Climate change models and policies: new ways to go?

Les nouvelles frontières de la modélisation prospective
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Why I got disillusioned about economy-environment IAMs

In the 1990s it was calculated that serious damage from climate change would cause higher economic growth: people started to exchange leisure for (more) work (Scheraga et al.)

After the serious floods in Germany in 2002, some economists expected a GDP-growth because the surge in construction activity could exceed the loss in consumption.

Both these model-based outcomes suggest the economic merit of (non-creative?) destruction in the modern capitalist economy.

In the early 1990s we discussed the impending problem of water shortage in many parts of the world. Should and could it be included in the Global Change models (such as IMAGE) in connection with macro-economic models. “Water is less than 1% of Gross World Product (GWP), so don’t bother” was the economists’ answer.

Why I got disillusioned about economy-environment IAMs

During the construction of the IPCC SRES scenarios in 1999-2000, the macro-economic growth paths for regions were constructed by convergent labour productivity growth paths.

There were no questions asked or answers given about the role of technology and its possible direction; about the nature of incomes rising to 120.000 1995US$/cap/yr; and about the possible feedbacks from social and ecological constraints.

Despite improvements, the situation is still largely unchanged. This leads to a focus on esoteric and abstract questions like the discount rate and the elasticity of the marginal utility of consumption 100 years into the future.

During the IPCC SRES scenario construction process, macro-economic models were biased towards globalization (trade advantages) and efficiency orientation (market vs. regulation). One consequence was that narratives about regional orientations towards sustainable development and/or towards catastrophic mismanagement could not be told (excluding and debasing B2/A2 futures) (De Vries 2006).

Serious objections about economy-environment IAMs:

- The equilibrium paradigm is a fallacy, borrowed in the name of positivism from 19th century physics
- The representative economic agent (Representative Agent with Rational Expectations – RARE) is a shameful reduction of what human beings are, are capable of, and are aspiring for
- Mathematical and accounting methods (optimal control, cost-benefit etc.) falsely suggest the legitimacy of a normative economic science
- The absence of the physical and social reality in the models blinds the users for the real-world risks and opportunities.

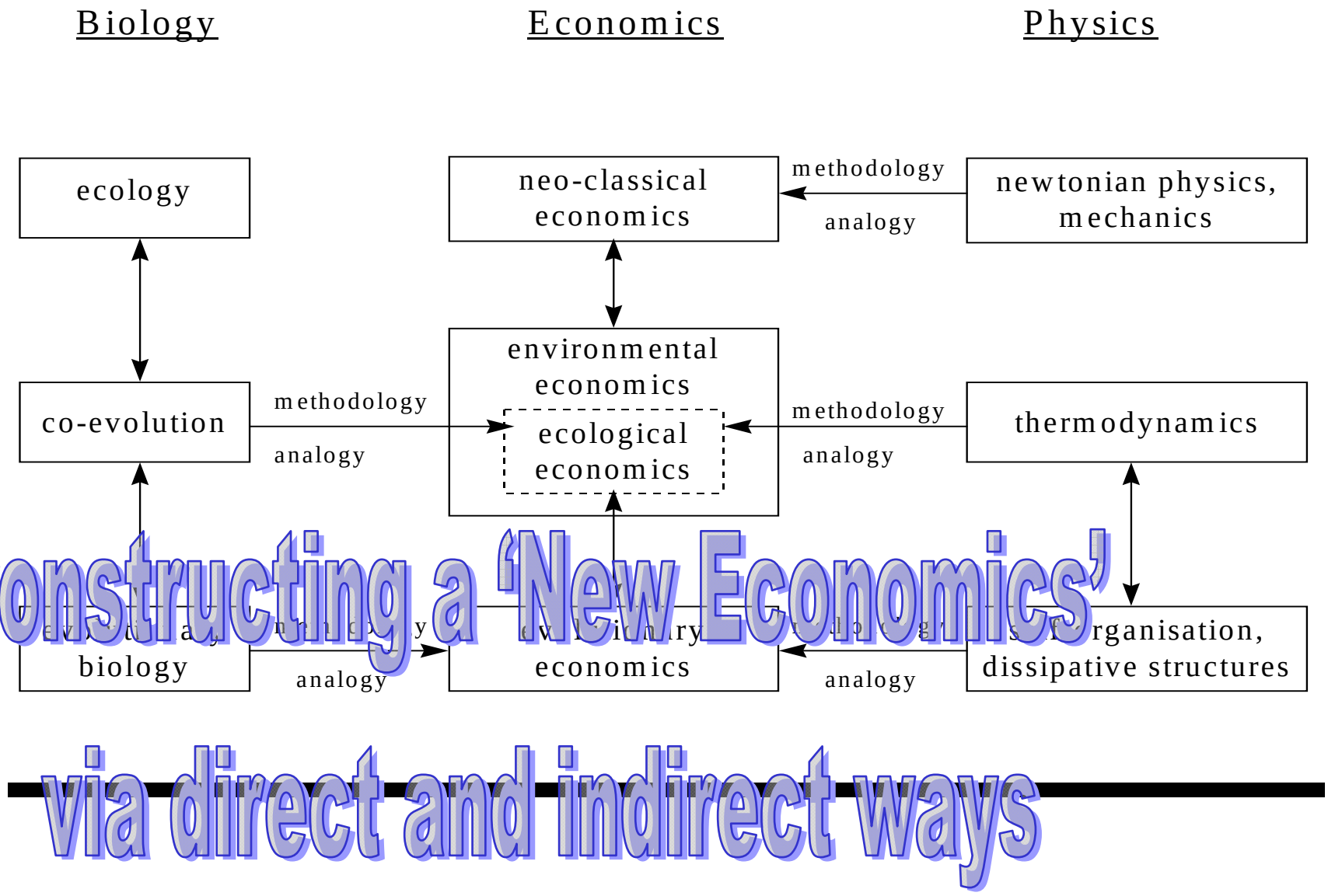
"It is an unexamined presumption, not a known fact, that economics can determine the proper level of regulatory stringency for greenhouse gas emissions." (DeCanio (2009). ***Can we accept that the whole approach of calculating costs and benefits using IAMs is a delusion?***

Imagine an IAM exercise done in 1900 to forecast the 20th century – it would have utterly failed but for some abstract numbers. Besides, the present situation is different and more complex. ***What justifies the idea that we can use meaningfully a model-based optimal control approach to recommend what governments should do?***

Economic-environment IAMs

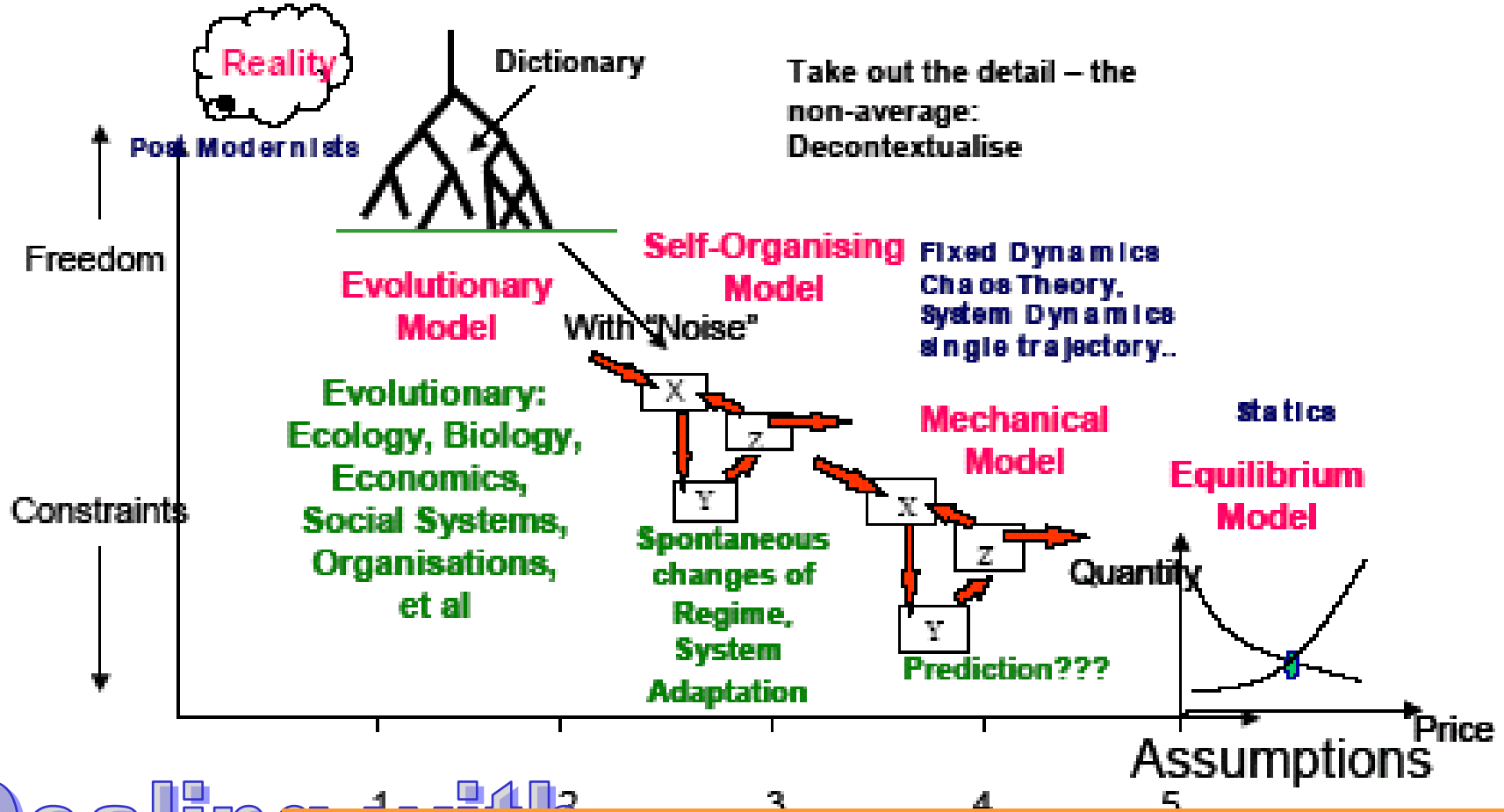
- Supply-demand market clearing via prices (equilibrium)
- Capital stock dynamics: aggregate and largely implicit
- Growth dynamic: aggregate technology driven (exogen productivity incr)
- Labour skill evolution: aggregate and implicit (education, health…)
- [In]equity issues: implicit as trickle-down and convergence
- Resource constraints: resolved via prices (substitution and depletion)
- Policies: very limited ways to explore real-world options

Interactions between disciplines: physics-biology-economy



(Mulder & van den Bergh 2000)

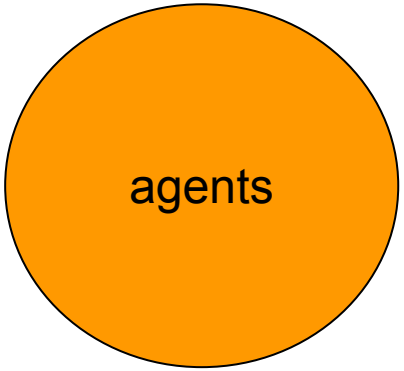
Modelling: from complexity to simplicity – and back?

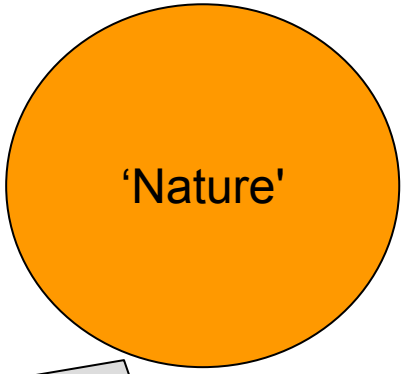


Dealing with complexity

When Keynes asked [Planck] whether he had ever thought of taking up economics, Planck thought for a moment. "No,", he replied, "the math is too hard." (Ormerod 1998:191)

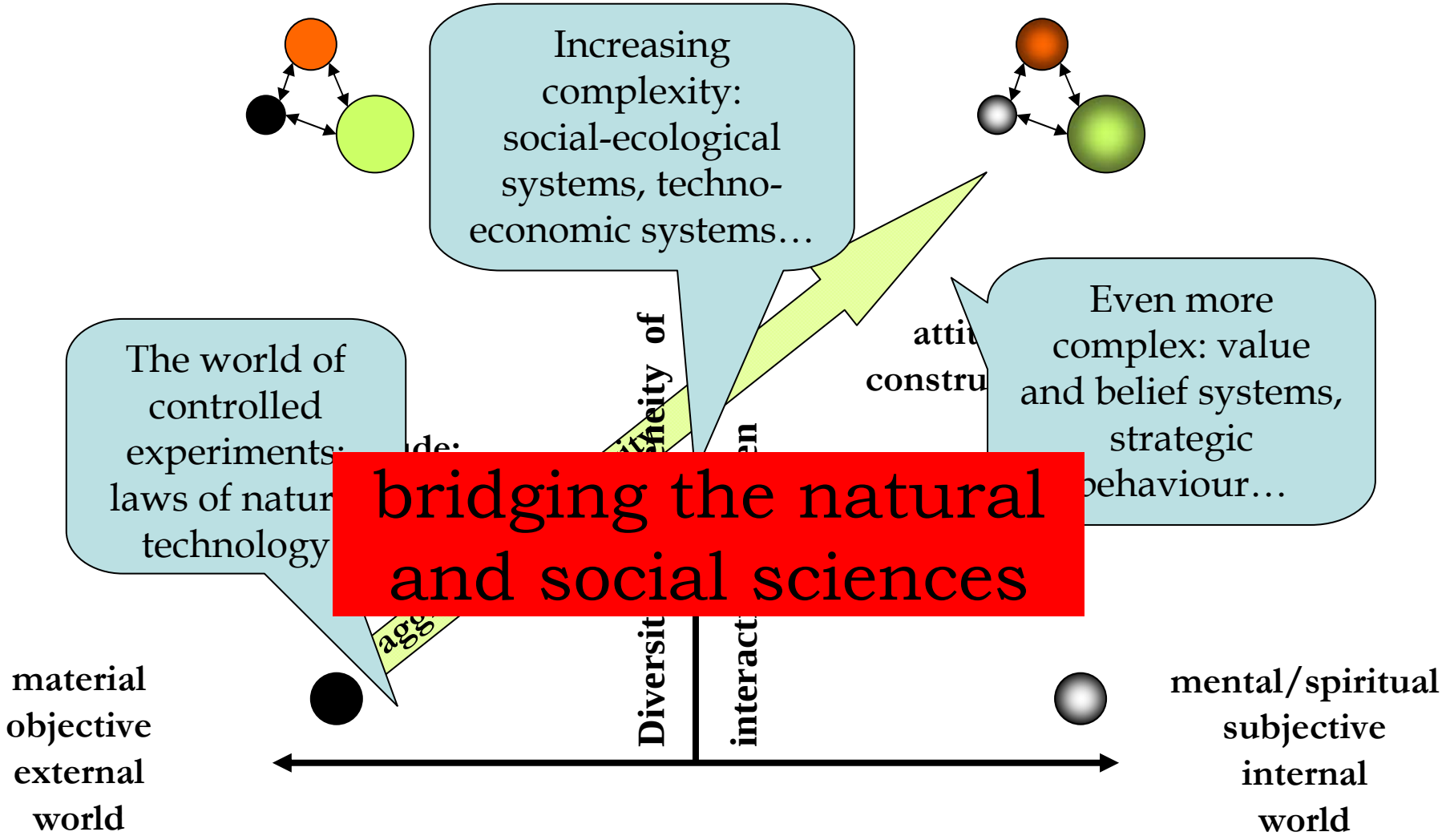
(Allen et al. 2004)





- Large parts of social-ecological systems (SES) are often not engaged in monetary transactions, but cannot be neglected
- Resource scarcity, expressed in supply-cost and ecosystem service cost curves, have to become integral parts of IAMs in order to explore regulatory policies regarding supply and degradation risks and uncertainties
- Managing (open-access) common pool resources (CPR) is a complex, local issue with no clearcut solutions (market vs. central gov't). It should become part of the toolbox
- Ecosystems are complex dynamic systems, with thresholds, non-linearities and catastrophic change. Their behaviour and associated risk/uncertainty should become part of the toolbox

Research challenge 1: complexity and uncertainty



It would be a fallacy to think that the uncertainty is merely in the model parameter assumptions…e.g. the discount rate or the climate sensitivity

