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Seminar:

Institutional and Evolutionary Economics

(Evolutionary-Institutional Economics)

Seminar: Evolutionary-Institutional Economics

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Fachbereich Wirtschaftswissenschaft
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Structure

Part I Economic Evolution

Part II (Socio-Economic) Institutions

Part III Institutional Emergence

Part IV Institutional Emergence as "Meso"

Part V Structural Emergence: Selected Models

(0) Das Grundmodell der 'evolutionär-institutionellen' ökonomischen Theorie

"Struktur"	"Prozess"	Ergebnis/ Performance
Feedback		
Komplexe Entscheidungs-struktur: Direkte Interdependenz; z.B. Netzeffekte, Inap-propriability; echte Unsicherheit dilemmabehaftete Anreize; Koordinationsfehler, 'Marktversagen'; v.a. mutual blockage, lock-ins.	Rekurrenz, Sequentialität, Topologie: Neighborhood, Dichte/Proximity; Erfahrungen, Erwartungen/Futurity, Reputationsgenerierung; Suchen/Experimentieren; Joint Learning von Koord.; Kumulativität; Replikatoren/Group Selection; Multiple GG/Attraktoren, Komplexe Orbits; Evolutionärer Prozeß.	Emergenz von In-stitutionen der Koordination/Kooperation als 'Lösung'; Reziprozität; Konstitution der 'Arena'/Platform der Interaktion/Gruppen-grösse; ggf. neue lock-ins im Zuge des. Lebenszyklus der Institutionen/Normen/zere-monielle Dimension d. Inst!

Seminar: Evolutionary-Institutional Economics

Subject:	Readings:
Introduction and Overview	**./.**
Part I Core Conceptions 1: Economic Evolution, Elements and System Properties	**Articles:** **"Biology and Economics",** **"Darwinism",** **"Evolution, Theories of",** **"Evolution, Formal Models of",** **"Evolution and Optimality",** **"Atomism and Organicism",** **"Selection",** **in: The Elgar Companion to Institutional and Evolutionary Economics, ed. by G.M. Hodgson, W.J. Samuels, M.R. Tool, Aldershot/Hants, UK, Brookfield, VT, USA: E. Elgar, 1994.**

Part II: Core Conceptions 2: (Socio-Economic) Institutions, and Evolutionary-Institutional Economics

Articles:

"Institutions",
"Veblenian Dichotomy and Its Critics",
"Institutionalism, Old and New",
"Rationality and Maximization",

in: The Elgar Companion to Institutional and Evolutionary Economics", ed. by G.M. Hodgson, W.J. Samuels, M.R. Tool, Aldershot/Hants, UK, Brookfield, VT, USA: E. Elgar, 1994.

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Part III: Institutional Emergence 1: A Benchmark	**Articles:** **"Game Theory and Institutions", "Schotter, Andrew",** **in: The Elgar Companion to Institutional and Evolutionary Economics", ed. by G.M. Hodgson, W.J. Samuels, M.R. Tool, Aldershot/Hants, UK, Brookfield, VT, USA: E. Elgar, 1994;** **W. Elsner, "Real-World Economics Today: The New Complexity, Co-ordination, and Policy", Review of Social Economy, Vol. LXIII.1 (2005), 19-53.**

Institutional Emergence 2: Variants and Models

Self-Governance:

E. Ostrom, J. Walker, R. Gardner, „Covenants With and Without a Sword: Self-Governance is Possible", American Political Science Review, 86.2 (1992), 404-17.

Games That "Play People" and the "Tragedy of the Commons":

H. Alverson, "Culture and Economy: Games That 'Play People'", Journal of Economic Issues, XX.3 (1986), 661-79.

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Increasing Returns, Technology Choice and Technological Lock-in:

W. Brian Arthur, "Competing Technologies, Increasing Returns, and Lock-In by Historical Events", The Economic Journal, 99 (1989), 116-31.

QWERTY:

Paul A. David, "Clio and the Economics of QWERTY", American Economic Review, PP, 75.2 (1985), 332-7.

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	Experience, Expectations, and Coordination: **W. Brian Arthur, "Inductive Reasoning and Bounded Rationality (The El Farol Problem)", American Economic Review, PP, 84 (1994), 406-11.**
Part IV: Institutional Emergence as "Meso"	**K. Dopfer, J. Foster, J. Potts, "Micro-meso-macro", Journal of Evolutionary Economics, 14 (2004), 263-79.** **W. Elsner, "The Process and a Simple Logic of 'Meso': 'Emergence' and the Co-Evolution of Institutions and 'Meso' Group Size", mimeo., Bremen 2007.**

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	G.M. Hodgson, "From micro to macro: the concept of emergence and the role of institutions", in: Institutions and the Role of the State, ed. by L. Burlamaqui et al., Cheltenham, UK, Northampton, MA, USA: E. Elgar, 2000, 103-26.
Part V: Structural Emergence: Selected Models	**R. R. Nelson, S. G. Winter, An Evolutionary Theory of Economic Change, Cambridge, MA, USA, London: The Belknap Pr. of Harvard Univ. Pr., 1982, Chpt. 9.**

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Paper Assignments:

- **Peter S. Albin, Barriers and Bounds to Rationality: Essays on Economic Complexity and Dynamics in Interactive Systems, ed. with an Introduction by Duncan K. Foley, Princeton, NJ: Princeton Univ. Pr., 1998, Chpt. 1, Introduction, pp. 3-72.**

- **Susan Himmelweit et al., Microeconomics. Neoclassical and Institutionalist Perspectives on Economic Behaviour, London: Thomson Learning, 2001, Chpt. 16.**

- **Richard R. Nelson, Sidney G. Winter, An Evolutionary Theory of Economic Change, Cambridge, MA, USA, London: The Belknap Pr. of Harvard Univ. Pr., 1982, Chpt. 9.**

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- **Elonor Ostrom, J. Walker, R. Gardner, „Covenants With and Without a Sword: Self-Governance is Possible", American Political Science Review, 86.2 (1992), 404-17.**

- **Paul D. Bush, "The Theory of Institutional Change", Journal of Economic Issues, XXI.3 (1987), 1075-116.**

- **Duncan J. Watts, Small Worlds. The Dynamics of Networks between Order and Randomness, Princeton and Oxford: Princeton Univ. Pr., 1999, 8th pr. 2004, Chpt. 8, 199-222.**

- **W. Brian Arthur, "Competing Technologies, Increasing Returns, and Lock-In by Historical Events", The Economic Journal, 99 (1989), 116-31.**

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- **Thomas C. Schelling, Micromotives and Macrobehavior, New York, London: W.W. Norton, 1978, pp. 147-66 ("A Self-Forming Neighborhood Model").**
- **Robert Axelrod, The Evolution of Cooperation, New York: Basic Books, 1984, rev ed. (with a new foreword by Richard Dawkins) 2006, Chpts. 2, 3, 8 (Territoriality, pp. 158-68).**

Part I:
"(Economic) Evolution"

Core Conceptions I: Econ. Evolution

1) A Non-Metaphorical, Non-Ontological Approach

- „Evolution“ – a metaphor, an ontology, or a „direct integration“ of bio-physical knowledge?
- (1) *Man* and man-man relations as a part of the *natural/ biological evolution*: genes, “instincts”, habits … natural dispositions
- but also: man and man-man relations as *cultural evolution*
- “*principle of continuity*” (U. Witt, 2003)
- *bridging* natural and cultural evolution: *K.W. Kapp*’s “*bio-cultural” conception of man*→“*direct integration*” of natural-science knowledge into economics:

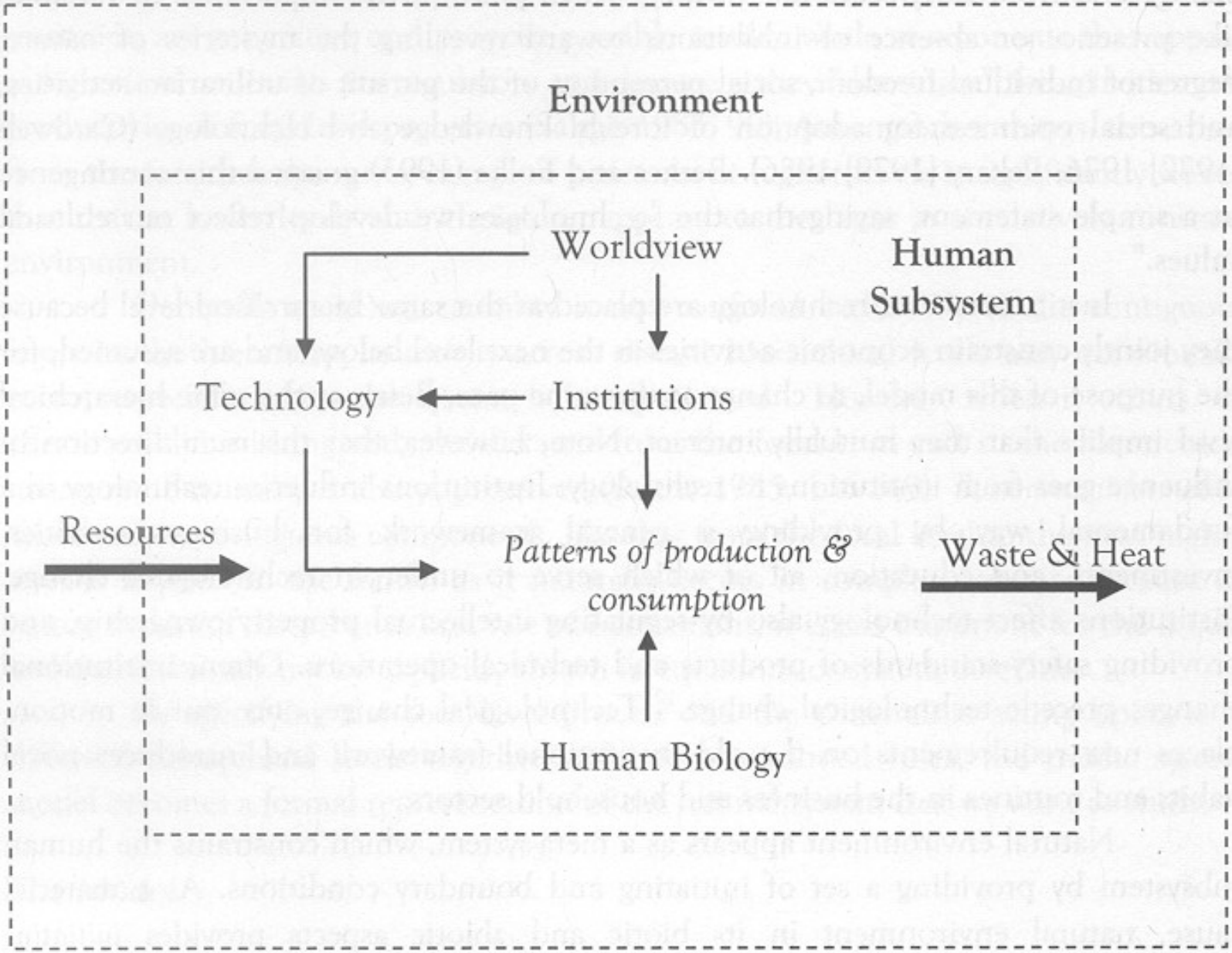
  premature birth, extreme dependence, high degree of plasticity, long maturation period, through enculturation and interpersonal relations → shapes the “instincts” and needs and habits of a “homo culturalis” (not an ontology, nor an analogy or metaphor)

1) A Non-Metaphorical, Non-Ontological Approach, Cont'd.

- also: "direct integration" of physical and biological knowledge into economics through the *open systems approach*
- referring to L. v. Bertalanffy (1950) and *I. Prigogine*: *man* as an *open system*, building up *complexity* through taking in low-entropy matter, exporting high-entropy matter, thus *escaping entropy* (the 2nd law of thermodynamics).

- (2) Kapp (1961), N. Georgescu-Roegen (1966), K. Boulding (1981): the *economy as an open (sub-)system*, building complexity, avoiding entropy, at the expense of the *natural and social sub-systems*
- the whole physico-socio-economic system *cannot avoid entropy*!
- particularly: the *capitalist "market" economy* is *designed to exploit* the inevitable openness at the extreme!
- → *institutional* analysis of the (socio-) economy.

Figure 2. The Model



Core Conceptions I: Economic Evolution

2) Misconceptions of Evolution

- (1) *R. Malthus*' "naturalistic" population and production "laws"
- *Ch. Darwin*'s reference to Malthus (and thus in turn *K. Marx's* skeptical view of Darwin's achievement)
- (2) "reductionist" interpretations: evolution as *pure selection* and "*survival of the fittest*" – and racist variants;
- "*Panglossian*" variant: What is, is "right", "fit", "optimal", because it has survived (circularity), "*optimal*" selection as *axiom*
- similar: the *neoclassical* axiom of maximization behavior
- but: inconsistency between neoclassical "perfect-market" theory (GET) and the conception of selection – where does *diversity* (to select from) come from when *information* is *perfect*?
- affinity of Austrian theory for *evolution as (optimal?) "market selection"* (Hayek's spontaneous order?) → laissez-faire
- implication: the larger a firm's *profit* the greater its *fitness*?

2) Misconceptions of Evolution, Cont'd.

- **(3) the „*fundamental theorem of (natural) selection*" (s. below)**
- **equivalent (has same logical structure) to a *replicator mechanism* (i.e. pseudo-*learning*)**
- **may be supported by an *imitation* mechanism (s. below); (*selection*, *imitation*, *replication* have *same logical structure*)**
- **(4) but yields a *teleological* end-state if used as the only mechanism: uniformity (e.g. same price, same costs, same profits), (quasi-) monopoly**
- **pure selection: end of history, stable "optimal" "equilibrium"**
- **(5) a first *counterexample* against an "optimal" outcome (of "optimal" individual decisions): the *collective-good/social-dilemma* problem: *fallacy of aggregation* (or: "fallacy of composition", Samuelson/Nordhaus, Economics); also: "improving oneself to collective extinction" (J. Elster, s. G.M. Hodgson, Art. "Evolution and Optimality" re. the iterated *Prisoners' Dilemma* – PD, or PD supergame) → *unintended consequences* of interdependent individual behaviors.**

2) Misconceptions of Evolution, Cont'd.

„fundamental theorem of natural selection“:

i = 1 ... n individual agents, "strategies", sub-populations or sub-cultures

p_i = success or "fitness" indicator (pay-off, profit, etc.)

p_r = reference success indicator (weighted *average* success, *maximum* success in the population, interaction *partner* pay-off, etc.)

s_i = "market" share, population share of i

α = selection/replication intensity parameter

$$ds_i/dt = \alpha\,(p_i - p_r)\,s_i.$$

If $p_r = p_{av}$ = *average* success in the population, then:

$$dp_{av}/dt = f[\sigma^2(p_i)] \geq 0$$

=> uniform maximum fitness!

If $p_r = p_{max}$ = *maximum* success occurred in the latest decision or interaction round, then

$$ds_i/dt = \beta\,(p_i - p_{max})\,s_i$$

= *imitation* mechanism, with β: imitation intensity parameter.

Selection can be *accelerated* through *additional* imitation, selection and imitation can add up.

Core Conceptions I: Economic Evolution

3) Evolutionary-Institutional Understandings

- **(1) *non-Panglossian*: (1) *unintended consequences*; (2) *Th. Veblen*'s "*institutional dichotomy*" (s. below) gives way for a *critique of "what is"*: outcomes may be purely "*ceremonial*", non-problem-solving; *unintended* outcomes;**
- **(2) *non-teleological*: *complex* situations and processes may lead to *anywhere* but optimality and equilibrium**
- **the *differencia specifica* is: *direct interdependence* and interaction between (potentially *diverse*) agents, and thus *complexity* incl. incomplete/*imperfect information;***

- **(3) re. *evolutionary biology*: natural environment is differentiated, composed of "niches" → *no general fitness* measure, but "multiple, local, and punctuated equilibria" (St. Gould) – "*peaks on the fitness surface*" → "no general selection principle" – no dominant strategy;**

3) Evolutionary-Institutional Understandings, Cont'd.

- **(4) in addition, in a *socio-economic environment*: an important "environmental" factor changes continuously with evolution – the *composition of the whole population* (if diversity exists)**
- **→ a "*moving fitness surface*"**
- **example: a quasi-evolutionary *simulations* à la *R. Axelrod*'s computer tournaments (s. next slide)**

- **(5) thus, if:**

***rate of change* of physico-socio-economic environment > *selection rate*,**

=> *no "improvement"* to some given end.

3) Evolutionary-Institutional Understandings, Cont'd.

- **(6) furthermore: in the socio-economy, with *expecting*, (imagining, anticipating, aspiring, planning, etc.) agents → *reinforcing, positive feedback* may come into existence ("*circular cumulative causation*" (*G. Myrdal*, based on Veblen's "cumulative causation")**
- **cumulation: negative or positive mutual externalities ("synergies", e.g. R. Cooper/A. John 1988), net-effects, etc. may generate different *"attractors"* (→ *path dependence*);**
- **(7) example models: *coordination game* (*S.P. Hargreaves Heap*, the *Polya urn*, also: *technology choice* with net-externalities (*W.B. Arthur*), where the *outcome* even may be the *worse of two alternatives***
- **real-world examples: QWERTY (W.B. Arthur, *P.A. David*) (→"*lock-in*"), MS DOS/Windows, traffic rules, voltage and plugs regimes, rail gauges, etc.**

3) Evolutionary-Institutional Understandings, Cont'd.

