27 November 2007

The evolution of money: theory and predictions

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Edinburgh and LSE

and

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Princeton University

problem:

money & financial intermediation
don’t fit into standard framework

need to model: LIQUIDITY

two aspects of financial contracting:

- bilateral commitment
- multilateral commitment

two aspects of financial contracting:

- bilateral commitment
- multilateral commitment

both may be limited

limited bilateral commitment:

limit on how much borrower can credibly promise to repay *initial lender* limited bilateral commitment:

limit on how much borrower can credibly promise to repay *initial lender*

limited multilateral commitment:

limit on how much borrower can credibly promise to repay *any bearer* of the debt multilateral commitment is harder than bilateral commitment

– because the initial lender, as an insider, may become better informed about the borrower than outsiders

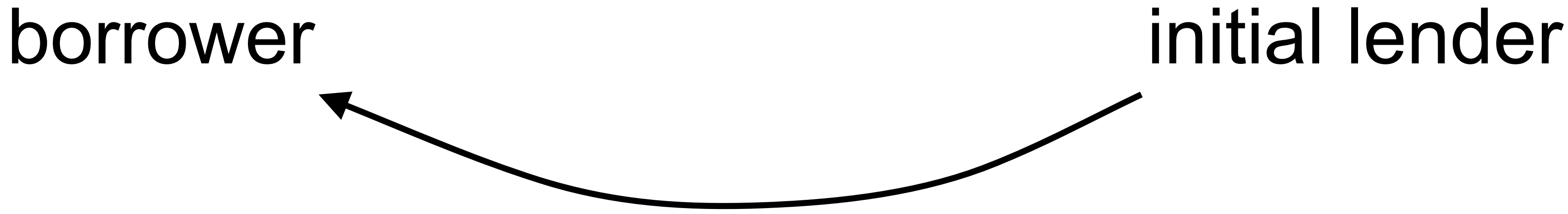
multilateral commitment is harder
than bilateral commitment

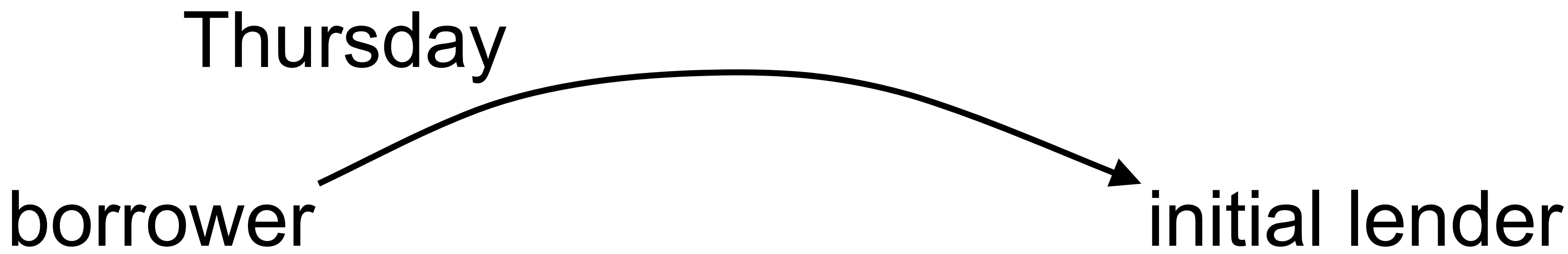
– because the initial lender, as an insider, may become better informed about the borrower than outsiders

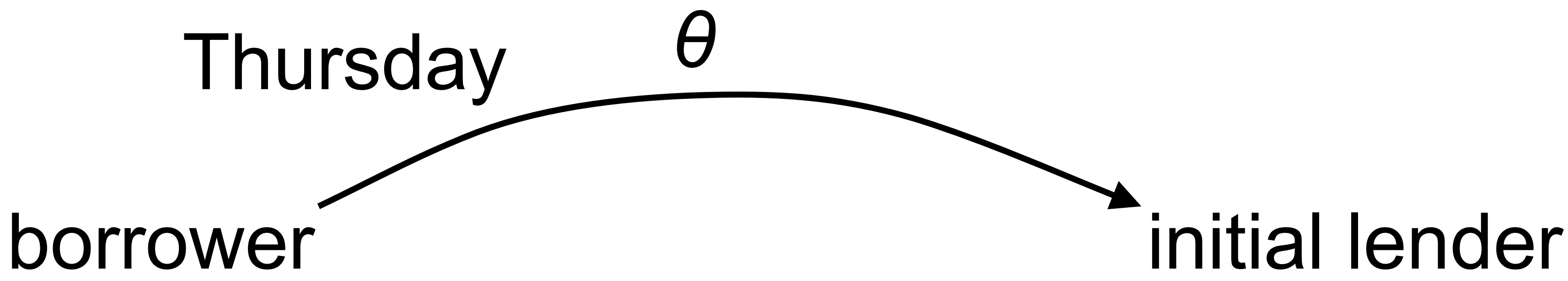
$\Rightarrow$ adverse selection in secondary market for debt borrower

initial lender

Tuesday

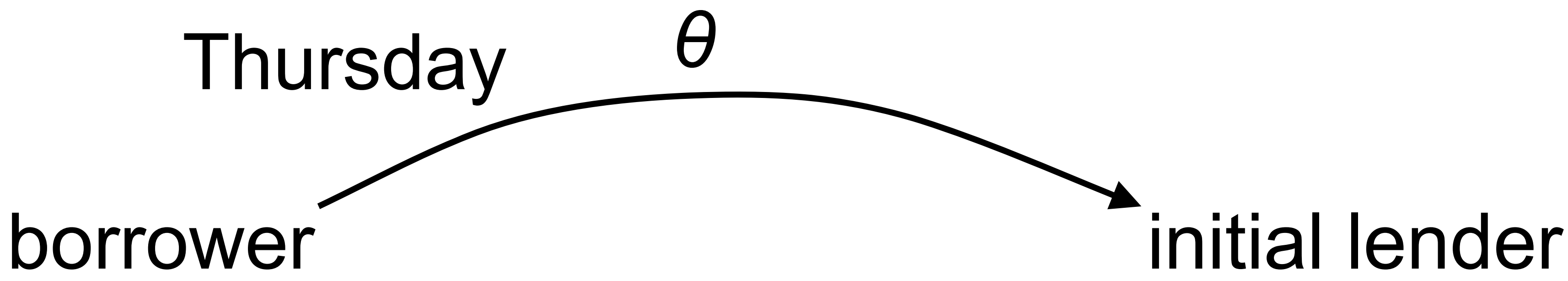



Thursday
borrower
initial lender



θ = fraction of output that borrower can credibly commit to repay initial lender

θ *less* than 100%, because of moral hazard



θ = fraction of output that borrower can credibly commit to repay initial lender

θ in part reflects legal structure;
one simple measure of financial depth;
captures degree of "*trust*" in economy

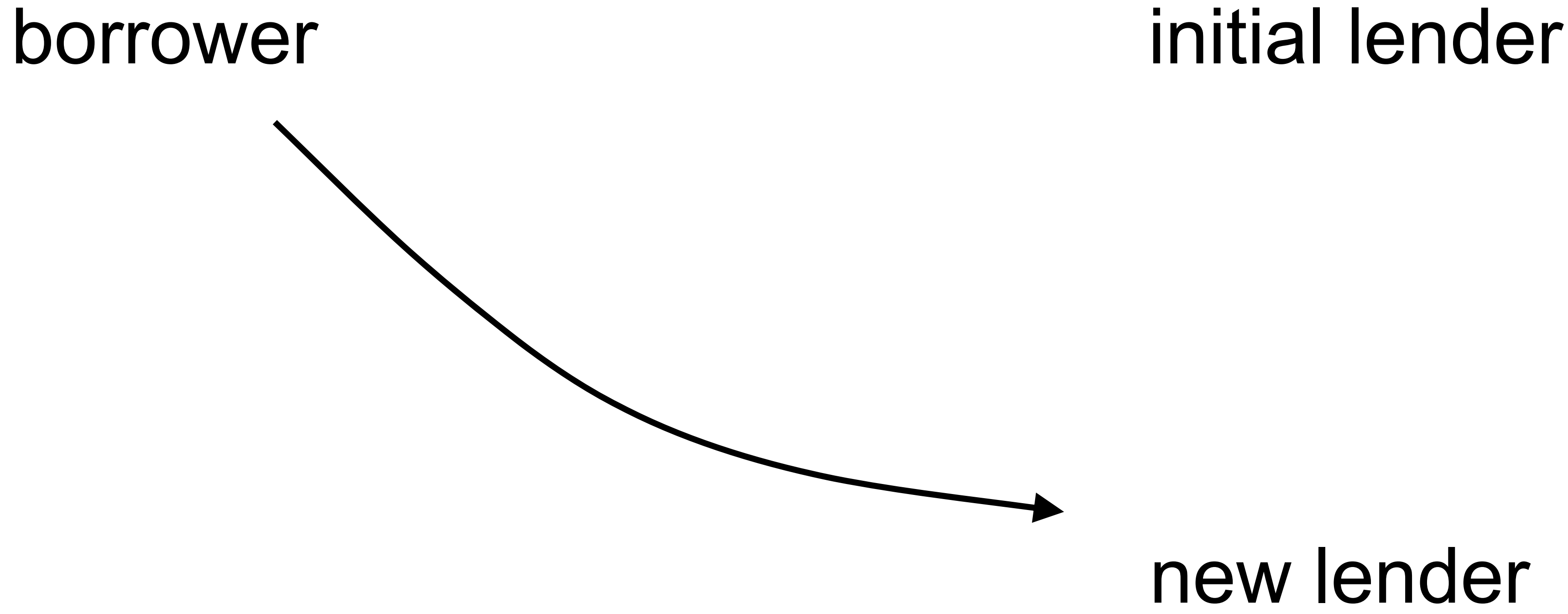
Wednesday

borrower

initial lender

Wednesday

Thursday



Wednesday

Wednesday


borrower
initial lender
(insider)
secondary
market
new lender
(outsider)

Wednesday

ϕ indexes the efficiency of secondary market;

another simple measure of financial depth;

captures degree of "*liquidity*" in economy

3 types of paper

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blue paper $\equiv$ non-circulating private paper (sold on Tuesday: but cannot be resold on Wednesday)

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King
("outside money")

mnemonic

blue paper – ice: illiquid

red paper – blood: liquid: circulates around economy

green paper – dollar bills (“greenbacks”)

coming next ….

coming next ….

A Brief History of Money

(very brief!)

coming next ….

A Brief History of Money

(very brief!)

and also …

coming next …

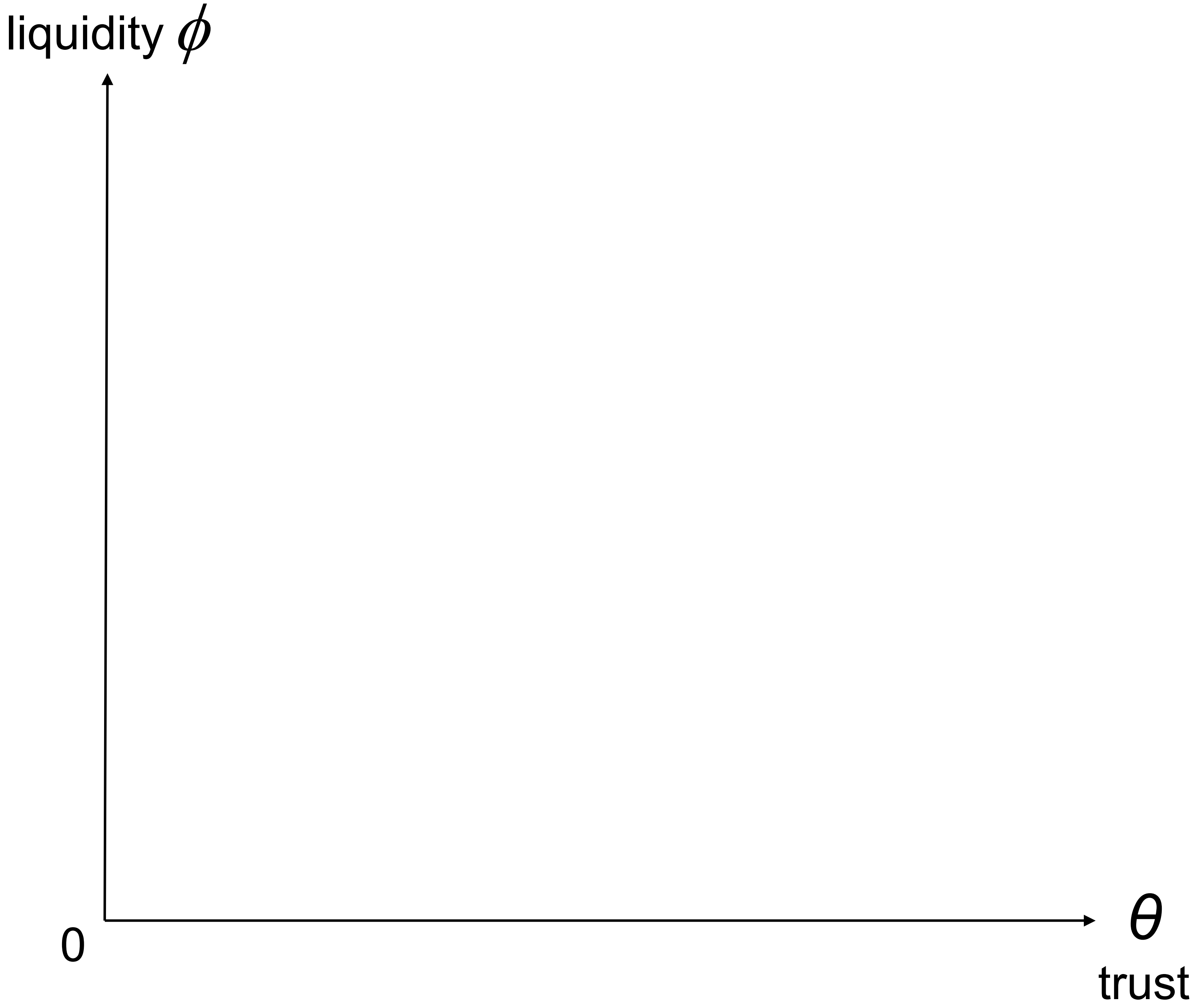
A Brief History of Money

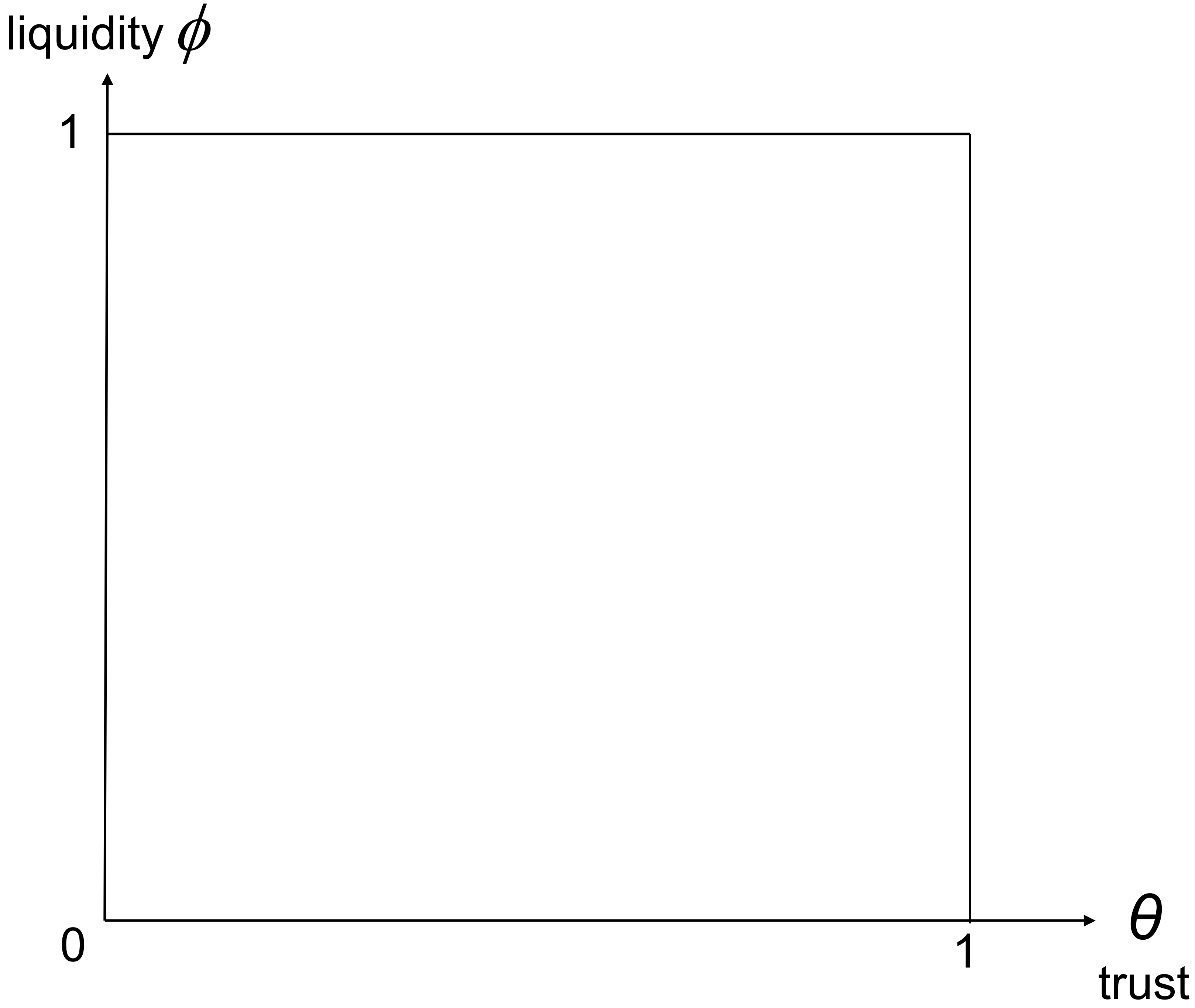
(very brief!)

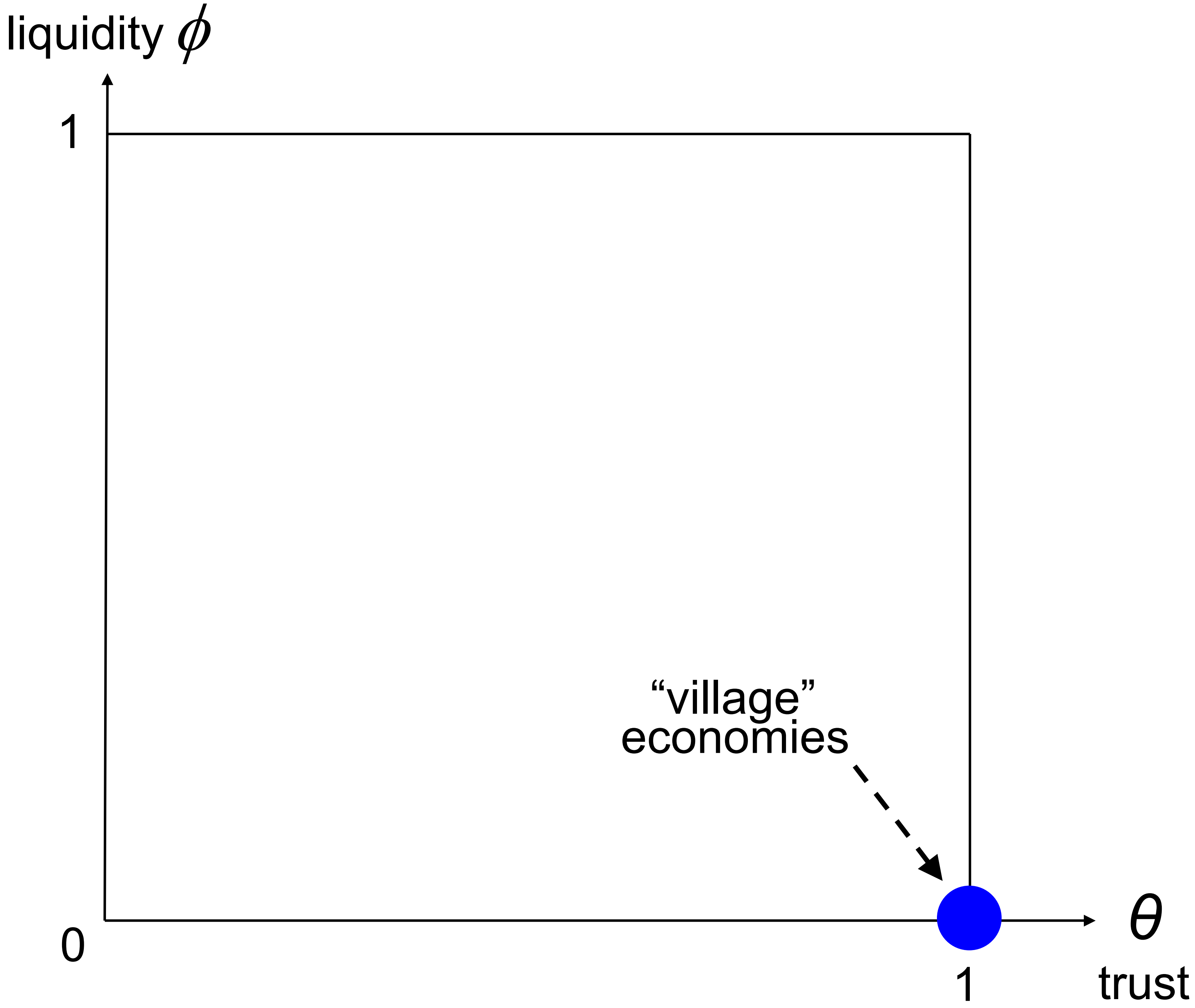
and also …

A Vision of the Future

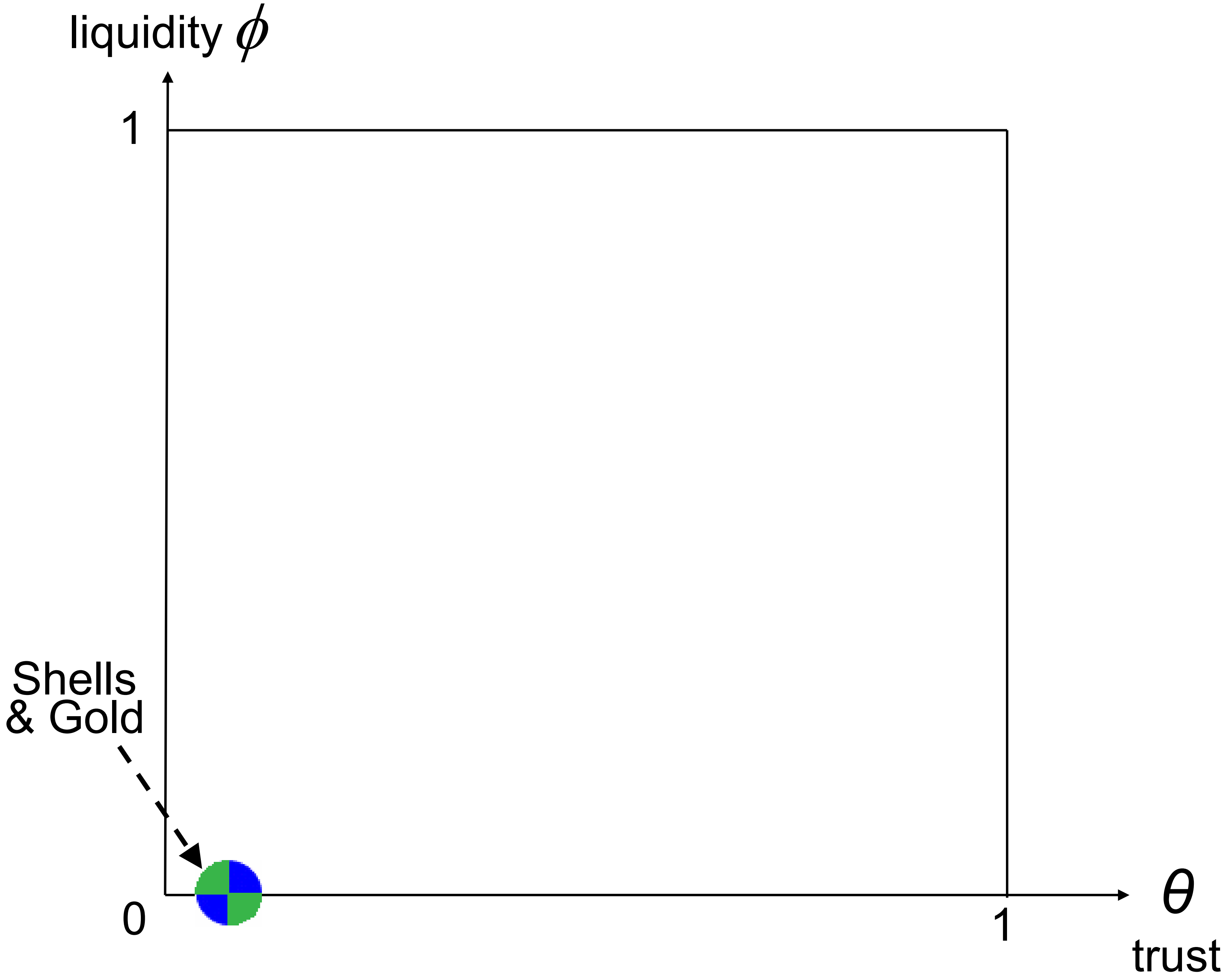
(two visions)


