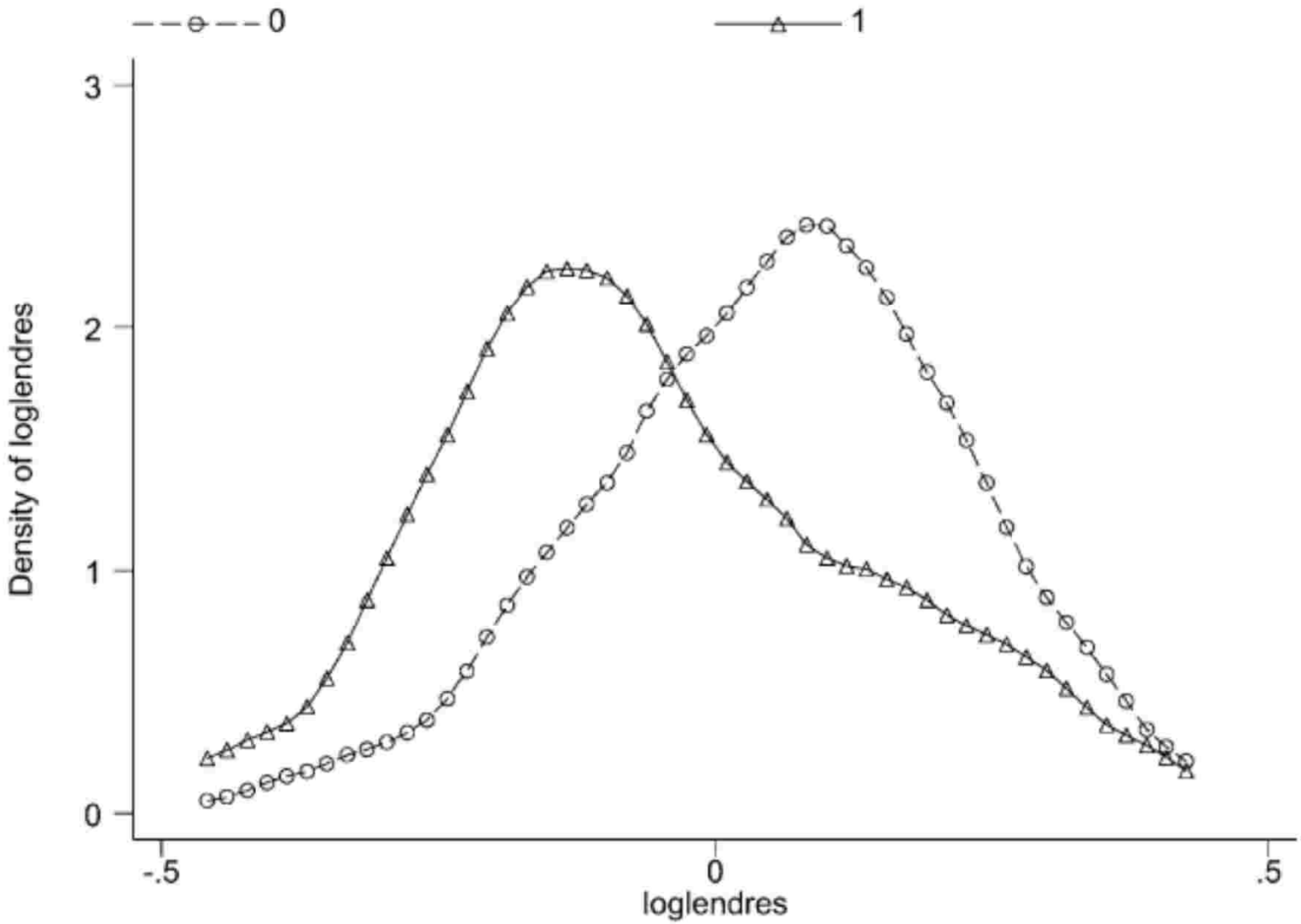
> At present we do not advance Money to anyone on any security. . .The uncommon supply of millions and millions granted and now raised [to pay for the Seven Years' War] obliges all of our Profession to be prepared for the Payments [to customers moving their money from the bank into government stock] coming on, so that instead of lending out money, we have called it in on this occasion.

