



System. Dynamics. Economics

A look back & aside & ahead

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for FGP 2022 ceremony at UCB (oct 13th)

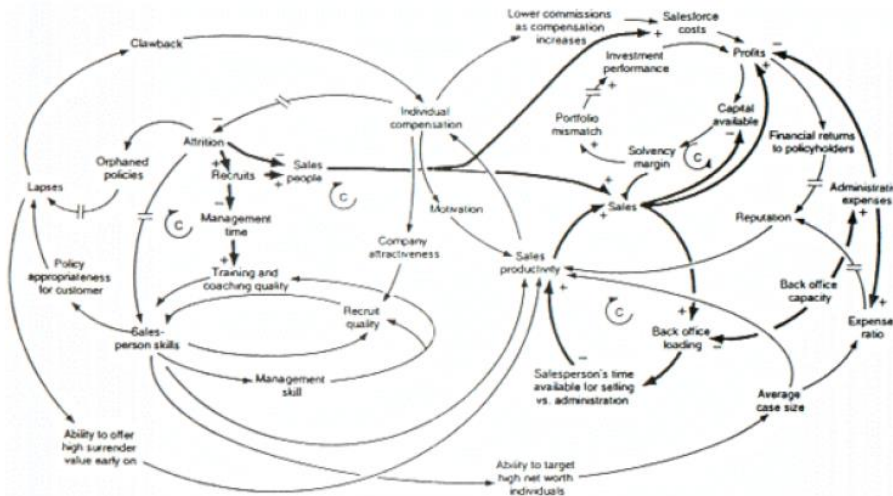


Overview

- A look back:
 - Jay Forrester & System Dynamics
 - Donella & Dennis Meadows & ‚The Limits to Growth‘
 - Hartmut Bossel & Orientors for ‚System Design‘
- A look aside:
 - Biology: Cell -> Organism -> Ecosystem
 - Medicine: Brain // Pathology – Diagnosis - Therapy
 - Computer science: object orientation & hierarchies
- A look ahead:
 - Mainstream Economics: Growth, Equilibrium & Optimality
 - ‚New Economics‘: Dynamics & Complexity
 - Challenges // ‚Green Growth‘ vs. ‚Green Degrowth‘

Forrester & System Dynamics

- Jay Forrester (1918 - 2016)
 - ‚Father‘ of System Dynamics
 - 1958 Industrial Dynamics ... 1971 World Dynamics
- System Dynamics
 - Broadly adopted in many sciences, e.g. climate science
 - Systems View + Dynamics, e.g. causal loop diagram





Meadows & ‚Limits to Growth‘

- Dennis (*1942) & Donella Meadows (1941-2001)
 - ‚Master Minds‘ of the ‚Limits to Growth‘ Series
 - Reports to the Club of Rome 1972, 1992, 2004, 2012
- ‚World 3‘ - System Dynamics Model of Growth
 - Growth of population, ‚nature use‘ & world economy
 - Prices & monetary side missing
 - Model equations & other details in 1974 ‚Technical report‘ „The Dynamics of Growth in a Finite World“
- ‚Killed‘ by Nordhaus & followers

