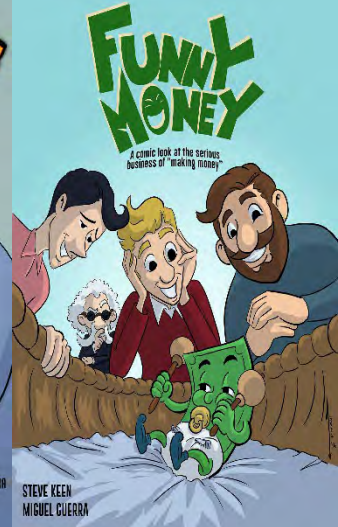
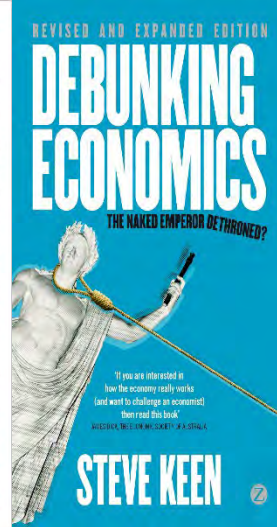
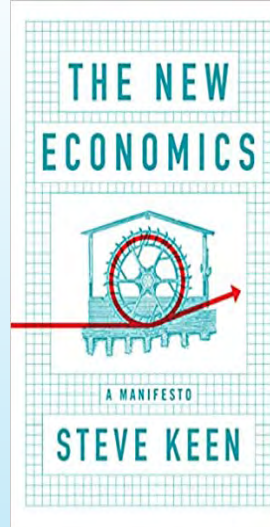


# Acceptance Speech Prof. Steve Keen, PhD





## ***Friede-Gard Prize 2022 Acceptance Speech***

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# My heartfelt gratitude to the [Friede-Gard Foundation](#)

- Prizes in Economics normally reward believers in the Neoclassical religion
- I'm honoured to be the 3<sup>rd</sup> recipient, in the 2<sup>nd</sup> year, of the 1<sup>st</sup> prize for the heretics
- The [Friede-Gard Prize](#) rewards “scientific achievements that signify particular advances in the further development of economics into an economics of sustainability”
- Prof. Dr. dr hc mult. Hermann Haken for **Synergetics**: analysis of self-organizing complex nonlinear non-equilibrium systems
- Prof. Dr. Peter Flaschenel for **‘The Bielefeld School’**: modeling and analysis of social sustainability in macroeconomic models with a Keynesian character
- My award is for
  - “Mathematical modelling of Hyman Minsky's "Financial Instability Hypothesis" ...
  - Modelling an economy involving energy and natural resources, ...
  - [Minsky](#), a system dynamics software specifically for economic modelling.”
- Key components of a Complex Biophysical-Systems Economics...



# Quick personal economic history

- Studies Economics, Maths & Law at Sydney University 1971-75
- Exposed to “Theory of Second Best” (Lipsey & Lancaster 1956) by rebel 1<sup>st</sup> year lecturer Frank Stilwell in 1971
- Realised education was mendacious:
  - No mention of this or Capital Controversies, despite Samuelson admitting defeat in “A Summing Up” (1966)
- Led student revolt against mainstream economics in 1973 “The Day of Protest”...



- Revolt successful, Department of Political Economy established
- But staff saw maths as the enemy—a mistake.
  - Neoclassical economists do “mythematics”, not mathematics!
- Continued my own study via journals, reading post-University



# Quick personal economic history

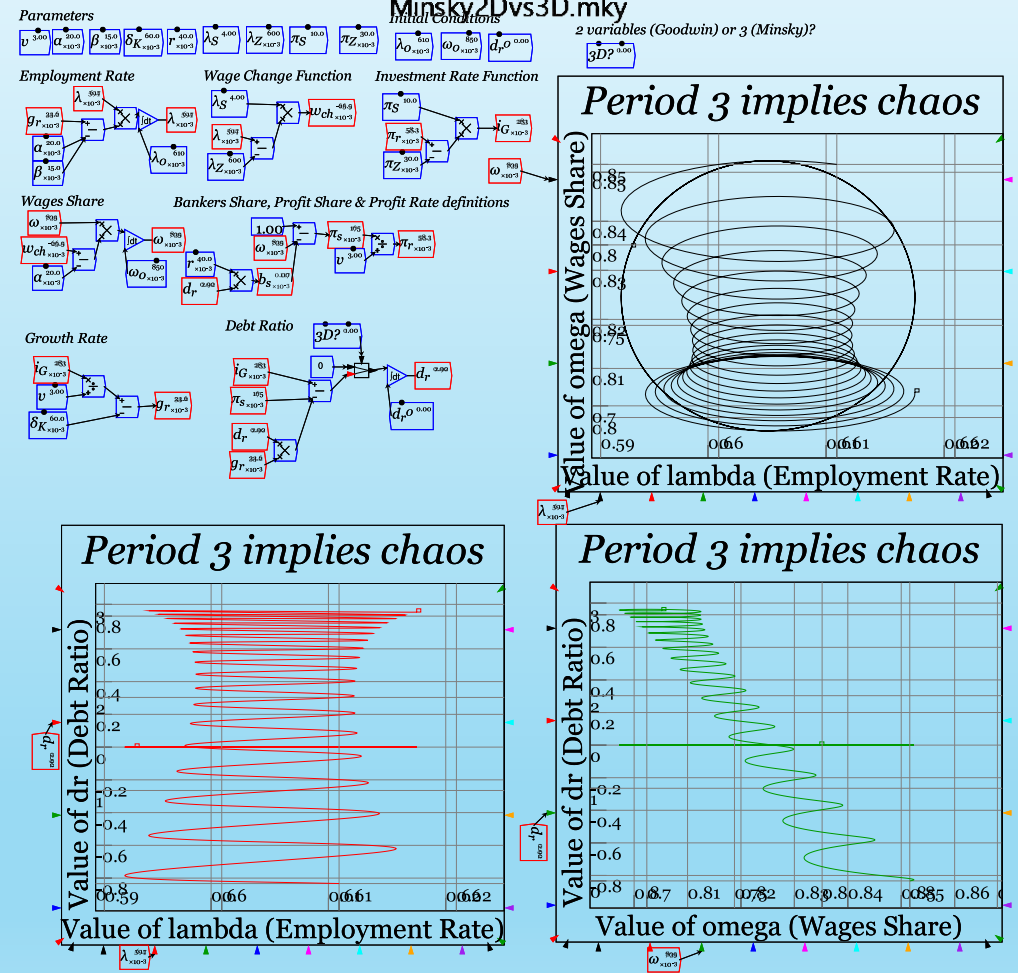
- Briefly a schoolteacher in 1977, then [Freedom From Hunger](#) Education Officer 77-83
- Incidental career as software editor for computing magazines 1981-1998
  - Reviewed 100s of computer programs during “Cambrian Explosion” of early PCs
- Worked in “Business-Union Accord” of Hawke Labor Government 84-87
- Saw Neoclassical public servants subvert social-democratic intentions of Accord
- Realised I had to fight Neoclassicals in their breeding grounds—Universities
- Started Masters part-time aged 31; became academic in 1987; began PhD at 40 in 1993
- [Masters thesis & first research papers](#) on how Marx’s philosophy contradicts the Labor Theory of Value (Keen 1993a & 1993b)
- Inspired by Minsky’s *John Maynard Keynes* in 1987, resolved to do what Minsky hadn’t managed—produce a mathematical model of the *Financial Instability Hypothesis*
- Wrote [Debunking Economics](#) (2001, 2011) and became well-known internationally...

