

Climate change mitigation: a key component of global risk management

Klaus Hasselmann
Max-Planck-Institut for Meteorology, Hamburg,
and
Global Climate Forum

25 years anniversary celebration
Nansen Center, 18 Nov 2011



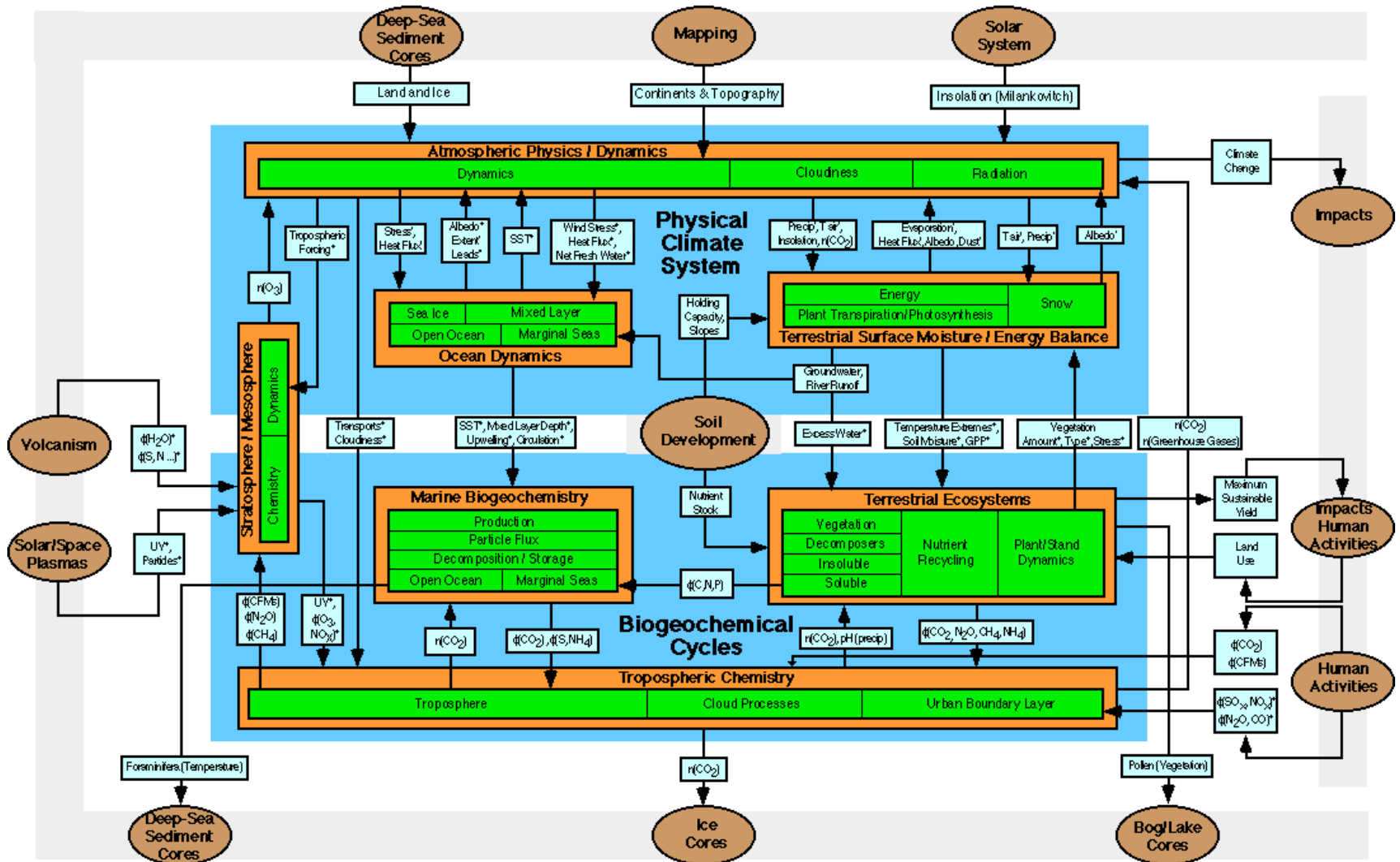
25 YEARS COLLOQUIUM, 18TH NOVEMBER
2011

25 years
in science
1986 - 2011



The Bretherton Earth System Diagram

CONCEPTUAL MODEL of Earth System process operating on timescales of decades to centuries



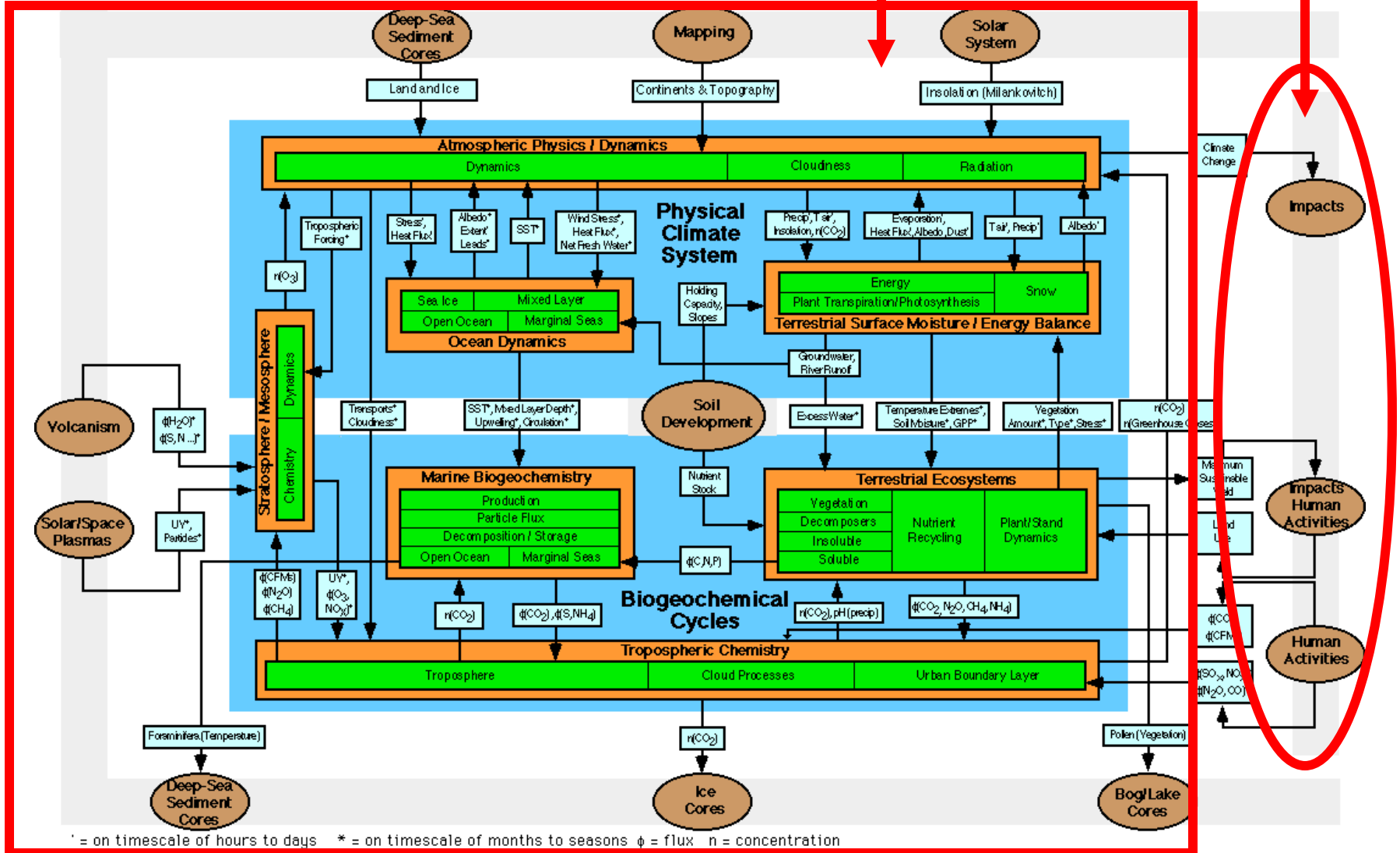
The Bretherton Earth System Diagram

Traditional view of climate scientists

Natural system

Human system

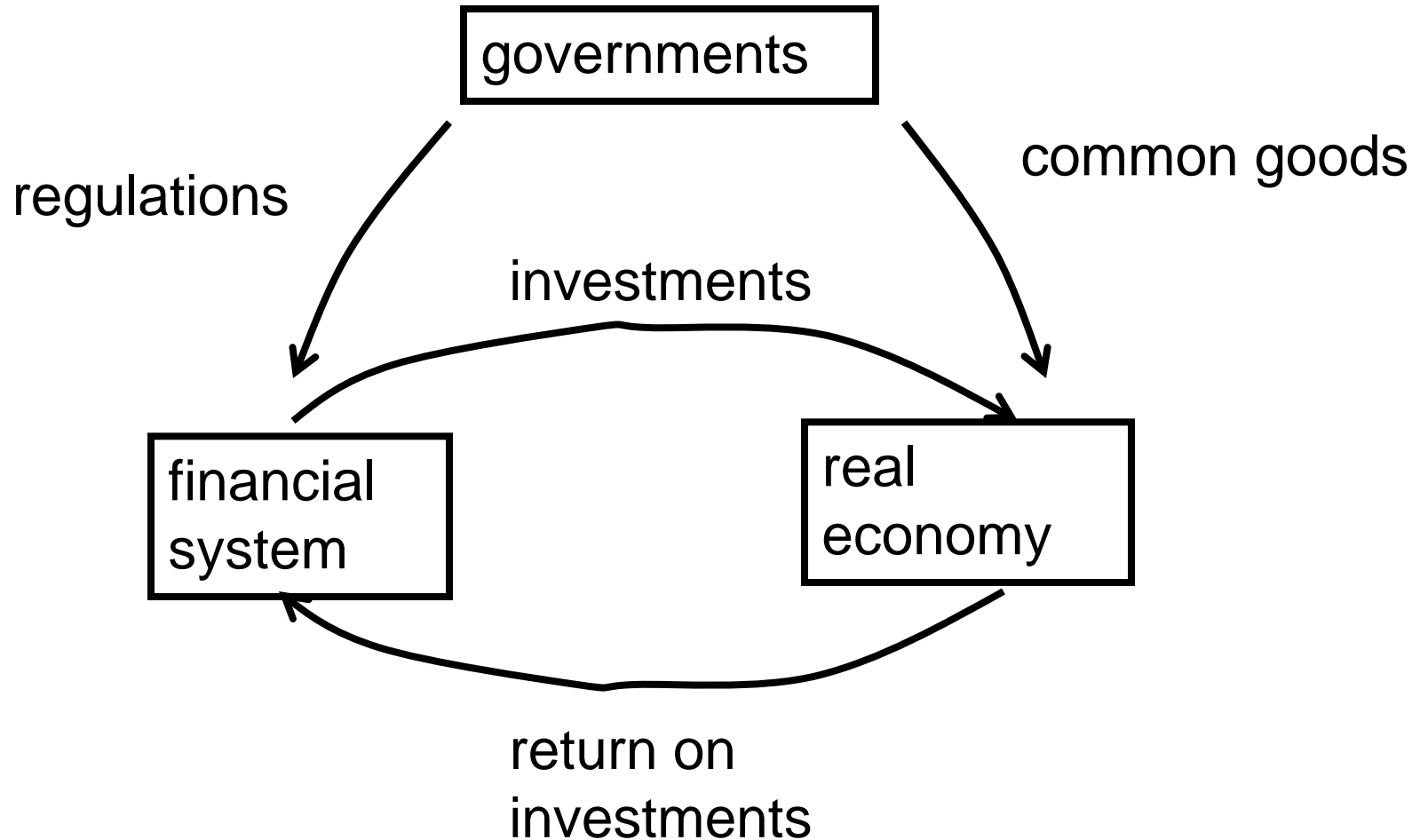
CONCEPTUAL MODEL of Earth System process operating on timescales of decades to centuries



ϕ = on timescale of hours to days * = on timescale of months to seasons ϕ = flux n = concentration

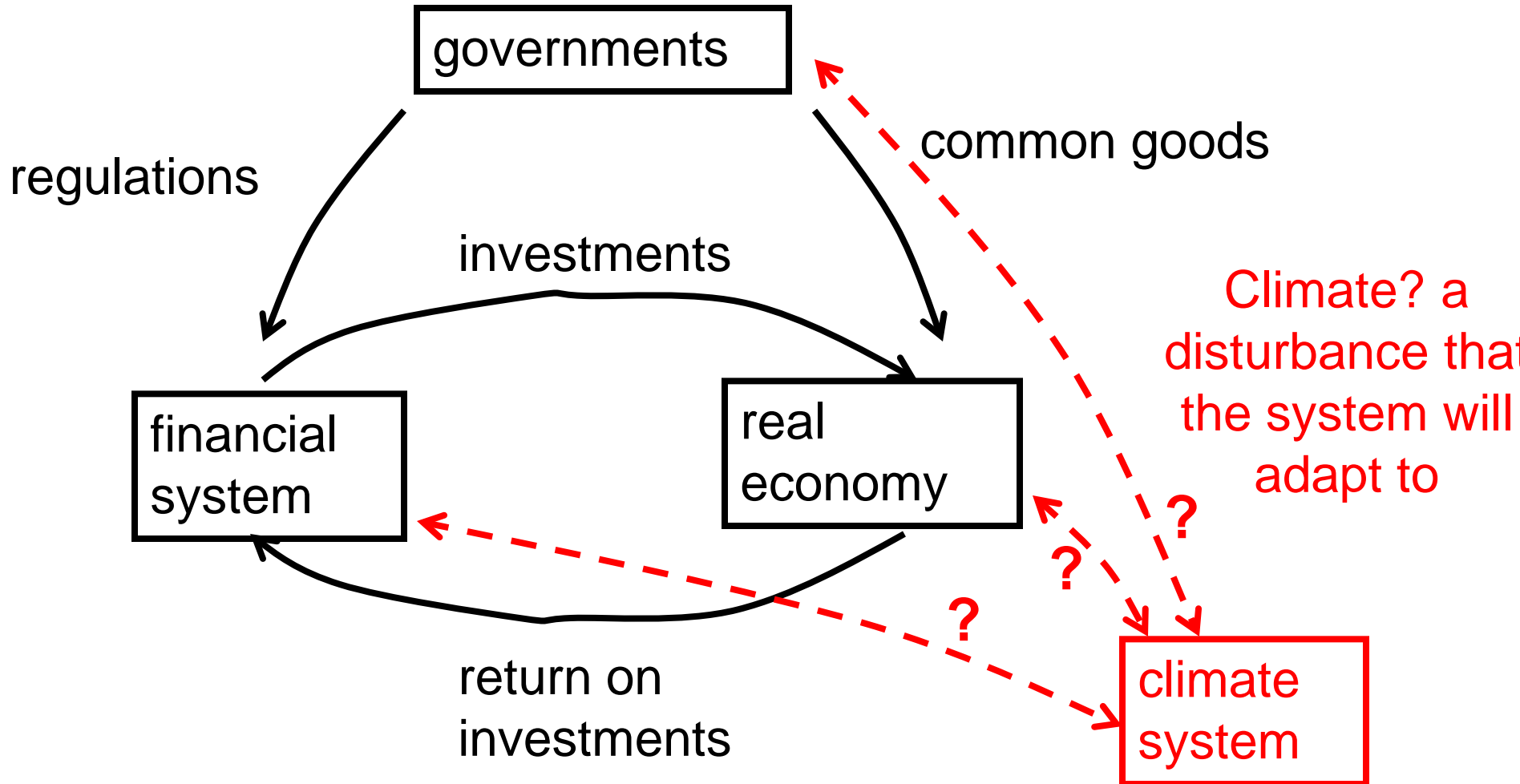
The economist's traditional view
of the earth system:

The market stabilizes and optimizes



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Attempts to connect the climate scientist's and economist's view of the Earth System

1. IPCC

WG 1 (science) very successful,
WG 2 (adaptation) & WG 3 (mitigation)
very diffuse, little impact