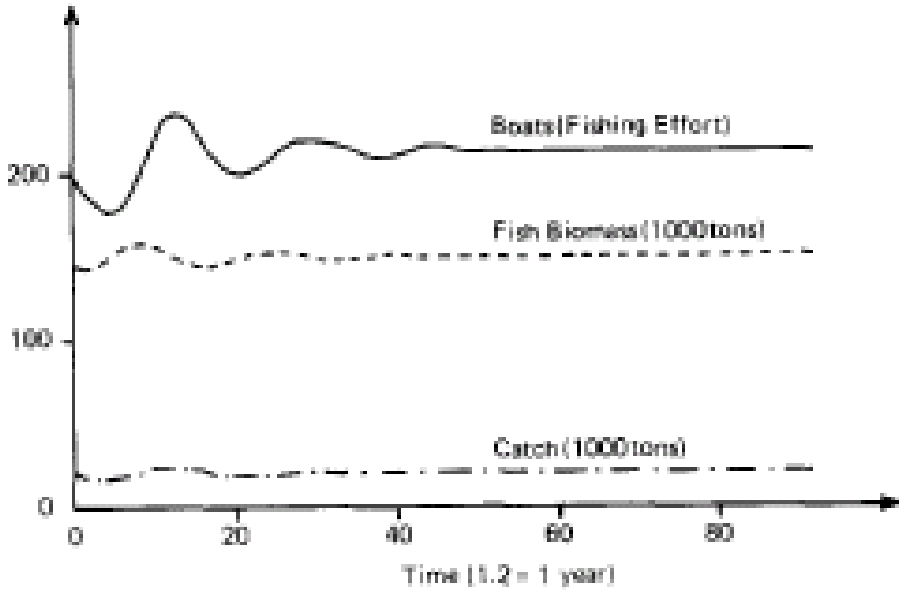


Figure 3. The model of equations (1) run deterministically

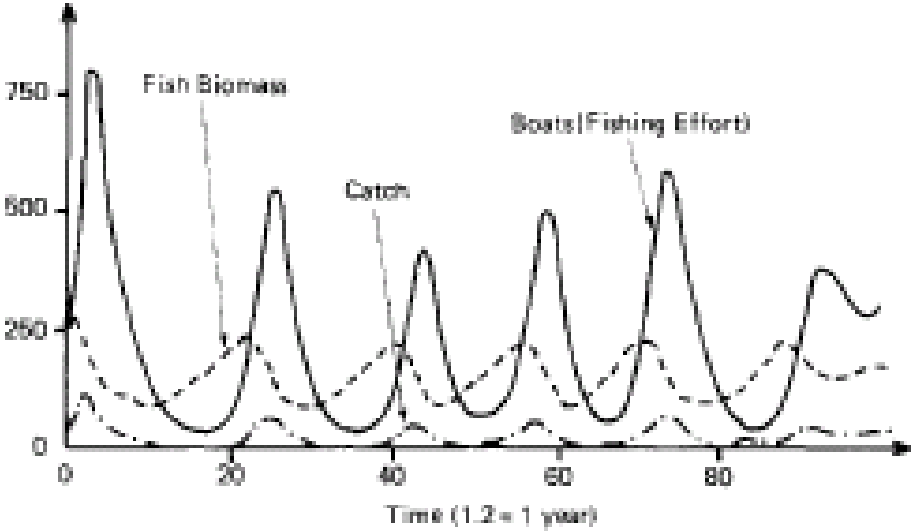
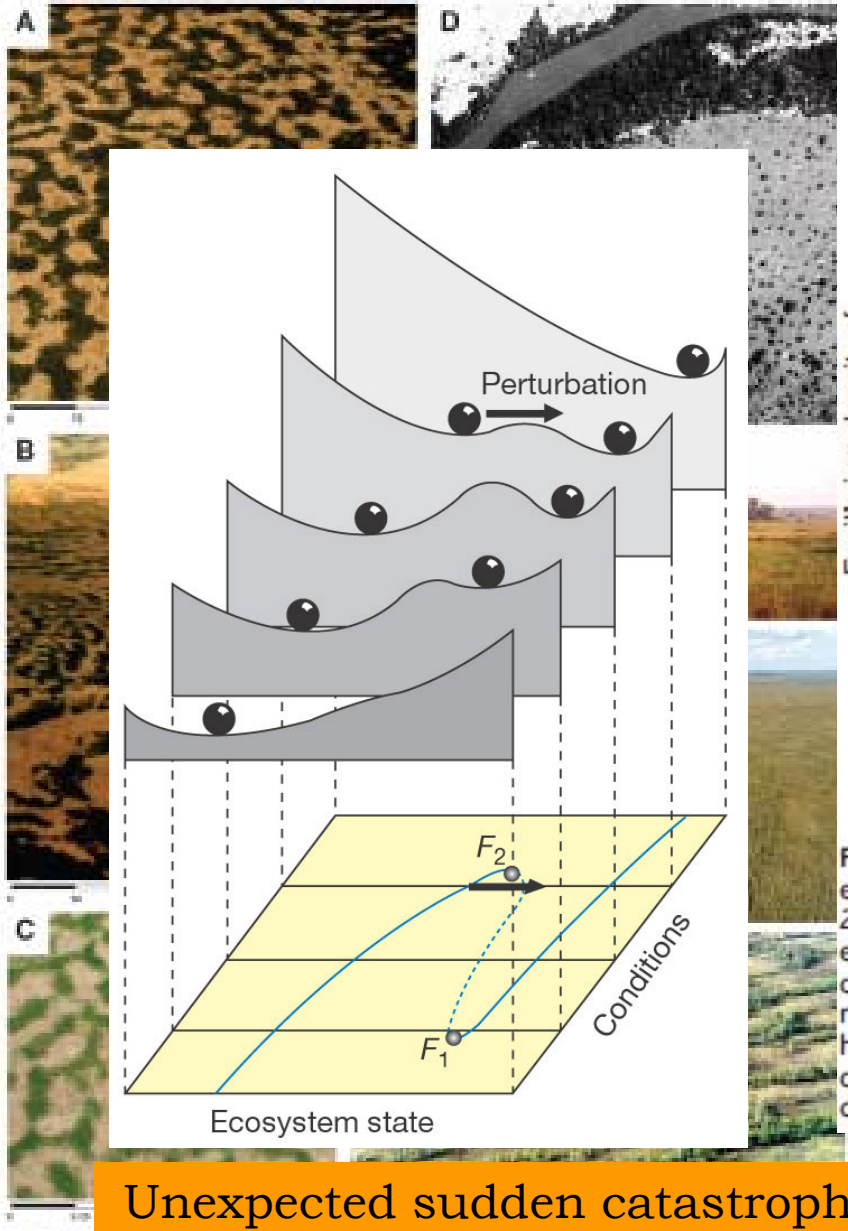


Figure 4. Exactly the same model and parameter values, but with '*b*' fluctuating

Endogenous ecosystem dynamics: the role of natural fluctuations in exploitation of renewable resources.

We do know that such endogenous dynamics is also part of economic and social systems.

(Allen and McGlade 1987; Anderson et al. 2008)



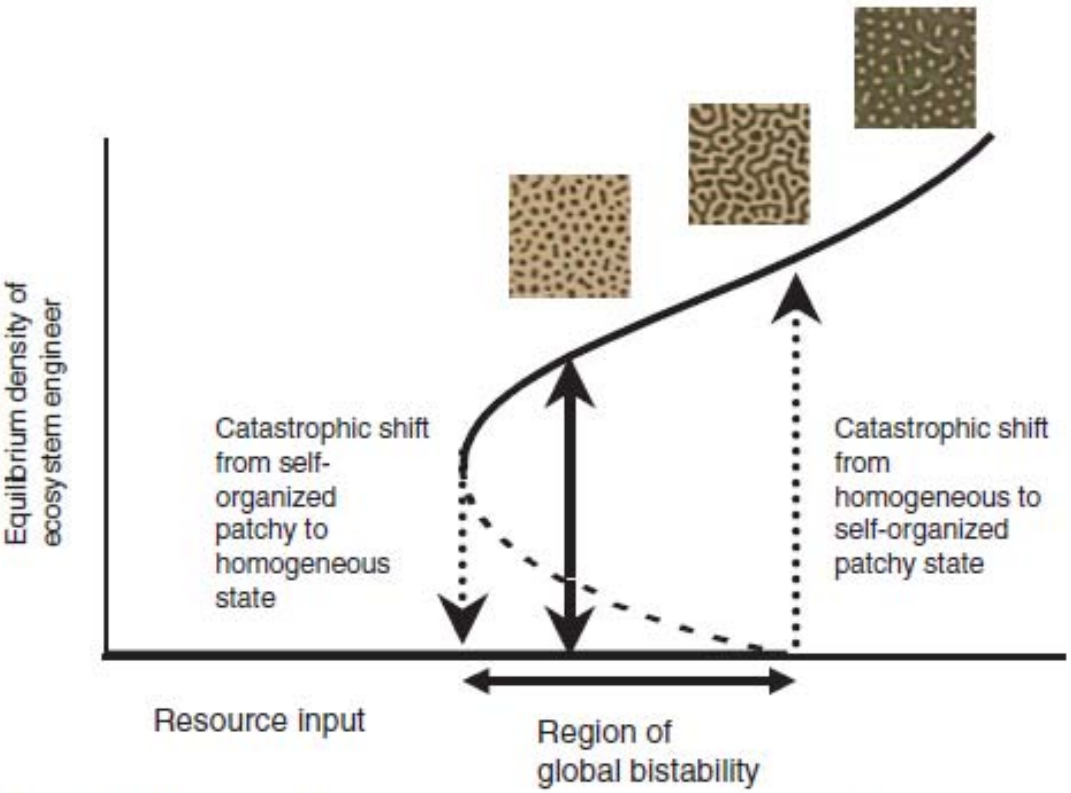


Fig. 3. Model showing how ecosystems may undergo a predictable sequence of emerging self-organized patchiness as resource input decreases or increases (*11*, *12*, *14*, *25*). Thick solid lines represent mean equilibrium densities of consumers functioning as ecosystem engineers. Dotted arrows represent catastrophic shifts between self-organized patchy and homogeneous states, and vice versa. Dark colors in the insets represent high density. The range of resource input for which global bistability and hysteresis exists is between these dotted arrows. Solid arrows represent development of the system toward the coexisting self-organized patchy state or homogeneous state, depending on initial ecosystem engineer densities.

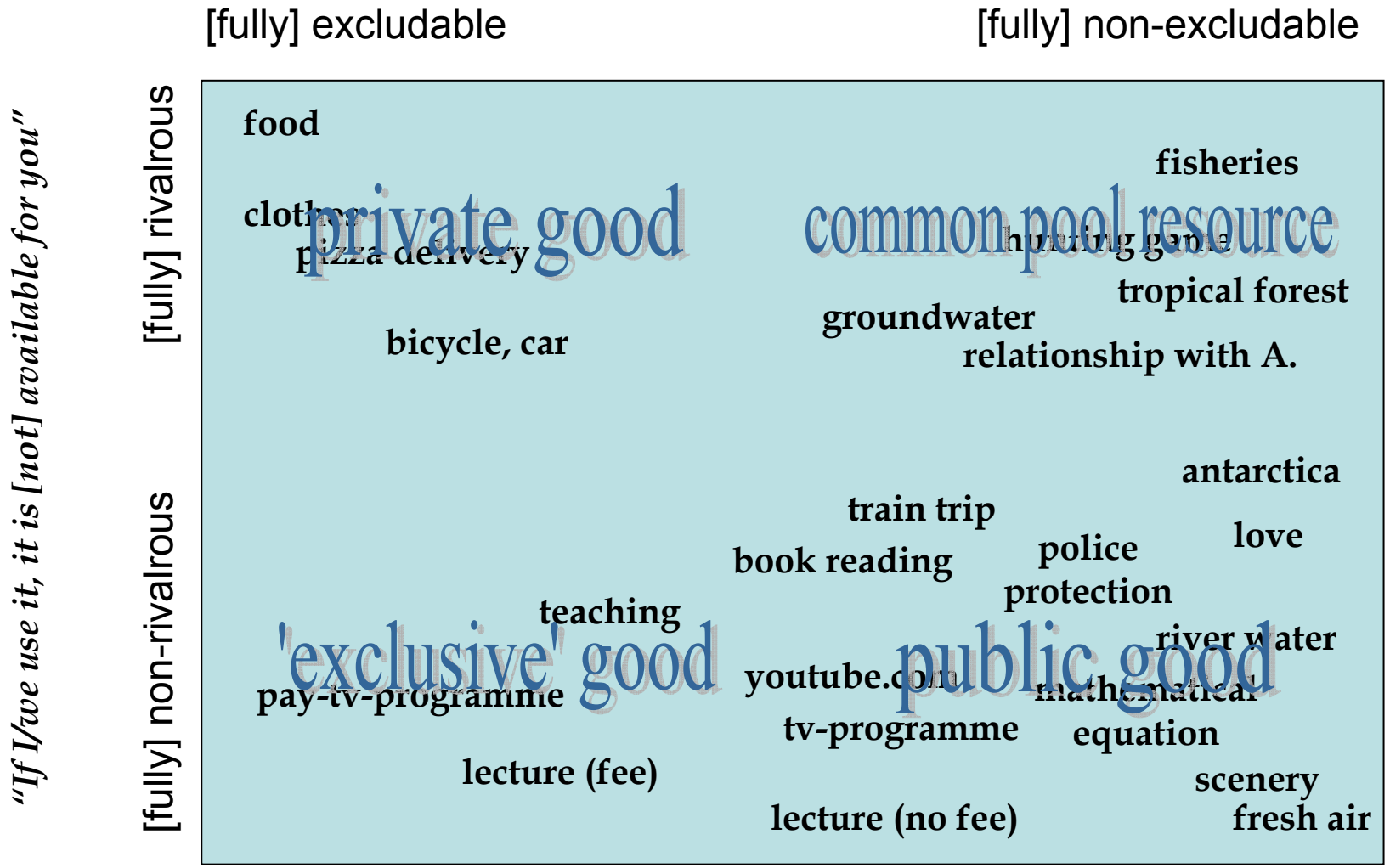
Unexpected sudden catastrophic shifts may occur in ecosystems, with concomitant losses or gains of ecological and economic resources.

(Rietkerk et al. 2004; Scheffer et al. 2009)

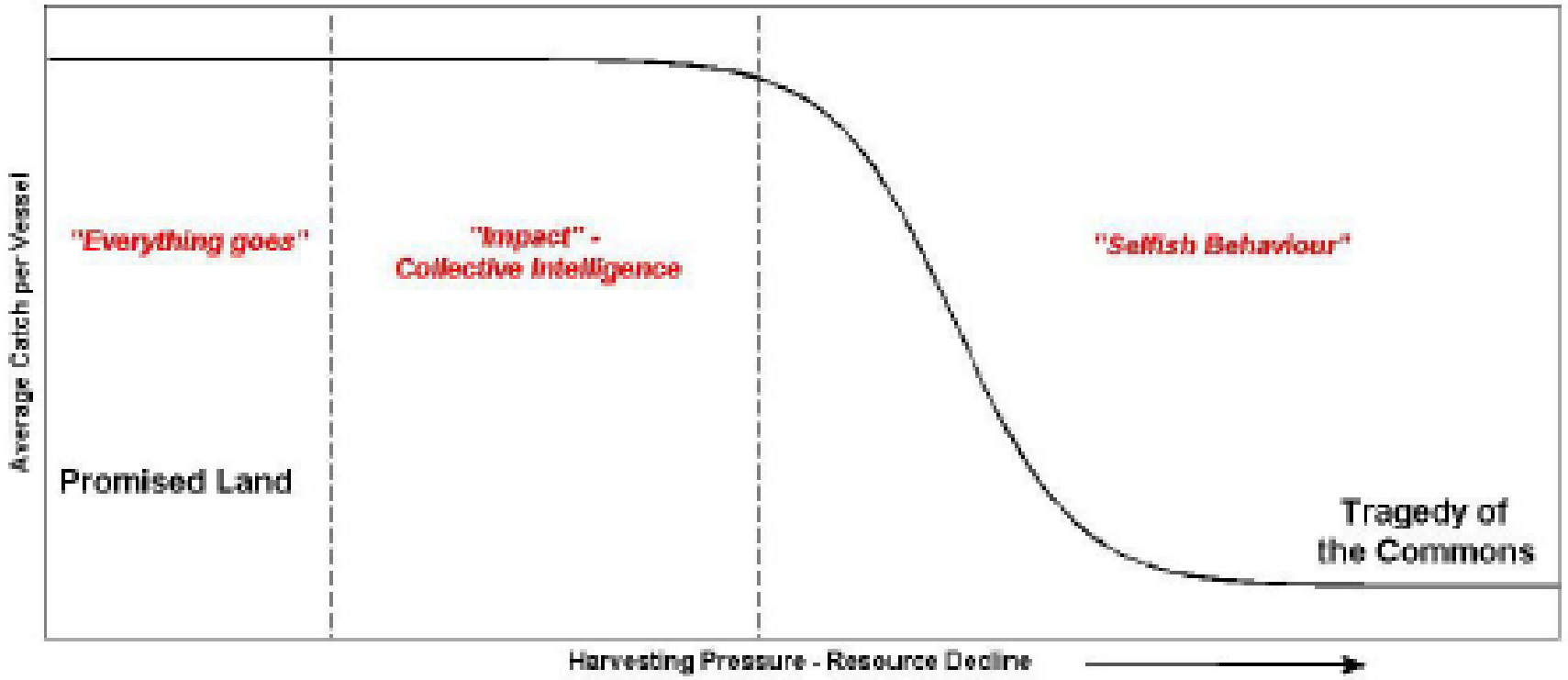
The Commons: one of the categories of goods and services in economic science

"I/we can[not] prevent someone else from enjoying it"

"If I/we use it, it is [not] available for you"



Resource Abundance/Strategy

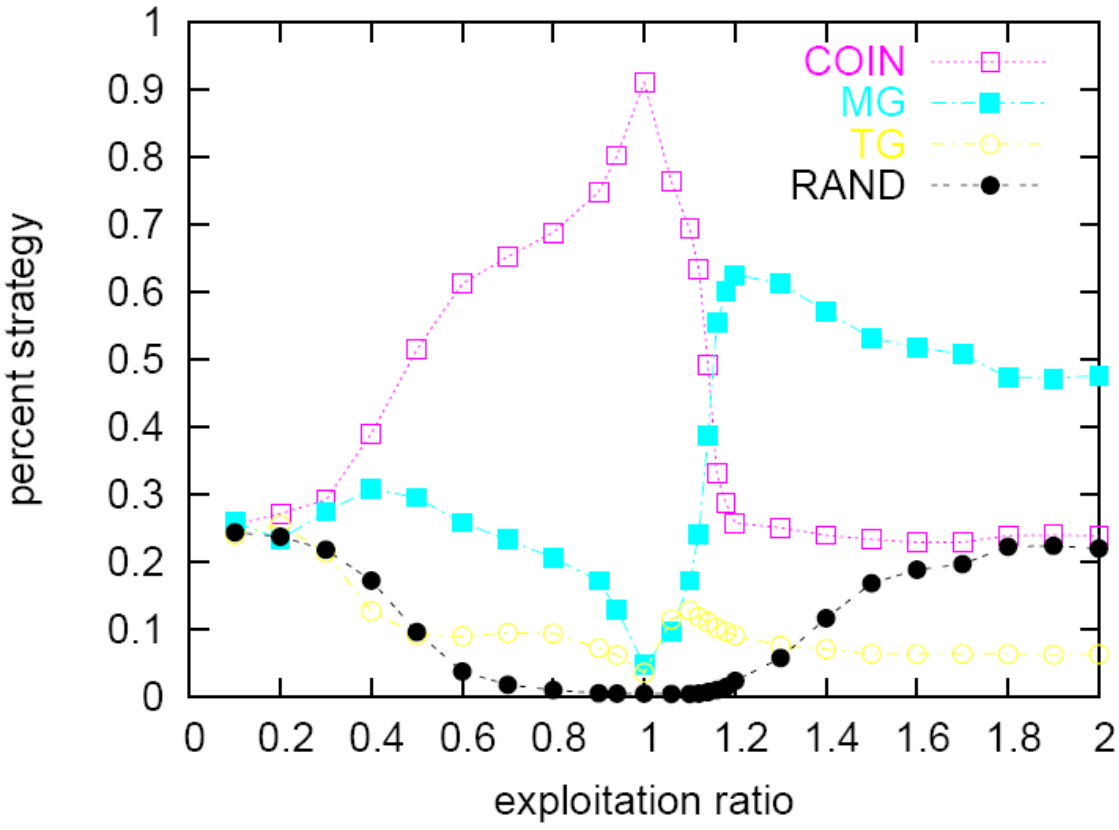


- Dominant strategy depends on resource abundance
  - Very abundant resource: “Everything goes”
  - Sufficient resource: Collective Intelligence
  - Very scarce resource: Selfish behaviour
- Also: the scarcer the resource, the more short term oriented becomes behaviour