liquidity ϕ
0
θ
trust

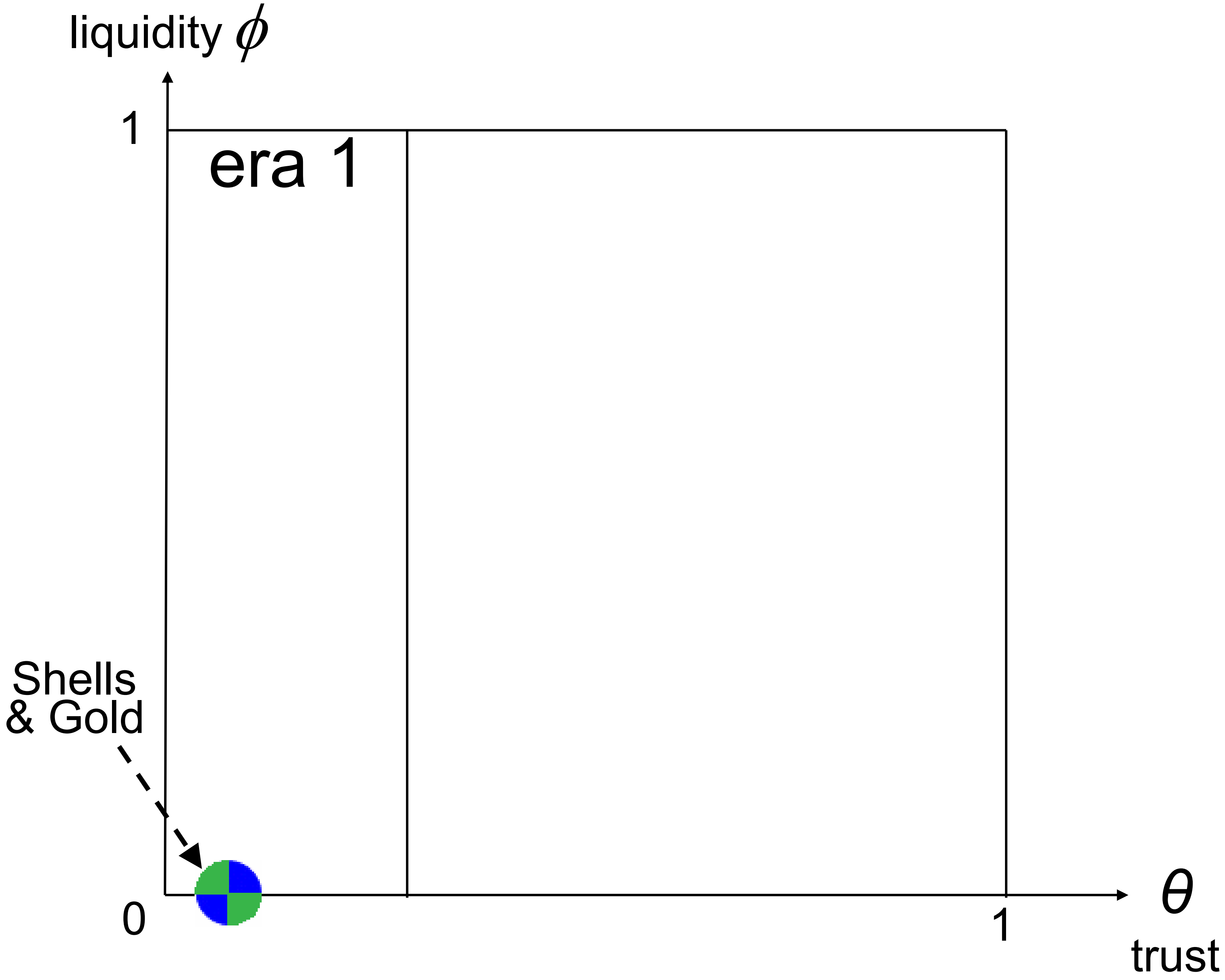

liquidity ϕ
1
0
θ
1
trust

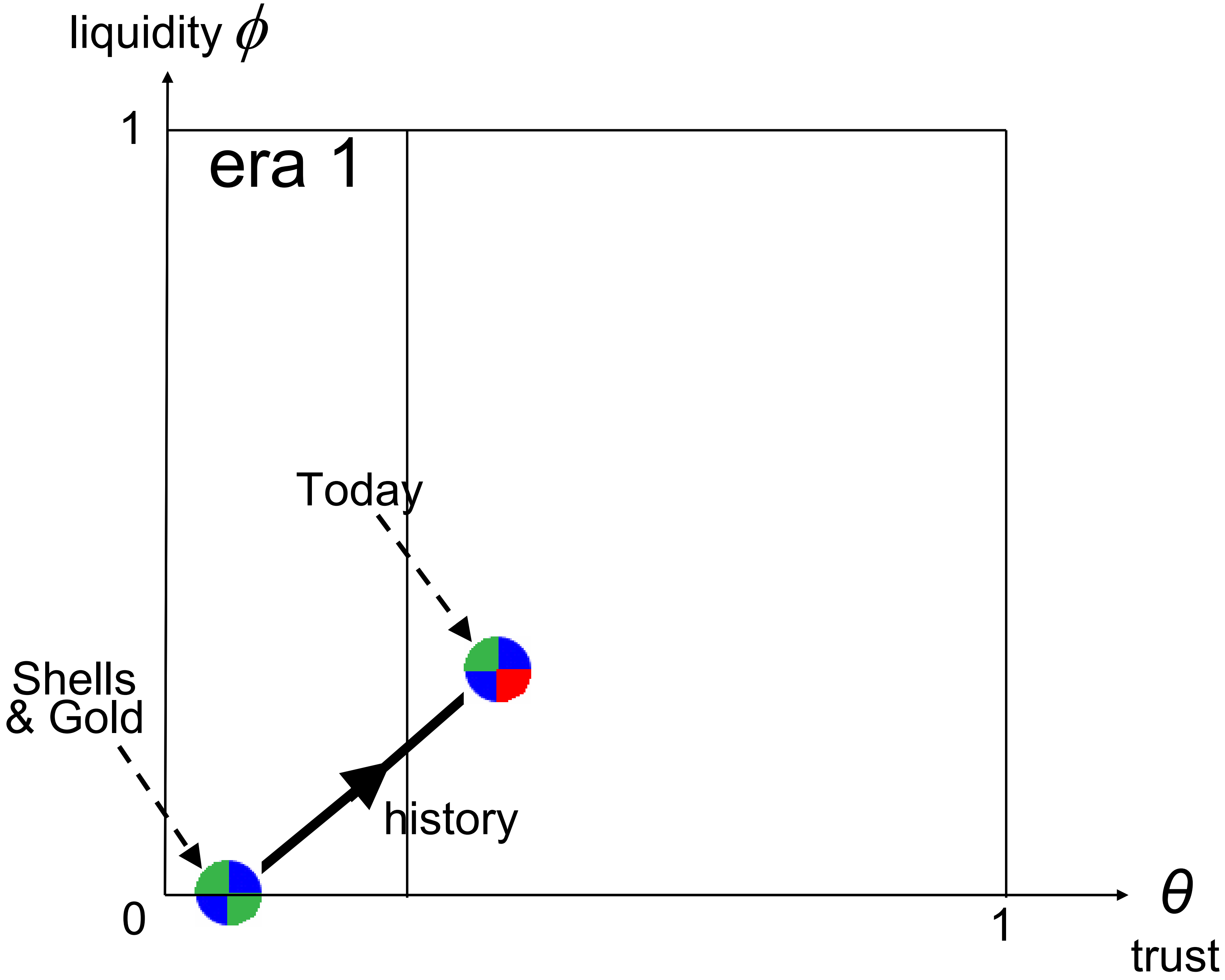


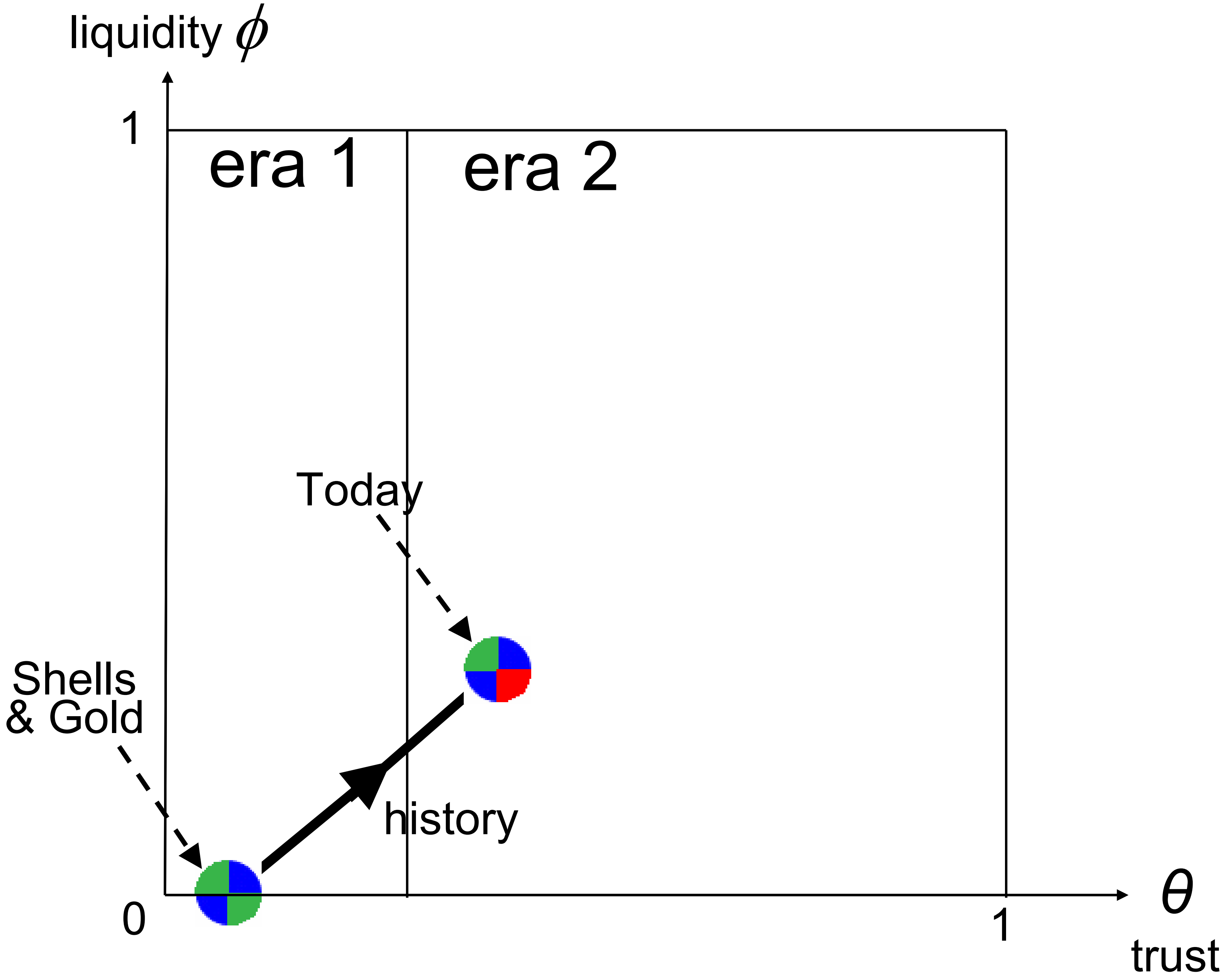
liquidity ϕ
1
0
"village" economies
1
θ
trust

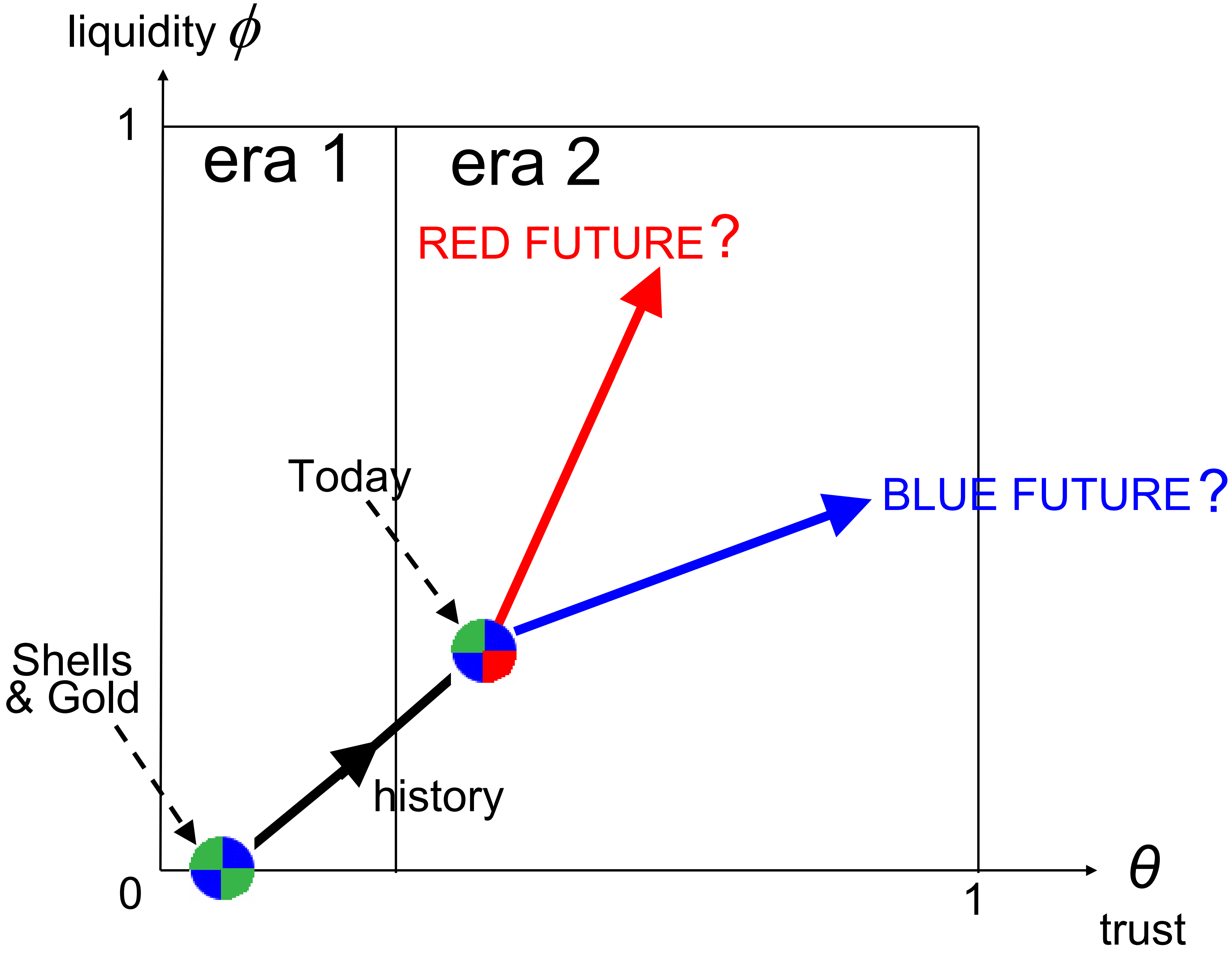


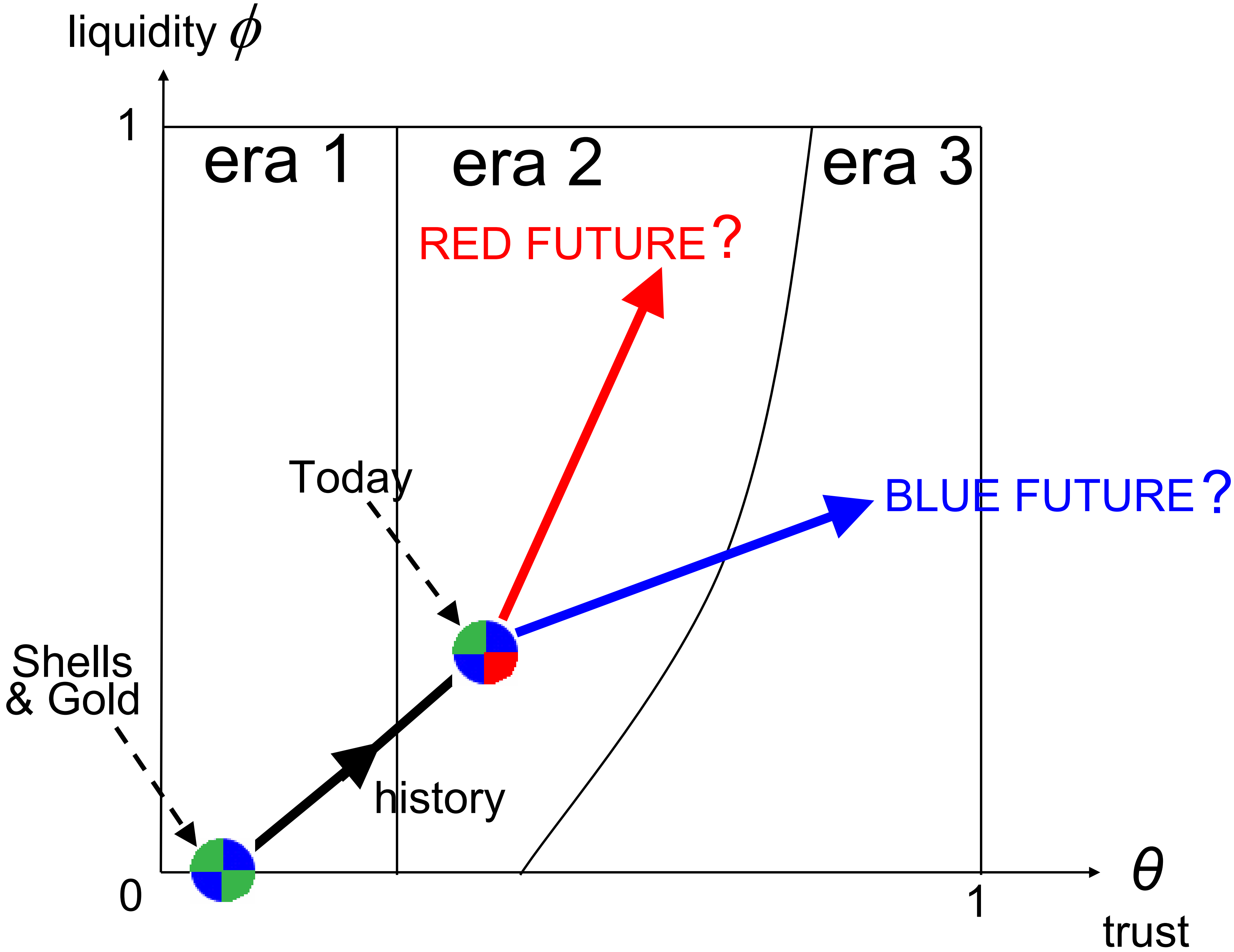
liquidity ϕ
1
Shells
& Gold
0
1
θ
trust

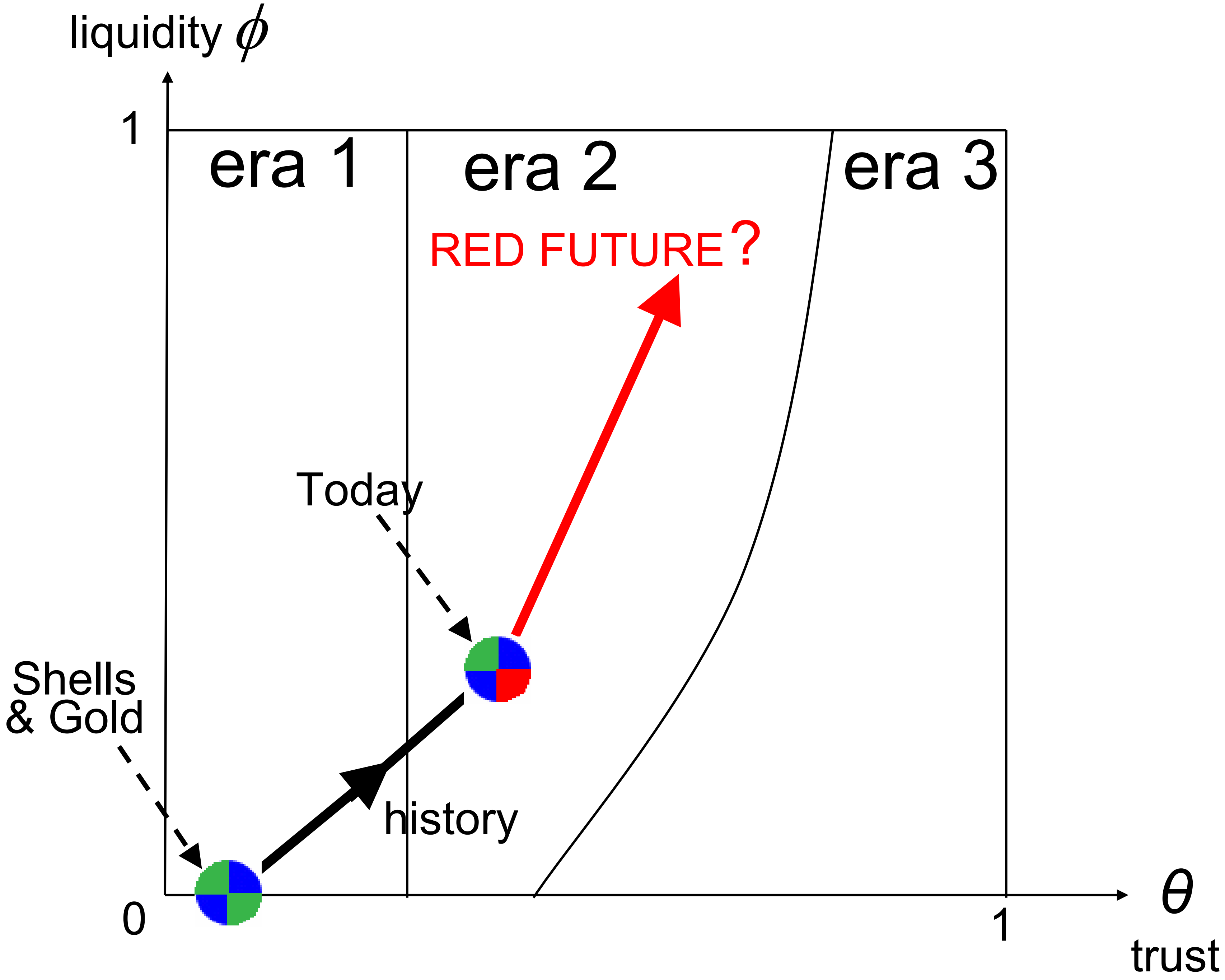

liquidity ϕ
1
era 1
Shells
& Gold
0
1
θ
trust


liquidity ϕ
1
era 1
Today
Shells
& Gold
history
0
1
θ
trust


liquidity ϕ
1
era 1
era 2
Today
Shells
& Gold
history
0
1
θ
trust


liquidity ϕ
1
era 1
era 2
RED FUTURE?
Today
BLUE FUTURE?
Shells
& Gold
history
0
θ
1
trust


liquidity ϕ
1
era 1
era 2
era 3
RED FUTURE?
Today
BLUE FUTURE?
Shells
& Gold
history
0
1
θ
trust