- **(8) theoretical elements: increasing/decreasing returns to scale, first-mover advantage, the learning curve, inappropriability, agglomeration and clustering externalities, net-externalities, etc.;**

- **(9) applying also to the use of *institutions* (s. below): *cumulative* institutional emergence, "exploiting" existing vs. "exploring" new institutions; institutional lock-in and the best point in time to change/exit an "outmoded" institution …**

- **(10) implication of complexity, cumulativeness and path dependence: "*fitness*" may become dependent on *size* (or received population share; frequency dependence theorem) rather than the other way round.**

Core Conceptions I: Economic Evolution

4) Evolution Requires *Diversification First*, Rather Than Selection

- (1) diversification increases adaptability and *resilience* of the whole systems against external impacts;
- diversification generates the "raw material" for selection to apply;
- (2) *diversification rate ≥ ! selection rate*,
  for the system not to end in a "uniform" state;
- but *if* diversification rate ≥ selection rate, then *no "improvement" towards a given end* (s. above);
- the system may fluctuate between multiple "attractors";
- (3) *socio-economic diversification mechanisms* (and analogies): search, experimentation ("mutation"), "learning", exchange and recombination of knowledge ("crossing"), incl. *Lamarckian* inheritance of acquired chrct.
- (4) "source" or "reason" of diversification: incomplete/*imperfect knowledge*.

Core Conceptions I: Economic Evolution

5) The *Unit* of Diversification and Selection

- **rarely (hopefully): the *physical agent* (Malthus), but in general: the *institution* (to be defined);**
- ***many* social institutions and/or many realizations of an institution at the (inter-) individual level → *phylogenetic* (or *population*) approach, compared to "*ontogenetic*" ("organic");**
- **also: "*group selection*" through institutions shared by groups (s. Hodgson, Art. "Selection, Units of Evolutionary").**

Core Conceptions I: Economic Evolution

6) *Properties* of Evolutionary Socio-Economic Systems

(1) conditional:

- ***direct interdependence*, gives room for *direct interactions***
- ***social dilemma* decision structure: different options to act**
- ***recurrent*, i.e. no defined end ("supergame"), gives room for "learning"; and *sequential*, gives way for "responsiveness"**

(2) resulting:

- ***complexity*, "many" and "multiple"/diverse agents&relations**
- ***strong uncertainty*, e.g. "initial strategic strong uncertainty"**
- ***path dependence*, cumulativeness, irreversibility**
- ***non-ergodicity*: non-"representative" agents, actions, or relations**
- ***idiosyncrasy*: butterfly effects**
- ***non-teleology*: open-ended**

Core Conceptions I: Economic Evolution

6) *Properties* of Evolutionary Socio-Economic Systems, Cont'd.

- non-equilibrium, non-efficiency, non-optimality; non-stability
- *morphogenesis, autopoiesis*: emergence, "self-organization" … informally, unintentionally/fallacious, without design
- *homeostasis*, *hysteresis*: after an external shock, total break down? keeping the direction?, returning to the earlier path?; blind drift or purposeful deliberation involved?
- depending on model specifications …

TABLE 4-1

Five "Big Ideas" That Distinguish Complexity Economics from Traditional Economics

	Complexity Economics	Traditional Economics
Dynamics	Open, dynamic, nonlinear systems, far from equilibrium	Closed, static, linear systems in equilibrium
Agents	Modeled individually; use inductive rules of thumb to make decisions; have incomplete information; are subject to errors and biases; learn and adapt over time	Modeled collectively; use complex deductive calculations to make decisions; have complete information; make no errors and have no biases; have no need for learning or adaptation (are already perfect)
Networks	Explicitly model interactions between individual agents; networks of relationships change over time	Assume agents only interact indirectly through market mechanisms (e.g., auctions)
Emergence	No distinction between micro- and macroeconomics; macro patterns are emergent result of micro-level behaviors and interactions	Micro- and macroeconomics remain separate disciplines
Evolution	The evolutionary process of differentiation, selection, and amplification provides the system with novelty and is responsible for its growth in order and complexity	No mechanism for endogenously creating novelty, or growth in order and complexity

Source: E. D. Beinhocker, The Origin of Wealth. Evolution, Complexity and the Radical Remaking of Economics, London: Random House Business Books, 2007, p. 97.

6) *Properties* of Evolutionary Socio-Economic Systems, Cont'd.

N. Clark, 'Some New Approaches to Evolutionary Economics', JEI XXII (1988), p. 518.

Conception / Criterion	Neoclassical Perspective	Evolutionary-Institutional Perspective
(1) Technology	unit capital/labor ratio	systems/paradigms/ trajectories
(2) Equilibrium	identifiable point of convergence and reference	does not exist; far from equilibrium behavior, complex cycles
(3) Information	perfect knowledge, risk	uncertainty, ignorance

6) *Properties* of Evolutionary Socio-Economic Systems, Cont'd.

N. Clark, 'Some New Approaches to Evolutionary Economics', JEI XXII (1988), p. 518, cont'd.

(4) Analytical Units	**homogeneous**	**complex**
(5) Determinacy	**complete, "closed" systems, uncreative**	**weak, "open" systems, creative**
(6) Morphogenesis	**none**	**permitted**
(7) Analytical Style	**deductive**	**inductive**
(8) Institutions	**barriers to market forces**	**enablers of technical change**

6) *Properties* of Evolutionary Socio-Economic Systems, Cont'd.

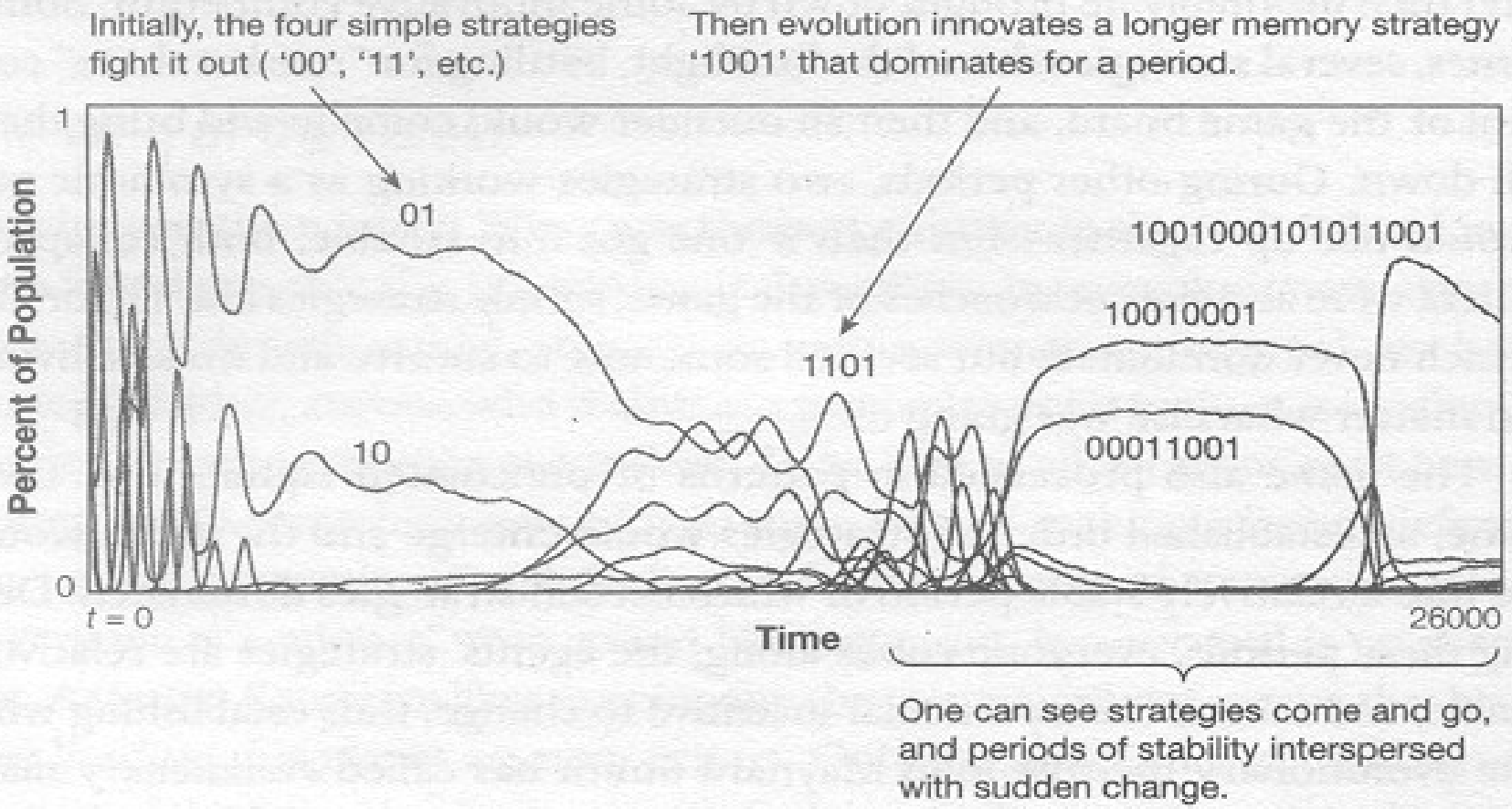
Two Worlds – Necessity and Chance

Necessity – A Simple World	Chance – A Complex World
Decreasing Returns	Increasing Returns
Convex Functions	Nonconvex Functions
Unique Outcome	Multiple Outcomes
Stasis	Morphogenesis
Equilibrium	Path Dependence
Mechanistic Analogy	Biological Analogy (Phylogenesis)
Predictability	Unpredictability
Relatively Easy to Model	Relatively Difficult to Model

Adapted from: The Annals of Regional Science, 2001
D.F. Batten, 'Complex landscapes of spatial interaction', 35.1, 81-111, p. 85.

FIGURE 10-4

The Population of Strategies over Time



Source: Lindgren (1997).

Source: E. D. Beinhocker, The Origin of Wealth. Evolution, Complexity and the Radical Remaking of Economics, London: Random House Business Books, 2007, p.232.

Core Conceptions I: Economic Evolution

7) Examples: Path-Dependent Knowledge

- „The worldwide demand for automobiles will not exceed one million – least because of a lack of chauffeurs." (Gottlieb Daimler, 1901)

- "… unless the objectionable features of the petrol carriage can be removed, it is bound to be driven from the road by its less objectionable rival, the steam-driven vehicle of the day." (W. Fletcher 1904, cit. after W.B. Arthur 1989)

- „I think there is a world market for perhaps five computers." (Thomas Watson, IBM CEO, 1943)

- "Who actually needs that silver disc?" (Jan Timmer, Phillips CEO, 1982)

Evolutionary-Institutional Economics

Part II:
"(Socio-Economic) Institutions"

Core Conceptions II: „Institutions“

1) Starting From Personal Experience (1)

- **(a) an example: “*order*” in the classroom !?**
- **“*a” coordination*, or an optimal coordination?**
- ***forecasting* behavior: is knowing the “*motivation*” (e.g. “maximization”) required?**
- **are *power* or *hierarchy* necessary for coordination?**
- **is a “*market*” working? are *prices* involved?**

Core Conceptions II: „Institutions“

1) Starting From Personal Experience (2)

- **which *information* is being told us while entering a social situation?**
- **which future *expectation* is generated?**

- **(b) *rule breaking* and *surprise*: what if I just were the janitor?**
- **and what if your fellow student were a neoclassical individual?**
- **are you neoclassical/“*rational*”?: the classroom *reputation* “game”. do you *reciprocate*? do you make even *gifts*?**

- **… and if “motivation”: “extrinsic” and/or “intrinsic”?**

Core Conceptions II: „(Socio-Economic) Institutions“

2) Which “Rationality“? (1)

- which *rationality* do you pursue: *short*-run, *long*-run, “*procedural*”, “*relational*” …
- (a) Expl.: „relational” rationality: the dating game/“*battle of the sexes*” and “relational contracting”:

		she B	she F
he	B	3,2	1,1
	F	0,0	2,3

- (b) “procedural” rationality and norms (“justice”), the ancient version of justice … a *rational institution/norm*!?
- the *ultimatum game* in the lab …
- (c) *from rules to norms*, *beliefs*, and *values, ethics, religion, …*
- from problem-solving to *status- and power-preserving*: from *instrumental* to *ceremonial*.

2) Which "Rationality"? (2)

A Story From a 50,000 Years Ago:

- **wandering nomad groups …**
- **getting into exchange at specific common places …**
- **first bargaining, then partying …**
- **the first 'market' places, the first fairs, the first common places, the first common institutions …**
- **but that night that guy became a neoclassical hyper-rational individual … and they were best-off ever during that winter …**
- **… but in the long-run … they were dead.**

2) Which "Rationality"? (3)

A Final Story:

Remember the NYT cartoon

„The two hours missing that Saturday night when Frank Hahn saved the world …"

Core Conceptions II: „Institution“

1) Art. „Institutions“, Walter C. Neale, The Elgar Companion to Institutional and Evolutionary Economics (1)

Definitions given in the literature by famous institutional economists:

- **“Regular, patterned behavior of people in a society”**
- **“*Habits* of thought” (Th. B. Veblen)**
- **“*Standardized* behavior”**
- **“*Axiomatic* by habituation”**
- **“*Prescribed* patterns of correlated behavior”**
- **“*Collective* action in *control of individual* action” (J. R. Commons)**
- **“Ideas and norms (beliefs and values) associated with these regularities” …**

Core Conceptions II: „Institution“

3) Art. „Institutions“, Walter C. Neale, The Elgar Companion to Institutional and Evolutionary Economics (2)

- institutions convey „*meaning*“ (beliefs, „mental models“, “worldviews”, “folkviews”) often both *explaining* (~ “instrumental”, “technological”) and *justifying* (~ “ceremonial”) simultaneously
- while the instrumental is often subordinated to (or “*encapsulated*” in) the ceremonial (s. *P. D. Bush* below)
- institutions are *enablers* that “*allow us to act”* reasonably “*and to create*” (becoming *innovative*!) where we otherwise would be strongly uncertain and prevented from acting at all (“*mutual blockage*” or “*lock in*”)

1) Art. "Institutions", W. Neale (3)

- **i.e., institutions provide *liberties* and *opportunities* rather than "restrictions" (as conceived in neoclassicism)**
- **the sum of interrelated institutions is a „*culture*"**
- **real „*markets*" are institutions, i.e. de-central mechanisms based on institutionalized behavior (bidding, accepting, paying etc. rules, e.g. hand-shake at the horse market, *symbolic actions* and hand signals at the stock market are given "meaning") –> *institutionally* "*embedded*" markets**
- **going into an strongly *uncertain future* requires referring to past experience: *past experience → future expectations → present decision and action***
- **institutions "inevitably" both instrumental and ceremonial (W. Hamilton, C. A. Ayres, J. F. Foster et al.).**

Core Conceptions II: „Institution“

4) What Have We Learned So Far? (1)

- **institutions are *rules* (“*standards*”) of the behavior/ thought/decisions/choices of individual agents**
- **that have been *learned* (in a recurrent, interactive *process*, i.e. from past experience, *past-bound*)**
- **to solve a current *social* (*coordination*) *problem* (the *instrumental* dimension of institutions)**
- **i.e. institutions as *enablers* under conditions of *direct interdependence* and related “*strong uncertainty*” when “progressive” action otherwise would be “blocked” or “locked-in”)**
- **and thus are *shared* (*collectively* owned) by a relevant group (*correlated* behavior)**
- **they are *informational* and “*expectational*” devices (future!)**
- **as a metaphor: the set of institutions (in an individual or a group) is its “gene pool” (“routines as genes”, Nelson/Winter 1982)**

Core Conceptions II: „Institution“

4) What Have We Learned So Far? (2)

- **while we do *not* behave (hyper-)*rational* (be not too clever)**
- **but rather have the rules “*habitualized*” (they are “*semi-conscious*”, “*tacit*”, as long as expectations are met, rules not broken, no surprise, otherwise will be reconsidered by “rational” *deliberation*)**
- **the *rule* may be “condensed” into a *norm*, *belief*, and *value* (while still being *problem-solving*, i.e. *instrumental*)**
- **but may also lose connection to the problem to be solved and thus switch over to *power- and status-preservation*, and *identity/belonging* provision (*ceremonial* dimension of the institution)**
- **in all, it “controls” individual(ist) action in favor of “collective” „correlated“, „coordinated” or “cooperative” behavior.**

Core Conceptions II: „Institution“

5) The Interplay of Genes/Instincts, Habits/Institutions, Deliberation, Valuation, Action, and Experience/Feedback

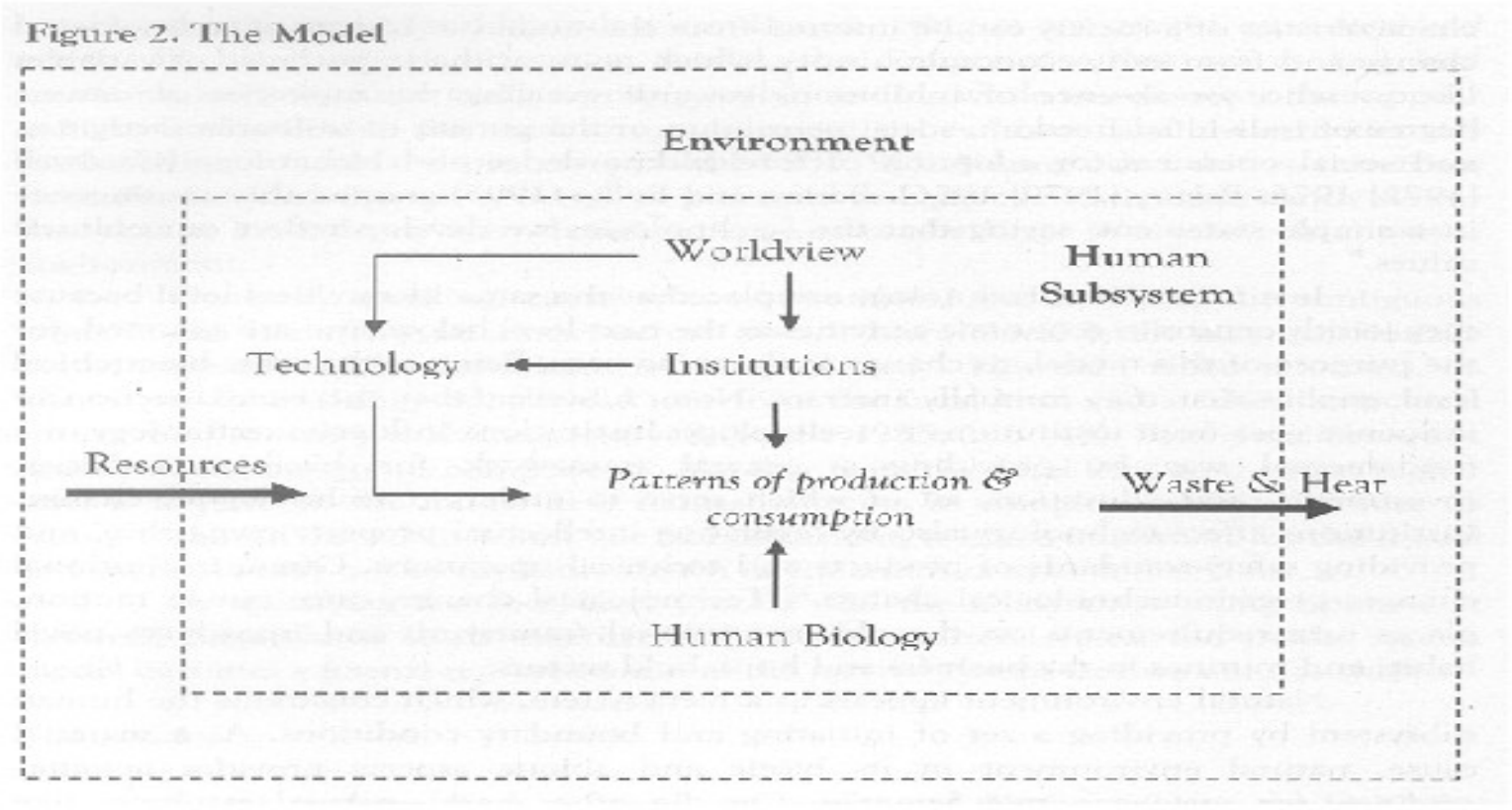
5.0) The Economy as an Open System Towards the Natural Environment, the Human Biology, and the Social/Institutional/Value System

The following figure taken from:

Igor Matutinovic, ‘An Institutional Approach to Sustainability: Historical Interplay of Worldview, Institutions and Technology’, *Journal of Economic Issues*, XLI.4, 2007, p. 1118.