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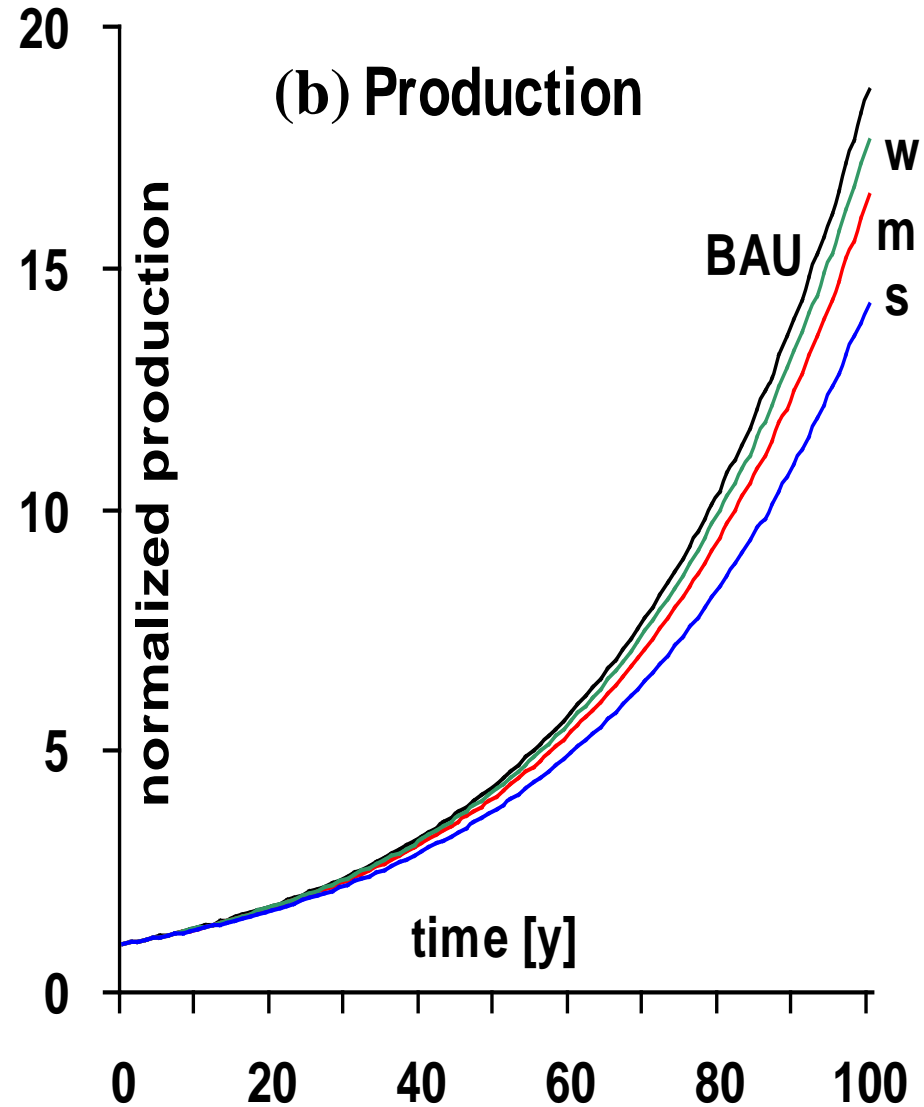
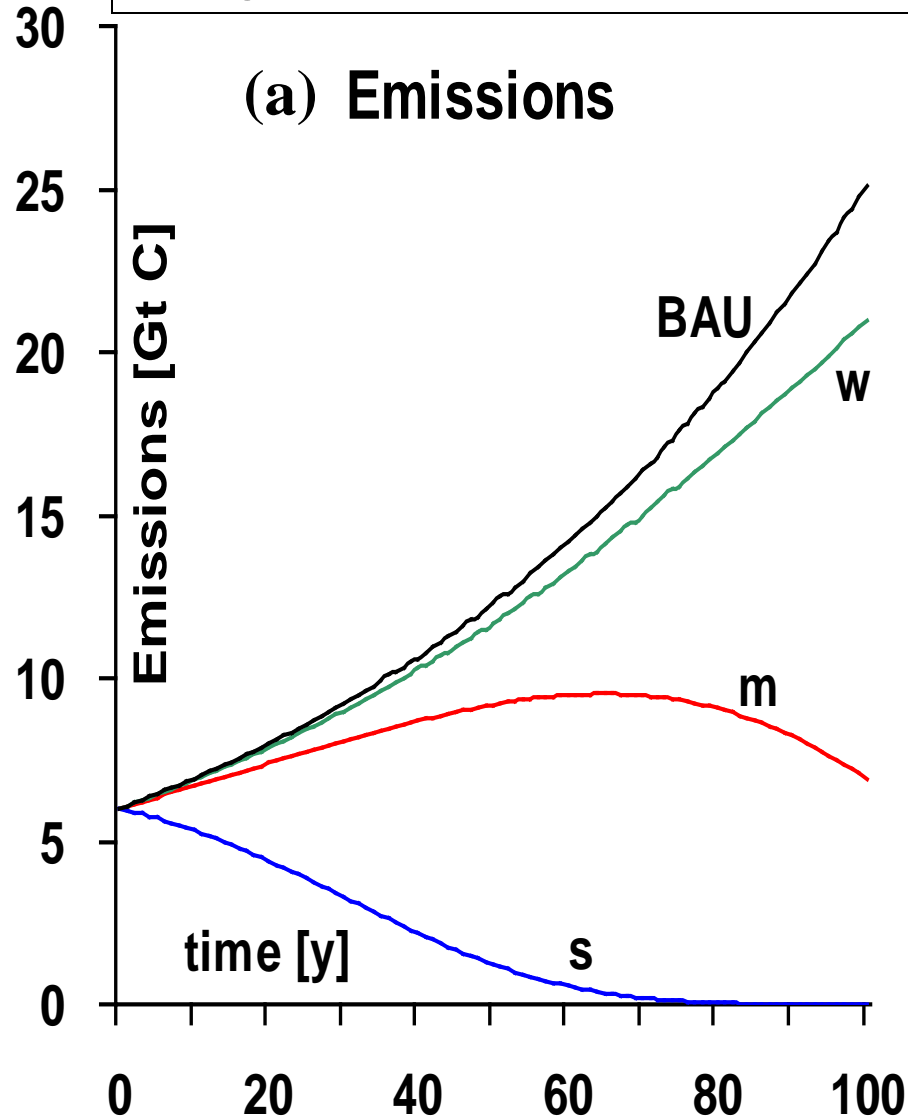
WG 1 (science) very successful,
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2. Stern review 2007

strong public and political impact, as clear
statement on economics of climate change
(although controversial among economists)

Stern supported earlier estimates of mitigation costs
(e.g. MADIAM model, Weber et al, Ecol. Econ. 2005)

mitigation measures: w: weak, m: moderate, s: strong



Estimates of the costs of climate change mitigation:

~ 1 % of GDP

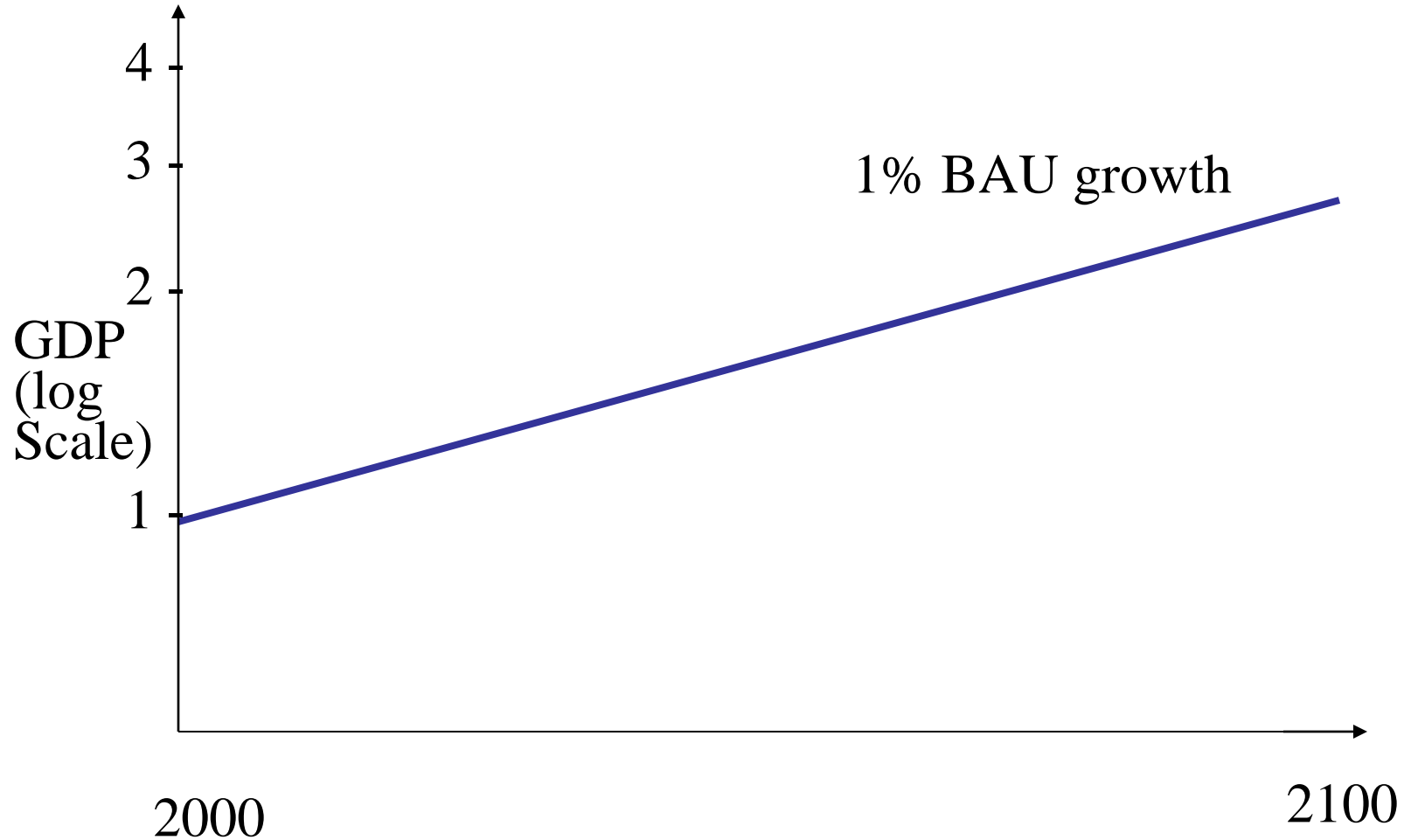
Consistent with:

- IPCC 4th Assessment Report, 2007
- macro-economic model intercomparison,
The Energy Journal, Special Issue, 2006

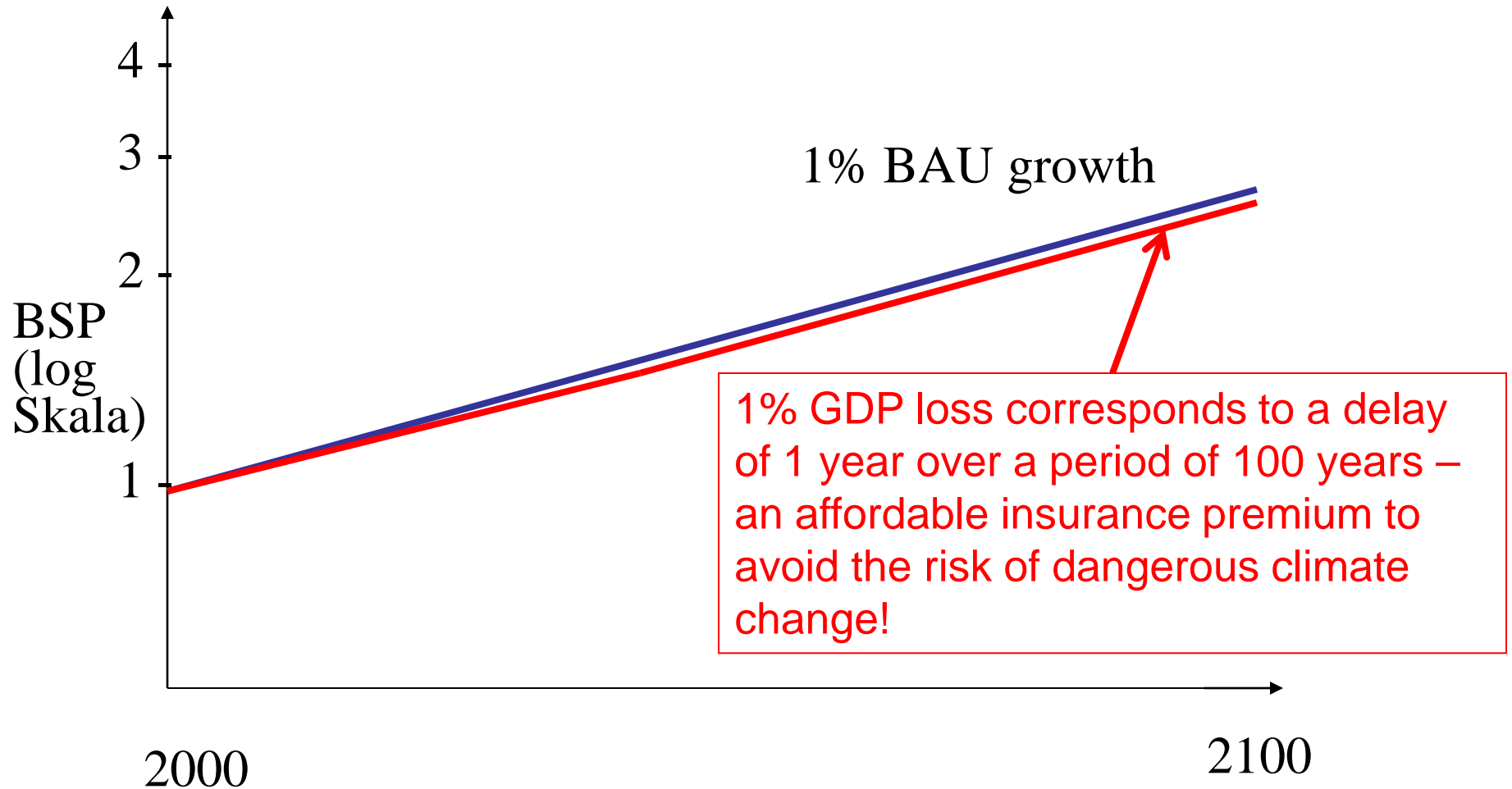
Range of other estimates:

-1 % to + 4% of GDP

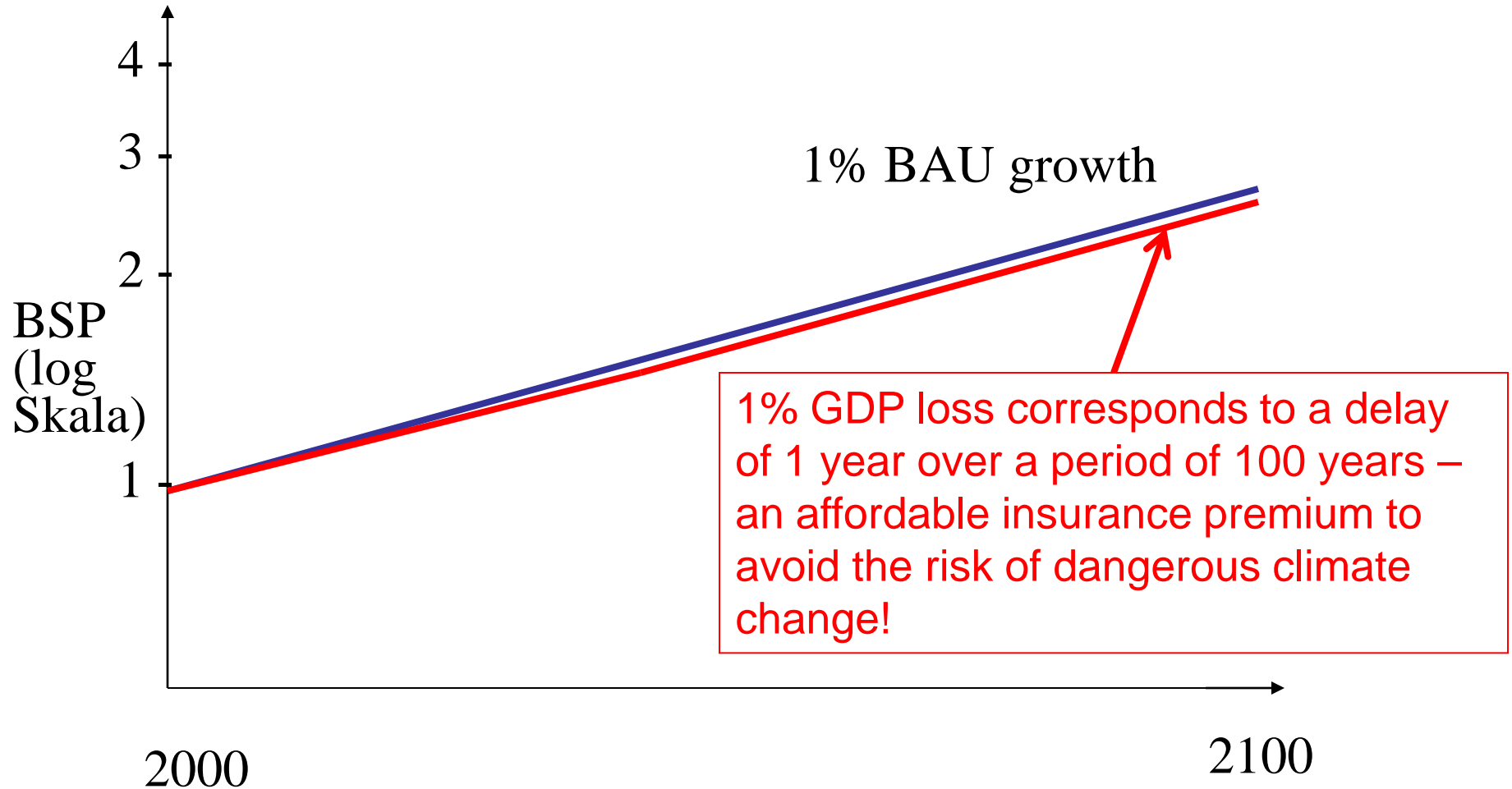
Is climate change mitigation affordable?