liquidity ϕ
1
era 1
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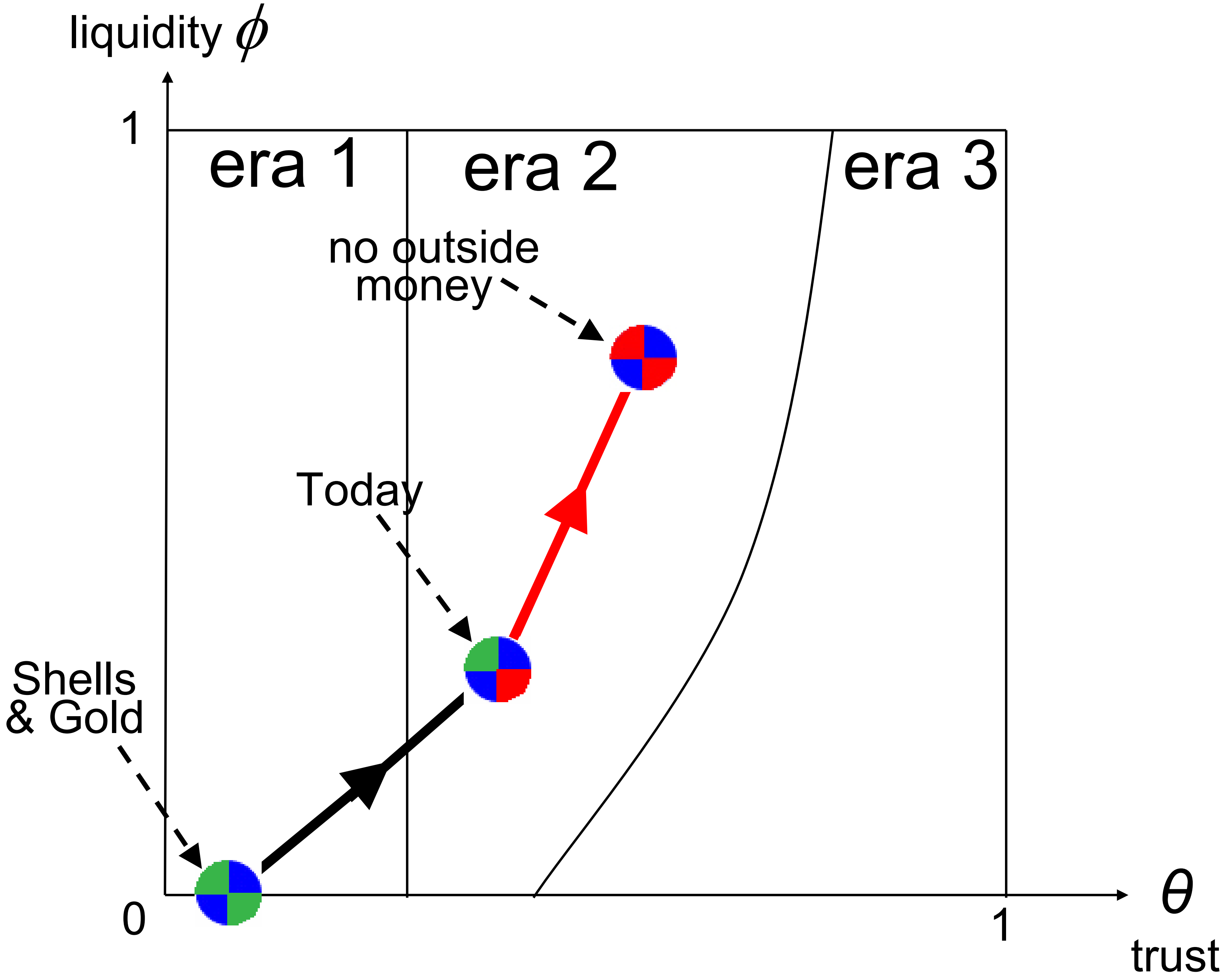
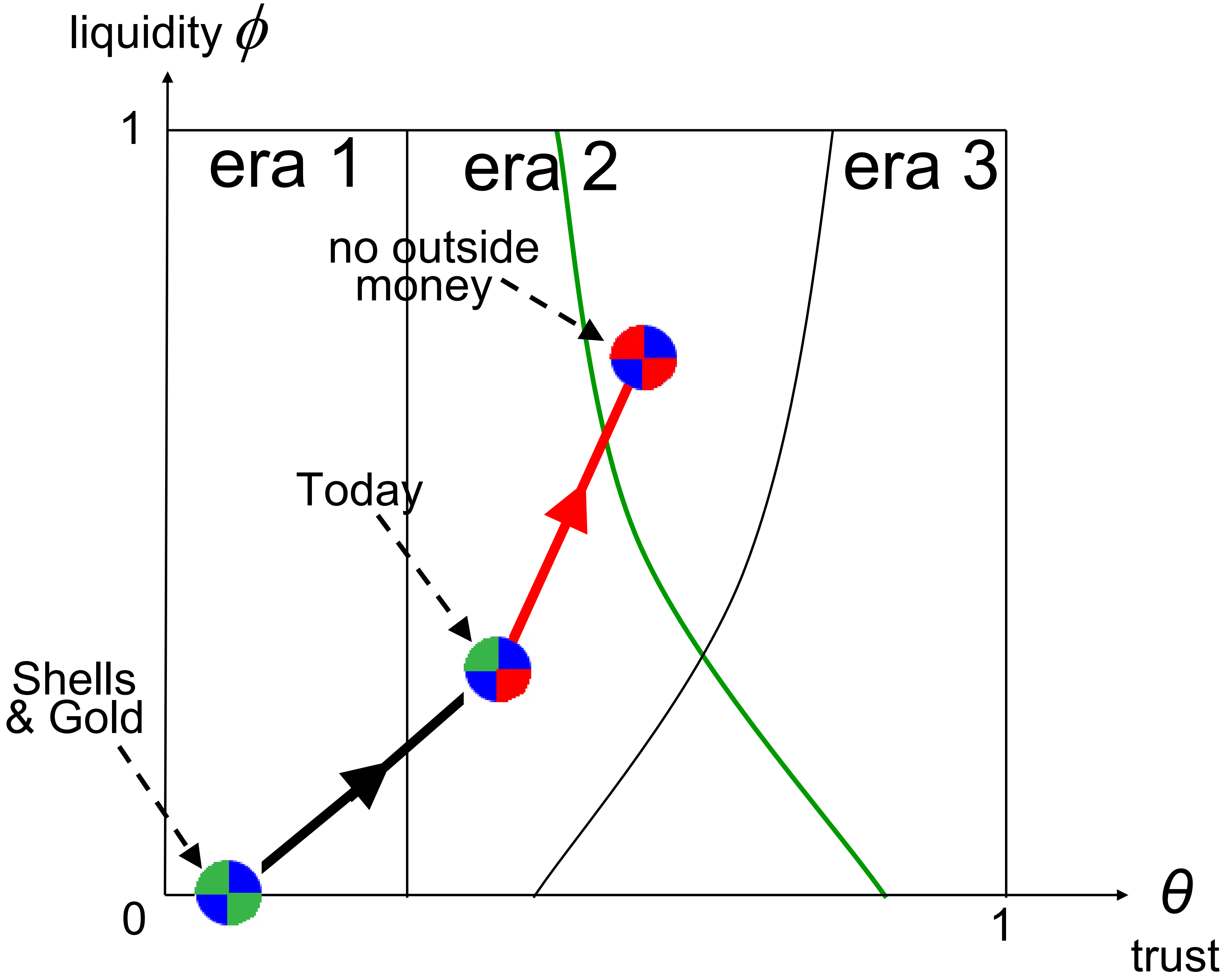
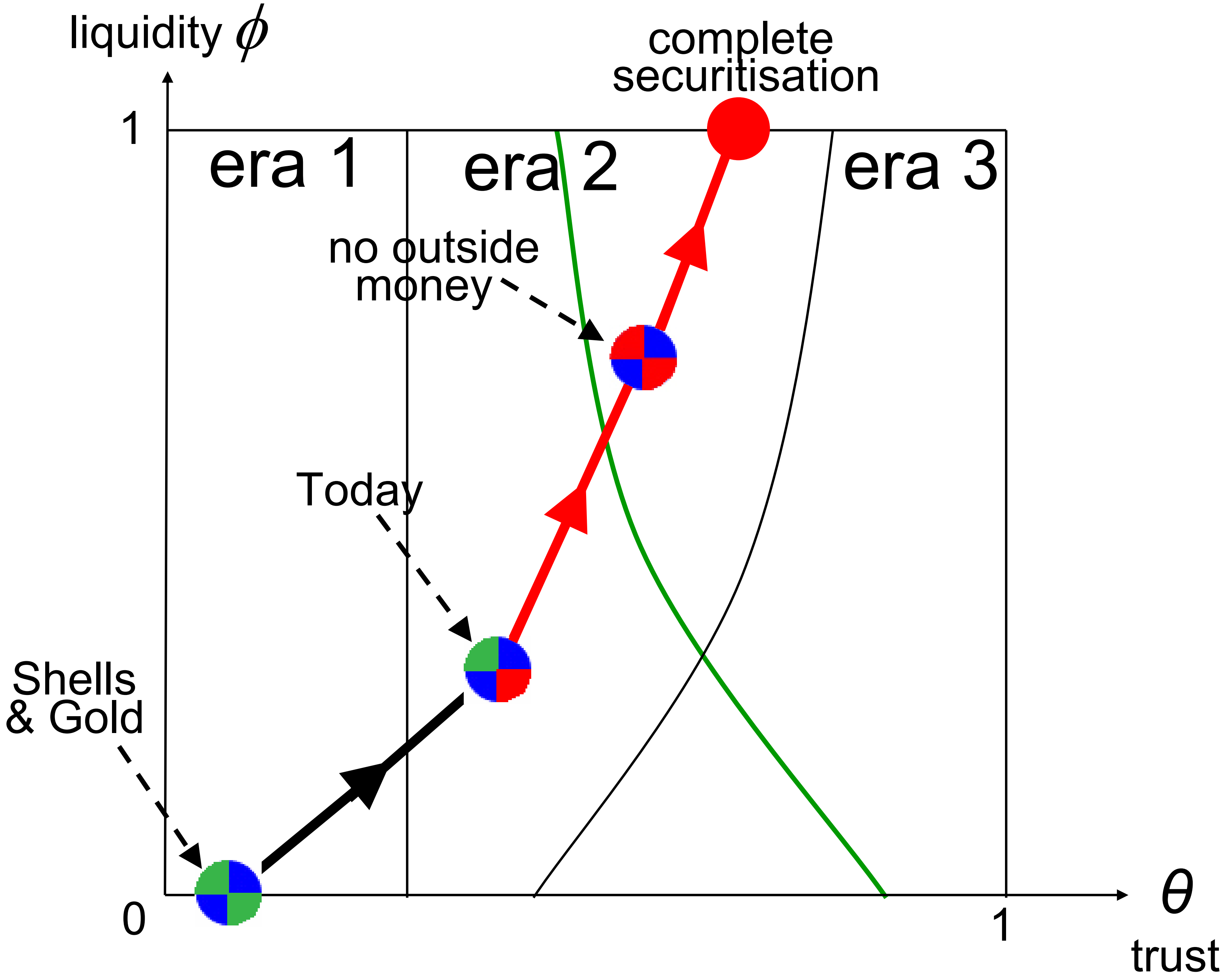
era 3
RED FUTURE?
Today
Shells & Gold
history
0
1
θ
trust

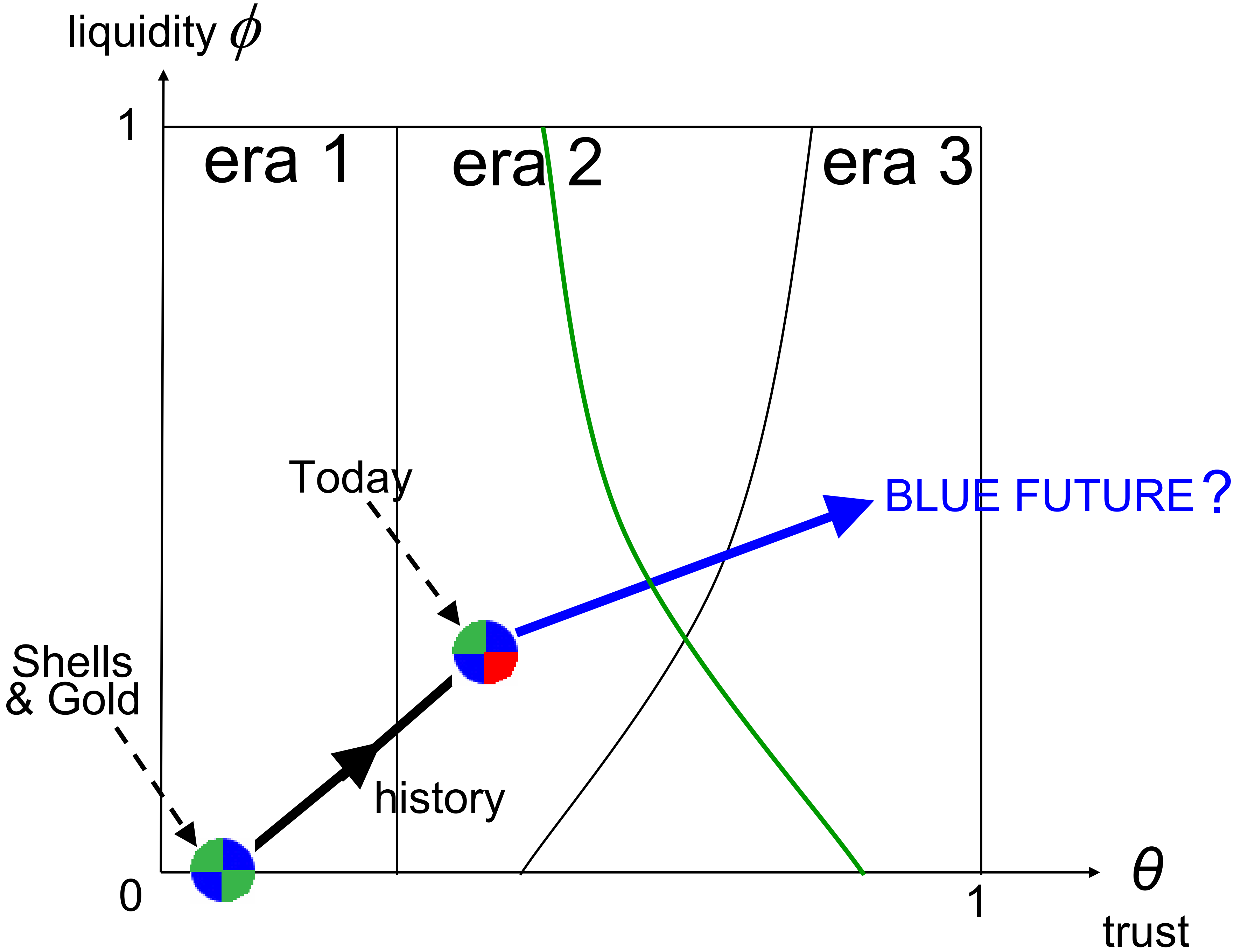


liquidity ϕ
1
era 1
era 2
era 3
no outside
money
Today
Shells
& Gold
0
1
θ
trust

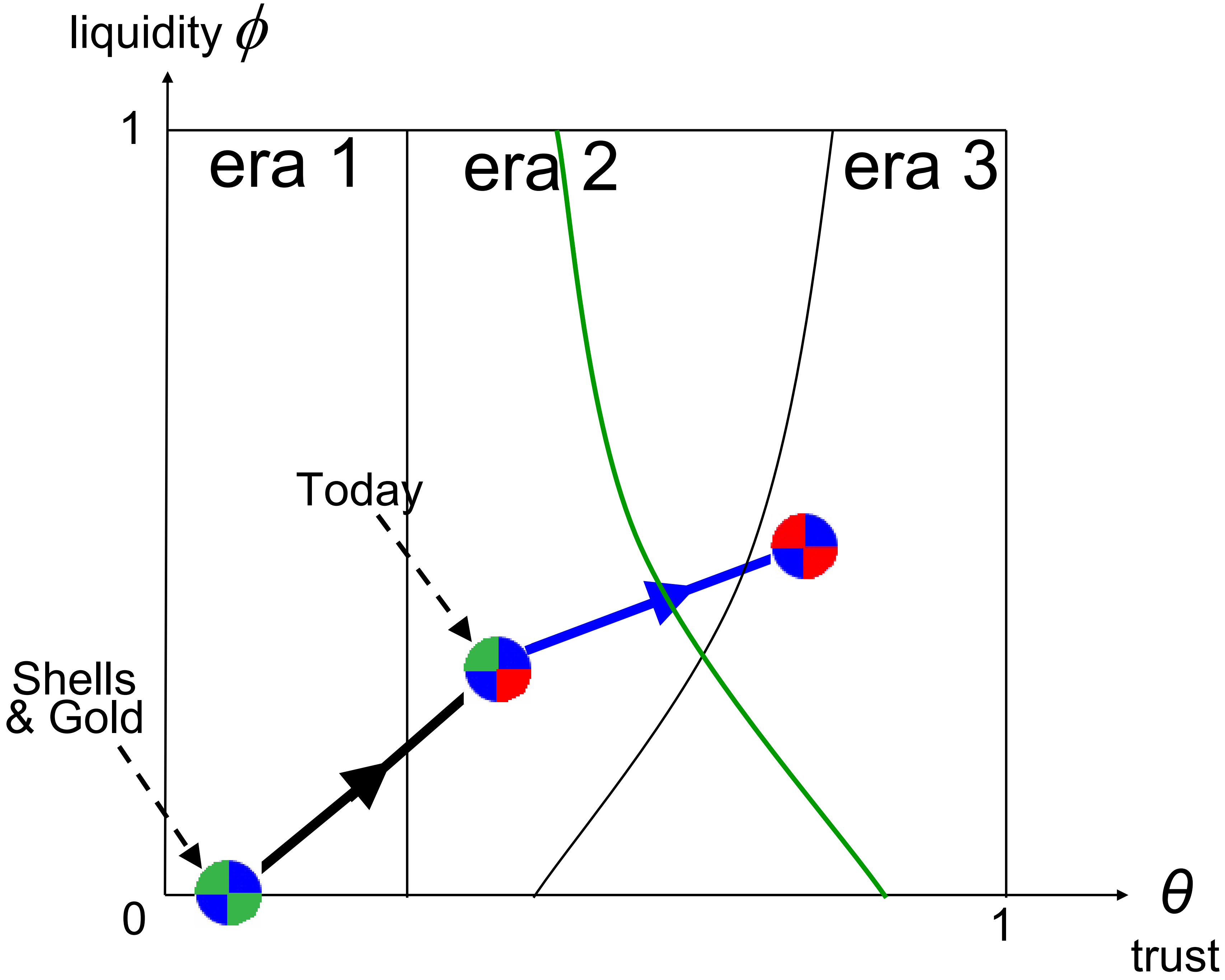


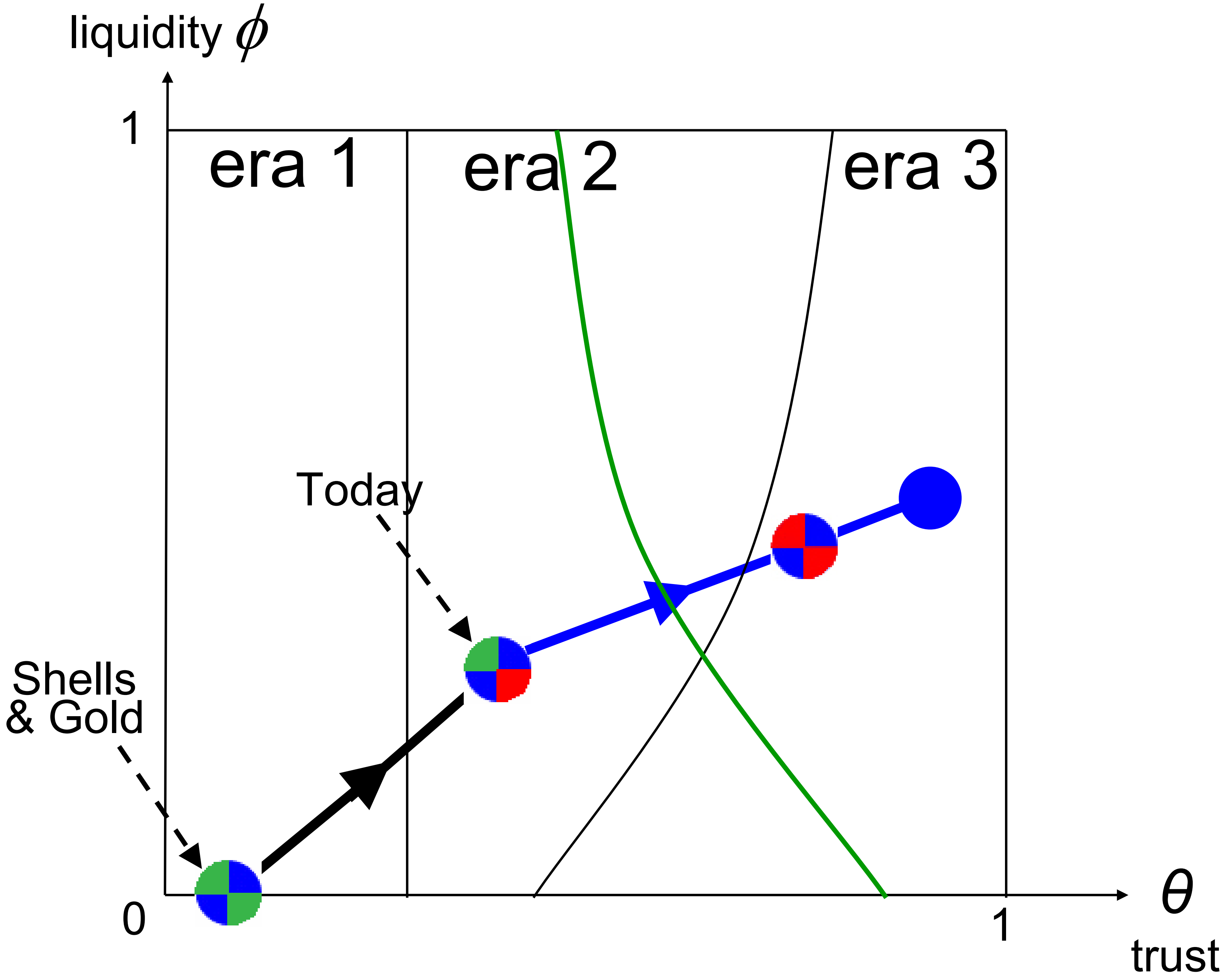
liquidity ϕ
1
era 1
era 2
era 3
no outside money
Today
Shells & Gold
0
θ
1
trust


liquidity ϕ
complete
securitisation
1
era 1
era 2
era 3
no outside
money
Today
Shells
& Gold
0
θ
1
trust

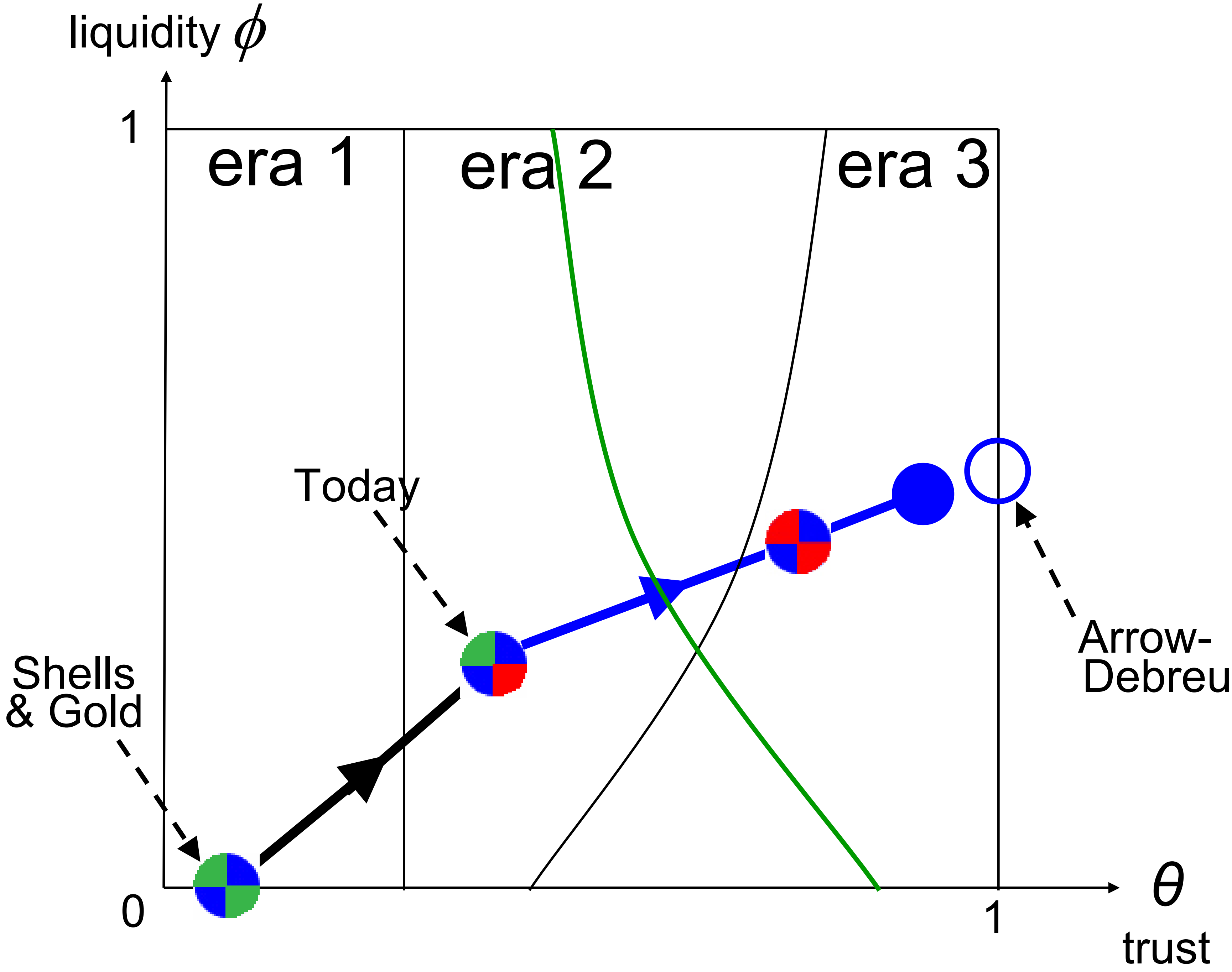


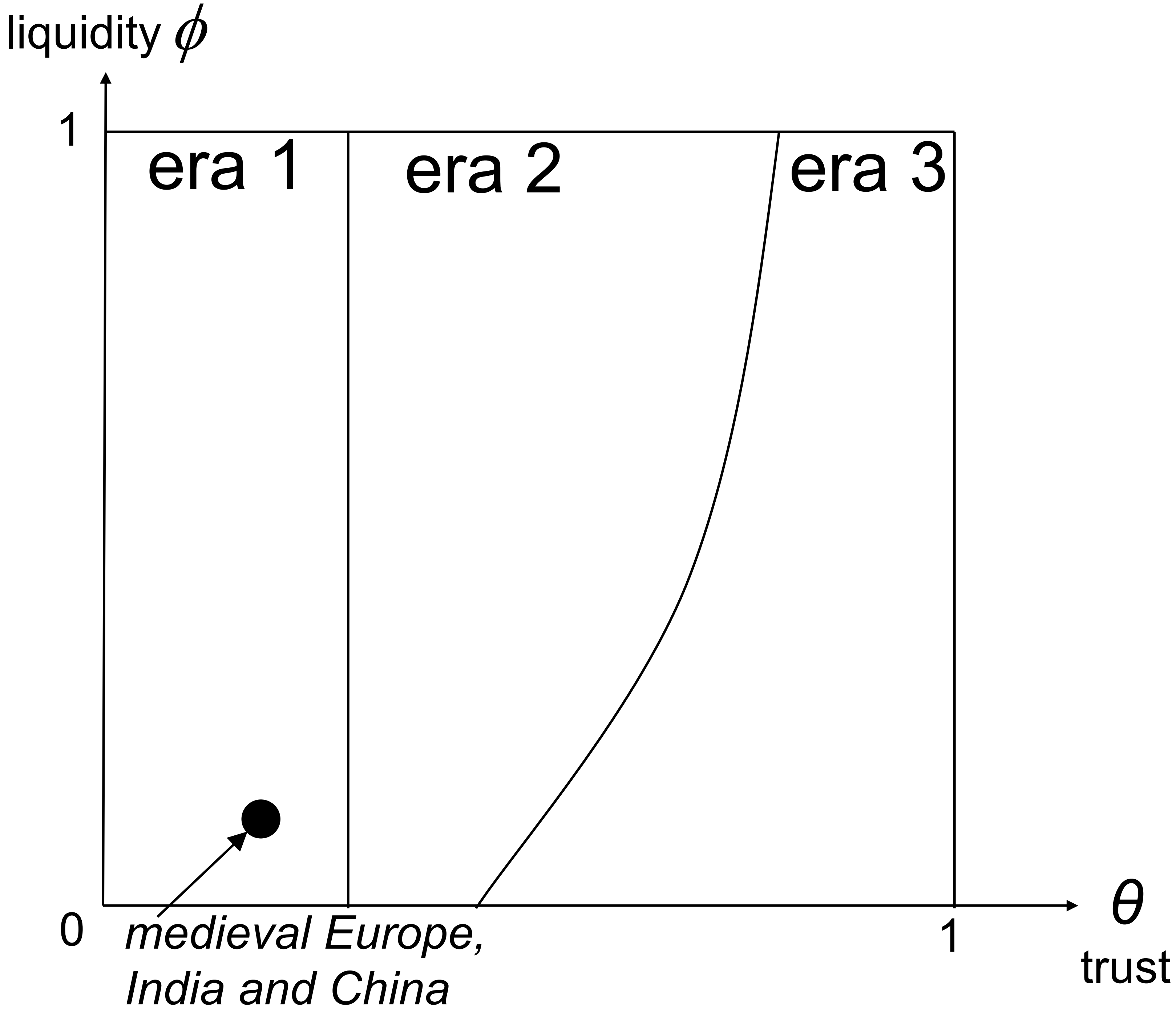
liquidity ϕ
1
era 1
era 2
era 3
Today
BLUE FUTURE?
Shells
& Gold
history
0
θ
1
trust