# “Minsky + Goodwin = Chaos”



Minsky2Dvs3D.mky

- Goodwin’s “Growth Cycle”: “A starkly schematized and hence quite unrealistic model of cycles in growth rates” (Goodwin 1967, p. 54)
- Minsky’s “FIH”: a theory which “makes great depressions one of the possible states in which our type of capitalist economy can find itself” (Minsky 1982, p. xi)
  - But no (workable) mathematics
- Keen: “Minsky + Goodwin = Chaos”
- “The chaotic dynamics explored in this paper should warn us against accepting a period of relative tranquility in a capitalist economy as anything other than a lull before the storm” (Keen 1995, p. 634)



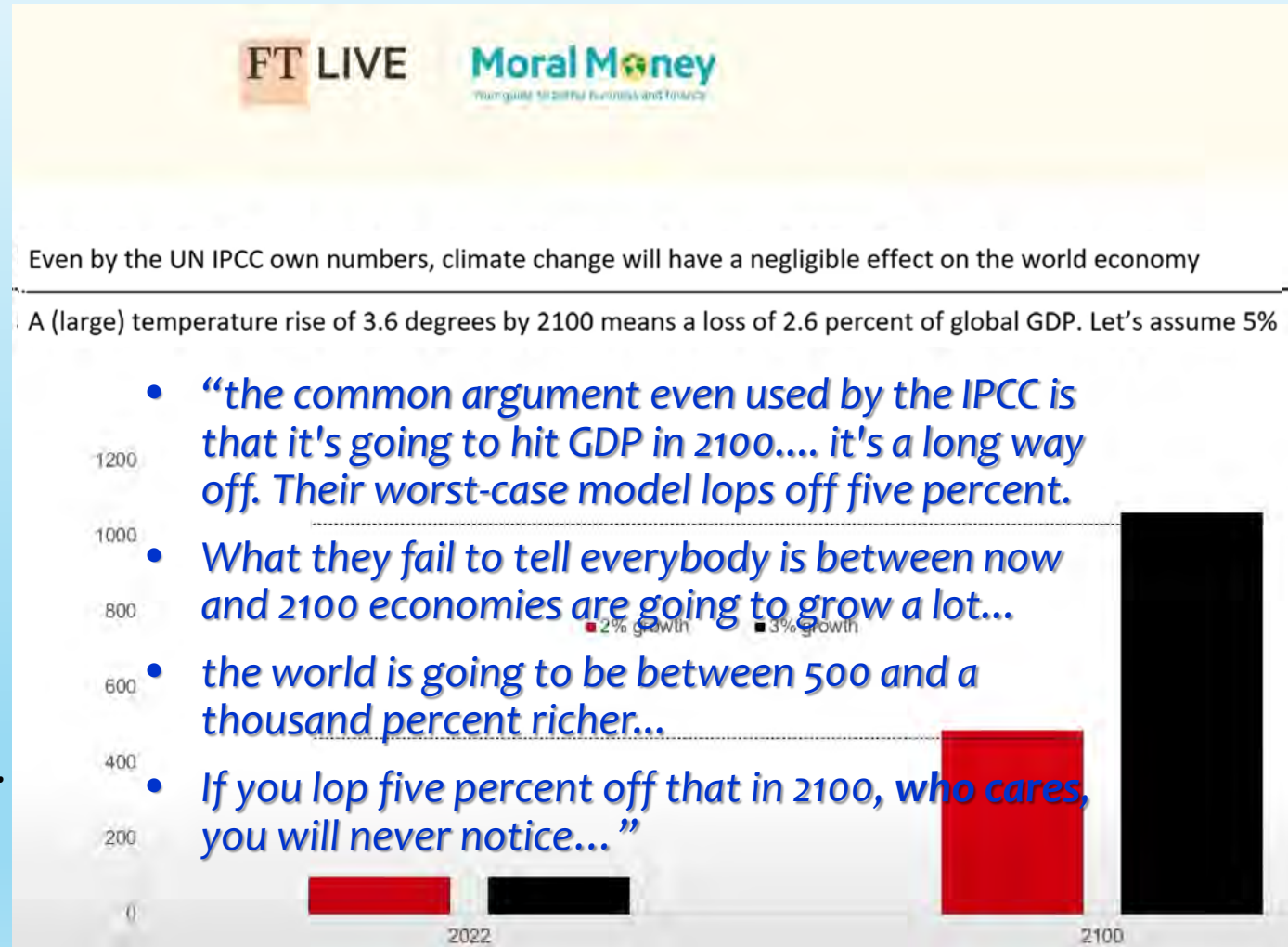
# Macroeconomics from macroeconomic definitions

- Minsky model originally built as extension to Goodwin
- In recent years I realized **it can be derived directly from macroeconomic definitions**
  - Employment Rate:  $\lambda \equiv \frac{\text{Employment}}{\text{Population}} \equiv \frac{L}{N}$
  - Wages share of Output:  $\omega \equiv \frac{\text{Wages}}{\text{GDP}} \equiv \frac{W}{Y}$
  - Debt to Output Level:  $d \equiv \frac{\text{Debt}}{\text{GDP}} \equiv \frac{D}{Y}$
- Differentiate  **$\lambda, \omega, d$**  with respect to time yields 3 **Logically true statements** statements:
  - **The employment rate will rise if economic growth exceeds the sum of change in the output to labour ratio and population growth;**
  - **The wages share of output will rise if the total wages grow faster than GDP; and**
  - **The private debt to GDP ratio will rise if private debt growth exceeds the rate of economic growth**
- Not yet a model. **But shows complex macroeconomic cycles are an emergent property of capitalism—no need for “microfoundations”, let alone Neoclassical fetish for equilibrium thinking**



# The Neoclassical blindspot on energy—and physical reality

- If you take economists seriously, then you don't take climate change seriously:
- [HSBC's Stuart Kirk tells FT investors need not worry about climate risk](#)
- These numbers were **made up by Neoclassical economists...**
- Nordhaus on whether global warming will affect manufacturing...