Is climate change mitigation affordable?



Is climate change mitigation affordable?



Comment last year: “GDP loss” relative to BAU is wrong measure anyway. BAU GDP doesn’t grow but decreases. Mitigation **increases** VDP (Value of Domestic Product).

Stern review plus statements by Barack Obama and many other national leaders

→ high expectations in Dec 2009
Copenhagen UNFCCC Climate Conference

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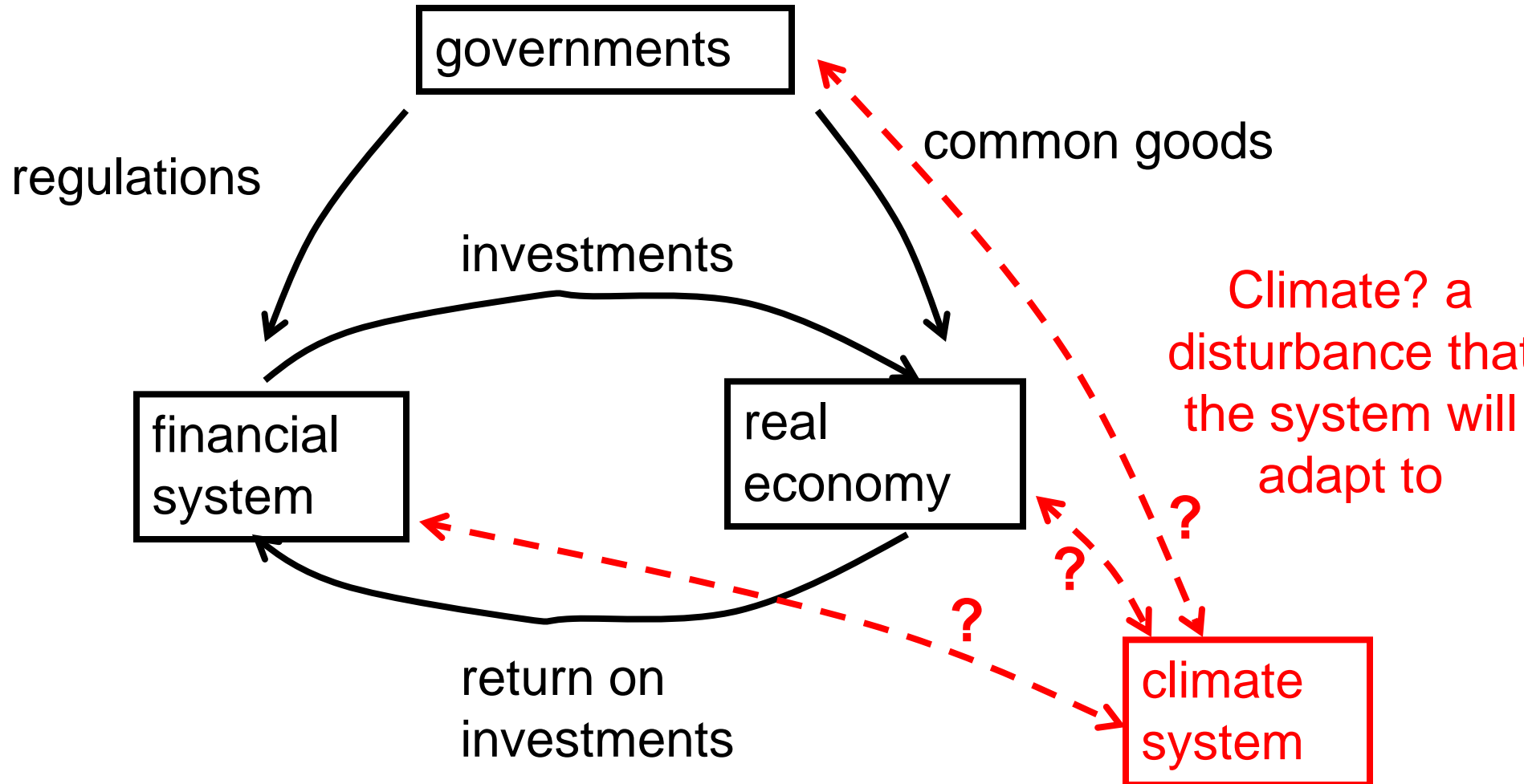
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Global financial crisis 2008 followed by continuing problems in US and Europe (national debt levels, threat of sovereign insolvencies, rising unemployment, ...)

→ collapse of Copenhagen hopes and removal of the climate issue from political agenda

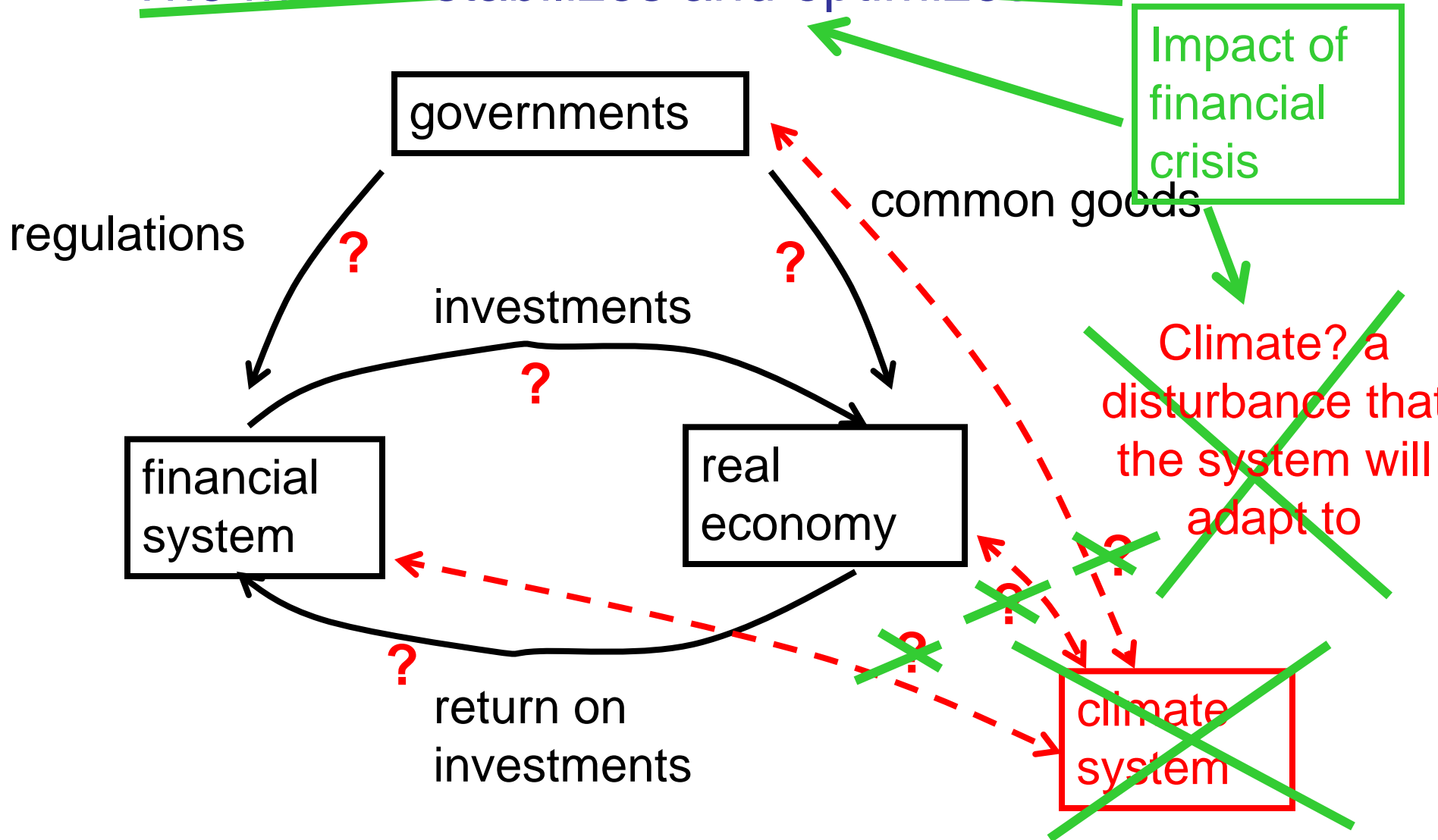
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General agreement following the crash:

The economy needs government stimulated investments to recover (Keynes prescription)

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The economy needs government stimulated investments to recover (Keynes prescription)

But: climate scientists' call for investments in renewables and energy efficiency are not heeded

- as economists paralyzed by inability to stabilize the financial market

How can scientists help overcome this impasse?

Needed: *simple* models of the coupled climate-economic-financial system that highlight the basic interactions, and that everybody can understand.

Example: C-ROADS model of climate system
(John Sterman project, MIT)

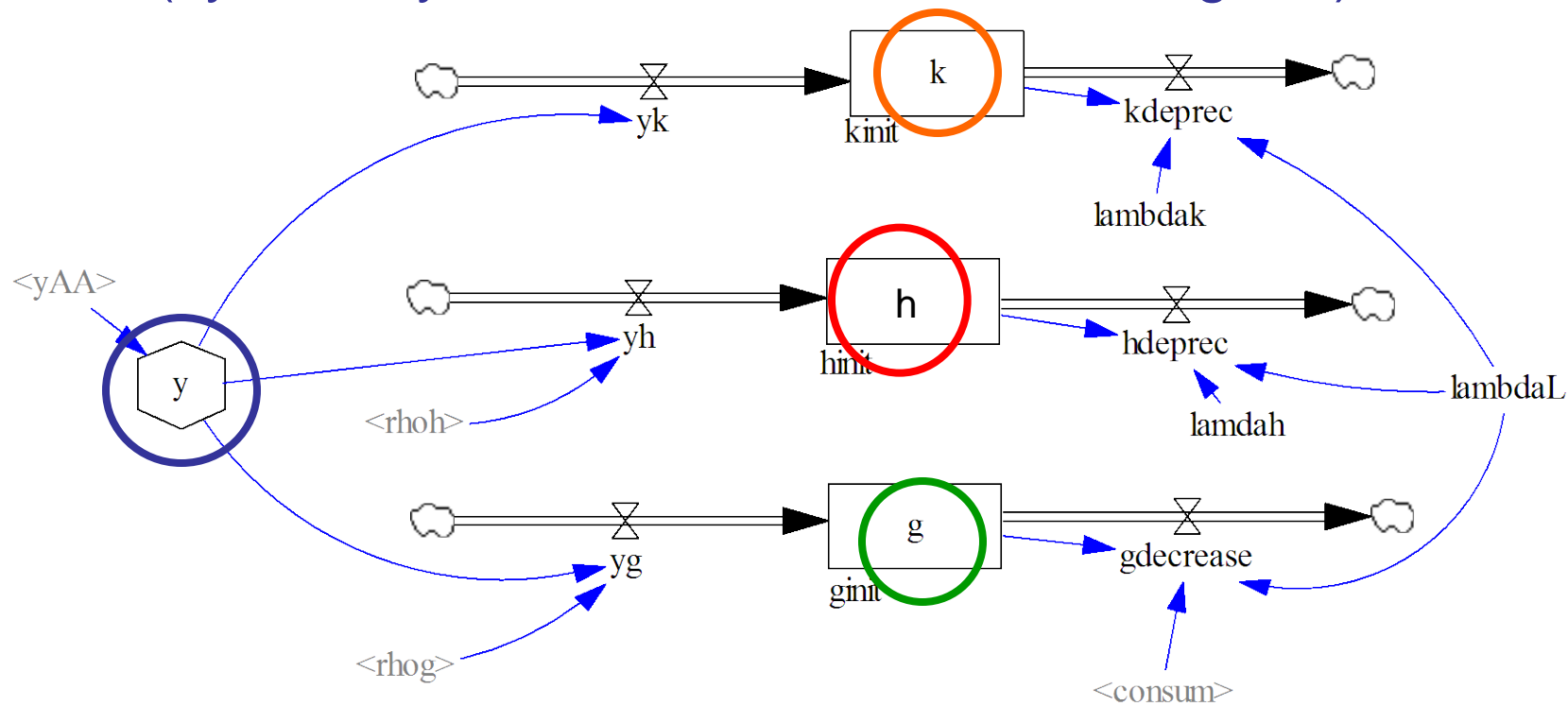
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This needs to be augmented by similar models of the economic-financial system.