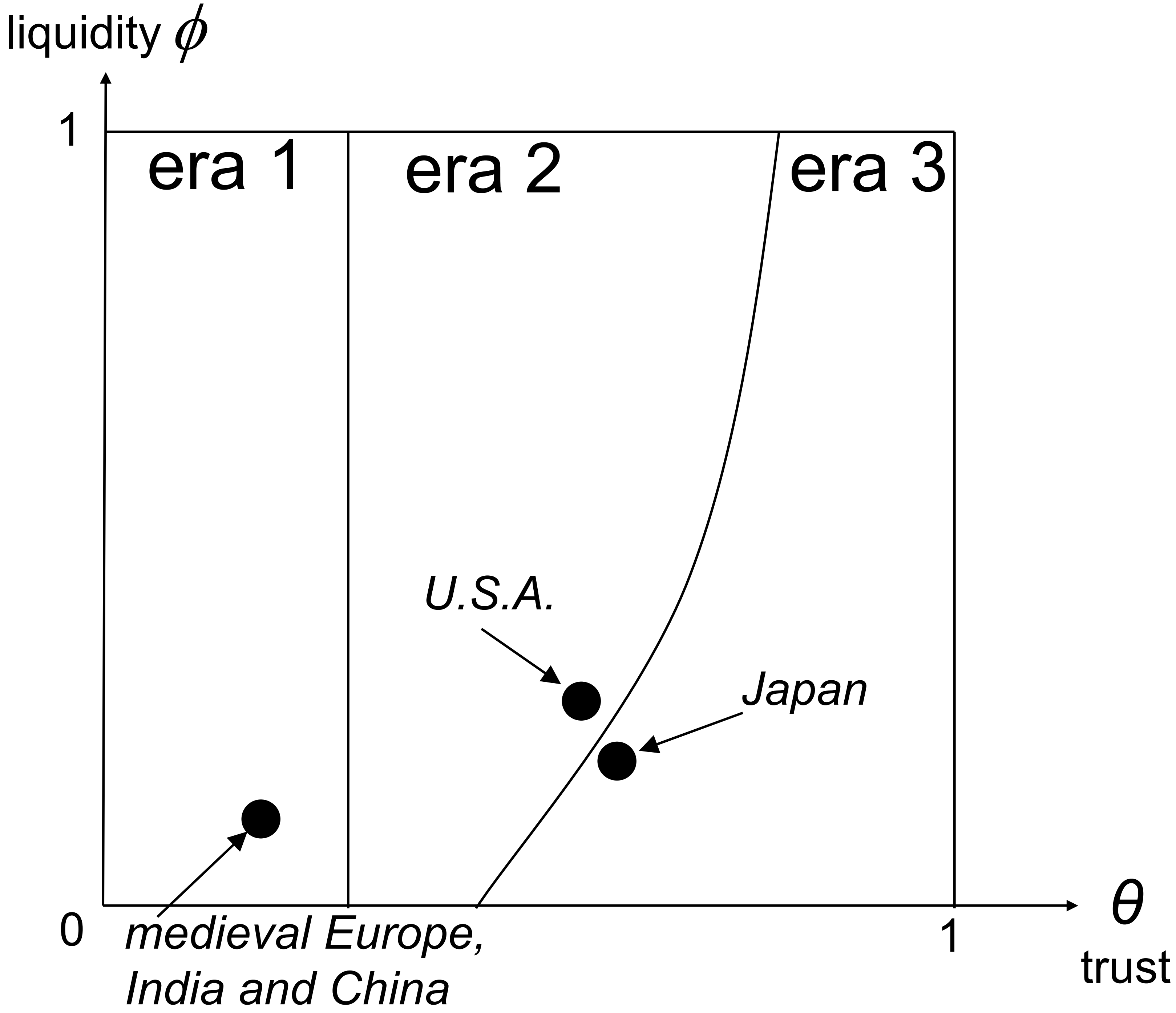

liquidity ϕ
1
era 1
era 2
era 3
Today
Shells
& Gold
0
θ
1
trust



liquidity ϕ
1
era 1
era 2
era 3
Today
Shells
& Gold
0
θ
1
trust


liquidity ϕ
1
era 1
era 2
era 3
Today
Shells
& Gold
Arrow-
Debreu
0
1
θ
trust


liquidity ϕ
1
era 1
era 2
era 3
0
medieval Europe,
India and China
1
θ
trust


liquidity ϕ
1
era 1
era 2
era 3
U.S.A.
Japan
0
medieval Europe,
India and China
1
θ
trust

THE MODEL

THE MODEL

discrete time $t = 1, 2, 3, \ldots$

one homogenous good, corn, storable
(one for one)

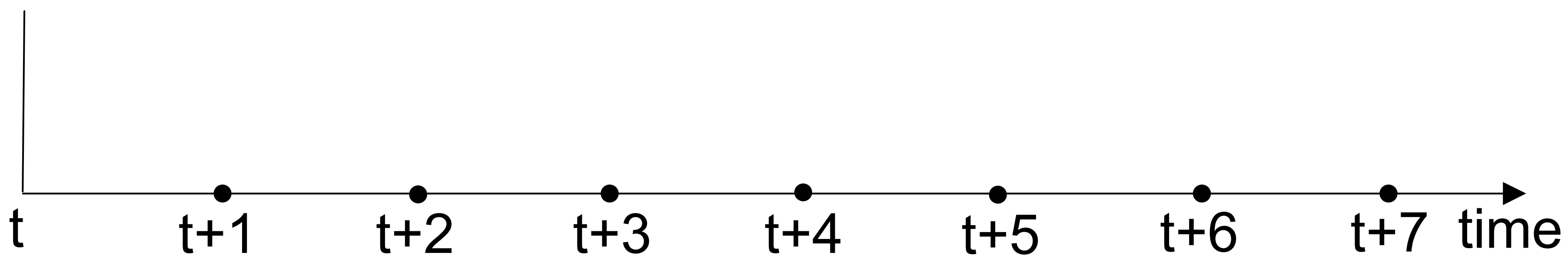
no uncertainty

infinitely lived agents choose consumption path $\{c_t, c_{t+1}, c_{t+2}, \ldots\}$ to maximise

$$\sum_{s=0}^{\infty} \beta^s \log c_{t+s} \qquad 0<\beta<1$$

each agent undertakes a sequence of projects

every 3 days, an agent starts a project that completes 2 days later:



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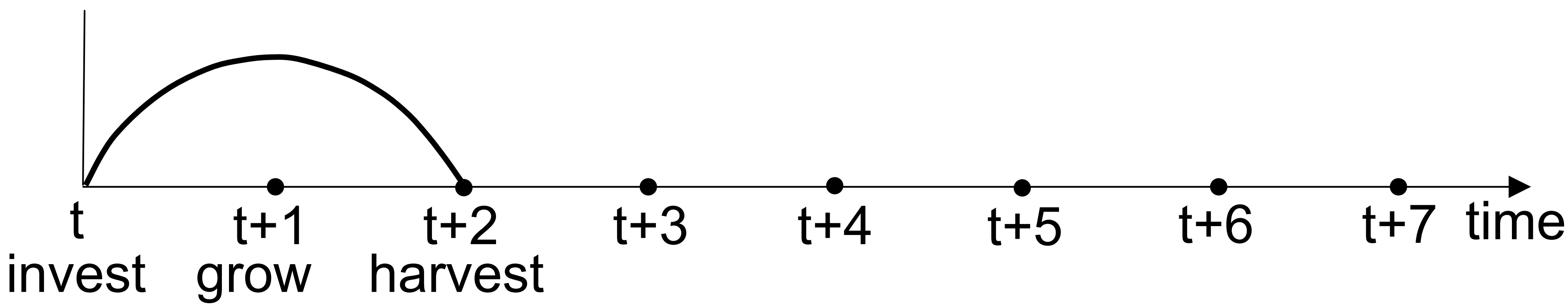

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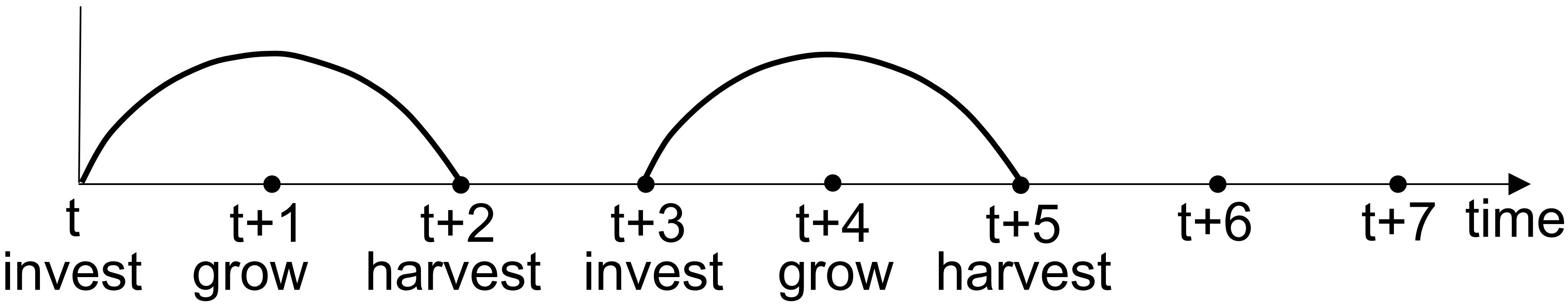

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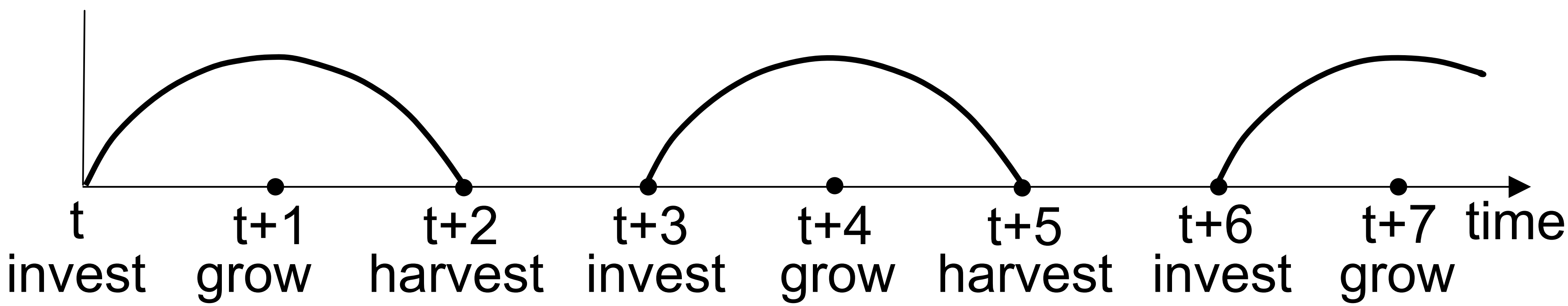

to produce y corn on day t+2 requires input G(y) corn on day t:

where $G(y) \propto y^{1/(1-\lambda)}$ $0<\lambda<1$

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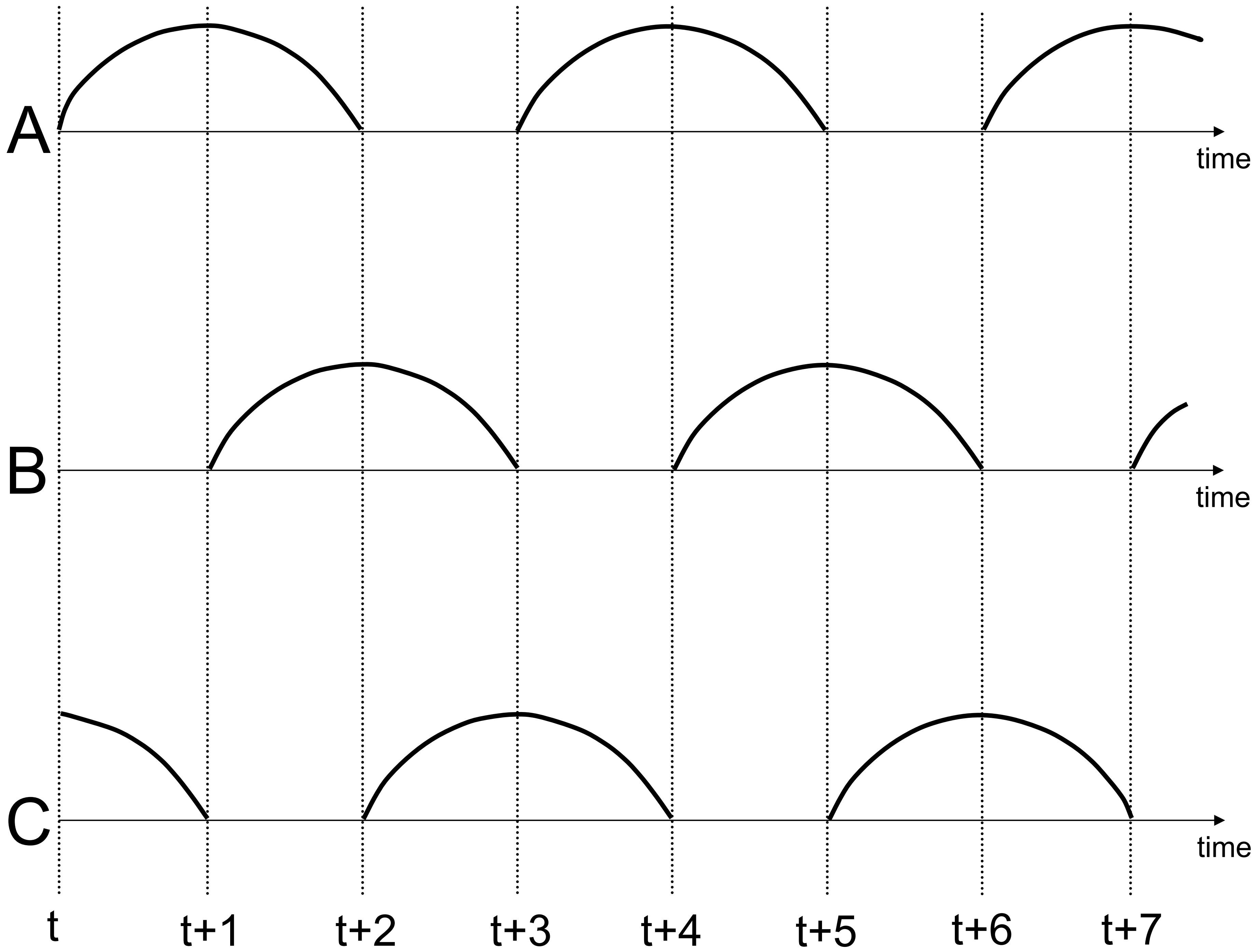
in a symmetric allocation, population is equally divided into 3 groups:

(normalise aggregate population = 3)



A
time
B
time
C
time
t
t+1
t+2
t+3
t+4
t+5
t+6
t+7

first-best (Arrow-Debreu):

efficient production: $G'(y^*) = \beta^2$

smooth consumption: $c_t \equiv \frac{1}{3}[y^* - G(y^*)]$

first-best (Arrow-Debreu):

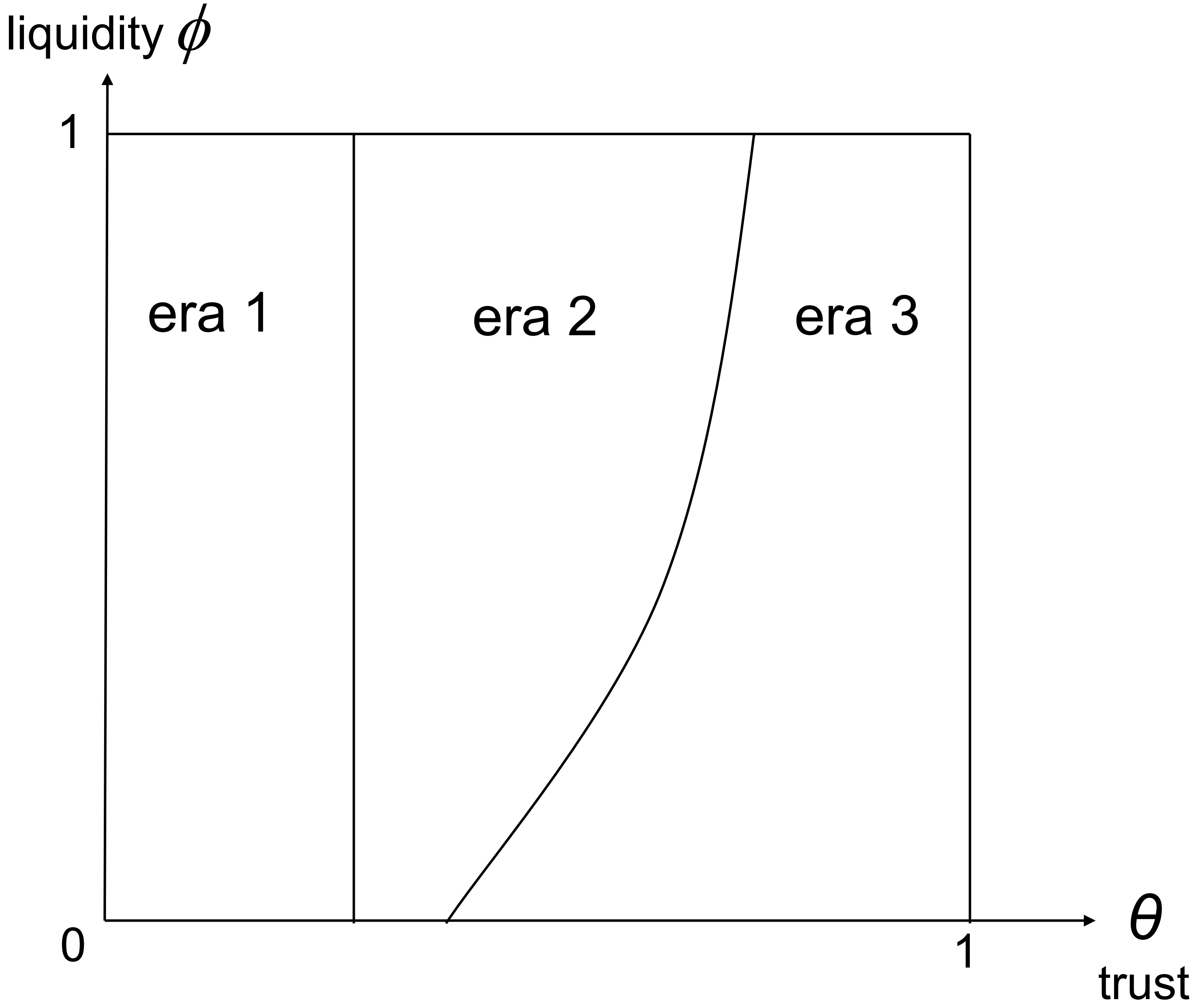
efficient production: $G'(y^*) = \beta^2$

smooth consumption: $c_t \equiv \frac{1}{3}[y^* - G(y^*)]$

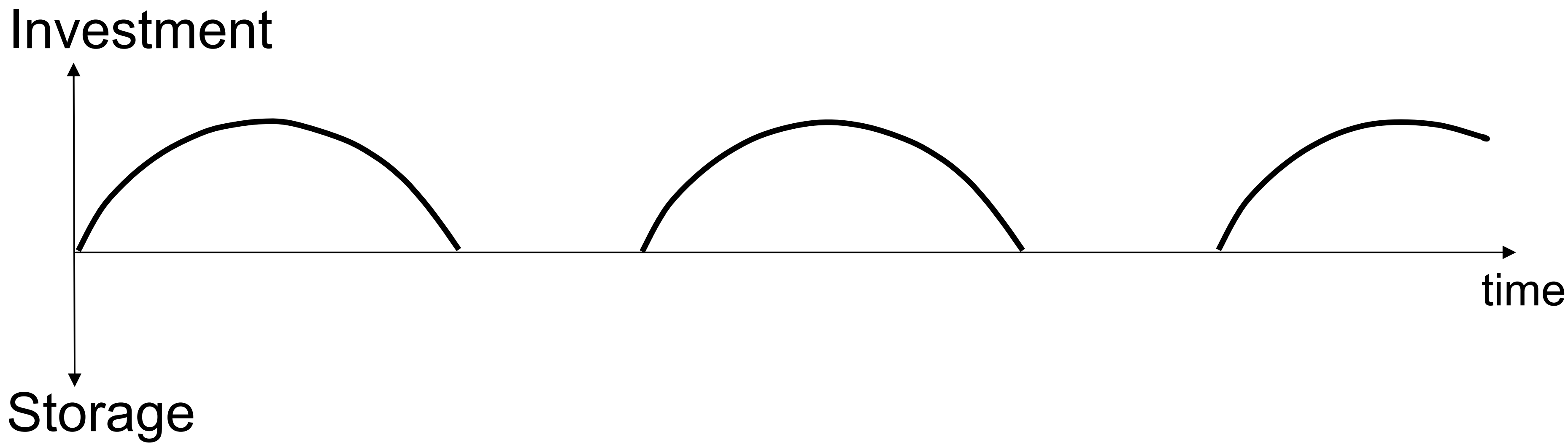
BUT, unlike in Arrow-Debreu, we assume

$$\theta < 1$$

at start of a project, investing agent can credibly promise at most θy of harvest y


liquidity ϕ
1
era 1
era 2
era 3
0
1
θ
trust

extreme case: θ = 0 (autarky; Robinson Crusoe)



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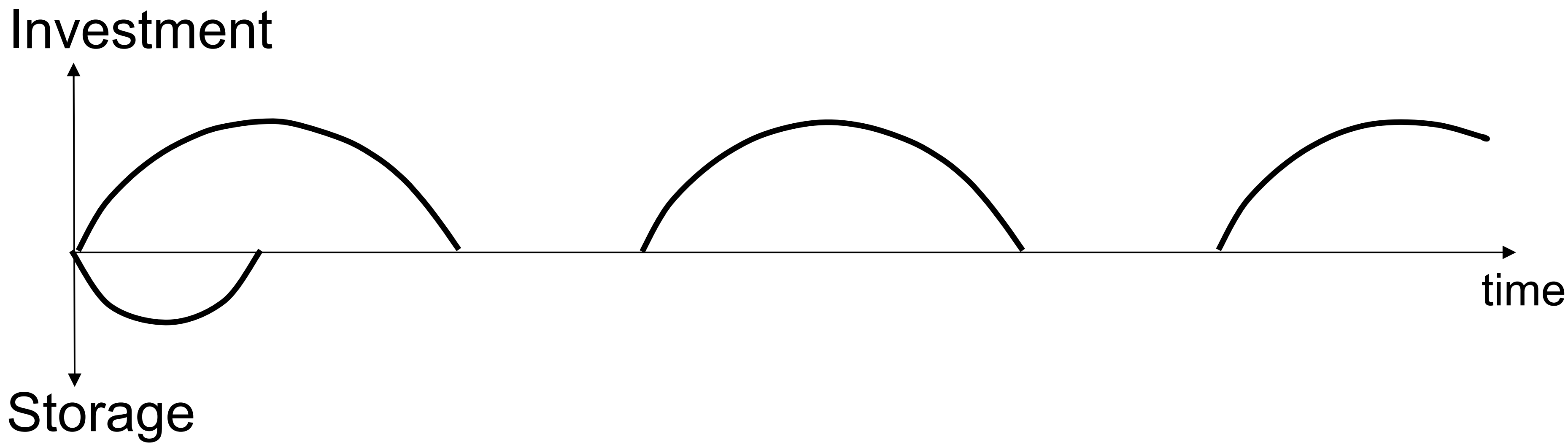

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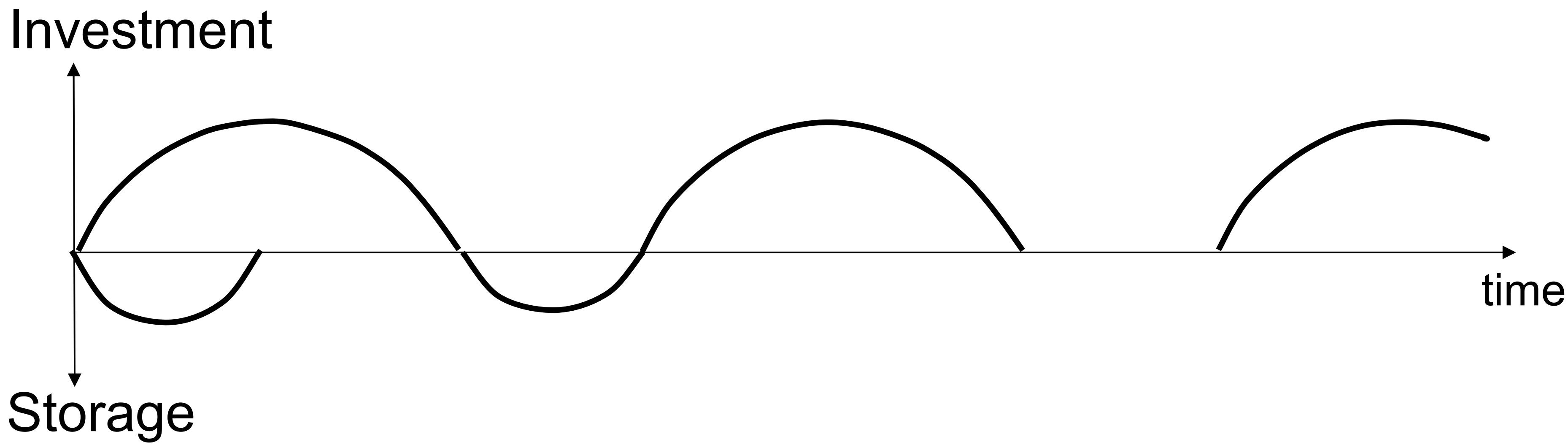

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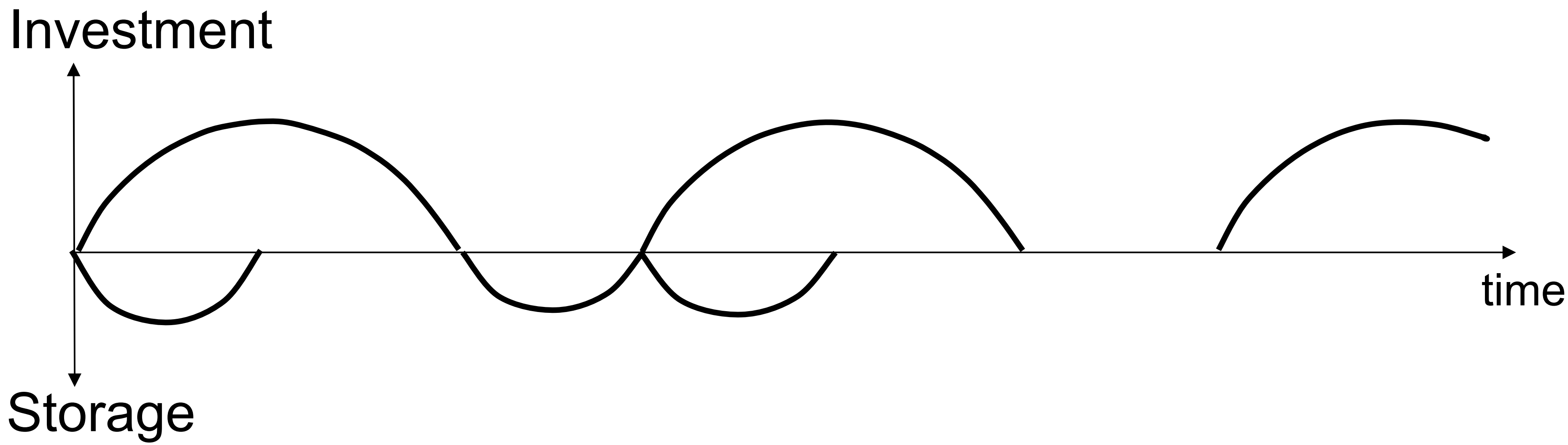