Exploiting a renewable resource: fisheries

the ‘optimal’ i.e. most effective strategy depends on exploitation depth

Dependence on the exploitation ratio $r = \frac{NC_{\max}}{\sum_i Z_i}$



COIN COllecitive INtelligence
MG Minority Game
TG Team Game
RAND Random

under-exploited

over-exploited

(Brede and De Vries 2007)

- What are the best strategies for exploitation of distributed resources in different environments?
- Some outcomes:
  - Random strategy not viable in realistic scenarios
  - Only small teams can compete
  - COIN very insensitive to noise
- Balance between COIN and MG may be used as an indicator of exploitation ratio itself

COIN COllecitive INtelligence
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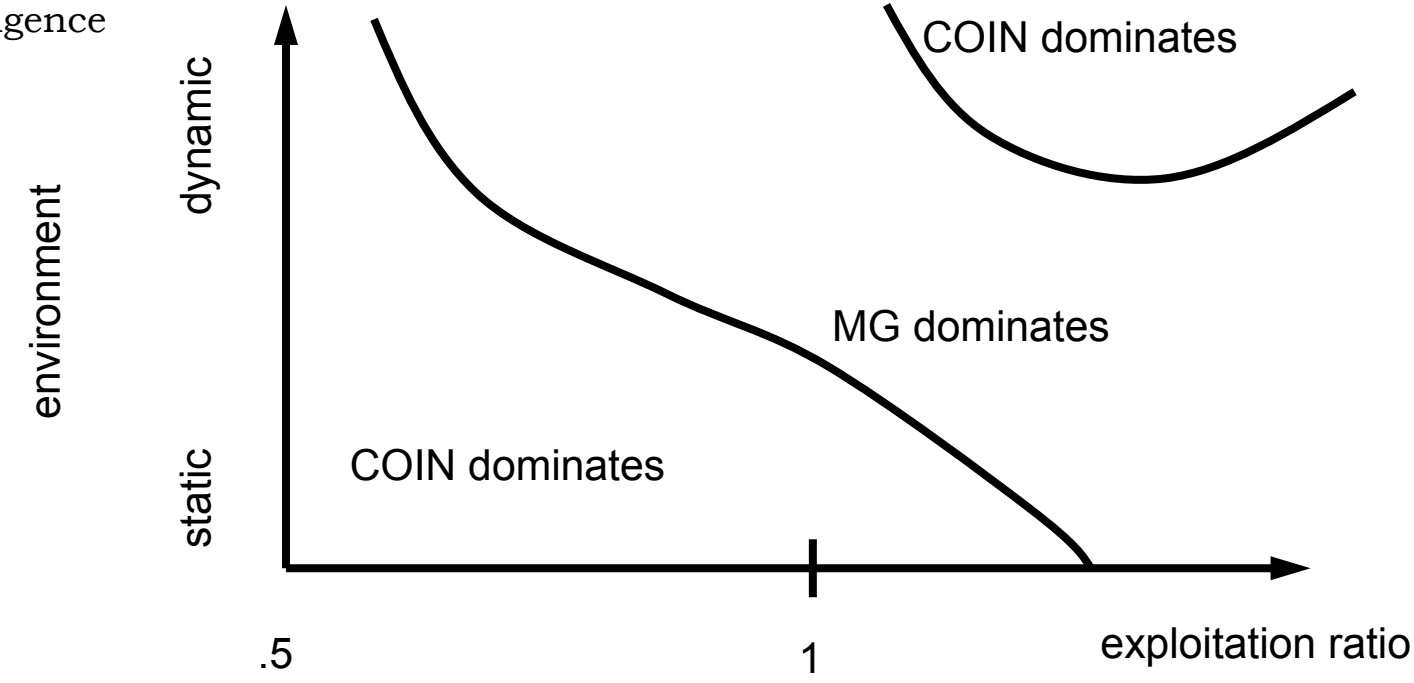
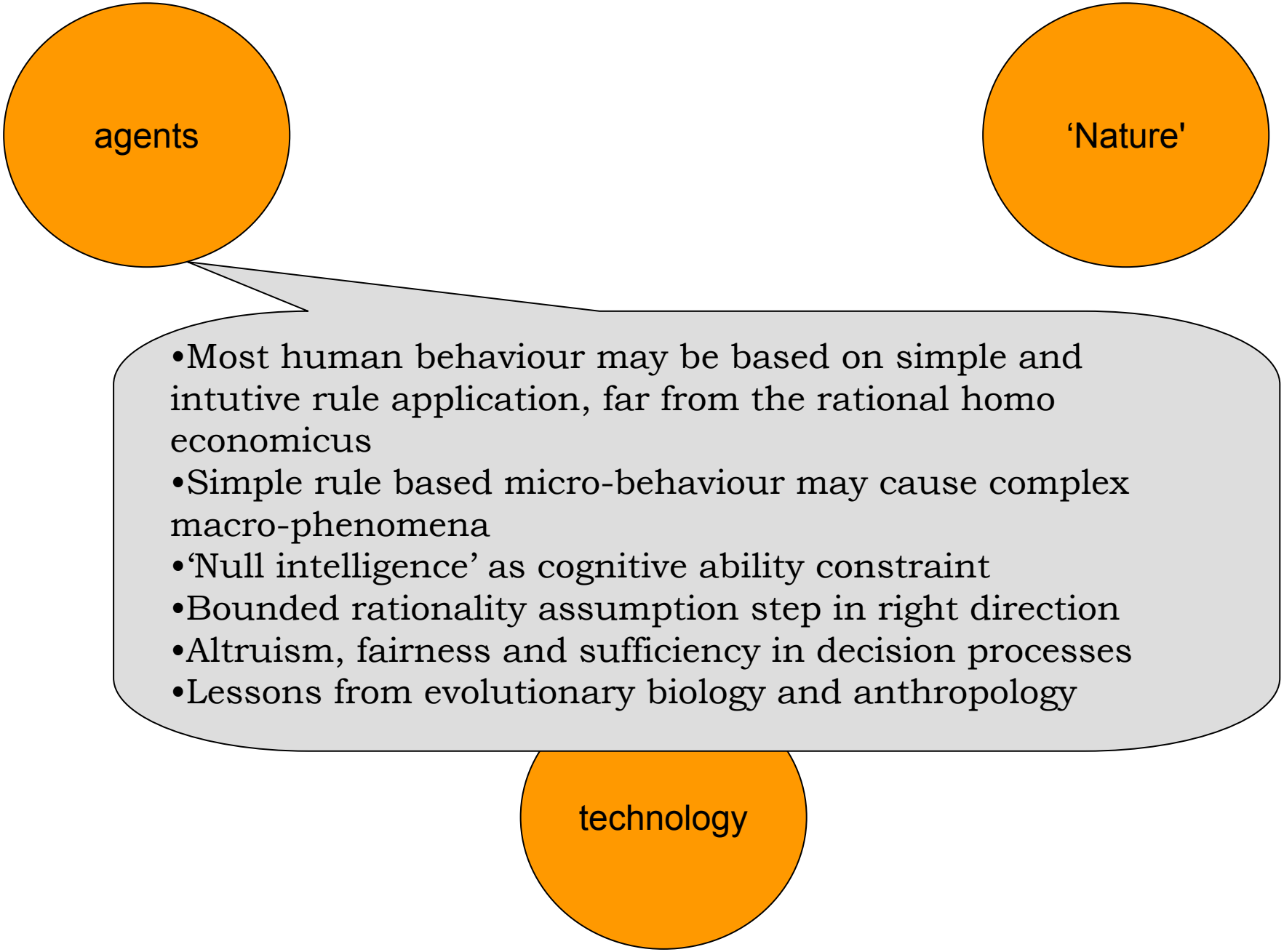
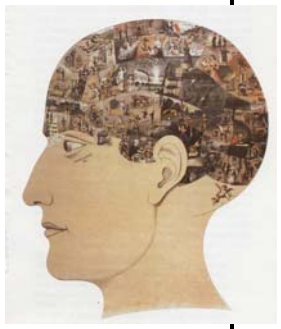
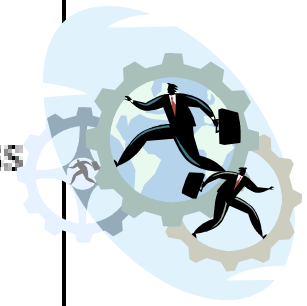



agents
'Nature'
•Most human behaviour may be based on simple and intutive rule application, far from the rational homo economicus
•Simple rule based micro-behaviour may cause complex macro-phenomena
•'Null intelligence' as cognitive ability constraint
•Bounded rationality assumption step in right direction
•Altruism, fairness and sufficiency in decision processes
•Lessons from evolutionary biology and anthropology
technology

Research challenge 2: From inner to outer, from ME to US





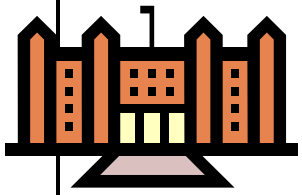


Figure 4: The 4-Quadrant map
(adapted fr[illegible]ber 2007a-b, [illegible]Ferber 2007)

Internal-Indiv[illegible]-I)	E[illegible]ndividual (E-I)
I → Subjectivity	It, This → Objectivity
< [illegible]l states, emotions, b[illegible] desires, intentions, cognition >	<agent behavior, obje[illegible]cess physical entities>
"Interi[illegible]	, exteriority"
[illegible]nternal-Coll[illegible]	[illegible]ective (E-C
[illegible] → Inter-Subjectivity	Them, All This → Objectivity
< sha[illegible]collective knowledge invisi[illegible]e social c[illegible]s and implicit ontologie[illegible]nal norms and conventi[illegible]	<re[illegible]ocial fac[illegible] and str[illegible], Organizations, Institutions>
"Noosphere"	"SocioSphere"

bridging micro and macro

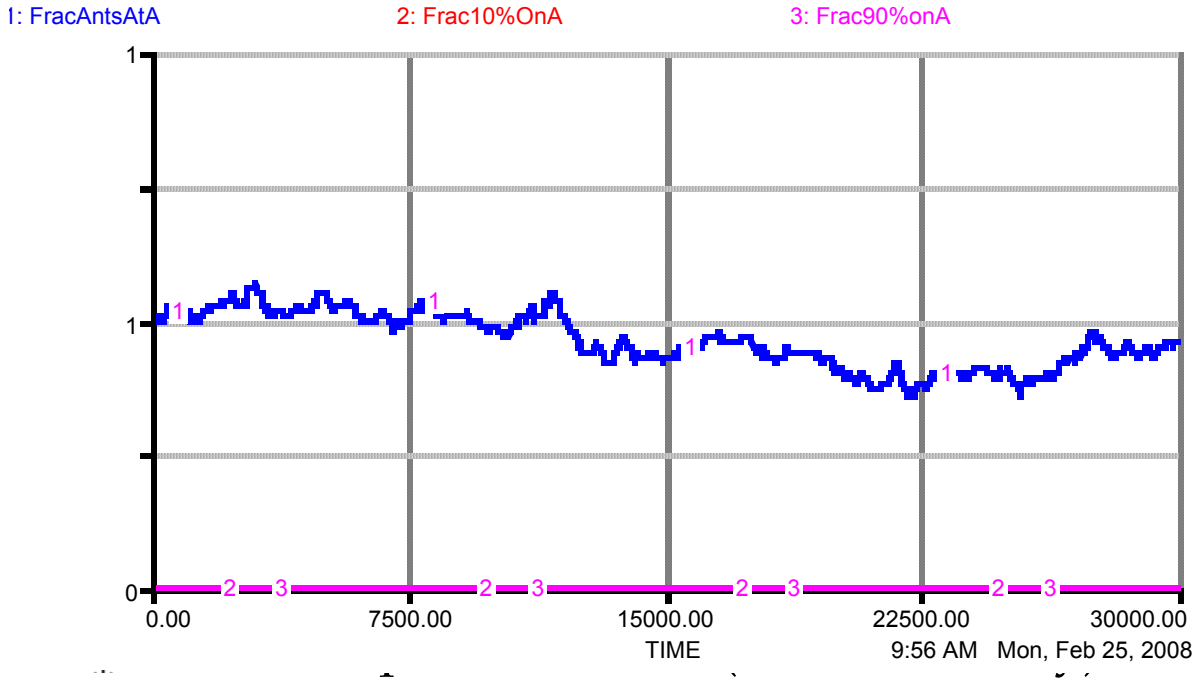
(Dessalles et al. 2007, Wilber 2000)

Internal-Individual (I-I)	External-Individual (E-I)
I→Subjectivity [mental states, emotions, desires, intentions, cognition] **"Interiority"**	It, This→Objectivity [agent behaviour, object process, physical entities] **"Observables, Exteriority"**
Internal-Collective(I-C)	**External-Collective(E-C)**
We→Inter-Subjectivity [shared/collective knowledge, invisible social codes and implicit ontologies, informal norms and conventions] **"Noösphere"**	Them, All this→Inter-Objectivity [reified social facts and structures, organizations, institutions] **"Sociosphere"**

humans:

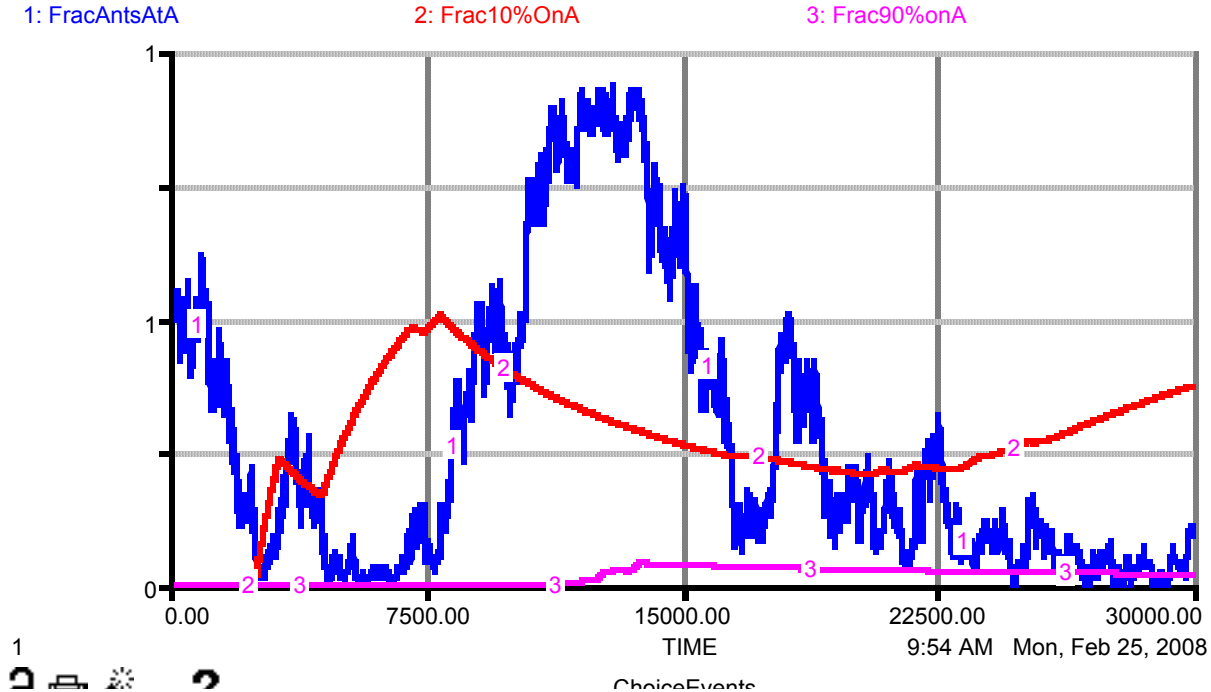
a source of complexity

(Ferber, in: Dessalles et al. 2007;Wilber 2000)



ce processes

If only the probability of individual ants play a role, there will be an average around 50-50%



tion, persuasion)