A start: MADIAMS (Multi-Actor Dynamic Integrated Assessment Model System)

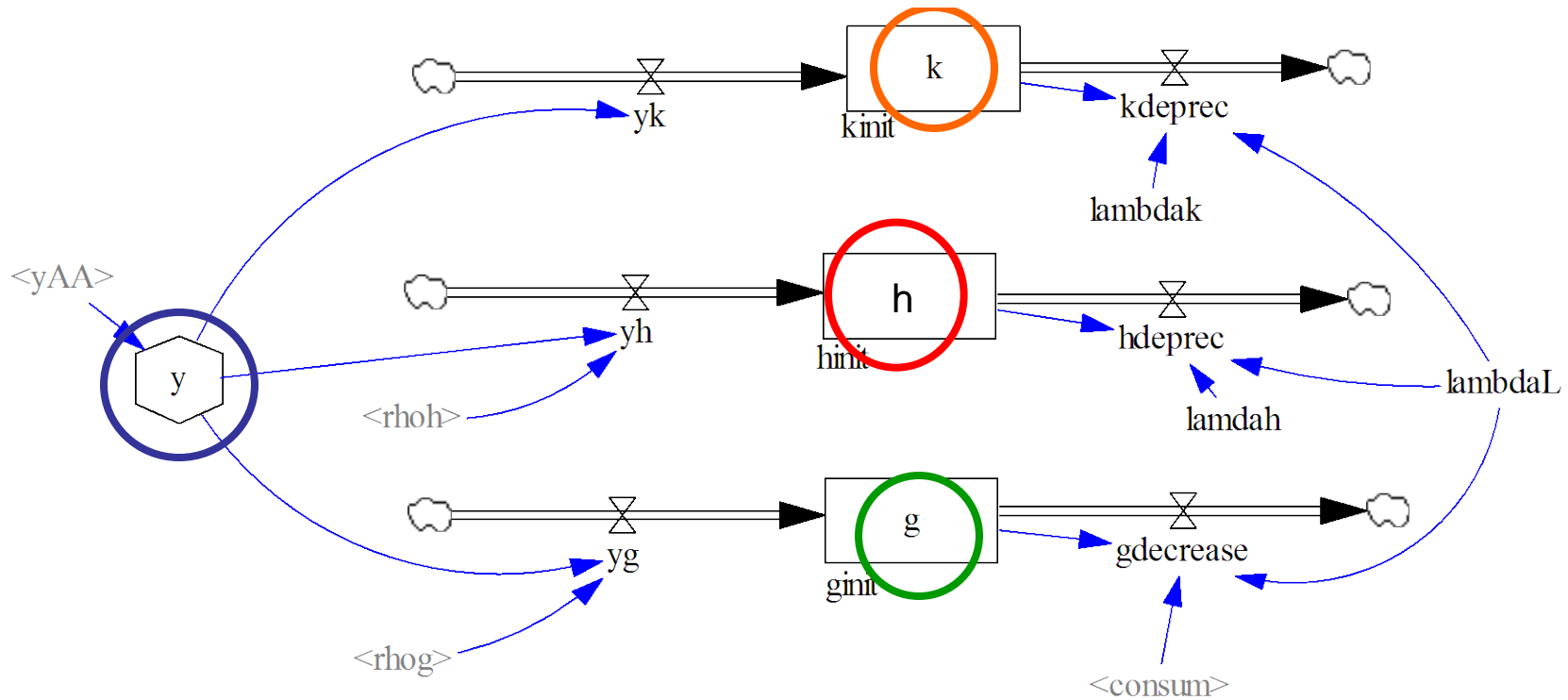
MADIAM model of the “real economy”: production flows in physical units (system dynamics stocks and flows diagram)



y : total production , invested in:
 k : physical capital
 h : human capital
 g : consumer goods and services

growth governed by
distribution of production
between these three
investment streams

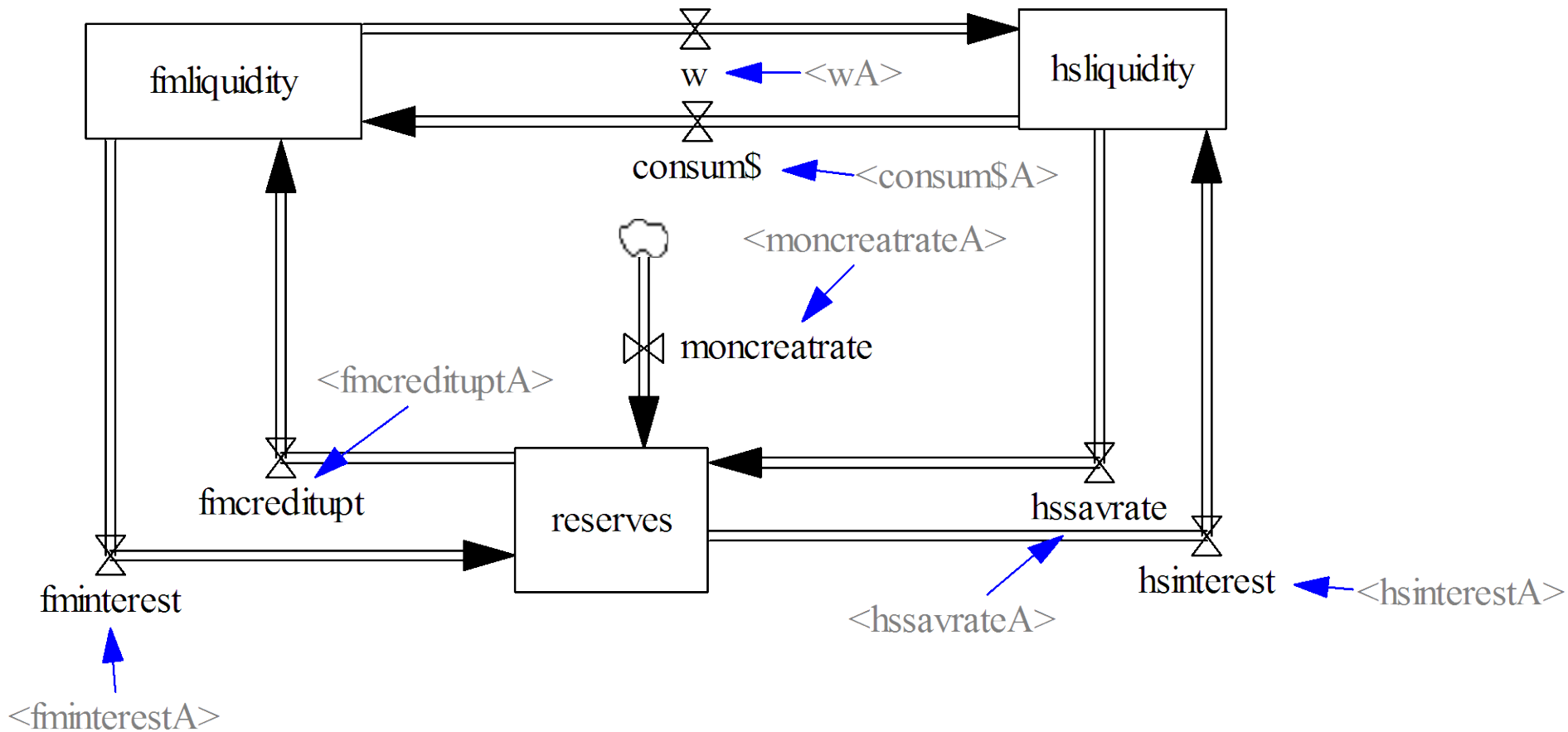
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Not shown: 1) subdivision of k and h into carbon-based and renewable economy. 2) Role of actors: investors, banks, consumers, governments

The “virtual economy” (financial system): money circulation between firms, banks and households



Basic approach: the dynamics of the coupled climate-economic-financial system is governed by the goals and strategies of a number of key actors (investors, consumers, voters, governments, media, ...)

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Thus: the ***key model ingredient is the specification of the actor strategies*** - the rest follows from straightforward conservation laws (stocks and flows diagrams)

Efficient market paradigm

The market automatically adjusts to an optimal equilibrium state governed by Adam Smith's benevolent "invisible hand". Individual actor strategies are irrelevant, the market prescribes actor behaviour.

Governments distort markets,
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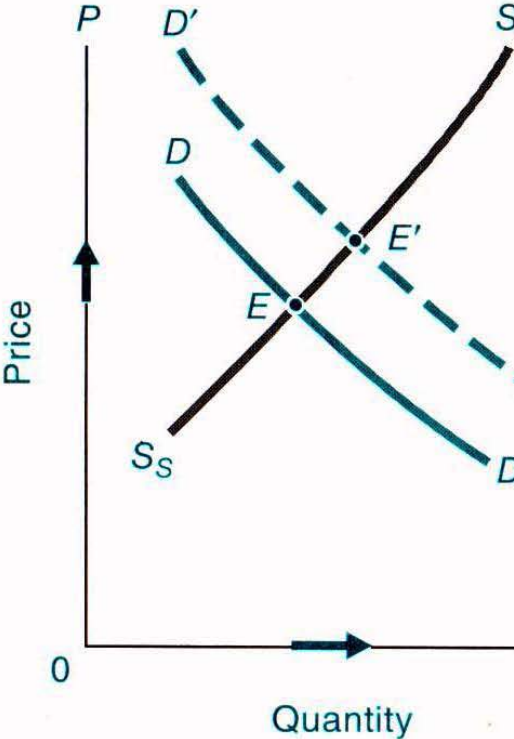
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Actor-based view of markets

The market is dominated by actor behaviour. This is highly variable, depending on feedbacks between actor perceptions – producing business cycles, boom and bust events, financial crises and other large-scale instabilities.

Governments are essential to stabilize the system

Textbook view of equilibrium in supply, demand and price (e.g. Samuelson and Nordhaus)



System dynamics representation of supply-demand-price interdependence

$$dS/dt = F(S, D, P) \quad (S = \text{supply})$$

$$dD/dt = G(S, D, P) \quad (D = \text{demand})$$

$$dP/dt = H(S, D, P) \quad (P = \text{price})$$

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General result: A Lorenz system of three 1st-order differential equations can have solutions representing:

- a transition to a stable equilibrium point
- a stable convergence to a periodic limit cycle
- an unstable trajectory diverging to infinity
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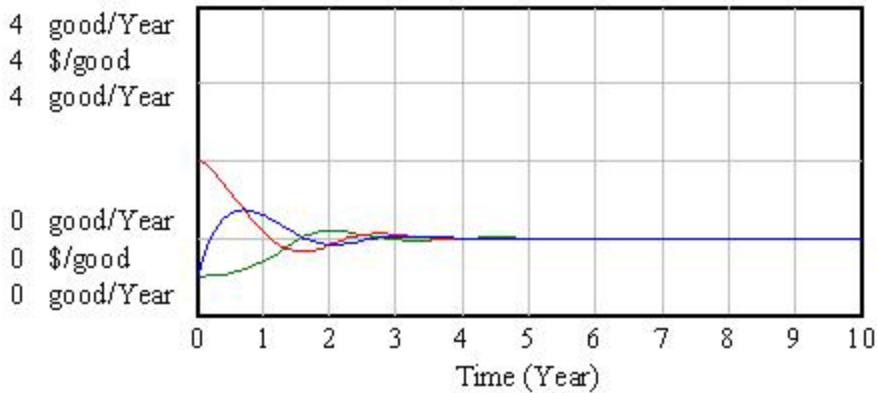
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Which type of solution is realized depends on the initial conditions and the ***behaviour of the economic actors***

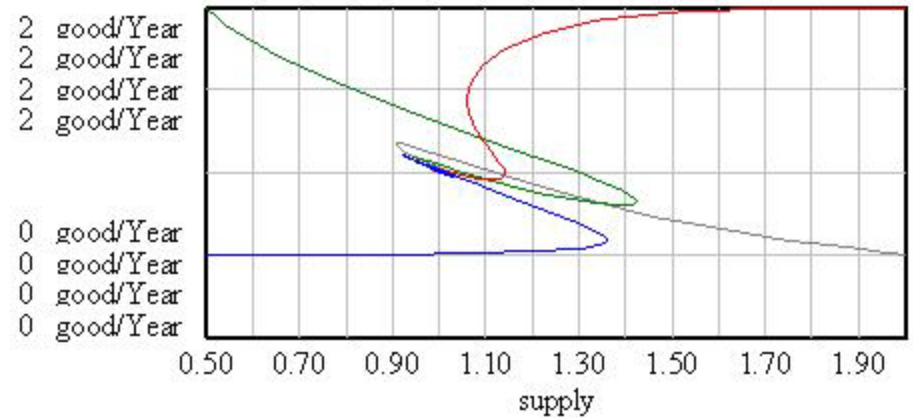
(supply, price, demand) - time



supply ————— good/Year
 price ————— \$/good
 demand ————— good/Year

(a)

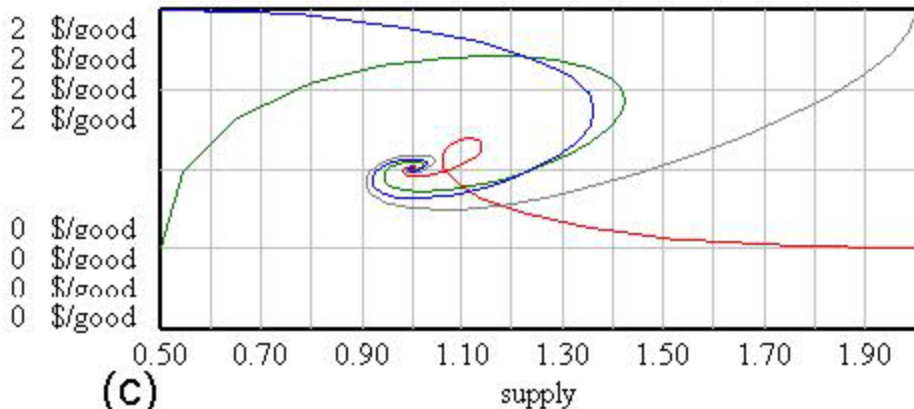
supply-demand



demand : Talk 1 M7 ————— good/Year
 demand : Talk 2 M7 ————— good/Year
 demand : Talk 3 M7 ————— good/Year
 demand : Talk 4 M7 ————— good/Year

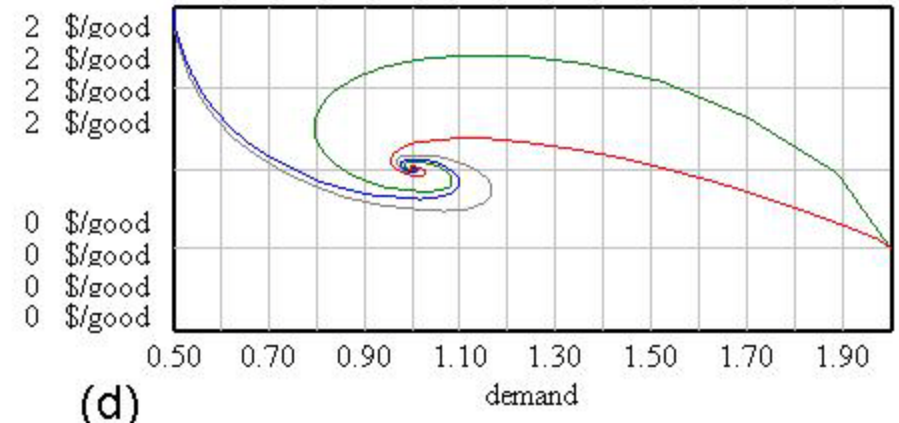
(b)

supply-price



(c)

demand-price

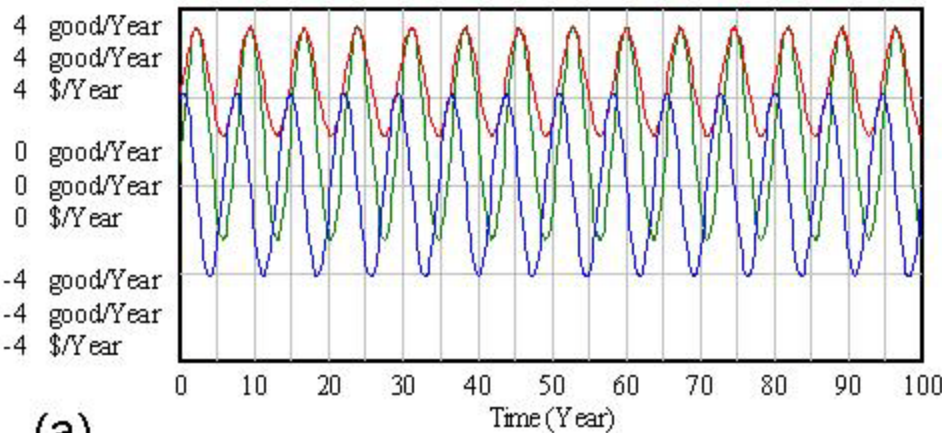


(d)

Example 1: Stable actor behavior assumed in the standard supply-demand diagram, yielding equilibrium in supply, demand & price.