Core Conceptions II: „Institution“

Figure: The Model
Aus „An Institutional Approach to Sustainability: Historical Interplay of Worldviews, Institutions and Technology „ von Igor Matutinovic
Journal of Economics Issue, **XLI 4**, (2007), p. 1118.



Core Conceptions II: „Institution“

5) The Interplay of Genes/Instincts, Habits/Institutions, Deliberation, Valuation, Action, and Experience/Feedback

5.1) A First Simple *Cycle*:

- “*instincts*” – biological genes – *natural* (biologcl.) evolution
- “*habits*” - rules that make agents “*tend*” to, or being “*inclined*” to certain individual *actions* – “*dispositions*” emerged in *cultural* evolution
- the *interplay* of instincts, habits, beliefs/norms/values, deliberation, and specific resulting action (e.g., U. Witt’s *principle of continuity*).

The following figure taken from:

G. M. Hodgson, The Hidden Persuaders, mimeo, 2000, p. 15; repr. as ‘The hidden persuaders: institutions and individuals in economic theory‘, *Cambridge Journal of Economics,* 27, 2003, 159-75.

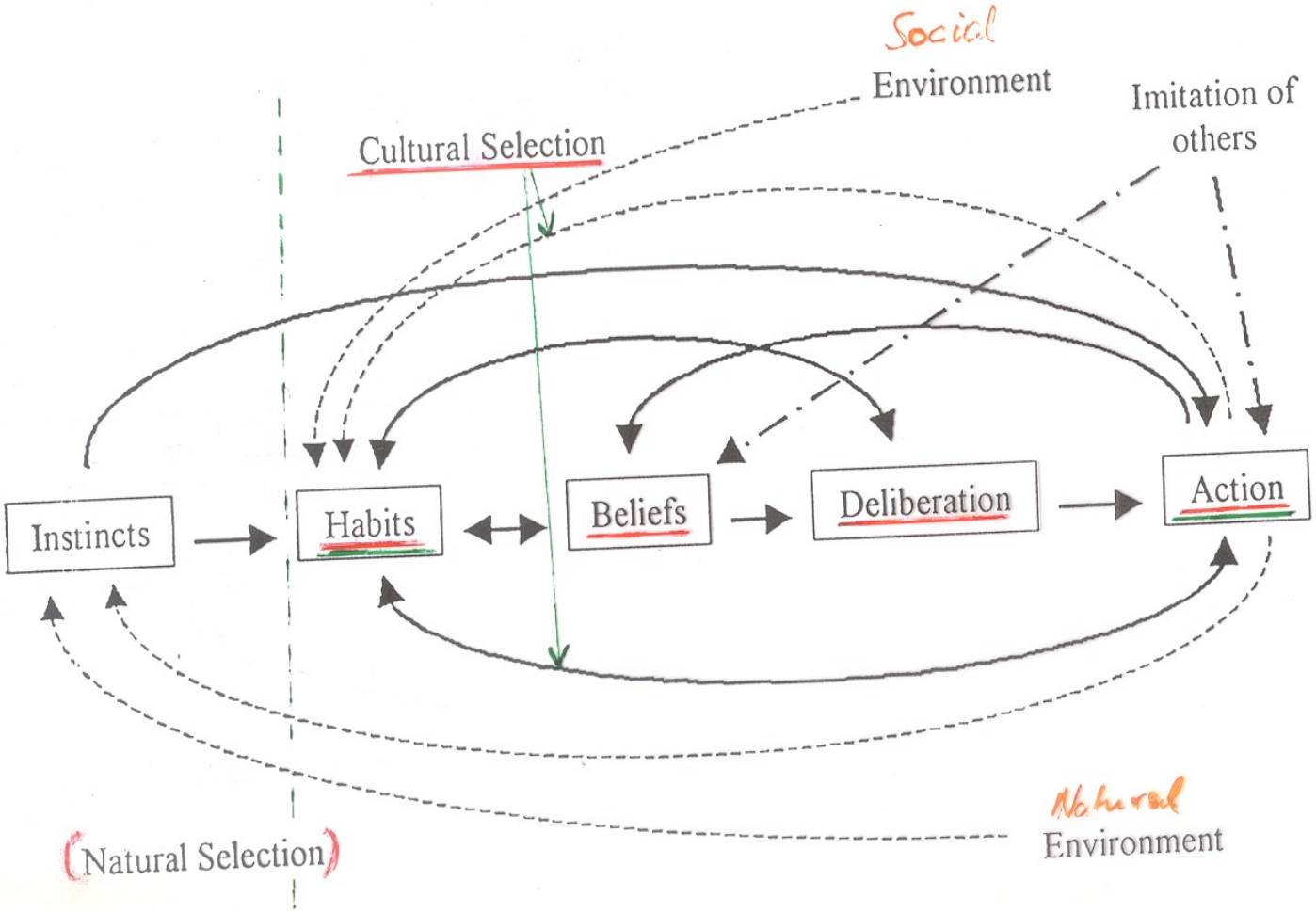


Figure 2: Veblenian Cultural Evolution

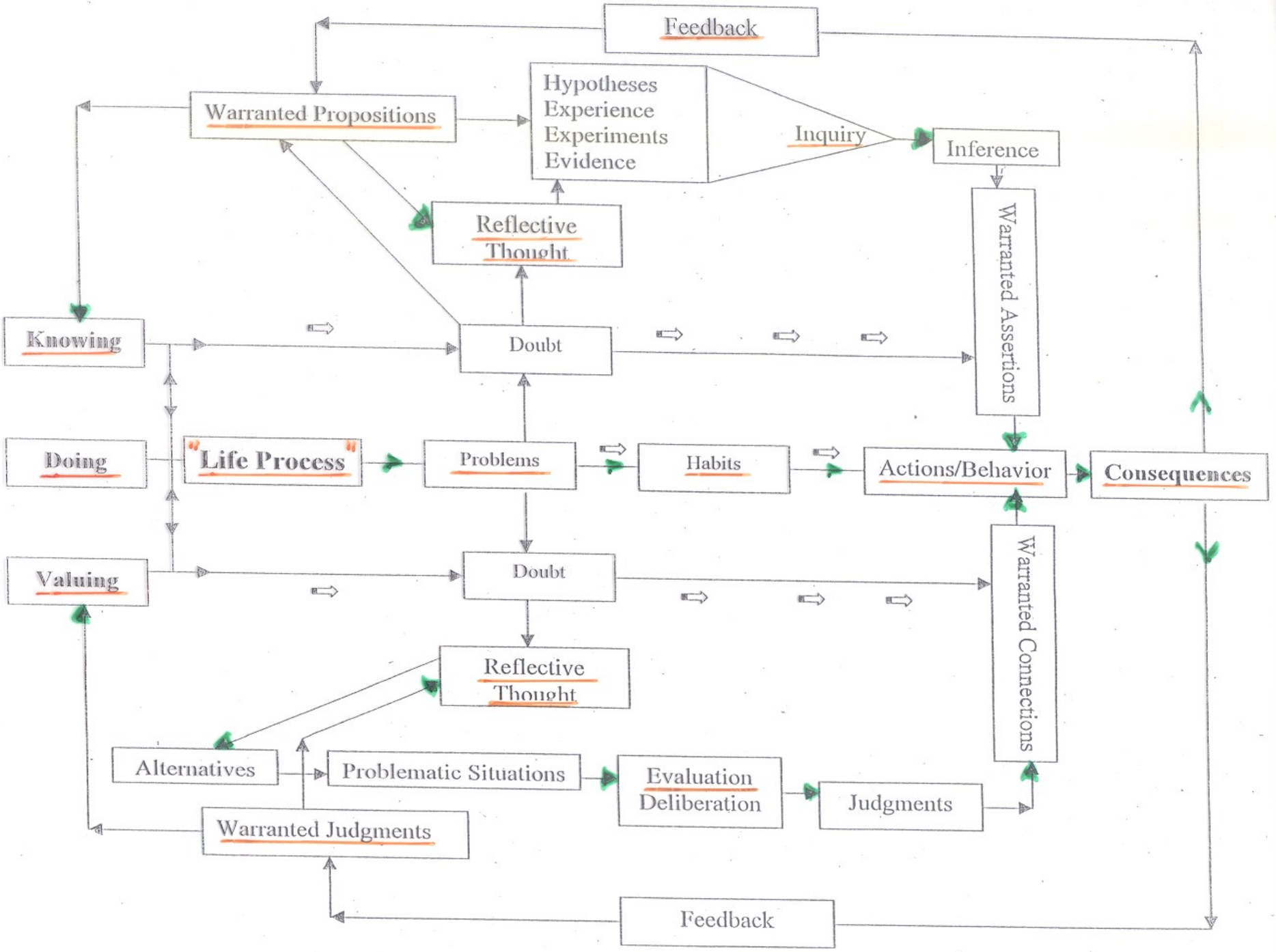
5) The Interplay of Genes/Instincts, Habits/Institutions, Deliberation, Valuation, Action, and Experience/ Feedback

5.2) A More Elaborate Cycle:

- ***problems*** **(which and how specified?),**
- **received *knowledge* (i.e. institutionalized information)**
- **received *habits* (i.e. institutionalized dispositions to act)**
- **received *valuations* (i.e. institutionalised value judgements)**
- **reflective thought (*deliberation*)**
- **specific *action*/behavior**
- **consequences (*performance*), and**
- ***feedback*.**

The following figure is taken from:

J. Sturgeon, UMKC, Class Material, paper presented at the Annual AEA/ASSA/AFEE meetings, New Orleans, January 2008


Feedback
Warranted Propositions
Hypotheses
Experience
Experiments
Evidence
Inquiry
Inference
Reflective Thought
Warranted Assertions
Knowing
Doubt
Doing
"Life Process"
Problems
Habits
Actions/Behavior
Consequences
Valuing
Doubt
Warranted Connections
Reflective Thought
Alternatives
Problematic Situations
Evaluation Deliberation
Judgments
Warranted Judgments
Feedback

5.3) An „Integrated Systems Model“ of:

- **“*attitudes*” (i.e. institutionalized *habits*)**
- ***beliefs* and *values***
- **given “*technology*” and *ecology* (the natural environment as *problem* definition), and**
- ***institutions* (as rule-based action).**

Figure taken from:

F. G. Hayden, “Policy Concerns Regarding Ecologically Sound Disposal of Industrial Waste Materials”, Institutional Analysis and Economic Policy, M. R. Tool, P. D. Bush (eds.), Boston, Dordrecht, London: Kluwer Acad. Publ., 2003, p. 463.

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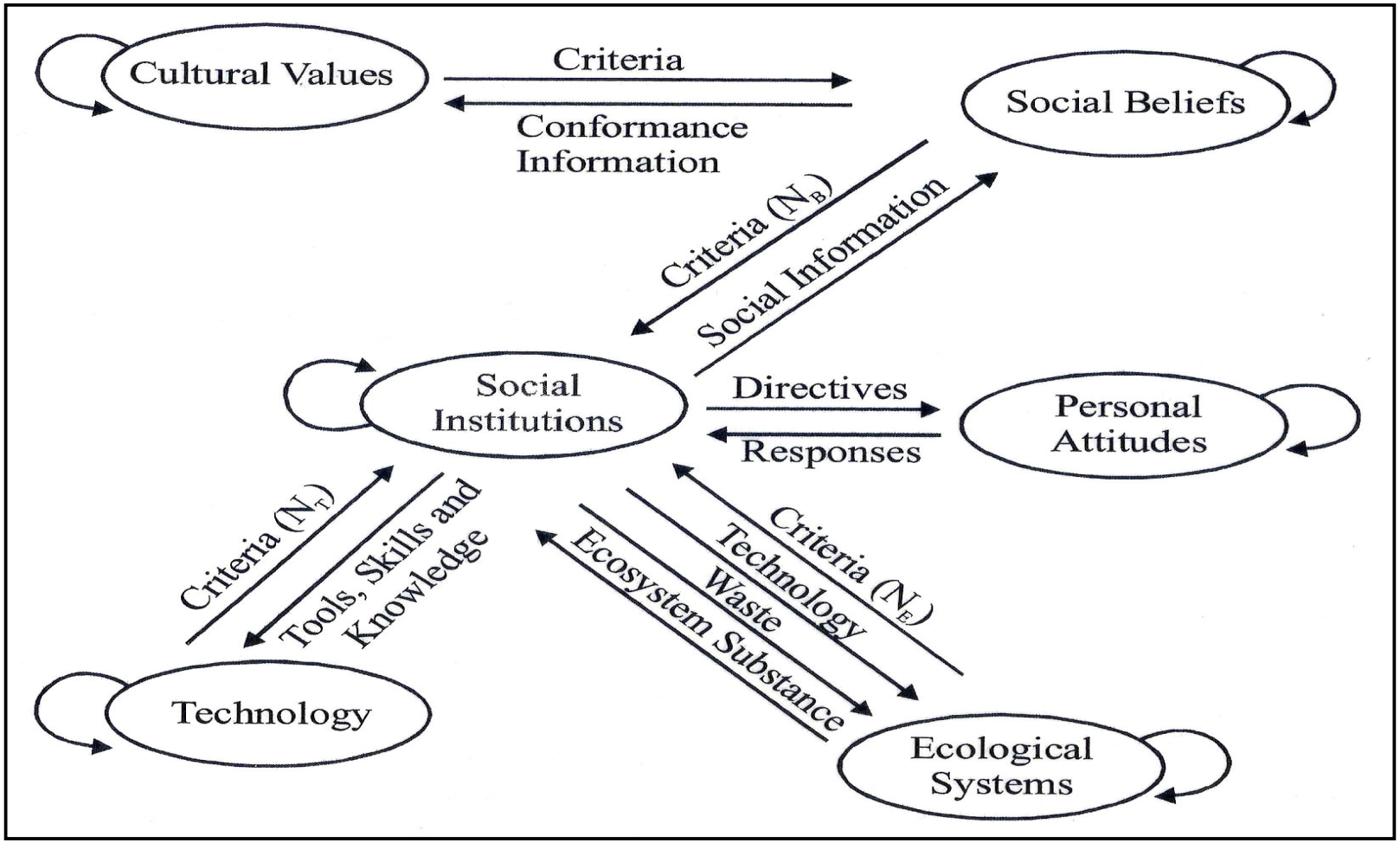
Bereich Wirtschaftspolitik/Wirtschaftsstrukturforschung

Integrated Systems Model of Institutional Economics



Quelle: F. G. Hayden, M. R. Tool, P. D. Bush, Institutional Analysis and Economic Policy, Kluwer Accad. Publ., Policy Concerns Regarding Ecologically Ground Disposal of Industrial Waste Materials, 2003, S. 463

Core Conceptions II: „Institutions“

6) The ‘Veblenian Dichotomy’

William Waller, Art. „Veblenian Dichotomy and Its Critics“, The Elgar Companion to Institutional and Evolutionary Econ., 1994, Vol. 2, 368-72:

- **Thorstein Veblen: “business” vs. “industry”, “conspicuous consumption” vs. “serviceable consumption” etc.**
- **“*institutions*” vs. “*technology*”, *past-bound* habits vs. *matter-of-fact* knowledge → institutions always “ceremonial”?**
- **Clarence Ayres: institutions always have *both* “technological” and ceremonial aspects → introducing pragmatist philosophy → coining “*instrumental*” (*valuation*) rather than “technological”**
- **John Fagg Foster: redefining institutions with *both* ceremonial and instrumental aspects in *all* behavior.**
- **Marc R. Tool, Paul D. Bush: soc. *behavior* and social *valuation*, *dominance* of either ceremonial or instrumental, → s. Bush’s Theory of Institutional Change (“*ceremonial encapsulation*”).**

6) The Veblenian Dichotomy, Cont'd.