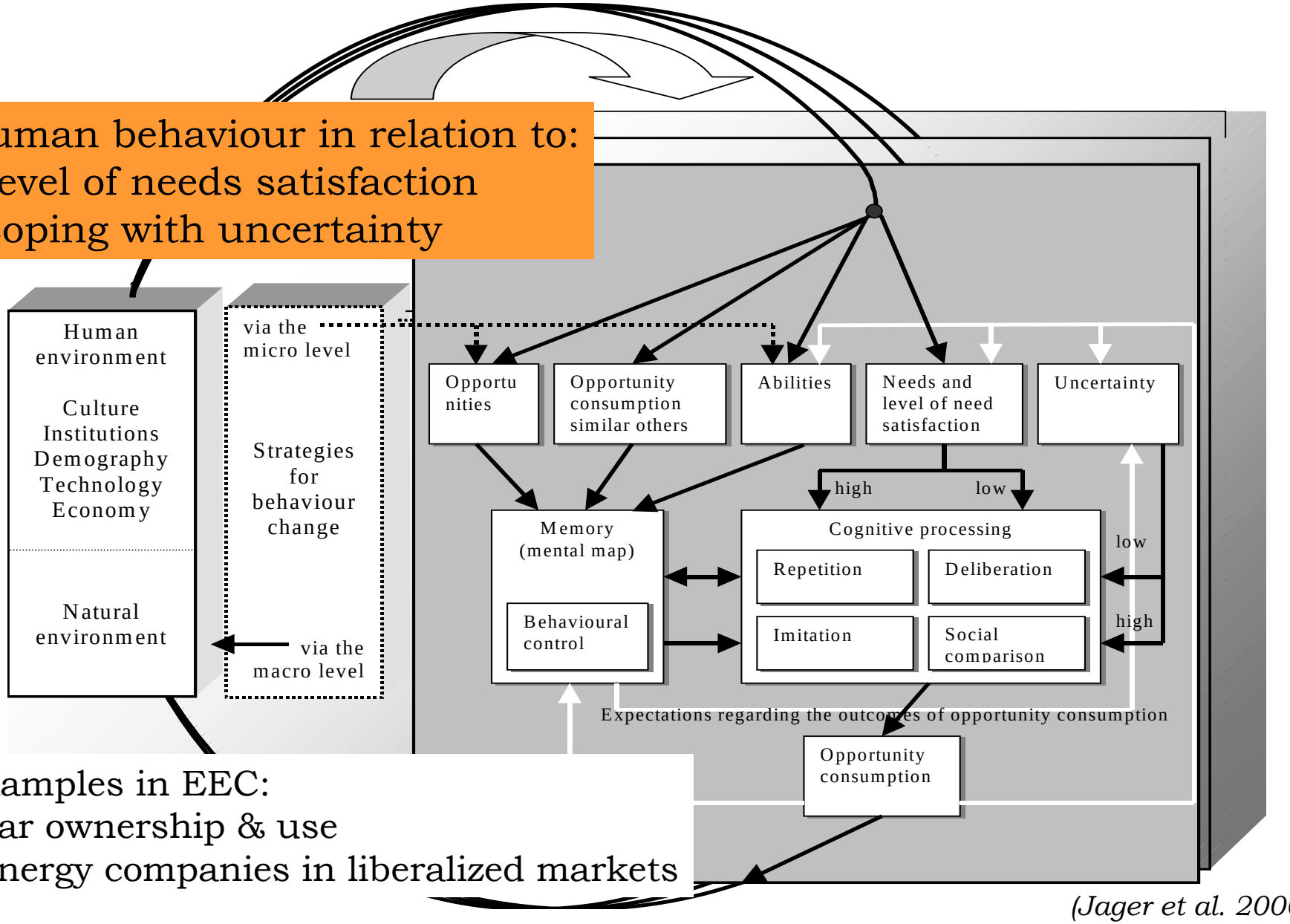
…but if encounters with other ants (interaction) plays a role, the behaviour may become very different (contagion)

(Kirman 1994, Ormerod 1998)

A set-up for multi-agent simulation (MAS)

insights from environmental psychology

Human behaviour in relation to:
- Level of needs satisfaction
- Coping with uncertainty



Examples in EEC:
- Car ownership & use
- Energy companies in liberalized markets

(Jager et al. 2000)

Evolutionary biology: adaptation dynamics

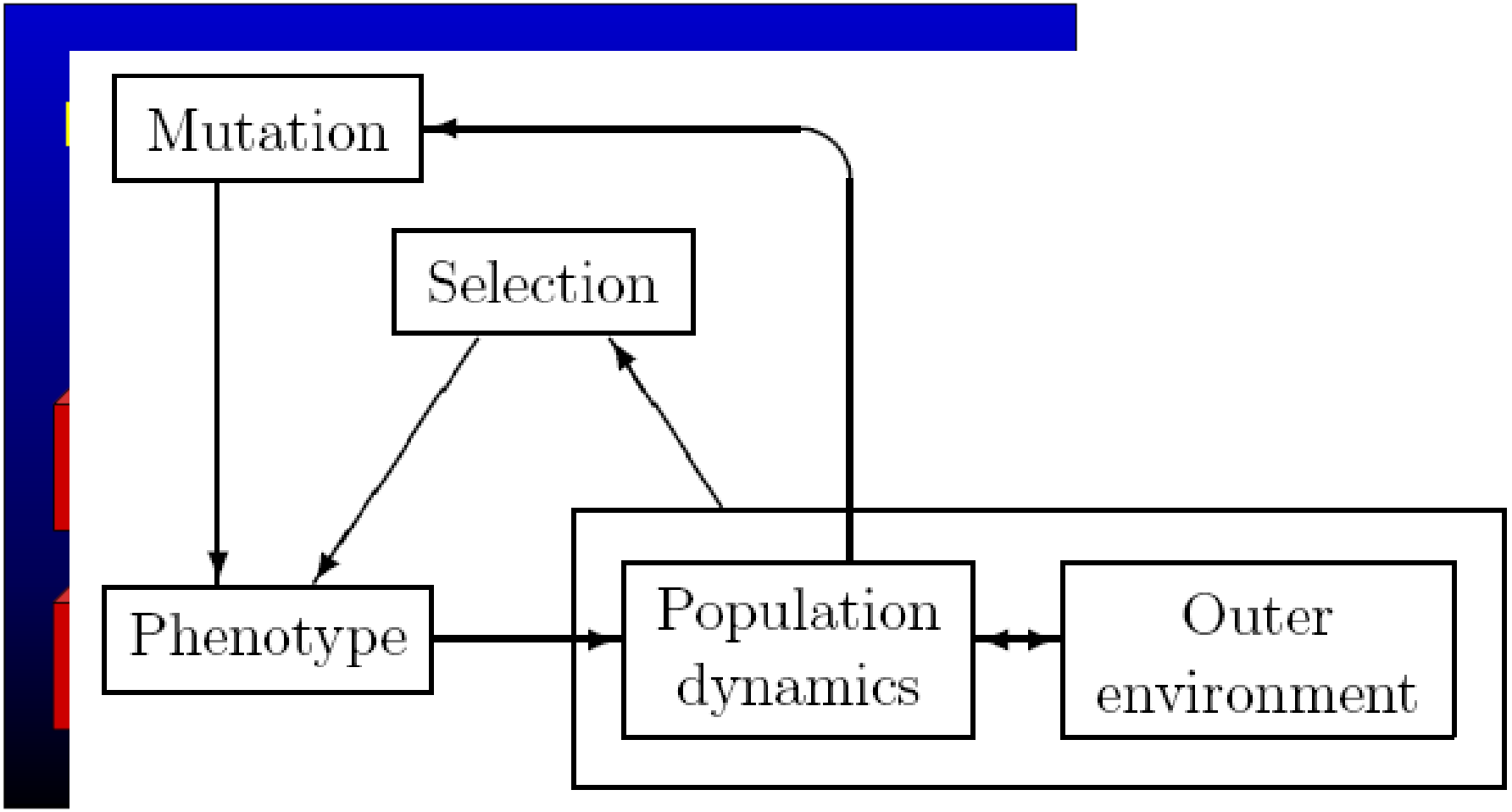
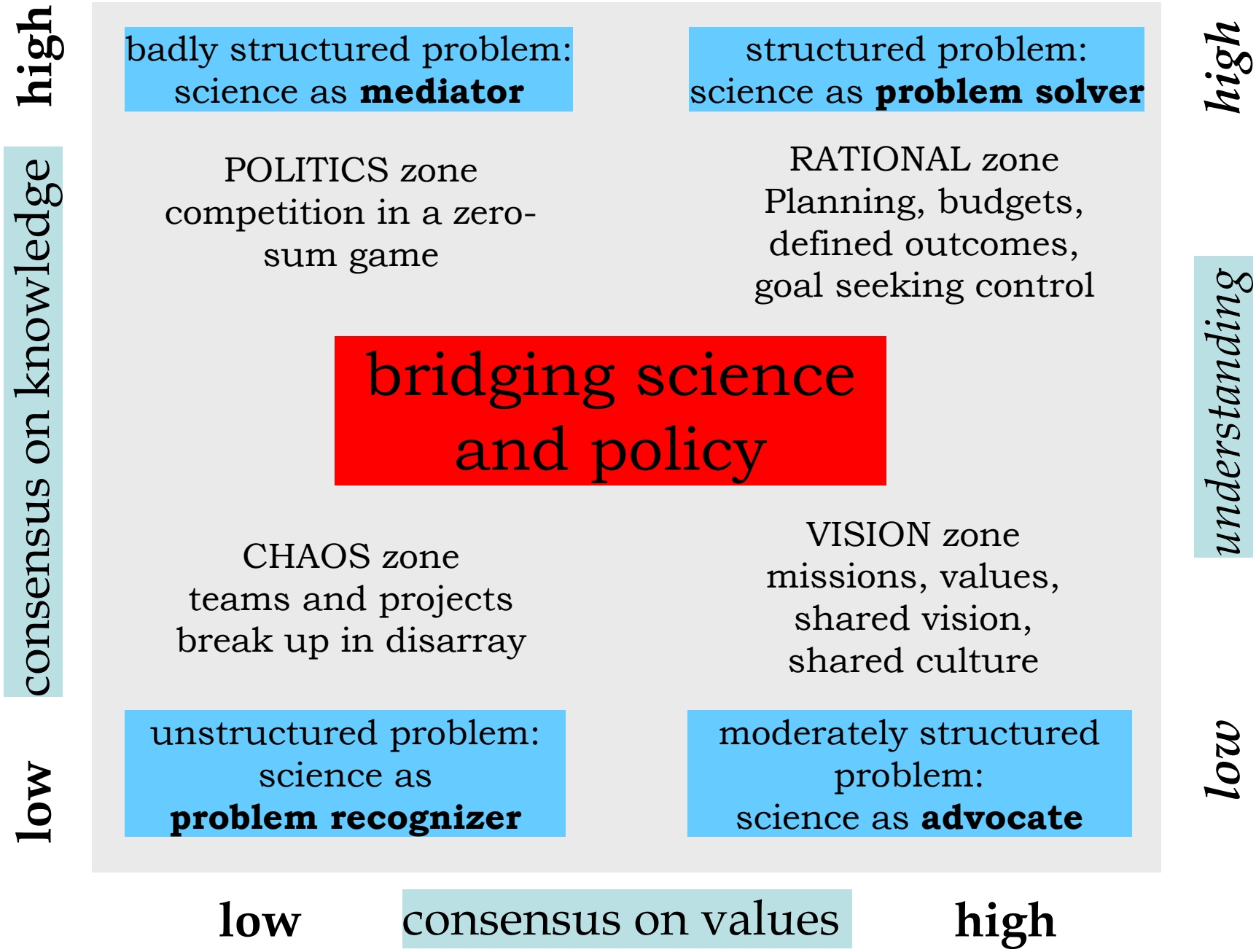


FIG. I.2 – *Modelling principle of adaptive dynamics.*

(Dieckmann 2002, Champagnat 2004)

Research challenge 2: supporting macro-problem decisionmaking



Dialogue in value and knowledge dis/consensus

low *agreement* ***high***

high consensus on knowledge **low**

high *understanding* *low*

badly structured problem: science as **mediator**

Politics zone
Competition in a zero-sum game

structured problem: science as **problem solver**

Rational zone
Planning, budgets, defined outcomes, goal seeking control

Chaos zone
Teams and projects break up in disarray

Vision zone
Missions, values, shared vision, shared culture

unstructured problem: science as **problem recognizer**

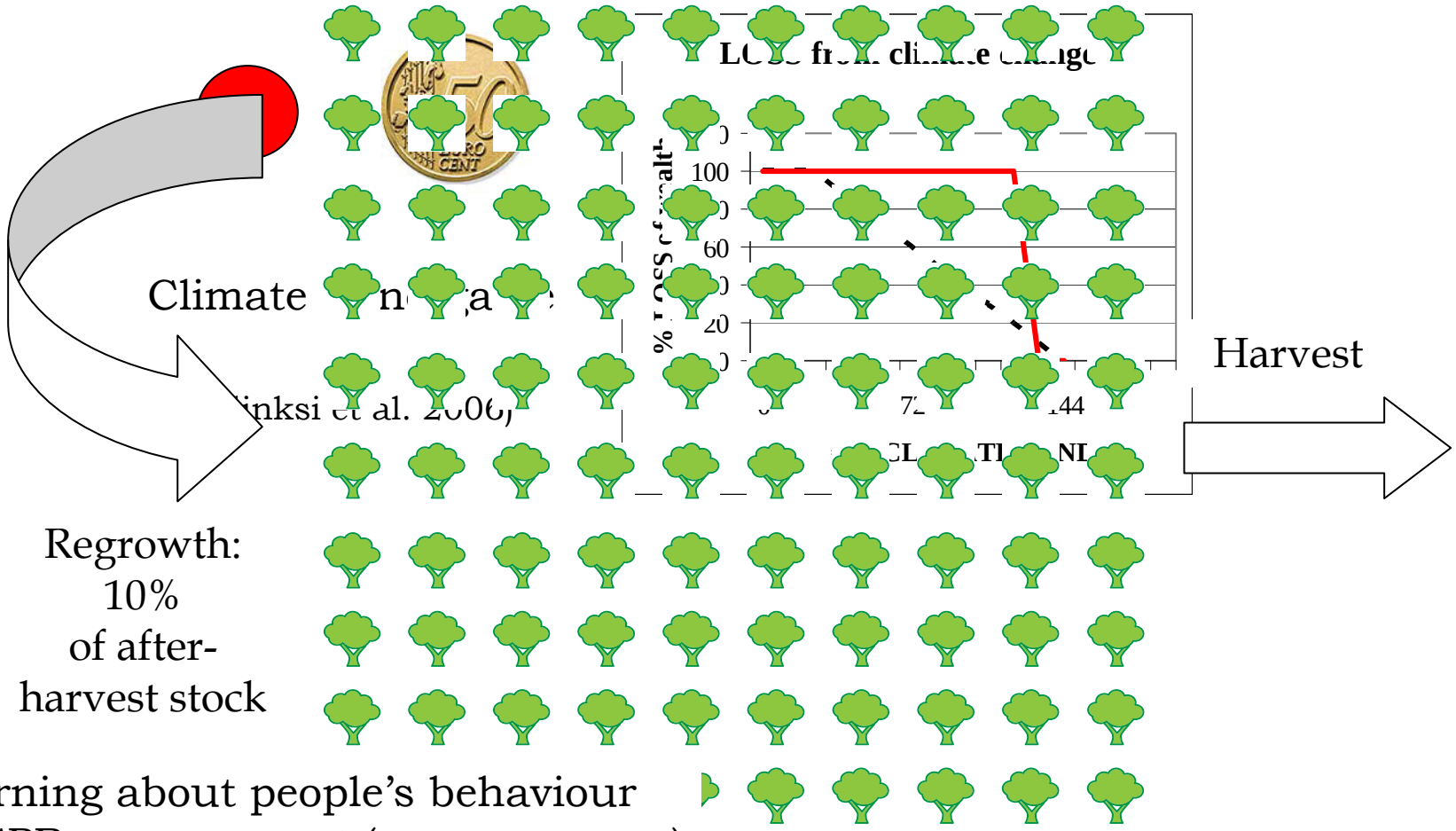
moderately structured problem: science as **advocate**

low consensus on values **high**

(De Vries 2006)

Example interactive model/game:

- Governing the commons: cooperation and competition
- Web-based interactive (EEC) games and surveys
- Web-based interactive (EEC) models e.g. GET



Learning about people's behaviour
In CPR-management (coop vs. comp)

(see e.g. Ostrom, Janssen and Bousquet, Sterman…)

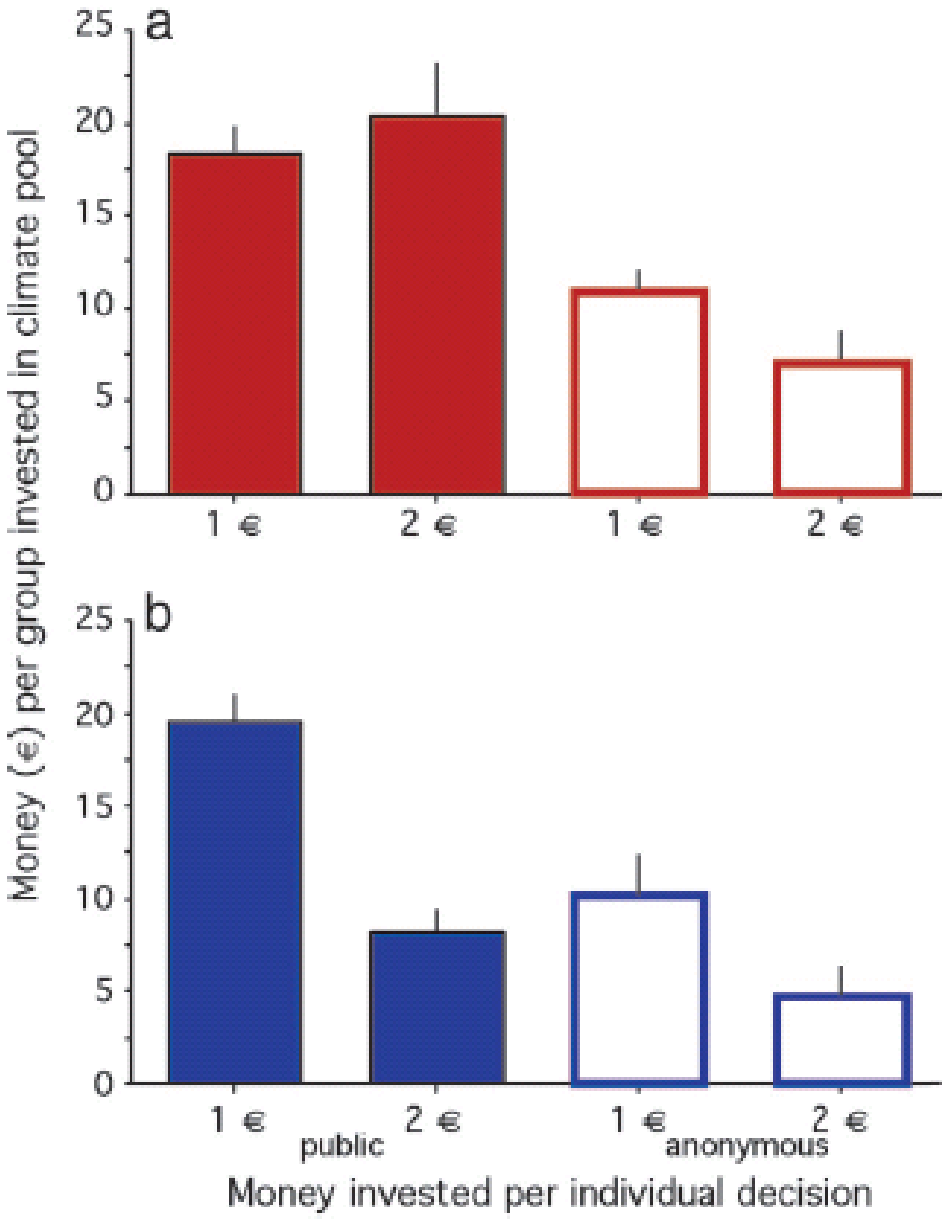


Fig. 3. Money (€) per group of six subjects invested in the climate pool. The mean (±SEM) sum of money invested in €1 and €2 contributions both in nonanonymous (filled) and anonymous (open) climate public goods rounds is shown. (*a*) Well-informed groups. (*b*) Little-informed groups.