# The Neoclassical blindspot on energy—and physical reality

- [Nordhaus 1991](#): “for the bulk of the economy—manufacturing, mining, utilities [things like energy, sewerage, water!!], finance, trade, and most service industries—**it is difficult to find major direct impacts of the projected climate changes over the next 50 to 75 years.**”
- Nonsense! This ignorance has its origins in Neoclassical production theory:
  - Labor, Capital & “Technology” in → Goods & Services out
  - No role for energy or raw materials
- Real world: “**Labor without energy is a corpse, capital without energy is a sculpture**” ([Keen et al. 2019](#))
  - Labor & Capital convert energy into useful work, raw materials into useful products
  - Waste energy & matter inevitable & unavoidable (2<sup>nd</sup> Law of Thermodynamics etc.)
- **When (not if)** climate change forces drastic reductions in CO<sub>2</sub> output, energy will plunge
  - What will the effects on GDP be?
    - If you ask a Neoclassical economist, “[small potatoes](#)”...

# The Neoclassical blindspot on energy—and physical reality

- Economists estimates of impact of global warming on GDP are delusional
- [Keen \(2020\) “The appallingly bad neoclassical economics of climate change”](#)
- [Keen et al. \(2022\) “Estimates of economic and environmental damages from tipping points cannot be reconciled with the scientific literature”](#)

## ABSTRACT

Forecasts by economists of the economic damage from climate change have been notably sanguine, compared to warnings by scientists about damage to the biosphere. This is because economists made their own predictions of damages, using three spurious methods: assuming that about 90% of GDP will be unaffected by climate change, because it happens indoors; using the relationship between temperature and GDP today as a proxy for the impact of global warming over time; and using surveys that diluted extreme warnings from scientists with optimistic expectations from economists. Nordhaus has misrepresented the scientific literature to justify the using a smooth function to describe the damage to GDP from climate change. Correcting for these errors makes it feasible that the economic damages from climate change are at least an order of magnitude worse than forecast by economists, and may be so great as to threaten the survival of human civilization.

Tipping points reduce global consumption per capita by around ... 1.4% upon 6 °C warming, based on a second-order polynomial fit of the data — Dietz et al. (1).

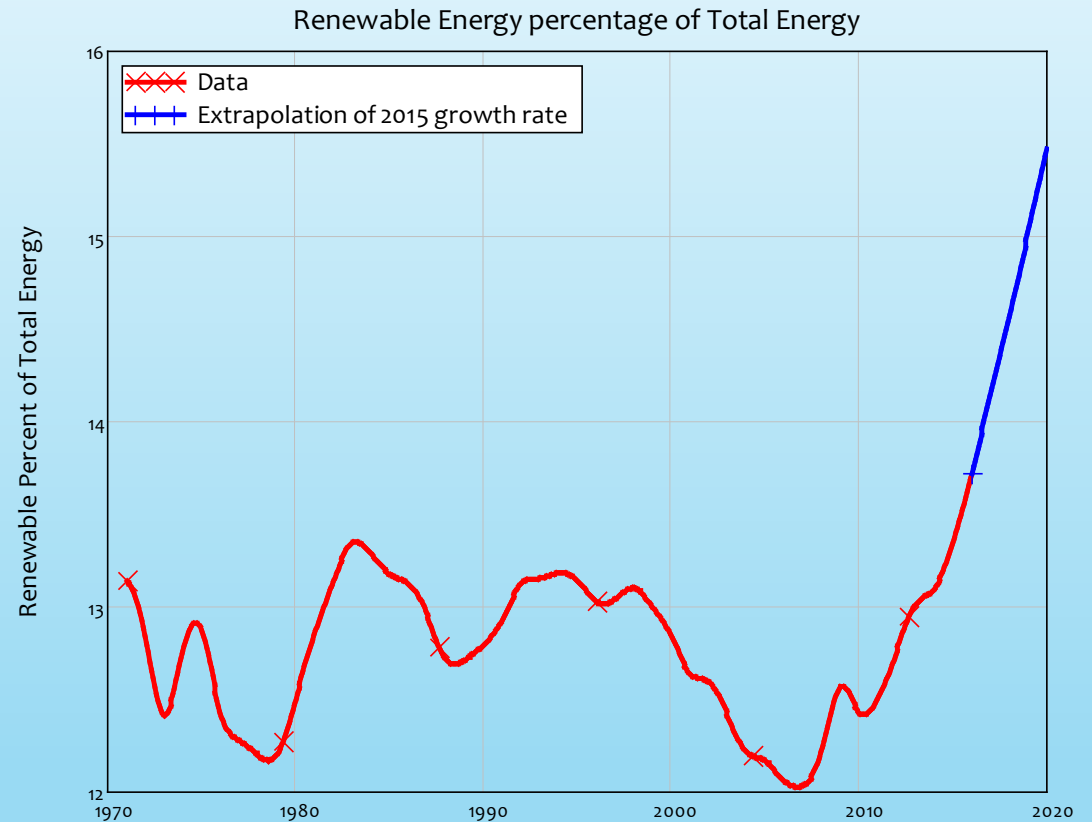
As Nobel laureate Solow said to Congress when criticizing economic models for failing to anticipate the “Great Recession,” “Every proposition has to pass a smell test: Does it really make sense?” (2). The methods and conclusions in Dietz et al. (1) do not make sense.

Earth last experienced 6 °C warming in the Eocene epoch, ≈40 million years ago (3). Asserting consumption would be just 1.4% lower with all tipping points breached, i.e., critical elements of the current climate destroyed—while also being much larger than today—is inconceivable, and impossible to reconcile with scientific literature (3-6).

- Damages will be far greater, & far sooner, than those who trust economists expect

# The Neoclassical blindspot on energy—and physical reality

- Reality makes a mockery of Nordhaus’s “it is difficult to find major direct impacts of the projected climate changes over the next 50 to 75 years”
- “**Labor without energy is a corpse, capital without energy is a sculpture**”
- If When climate catastrophes from global warming force end of use of fossil fuel energy sources, GDP will plummet, since <20% of energy comes from non-fossil sources
- As usual, Neoclassicals won’t see it coming...