,Limits to Growth'-World3

- Subsystems: Population, Capital, Agriculture, Resources, Pollution

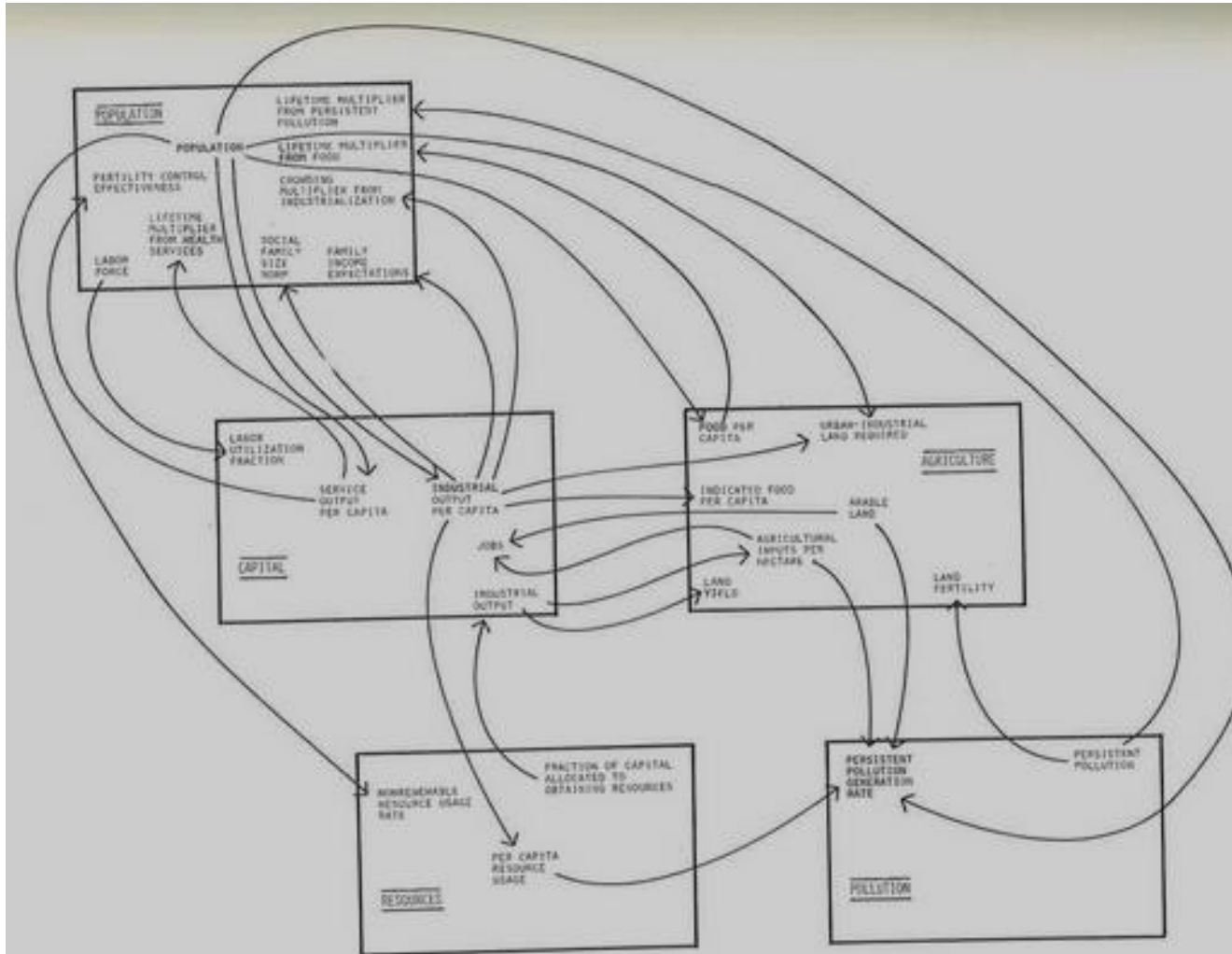
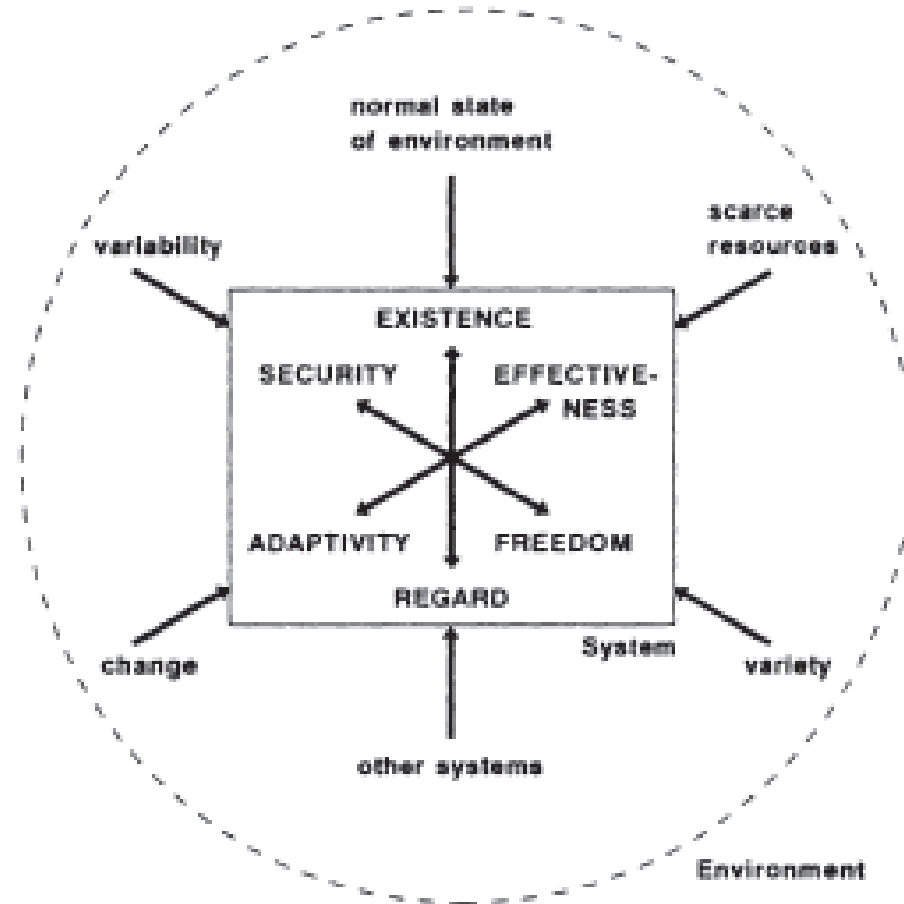