Examples From the Business Area:

(taken from: S. Parto, "Economic Activity and Institutions: Taking Stock", Journal of Economic Issues, XXXIV.1 (2005), p. 34, selected)

ceremonial	technological
business	industry
ownership	production
salesmanship	workmanship
pecuniary	industrial
invidious emulation	technological efficiency
sabotage	serviceability

6) The Veblenian Dichotomy, Cont'd.

The Interplay of „Instrumental" and „Ceremonial" Behavior and Valuation: „Institutional Adjustment" (P.D. Bush)

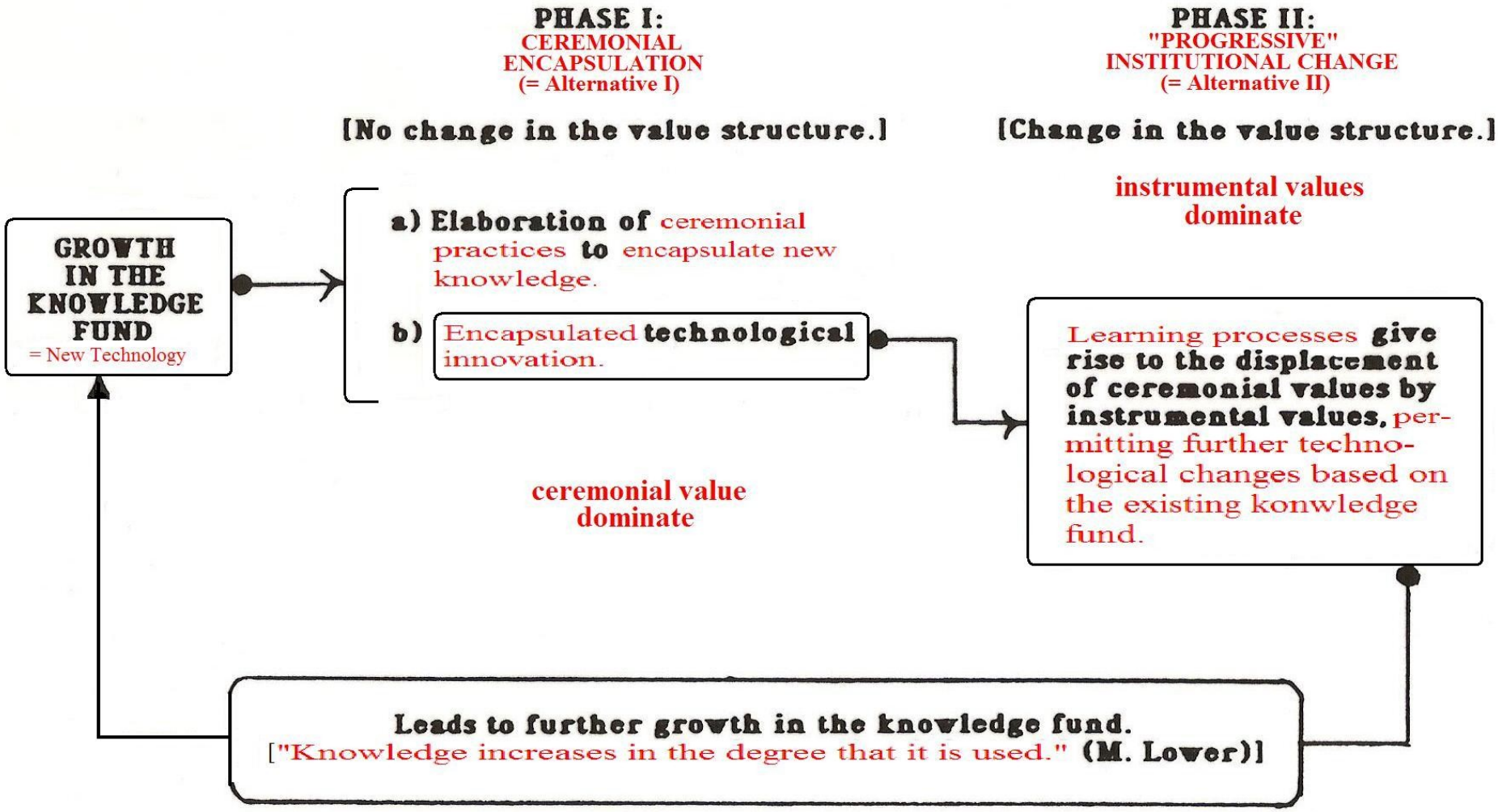


FIGURE 2. THE DYNAMICS OF THE RELATIONSHIP BETWEEN GROWTH IN THE KNOWLEDGE FUND AND "PROGRESSIVE" INSTITUTIONAL CHANGE

6) The Veblenian Dichotomy, Cont'd.
The Interplay of „Instrumental" and „Ceremonial" Behavior and Valuation (Analytical, Methodological)

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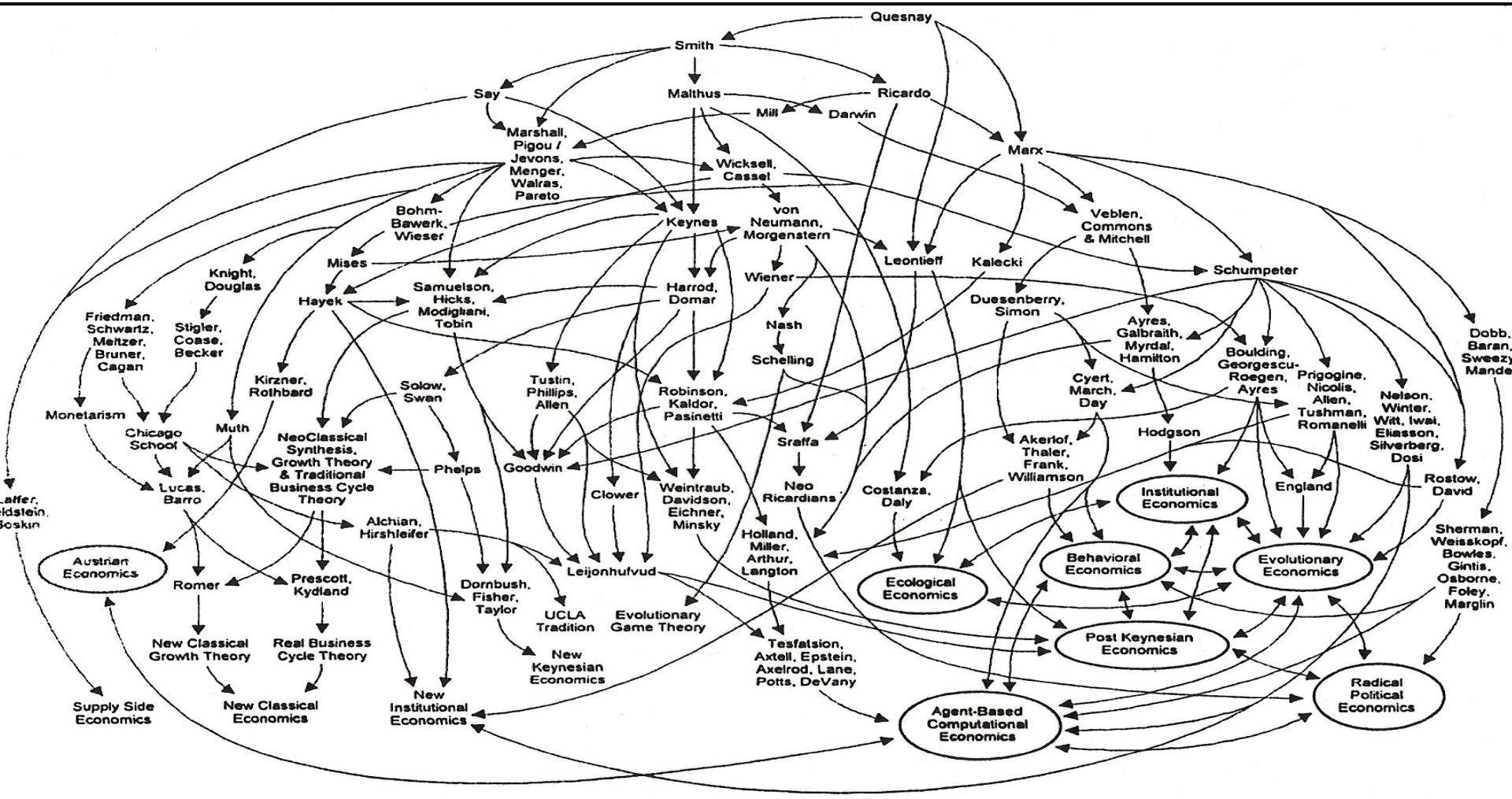
Bereich Wirtschaftspolitik/Wirtschaftsstrukturforschung

Mode of Valuation				
(1) Process by Which Values are Formed	(2) Values are Formed (Selection of Standard of Judgment)	(3) Valuations (Applying Standard of Judgment)	(4) Consequences	(5) Problem Solving
Institutional				
Examines the evolutionary processes by which cumulative causation brings about changes in value structure.	Postulates two types of normative systems in society: the ceremonial and the instrumental	Analyzes valuations in terms of: ceremonial warrant, and instrumental warrant	Applies a criterion of "coherence" to test the implications of thought and action in terms of developemental continuity of the process of inquiry.	Problem: Institutional structure interferes with the developmental continuity of instrumental processes. Solution: Change in the institutional (value) structure.

Quelle: P. D. Bush

A Selected Genealogy of Economic Thought and Economic Thinkers from Francois Quesnay and the Physiocrats to the Present



Quelle: Michael Radzielu, OEI, VOL XXXVII, No. 1, Rerol 2003, p. 135 **M. Radzicki, JEI XXXVII (**

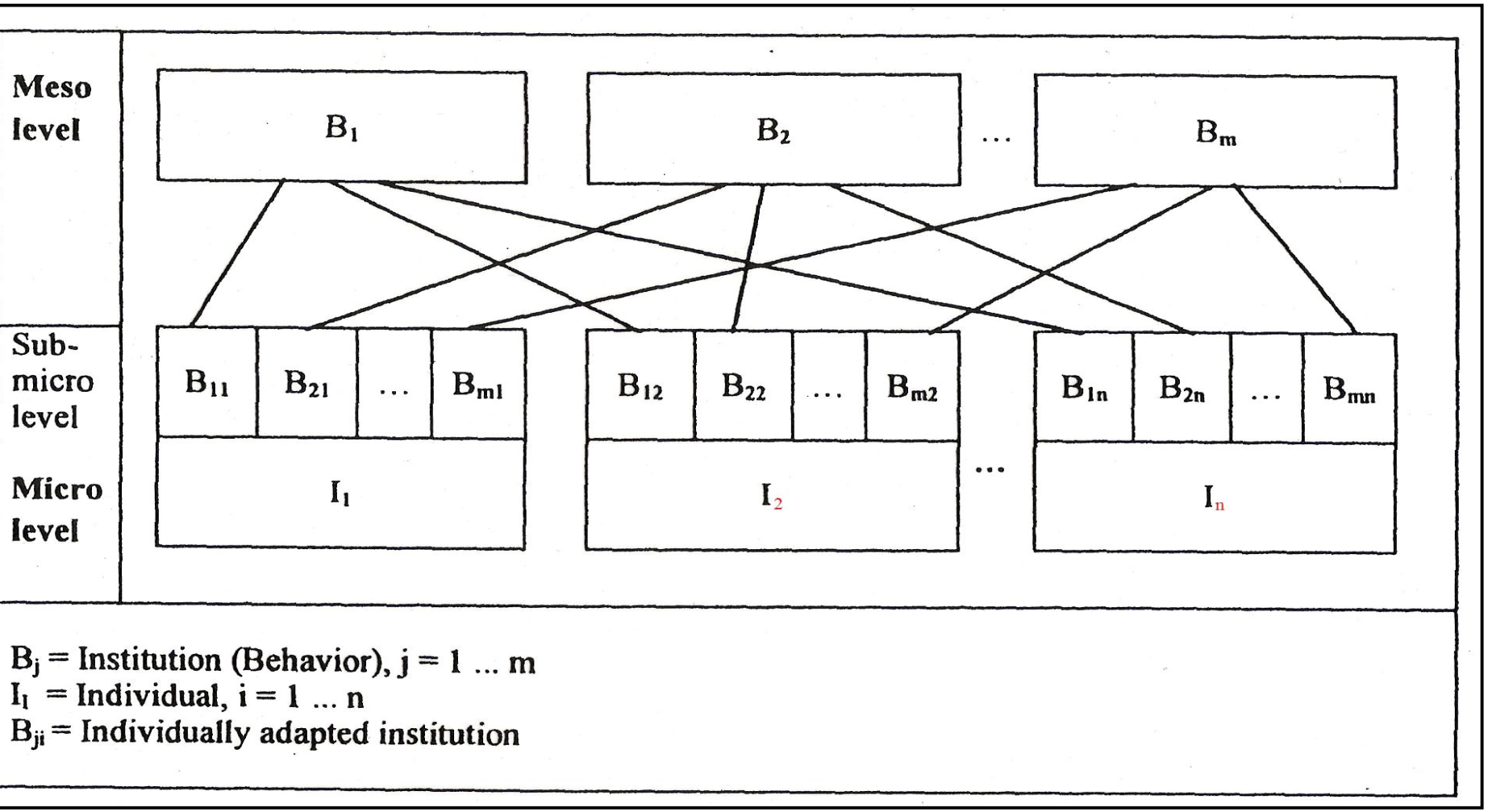
Core Conceptions II: „Institutions“

7) Institutionalism: Individuals and the „Whole“

G. M. Hodgson, Art. „Institutionalism, ‚Old‘ and ‚New‘“, The Elgar Companion to Institutional and Evolutionary Economics, 1994, Vol. 1, 397-402:

- **neoclassicism: methodological individualism - *autistic*, taken for granted, *representative* individuals; “atomism”**
- **„*reductionist*“: „*macro*“ as the *sum* of „*micro*“; macro explained from the properties of the micro units**
- **institutionalism: real-world, diverse directly-interdependent and interacting agents → „agent-based“ modeling**
- **„*emergence*“ rather than „aggregation“: complexity of situations and processes (strong and „strategic“ uncertainty)**
- **the individual changes: its behavior, and “preferences”**
- **shared *institutions emerge* in a complex process**

The sub- micro and meso- levels of institutions- an illustration



B_j = Institution (Behavior), j = 1 ... m
I_i = Individual, i = 1 ... n
B_{ji} = Individually adapted institution

Quelle: W. Eslner, An Industrial Policy Agenda 2000 and Beyond- Experience, Theory and Policy, in: W. Elsner, J. Groenewegen, Industrial Policies After 2000 and, Kluwer Acad. Publ. 2000, 411- 486, S. 444

Core Conceptions II: „Institutions“

8) Institutionalism and Game-Theory (1)

- **institutionalist game-theorists: Alexander J. Field, Shaun P. Hargeaves Heap**
- **S. P. Hargreaves Heap, Art. “Rationality and Maximization”, The Elgar Companion to Institutional and Evolutionary Economics, 1994, Vol. 2, 215-19:**

- **Hodgson: “game theory is neoclassical”**
- **Hargreaves Heap: “*instrumental rationality*” is not just that people do something because they “maximize” something**
- **“instrumental rationality” may generate surprisingly *complex types of behavior***
- ***repeated interaction* in games: emergent behavior may *contrast with immediate self-interest*, causing a *change in the beliefs of others* → e.g., *trust*, or *reputation*, building**

8) Institutionalism and Game-Theory (2)

- **allows maximizing "something" in the future**
- ***past* experience → *future* belief (expectation) → *present* behavior; *present* interaction *becomes past* experience in the next interaction etc.**
- **example: *entry (deterrence) game* (with credible threat, self-commitment to sunk costs, reputation for fighting)**
- **we do not have to (and should not, for many reasons) assume well-behaving utility functions behind the pay-offs**
- **example: consumption as communication, status definition**
- **where do "beliefs" come from, when there are different behavioral options and "multiple equilibrium" outcomes ("attractor points") (s. e.g. W.B. Arthur's technology choice, or a coordination or social dilemma game)?**

9) Institutionalism and Game-Theory (3)

Institution – A Definition

An Institution is a *rule* (or custom, or norm)
for the decision and/or *behavior* of *individual agents*
for (infinitely, or indefinitely) *recurrent* and
***multi-personal* (i.e. *directly interdependent*, i.e. genuinely *social*) situations (repeated direct *interactions*),**
with *social coordination problems* involved (behavioral alternatives existing, collective goods problems, social dilemmas),
that has gained, through a process of *social learning*,
a *general approval*
so that it can *inform* the agents
about *mutual* (mutually consistent) *expectations* of behavior
and about the fact that with *unilateral deviation* from the rule (i.e. defection) other agents also will *deviate in the future*
so that *all will be worse off* than with rule-conforming behavior
(endogenous *sanction mechanism*).