- Investment in agriculture declines in relative terms (by more than one would expect, given population change)

Private sector lending and government borrowing



Changes in lending, war vs peacetime



Changing asset holdings of the nobility

- Earl of Shelburne (d. 1751) held 99% of his wealth in government bonds
- “every landowner ought to have as much property (as his estate) in consols or other securities” (Robert Peel, PM)
- “What an infernal bore is landed property. No certain income can be reckoned upon. I hope your future wife will have consols…” He is selling land **“**because I do not think it worth while to keep a security paying 2 per cent, when I can get an equally good one paying 5. “ **(**Lord Monton, 1770)

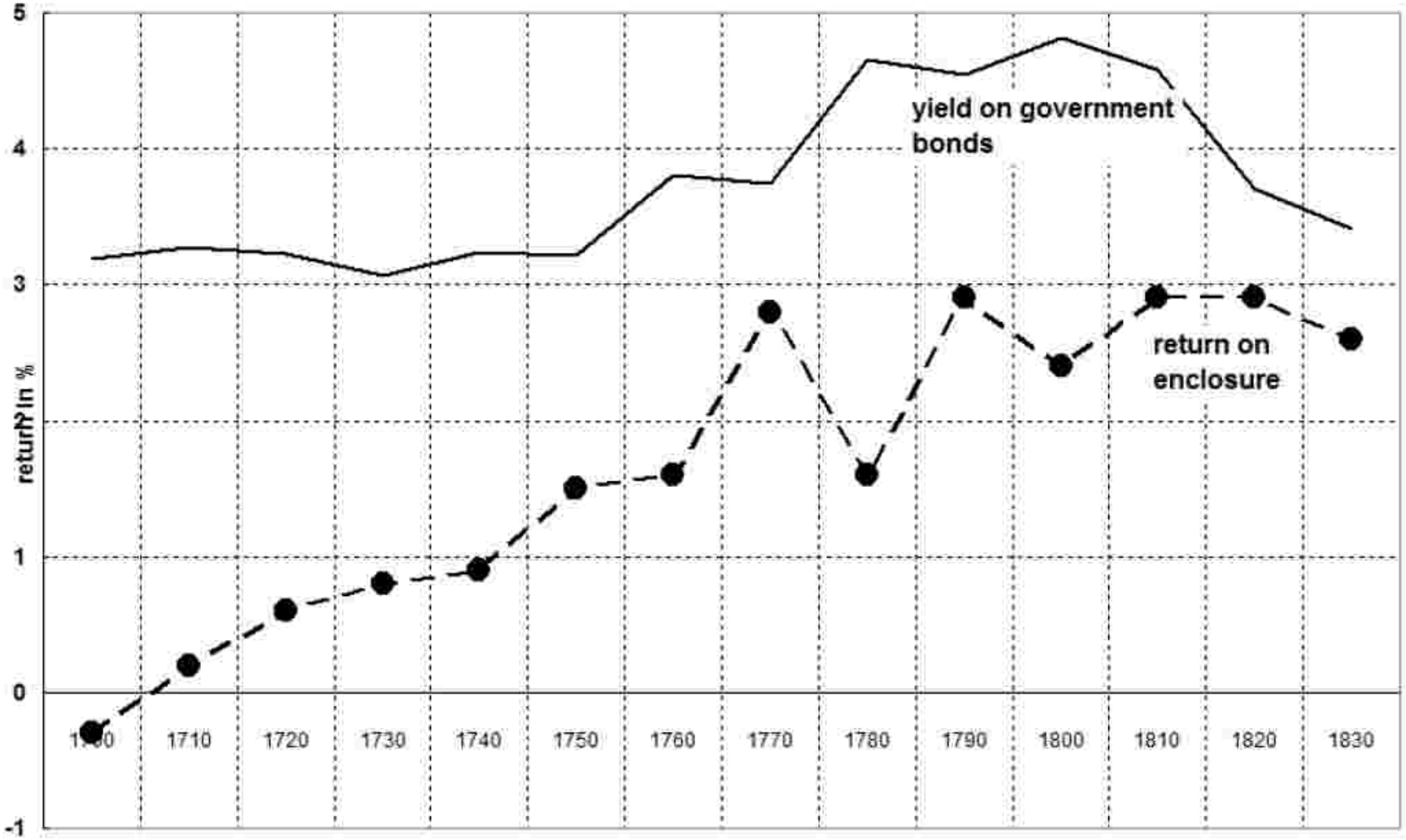


FIGURE 2.5. Yield on Government Bonds and Returns to Enclosure, 1692-1860

Conclusion: What's the role of debt in the British Industrial Revolution?

- Traditional interpretation – debt bad ("crowding out") or neutral ("Ricardian equivalence")
  - This paper – beneficial effect
  - Appearance of government bonds creates a store of value for the old elite
  - They reduce involvement in low-return activities; wages decline (at least in relative terms)
  - Returns to entrepreneurship go up
  - Capital accumulation increases for the new sectors
- Bigger picture. Our story explains why
  - growth was slow (financial friction)
  - there was social change (old elites failed to invest in new tech)
  - growth didn't disappear despite massive gov borrowing (efficiency-enhancing effect in the presence of heterogenous investment opportunities)

Backup