# The Neoclassical blindspot on energy—and physical reality

- Recent Neoclassical paper (Bachmann et al. 2022) predicts “economic losses from a **–10% energy shock ... 1.5% of German GNE**”
- 10% fall in energy causes:
  - → 0.3% fall in GDP (Standard Neo);
  - → 1.5% fall in GDP (Advanced Neo—using CES production function)
- Versus Post-Keynesian prediction:
  - **10% fall in energy, 10% fall in GDP...**

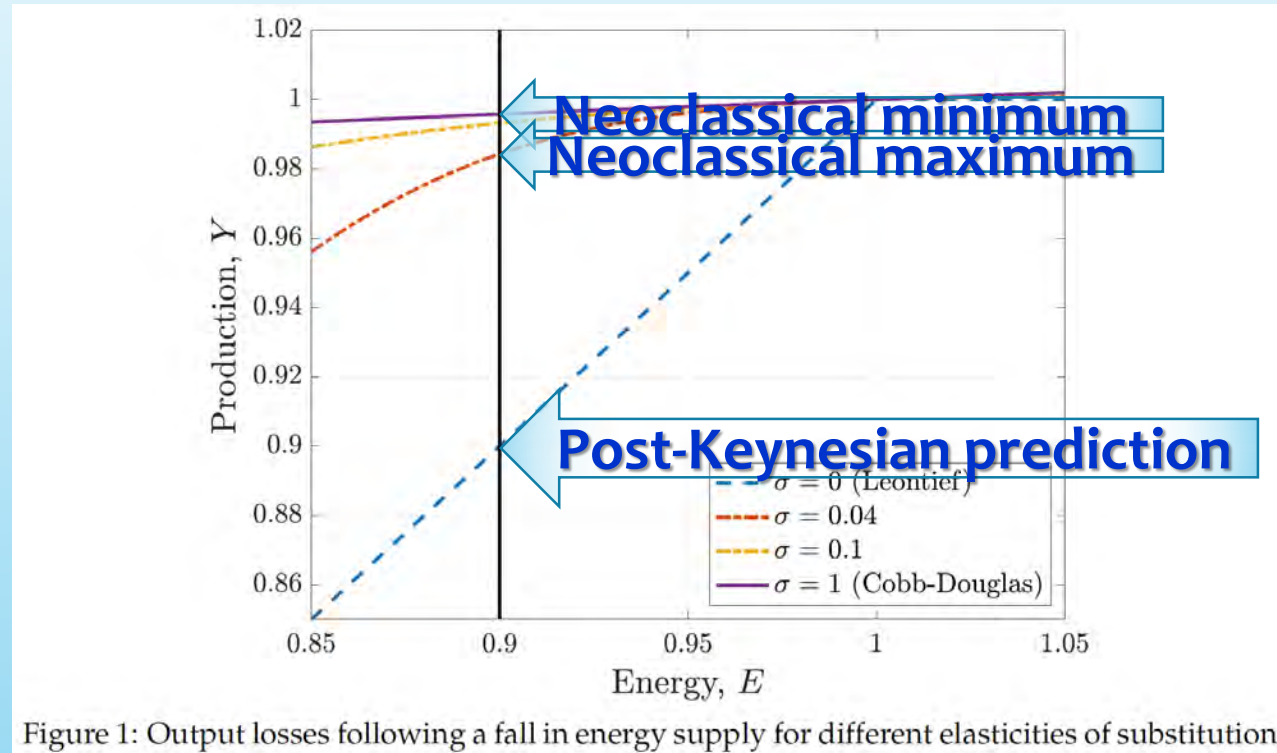
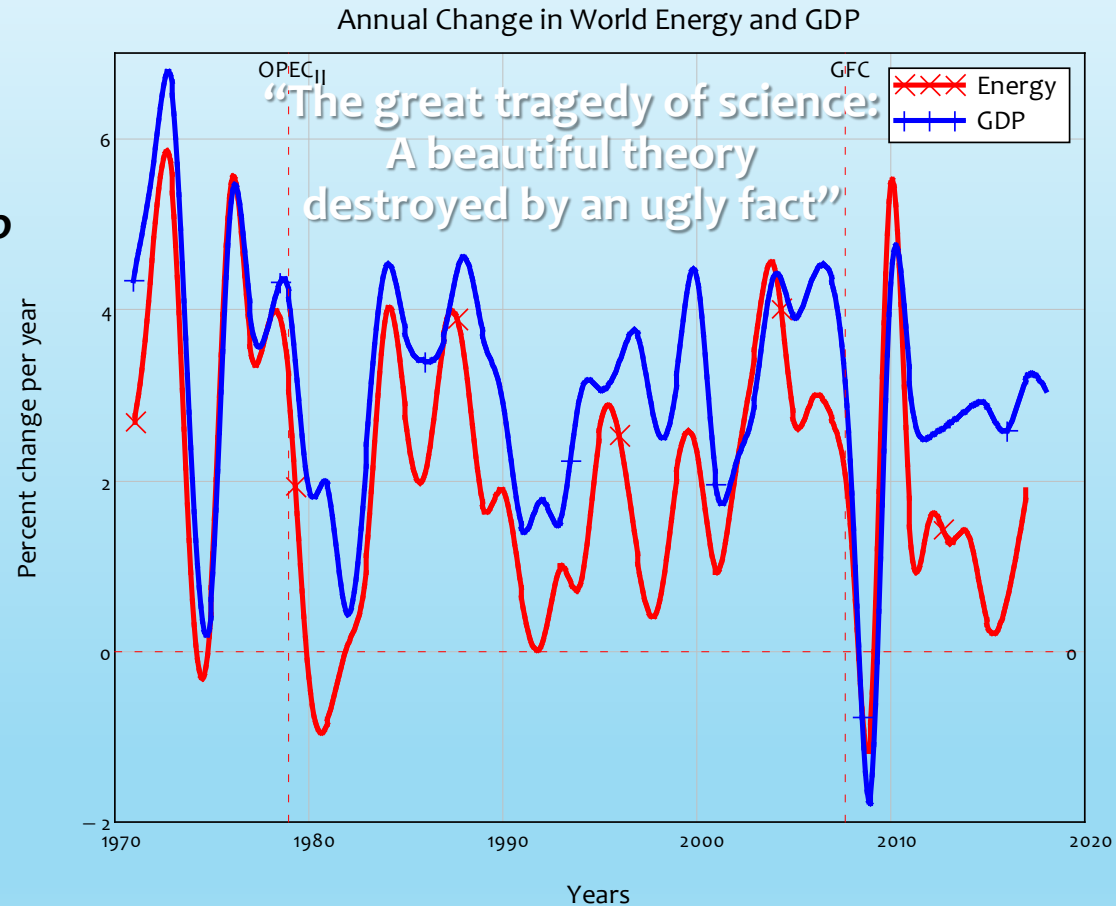