Evolutionary-Institutional Economics

Part III:
"Institutional Emergence"

Core Conceptions III: "Institutional Emergence"

1) **Institutional Emergence (1) - Again: Institutions and Game Theory**

   Alexander J. Field, Art. "Game Theory and Institutions", The Elgar Companion to Institutional and Evolutionary Economics, 1994, Vol. 1, 271-76:

   - **individuals (directly) interact (→imperfect information)**
   - **"deterministic" world (at first)**
   - **helps analyzing the consequences of rule variation**
   - **not a causal-genetic analysis (at first)**
   - **basic rules of the game are given: thus some institutions must exist prior to the process (→complete information)**
   - ***limited* power to *explain the origins* (emergence) of rules**

1) Institutional Emergence (1) - Instit. And Game Theory

A.J. Field, Art. "Game Theory and Institutions":

- **the repeated PD: *incentive structure* and *future expectations* are crucial, verbal communication and commitment are "cheap talk", i.e. no external enforcement: "non-cooperative" GT**
- **finite repetition: backward induction**
- ***supergame*: agents stay in the game for an infinite or unspecified number of periods**
- **the *success of "tit-for-tat"* in *Axelrod's quasi-evolutionary* tournaments (computer programs are fixed, but replicator)**
- **"Students of institutions should neither reject game theory as without interest nor embrace it with such enthusiasm that its limitations are overlooked."**
- **useful metaphors for *ubiquitous everyday* socio-economic problems and decisions: *PD*s and *coordination games*: *emergence of standards* (behavioral and technical)**
- **must be *complemented* by *descriptive/historical* "story-telling"**

Core Conceptions III: "Institutional Emergence"

2) Institutional Emergence (2): A Simple Benchmark – The Static ("Single-Shot") PD Supergame Solution

a,a	**d,b**
b,d	**c,c**

with $b > a > c > d$ **and** $a > (d + b)/2$.

$$\text{ALL C/ALL C} = \text{TFT/TFT} = a + \delta a + \delta^2 a + \ldots$$

$$= \frac{a}{1 - \delta}.$$

2) Institutional Emergence (2): A Simple Benchmark – The Static ("Single-Shot") PD Supergame Solution

$$\text{ALL D/TFT} = b + \delta c + \delta^2 c + \ldots$$

$$= \frac{c}{1 - \delta} + b - c \,.$$

Cooperation pays, if TFT/TFT => ALL D/TFT.

This can be calculated as

$$\delta \geq (b - a) / (b - c).$$

2) Institutional Emergence (2): A Simple Benchmark – The Static (Single-Shot) PD Supergame Solution

- ***analytical* implications: a *logical* condition, dependent on an *endogenous sanction* mechanism,**
  - **o *incentive structure* variations: a_{min}?, b_{max}?**
  - **o importance of the *common future*: δ_{min}?**
- **procedural and evolutionary interpretation:**
  - **o *motivation* for "rational" agents to deviate from always defecting: repeated *frustration*, "idle *curiosity*", long-run "*improvement*", not even necessarily knowing the upper left situation…("incomplete" info)**
  - **o no narrowly "rational" explanation: *habituation***
  - **o *risk-taking*, being *non-envious***
  - **o *cumulation*: recurrent *reinforcing* contributions, reinforcing expectations**
  - **o but opportunities, and even increasing *incentives*, to exploit and *destabilize* an existing institution again …**

2) Institutional Emergence (2): A Simple Benchmark – The Static (Single-Shot) PD Supergame Solution

- **example and a variant: *non-enviousness* (not being too "*rational*") (K. Basu, The *Traveler's Dilemma* (TD), AER 1994, The Scientific American, 5/20/2007). The two- choice version (numerical example):**

100, 100 97, 101

101, 97 2, 2. (*downward induction*!)

- **example and a variant: The *Public Good Contribution Game* (PGC-G)/*Common Pool Resource Game* (CPR-G) (e.g. E. Ostrom et al. 1992). The simple two-choice two-agents version (and an 'additive' public good), numerical example:**

5-3+2+2=6; 5-3+2+2=6 5-3+2=4; 5+2=7

5+2=7; 5-3+2=4 5; 5

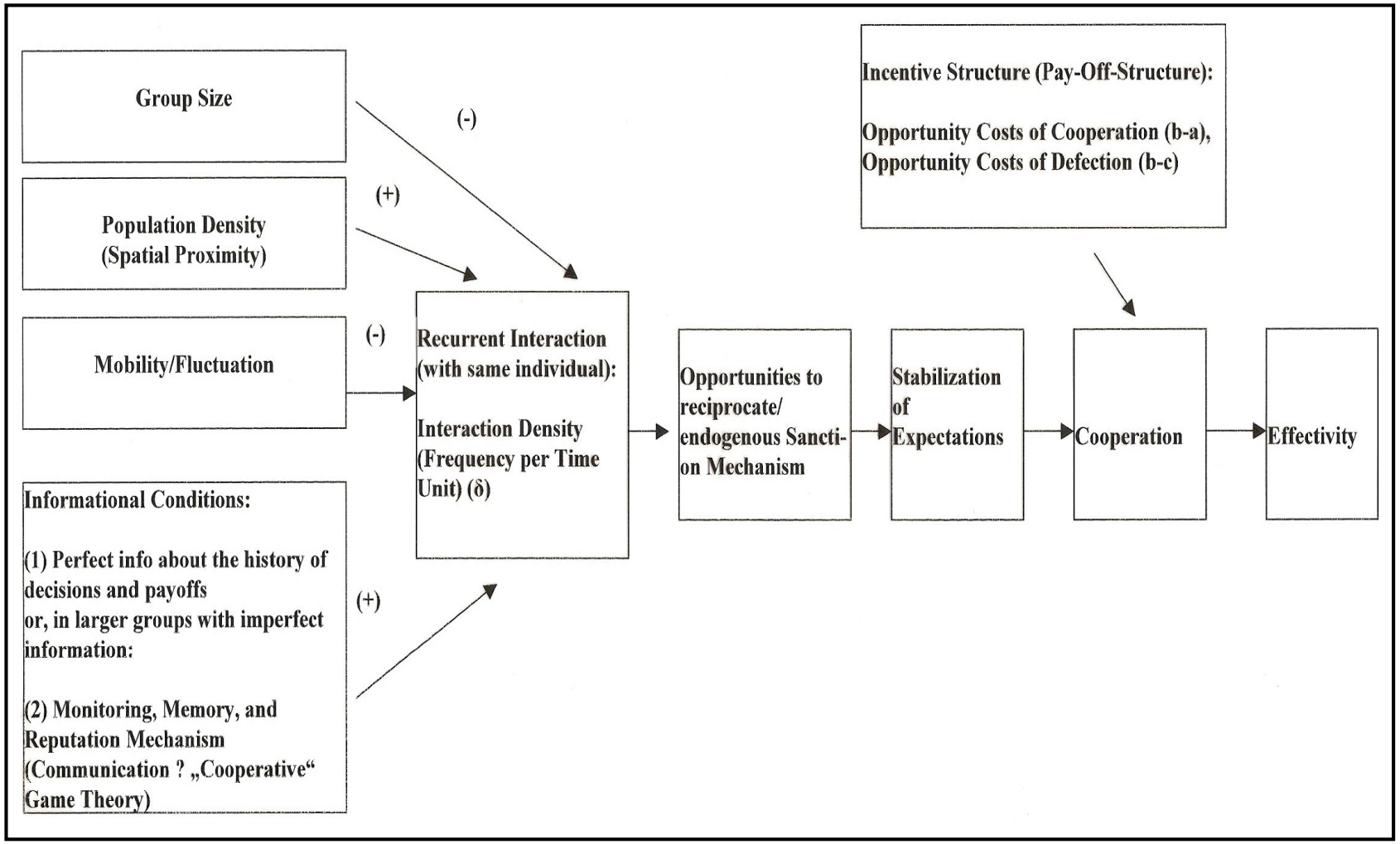
- **example and a variant: from the PD-SG to the *Stag Hunt*/ *Assurance Game* (J.J. Rousseau (1762), A.K. Sen (1967), B. Skyrms (2004)) (*see below*, Part V).**

2) Institutional Emergence (2): A Simple Benchmark – The Static (Single-Shot) PD Supergame Solution

- ***policy*** **implications for (1) agents involved, (2) private neutral advisors, (3) public policy makers:**
  - **change the incentive structure**
  - **change the weight of the common future for the agents**

- ***applied*** **socio-economic interpretation …**

Socio Economic Conditions in Recurrent Collective-Good Decisions („Prisoners´ Dilemma“-Super Game) (s. below Part IV.)



Nach: W. Raub, T. Voss, Die Sozialstruktur der Kooperationen rationaler Egoisten, Zeitschrift für Soziologie, Vol. 15 (1986), S. 309- 323

Core Conceptions III: "Institutional Emergence"

3) Institutional Emergence (3): 'Games That "Play People"' – The Example of the "Tragedy of the Commons"

H. Alverson, 'Culture and Economy: Games That "Play People"', JEI 1986:

- **institutions "playing" the set of people, rather than the reverse**
- **neoclassicism: a presupposed "human nature" as a pre-cultural cause**
- **modern anthropology: "human nature" as a set of genetically endowed potentialities, not itself determining culture. Rather, "ecology", "ideology" (symbols, language, the "conditions of knowledge", beliefs and values), and institutions together define "culture"**
- **comparative analysis of cultural forms of exchange and transaction: "*market economy*" vs. "*gift economy*"**
- **a "*tragedy of the commons*" or none …**

3) Institutional Emergence (3): 'Games That "Play People"' – The Example of the "Tragedy of the Commons", Cont'd. Ideal Individualist Culture (no Cooperation) vs. Gift Economy

Illustration 2: Individualistische Kultur mit unvollständiger Information über die Interdependenzstruktur.

?	d, b
b, d	c, c

Illustration 5: Gift-Economy.

a, e	

mit a ≠e.

gift economy: no equivalence nor even reciprocity; gifts independent of each other.

3) Institutional Emergence (3): "Games That "Play People"" – The Example of the "Tragedy of the Commons"

(2-lbs-"*Technology*", 10 Shepherds à 10 Sheep à 100 lbs, *'large' group*, many defectors; no PD!)

		Alle anderen Schäfer / All other Shepherds: c	Alle anderen Schäfer / All other Shepherds: nc
Schäfer X / Shepherd X: c		90 Schafe à 100 Pfd= 1000 Pfd/Schäfer 10 Schafe à 100 Pfd= 1000 Pfd	99 Schafe à 82 Pfd = 902 Pfd/Schäfer 10 Schafe à 82 Pfd= 820 Pfd
Schäfer X / Shepherd X: nc		90 Schafe à 98 Pfd= 980 Pfd/Schäfer 11 Schafe à 98 Pfd= 1078 Pfd	99 Schafe à 80 Pfd= 880 Pfd/Schäfer 11 Schafe à 80 Pfd= 880 Pfd

1) Institutional Emergence (3): 'Games That "Play People"' – The Example of the "Tragedy of the Commons", Cont'd.

(2-lbs-"*Technology*", 2 Shphrds à 10 Shp à 100 lbs, *'small' group*: 2, no PD!)

1,000 **lbs**	**11 sheep à 98 lbs = *1,078* lbs**
1,000 **lbs**	**10 sheep à 98 lbs = *980* lbs**
980 **lbs**	**11 sheep à 96 lbs = *1,056* lbs**
1,078 **lbs**	**11 sheep à 96 lbs = *1,056* lbs**

- ***no PD*** **so far, the common resource is not 'rivalrous' yet**
- **depends on the "technology", i.e. the "production function" of the common-pool resource …**

3) Institutional Emergence (3): 'Games That "Play People"' – The Example of the "Tragedy of the Commons", Cont'd.

(5-lbs-"*Technology*", 2 Shepherds à 10 Sheep à 100 lbs, *'small' group*: 2, PD!)

Shepherd I \ Shepherd II	c	nc
c	10 Schafe à 100 Pfd. = 1000 Pfd. (3) 10 Schafe à 100 Pfd. = 1000 Pfd. (3)	11 Schafe à 95 Pfd. = 1045 Pfd. (4) 10 Schafe à 95 Pfd. = 950 Pfd. (1)
nc	10 Schafe à 95 Pfd. = 950 Pfd. (1) 11 Schafe à 95 Pfd. = 1045 Pfd. (4)	11 Schafe à 90 Pfd. = 990 Pfd. (2) 11 Schafe à 90 Pfd. = 990 Pfd. (2)

Schäfer I

3) Institutional Emergence (3): 'Games That "Play People"' – The Example of the "Tragedy of the Commons", Cont'd.

- **conditions: the *"technological" conditions* of the *ecology* (the capacity of the commons, or its "*production function*") determines at how many sheep (or shepherds defecting) the *collective good* becomes "*rivalrous*", i.e. a competitive interaction generates a *social dilemma* (a prisoners' dilemma)**
- **e.g., *10-lbs-technology* yields: 11sheep x 90lbs = 990lbs, *no PD*!**
- **suggestion for *definitions*:**

  "*externalities*" = *redistribution* + "*social costs*"

  example for one free rider, one "sucker":

  50 ext. = 45 redistr. + 5 sc.
- **the wider ecological perspective with *global commons*: complex externalizations, redistributions, and social costs on a *global spatial* scale and on a long-run *inter-generational time* scale.**

Evolutionary-Institutional Economics

Part IV:
"Institutional Emergence"
as 'Meso'-Economics.

The Process and a Simple Logic of "Meso" Economics

1) The Question

- **What is the *locus*, *level*, or *size* dimension of *institutional* production and reproduction, 'culture' *generation* and *regeneration*?**
- **Are *basic informal* social rules generated and retained at the *micro* or conventional '*macro*' (or *nation-state)* levels?**
- **Have evolutionist and institutionalist socio-economists always presumed some *medium-sized 'platforms'* of cultural emergence, such as any *sub-populations*, social groups and milieus, regions, communities, industries, agglomerations, clusters, networks, professional groups, etc.?**

- **→ This paper is an exploration in the *process*, *logic* and *explaining factors* of structural emergence and 'meso' size.**

2) Approaches to ‚Meso' so far (1)

- **<u>K. Dopfer, J. Foster, J. Potts, 'Micro – meso – macro', JEE 2004, Dopfer/Potts (2007), etc.:</u>**
  - **origination, adoption/diffusion, and retention of an institution is predominantly a 'meso' phenomenon;**
  - **a 'generic' rule plus a population of its actualizations in a 'carrier group' = *meso unit*;**
  - **origination, adoption/diffusion, and retention of a meso unit is a *meso trajectory*;**
  - **the source and first user of the generic rule is the inventing entrepreneur;**
  - **'our approach is *ontological*' (DFP).**
- **But: *Why* and *how* 'meso'? What is the problem solved by a meso unit? And how is it solved?**

2) Approaches to ‚Meso' so far (2)

- **T.C. Schelling, Micromotives and Macrobehavior, 1978:**

  (1) attendance problem, (2) segregation (clustering) model: emerging consistent *mutual expectations* and interdependent *behaviors* → an *implicit group size* problem, minimal and maximal *critical masses.*

- **W.B. Arthur, (on The El Farol Problem), AER 1994:**

  attendance problem, emerging consistent mutual *expectations* and behaviors→an implicit group size problem.

- **R. Axelrod, 'Effective Choice in the PD', J of Conflict Resolution (1980), The Evol of Cooperation (1984/2006):**

  (1) deterministic *single-shot* condition for PD supergame; (2) stochastic *evolutionary stability* of institutionalized cooperation: minimal *critical masses;* (3) spatial *segregation* dynamic: maximal *critical masses*; (4) role of *expectations* to 'meet again': *discount factor δ* indicative of *group size*.

2) Approaches to ‚Meso' so far (3)

- **BUT: group size is *only a tacit problem* in Schelling, Axelrod, and Arthur. PLUS: Axelrod's topical approach is 'tricky'.**
- **R. Gibbons (on the 'folk theorem'), Ind&Corp Change (2006).**
- **Furthermore: many formal complex models of group formation, segregation, clustering, network formation, institutional emergence …**
- **The evolutionary and institutional(ist) traditions:**
  - **G.M. Hodgson (2000) on 'emergence'**
  - **J.B. Davis (2007) on the 'network conception of the individual' and on 'agency'**
  - **Dolfsma/Verburg (2006) on 'agency' and institutional change, Leydesdorff (2007) on 'intentionality'**
  - **earlier uses of the 'meso' idea: v. Staveren (2001), Elsner (2000), …**

3) Institutional Emergence as "Meso": DFP (1)

Dopfer, Foster, Potts (DFP), "Micro-meso-macro", JEE 2004 (1):

- **"From an evolutionary perspective, one cannot directly sum micro into macro."**
  - **economics is about *coordination* and *change***
  - **"economic evolution is a *growth of knowledge* process"**

  which makes economic evolution differ from biological evol.
  - ***knowledge* is a *rule structure,* rules as *informational* devices**
  - **knowledge refers to *variety* (*novelty*) first, then selection**
  - **micro: individual carriers of rules, and their interactions**
  - **meso: "the *population aspect* of a rule"**
  - **macro: "population structure of systems of meso"**

    (statistically, rather than analytically connected to micro), i.e. The coordination and order of meso units

3) DFP (2)

- "*evolution* as *change in the meso* domain", *change in the population of rules*
- def.: "meso unit": a "*generic rule*" plus its *population of actualizations*.
- evolutionary factors: *size* and *variance* of a rule-population, e.g. logistic diffusion, replicator dynamics
- def.: "*trajectory*" – *origination*, *adoption/adaptation*, and *retention* of a generic rule and its actualizations

- micro: *origination* - each agent is continually engaged in *problem-solving*, which *results in rules*; but "agents continually exploring new ideas", because "minds are naturally restless" (solving which problem?) - "Our use (…) is more (…) *ontological* (…)" (!)

- macro: "*deep structure*" – division of knowledge and coordination of rules, inconsistencies, missing rules, gaps "*surface structure*" – capacity, effective demand, etc.