Figure I-2 Interactions among the five basic sectors of World3



Bossel & ‚System Design‘

- Hartmut Bossel (* 1935)
 - ‚Master Mind‘ of System Dynamics in Germany
 - Pioneer of Ecological System Dynamics
 - ‚Energiewende‘ pioneer
- Fundamental properties of environment & basic Orientors
[Bossel 1994, p.244]





Perspective for ‚look aside‘

- Complexity ... Self-Organization
 - Issue in many scientific fields – differently advanced
 - Worthwhile to look for analogies, transferability of methods & results
- System Control ... ‚System Design‘
 - Task of influencing the behavior of a system common to many scientific fields – differently advanced
 - Worthwhile to look for analogies, transferability of methods & results
- -> Every expert in such a scientific field is potential contributor to progress in economics

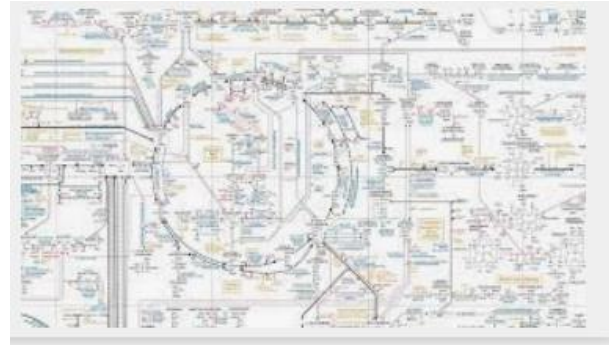


Cell -> Organism -> Ecosystem

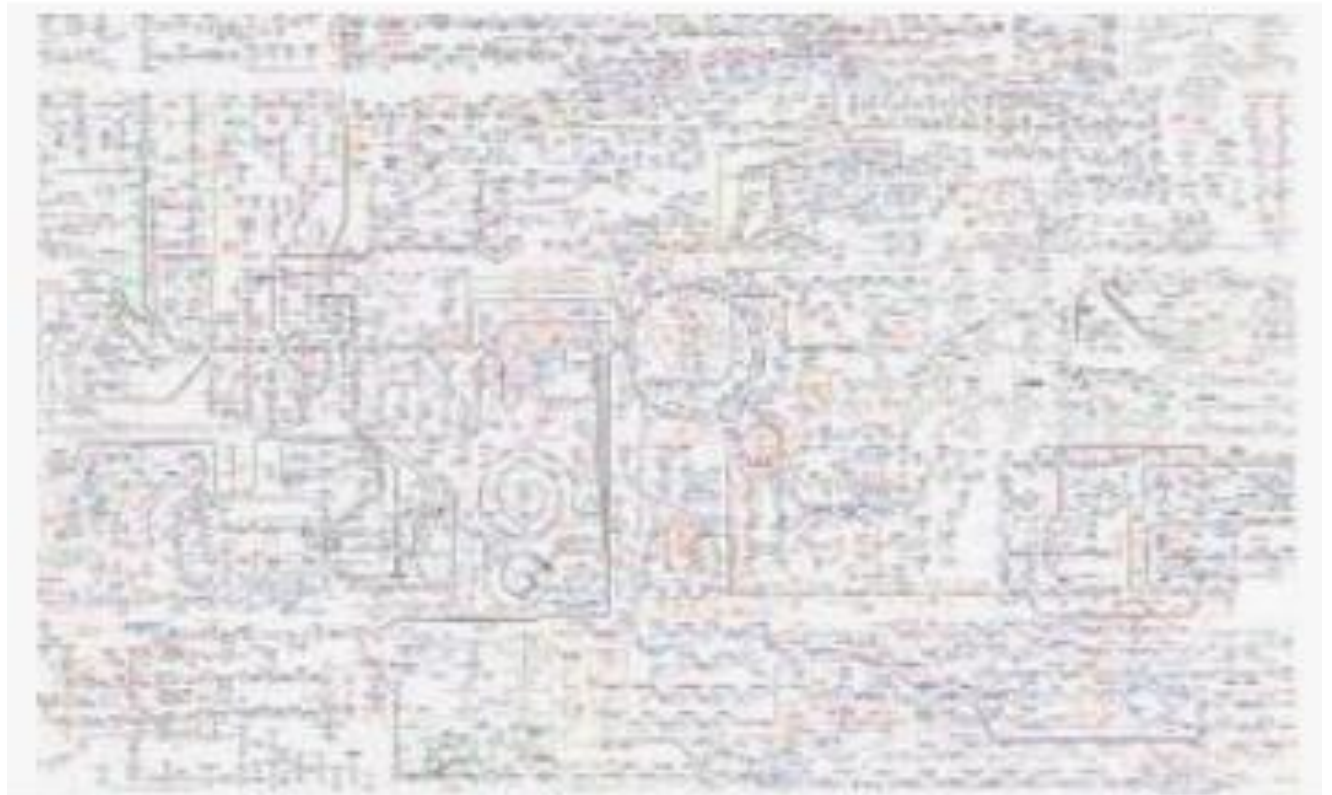
- Cell
 - ‚Biochemical Pathways‘: some ten-thousand reactions
 - Fine structures for specific purposes (organelles)
 - Regulation: nested negative feedback structures (energy & information)
- Organism
 - ‚System‘ made of organs
 - Regulation: neuro-psycho-immuno-endocrinological
- Ecosystem
 - Many species with competition, cooperation, synergism
 - Food chains ... ‚web of life‘
 - Regulation: self-organization

Biochemical Pathways

- 1970's
Citric Acid Cycle
in the centre



- 2010's
Citric Acid Cycle
small spot
in centre
only





Brain

- Neurons
 - Special cells ... electric abilities
 - Ability to connect to very many other neurons
 - Ability to built new connections (synapses) - learning