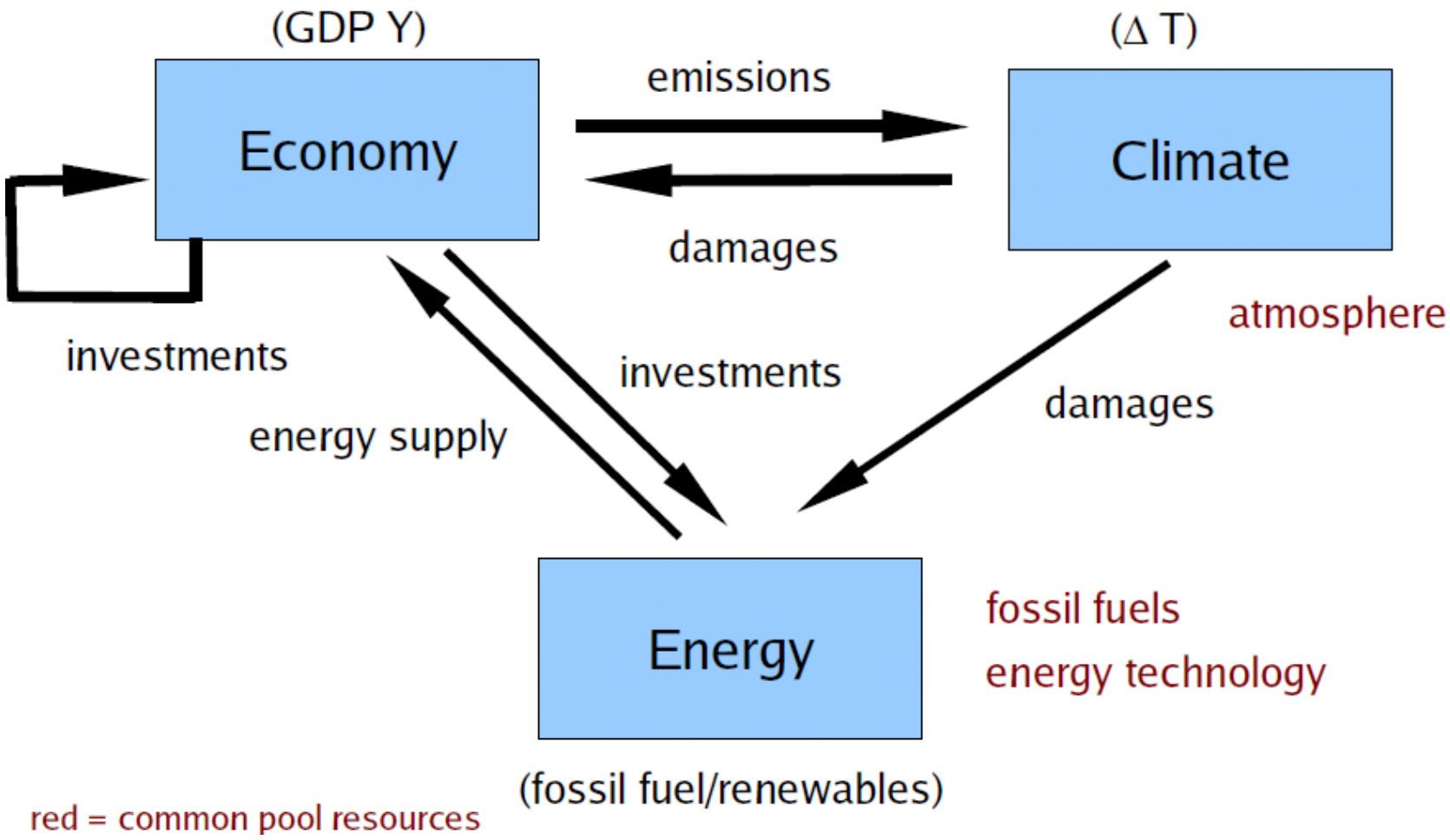
Where does cooperation enter the behavioural repertoire of producers and consumers?

Interactive web-based models and games may provide insights into people's worldviews and behaviour

(cf. experimental and behavioural economics)

Milinski et al. 2006

Economy-Energy-Climate Model



Brede and De Vries 2009

Conclusions

- Potentially huge differences between collaborative and competitive management!
  - threshold-like separation of different regimes
- Different resource use patterns in collaboratively/competitively managed worlds; competition leads to
  - a tendency to a hastened growth of oversized fossil fuel based economies
  - "overuse" of fossil fuel resources (even without climate change)
  - trend to very abrupt energy transitions

Examples of new directions:

- IMACLIM-R model: dealing with readjustment dynamics and inertia, and reinforcing links between technology and economic data
- WITCH model: linking energy system endogenously to economic development (hybrid), and putting economic development, and climate policy in an international strategic (game) context
- MADIAM model: dealing explicitly with behavioural diversity of producers and consumers and investing in labour skills, in combination with a climate change response model
- GISMO-model: considering explicitly links between investments in education and health, within a dynamic population model, to assess MDGs in an economy-environment IAM-setting
- Etc.

What to expect from these developments?

Branching of economic science: resource economics, environmental economics, ecological economics, institutional economics, structural economics evolutionary biology, economic psychology, experimental and behavioural economics…

1. Better assessment of **risks and uncertainty** of resource (over)exploitation may improve individual and collective decisionmaking
2. An enriched **image of (wo)man** in our models will broaden the scope of the possible and the desirable
3. Interactive simulation models and games can deepen understanding and **enlarge engagement** of citizens in macro-issues

The new directions indicated above should be given a place in a DIALOGUE and NARRATIVE setting.

Key questions now:

•How to engage people as stakeholders in an issue (climate change) with large costs and benefits, unequally divided in necessary efforts and potential damages, and long-term

•How to find cooperative strategies/coalitions in an inherently competitive and/or protectionist world with still huge aspirations for a (better) material quality of life?

Subsequently:

•Which role can the scientific [EEC-modelling] community play?

•Model improvements: behavioural depth, technolical regimes, socio-cultural and income (HI-LI) differences, nature of €-growth…

•New frames and methods: evolutionary game theory, agent-based modelling, interactive web-based model use, negotiotation platform…?

•If we know the answer, how then to become more effective in the actual policy processes?

Directions for answers:

1. Investigate the diversity in physical and economic circumstances in which people live and respect these, as part of NARRATIVES and DIALOGUE

2. Investigate the values (concerns) and mental maps (interpretations) and respect these, as parts of a DIALOGUE

3. Develop scientific tools which can support such a DIALOGUE, e.g. interactive simulations/games and agent-based models

4. Make explicit, creative NARRATIVES about particular groups and regions, using participatory methods and simulation model support, as part of policy design and implementation efforts at all scales

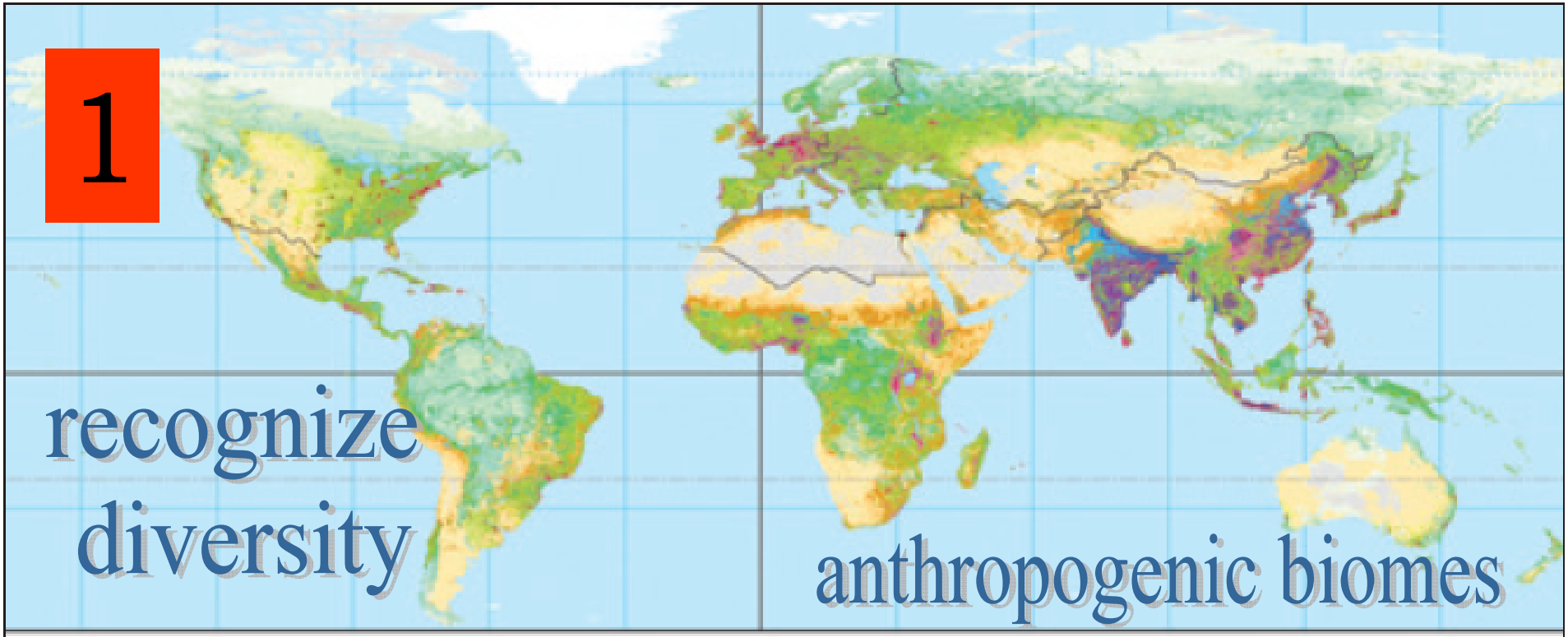
5. On the mitigation side, this demands large-scale efforts into RD&D projects on energy efficiency, renewables and other options

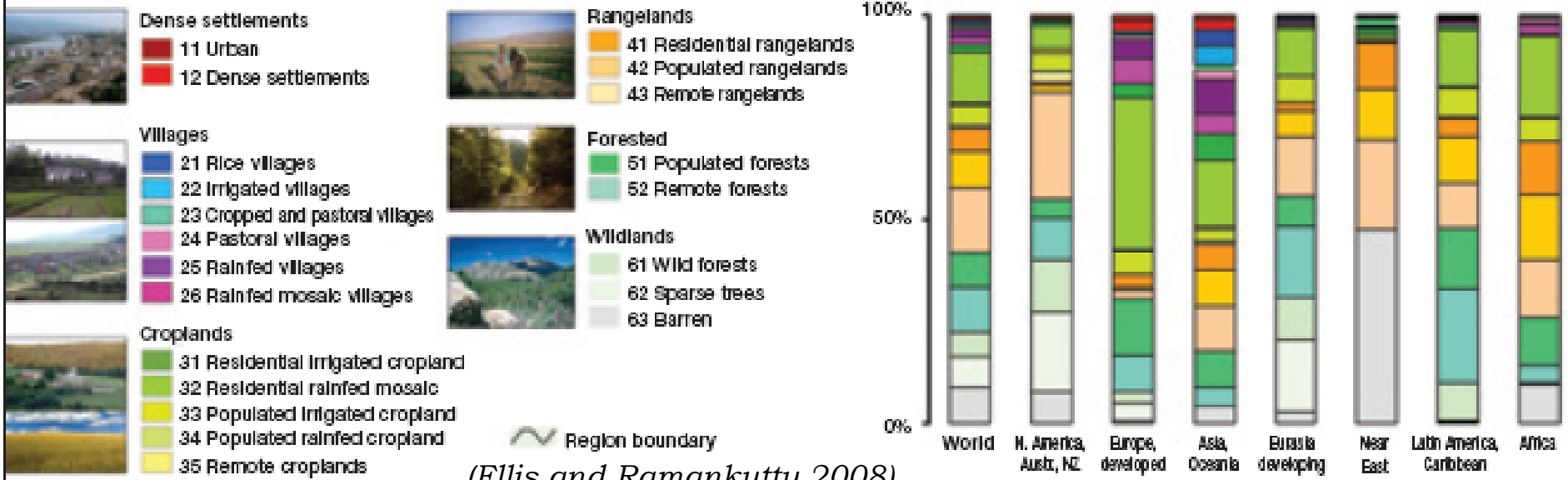
6. On the adaptation side, it should be part of the aspirations as expressed in the Millennium Development Goals (MDGs)

1

recognize diversity

anthropogenic biomes





(Ellis and Ramankutty 2008)

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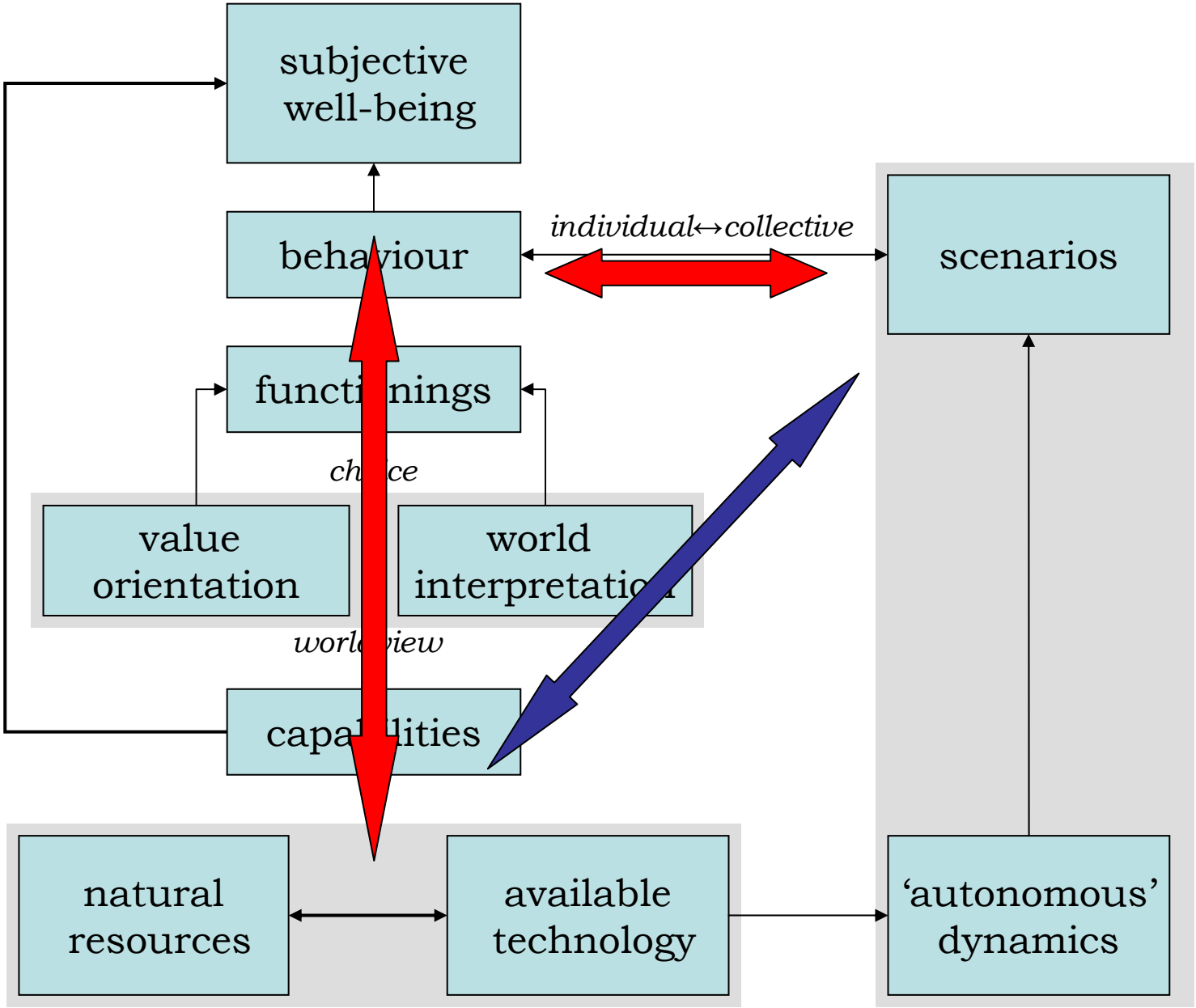
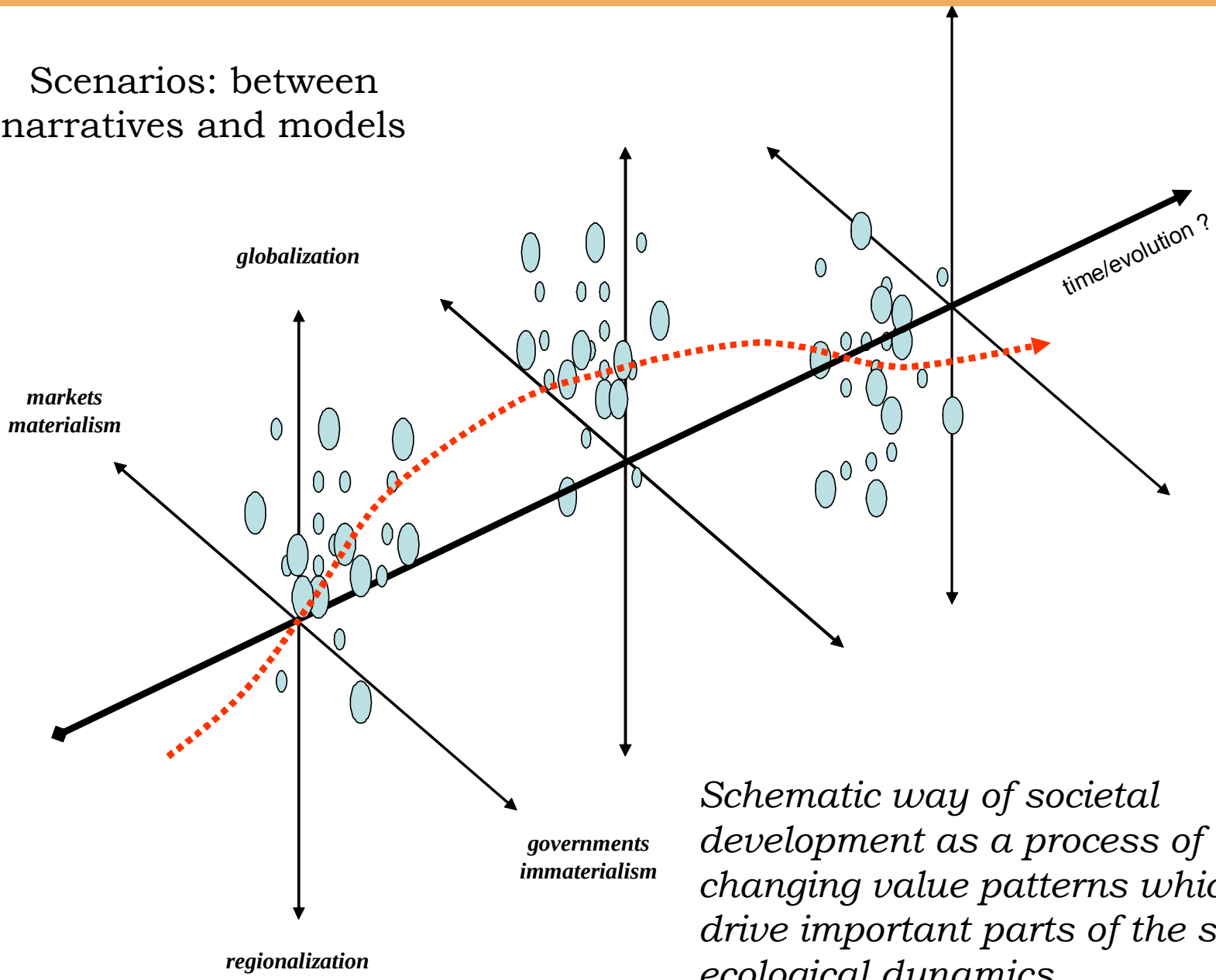