3) DFP (3)

- **the "*meso trajectory*":**
- **Meso 1, *origination*: "an agent develops an idea/rule" (!) ("meso", because it is a *generic* rule?), many agents doing so, generating variety**
- **Meso 2, *diffusion*: mass adoption and adaptation, many actualizations, "re-normalization of behavior", institutionalization (saturation region of a logistic curve); (micro implications: contesting an older monopoly; macro implications: fast growth, re-coordination)**
- **Meso 3, replication, maintenance, repair, *retention*: a hypothetical stationary state (akin to neoclassical GE, a special case); (micro: new agents prone to disturb the stability; macro: stability provides condition for novelty)**

3) DFP (4)

- **„the meso perspective gives us a much needed ontology“ (!)**
- **a meso trajectory “results in the growth of knowledge” (what for?)**
- **DFP:** ***micro <= meso => macro***
- **meso as ontological unit, micro as a “creative Schumpeterian entrepreneur”**

- **which problem does a rule solve?, “genetic explanation” from micro interactions; microfoundation of meso, and mesofoundation of micro (Hodgson: “reconstitutive downward causation”)?**

4) This Approach to ‚Meso'

- **Perspective of *institutional emergence* (origination and diffusion)**
- **building on and exploring the *single-shot* logic of a *social-dilemma* type supergame problem, its relevance and properties**
- **exploring the roles of *past experience*, *future expectations*, *interests/incentives*, and also of individual creativity/*agency***
- **'instrumental' perspective: individual and collective *problem*-solving**
- **exploring the *deterministic* and the *stochastic* perspectives**
- **building an *evolutionary 'process story'* (Dosi/Winter) that integrates that logic**
- **exploring *minimal critical masses*, the *maximum critical mass*, and the *'relevant' cooperating group* being below the size of the whole population**
- **making use of Axelrod's formalisms and Schelling's graphical representations.**

5) The Coordination Problem, Institutional Emergence, a Formal Solution, and a Process Story (1)

- ***the complex structure*: direct interdependence and a coordination and social dilemma problem structure, generate complexity and strong uncertainty**
- **'fallacy of aggregation': '*unintended consequences*' inverted**
- ***the evolutionary process*: recurrence, sequentiality, interaction, cumulativity, learning, institutionalization of coordination.**
- ***Relevance*: the dilemma approach in every-day decision-making**
- **'surface' structures: institutionalizations, either problem-solving or ceremonial, locked in or mutual blockages/non-action/non-innovation, perceived or not.**
- ***The pros and cons*: of an evolutionary interpretation of a game: simplistic or complex, reflexive behavior, networked individuals.**

5) The Coordination Problem, Institutional Emergence, a Formal Solution, and a Process Story (2)

$$\begin{matrix} a, a & d, b \\ b, d & c, c \end{matrix}$$

with $b > a > c > d$, and $a > (d + b)/2$.

$$P_{C/C} = P_{TFT/TFT} = a + \delta a + \delta 2a + \ldots$$

$$= \frac{a}{1 - \delta}$$

$$P_{ALL\ D/TFT} = b + \delta c + \delta 2c + \ldots$$

$$= \frac{c}{1 - \delta} + b - c.$$

$$P_{TFT/TFT} >\ ! P_{ALL\ D/TFT}.$$

$\underline{\delta >\ ! (b - a) / (b - c)}$, the 'single-shot' solution. (1)

5) The Coordination Problem, Institutional Emergence, a Formal Solution, and a Process Story (3)

Explaining factors and their evolutionary embedding:

- ***incentive structure*** **and the common future, the probability to 'meet again', i.e. the discount factor, indicating group size → the static deterministic** ***logical condition*** **for emerging institutions**
- ***cooperation*** **emerges as a** ***coordinating institution*** **including a** ***sanction*** **mechanism, requiring a sacrifice**
- **a process of** ***habituation*****, cannot be short-run rational, but 'semi-conscious', a** ***different rationality*****, possibly** ***motivated/supported*** **by a** ***'favorable' logical condition*** **[inequality (1)]**
- **possibly also** ***motivated*** **from** ***repeated frustration*****,** ***search for improvement*****,** ***experimentation*****, instinct of workmanship, idle curiosity, …random** ***diversification of behavior*****, probabilistic app.**

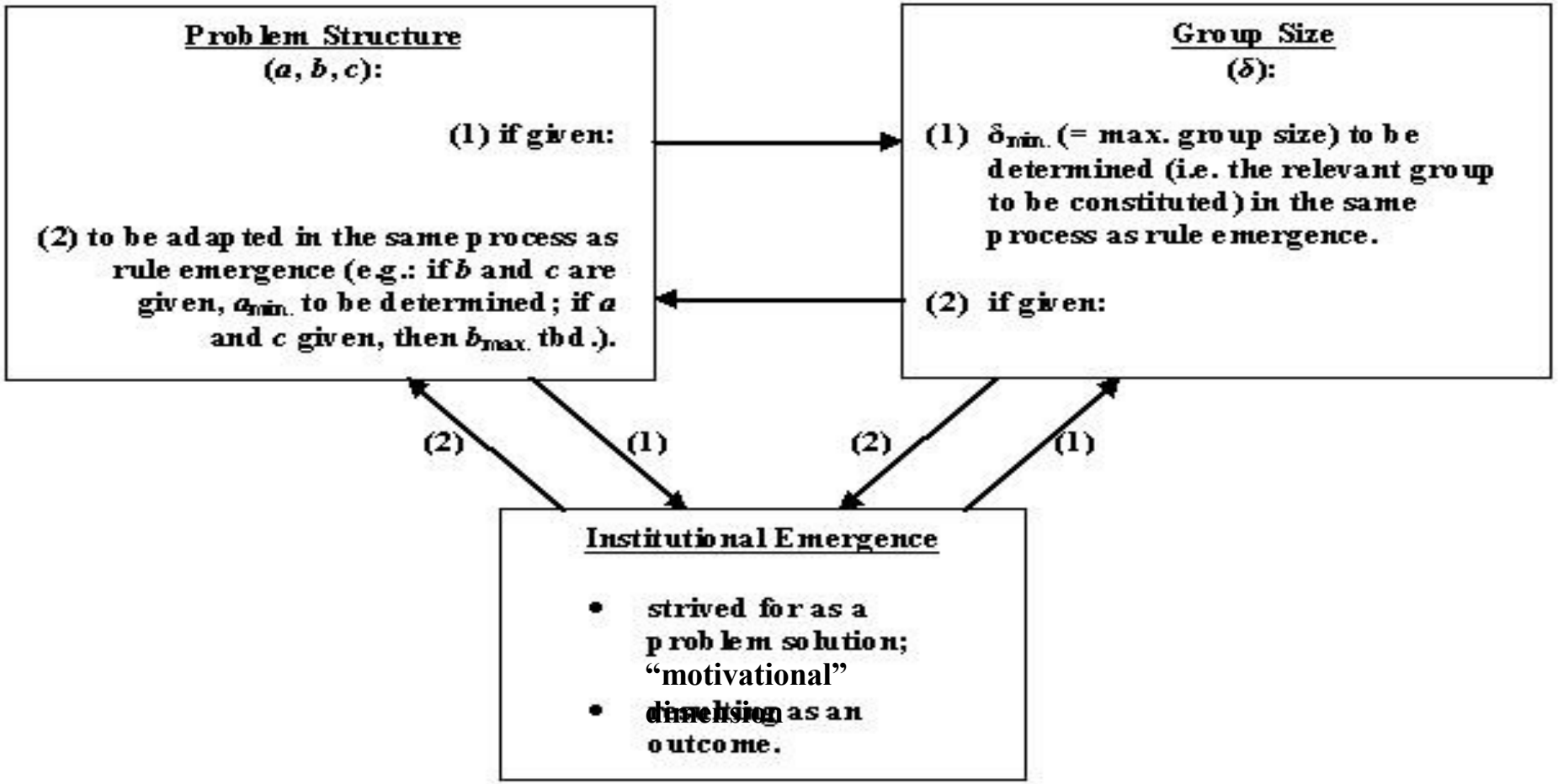
5) The Coordination Problem, Institutional Emergence, a Formal Solution, and a Process Story (4)

- **imagination, creativity, intentionality, reflexivity, innovation, *agency* … required**
- ***cumulative* interaction, path dependence in diffrnt directions …**
- **'attractor' points … including *destabilizing* incentives to defect while the institution emerges**
- ***risk taking* and *not being too envious* … (s. traveler's dilemma, K. Basu 1994/2007)**
- ***agency* assumption: co-determining *group size* through *active partner selection* (maximum number of partners), establishing a 'neighborhood', a segregation…**

- **→ *group size* becomes *cause and effect*, δ a variable, a *co-evolutionary* three-sided interrelation of *group constitution* (size determination), *incentive structure* and *institutional emergence*.**

5) The Coordination Problem, Institutional Emergence, a Formal Solution, and a Process Story (5)

Figure 1: A Simple Logic of the Co-Evolution of the Problem Structure, the Efforts of Agents for Problem-Solving, and Group Size.



5) The Coordination Problem, Institutional Emergence, a Formal Solution, and a Process Story (6)

- ***The limits of the deterministic logic*, of 'pure expectations' ('pure group size'), i.e. of the *first and general interpretation of the discount factor*:**

  group sizes tend to be *very small*, would be practically *irrelevant*, and '*evolutionarily instable*', unsustainable–numerical examples.
- **However: *Axelrod*'s 'trick', a *second, specific interpretation*, i.e. a *self-commitment* of cooperating agents for long-run relations among themselves, while invading a population of 'meanies', δ then indicating the *number of rounds between same agents* !! → δs around 0.996!→high probability for a meso group to evolve…**
- **in addition: the pay-offs of the large group of 'meanies' remains unaffected by the invading cooperators !! – favorable calculations → high probability for a meso group to survive …**
- **rejected here. However: the logic of *minimal critical masses* established by Axelrod.**

5) The Coordination Problem, Institutional Emergence, a Formal Solution, and a Process Story (7)

Expectations and Group Size: Examples

Table 1: Variable Constellations, Minimum/Maximum Values of 'Dependent' Variables, and Related Group Sizes.

Given Variable Values	Minimum/Maximum Values Required of 'Dependent' Variables	Related Group Sizes (No. of Agents)
(1a) b=4; a=3; c=2	! δ>0.5	3
(1b) b=1,000; a=3; c=2	! δ>0.999	->2
(1c) b=1,000; a=999; c=2	! δ>0.001	1,001
(2a) b=4; c=2; δ=0.95	! a>2.1	->2
(2b) b=1,000; c=2; δ=0.95	! a>52	->2
(3) a=3; c=2; δ=0.95	! b>22	->2

6) The Stochastic (Population) Perspective (1)

Pay-off functions (*two* pure strategies/prototypes case) to determine ***evolutionary stability***, i.e. *minimal critical masses*, with k = *number of co-operators*, and *population size* = n+1:

$$f_{ALL\ D} = [k/(n+1)][c/(1-\delta)+b-c] + [(n+1-k)/(n+1)][c/(1-\delta)] \qquad (2)$$

$$g_C = [k/(n+1)][a/(1-\delta)] + [(n+1-k)/(n+1)][c/(1-\delta) + d - c], \qquad (3)$$

with *C* to be either (1) *ALL C* or (2) *TFT* players.

→ Using *Schelling*'s depictions …

6) The Stochastic (Population) Perspective (1a)

Simplification: $\kappa = k/(n+1)$

$$f_{ALL\ D} = \kappa\,[c/(1-\delta)+b-c] + (1-\kappa)[c/(1-\delta)] \qquad \textbf{(2a)}$$

$$g_{TFT} = \kappa\,[a/(1-\delta)] + (1-\kappa)[c/(1-\delta) + d - c]. \qquad \textbf{(3a)}$$

Applications:

(1) The *relevance of* δ, given κ, Axelrod's propositions 2 and 3:

***If*: $\kappa[a/(1-\delta)] + (1-\kappa)[c/(1-\delta)+d-c] >! \kappa[c/(1-\delta)+b-c] + (1-\kappa)[c/(1-\delta)]$,**

$\rightarrow$ *calculate* δ_{min}! (interpretations: no. of rounds, group size!)

(also for the stability of an "incumbent" *ALL D* culture! $\rightarrow \delta_{max}$!)

Note: Axelrod's assumptions

- **a small *TFT* cluster invades a very large incumbent *ALL D* population;**
- ***TFT* agents "self-commit" to lasting interactions among themselves, $\delta \rightarrow 1$;**
- ***ALL D* agents may ignore the *TFT*s: $f_{ALL\ D}$ simplifies to $f_{ALL\ D} = c/(1-\delta)$**

$\rightarrow$ facilitates the invasion (collective/evolutionary stability) of cooperation!

6) The Stochastic (Population) Perspective (1b)

(2) The *relevance of* κ, given δ, Axelrod's proposition 6:

***If*: $\kappa[a/(1-\delta)] + (1-\kappa)[c/(1-\delta)+d-c] >! \kappa[c/(1-\delta)+b-c] + (1-\kappa)[c/(1-\delta)]$,**
$\rightarrow$ *calculate* κ_{min}!

(also for the stability of an "incumbent" *ALL D* culture! $\rightarrow$ κ_{max}!)

"At which composition of the population does it pay for me to cooperate or to defect?"

Numerical example:

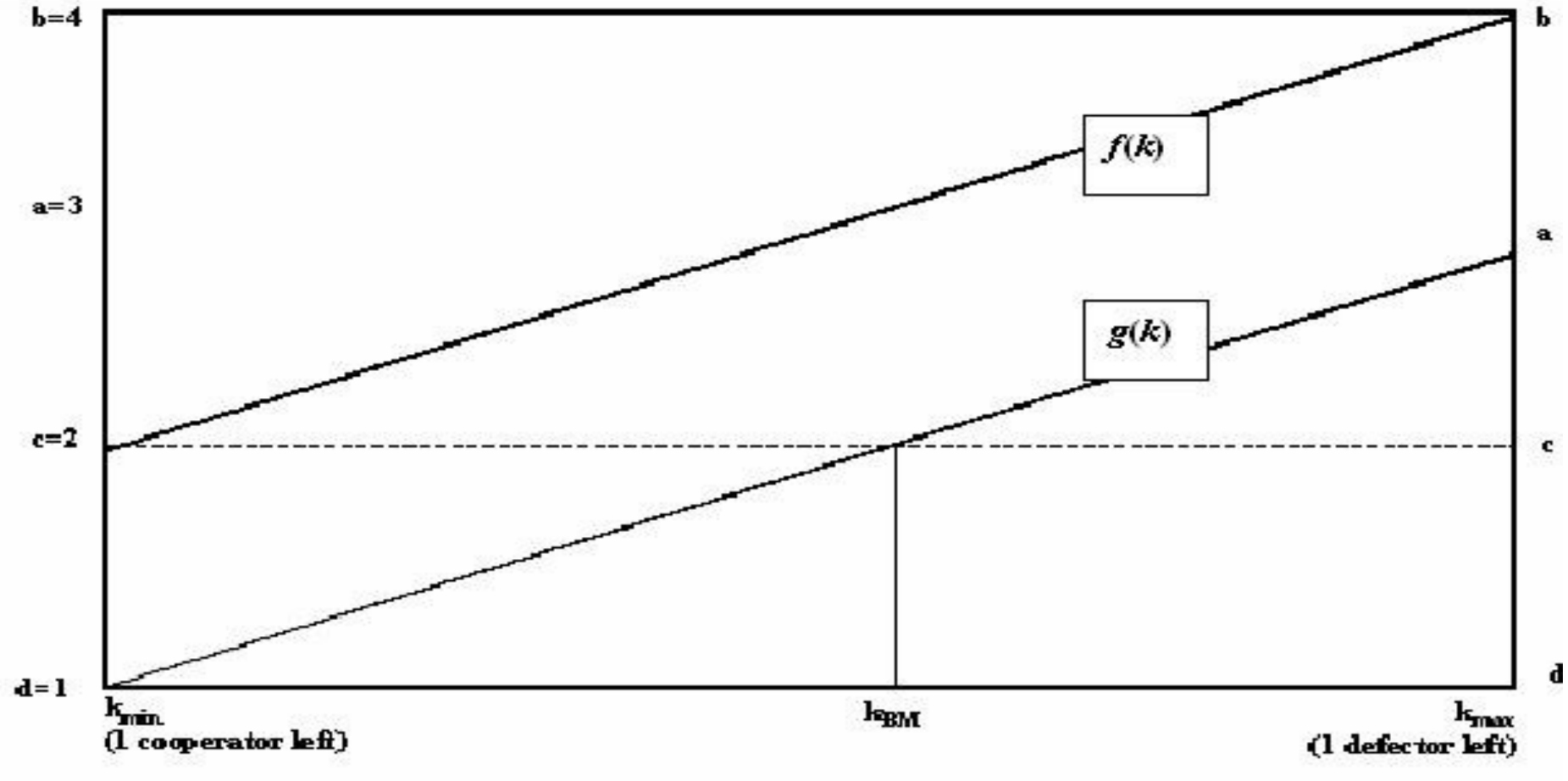
given δ=.9, b=5, a=3, c=1, d=0 $\rightarrow$ for evolutionary stability of *TFT*, $\kappa_{min} >!$ 1/17 = .0588.

5.9% of the whole population must be *TFT*s in order for *TFT* to invade and survive (and perh. expand) (under given conditions!).

6) The Stochastic (Population) Perspective (2)

Figure 2: Illustration of the ALL D and ALL C Pay-Off Functions, Depending on the Number k of Co-operators in a Population, Yielding a 'Minimum-Size Cooperating Group', k_{BM}.