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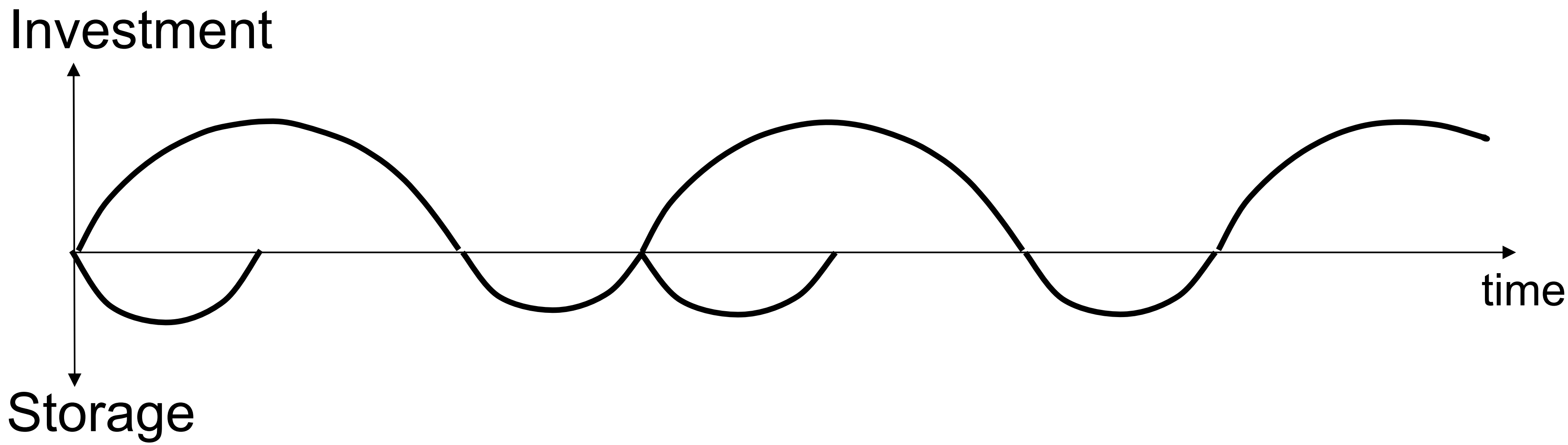

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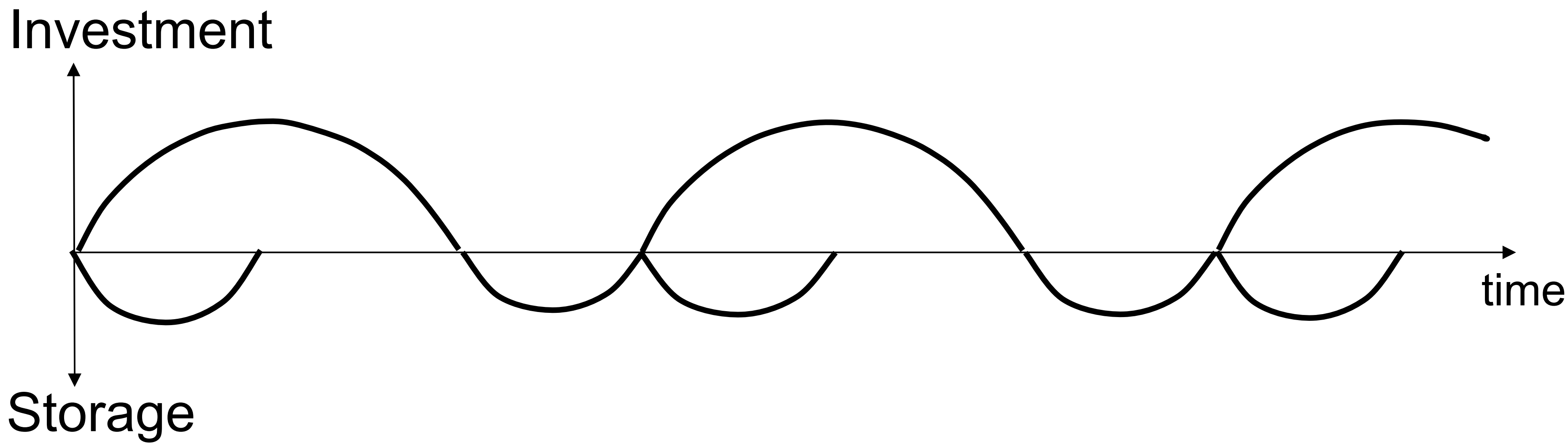

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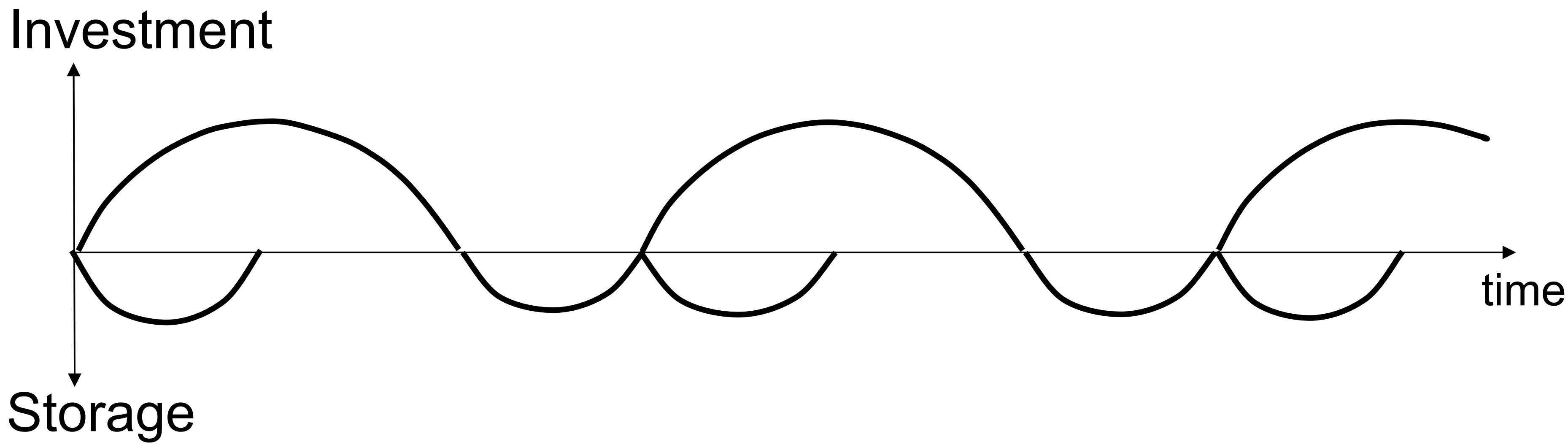
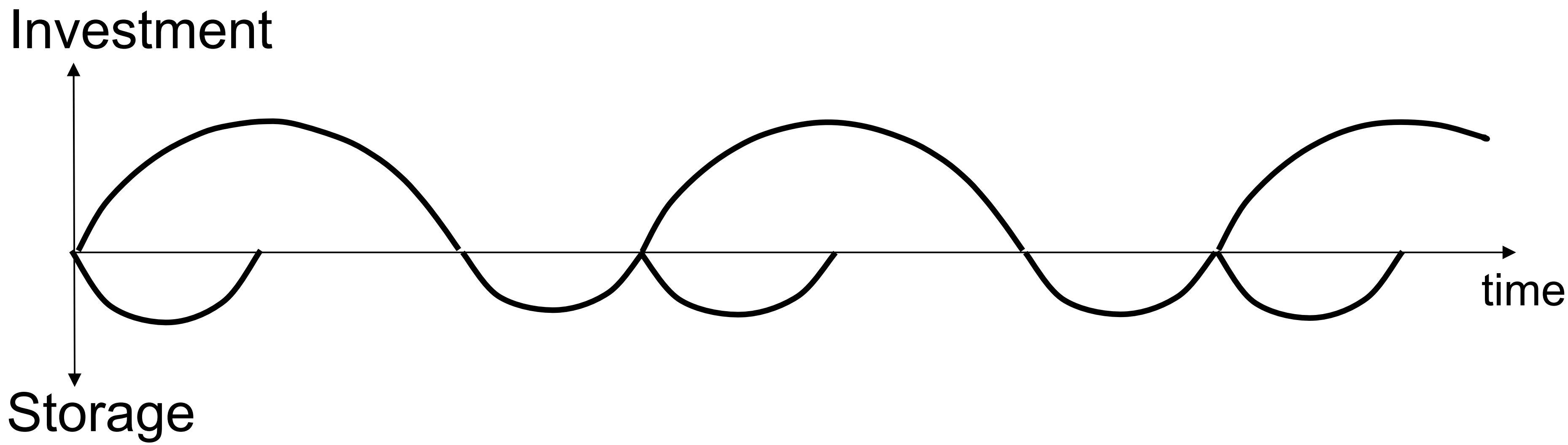


$G'(y) = \beta^3$ => y below y^*

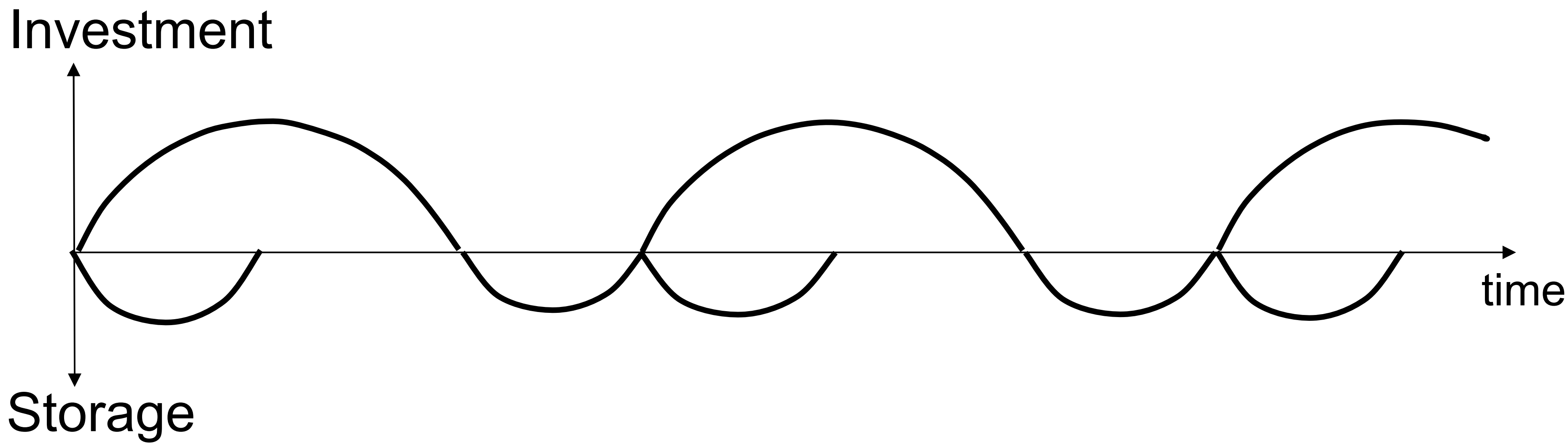
under-investment

extreme case: θ = 0 (autarky; Robinson Crusoe)



not only is there under-investment,
but there is also jagged consumption:

extreme case: θ = 0 (autarky; Robinson Crusoe)



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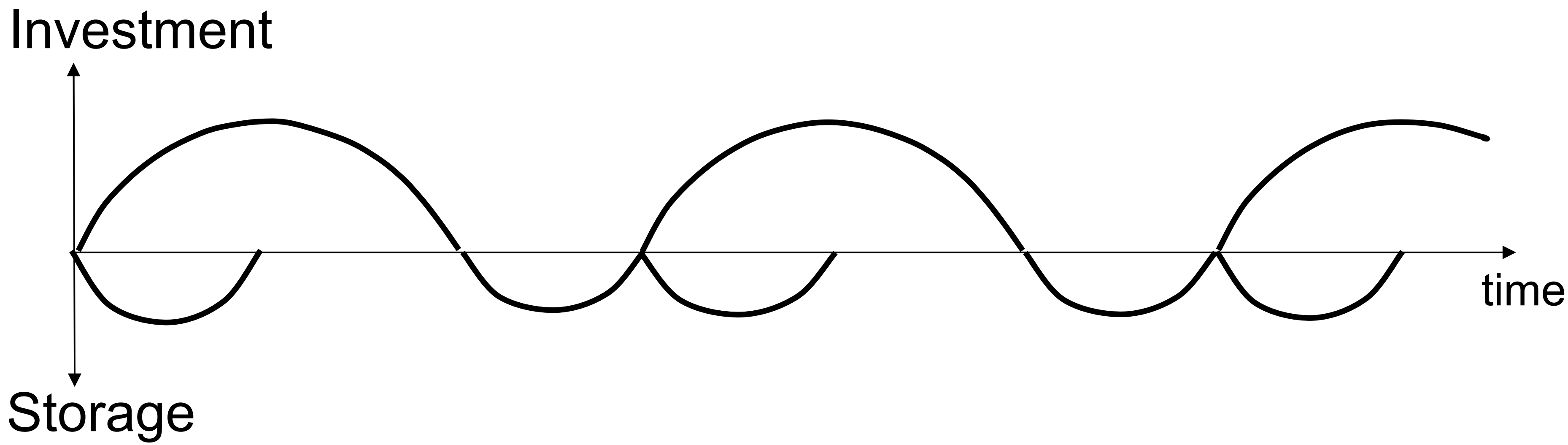

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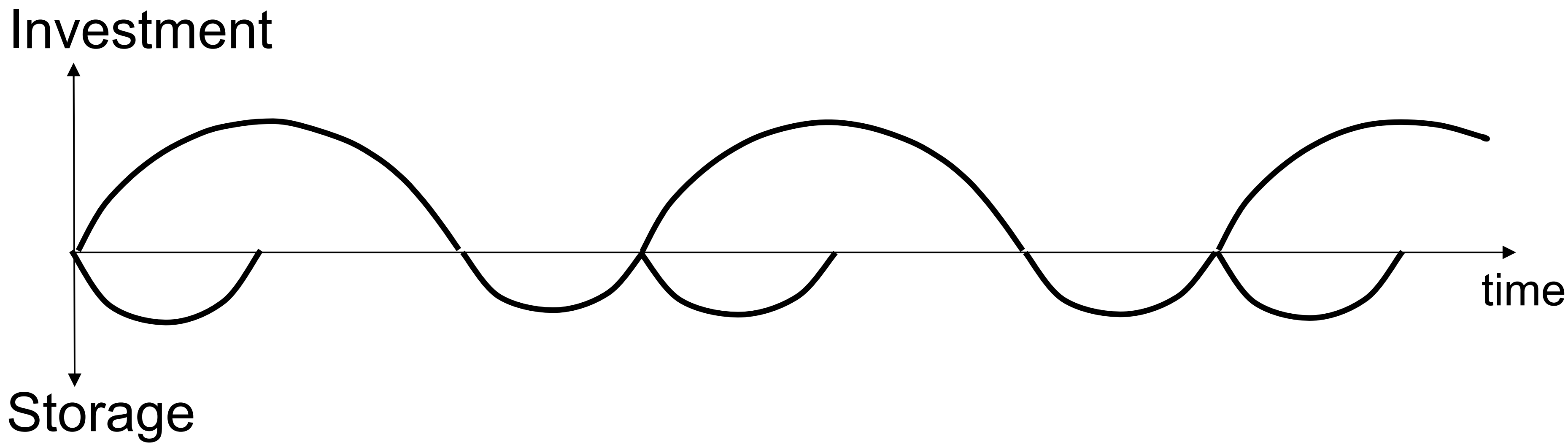

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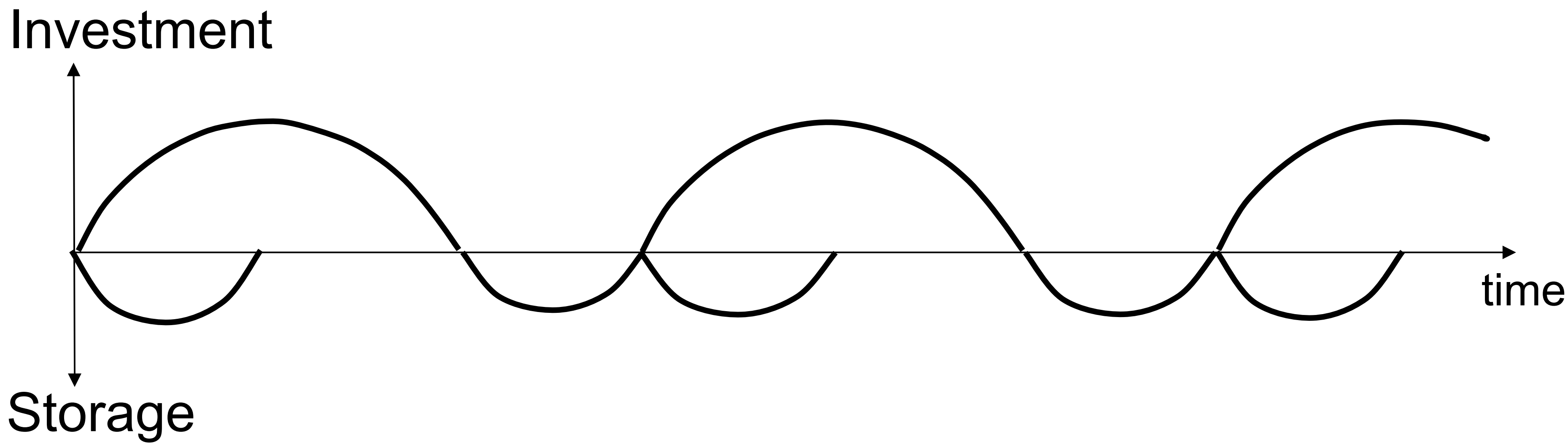

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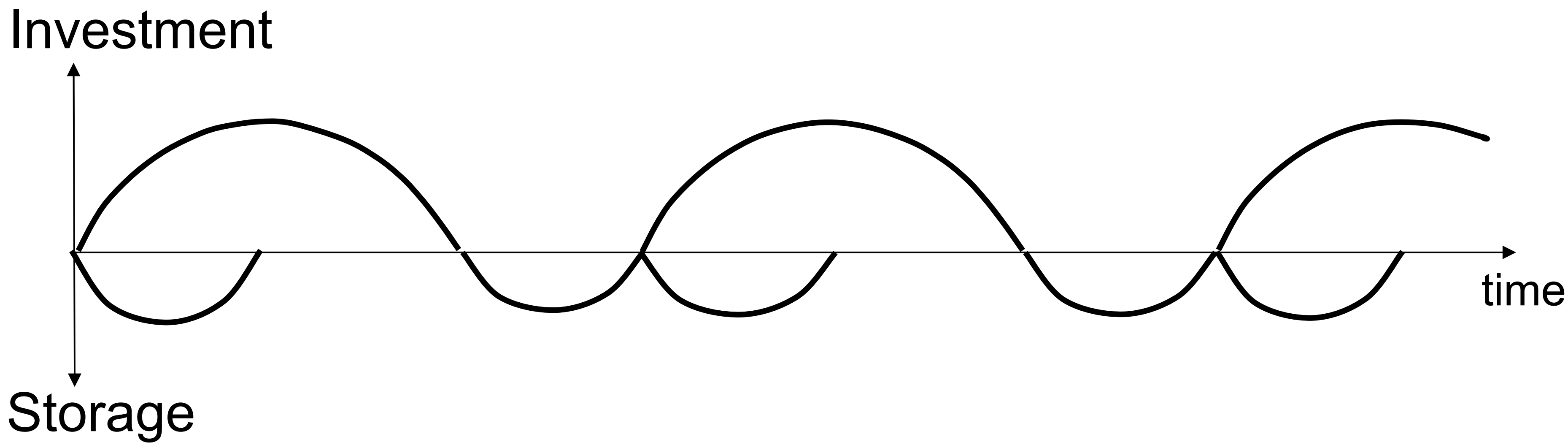

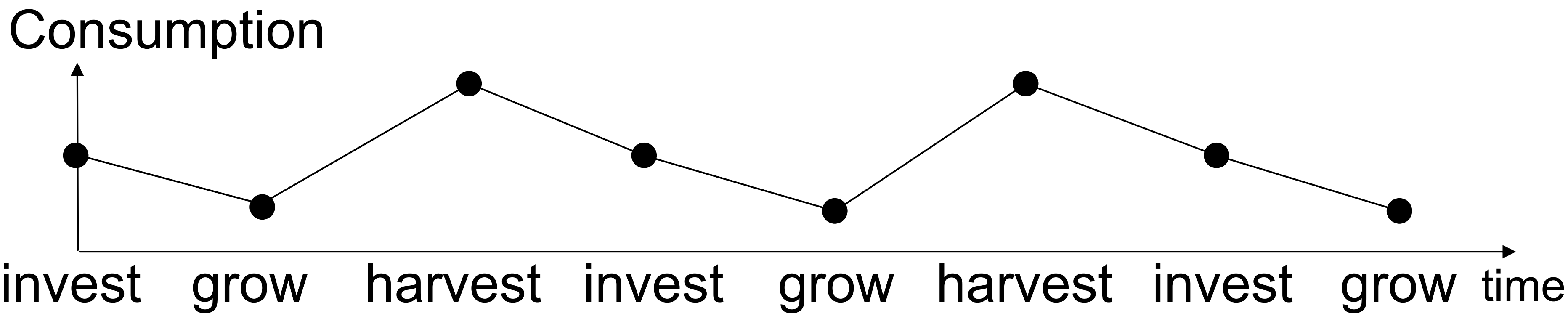

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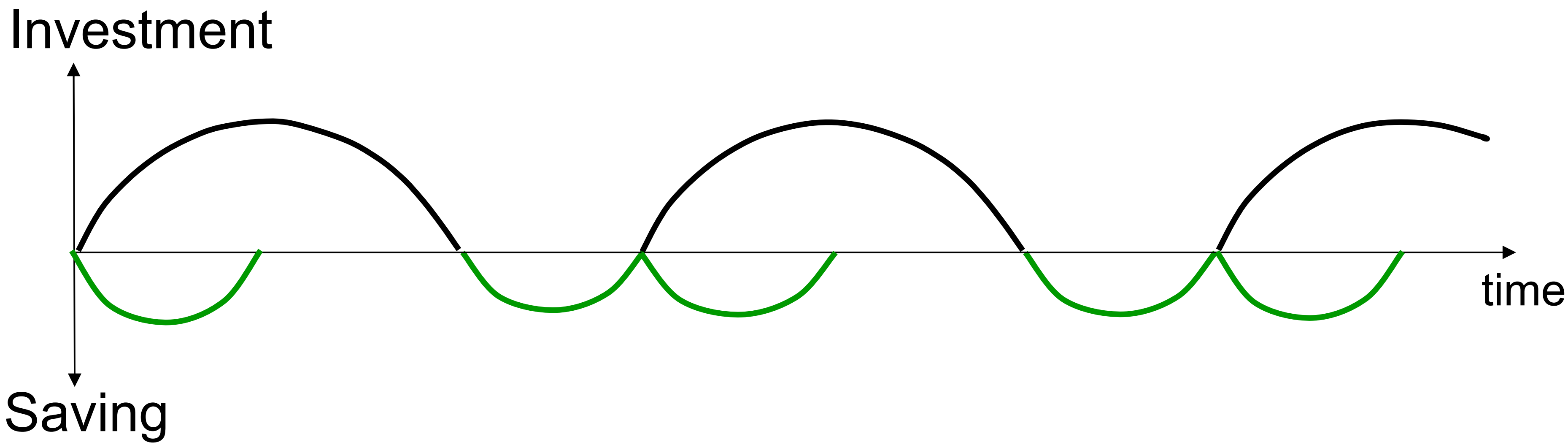

introduce outside money (green paper): same steady-state allocations as in autarky except that no corn need be tied up in storage (Samuelson, 1958) less extreme: $\theta > 0$

i.e. investing agent *can* issue private paper

but adverse selection causes the
secondary market to break down …

assume project comprises a large number of parts, some of which are lemons

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no-one can distinguish lemons on day of investment, day t

insiders privately learn which parts are lemons by day t+1

outsiders remain uninformed until day t+2

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no-one can distinguish lemons on day of investment, day t

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outsiders remain uninformed until day t+2

but there is a remedy …

at start of project (day t), investing agent can bundle parts together so that lemons cannot be separated out later (day t+1) at start of project (day t), investing agent can bundle parts together so that lemons cannot be separated out later (day t+1)

bundling $\equiv$ financial intermediation/banking

converts illiquid paper (blue paper)
that *cannot* be resold at t+1

into liquid paper (red paper)
that *can* be resold at t+1

cost of bundling a portion z ($\leq$ y) of output:

$$\frac{1-\phi}{\phi}\, G(z) \qquad\qquad 0<\phi<1$$

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costs are deadweight (no extra output)

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$$\frac{1-\phi}{\phi} G(z) \qquad\qquad 0<\phi<1$$

costs are deadweight (no extra output)

($\Rightarrow$ in first-best, there is

no bundling, no banking
no inside money, no red paper)

q = issue price of blue paper

(price in terms of day t corn of a credible claim to day t+2 corn, that *cannot* be resold on day t+1)

p^2 = issue price of red paper

(price in terms of day t corn of a credible claim to day t+2 corn, that *can* be resold on day t+1, at price p) basic inequalities:

$$1 \geq p^2 \geq q \geq \beta^2$$

result!