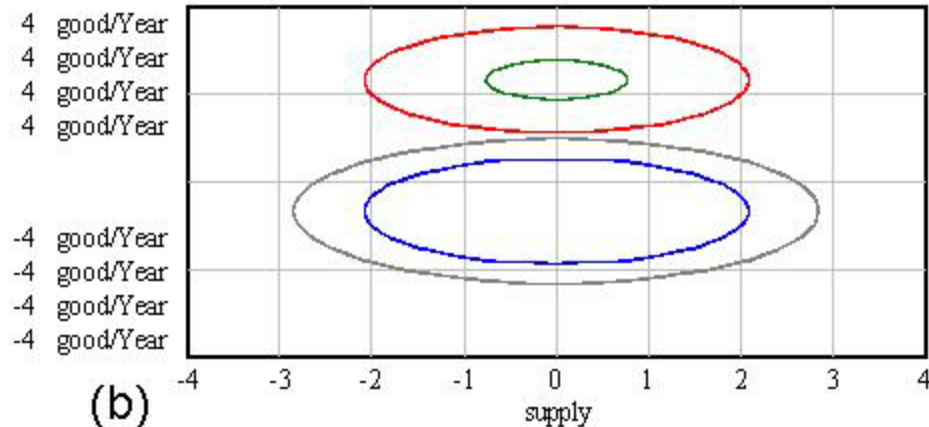
supply-demand-price



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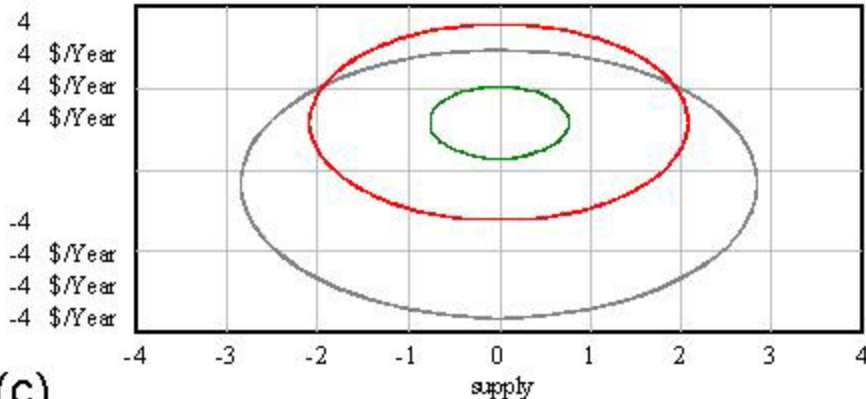
supply-demand



(b)

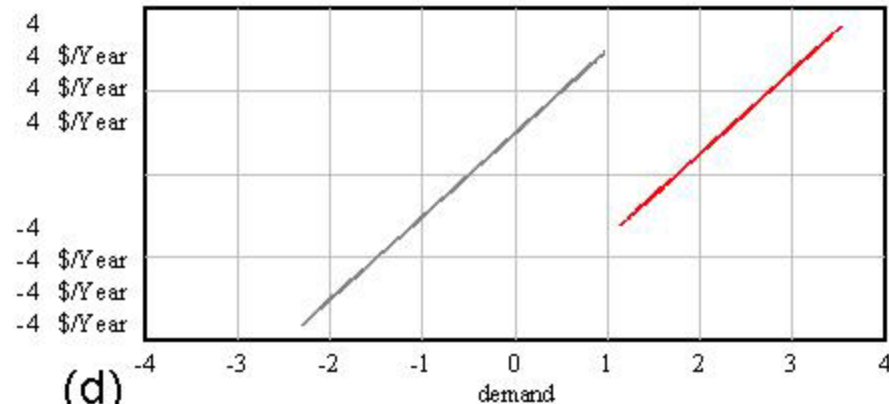


supply-price



(c)

demand-price

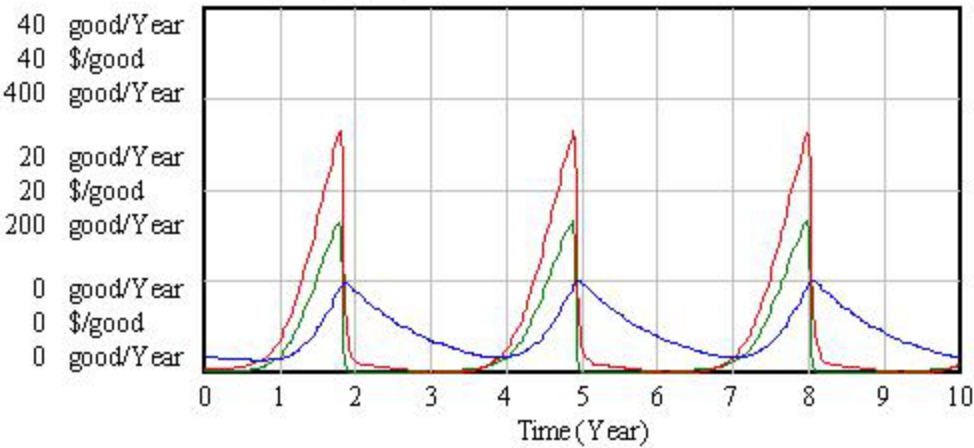


(d)

Example 2: low-confidence consumer-producer behavior leading to business cycles (see mental models of many classical economists).



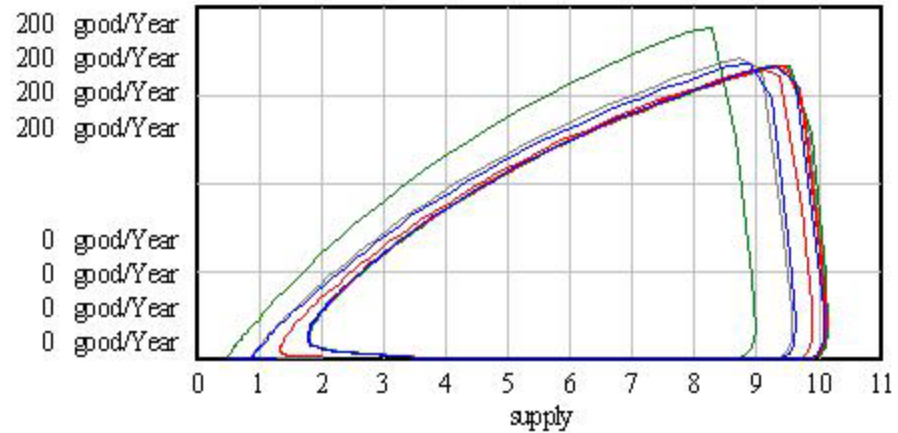
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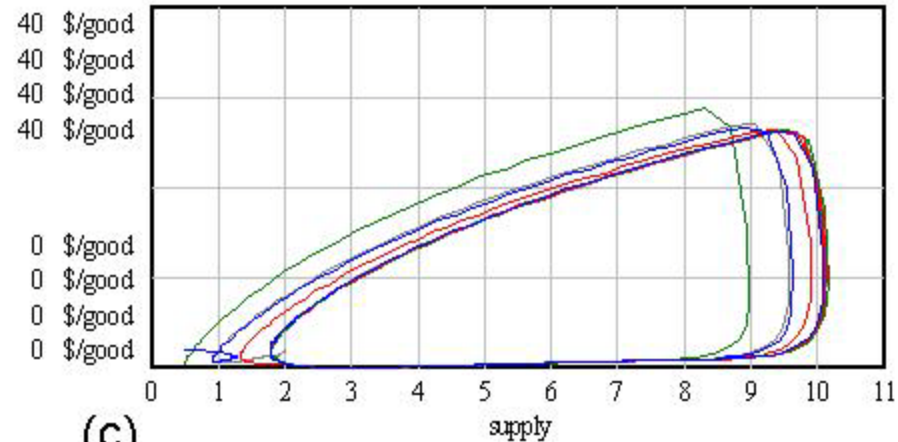
supply-demand



demand : bubb 1 ————— good/Year
 demand : bubb 2 ————— good/Year
 demand : bubb 3 ————— good/Year
 demand : bubb 4 ————— good/Year

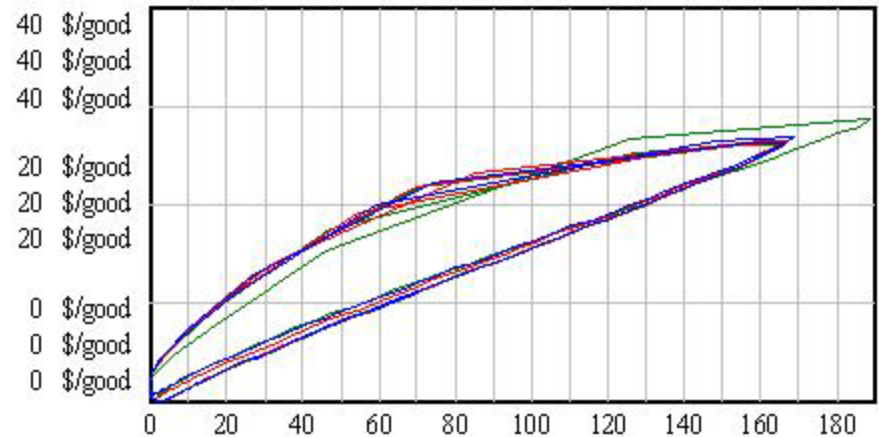
(b)

supply-price



(c)

demand-price



Example 3: Speculative demand and supply behavior in asset markets, leading to a boom-and-bust limit cycle (e.g. the dot.com bubble)



Compare with example 1; efficient market paradigm:

Example 1: Stable actor behavior assumed in the classical supply-demand diagram, yielding equilibrium in supply, demand & price.

↑ Price → ↓ Demand → ↓ Price = stabilizing feedback loop

In contrast, example 3, “herding”, producing bubbles:

Example 3: Speculative demand and supply behavior in asset markets, leading to a boom-and-bust limit cycle (e.g. the dot.com bubble)

↑ Price → ↑ Demand → ↑ Price = destabilizing feedback

How did these well known, normally “regional” instabilities escalate to global scales?

And, once globalized, what is their relevance for

“Climate change mitigation: a key component of global risk management”

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Escalation to global scales through:

- 1) technological advances (the internet, normalized container transport, open markets,...)
- 2) deregulation of financial markets (Reagan, Thatcher)
- 3) Major trading of new financial products that are claimed to enhance efficiency and distribute risk, but in fact enhance risk (hedge funds, credit-default-swaps and other derivatives [total 2008: ~ \$ 600 trillion !!!])

The transformation

fossil-based economy → sustainable low-carbon economy:

requires:

1) Major long-term investments with unavoidable uncertainties and attendant risks (long term roles of renewable energy: solar, wind, hydro, bio, geothermal etc.; future grid structures, hydrogen or electro-mobility, international energy inter-dependencies, etc).

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- 3) To achieve this: an understanding of the strategies of the actors governing the coupled financial-economic system

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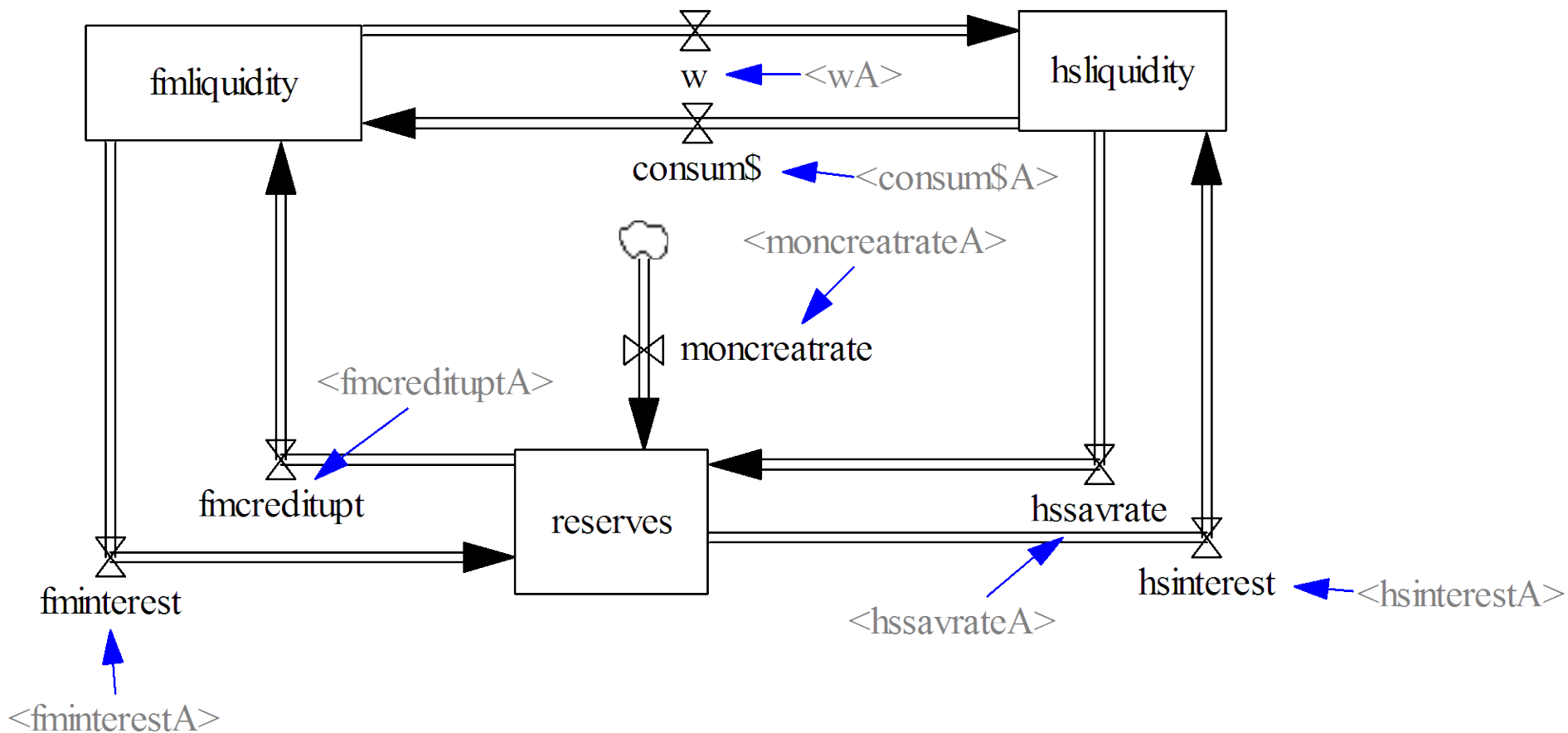
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- 3) To achieve this: an understanding of the strategies of the actors governing the coupled financial-economic system
- 4) A regulatory system that counters actor-created instabilities and encourages long term investments in green technologies.