(The 'very large group': $\delta = 0$); (1) C → *ALL C*



6) The Stochastic (Population) Perspective (2a)

For *ALL C* vs *ALL D* and a very large group ($\delta = 0$):

$$f_{ALL\ D} = \kappa\, b + (1-\kappa)\, c \qquad \textbf{(2b)}$$

$$g_{TFT} = \kappa\, a + (1-\kappa)\, d. \qquad \textbf{(3b)}$$

If: $\kappa\, a + (1-\kappa)\, d\ >!\ \kappa\, b + (1-\kappa)\, c \rightarrow$ ***no solution.***

6) The Stochastic (Population) Perspective (3)

<u>Combining 'group size' and 'evolutionary stability' perspectives</u>

with the minimum no. of cooperators now a function of δ: $k_{min}=k_{min}(\delta)$.

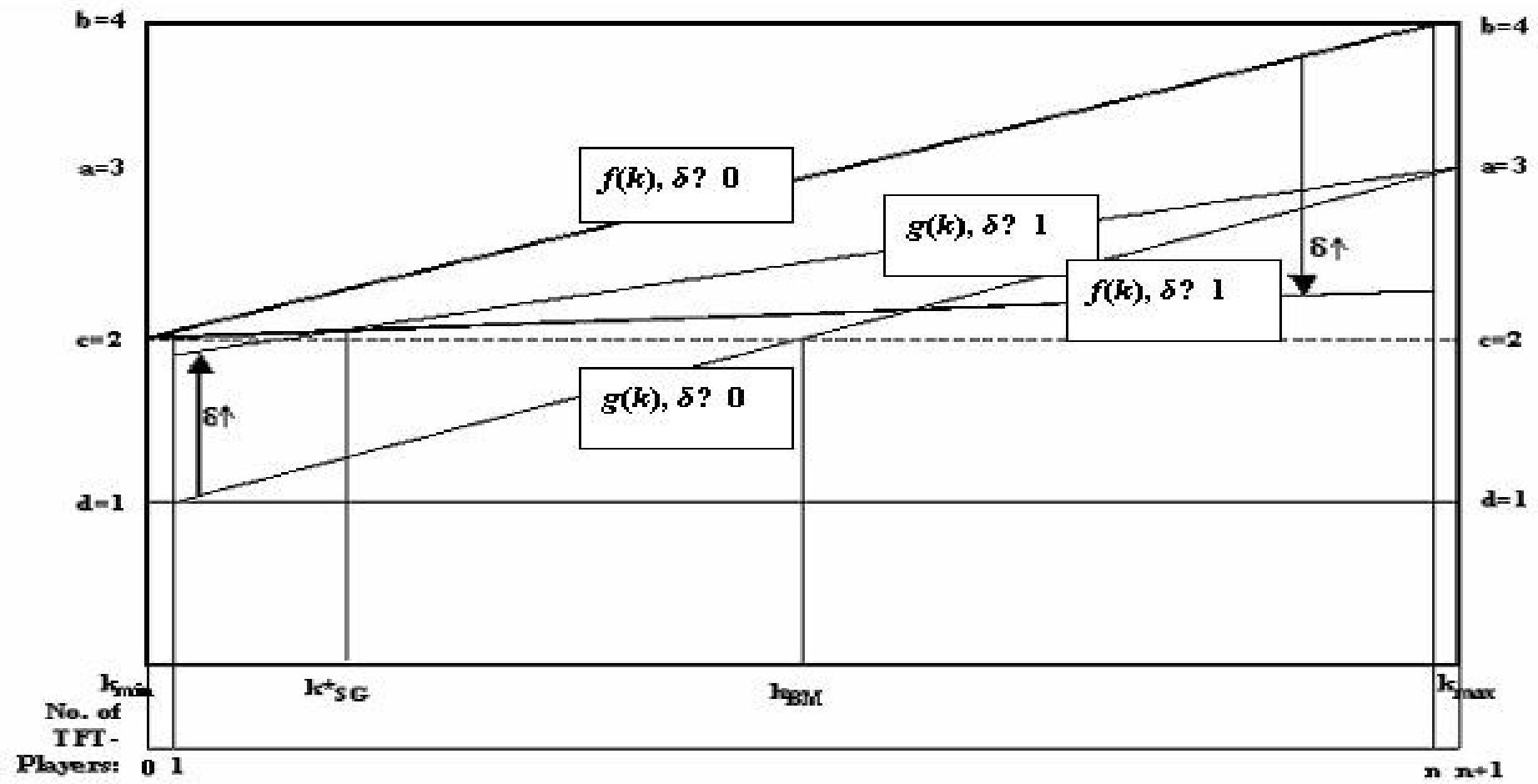
(2) C → *TFT*; ε = a margin around *c*:

- **the *very large group*** ($\delta \rightarrow 0$): $f(k=0) = c$; $f(k=n) = b$
  $g(k=1) = d$; $g(k=n+1) = a$
- **the *very small group*** ($\delta \rightarrow 1$): $f(k=0) = c$; $f(k=n) = c+\varepsilon$
  $g(k=1) = c-\varepsilon$; $g(k=n+1) = a$.

- **(1) → a *minimum critical mass* becomes feasible the smaller the group (possibly through search and random diversification, depending on the total constellation), but: k^*_{SG} = *meso size* !?**
- **(2) → the '*relevant cooperating group*' = *max. critical mass* = whole population.**

6) The Stochastic (Population) Perspective (4)

Figure 3: Illustration of the Pay-Off Functions for TFT vs. ALL D, Depending on the Group Size (δ), Yielding a Minimum 'Critical-Mass' Group Size For Institutional Emergence, k^*_{SG}, and the 'Relevant' Cooperating Group at k_{max}.



6) The Stochastic (Population) Perspective (5)

- **But the *group size still tends to be very small* in the numerical examples, as long as we use the static deterministic (first and general) *interpretation of δ as ‚pure group size'*, given the numerical example (of Axelrod!) of the incentive structure.**

- **→ From 'pure expectation' to '*contingent trust*': δ_k = the probability and expectation to *meet a cooperator next round***
- ***stochastic diversification of behavior* (motivated as said) presumed, then $\delta_k = k/(n+1)$, payoff next round again**

  $P_{t+1} = \{k/(n+1)a + [(n+1-k)/(n+1)]c\}*\delta = [a\delta_k + c(1-\delta_k)]*\delta$

  ($\delta \rightarrow k \leftarrow \delta_k$ => co-evolution …)

- **Comparing the *individual's knowledge about others* with the single-shot logic as benchmark: starting from '*knowing about*' one or two others *in the very small group* …**

7) Increasing Group Size

- **Mechanisms *monitoring*, *memory*, and *reputation* *chains* probably *multiplying the number* of potential partners whom the agent 'knows about'**
- **→ growing into *meso group sizes*, *keeping δ*s mid-sized or *high*, while *increasing the group size***
- **numerical examples: multipliers may assume 4-digit size: meso-groups of thousands …**

8) Decreasing Group Size: The Cooperative Group Smaller Than the Population (1)

- ***Non-linear pay-off curves:***

  - Schelling: *additional mutual externalities* on top of cooperators' pay-offs, e.g. net-externalities

  - neo-Schumpeterian understanding of *cumulative technological knowledge* (inter-personal and over time)

  - *replicator* mechanism (e.g. Axelrod), additional positive feedback, e.g. quasi-learning

  - Arthur: increasing returns, reflected in an *improvement function*, or additional 'coordination externalities'

  - Arthur: '*bounded improvement function*' – some minority remains

  - R. Cooper: '*strategic complementarities*' or '*synergies*' – coordination in supplier networks or among industries

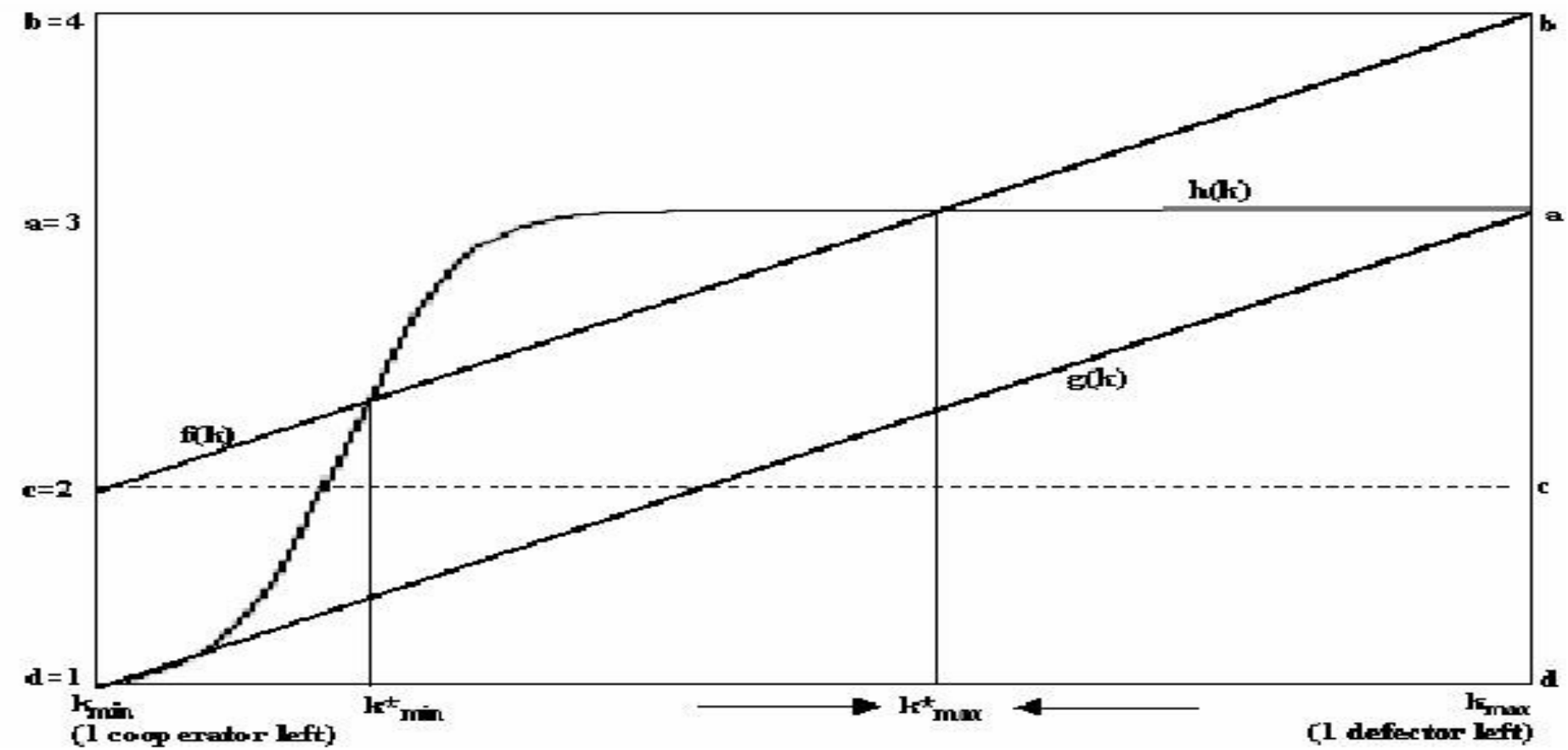
8) Decreasing Group Size: The Cooperative Group Smaller Than the Population (2)

- **Using convex, concave, or *S-shaped* (logistics) curves …**
- **S-shaped curves also reflecting the *exhaustion of additional externalities* from cooperation, maturity …**

- **(1) the average pay-offs of a *minimum critical mass* quickly exceed the defectors' av. pay-offs, *small minimum critical mass***
- **(2) the '*relevant cooperating group*' (upper 'equilibrium') becomes a *maximum critical mass below the size of the whole population***
- **(3) a *meso-sized area of stable cooperation* illustrated**
- **(4) *even in a very large group* (as in figure 4)**
- **(5) pay-off from cooperation must never exceed its original size, i.e. never exceed *a*.**

8) Decreasing Group Size: The Cooperative Group Smaller Than the Population (3)

Figure 4: Illustration of 'Synergies' (and 'Exhaustion of Synergies') in the Pay-Offs From Coordination, Indicating the 'Meso'-Size Area of the 'Relevant' Cooperating Group.



8) Decreasing Group Size: The Cooperative Group Smaller Than the Population (4)

- **(6) reflects the fact that an *existing institution* may easily *provoke* a *portion of 'defectors'* profiting from the cooperators, (or 'minority culture'?), to emerge**
- **(7) the institution has a *meso-sized problem-solving coordinated group of carriers* ('doves') and can *sustain a portion of deviators***
- **(8) cooperating and defection possibly not a *distinction among individuals*, but as *distinct types of actions* in the set of actions *of every individual***

8) Decreasing Group Size: The Cooperative Group Smaller Than the Population (5)

Adapting Group Size through 'Agency'

- **individuals capable of *co-determining* their social *interrelations* *adapting* their *individual maximum group sizes***
- **if selections correlate then *group boundaries*, or '*neighborhood*' structures may emerge**
- **Axelrod's *second, specific interpretation* of δ: (an invading cluster of) cooperators (can be evolutionarily stable through) *self-committing to long-run relations* among themselves, i.e. a *large number of interaction rounds*.**

9) A Real-World Example - General Trust

- **(1) international '*general trust*' polls showing considerable and increasing *differences among levels of trust*, increasing divergence, with *small countries* displaying higher levels**

  (2) high correlations between *trust*, *innovation*, and general *macro performance*

  (3) *diversity of capitalism* literature: smaller countries may have mechanisms to generate higher performance (e.g. Nielsen/Kesting 2007)

  (4) smaller, negotiated-economy countries (Skandinavia, Netherlands) use layered and *overlapping group* and network structures, thus e.g. making *reputation* chains working

  (5) looking for the mechanisms of *incentive structures*, *futurity, expectations* and *trust*, *group size*, *coordination* and *institutional emergence*.

10) Final Remarks (1)

- **The proof of the pudding is the eating.**
- **<u>Complex Modeling:</u> the *evolutionary frame* and its *integrated logic* may allow for a *class of complex models* and simulations that focus on the (group) *size dimension* of institutionalization or the sustainability of institutions in face of defections.**
- **<u>Factors:</u> (1) incentive structure, (2) initial neighborhood structure, incl. possibly mobility, (3) 'motivated' experimentation and diversification, supported by a 'favorable' single-shot calculation etc., (4) monitoring, memorizing, reputation chain, and partner selection mechanisms, (5) additional mutual externalities, (6) resulting or co-evolving minimal and maximal critical masses and their group sizes.**

10) Final Remarks (2)

- **Applied Areas: social groups, professional networks, industry clusters, local communities and regions as platforms of structural emergence and macro performance.**
- **Policy Implications: 'institutional policy'; frame-setting at the explaining factors, e.g. perceptions of interdependence and common futurity, rather than subsidies and tax exemptions; a new policy design, a leaner policy.**
- **Future Research: the logic and process of meso to be further explored by complex simulations, possibly with field data from e.g. small country participation, reputation, and performance processes.**

****

Evolutionary-Institutional Economics

Part V:
"Structural Emergence".
Selected Models

Part V: "Structural Emergence". Selected Models

1) From PD to a Coordination Game: Equilibrium Selection (1)

1.1) *Stag Hunt* (J.J. Rousseau (1762), A.K. Sen (1967), B. Skyrms (2004). A numerical Example:

	Stag	Hare
Stag	**3, 3**	**0, 1**
Hare	**1, 0**	**1, 1**

→ generic normal form: $a > b = c > d$, → no exploitation profit, no strictly dominant strategy

→ transforms a PD into a *coordination game*; two (pure-strategy) NEs, equilibrium selection problem

→ up left: '*pay-off dominant*' (PO); low right: '*risk-dominant*' (less to lose), also called 'trust dilemma';

→ Sen: optimal savings problem (a PD called an '*isolation paradox*')

Part V: "Structural Emergence". Selected Models

1) From PD to a Coordination Game: Equilibrium Selection (2)