if $p < 1$ then green paper not used

in terms of overnight net returns:

return on green	$\leq$	return on red	$\leq$	return on blue	$\leq$	subjective return
(zero)		$\left(\frac{1}{p} - 1\right)$	↑	$\left(\frac{1}{\sqrt{q}} - 1\right)$		$\left(\frac{1}{\beta} - 1\right)$
			liquidity premium			

in terms of overnight net returns:

return on green	$\leq$	return on red	$\leq$	return on blue	$\leq$	subjective return
(zero)		$(\frac{1}{p} - 1)$	↑	$(\frac{1}{\sqrt{q}} - 1)$		$(\frac{1}{\beta} - 1)$
			liquidity premium			

$$\frac{1}{\sqrt{q}} - \frac{1}{p} = \text{Keynesian interest rate } r$$

in terms of overnight net returns:

return on green	$\leq$	return on red	$\leq$	return on blue	$\leq$	subjective return
(zero)		$(\frac{1}{p} - 1)$	↑ *liquidity premium*	$(\frac{1}{\sqrt{q}} - 1)$		$(\frac{1}{\beta} - 1)$

$$\frac{1}{\sqrt{q}} - \frac{1}{p} = \text{Keynesian interest rate } r$$

when green paper used (p=1), $r = \frac{1}{\sqrt{q}} - 1$

flow-of-funds constraints

flow-of-funds constraints

investment day:

$$G(y) + \frac{1-\phi}{\phi}G(z) + c + pm + qn$$
$$= p^2\theta z + q\theta(y - z) + m'' + n'$$

flow-of-funds constraints

investment day:

$$G(y) + \frac{1-\phi}{\phi} G(z) + c + pm + qn$$

$$= p^2\theta z + q\theta(y - z) + m'' + n'$$

growing day:

$$c' + pm' + qn' = m + n''$$

flow-of-funds constraints

investment day:

$$G(y) + \frac{1-\phi}{\phi} G(z) + c + pm + qn$$

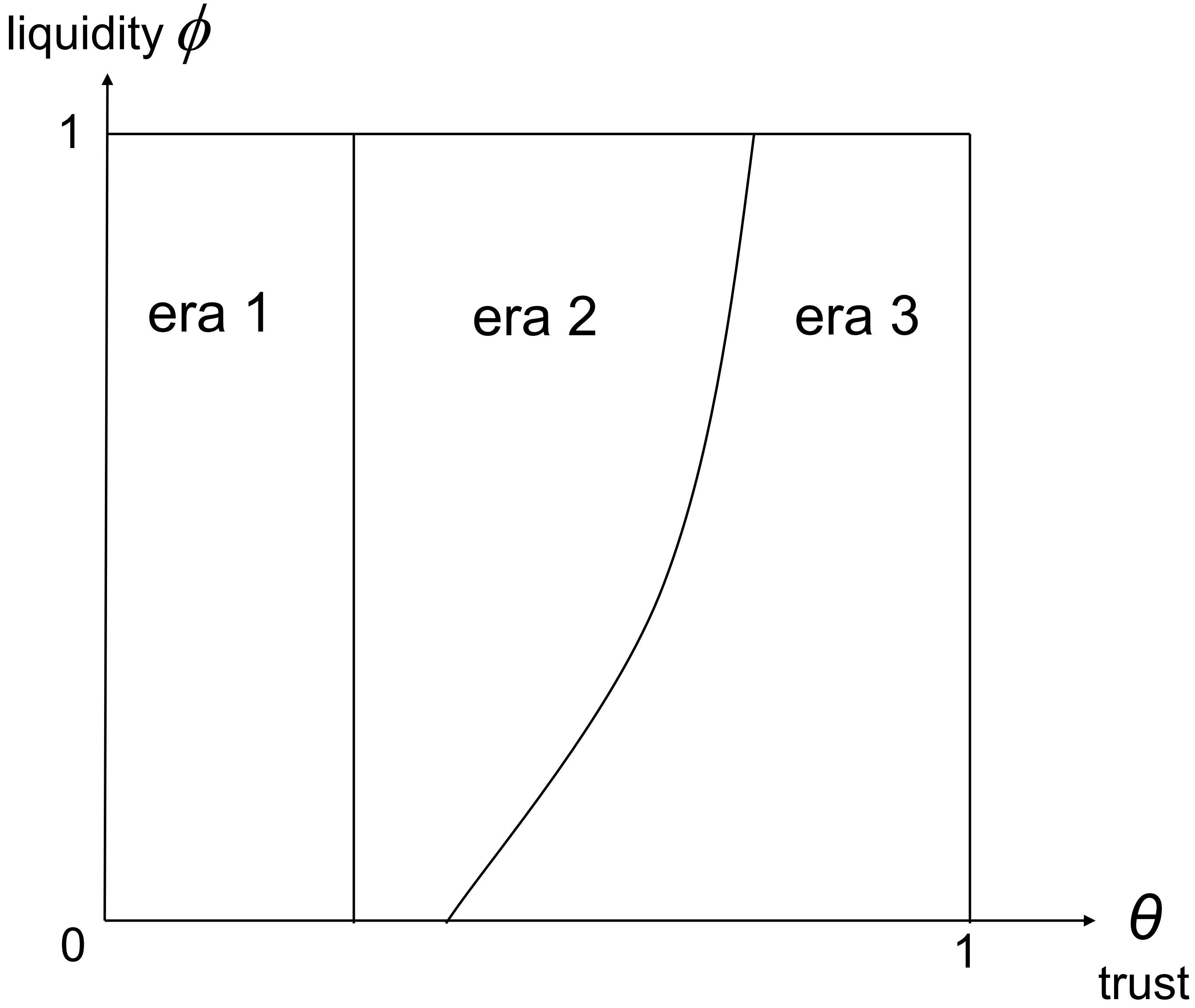
$$= p^2\theta z + q\theta(y - z) + m'' + n'$$

growing day:

$$c' + pm' + qn' = m + n''$$

harvest day:

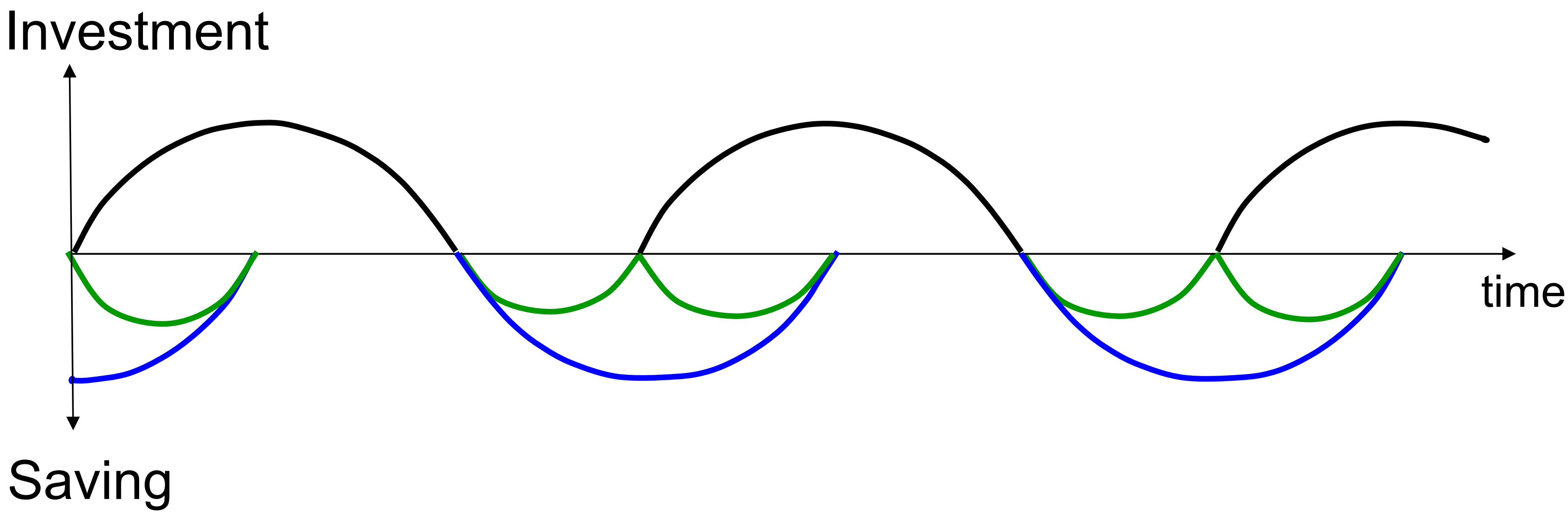
$$c'' + pm'' + qn'' = (1 - \theta)y + m' + n$$



liquidity ϕ
1
era 1
era 2
era 3
0
1
θ
trust

era 1

era 1



era 1

investment day:

$$G(y) + \frac{1-\phi}{\phi} G(z) + c + pm + \cancel{qn}$$
$$= p^2\theta z + q\theta(y - z) + m'' + \cancel{n'}$$

growing day:

$$c' + \cancel{pm'} + \cancel{qn'} = m + n''$$

harvest day:

$$c'' + pm'' + qn'' = (1 - \theta)y + \cancel{m'} + \cancel{n}$$

era 1

investment day:

$$G(y) + \frac{1-\phi}{\phi} G(z) + c + pm = p^2\theta z + q\theta(y - z) + m''$$

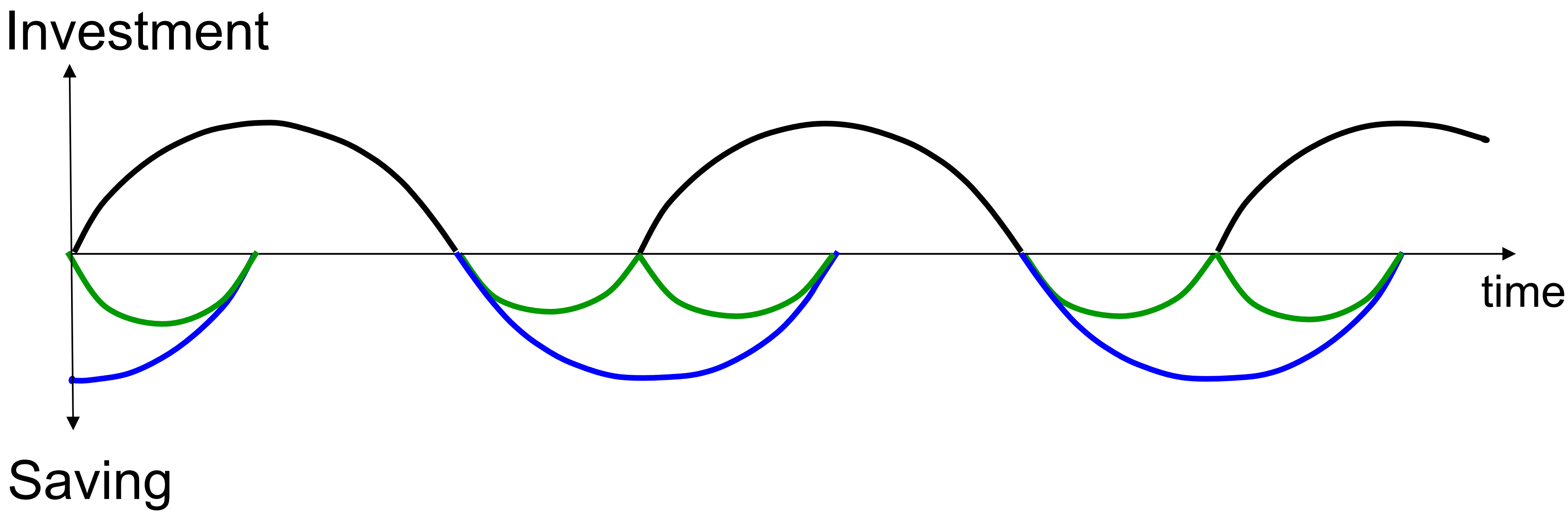
growing day:

$$c' = m + n''$$

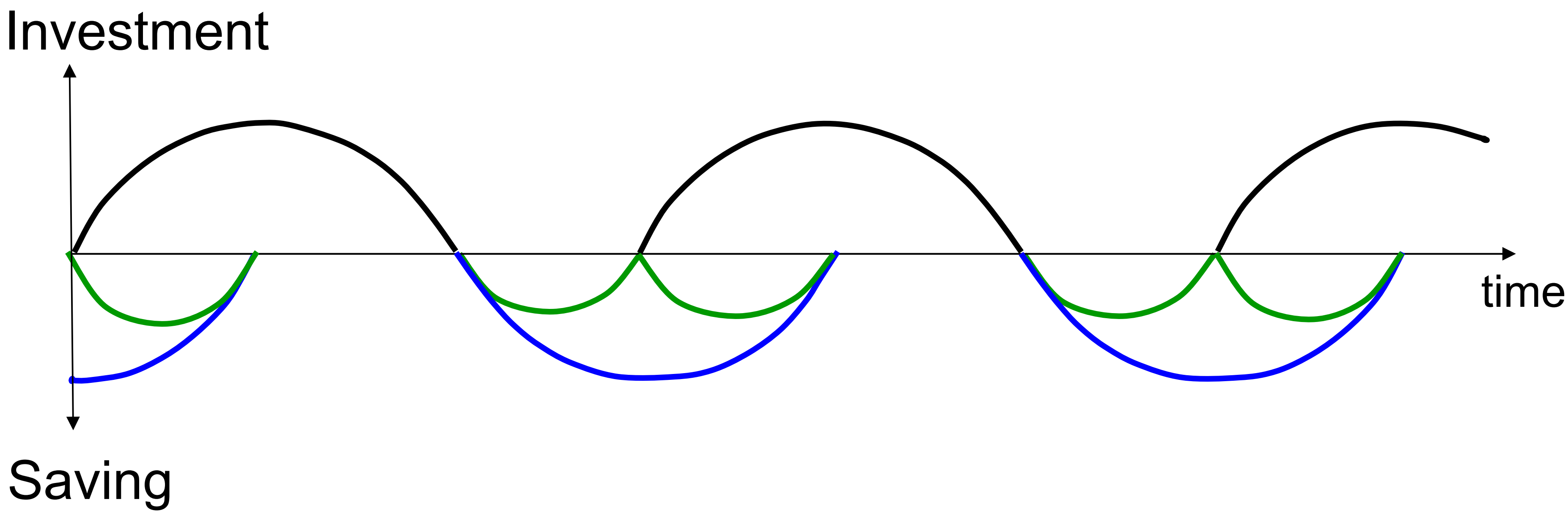
harvest day:

$$c'' + pm'' + qn'' = (1 - \theta)y$$

era 1



era 1



blue paper competes with green paper (held twice)

⇒ q = 1: no liquidity premium

⇒ no bundling: no red paper

era 1

investment day:

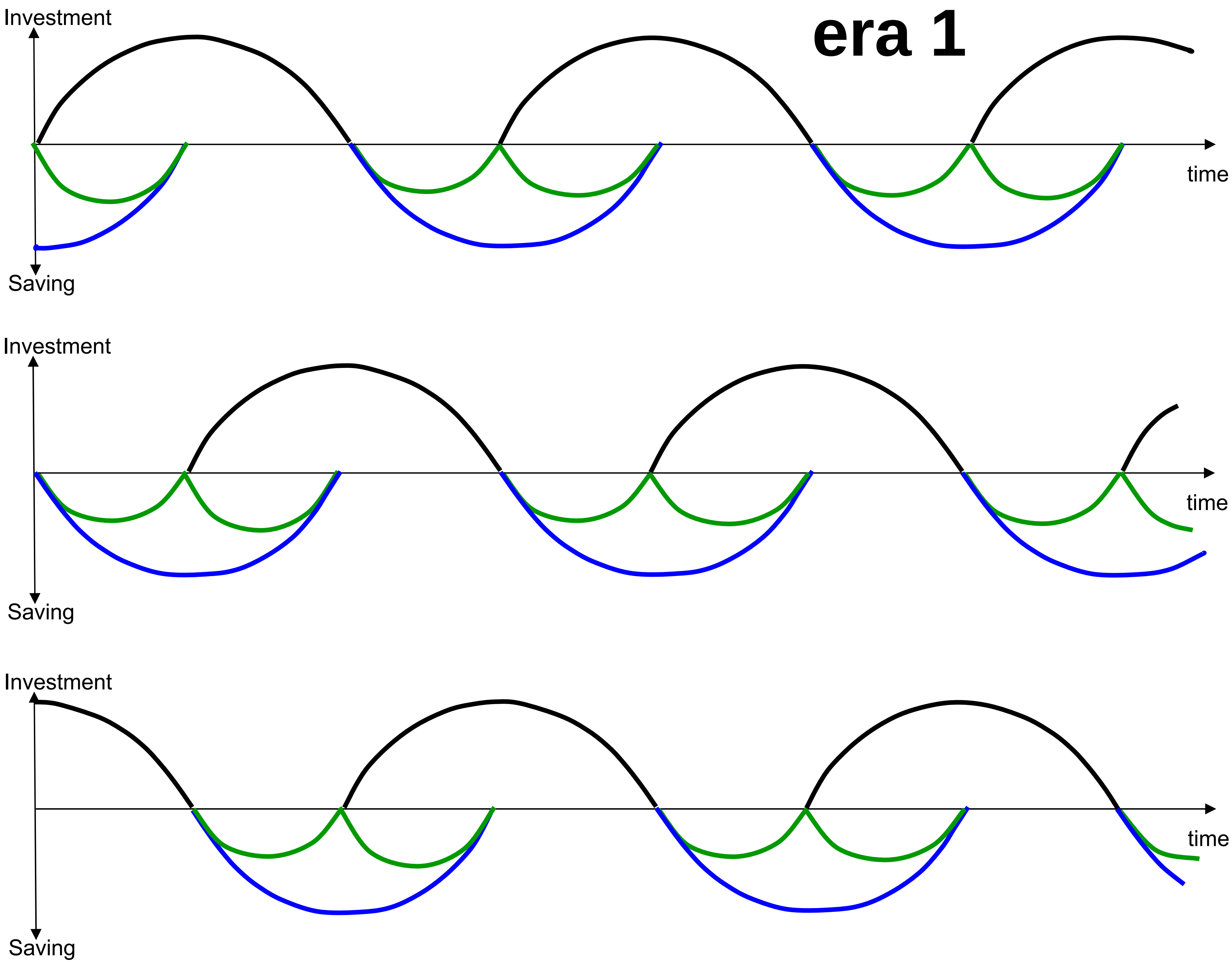
$$G(y) + \cancel{\frac{1-\phi}{\phi} G(z)} + c + pm = \cancel{p^2\theta z} + q\theta(y - \cancel{z}) + m''$$

growing day:

$$c' = m + n''$$

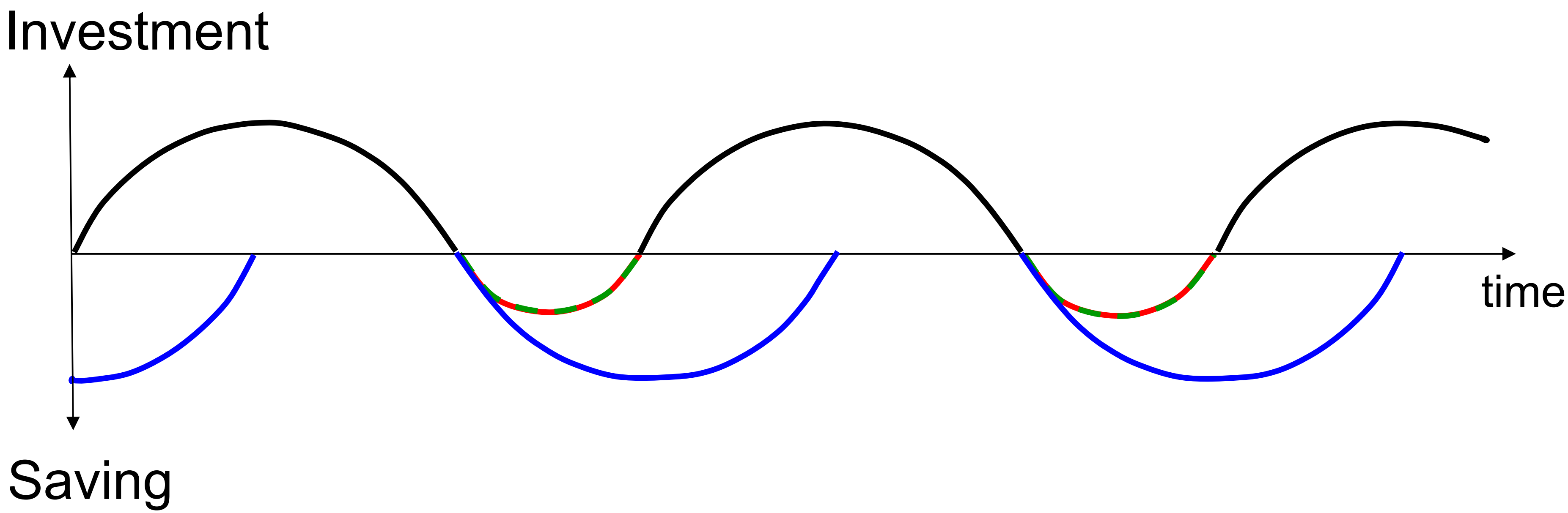
harvest day:

$$c'' + pm'' + qn'' = (1 - \theta)y$$


era 1
Investment
Saving
time
Investment
Saving
time
Investment
Saving
time

era 2

era 2



era 2

investment day:

$$G(y) + \frac{1-\phi}{\phi} G(z) + c + \cancel{pm}$$
$$= p^2\theta z + q\theta(y - z) + m''$$

growing day:

$$c' = \cancel{m} + n''$$

harvest day:

$$c'' + pm'' + qn'' = (1 - \theta)y$$

era 2

investment day:

$$G(y) + \frac{1-\phi}{\phi} G(z) + c = p^2\theta z + q\theta(y - z) + m''$$

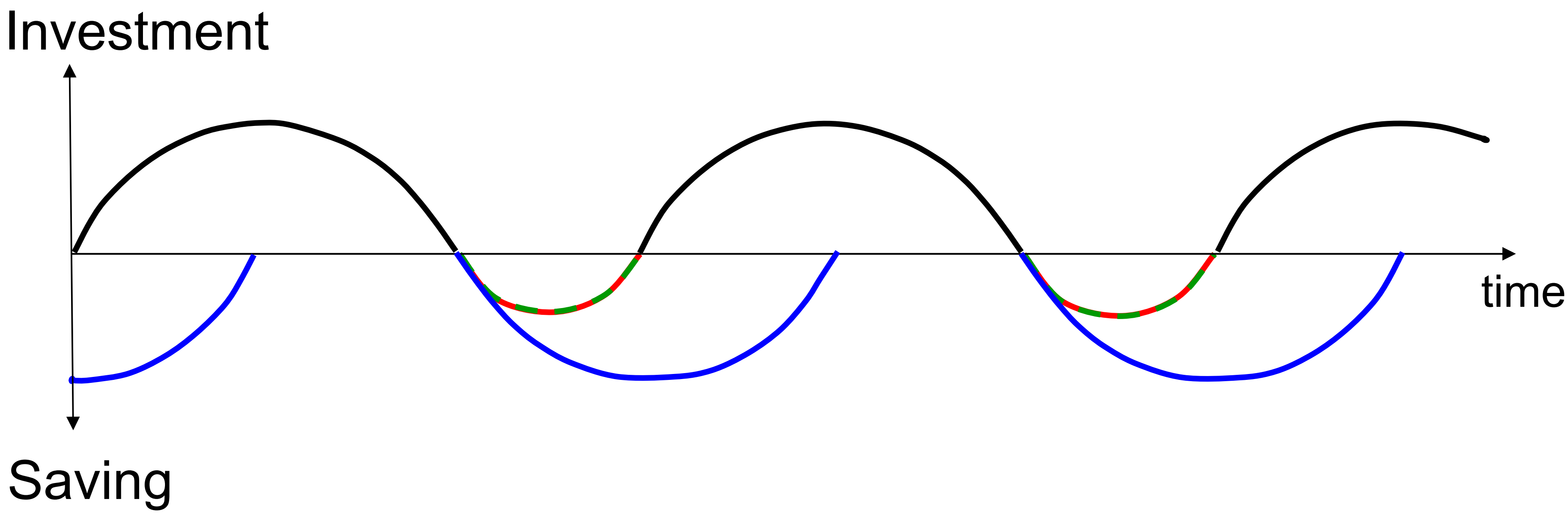
growing day:

$$c' = n''$$

harvest day:

$$c'' + pm'' + qn'' = (1 - \theta)y$$

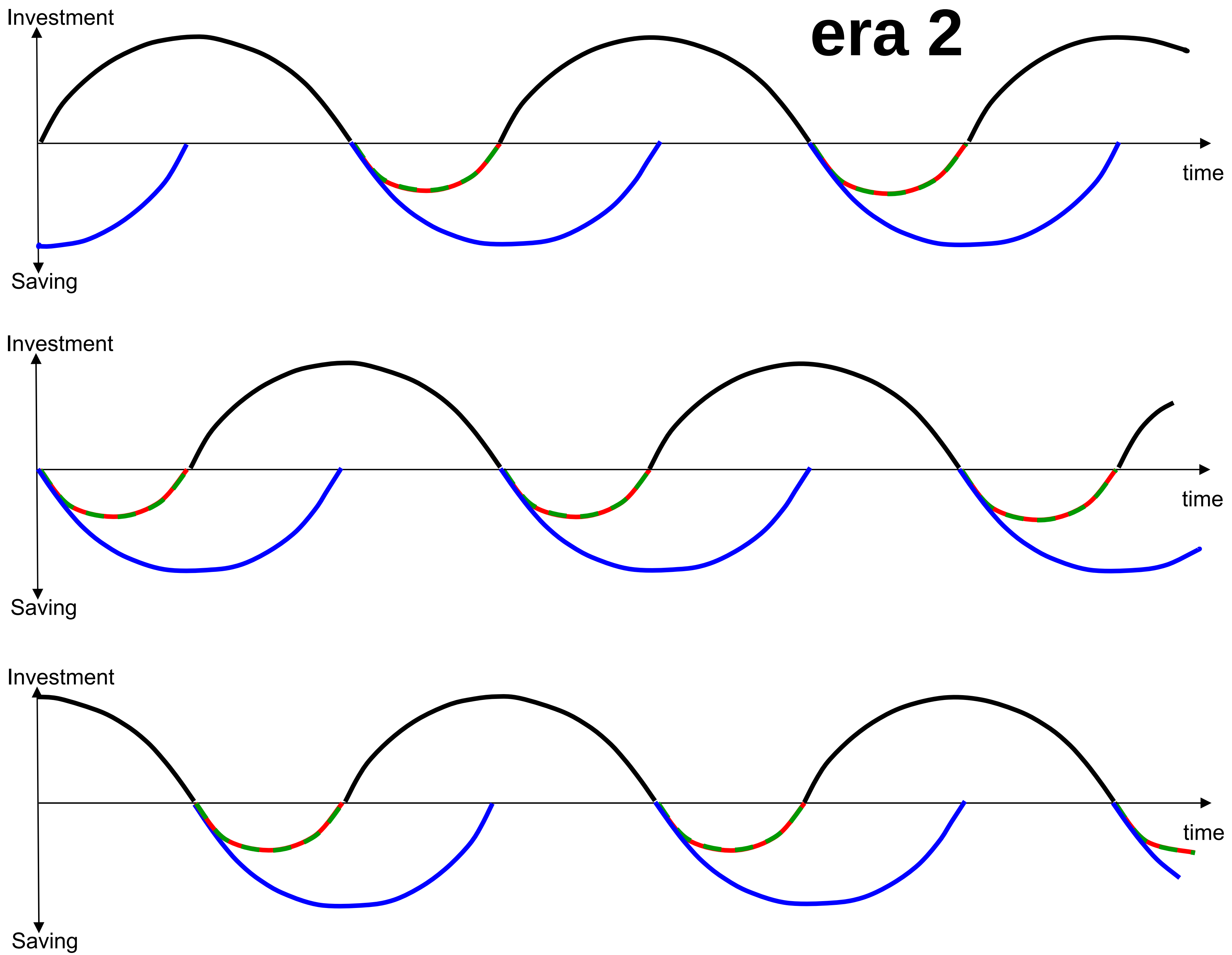
era 2



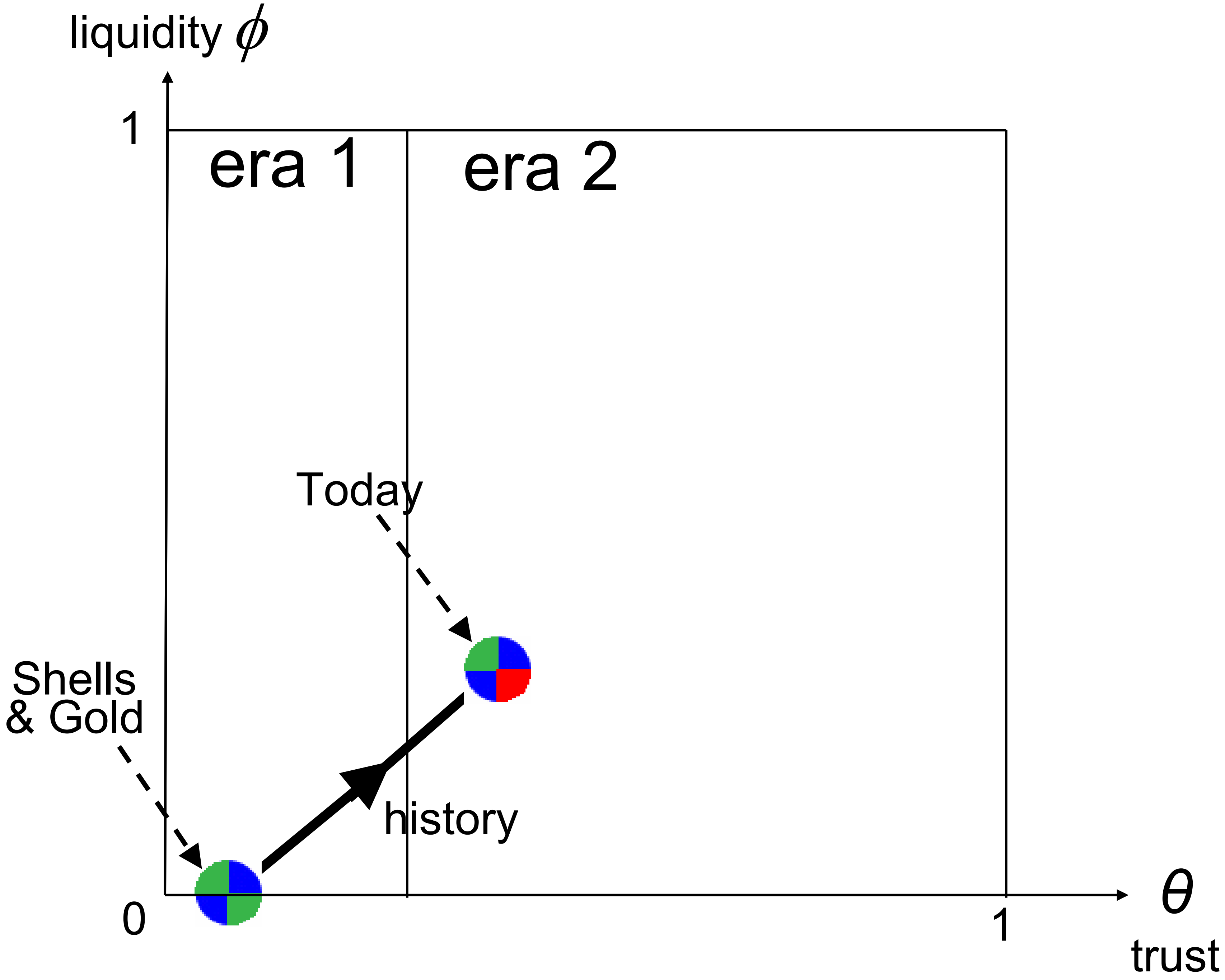
$$1 \geq p^2 > q > \beta^2$$

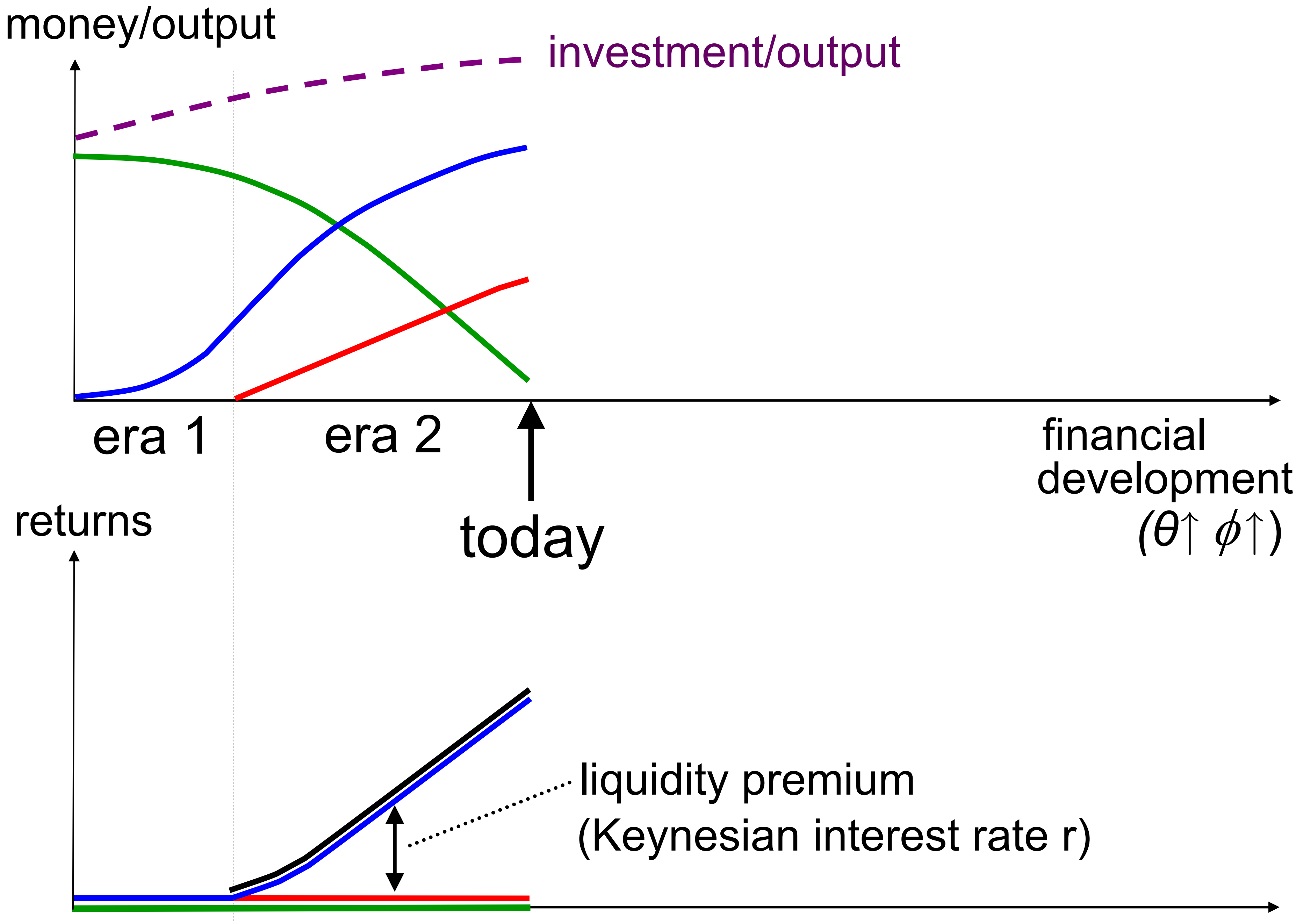
if strict, green paper does not circulate

positive liquidity premium
⇒ bundling, red paper


era 2
Investment
Saving
time
Investment
Saving
time
Investment
Saving
time

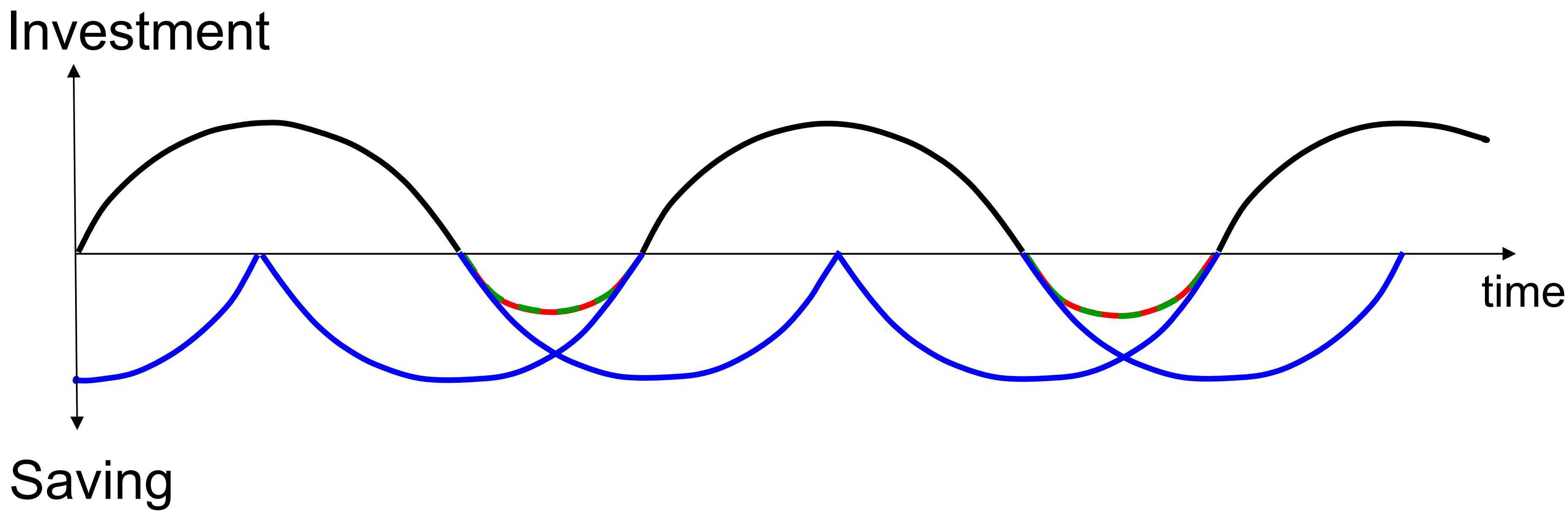
back to the history of money:


liquidity ϕ
1
era 1
era 2
Today
Shells
& Gold
history
0
1
θ
trust

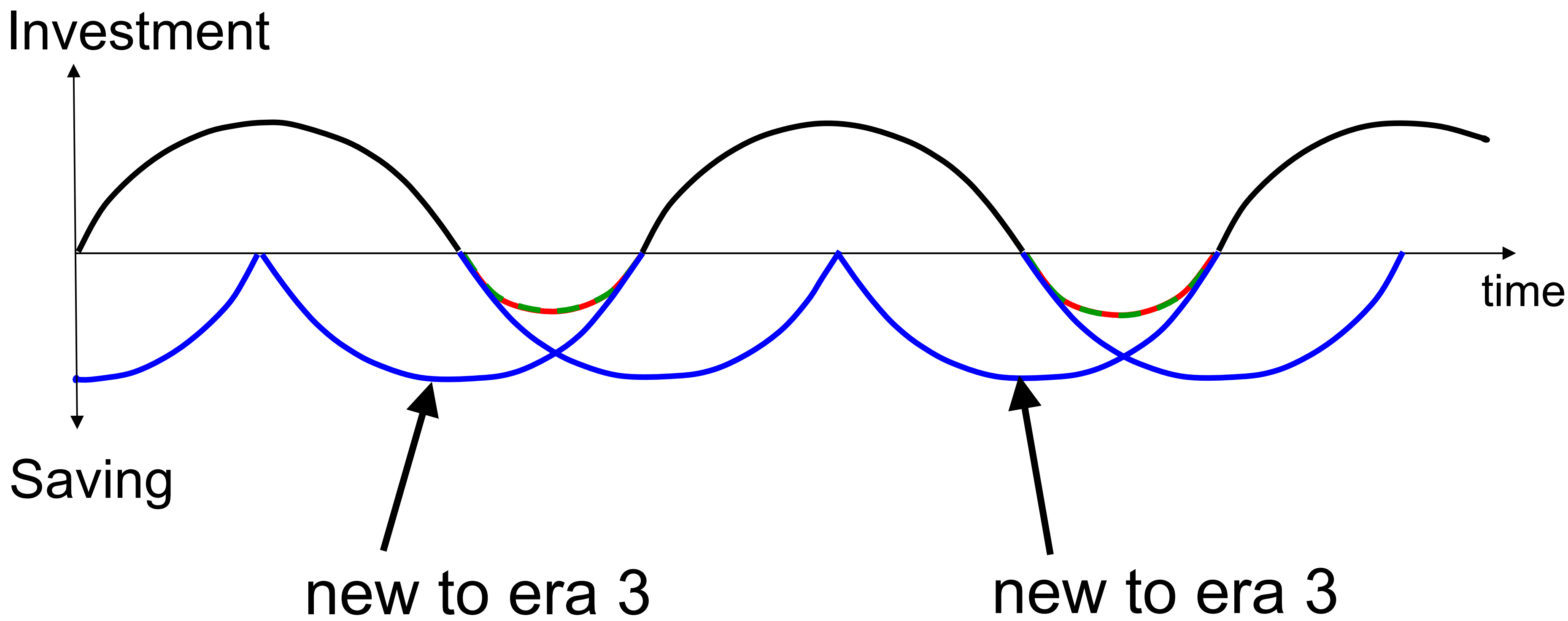

money/output
investment/output
era 1
era 2
today
financial development ($\theta\uparrow$ $\phi\uparrow$)
returns
liquidity premium
(Keynesian interest rate r)

era 3

era 3



era 3



era 3

investment day:

$$G(y) + \frac{1-\phi}{\phi}G(z) + c$$

$$= p^2\theta z + q\theta(y-z) + m'' + n'$$

new to era 3

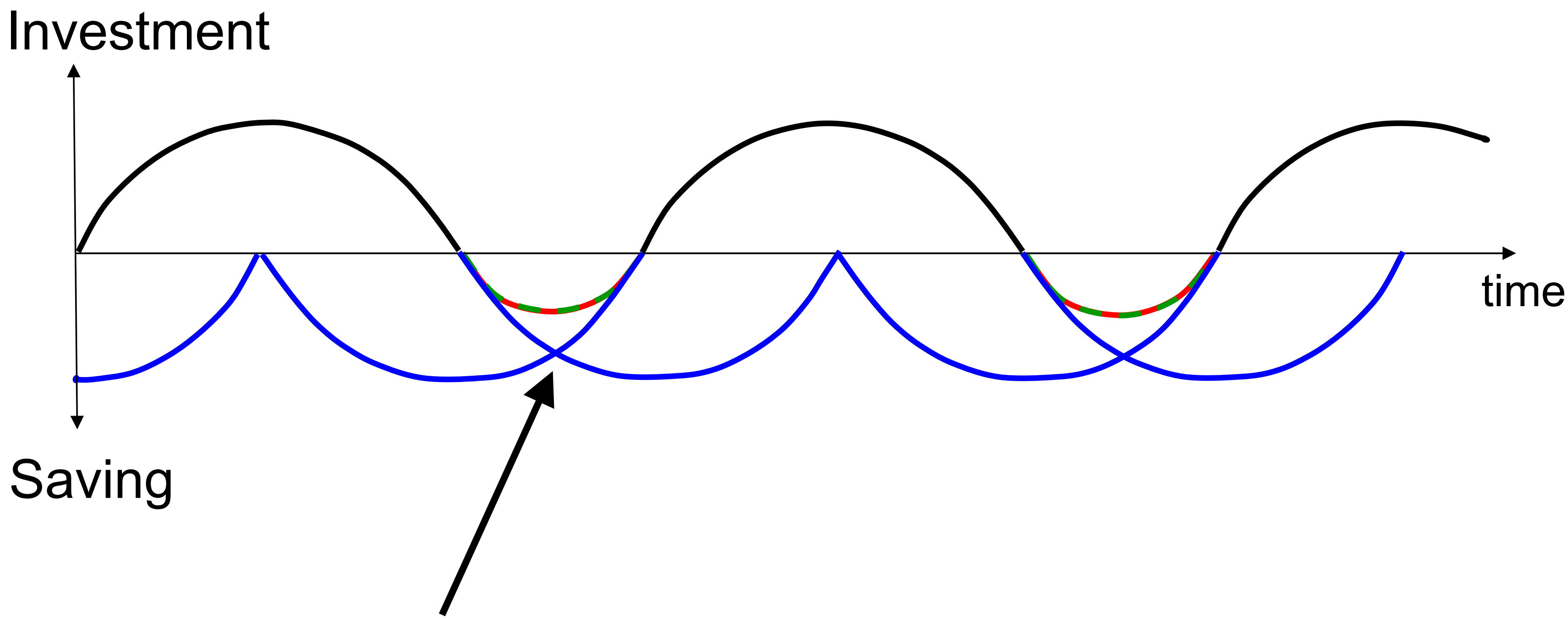
growing day:

$$c' + qn' = n''$$

harvest day:

$$c'' + pm'' + qn'' = (1-\theta)y$$

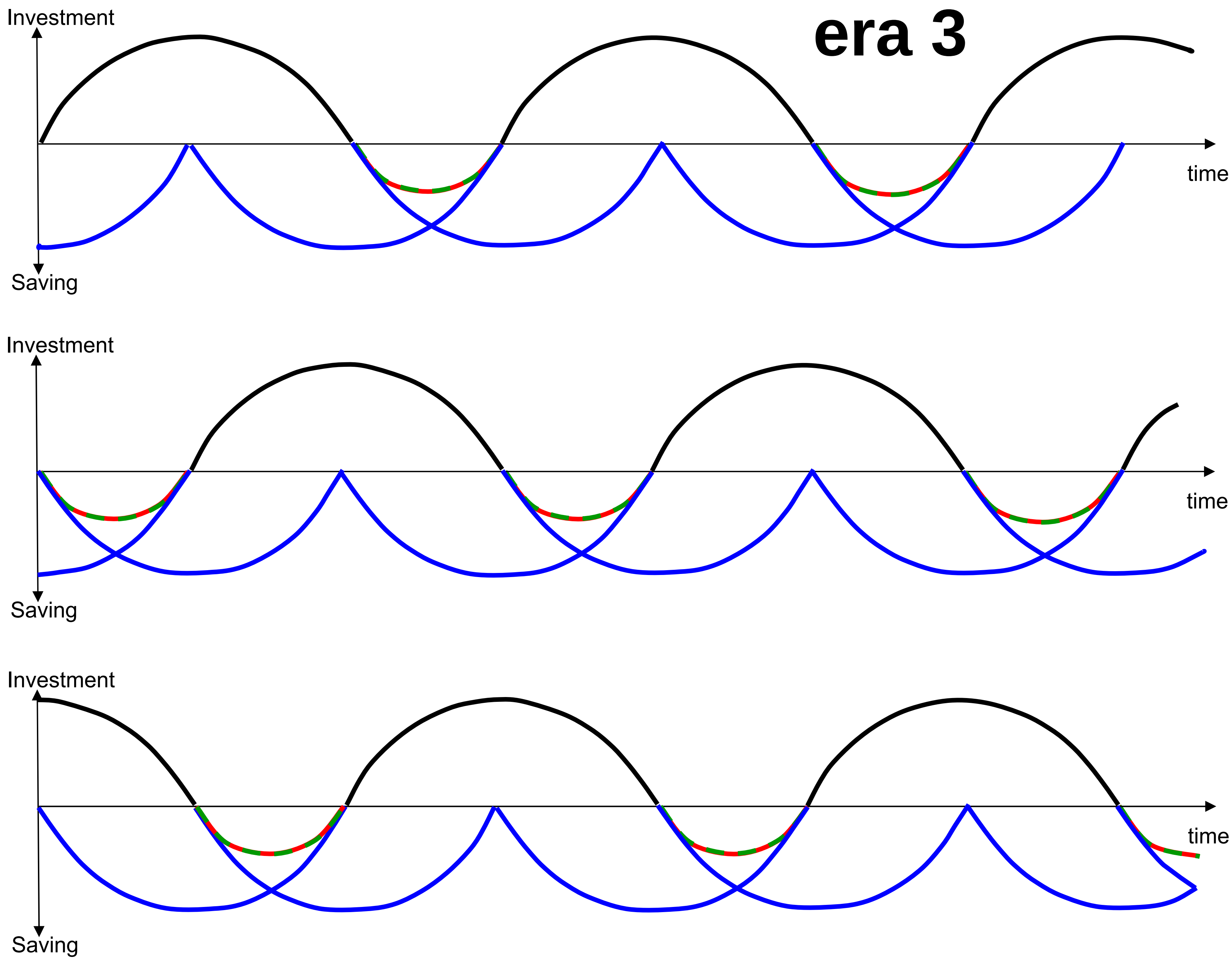
era 3



between projects, agent holds illiquid (blue) paper of different vintages

⇒ great weight on paper markets

era 3


Investment
time
Saving
Investment
time
Saving
Investment
time
Saving

era 3 is a nice example of the power of Adam Smith's "invisible hand":

to create double-coincidences-of-wants in dated goods,

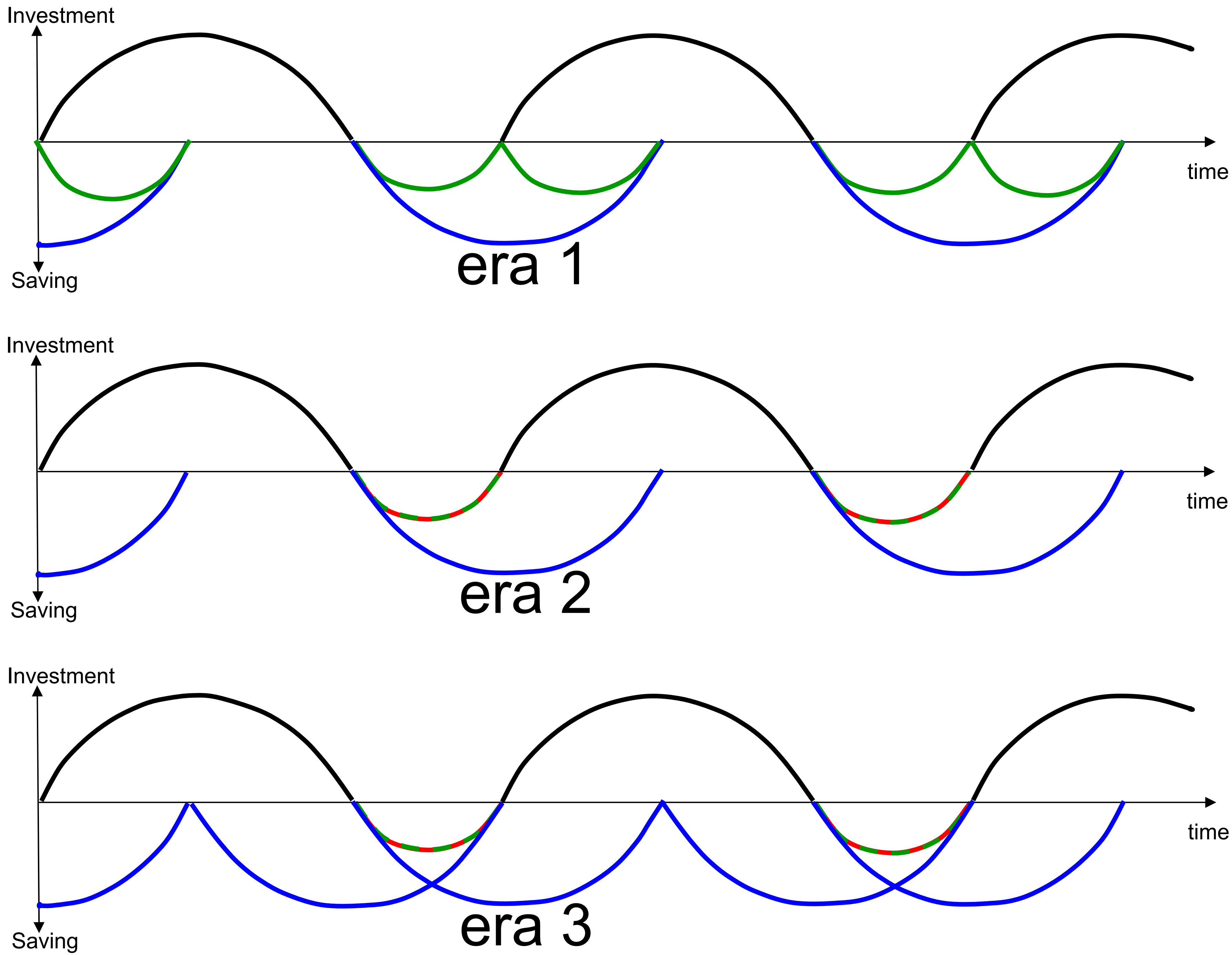
to wriggle round the inflexibility of illiquid paper era 3 is a nice example of the power of Adam Smith's "invisible hand":

to create double-coincidences-of-wants in dated goods,

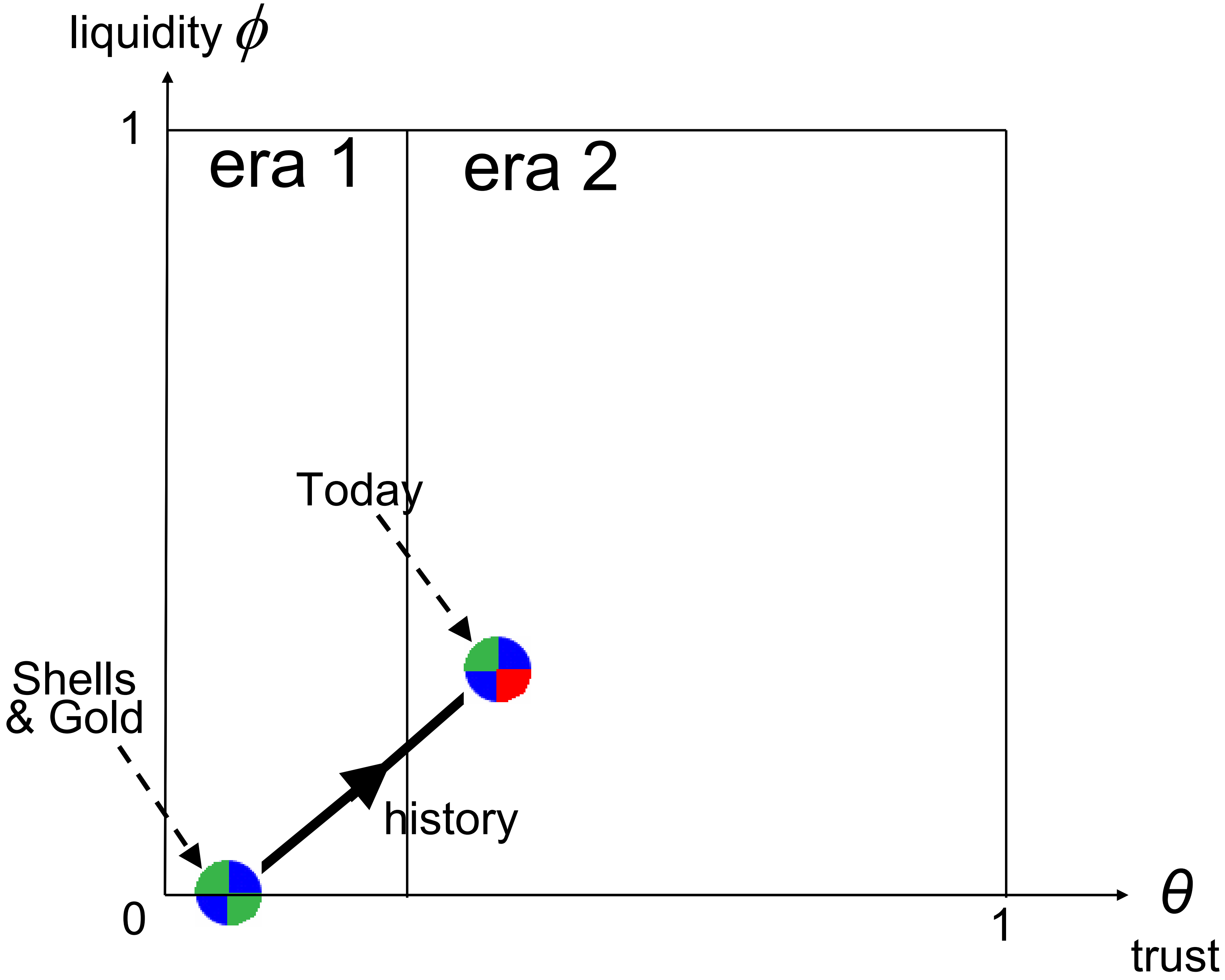
to wriggle round the inflexibility of illiquid paper