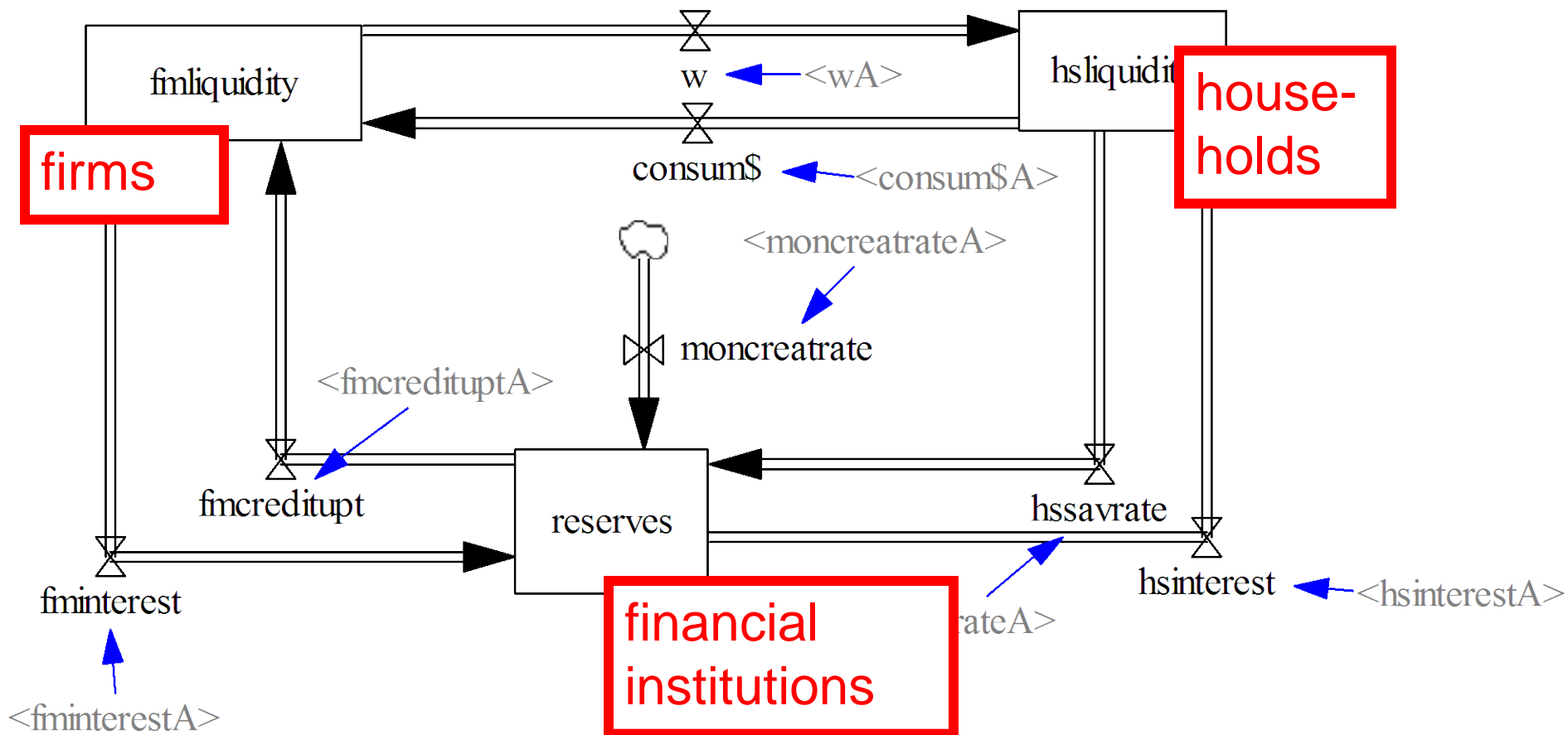
A system-dynamic view of the financial system

The “virtual economy” (financial system):
money circulation between firms, banks and households

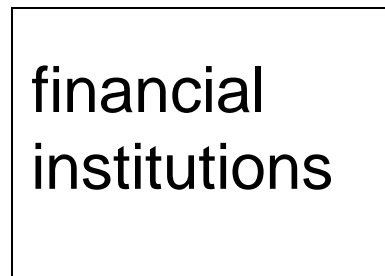
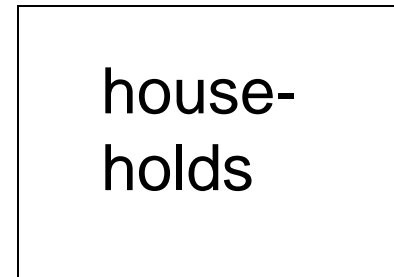


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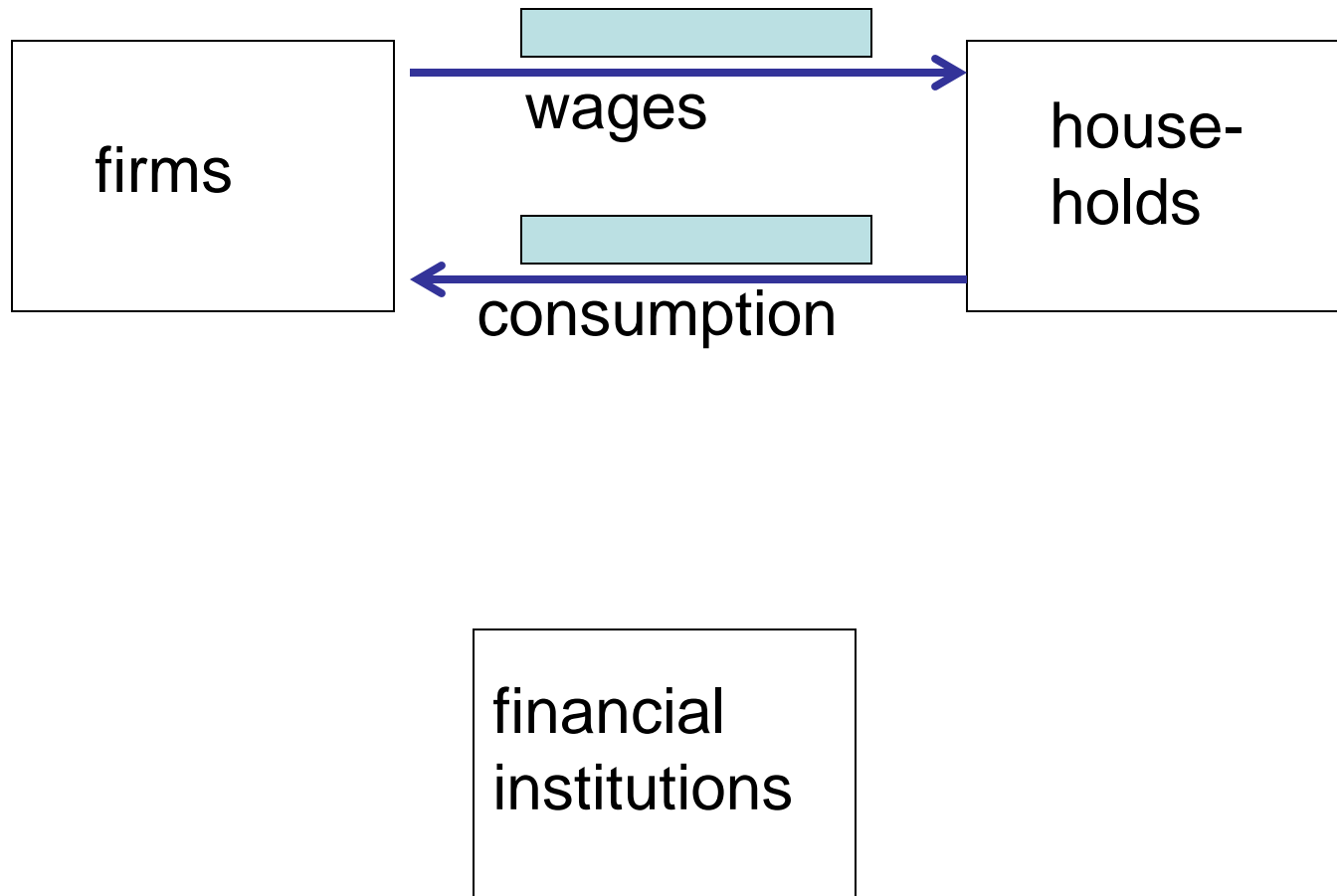
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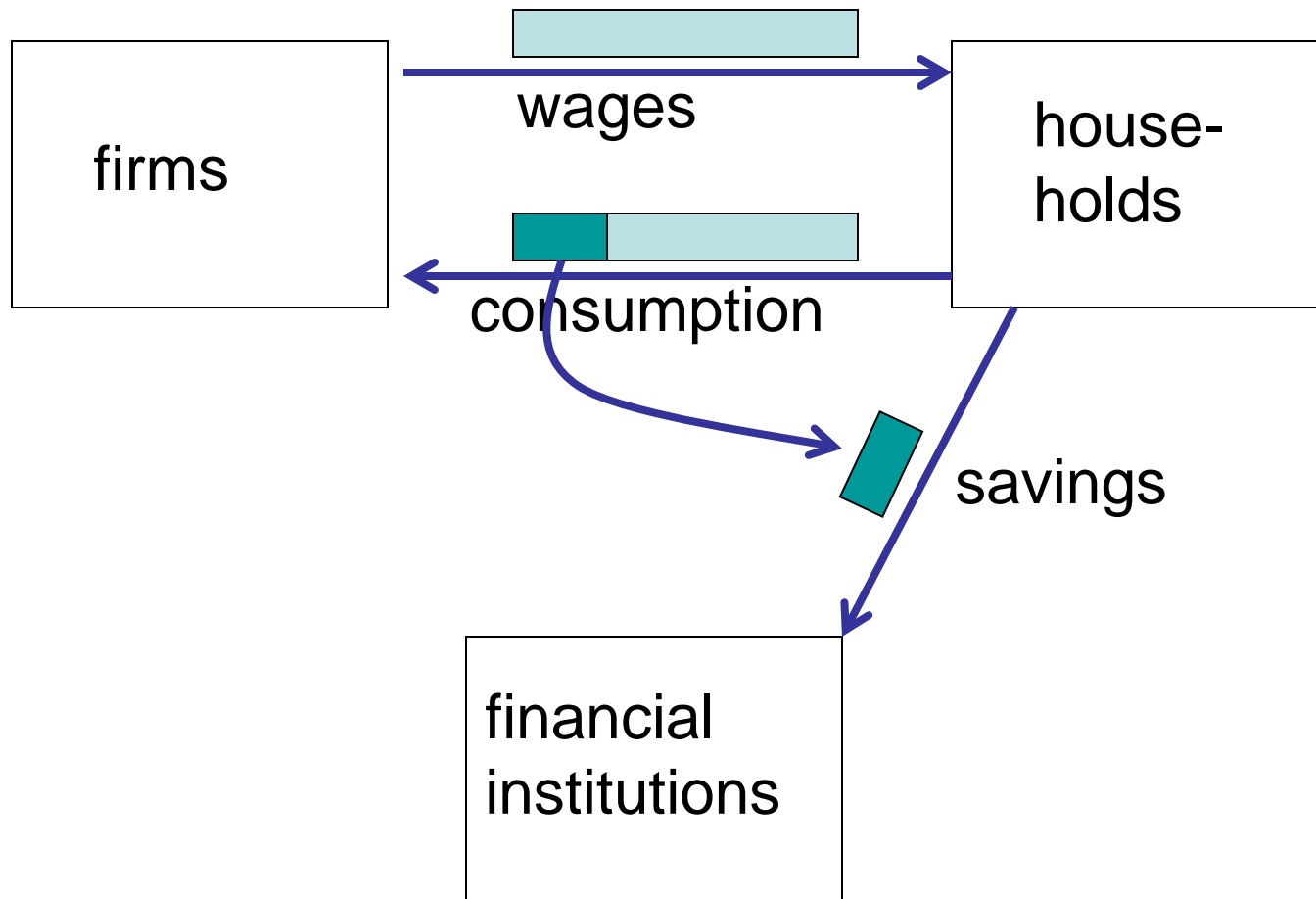
A simplified system-dynamic view