think plurally and inclusively

(De Vries and Petersen 2008)

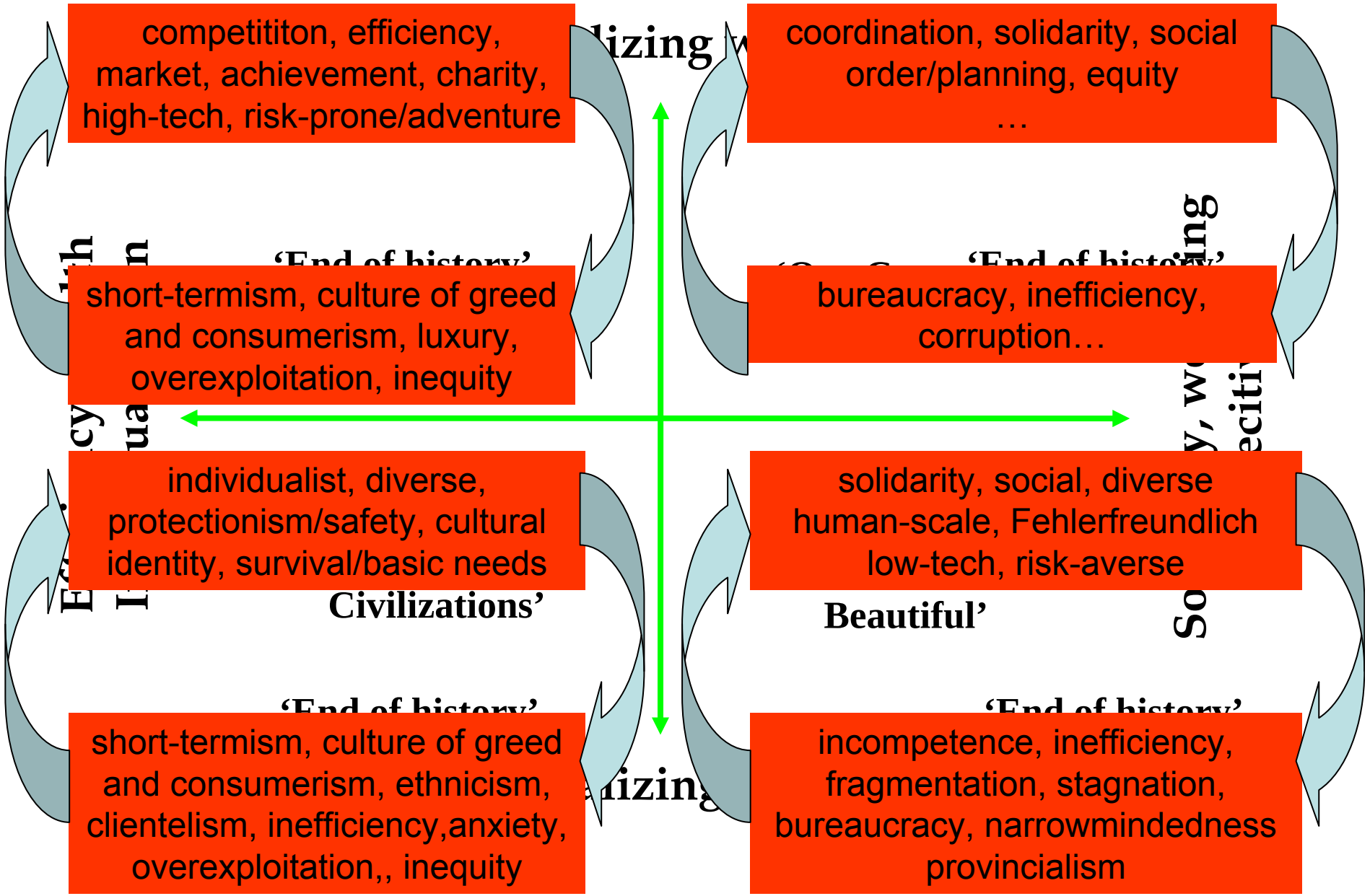
Storylines : evolution over time

Scenarios: between narratives and models



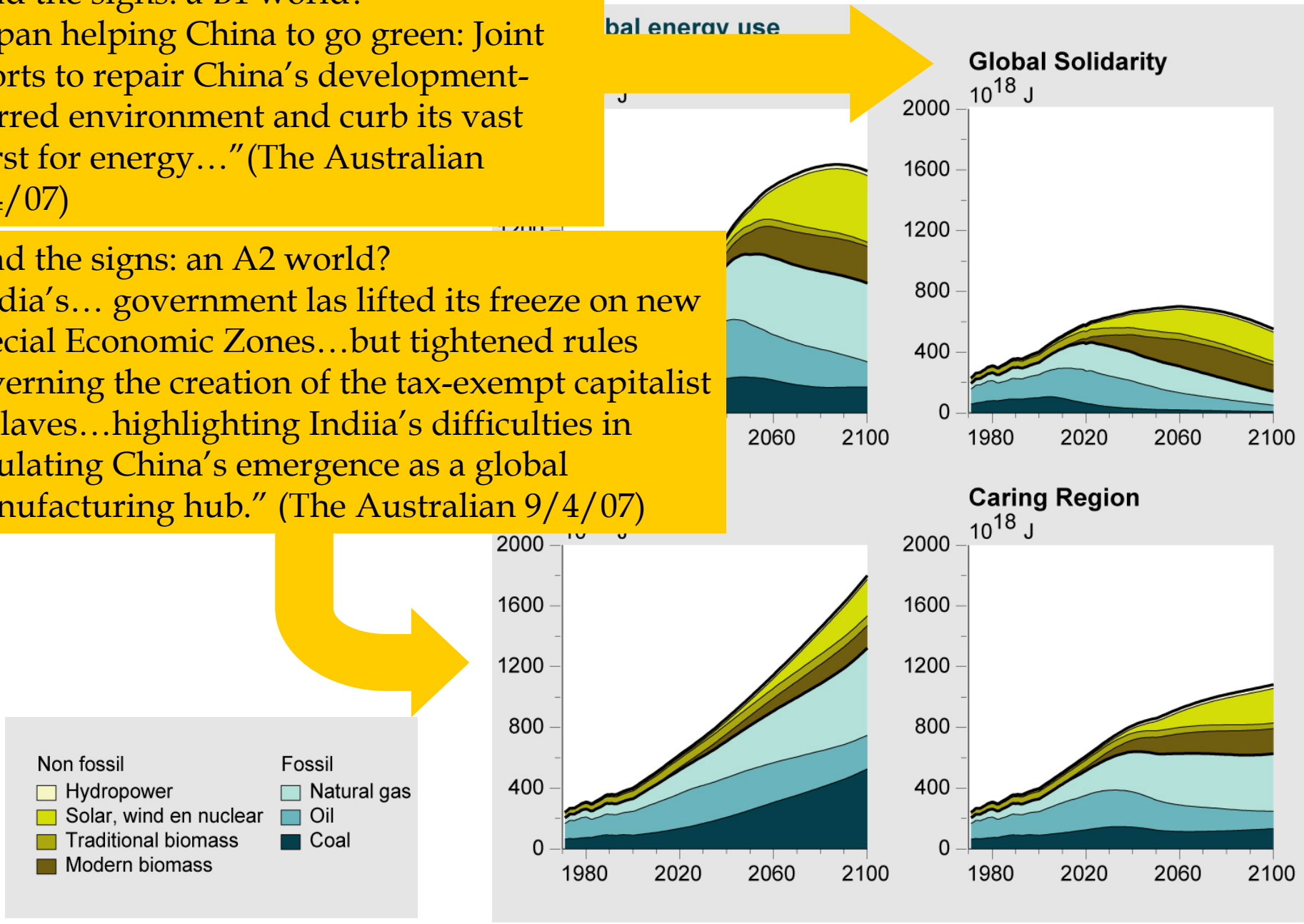
Schematic way of societal development as a process of changing value patterns which drive important parts of the social-ecological dynamics

Narratives and societal dynamics



Read the signs: a B1 world?
"Japan helping China to go green: Joint efforts to repair China's development-scarred environment and curb its vast thirst for energy…"(The Australian 9/4/07)

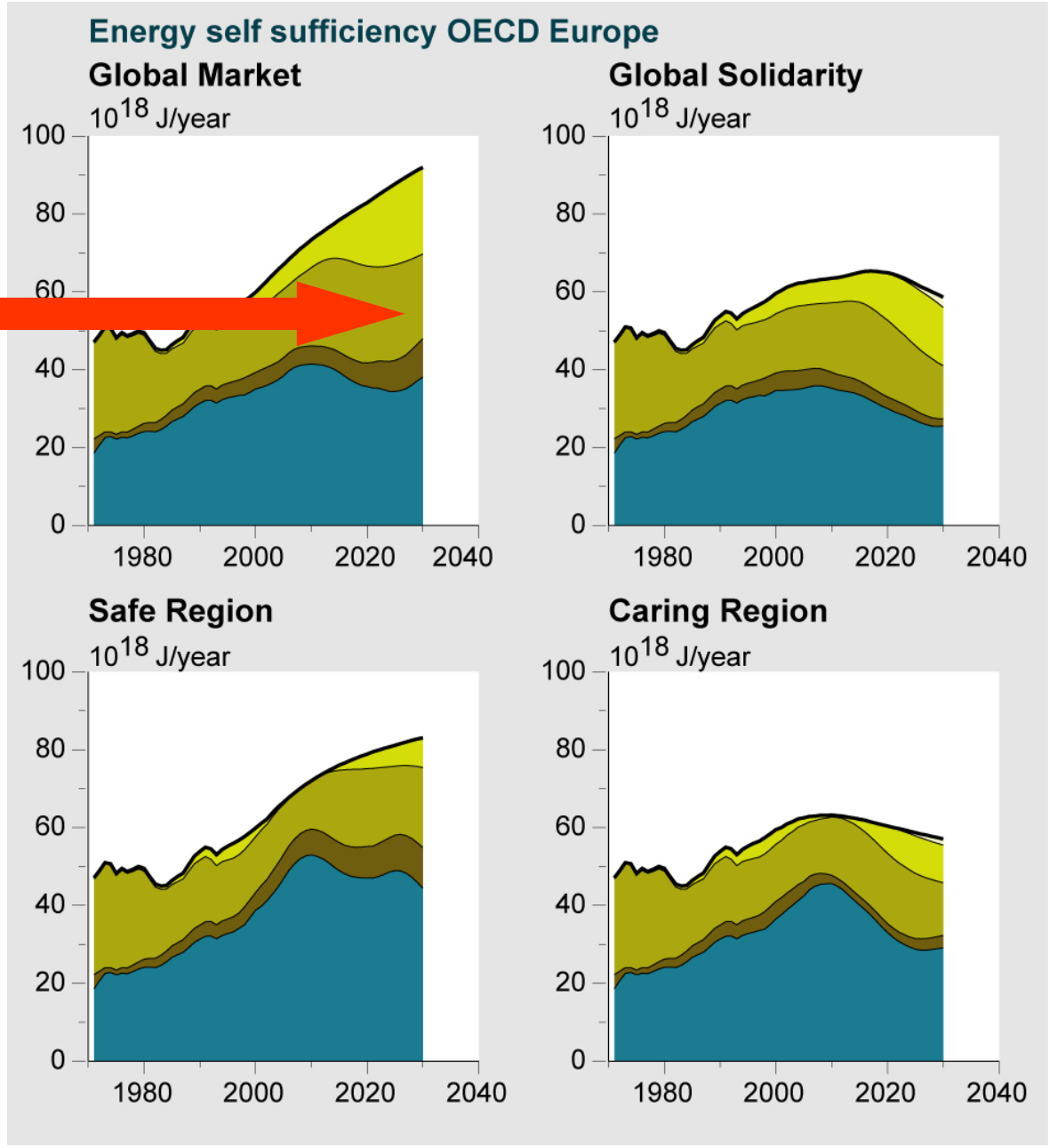
Read the signs: an A2 world?
"India's… government las lifted its freeze on new Special Economic Zones…but tightened rules governing the creation of the tax-exempt capitalist enclaves…highlighting Indiia's difficulties in emulating China's emergence as a global manufacturing hub." (The Australian 9/4/07)



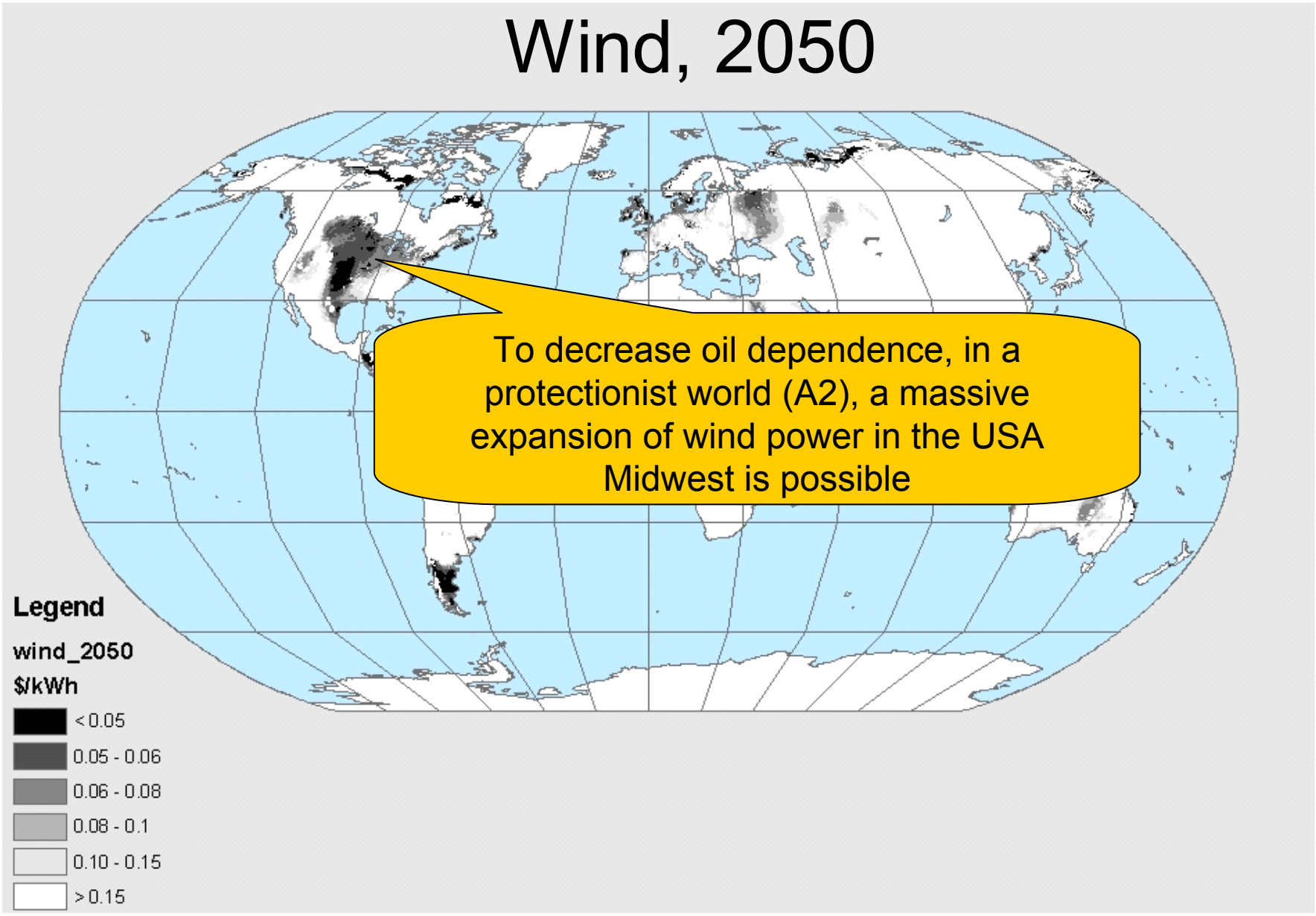
Four scenarios for the world energy supply. Source: Duurzaamheidsverkenning RIVM 2004