- Neural networks
 - Neuron ... {synapse} ... Neuron
 - Coupling ... Synchronization
 - Information ... Pattern Formation ... Pattern Recognition
 - Learning ... Adaptation
 - Regulation: (thought/ will/ mind) much to be discovered



Medicine

- Pathology ... Pathophysiology
 - Search for causal (material) roots of disease
 - Complex, e.g. 3 mechanisms for Long COVID discussed
 - Basis for ‚rational treatment‘ of disease
- Diagnosis
 - Pattern recognition task - thousands of patterns known
 - Complex: patterns often overlapping & new emerge
- Therapy
 - Sometimes causal, often symptomatic
 - Alternative ‚non-School-Medicine‘ approaches compete



Computer Science

- ‚Cell‘
 - Single computer (with hardware & software)
 - Hardware architectures (similar to organelles of cell)
 - Regulation: (hierarchies) of software programs
 - Software: object-orientation („network‘ of objects)
- Computer networks
 - Computer... {interface} ... Computer
 - Coupling ... Synchronization
 - Adaptation ... Machine Learning
 - ‚Regulation‘: interface protocols ... system administrators



Mainstream Economics (1)

- Equilibrium
 - Automatic balance of demand & supply (and whole economy)
 - Destabilization only by external shocks (but equil. is restored)
- Optimization (Maximization)/ Optimality
 - Profit maximization/ utility maximization
 - Optimal growth path
 - Rational expectations... perfect foresight
- Critique: insights from ‚reality‘
 - Prices only ‚work‘ if ‚they tell the truth‘ (no externalities)
 - No one ‚likes‘ perfect markets (zero profit), everyone wants to get rid of it (via marketing & lobbying to oligopoly/ monopoly)