Figure 1: Output losses following a fall in energy supply for different elasticities of substitution

# The Neoclassical blindspot on energy—and physical reality

- Bachmann rejects Post-Keynesian/Leontief 1:1  $\Delta$ Energy  $\rightarrow$   $\Delta$ GDP prediction *because it conflicts with Neoclassical theory:*
- **“If factors markets are competitive so that factor prices equal marginal products,**
- this then implies that similarly the price of energy jumps to  $1/\alpha$  and the prices of other factors fall to zero”
- But ***data rejects Neoclassical theory:***
  - $\Delta$ Energy  $\rightarrow$   $\Delta$ GDP  
Correlation=0.83
  - **$\Delta$ Energy  $\rightarrow$   $\Delta$ GDP relation IS 1:1 !**





# Biophysical Realism on Energy and Matter in Production

- Empirical data shows 1:1 relationship between  $\Delta\text{GDP}$  and  $\Delta\text{Energy}$ —why?
- Standard Leontief production function stated an empirical regularity:
  - $Q = u \times \frac{K}{v}$ ; where  $u$  is capacity utilization and  $v$  empirically-observed capital: output ratio. **But what is the explanation for the regularity?**
- Use  $K \rightarrow K(E) = K \times E_K \times e_k$ 
  - $Q = \frac{Y}{E_K} = u \times K \times e_k$ 
    - $Q$  → “Widgets/Year”
    - $Y$  → Output in Energy terms
    - $E_K$  → Energy per Widget
  - $K$  → Number of machines
  - $E_K$  → Energy per machine
  - $e_k$  → Efficiency → useful work
- Empirical Leontief is  $Q = u \times \frac{K}{v}$
- Energy-aware Leontief is  $Q = u \times K \times e_k$
- $e_k = \frac{1}{v}$ : “capital output ratio” is really “efficiency of conversion of energy into useful work”
- **Linear  $\Delta\text{Energy} \rightarrow \Delta\text{GDP}$  relationship: 10% fall in energy  $\rightarrow$  10% fall in GDP**

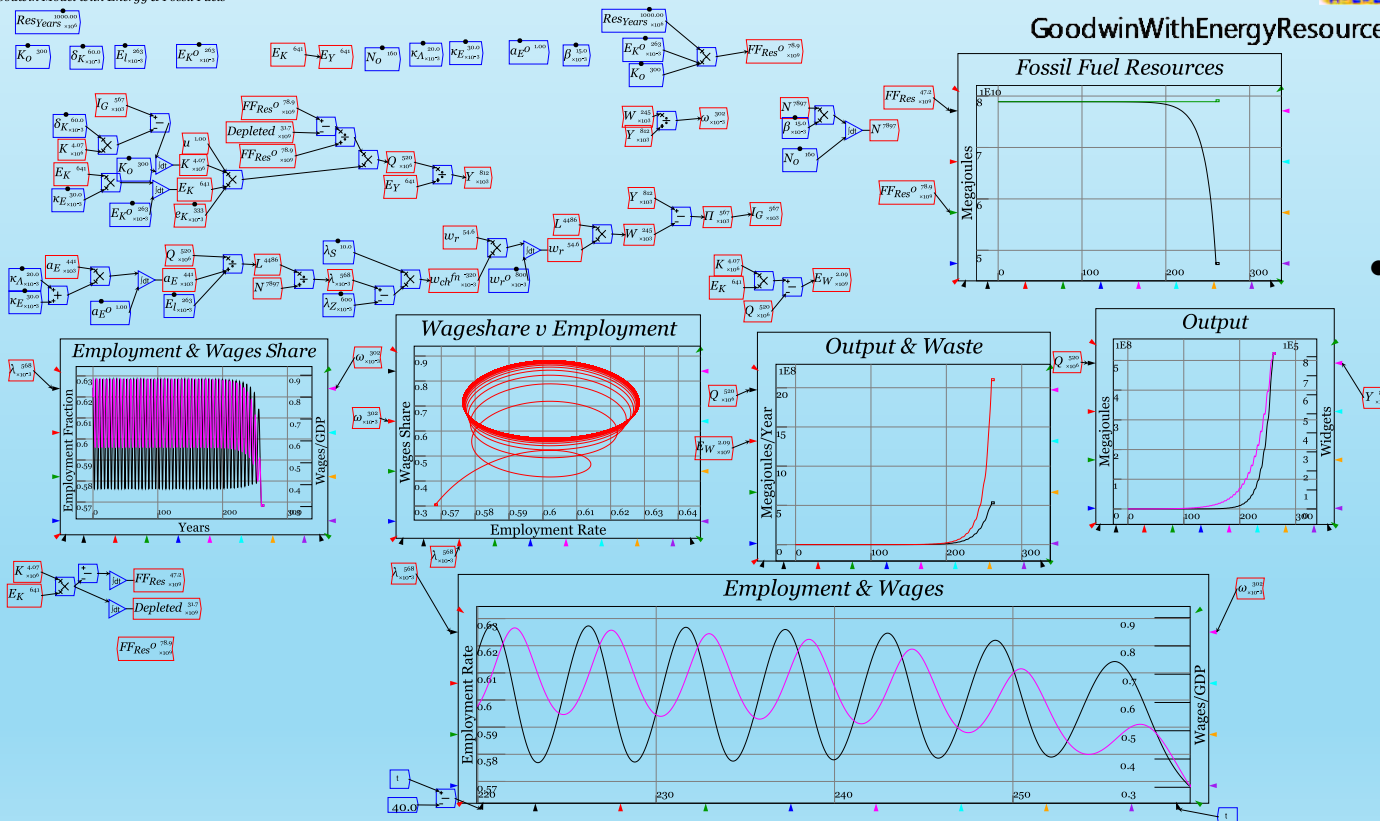
# Biophysical Realism on Energy and Matter in Production

- Any model based on Leontief Production Function is inherently energy-based
- Waste generation also implicit  $\rightarrow (1 - e_k) \times u \times K > e_k \times u \times K$ . Resource depletion/damage to capacity to produce, are easily added.