OECD Europe energy use

European dependency on oil/gas imports largest in high-growth future (A1)

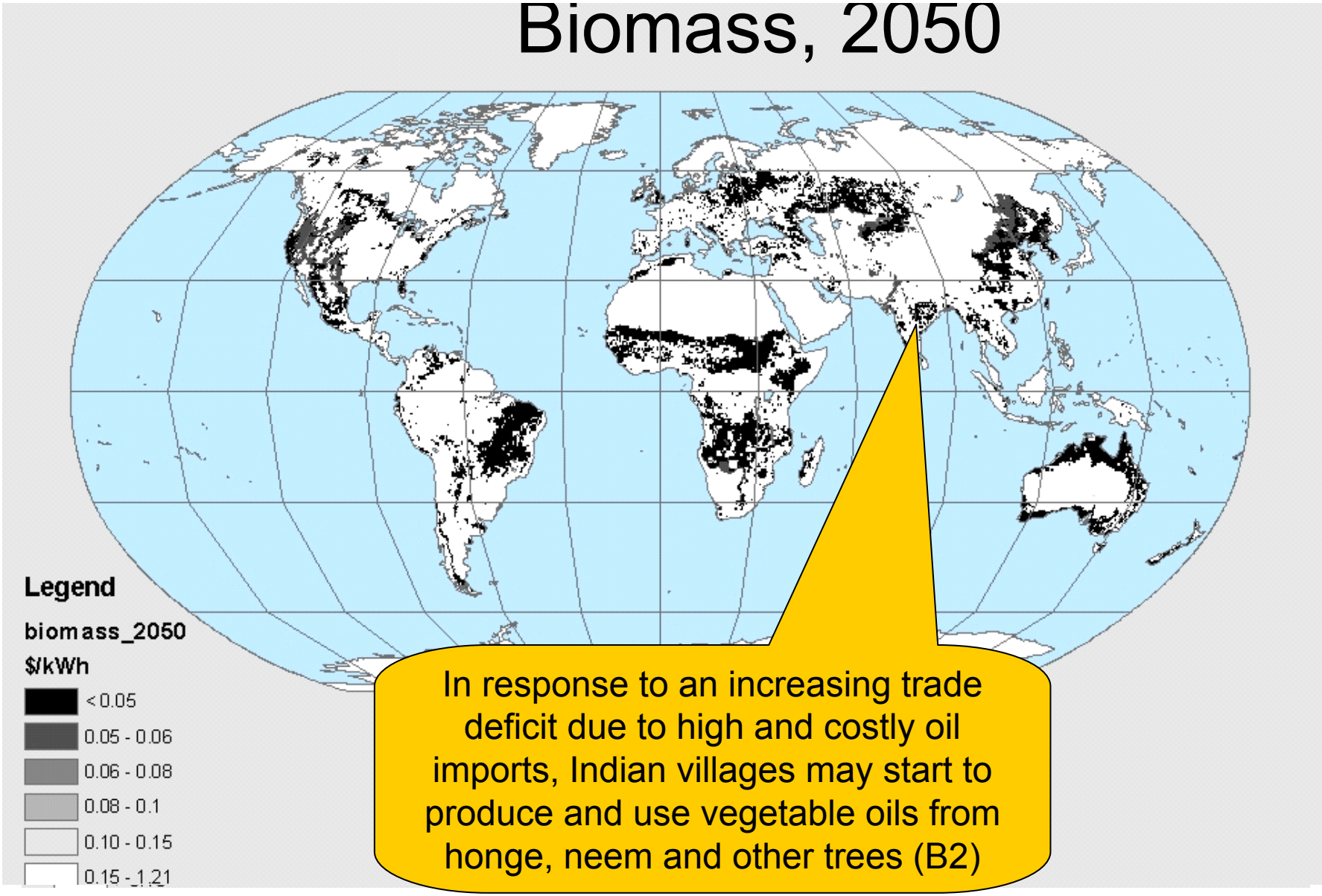


Wind, 2050

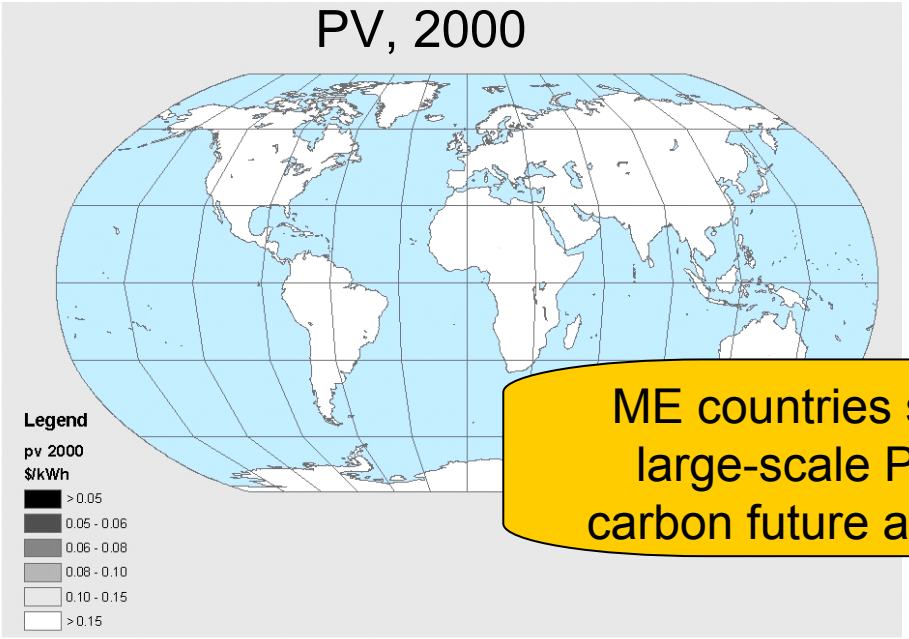


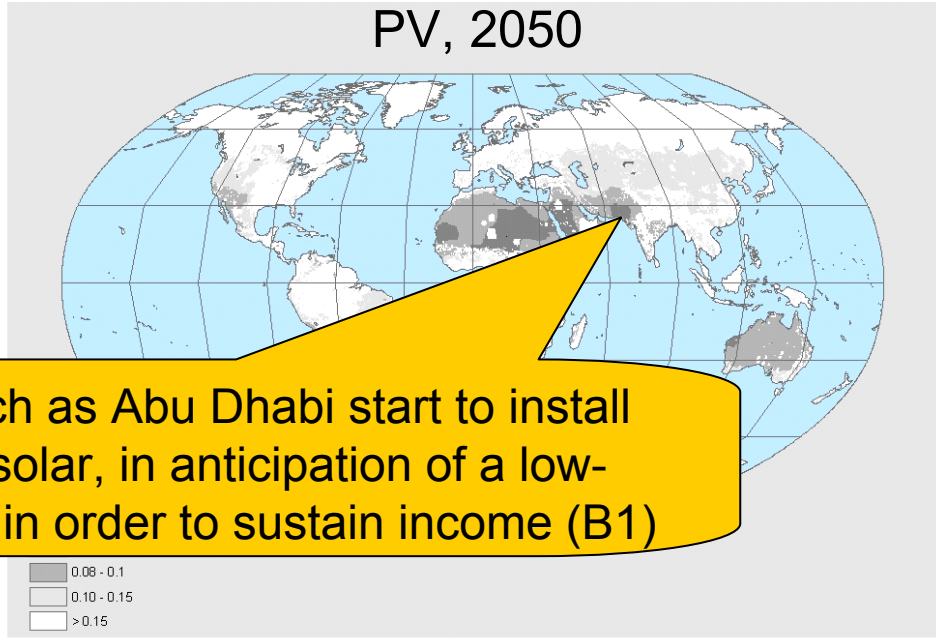
Electricity from wind: how much, where and at which costs…

Biomass, 2050



Electricity from biomass: how much, where and at which costs?



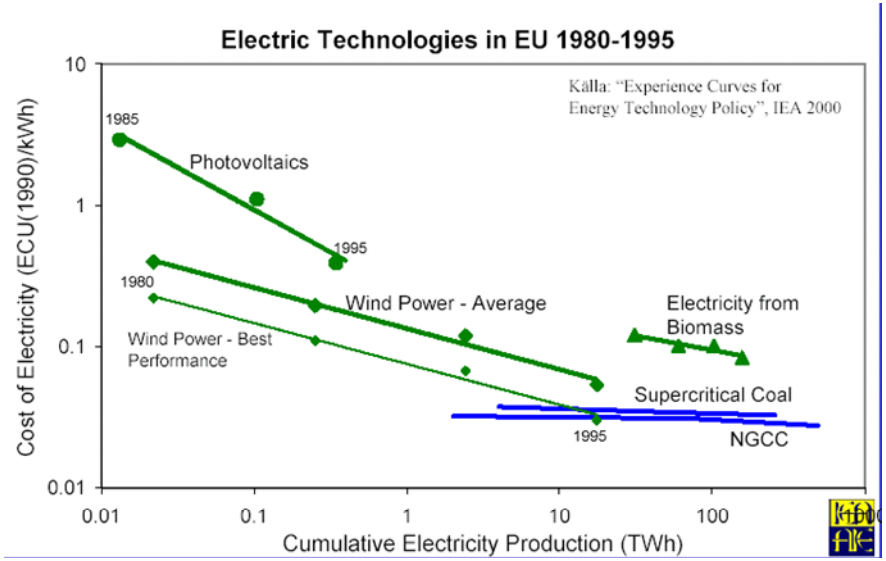


ME countries such as Abu Dhabi start to install large-scale PV solar, in anticipation of a low-carbon future and in order to sustain income (B1)

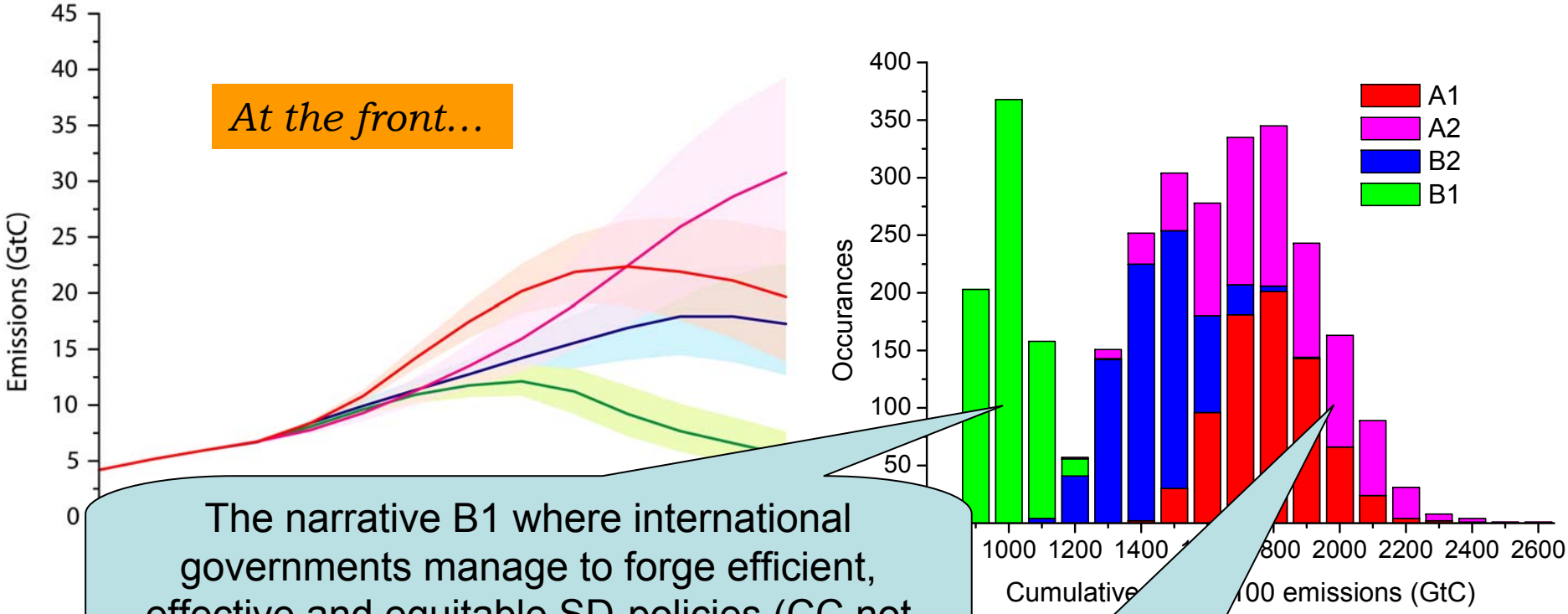
Electricity from PV-solar: how much, where and at which costs?

As of 2005 solar-PV electricity is not available at cost < 0,15 $/kWh
With the exception of some small niche markets.

This may change with continuing learning-by-doing and economies-of-scale cost reductions.




Dank voor uw aandacht
Merci pour votre attention
Thank you for your attention
Danke für Ihre Aufmerksamkeit



At the front…

The narrative B1 where international governments manage to forge efficient, effective and equitable SD-policies (CC not excplicitly included)

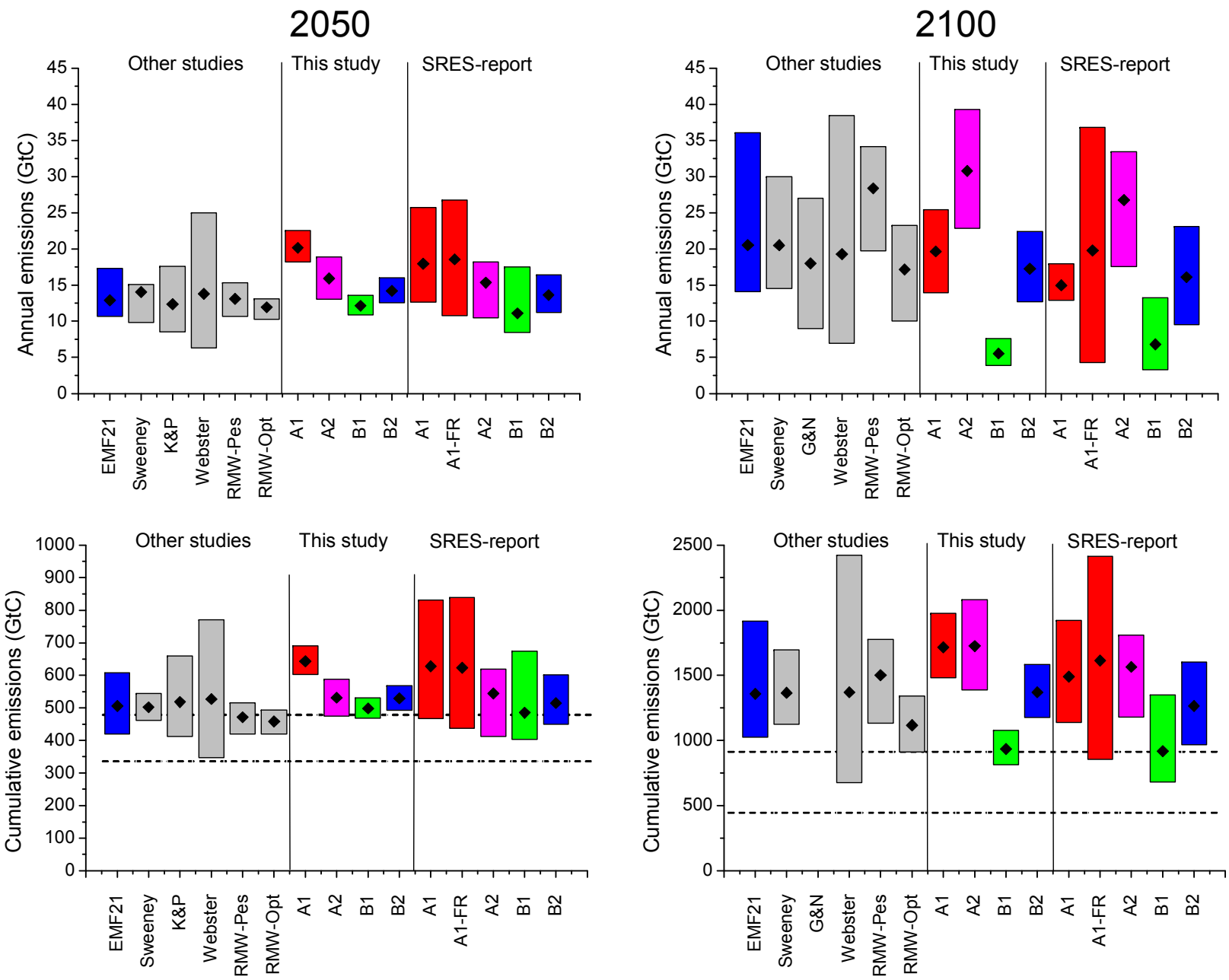
nergy chain:

Conditional probabilisti ch

Calculated C- for four storylines (lef d C- emissions in t four storylines (rig

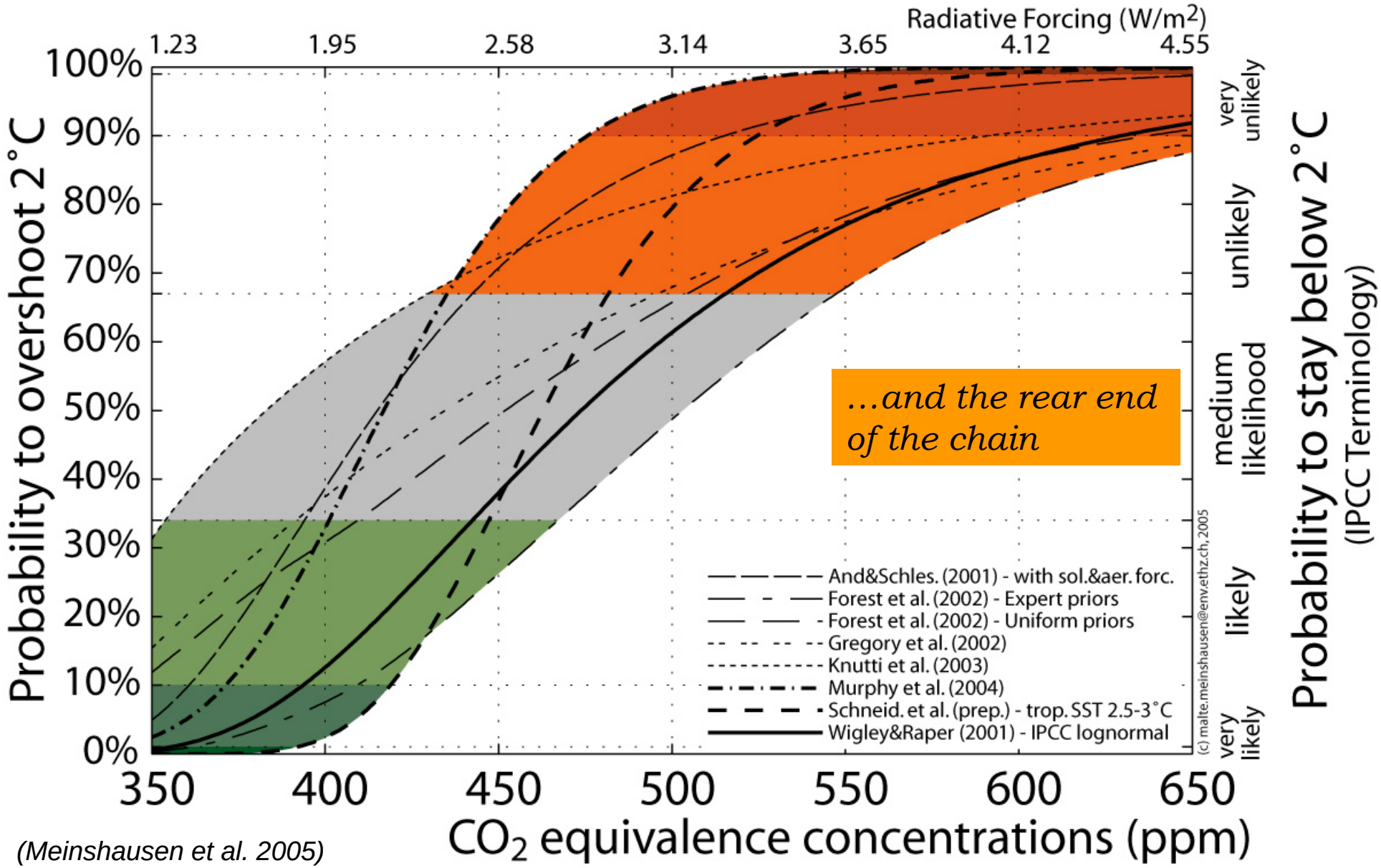
The narrative A2 where protectionism and nationalism, including search for socio-cultural identity, cause technological stagnation, slowdown of demographic transition – and high fossil fuel use and deforestation

(Van Vuuren et al. 2007)

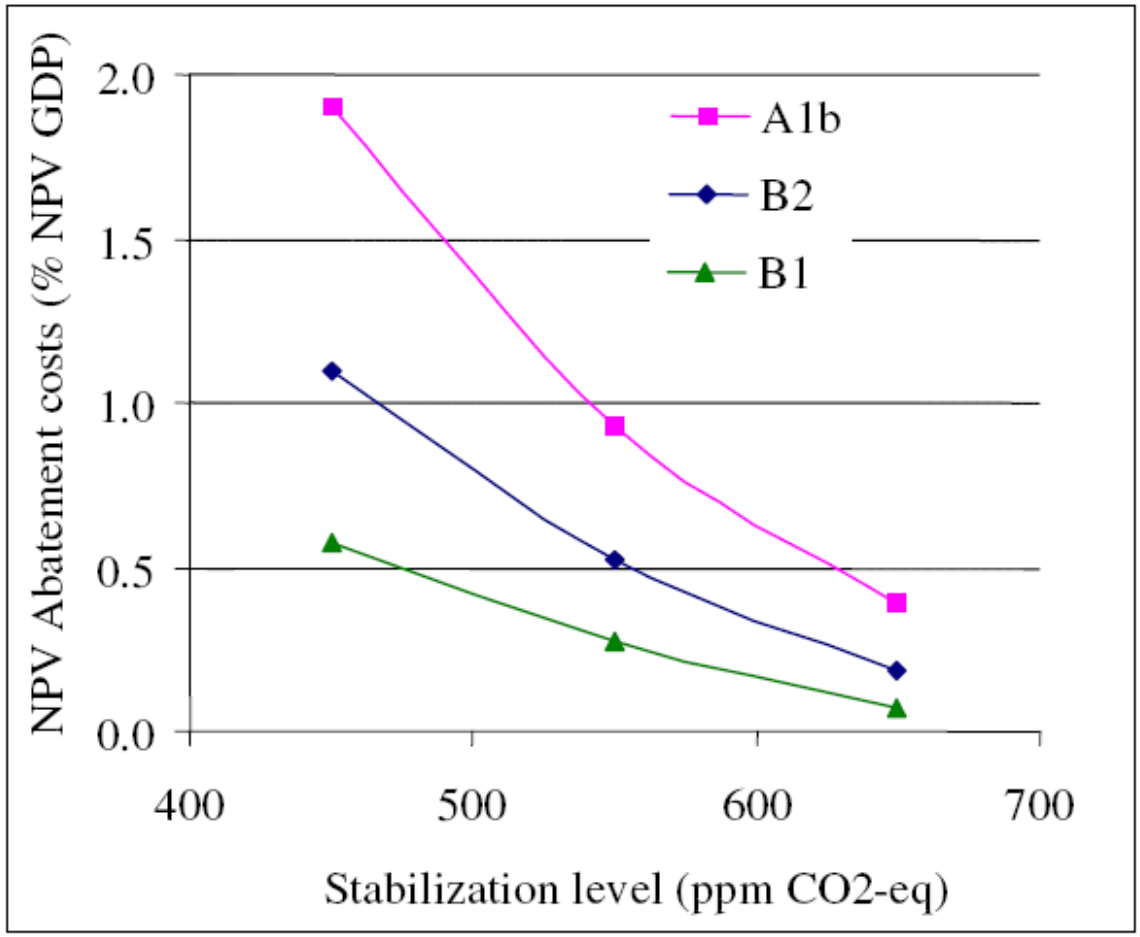


(Van Vuuren et al. 2007)

Probability to overshoot 2°C



(Meinshausen et al. 2005)



To reach targets will require inputs…

The pay-off matrix with cost and benefits

Figure 7.8: Net Present Value (NPV) of abatement costs for different stabilization levels as percentage of the NPV of GDP, starting from different baseline scenarios (discount rate 5%).

(Van Vuuren et al. 2008)

Energy use and GHG Mitigation and Abatement:

•Understand energy demand/use: role of price and innovations, lifestyle and worldview aspects…

•LDC: role of latent demand, relationship with income distribution

•Renewable energy potential and implementation: local factors, energy ladder (traditionals), GIS-based analyses…

•Transport: private-public interaction and infrastructure, role of ICT

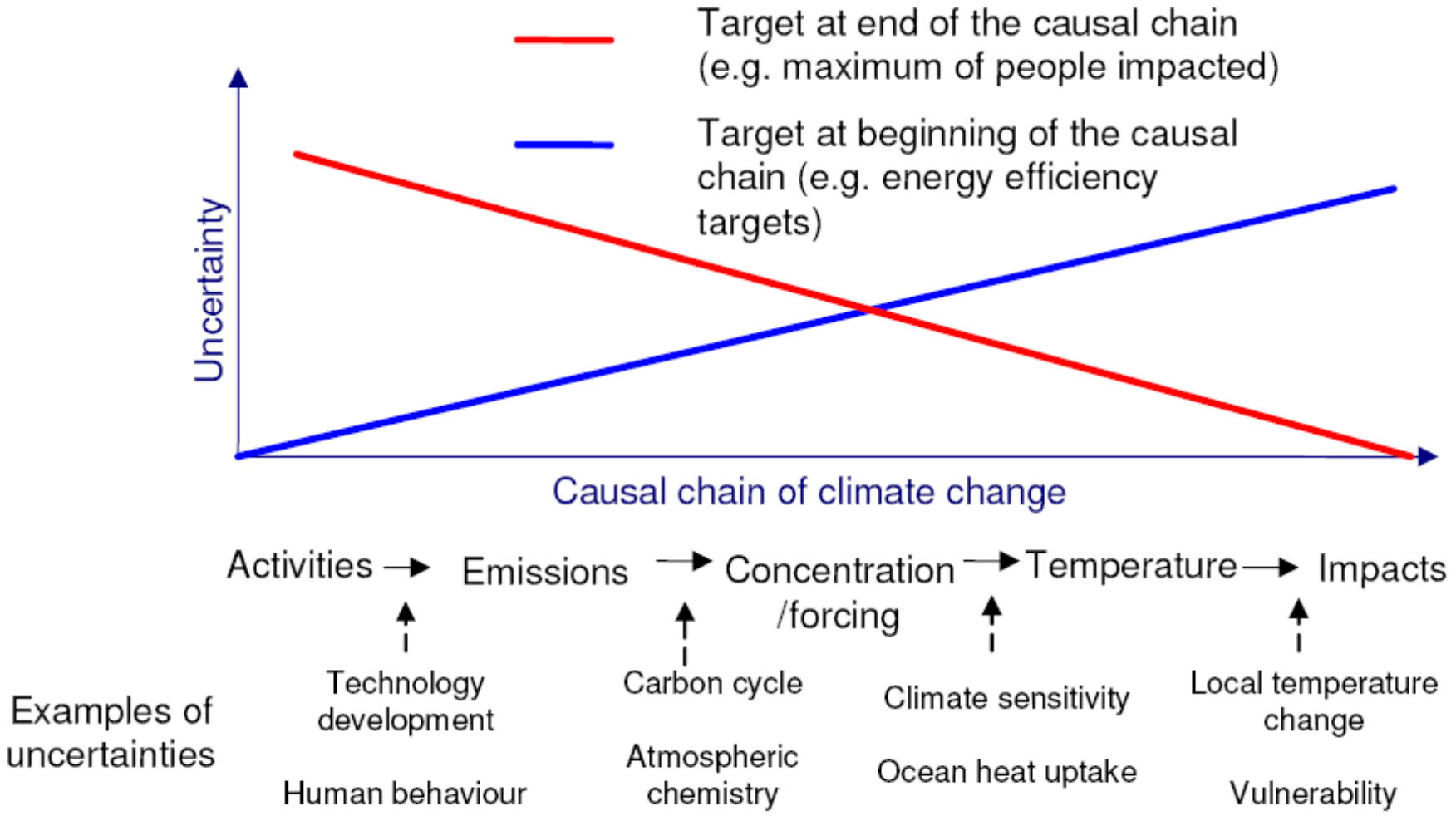
Energy supply and decarbonization:

•CCS and nuclear: in which future and under which conditions?

•Interaction central and decentral options (electric car, micro-CHP, fuel cell…)

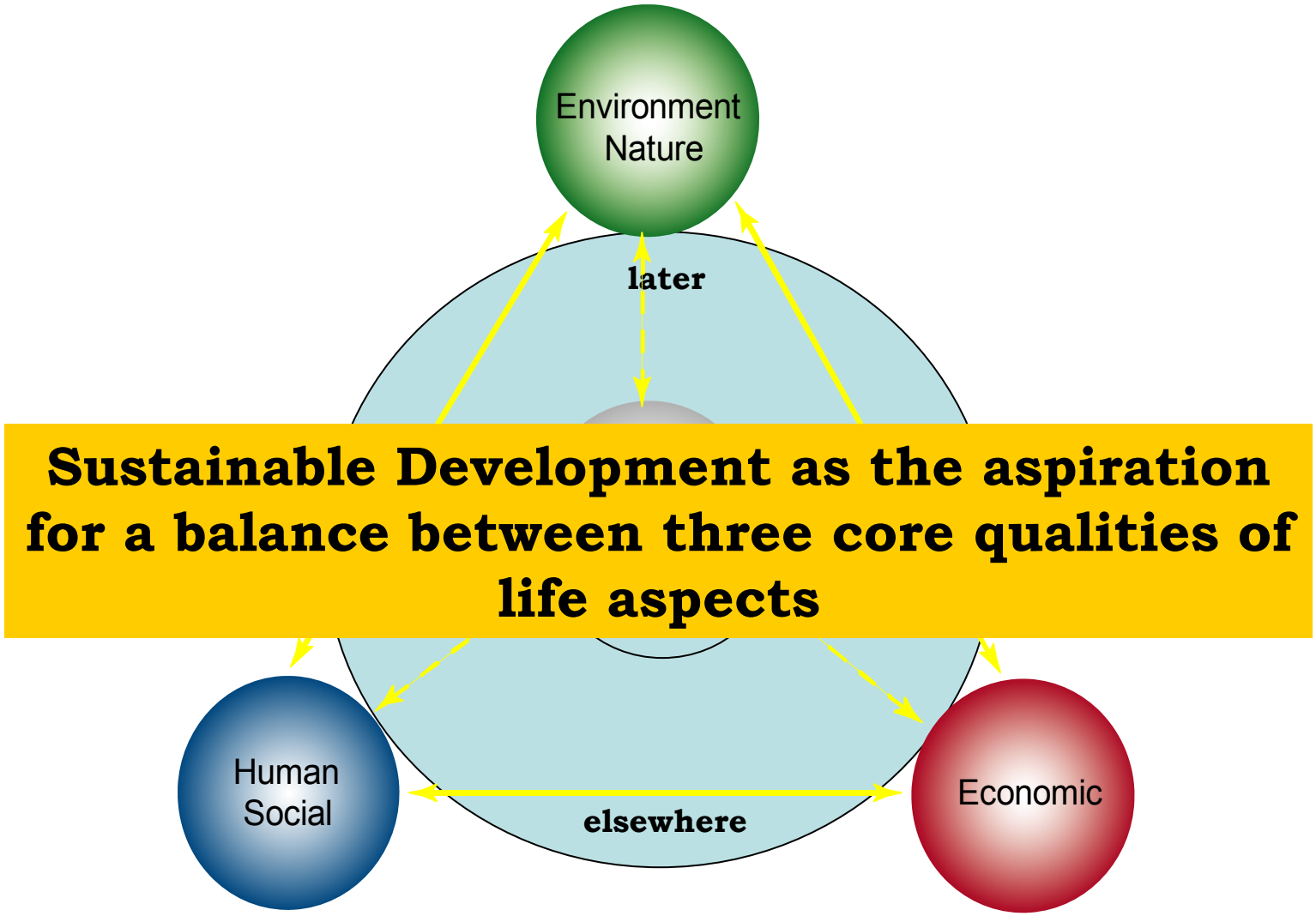
•Resilience of central-decentral systems, role of energy transport infrastructure

Figure 6.7: Simple representation of the cause-effect chain of climate change, illustrating the consequences for uncertainty from the choice of policy target within the chain.



Targets…and the mechanisms to implement them

(Van Vuuren et al. 2006)



people planet profit

The tasks to be undertaken

"… humans normally react to change by first trying to change the world, rather than changing themselves…"

"…defining unwelcome issues as 'external' (e.g. to the market place), and seeking a 'silver bullet' to address the issues and enable things to go on as before…"

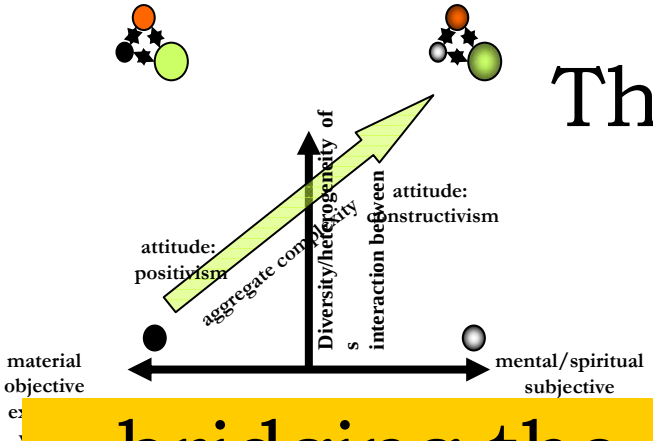
So what to do?

Three [research] challenges:

How to deal with instability / bistability, thresholds, non-linearities etc. and associated uncertainties in complex social-ecological systems (SES)?

How to engage people into the reality of problems and solutions, in order to make them participants instead of obstacles and victims?

How to improve the models in such a way that they represent the key features of the whole reality i.e. ecological, economic and social?



Three challenges

Figure 4: The 4-Quadrant map
(adapted from: Ferber 2007a-b, Phan, Ferber 2007)

Internal-Individual (I-I)	External-Individual (E-I)
I → Subjectivity < mental states, emotions, beliefs desires, intentions, cognition…> "Interiority"	It, This → Objectivity <agent behavior, object, process, physical entities > "Observables, exteriority"
Internal-Collective (I-C)	**External-Collective (E-C)**
We→ Inter-Subjectivity < shared / collective knowledge invisible social codes and implicit ontologies, informal norms and conventions> "Noosphere"	Them, All This → Inter-Objectivity <reified social facts and structures, Organizations, institutions> "SocioSphere"

bridging the natural and the social sciences

bridging micro and macro

bridging science and policy