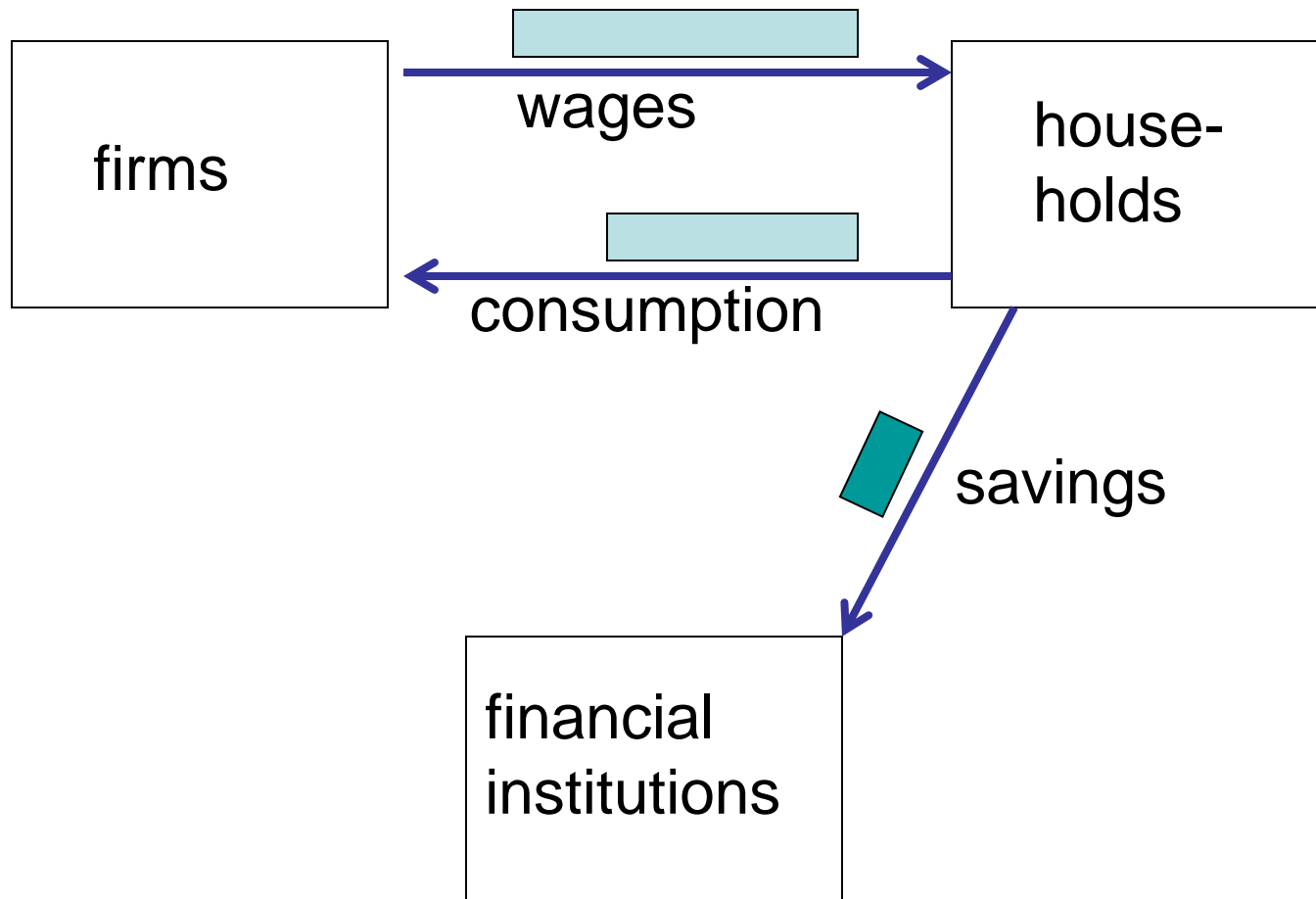
Money flows, no-growth economy



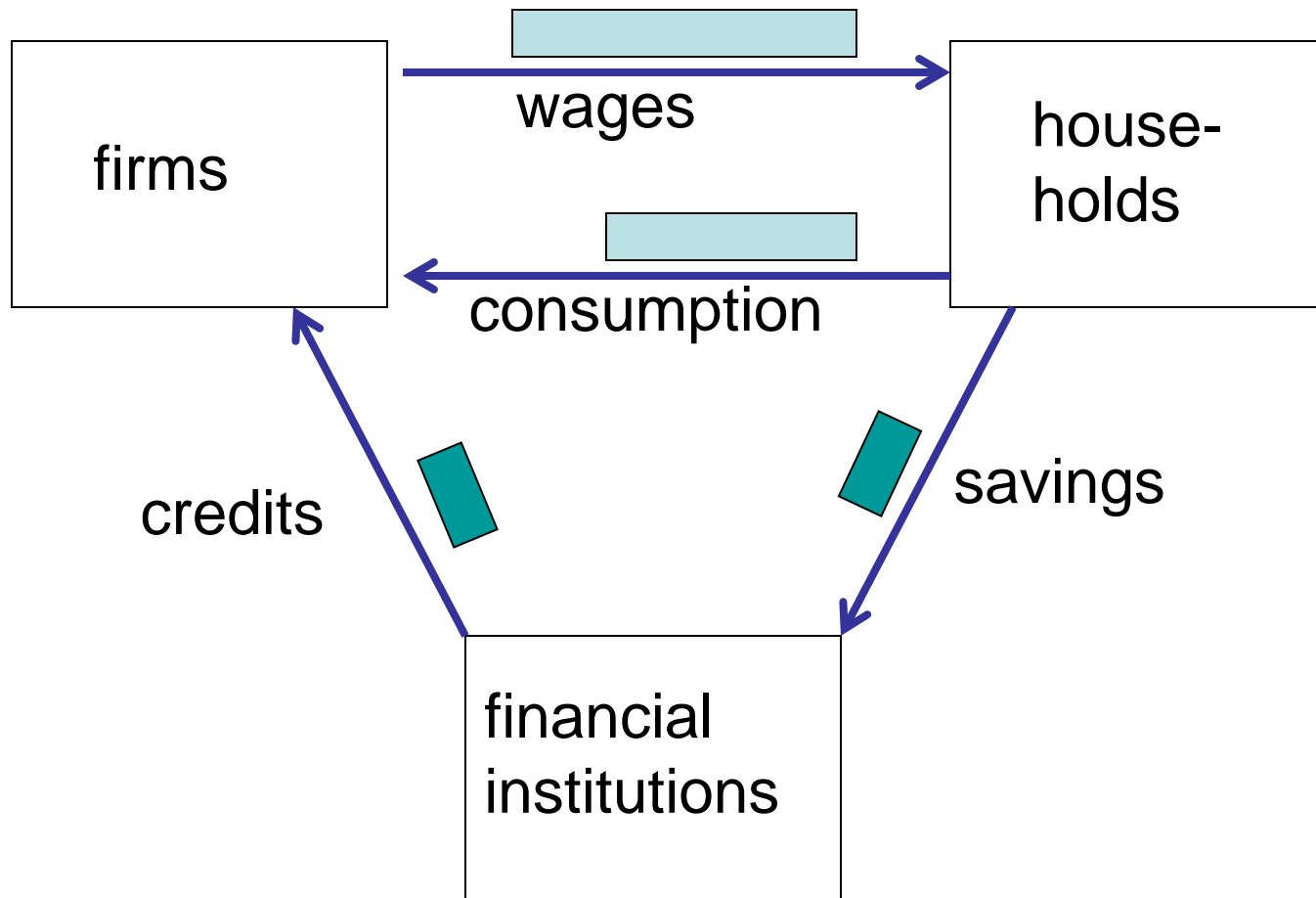
Money flows, constant-growth economy



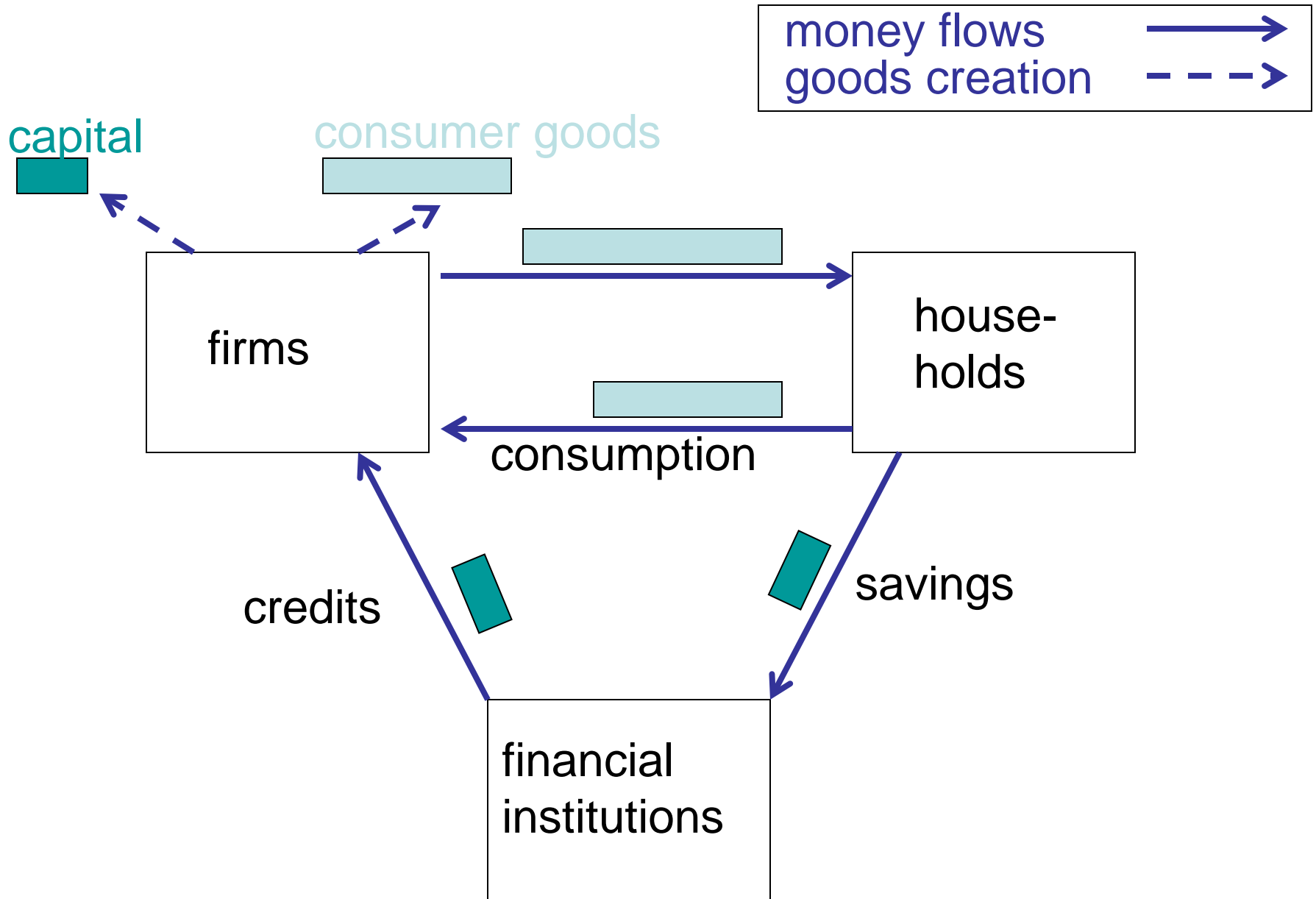
Money flows, constant-growth economy



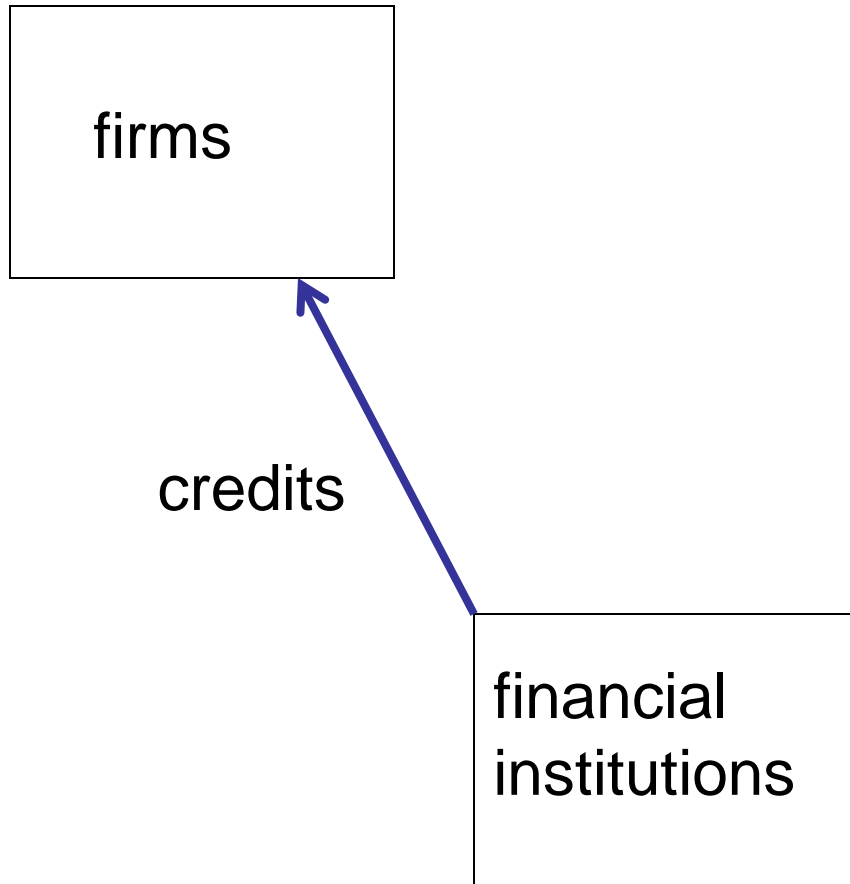
Money flows, constant-growth economy



Money flows and goods creation, constant growth

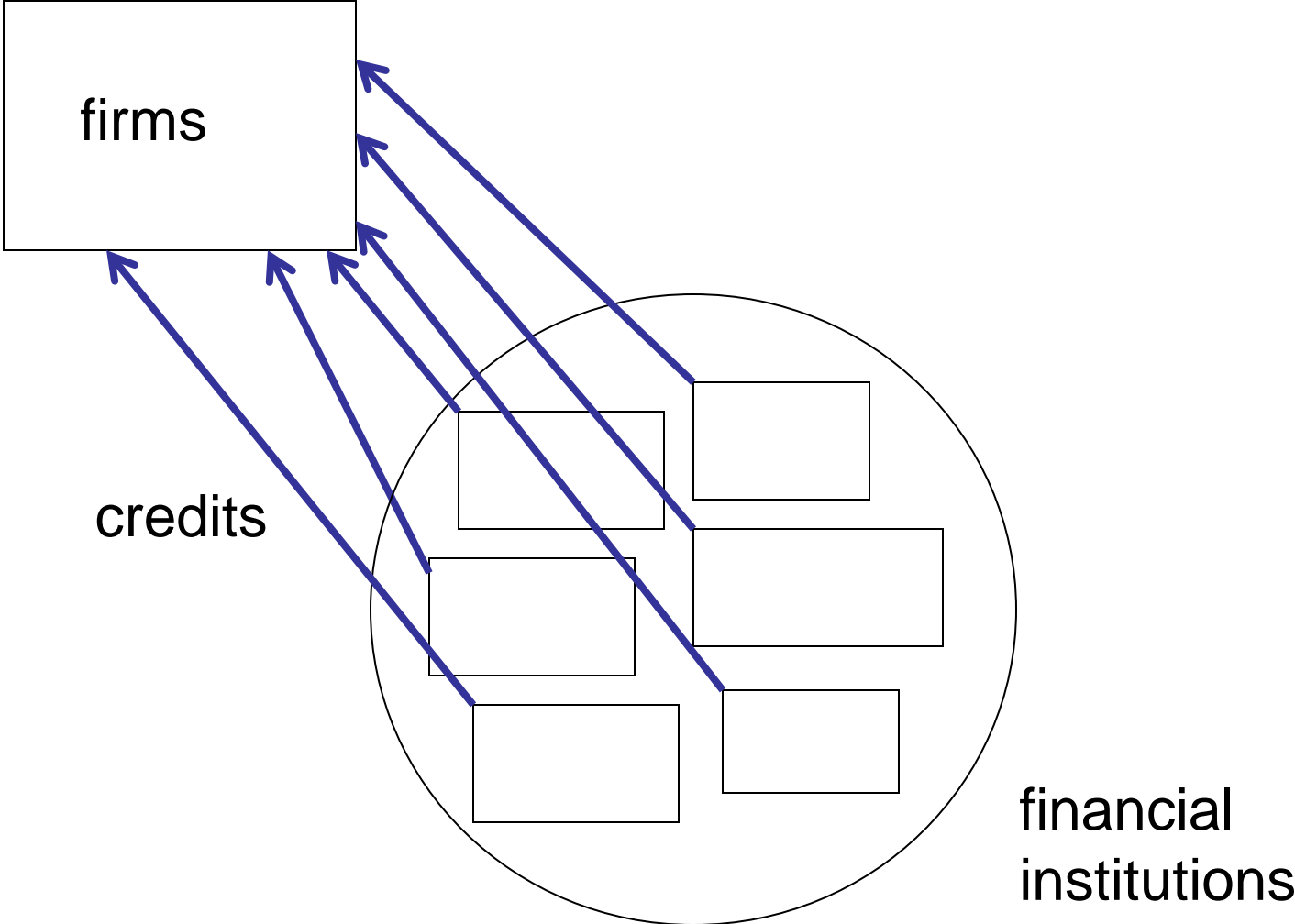


Money flows, interaction firms - financial institutions



Money flows, interaction firms – *many* financial institutions

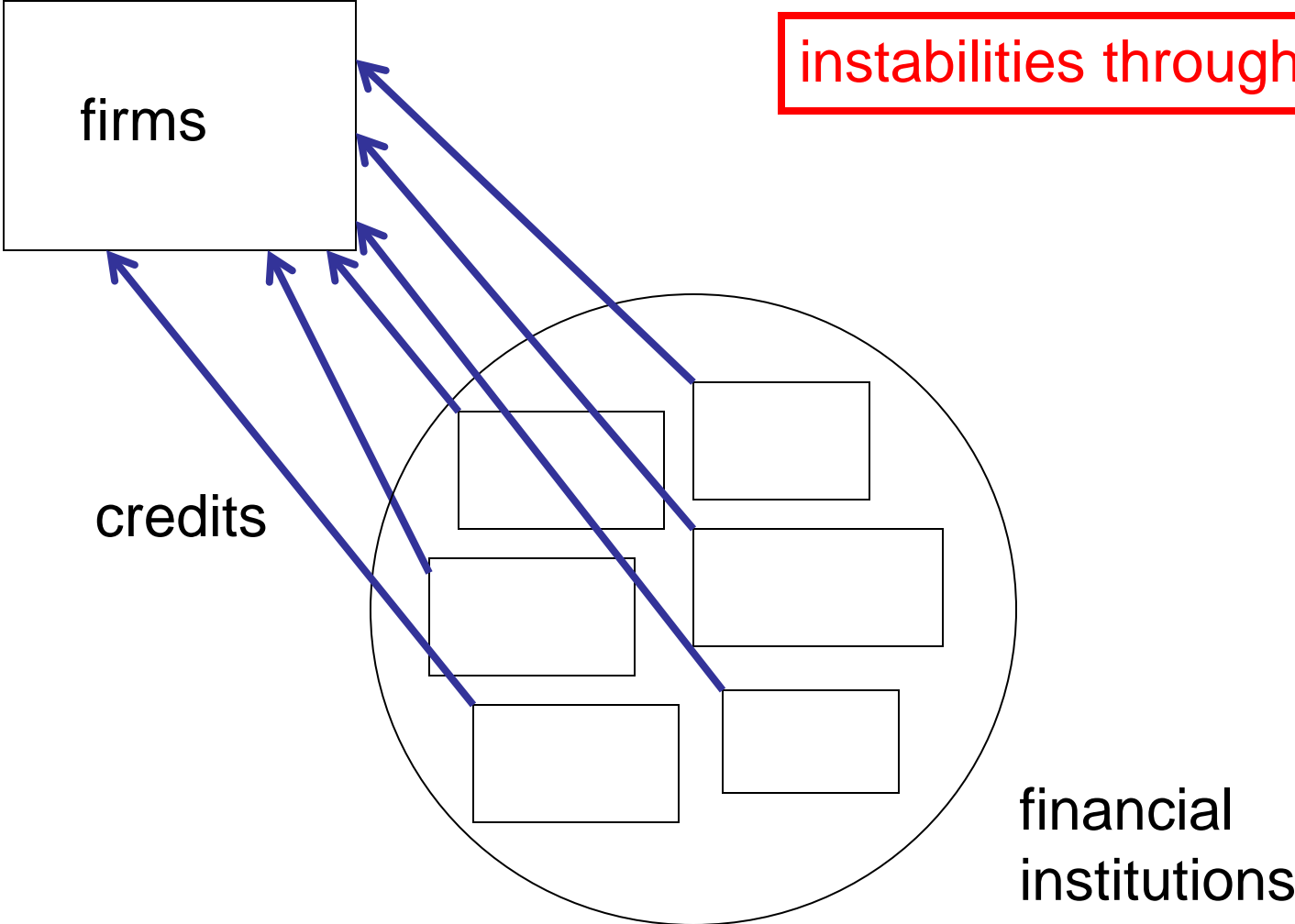
1. Independent credit policies



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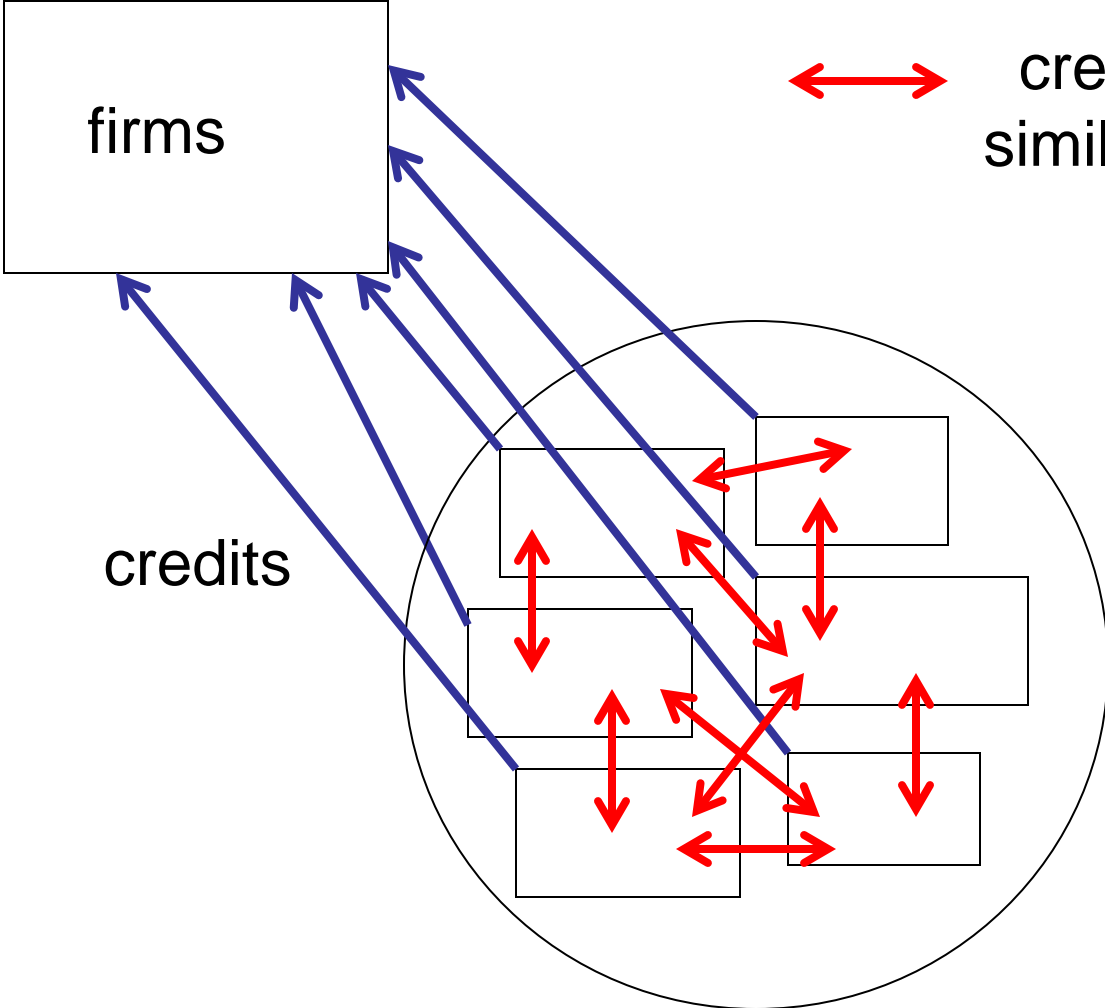
instabilities through herding



Money flows, interaction firms – many financial institutions

2. In addition: inter-financial trading of derivatives:

↔ credit default swaps (and similar derivatives)



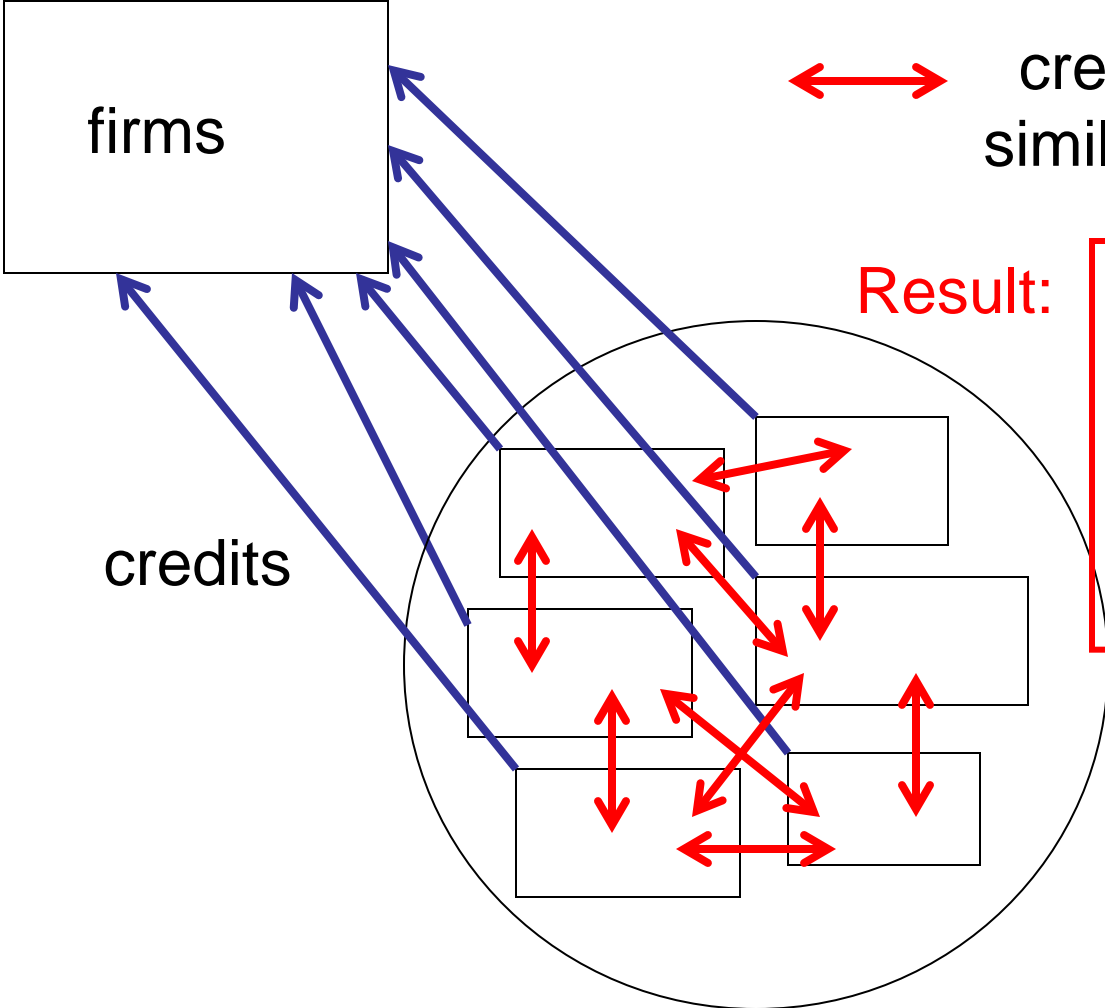
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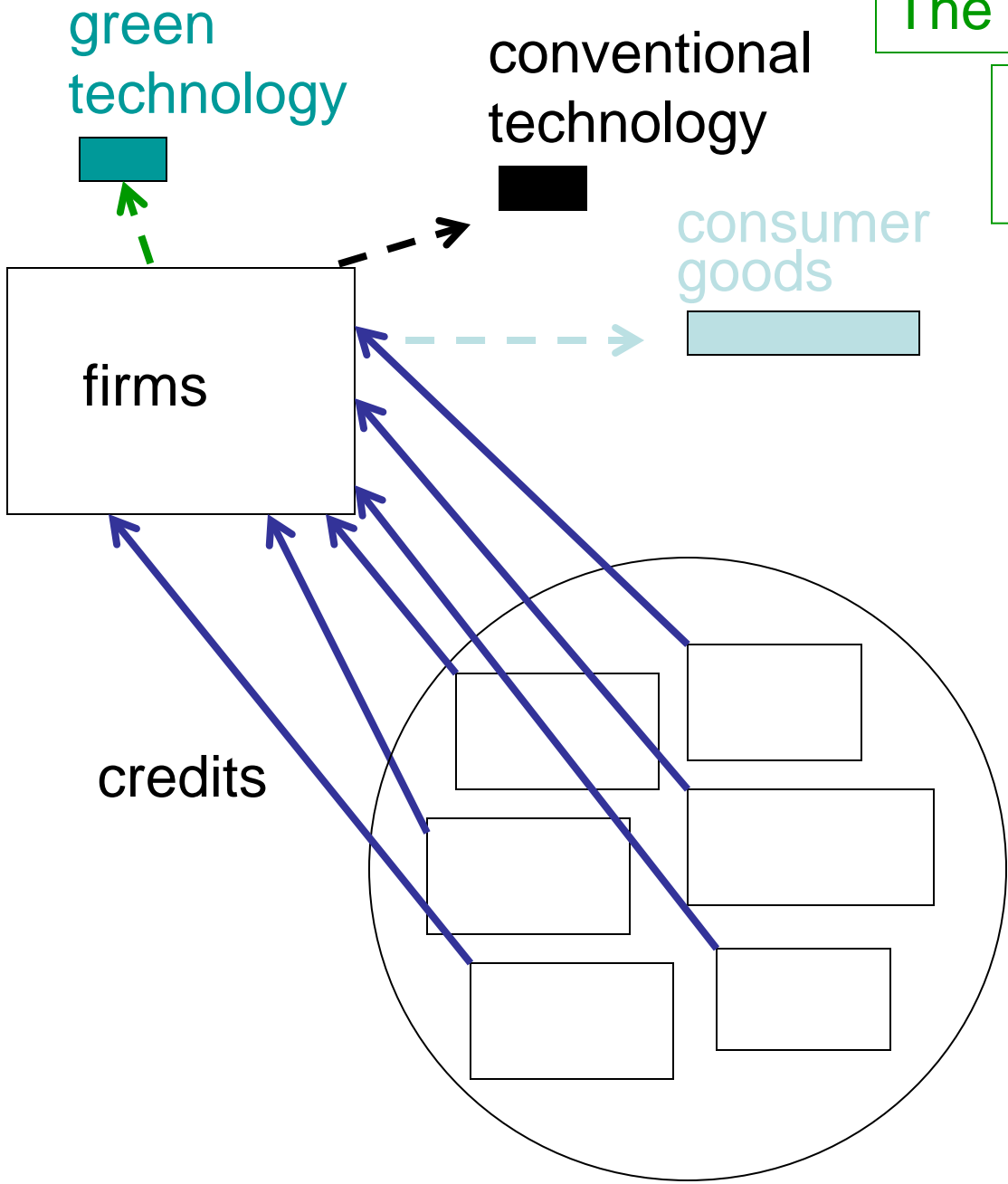
Result: Individual financial institutes take higher risks, which are traded "away"
Total risk increases

financial institutions

What does this imply for the green transformation?

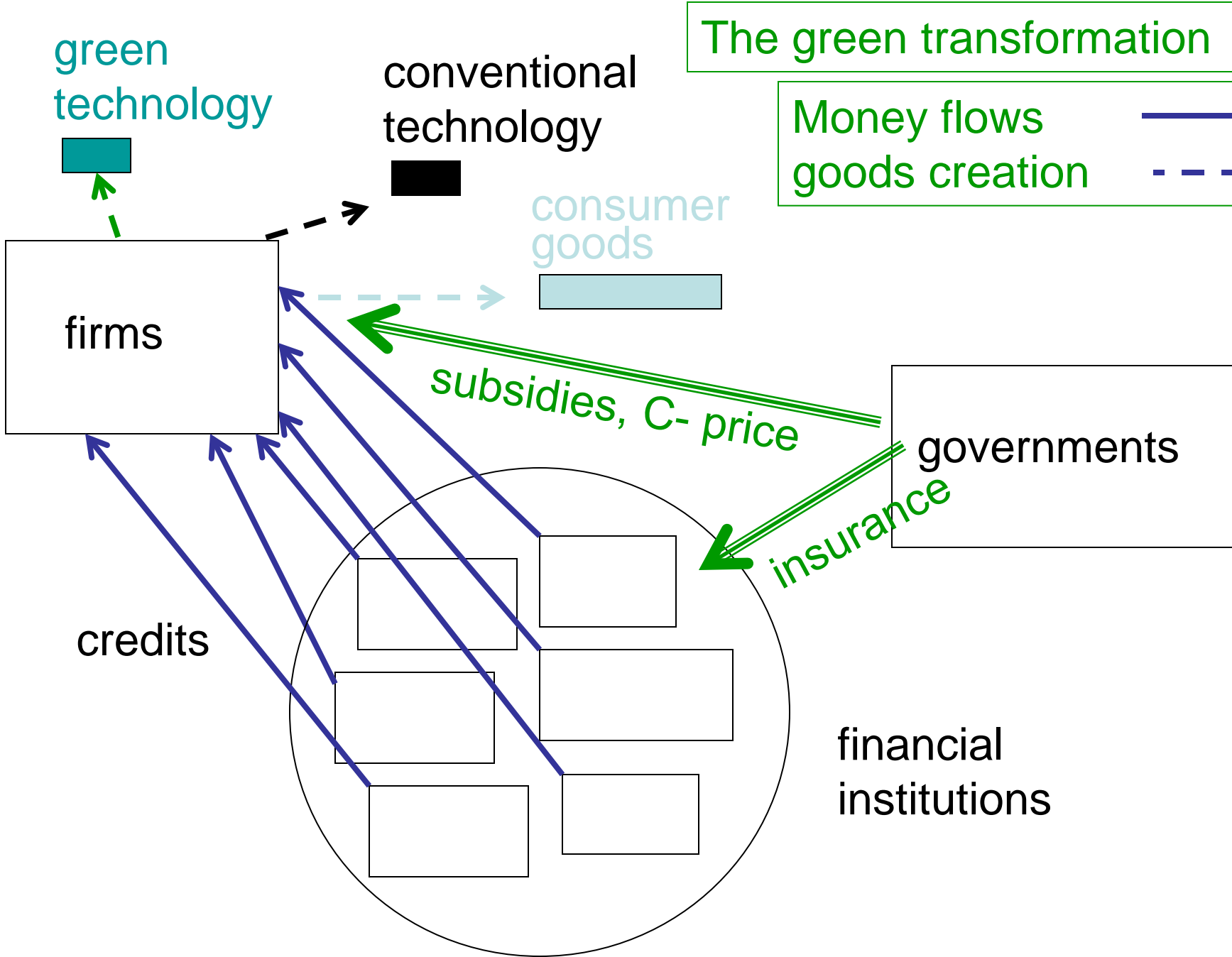
The green transformation

Money flows 
goods creation 



The green transformation

Money flows 
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(i) dampen business cycles through anti-cyclic government investments (Keynes)

(ii) regulate financial markets by forbidding or taxing de-stabilizing inner-market transactions

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2. The needed measures are obvious:
 - (i) dampen business cycles through anti-cyclic government investments (Keynes)
 - (ii) regulate financial markets by forbidding or taxing de-stabilizing inner-market transactions
3. Governments – also important financial actors- must be included in a redesigned global financial system

How can scientists contribute to solving these problems?

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An extension to a simple system-dynamic model of the global financial system is urgently needed!

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- Workshop “System Dynamic Models of Coupled Natural-Social Systems”, Bekkjarvik, 22-26 June 2009. Papers to be published in Thematic Issue of Environmental Modelling and Software (including papers on C-ROADS and MADIAMS)

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- Annual Conference of the European Climate Forum (now Global Climate Forum), “Action for Climate: Beyond the Zero-Sum Game” Barcelona, 9-10 April 2010 (book to be published 23 November 2011)
- Ongoing collaboration with socio-economic group (Dmitry Kovalevsky, Leonid Bobylev) at NIERSC (St. Petersburg)
- The future? Joint project with Nansen group (headed by NABIC), Global Climate Forum, and others.

Thanks Ola and the teams of the
Nansen groups for 25 years of fruitful
and enjoyable collaboration!

Carry on!