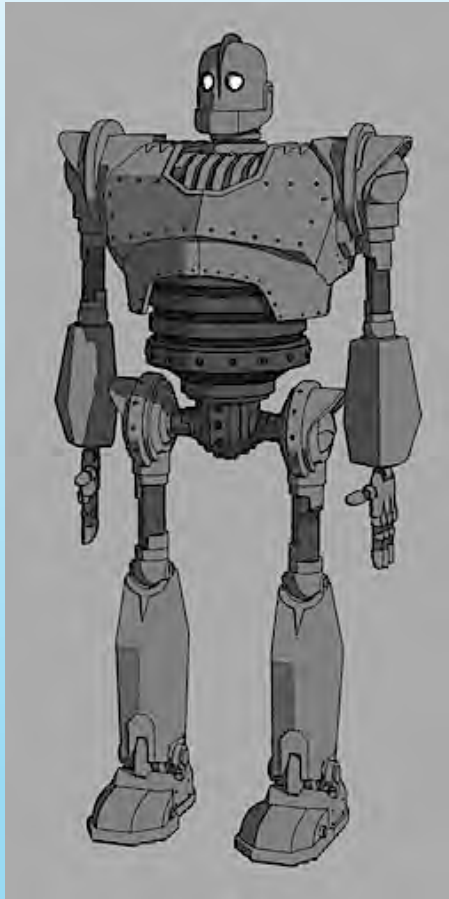
Goodwin Model with Energy & Fossil Fuels

GoodwinWithEnergyResourceDepletion20190823.mky



- Everything goes well for centuries, followed by a sudden collapse...

# Biophysical Realism on Energy and Matter in Production



- Reality—energy and matter as well as essential inputs to production
- Hicks tried in 1935: “[Wages and Interest: The Dynamic Problem](#)”
  - Unsuccessful—paper gave us IS-LM instead! (see [Hicks 1981](#))
  - His problem? He used a realistic consumption good (bread), which was an unrealistic investment good:
    - “the production of bread for the next market day, or in the production of bread for the more distant future (activity which, a week after, will only have resulted in the production of equipment)”.
    - ***Stale bread as capital equipment???***
- My solution (with Matheus Grasselli & Tim Garrett): *imagine an unrealistic consumption good which is a realistic investment good*
- **Production with matter and energy on the [Planet of the Iron Giants](#)**
  - [\(not yet published, but available on Patreon\)](#)

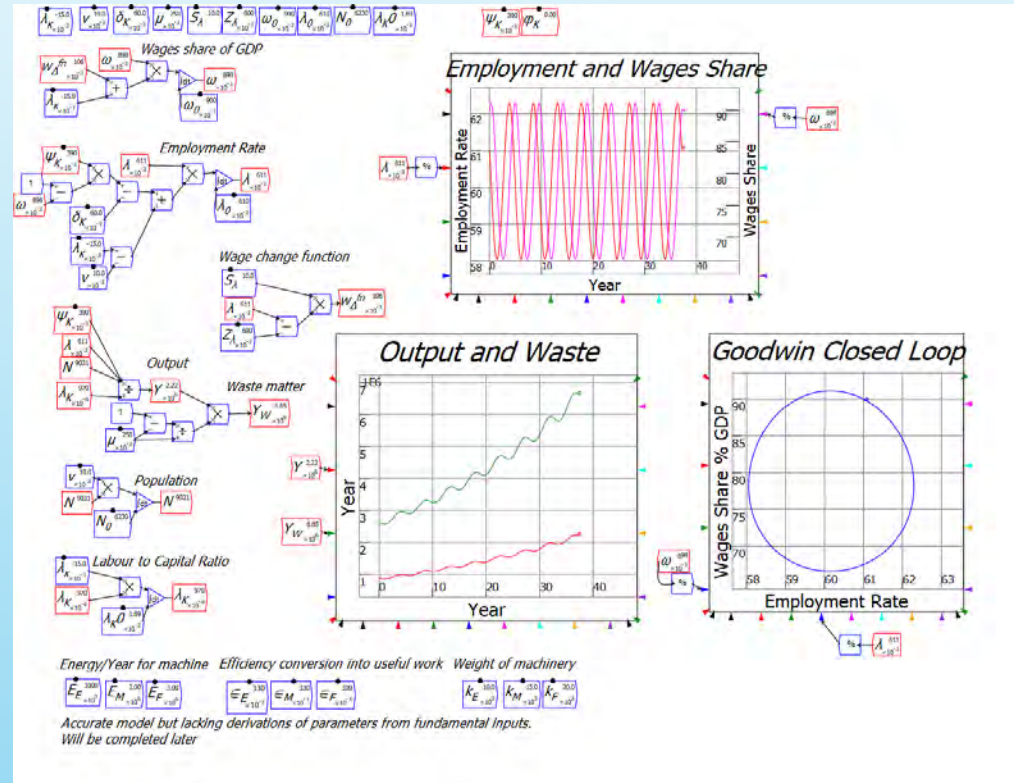
# Biophysical Realism on Energy and Matter in Production

- Two inputs: matter (Iron Ore) and energy (Coal)
- One output: Iron
- Three forms of machinery: Iron Ore mining; Coal mining; Smelting and Rolling
- One form of consumption: Wage of Iron Giant workers paid in Iron
- Required 3 additions to production equation:
  - Yield of output in terms of energy input
  - Waste in matter terms (“slag”) to apply Conservation of Mass to Iron Production
  - Units: Mass/Year (measured in kg) in addition to Energy/Year (Joules)

<i>Equation</i>	Units
$E = K_E \cdot E_E \cdot \varepsilon_E \cdot y_E$	Energy/Year
$M = K_M \cdot E_M \cdot \varepsilon_M \cdot y_M$	Mass/Year (Iron ore)
$F = K_F \cdot E_F \cdot \varepsilon_F \cdot y_F$	Mass/Year (Iron plus Slag)
$Y = \mu \cdot F$	Mass/Year (Iron)
$Y_w = (1 - \mu) \cdot F$	Mass/Year (Slag)

# Biophysical Realism on Energy and Matter in Production

- Only 1<sup>st</sup> pass: yields determined by needs of factory sector rather than determined by current state of resource (Minerals → Iron Ore; Energy → Coal)
- Full model would have yield of factory sector varying in response to the state of Minerals & Energy mining sectors
- Outcome generalized Goodwin model:
- Future extensions:
  - Generalized model with multiple inputs/outputs/forms of waste
  - Financial sector a la Minsky
- Foundation for a realistic biophysical monetary model of production