Mainstream Economics (2)

- Growth ... Energy ... Material Resources .. ,Nature'
 - Neverending growth is possible
 - Energy/ resources no issue, since there is plenty of everything
 - If scarcity would arise, substitution solves issue
- Climate Change ... Pollution
 - No issue, since damages to ,Nature' & ,Climate' today can be easily ,repaired' in future by capital generated in meantime
 - Impact on economy & civilization is ,peanuts'
 - All problems solvable by ,technological progress'/ innovations
- Political Impact
 - ,Monopoly' in teaching, research & political counselling
 - Dissenting opinions withheld or suppressed

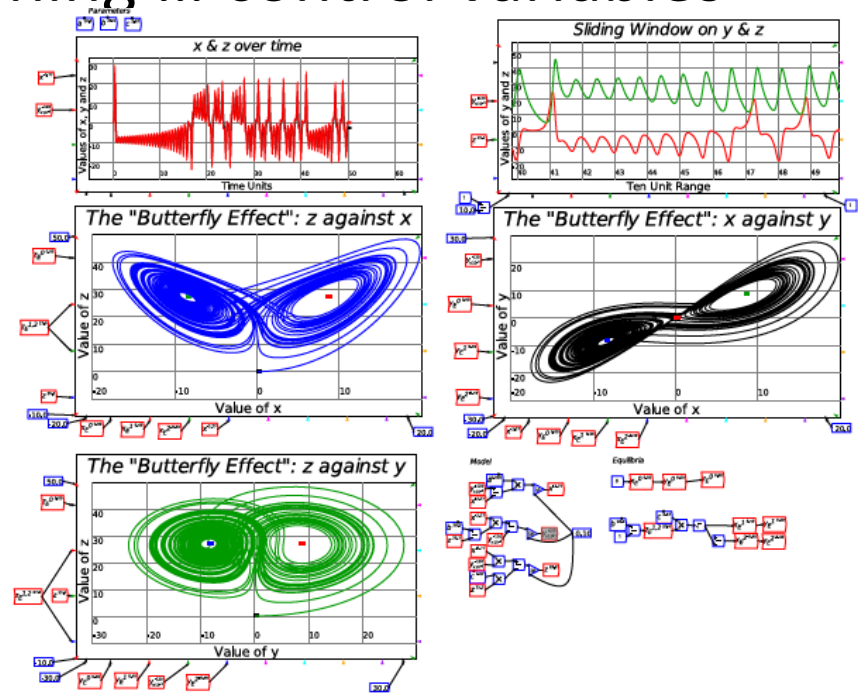
„New Economics“

- Dynamics

- „cells“: firms, households, economic agents,
- „regulation“: prices ... rationing ... control variables