1.1) *Stag Hunt/Assurance Game*

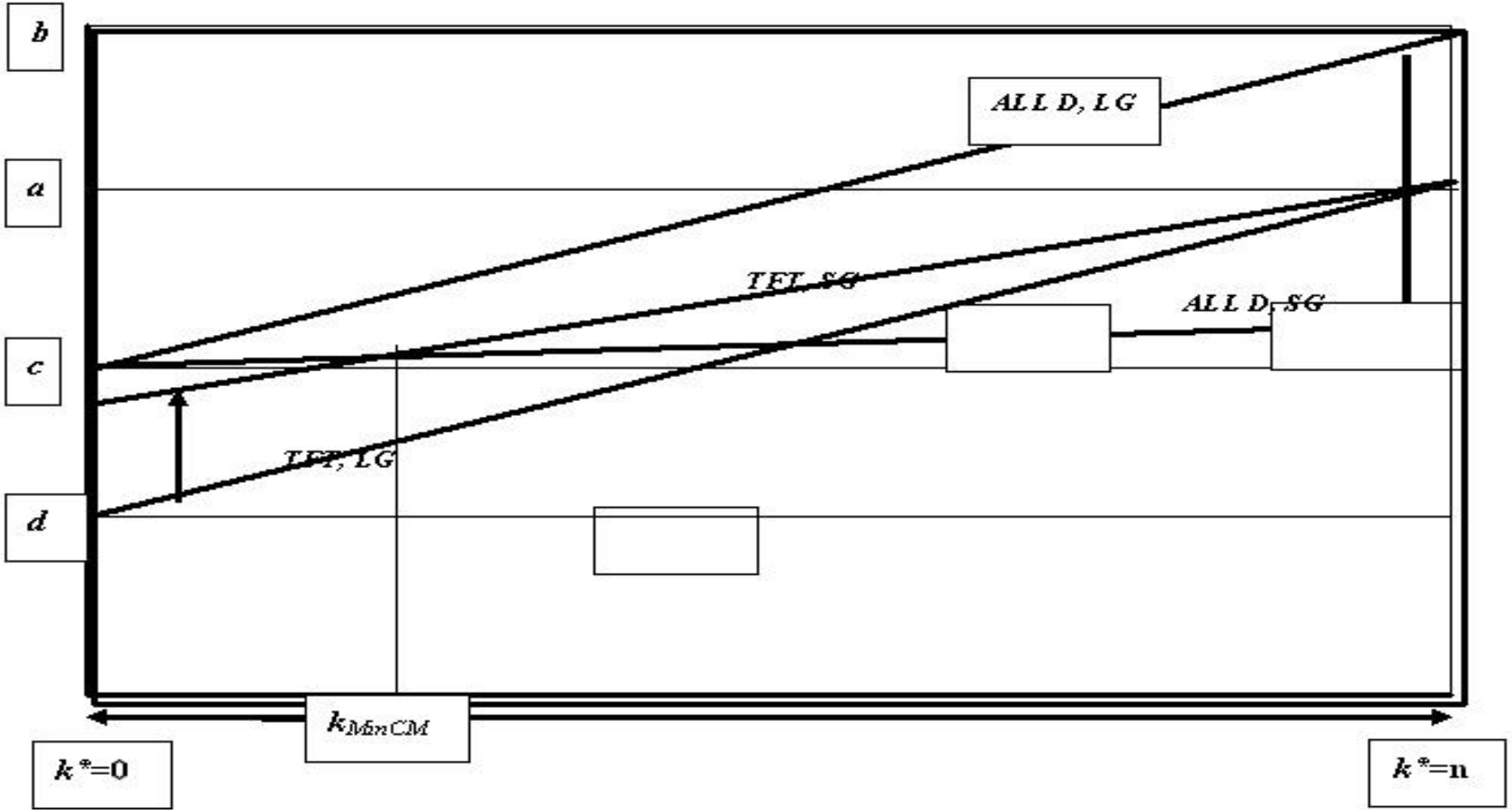
- Sen: "… *due to the indivisibility of public projects*"! Everyone has to contribute, and *non-contribution does not pay here*!
- *Select* the pareto-superior equ. through 'assurance' that other agents will do the 'right' thing, through a '*contrat social'*.
- A *logical transformation* of the PD in to a Stag Hunt, a '*designer's perspective*' … increase δ so that …
- there is a δ at which $a/(1-\delta) > c/(1-\delta)+b-c$ (s. single-shot) and at which $c/(1-\delta)+b-c \rightarrow c/(1-\delta)$, no profit from free riding → stag hunt, simple coordination game (s. also *popul. appr.*)

	L	R
U	$a/(1-\delta)$ $a/(1-\delta)$	$c/(1-\delta)+b-c$ $c/(1-\delta)+d-c$
D	$c/(1-\delta)+d-c$ $c/(1-\delta)+b-c$	$c/(1-\delta)$ $c/(1-\delta)$

Part V: "Structural Emergence". Selected Models

1) From PD to a Coordination Game: Equilibrium Selection (3)

1.1) *Stag Hunt*: From PD to Coordination Game, graphical illustr.



Part V: "Structural Emergence". Selected Models

2) Specific Properties of the Common Good

- **(1) Sen: "…** ***the indivisibility of public projects*****"**
- **applies to the** ***collective goods*** **in (1) the** ***PD*** **(2) the** ***stag hunt***
- **its generation requires** ***individual contributions*****: a 'sacrifice', risk-taking … generating positive externalities, synergies …**

- **(2) example: an "*output function*" of the "*Commons*" (s. above)**

- **(3) example:** ***learning effects*** **with a (technological) good; cumulativeness,** ***multiple equilibria*** **(attractor points) of random processes (W.B. Arthur) (s. below)**

- **(4) example: resourceful contributions:** ***common-pool resource game*** **(e.g. E. Ostrom et al.) (s. below)**

Part V: "Structural Emergence". Selected Models

3) Random Choice, Increasing Returns, Lock-in (Arthur)

I. The Simple Model

- **two competing technologies A, B**
- **agents who choose one of the two "*learn by using*" (Rosenberg 1982), thus developing through every choice a *latest version***
- **the latest version is *open* information, *shared knowledge* (!), *increasing the value* of the technology for every later adopter**
- ***returns* for A, B thus depend on the no. of previous adopters, n_A, n_B**
- **two agents R, S, with a 'natural' preference of R for A, S for B, i.e. $a_R > b_R$ and $a_S < b_S$; later returns are r, s resp.**
- **thus: return of R, for A: a_R+rn_A, for B: b_R+rn_B**

  return of S, for A: a_S+sn_A, for B: b_S+sn_B.
- **a random sequence of R and S adoption choices …**

Part V: "Structural Emergence". Selected Models

3) Random Choice, Increasing Returns, Lock-in (Arthur) (2)

- with improving technologies, i.e. *increasing returns*, new adopters will *switch to their not preferred technology* if:

  for R: $a_R+rn_A < b_R+rn_B \Rightarrow n_A(n) - n_B(n) < (b_R - a_R)/r$,

  for S: $b_S+sn_B < a_S+sn_A \Rightarrow n_A(n) - n_B(n) > (b_S - a_S)/s$

  with $n_A(n) - n_B(n) = d_n$

- these define *absorbing barriers* beyond which the process will be *locked-in* to *only one of the two technologies*

- *core theorem*: in a random process with absorbing barriers, d_n eventually crosses the barrier $d_n = n_A(n) - n_B(n)$ *with probability one*; the process converges with prob 1 to one of the stable fixed points

Part V: "Structural Emergence". Selected Models

3) Random Choice, Increasing Returns, Lock-in (Arthur) (3)

- ***system properties*: *non-predictable*, *irreversible* (if once locked-in, then progressively so), *non-ergodic*, *not path-efficient***

- **extension to the *rational expectations* case: rational expectation become *expectations of lock-in*, accelerating lock-in, narrowing the absorption barriers**

Part V: "Structural Emergence". Selected Models

3) Random Choice, Increasing Returns, Lock-in (Arthur) (4)

- basically, this describes a *coordination game* which emerges out of the *time-dependent return functions* which in turn reflect the assumed *type of innovation*: r, s = *f*r,s [nA,B(t)], specifically r_{t+1} [n(t)] = φ {r_t [n(t)]}.

		S	
		A	B
R	A	a_S a_R	b_S a_R
	B	a_S b_R	b_S b_R

- with $a_R > b_R$, $b_S > a_S$, the *initial state* after n_A, n_B = 1, the first adoption of each: [aR, bS] = equilibrium, with no interdependence yet

- asymmetric payoffs

Part V: "Structural Emergence". Selected Models

3) Random Choice, Increasing Returns, Lock-in (Arthur) (5)

- the state after $n_{A,B} > 1$: interdependence through n(t)-dependent innovation power of technologies

- two NEs (upper left and lower right), path-dependent

		S	
		A	**B**
R	**A**	$a_S + sn_A$ $a_R + rn_A$	$b_S + sn_B$ $a_R + rn_A$
	B	$a_S + sn_B$ $b_R + rn_B$	$b_S + sn_B$ $b_R + rn_B$

Part V: "Structural Emergence". Selected Models

3) Random Choice, Increasing Returns, Lock-in (Arthur) (6)

II. The General Formulation

- **(1) many technologies: K technologies 1 …K chosen at each adoption with probabilities p(x) = {*p1*(x), *p2*(x), …, *pK*(x)}, with x the vector of adoption shares 1 … K**
  p(x) *adoption function*

- **again, the stochastic process *will converge* with prob one to one of the fixed points of the adoption function (if several exist)**

- **e.g., where the *probability* of adoption of A is higher than its *adoption share*, A tends to increase its share, self-reinforcing**

- **→ multiple equilibria, thus equilibria selection problem which is path dependent**

Part V: "Structural Emergence". Selected Models

3) Random Choice, Increasing Returns, Lock-in (Arthur) (7)

Extensions:

- **(2) many adopters (adopter types): each adopter (type) has a vector of 'natural' preferences for fore the K technologies, a, a = (a_1, a_2, …, a_j, …, a_K); the continuum of agents is mapped as a distribution of points a**
- **n_j the number of earlier adoptions of technology j, a_j the agent's 'natural' preference for j**
- **(3) non-linear improvement of pay-offs: r the (technological) *improvement function***
- **next agent's pay-off to adopting j: $\Pi_j(n_j) = a_j + r(n_j)$**
- **→ applying the core theorem: if r increases at least at rate ε as n_j increases, the *process converges* to the dominance of a single technology, with prob 1! dominance of one technology**

Part V: "Structural Emergence". Selected Models

3) Random Choice, Increasing Returns, Lock-in (Arthur) (8)

- **(4) a bounded improvement function: *learning effects* may become *exhausted*, e.g. a sigmoid function (s-shaped curve)**
- **increasing, but *bounded returns* in general not sufficient to guarantee a single-technology fixed point; dominance by a single technology no longer inevitable**

III. Further Considerations:

- **increasing returns may arise from '*coordination externalities*' (s., e.g. PD/commons, stag hunt/coord game, CPR-G …) or *network externalities* …**
- **implications for *economic history*: no innate superiority of 'winning' technologies …**
- ***policy*: supporting less popular technological paths …**
- ***sponsored technologies*: monopoly-pricing problem …**

Part V: "Structural Emergence". Selected Models

5) Cooperation for a Collective Good: CPR-G (1)

- **E. Ostrom et al., Covenants With and Without a Sword: Self-Governance is Possible, Am. Pol. Sc. Rev., 1992**
- ***non-cooperative* game theory - the *sword* alone: *sanctioning*; → the *sanction as a variable*, decreasing the opportunity costs of cooperation (*b*-*a*), increasing the OC of defection (*b*-*c*), $b\downarrow$, $c\downarrow\downarrow$ …**
- **plus: *communication* in the lab, → *cooperative* game theory …**

(I) <u>The Game</u>

- **n, 1, …, i, …, n, users of the CPR**
- **resource endowment of each user, e**
- **marginal payoff for private use of e: w**
- **user i's investment in the CPR, x_i, $0 \leq x_i \geq 1$**
- **payoff for invest in the CPR: $F(\Sigma x_i)$, a concave function with $F(0)=0$, $F'(0) > w$, and $F'(ne) < 0$; initially investmt in CPR pays better than private use, but if all is invested in CPR, marginal payoff is below private marg. payoff, even below 0**
- ***net yield from CPR* has some *maximum* below max invest CPR.**

Part V: "Structural Emergence". Selected Models

5) Cooperation for a Collective Good: CPR-G (2)

- $\boldsymbol{x} = (x_1, \ldots, x_i, \ldots, x_n)$, the vector of individual investments in CPR
- <u>individual payoffs:</u> $u_i(x_i) = we$, for $x_i = 0$
- $u_i(x_i) = w(e - x_i) + (x_i/\Sigma x_i)\, F(\Sigma x_i)$, for $x_i > 0$, for all i
- a non-cooperative game with a symmetric NE at x_i^*, where $u_i'(x_i) = 0 = -w + (1/n)\, F'(nx_i^*) + F(nx_i^*)\, [(n - 1) / x_i^* n2]$, $\rightarrow$ $nw - F(nx_i^*) = F'(nx_i^*)$, *individualistic solution*
- <u>compared to an ideal, collectively optimal solution</u>:

  <u>group payoff:</u> $u(x) = nwe - w\Sigma x_i + F(\Sigma x_i)$, with

  $u'(x) = 0 = -w + F'(\Sigma x_i) = -w + F'(x^*) \leftrightarrow w = F'(x^*)$,

  group maximum
- in the *individualist* solution (NE), invest in the CPR is *above* the optimum! *Non-coordination* is *over-investment* in the CPR, *deteriorating the returns* from the CPR (see below).

Part V: "Structural Emergence". Selected Models

5) Cooperation for a Collective Good: CPR-G (3)

(II) <u>Lab Experiment Settings and Game-Theoretic Predictions:</u>

(1) *<u>finite repetition</u>*: common knowledge that it will be a 1-2 hours experiment → game theory would predict a finite sequence of one-shot NE outcomes (backward induction)

(2) *<u>communication</u>*, one-shot (at the beginning) or repeated (among interaction rounds) → game theory would predict the same NE outcome ('cheap talk')
(*Note*: communication is costless)

(3) *<u>sanctioning</u>*, and being sanctioned: both uses resources, thus reducing the payoffs: f_1 costs of fining, f_2 costs of being fined, Σs_{ij}, j=1…*n*, all sanctions of *i* against others, Σs_{ji} all sanctions *i* received from others, thus …

Part V: "Structural Emergence". Selected Models

5) Cooperation for a Collective Good: CPR-G (4)

$u_i(x,s) = u_i(x) - f_1(\Sigma s_{ij}) - f_2(\Sigma s_{ji})$ → game theory would predict that with no deviation from the unique NE path, there also will appear no sanctioning;

but allowing for *varying* f_1, f_2, also some *trigger strategy* may come about as an equilibrium;
trigger strategy: with $z_i < x_i^*$, always play $(z, 0)$; in case of deviation of others play $(x_i = e, s)$ for one round, then resume $(z, 0)$

Note: own reactive deviation includes a *sanction through over-investment* in the CPR ($x_i = e$) (plus explicit sanction s), thus decreasing $F(\Sigma x_i)$ into $F(ne)$, assumed to be a negative number

Part V: "Structural Emergence". Selected Models

5) Cooperation for a Collective Good: CPR-G (5)

(4) CPR production function specified as quadratic:

$$F(\Sigma x_i) = a\Sigma x_i - b(\Sigma x_i)^2,$$

with $F'(0) = a > w$ and $F'(nw) = a - 2bnw < 0$,

- thus *optimal group investment* [generally $0 = -w + F'(\Sigma x_i)$, as given above] is $0 = -w + a - 2b\Sigma x_i \rightarrow \Sigma x_i = (a-w)/2b$.
- And CPR yields 0 on net when invest is $\Sigma x_i = (a-w)/b$.
- *individualist NE invest* yields: $\Sigma x_i = [n/(n+1)](a-w)/b$.

Again: *NE* invest is *above maximal group net yield* invest:

$(a-w)/2b < [n/(n+1)](a-w)/b \rightarrow a-w < [2n/(n+1)](a-w)$,

and below 0 net yield: $(a-w)/b > [n/(n+1)](a-w)/b$,

approaching the latter as n gets larger.

Part V: "Structural Emergence". Selected Models

5) Cooperation for a Collective Good: CPR-G (6)

(III) <u>Experimental Design</u>:

<u>elements</u>

(1) *communication* (*one shot* in advance, or *repeated*, among rounds)

(2) *sanctioning* (imposed, within given limits)

(3) *communication plus imposed sanctioning*

(4) *communication* plus free choice of sanctioning mechanism ('endogenous sanctioning'),

resulting in <u>game types</u>:

(1) *baseline game*: no communication, no sanctioning

(2) game with *communication*

(3) game with *imposed sanctioning* mechanism

(4) game with *communication* and imposed *sanction*

(5) game with *communication* and *chosen sanctioning*.

Part V: "Structural Emergence". Selected Models

5) Cooperation for a Collective Good: CPR-G (7)

(IV) *The Baseline Game*:

with given numerical parameters,

i.e. number of users, initial money endowment, money return per unit of output,

***group maximum* and *NE* can be calculated;**

e.g., NE yields ca. 39% of maximum yield from CPR.

Baseline game played *20 rounds*, although players did not know the exact no of rounds (other ganmes played max. 32 rounds).

lab experiment confirms that individuals can not solve the collective action problem, they learn strategically to defect (!), ending up close to the predicted NE (36 and 32% of max, 39% predicted).

Part V: "Structural Emergence". Selected Models

5) Cooperation for a Collective Good: CPR-G (8)

(V) Summary of Results: Average Yield as Percentage of Maximum

Game Design	*Percentage Yield*	*Course over Rounds*
Baseline, low/high initl endow	36%/32%	rounds 16-20
One-shot communication alone, high initial endowment	59%	after round 25, down from 74% in rounds 11-15
Repeated communication alone, low initial endowment	*100%*	rounds 21-25, constantly increasing to 100%
Repeated communication alone, high initial endowment	69%	rounds 21-25, slightly falling
Imposed explicit sanction alone, high initl. endowment	39%	rounds 16-20, falling after
Imposed sanction alone, high initial endowment	29%	rounds 21-25, falling from 40% in rounds 11-15
One-shot communication plus different explicit sanctions, high initial endowment	*86-97%*	rounds 16-20, constantly above 90%

Part V: "Structural Emergence". Selected Models

5) Cooperation for a Collective Good: CPR-G (9)

(VI) Remarks/Qualifications

- **covenants without a sword: *one-shot communication* is not sufficient, gained agreements decayed soon**
- **in *repeated communication*, defections occurring after agreement could be discussed, with verbal sanctions directed at unknown defectors**
- **swords without covenants: *imposed sanctioning alone* occurs more frequently than predicted by the model, indicating that agents do want to foster cooperation**
- **but *imposed sanctioning alone* is often not focused, erroneous, lagged, or blind revenge, too high**
- ***imposed sanctioning alone* was too costly, in sum inconsistent with the prediction of a cooperative equilibrium**

Part V: "Structural Emergence". Selected Models

5) Cooperation for a Collective Good: CPR-G (10)

- **<u>covenants with swords</u>: *communication and sanctioning***
  - **(1) *one-shot communication and imposed sanctioning***
  - **(2) *one-shot communication and freely chosen (endogenous) sanctioning* (sanctioning and the levels of fees and fines agreed upon by discussion and voting)**
  - **→ high average yields.**
- **But: with *<u>higher endowments</u>* communication alone and sanctioning alone seem to be less effective. With high endowments, *one-shot communication* and a *freely agreed sanction* are most effective.**
- **Games need not to be truly infinitely repeated: subjective beliefs of some positive probability of repetition are sufficient.**