# Minsky

- Born of desire to enable proper dynamic modelling of money and debt
  - “Godley Tables” Inspired by Wynne Godley Stock-Flow consistent modelling

- All entries occur twice on each row

- Fundamental rule of accounting applies:

- **Assets** – **Liabilities** = **Equity**

- $A - L - E = 0$

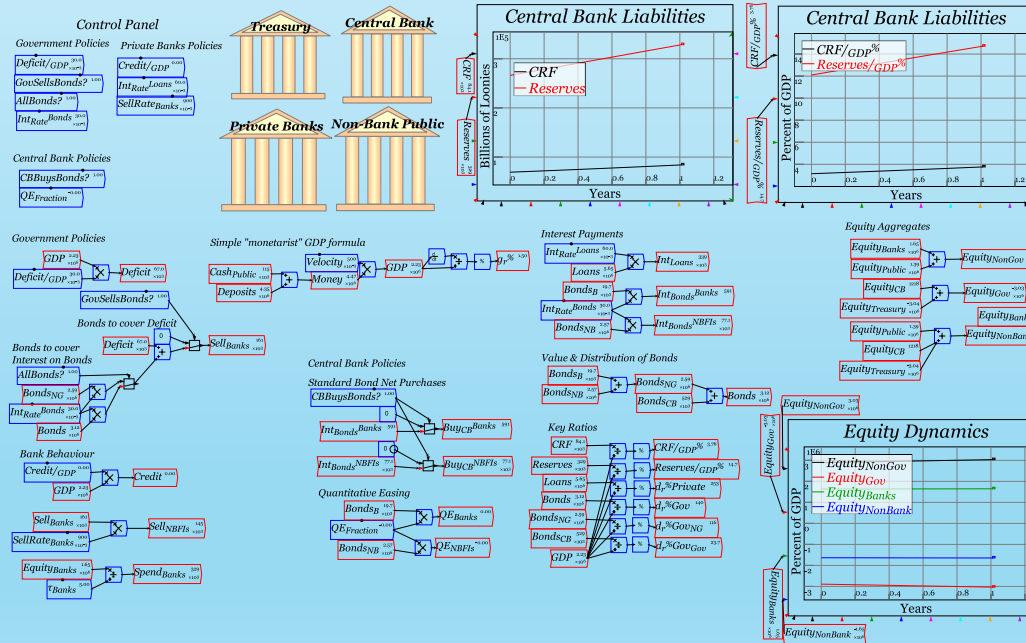
Flows ↓ / Stock Vars →	Reserves	Loans	Bonds <sub>B</sub>	Deposits	Equity <sub>B</sub>
Initial Conditions	266248	5651020	4129	4286520	1634877
Net lending		Credit		Credit	
Interest on bank loans				-Int <sub>Loans</sub>	Int <sub>Loans</sub>
Net government spending	Deficit			Deficit	
Bond sales to Banks	-Sell <sub>Banks</sub>		Sell <sub>Banks</sub>		
Bank Bond Sales to NBFIs			-Sell <sub>NBFIs</sub>	-Sell <sub>NBFIs</sub>	
BOC buys bonds from Banks	Buy <sub>CB</sub> <sup>Banks</sup>		-Buy <sub>CB</sub> <sup>Banks</sup>		
BOC buys bonds from NBFIs	Buy <sub>CB</sub> <sup>NBFIs</sup>			Buy <sub>CB</sub> <sup>NBFIs</sup>	
Bond interest to Banks	Int <sub>Bonds</sub> <sup>Banks</sup>			Int <sub>Bonds</sub> <sup>NBFIs</sup>	Int <sub>Bonds</sub> <sup>Banks</sup>
Bond interest to NBFIs	Int <sub>Bonds</sub> <sup>NBFIs</sup>				
Bank spending				Spend <sub>Banks</sub>	-Spend <sub>Banks</sub>
QE with Banks	QE <sub>Banks</sub>		-QE <sub>Banks</sub>		
QE with NBFIs	QE <sub>NBFIs</sub>			QE <sub>NBFIs</sub>	



- Brilliantly programmed by my long-term friend and research collaborator [Dr Russell Standish](#) (just 38,000 tightly coded lines of OO [Object-Oriented] C++)
- Could not have been developed as well—or maybe at all—without him...

# Minsky

- Interlocking Double-entry Bookkeeping tables yields **Octuple-entry accounting**
  - All entries occur at least 4, and **up to 8 times...**
- Enables easy modelling of actual monetary dynamics
- Exposes myths like “Money Multiplier”, etc.



Flows ↓ / Stock Vars →	Asset			Liability	Equity	A-L-E
	Reserves	Loans	Bonds <sub>B</sub>	Deposits	Equity <sub>Banks</sub>	
Initial Conditions	266248	5651020	4129	4286520	1634877	0
Net lending		Credit		Credit		0
Interest on bank loans				-Int <sub>Loans</sub>	Int <sub>Loans</sub>	0
Net government spending	Deficit			Deficit		0
Bond sales to Banks	-Sell <sub>Banks</sub>		Sell <sub>Banks</sub>			0
Bank Bond Sales to NBFIs			Sell <sub>NBFIs</sub>	-Sell <sub>NBFIs</sub>		0
BOC buys bonds from Banks	Buy <sub>CB</sub> <sup>Banks</sup>		-Buy <sub>CB</sub> <sup>Banks</sup>			0
BOC buys bonds from NBFIs	Buy <sub>CB</sub> <sup>NBFIs</sup>		-Buy <sub>CB</sub> <sup>NBFIs</sup>	Buy <sub>CB</sub> <sup>NBFIs</sup>		0
Bond interest to Banks	Int <sub>Bonds</sub> <sup>Banks</sup>				Int <sub>Bonds</sub> <sup>Banks</sup>	0
Bond interest to NBFIs	Int <sub>Bonds</sub> <sup>NBFIs</sup>			Int <sub>Bonds</sub> <sup>NBFIs</sup>		0
Bank spending				Spend <sub>Banks</sub>	-Spend <sub>Banks</sub>	0
QE with Banks	QE <sub>Banks</sub>		-QE <sub>Banks</sub>			0
QE with NBFIs	QE <sub>NBFIs</sub>		-QE <sub>NBFIs</sub>	QE <sub>NBFIs</sub>		0