- Complexity

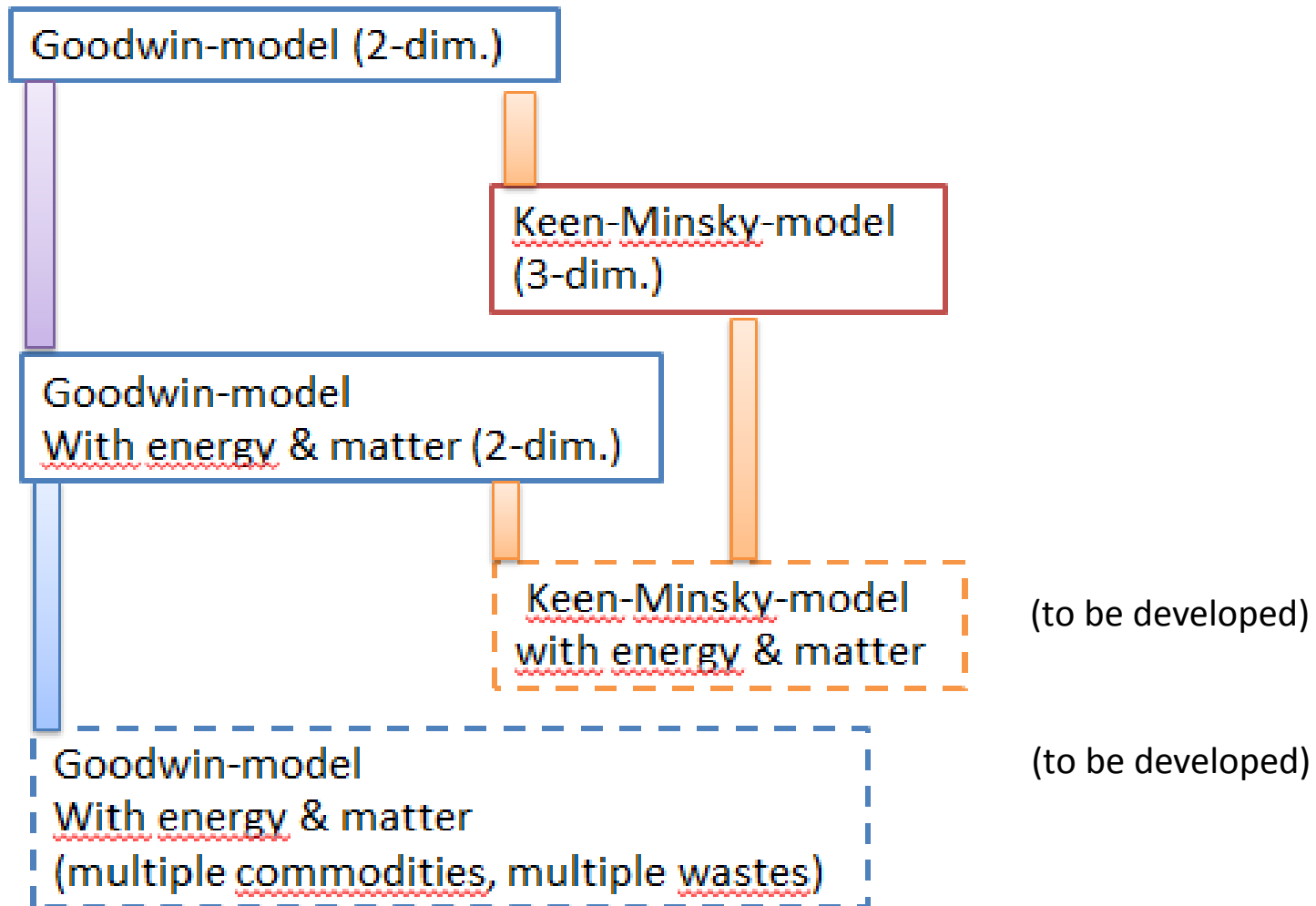
- From 3 dimensions on chaos possible (e.g. Lorenz-system with strange attractor – i.e. no fix points, no „equilibrium“)
- Self-organization, Synergetics, Phase transitions/ Tipping points





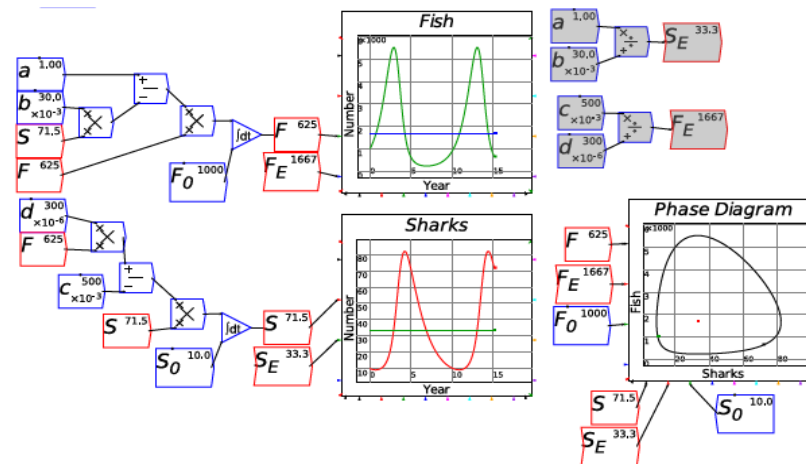
Steve Keen's 'New Economics'

- Model genealogy



Keen's Goodwin-model

- ‚Ingredients‘
 - Employment rate λ
 - Wage share ω (of whole income)(other ‚half‘ is profit)
- Dynamics