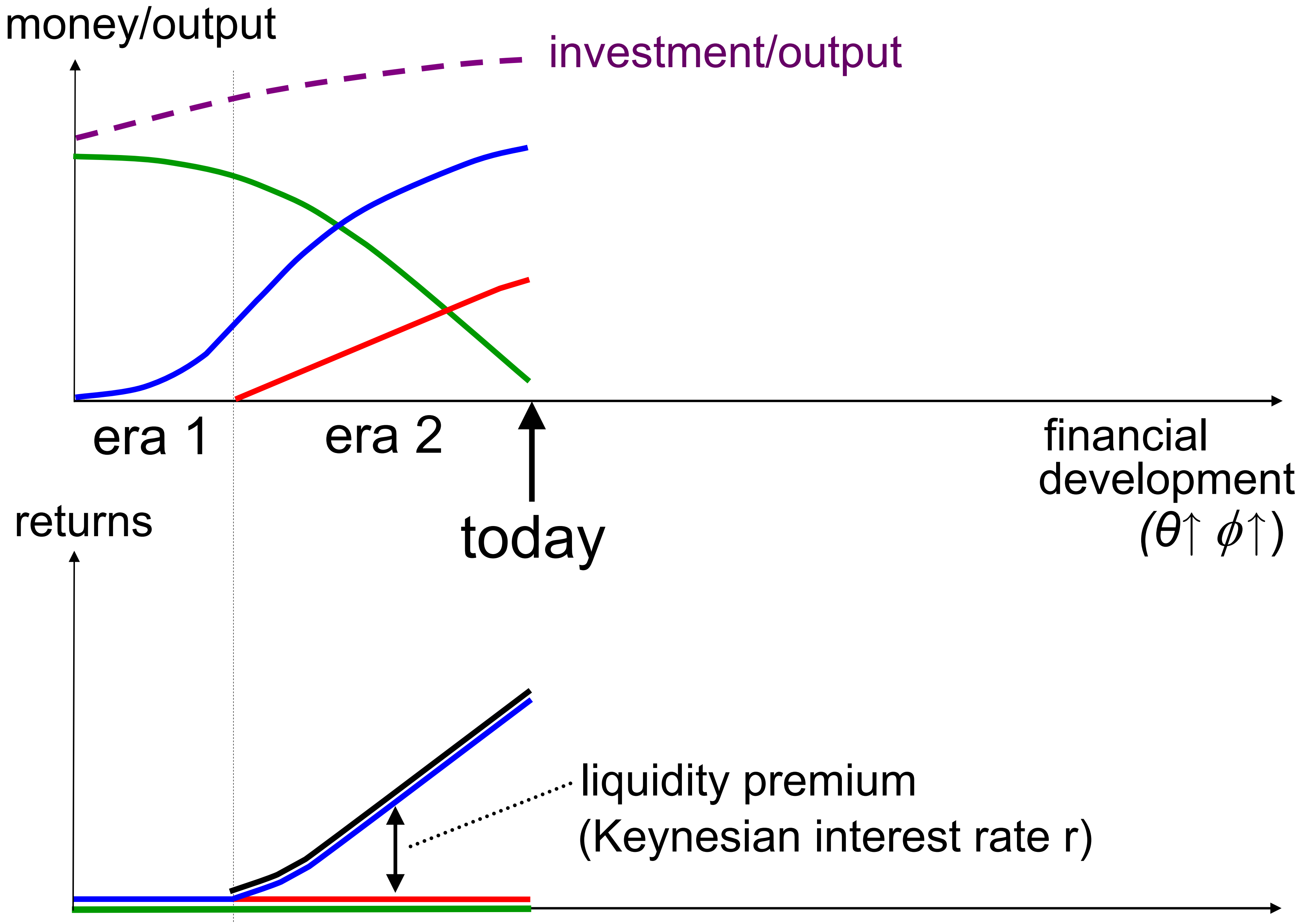
indeed, with enough trust (θ close to 1), first-best is achieved

(in the limit $\theta = 1$, Arrow-Debreu) overview of the 3 eras:

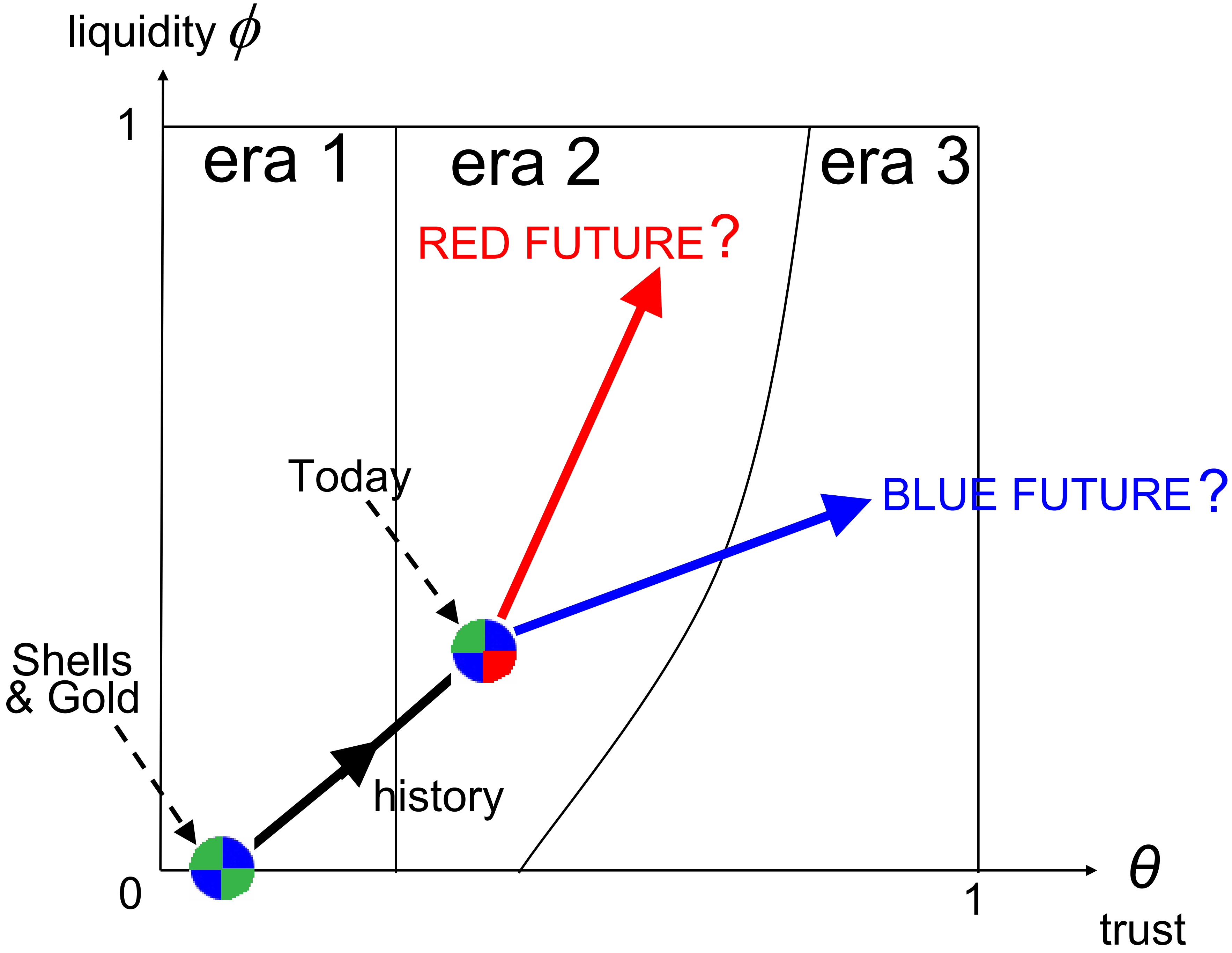

Investment
time
Saving
era 1
Investment
time
Saving
era 2
Investment
time
Saving
era 3

recall the history of money:

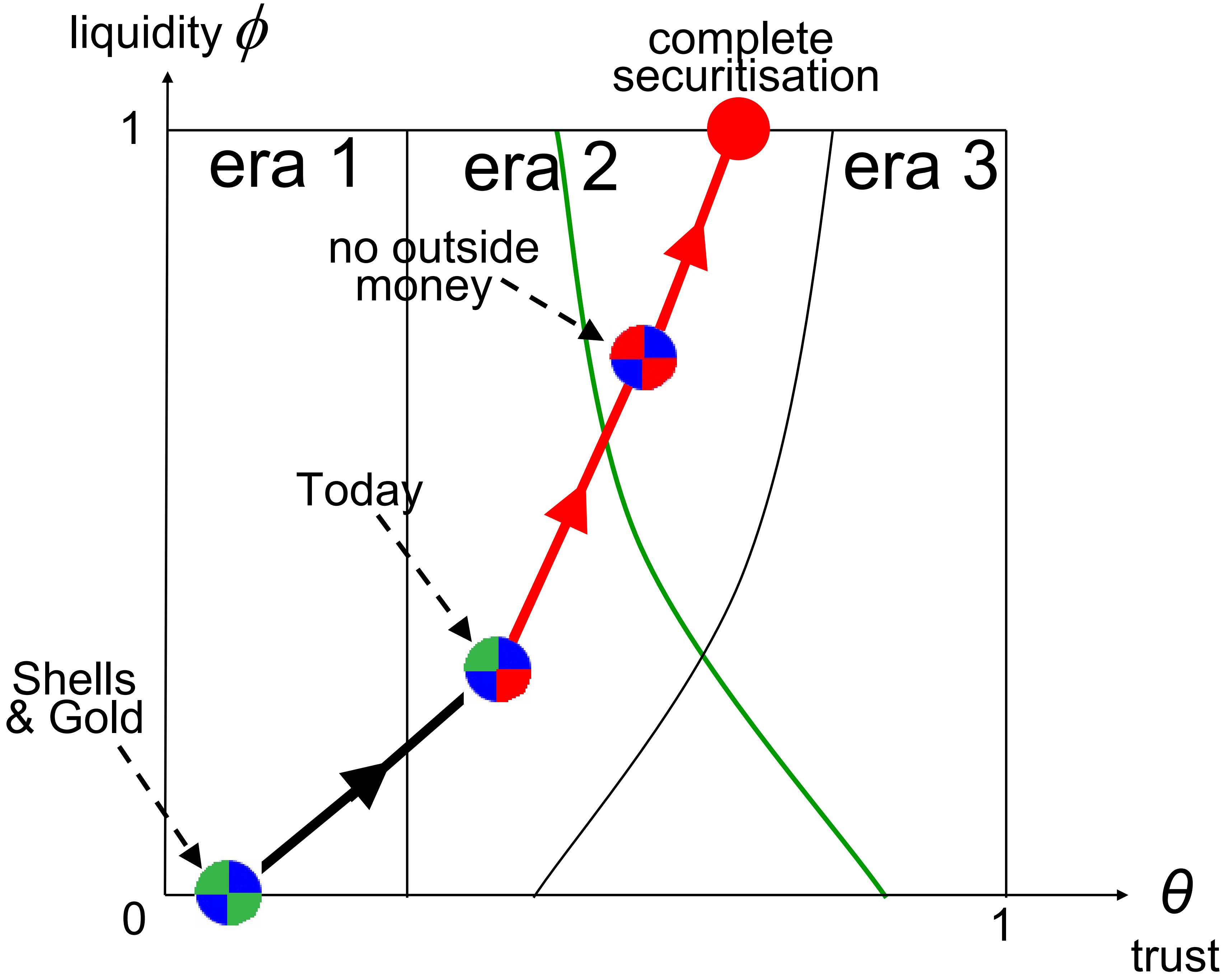

liquidity ϕ
1
era 1
era 2
Today
Shells
& Gold
history
0
1
θ
trust


money/output
investment/output
era 1
era 2
today
financial
development
(θ↑ ϕ↑)
returns
liquidity premium
(Keynesian interest rate r)

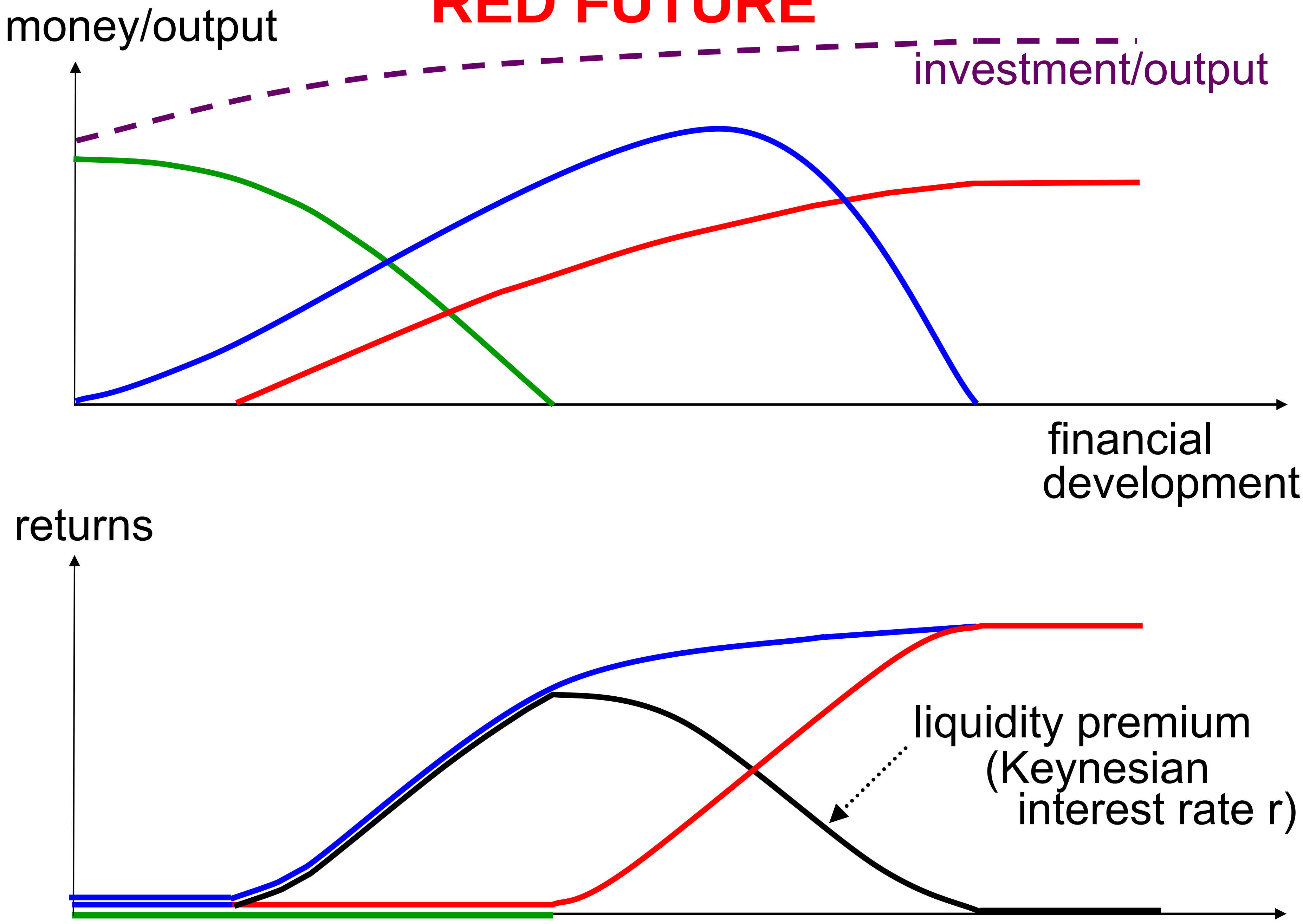
and now, the future:


liquidity ϕ
1
era 1
era 2
era 3
RED FUTURE?
Today
BLUE FUTURE?
Shells
& Gold
history
0
1
θ
trust

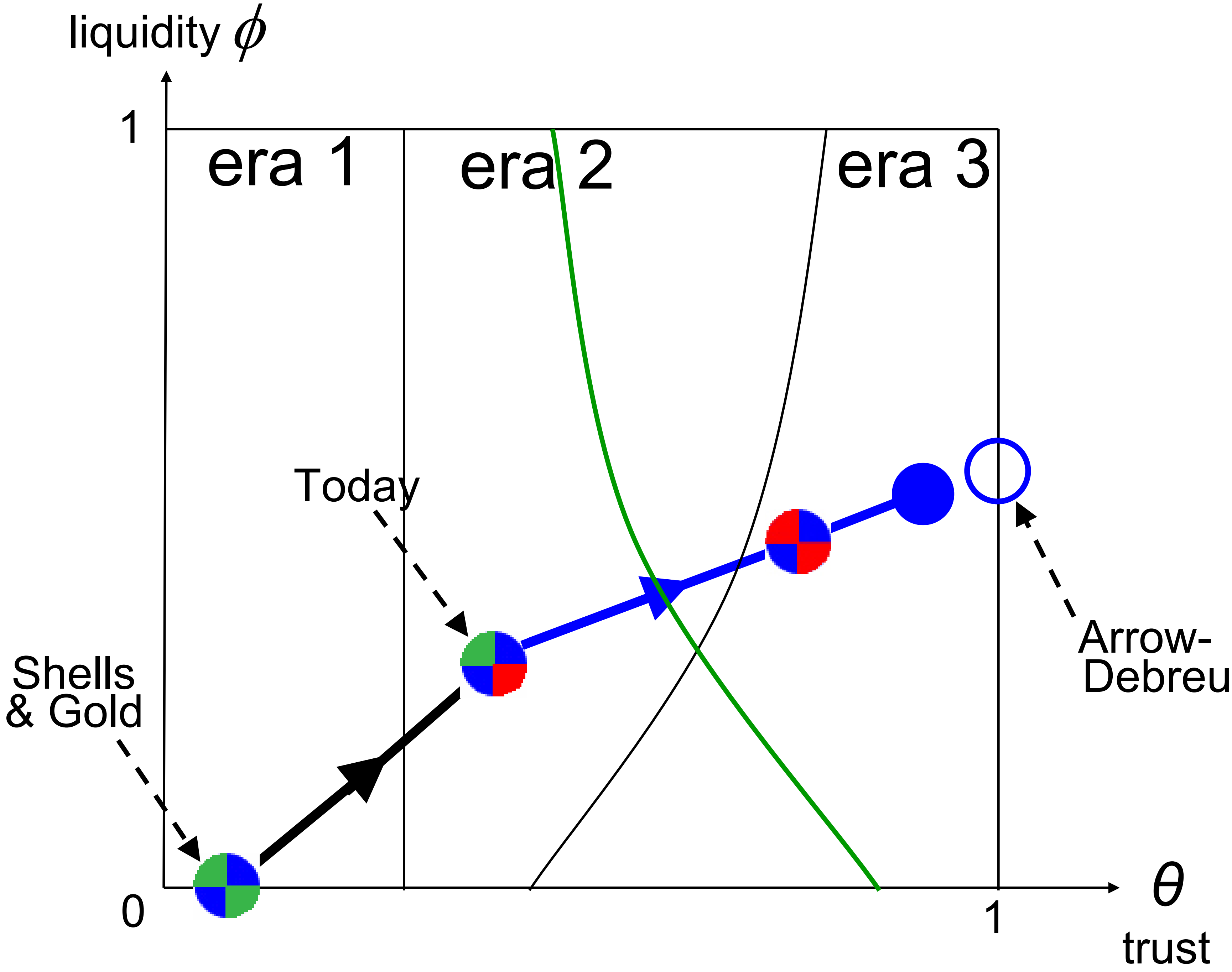
the RED FUTURE:

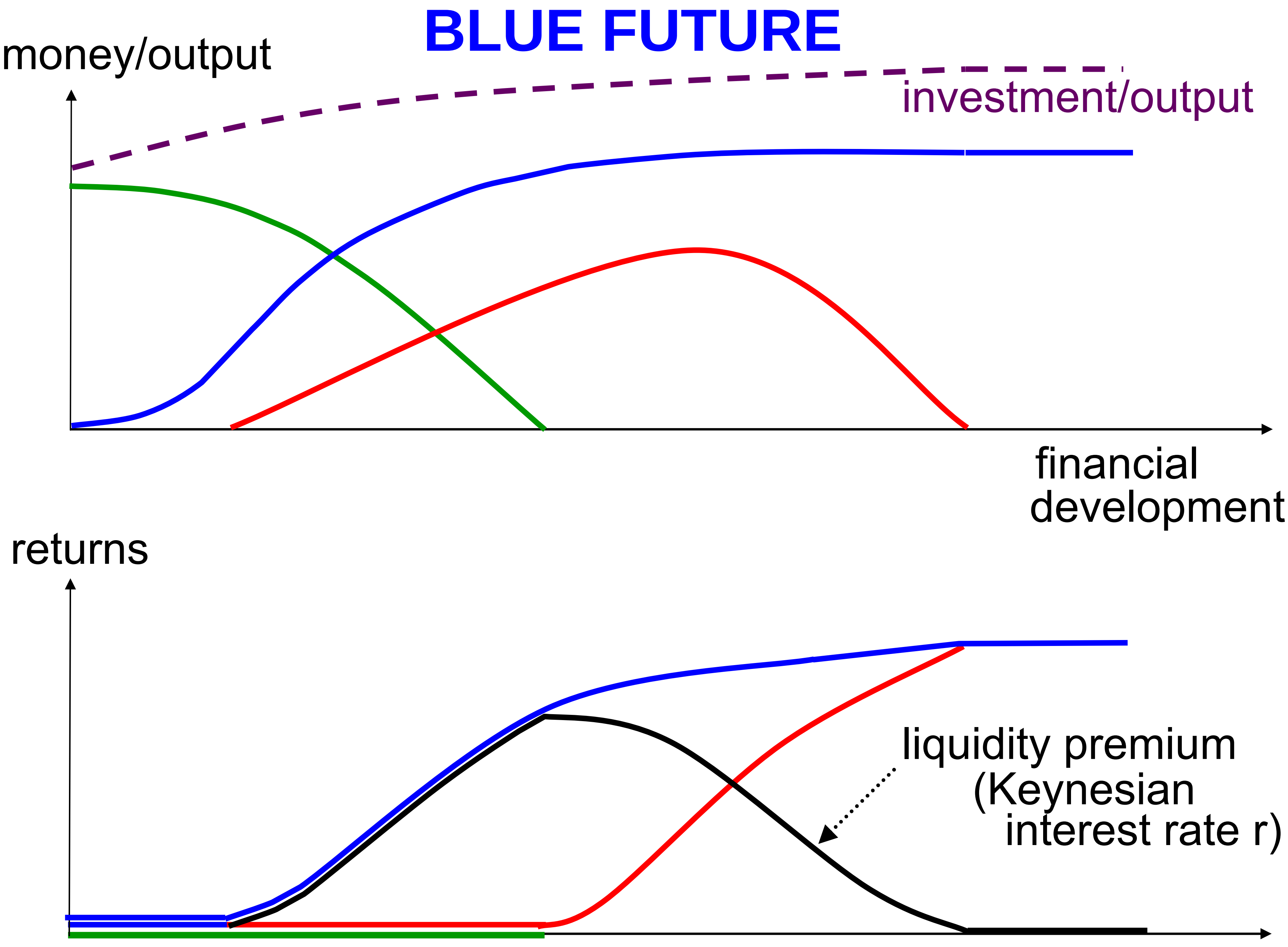

liquidity ϕ
complete securitisation
1
era 1
era 2
era 3
no outside money
Today
Shells & Gold
0
θ
1
trust

RED FUTURE


money/output
investment/output
financial
development
returns
liquidity premium
(Keynesian
interest rate r)

the BLUE FUTURE:


liquidity ϕ
1
era 1
era 2
era 3
Today
Shells & Gold
Arrow-Debreu
0
1
θ
trust


BLUE FUTURE
money/output
investment/output
financial
development
returns
liquidity premium
(Keynesian
interest rate r)