Flows ↓ / Stock Vars →	Asset		Liability	CRF	Equity	A-L-E
	Bonds <sub>CB</sub>	Reserves	Cash <sub>Public</sub>	CRF	Equity <sub>CB</sub>	
Initial Conditions	451717	266248	115006	69245	1218	0
Net government spending		Deficit		-Deficit		0
Bond sales to Banks		-Sell <sub>Banks</sub>		Sell <sub>Banks</sub>		0
Bond interest to Banks		Int <sub>Bonds</sub> <sup>Banks</sup>		-Int <sub>Bonds</sub> <sup>Banks</sup>		0
Bond interest to NBFIs		Int <sub>Bonds</sub> <sup>NBFIs</sup>		-Int <sub>Bonds</sub> <sup>NBFIs</sup>		0
Central Bank Bond purchases	Buy <sub>CB</sub> <sup>Banks</sup>	Buy <sub>CB</sub> <sup>Banks</sup>				0
BOC buys bonds from NBFIs	Buy <sub>CB</sub> <sup>NBFIs</sup>	Buy <sub>CB</sub> <sup>NBFIs</sup>				0
QE with Banks	QE <sub>Banks</sub>	QE <sub>Banks</sub>				0
QE with NBFIs	QE <sub>NBFIs</sub>	QE <sub>NBFIs</sub>				0

Flows ↓ / Stock Vars →	Asset		Liability	Equity	A-L-E	
	CRF	Bonds <sub>CB</sub>	Bonds <sub>B</sub>	Bonds <sub>NB</sub>	Equity <sub>Treasury</sub>	
Initial Conditions	69245	451717	4129	2505000	-2891601	0
Bond sales to Banks		Sell <sub>Banks</sub>	Sell <sub>Banks</sub>			0
Central Bank Bond purchases		Buy <sub>CB</sub> <sup>Banks</sup>	-Buy <sub>CB</sub> <sup>Banks</sup>			0
BOC buys bonds from NBFIs		Buy <sub>CB</sub> <sup>NBFIs</sup>	-Buy <sub>CB</sub> <sup>NBFIs</sup>			0
Net government spending	Deficit				-Deficit	0
Bond interest to Banks	-Int <sub>Bonds</sub> <sup>Banks</sup>				Int <sub>Bonds</sub> <sup>Banks</sup>	0
Bond interest to NBFIs	-Int <sub>Bonds</sub> <sup>NBFIs</sup>				Int <sub>Bonds</sub> <sup>NBFIs</sup>	0
Bank Bond Sales to NBFIs			-Sell <sub>NBFIs</sub>	Sell <sub>NBFIs</sub>		0
QE with Banks		QE <sub>Banks</sub>	-QE <sub>Banks</sub>			0
QE with NBFIs		QE <sub>NBFIs</sub>	-QE <sub>NBFIs</sub>			0

Flows ↓ / Stock Vars →	Asset		Liability	Equity	A-L-E	
	Deposits	Cash <sub>Public</sub>	Bonds <sub>NB</sub>	Loans	Equity <sub>Public</sub>	
Initial Conditions	4286520	115006	2505000	5651020	1255506	0
Net lending	Credit			Credit		0
Interest on bank loans	-Int <sub>Loans</sub>				Int <sub>Loans</sub>	0
Net government spending					Deficit	0
Bank Bond Sales to NBFIs			-Sell <sub>NBFIs</sub>	Sell <sub>NBFIs</sub>		0
Bond interest to NBFIs			Int <sub>Bonds</sub> <sup>NBFIs</sup>		Int <sub>Bonds</sub> <sup>NBFIs</sup>	0
BOC buys bonds from NBFIs			Buy <sub>CB</sub> <sup>NBFIs</sup>	-Buy <sub>CB</sub> <sup>NBFIs</sup>		0
Bank spending		Spend <sub>Banks</sub>			Spend <sub>Banks</sub>	0
QE with NBFIs		QE <sub>NBFIs</sub>	-QE <sub>NBFIs</sub>			0

# Minsky

- One of many “system dynamics” programs (Stella, Ithink, Vensim, Simulink)
- Cheaper than most ([free](#)). Manuals at <http://www.profstevekeen.com/Minsky>
- Many other innovations:
  - Equations on canvas rather than behind text boxes
  - Pass data by variable name as well as by wire—far less clutter
  - Direct generation of  $L^A T_E X$  equations for documentation
  - Live simulation with ability to vary parameters (& even the model) during a run
- One crucial omission
  - **Deliberately** does not support “periods”—Difference equations, “period analysis”
  - Periods are the crack cocaine of the economist
    - “**Friends don’t let friends use periods**”
- Capable now of extremely sophisticated modelling...



# Introducing **Ravel**®

- Funding for non-mainstream economics is woeful
  - Government funding bodies controlled by Neoclassical economists
- My long-term solution: fund my research by selling data analysis program Ravel®

• To be distributed soon to my supporters:

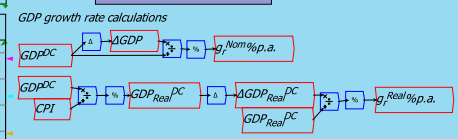
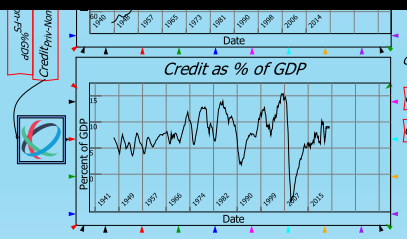
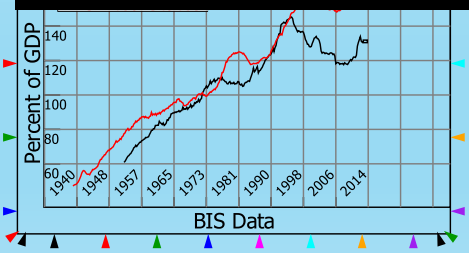
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• Substack:

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Debt  
BIS





# Thank you...

- Thank you to the Friede Gard Foundation for the recognition and support
- ***Time is of the essence***
- Neoclassical economics may destroy capitalism—via climate change trivialization and monetary idiocy—before complex biophysical economics is fully developed
- I conclude with a prescient quote from mathematician John Blatt from in 1983:
  - “At present, the state of our dynamic economics is more akin to a crawl than to a walk, to say nothing of a run.
  - ***Indeed, some may think that capitalism as a social system may disappear before its dynamics are understood by economists.”***  
(Blatt 1983, ***Dynamic Economic Systems*** , p. 5)
- I look forward to seeing (some of) you at the workshops tomorrow and Saturday...

To keep in touch with and support my work, join  
Patreon: <https://www.patreon.com/ProfSteveKeen> or  
Substack: <https://profstevekeen.substack.com/>

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