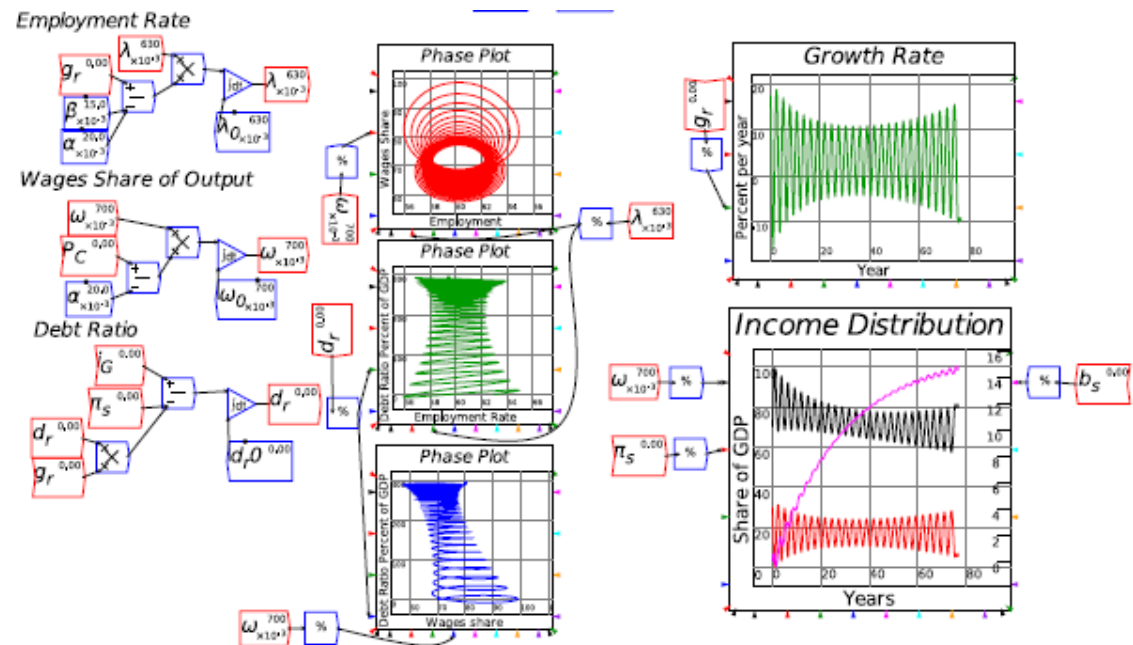


- high λ \rightarrow higher wages \rightarrow higher ω \rightarrow lower profits \rightarrow less investment \rightarrow lower λ \rightarrow higher profits \rightarrow more investment
- Structure as Lotka-Volterra-model (predator & prey)
- System is stable (limit cycle)

Keen's Minsky-model

- ‚Ingredients‘
 - Employment rate λ , Wage share ω (as in Goodwin-model)
 - (Private) debt ratio d_r (monetary side of economy)

- Dynamics



- Structure similar to Lorenz-attractor
- System is possibly chaotic (strange attractor)



Steve Keen's 'New Economics'

- Goodwin-model
 - Endogenous business cycles (no external shock needed)
- Keen-Minsky-model
 - Inherent financial instability of monetary economy (no automatic equilibrium, => constraints on economy needed (external order))
- Goodwin- model with energy & matter
 - Handling of energy & matter determines shape of limit cycle (can be more or less ,user-friendly‘)
 - First step ,only‘, but sound basis to build on
 - Some next steps clear
 - Further ,mega-hours‘ of work needed (as e.g. in biochemistry)



,Green Growth' vs. ,Green Degrowth'

- ,Green Growth' (could be unrealistic)
 - Decoupling (further growth with less material resources)
 - Abundance of renewable energy expected
 - Cave: ,heat death' in some hundred years [Murphy 2021]
- ,Green Degrowth' (prob. needed (living within planetary limits))
 - top 1%: 118 to CO², lowest 5 %; 5,4 to CO² (D 2021) planetary limit approx.1 to CO² (similar for whole ,Western Sphere')
 - Renewable energies remain expensive
 - Rebound effect
 - Consequence: ,war economy' (British Empire 1939ff)
 - Rationing – same share for everybody (instead of: everybody according to what (s)he can pay or force)



Steve Keen & ‚Green Degrowth‘

- Conceptionally clear, what & how to do
- Material side – difficult, but known from ‚war economy‘
 - Rationing of resources
 - Only life-essential goods are produced (e.g. infrastructure, housing, food)
 - Rationing also in distribution of goods
- Monetary side – critical, theoretically clear, but never done
 - ‚Modern debt jubilee‘
 - Change of money system
 - Change of bank system



Some ‚wishful thinking‘

- In economics
 - Quickly develop alternatives to neoclassical mainstream economics (attract researchers, spend money)
 - Make use of models & methods from other sciences
- Within alternative approaches
 - Cooperation & bundling of resources... master plan
 - Unite to build better alternative fast
 - ‚Self-Marketing‘ to gain resources & ‚admission‘ to govmt
- In politics
 - Debate & consensus on technological, economic and behavioral changes needed to save our civilization
 - Prerequisite: accept the truth about the critical situation (technological progress alone will not fix it)

Last warning

- Lotka-Volterra model
 - Stable limit cycle: sounds nice ... not really
 - Can be unemployment fluctuating e.g. $4 \leftrightarrow 7\%$
 - But: Predator-Prey cycle: goes to (near) extinction (especially when allowing for stochastic influences)
- And think about...
 - ‚Nature‘ = prey
 - Human greed for growth and wealth = predator

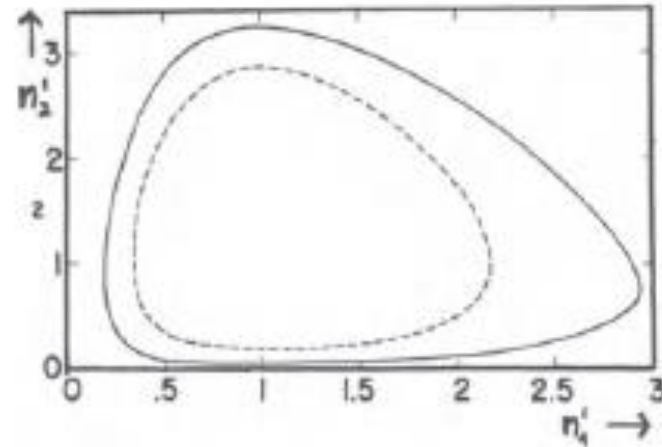
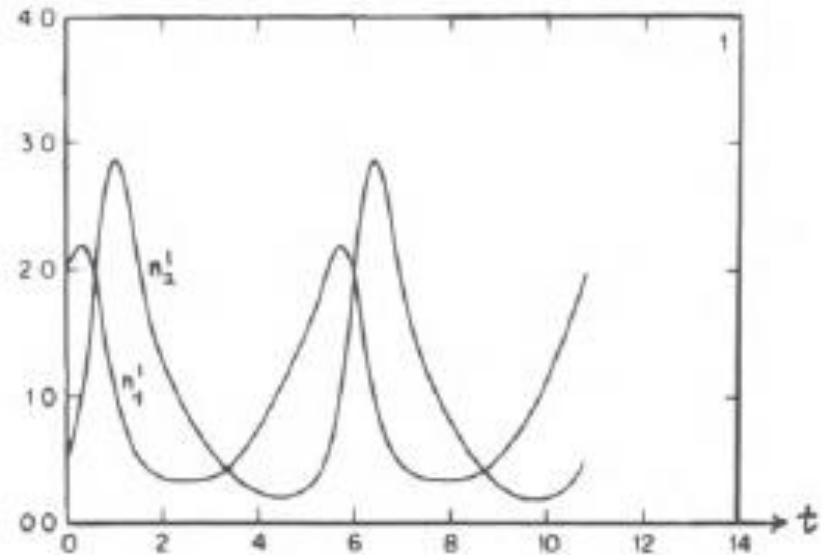


Fig. 5.17
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~~That's it(High) Time to act!~~ Oh NO, not this one again

Otherwise



<https://www.lukaskoehler.de/GoodNewsSunday>

Thank you for your understanding !

References:

Bossel: Modeling and Simulation (1994)

Haken: Synergetics – an introduction (1983, 2004)

Keen: The New Economics - a Manifesto (2022)

Keen: Modeling with MINSKY (2022)



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Proposal with regard to Modeling

- Model the two sides of reality:
 - The material stocks & flows
(analogous to business economics)
 - The monetary side ,on top‘
- Adaptation is happening on both ,layers‘
 - E.g. to constraints (e.g. scarcity, non-substitutibility, deviations between ,as planned‘ & ,as is‘, changes of external order)
- Adaptation is needed because we are living far in excess of planetary limits