#### MISTRA FINANCIAL SYSTEMS

## RESEARCH WEBINARS

#### WEBINAR 2: Systems, Tipping Points and Cascades – The Future of Sustainable Finance?

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#### **ACADEMIC REFERENCES**

Galaz, V., Crona, B., Dauriach, A., Jouffray, J-B., Österblom, H., and Fichtner, J. 2018. Tax havens and global environmental degradation. Nature Ecology and Evolution (Perspective). <u>https://doi.org/10.1038/s41559-018-0497-3</u>

Paper picked up in several media outlets, including Reuters' "As Amazon burns, 230 big investors call on firms to
protect world's rainforests" available <u>here</u>.

Galaz, F., Crona, B., Dauriach, A., Scholtens, B., Steffen, W. 2018. Finance and the Earth system – Exploring the links between financial actors and non-linear changes in the climate system. Global Environmental ChangeVolume 53, November 2018, Pages 296-302. DOI: 10.1016/j.gloenvcha.2018.09.008

Gunderson, L. H., & Holling, C. S. 2002. Panarchy: Understanding transformations in human and natural systems. Washington: Island Press.

Hubau, W., Lewis, S.L., Phillips, O.L. et al. 2020. Asynchronous carbon sink saturation in African and Amazonian tropical forests. Nature 579, 80–87. <u>https://doi.org/10.1038/s41586-020-2035-0</u>

Meadows, D.H., Wright, D. 2009. *Thinking in systems: a primer*, Earthscan, London; Sterling, VA. doi:10.4324/9781849773386

Steffen, W. L. 2005. Global change and the earth system: A planet under pressure. New York; Berlin: Springer.

Additional references in the following slides.

## Systems and finance

The Swedish Foundation for Strategic Environmental Research

#### **Eric Kemp-Benedict**



Mistra Financial Systems Webinar, 22 October 2020

#### System: The most general definition

A set of **elements** that are **connected** in such a way that they produce their **own pattern of behavior** over time.

May be buffeted, constricted, triggered, or driven by outside forces, but the response is characteristic of the system.

Identified as a system because it serves some **function**.

Based on Meadows, *Thinking in Systems* 



### Socio-ecological System (SES)

- 1. A coherent system of **biophysical** and **social** factors that regularly interact in a **resilient**, **sustained** manner
- 2. A system that is defined at **several spatial, temporal, and organizational scales**, which are typically linked across scales
- 3. A set of **critical resources** (natural, socioeconomic, and cultural) whose flow and use is regulated by a combination of ecological and social systems
- 4. A perpetually dynamic, complex system with continuous adaptation

Adapted from Redman et al., "Integrating Social Science into the Long-Term Ecological Research (LTER) Network"



#### What does this have to do with finance?



Each layer is a "perpetually dynamic, complex system with continuous adaptation". Together, complexity is compounded.



#### Changes can be abrupt and irreversible

**Ecosystem layer:** "Human populations and their use of land have transformed most of the terrestrial biosphere... At present, even were human populations to decline substantially or use of land become far more efficient, the current global extent, duration, type and intensity of human transformation of ecosystems have already irreversibly altered the terrestrial biosphere... It remains to be seen whether the anthropogenic biosphere will be sustained and continue to evolve."<sup>a</sup>

**Production layer:** "For the past 200 years, humans have benefited from the abundant, inexpensive, and easily obtained energy of fossil fuels... [W]hen energy is readily available, societies respond by growing rapidly. They must become more complex in response... More complex societies are more expensive, requiring greater energy per capita. The process of increasing complexity necessitates greater energy production, creating a positive feedback cycle. Past societies have collapsed under such pressures."<sup>b</sup>

**Finance layer:** "George Soros's theory of reflectivity focuses on the interactions between expected, actual, and fundamental values [that] are affected by the historically contingent paths... [T]he equilibrating process is turbulent, path dependent (nonergodic), and may give rise to extended disequilibrium boom-bust phases. Such patterns...invalidate notions such as rational expectations and the efficient market." <sup>b</sup>



<sup>&</sup>lt;sup>a</sup> Ellis (2011), "Anthropogenic transformation of the terrestrial biosphere"

<sup>&</sup>lt;sup>b</sup> Taylor and Tainter (2006), "The nexus of population, energy, innovation, and complexity"

<sup>&</sup>lt;sup>c</sup> Shaikh (2010), "Reflexivity, path dependence, and disequilibrium dynamics"

#### A financial focus can impair ecosystem function



\* ES = "Ecosystem Services"

Kemp-Benedict and Kartha (2019), "Environmental financialization: what could go wrong?"



#### Financial systems and the "real" economy MISTRA

The Swedish Foundation for Strategic Environmental Research

With contributions from Louison Cahen-Fourot, Emanuele Campiglio, Elena Dawkins, Antoine Godin, and Eric Kemp-Benedict



Mistra Financial Systems Webinar, 22 October 2020

## The economy as a "going concern"\*

- Businesses produce and offer services in advance of sales
- They buy new equipment, hire, and possibly expand their operations
- Financial institutions and individuals advance them funds

...and people go to the store knowing what they want is likely on the shelf The result:

- A vast and complex web of B2B, B2C, and employment relationships
- A reasonably resilient system punctuated by periodic crises





#### The sustainability challenge

#### **Market perspective**

- The sustainability challenge is about externalities: costs and benefits not priced in markets
- Policy instruments should internalize externalities through resource prices, cap-and-trade, etc.

#### "Going concern" perspective

- A sustainability transition implies *structural transformation*:
  - Rewiring the network of economic relationships
  - Replacing fundamental raw materials
- Many policy instruments are possible; some will impact economic activity
- Conflicts between instruments (ineffectiveness and inefficiency) are highly likely



#### **Cascading linkages in the production layer**





#### Multiple entry points (and risks!) for finance





#### Forward and backward linkages

**Forward linkage:** Through the provision of outputs of a sector, "induce attempts to utilize its outputs as inputs in some new activities."

**Backward linkage:** Through demand for inputs, "induce attempts to supply through domestic production the inputs needed in that activity."

A demand-oriented view of the economy: Induce investment by ensuring the existence of a market. As a sector or product becomes established, downstream innovation generates novel uses for the output.



# Asset stranding cascades

### Why a cascade

- Loss of a sector with high forward linkages
- Replacement with a new sector with high *potential* but (initially) unrecognized forward linkages
- Can require substantial "rewiring" of the economy, with stranded assets at each stage in the supply chain



#### **Rewiring the economy: An example**

The **chemical industry** shifts entirely toward biologically-based inputs and platform chemical manufacturers retool for biorefinery operation. They can either:

- 1. Produce existing platform chemicals from biomass
- 2. Construct entirely new platform chemicals better adapted to the underlying feedstock

If option (1), nothing else needs to change 🗸

If option (2), downstream firms must adjust ×, e.g.

- A chemicals manufacturer adapts production of plastics to the new platform chemicals
- A toy manufacturer makes small changes to handle the characteristics of new plastics and ships to a retailer on unmodified trucks using biodiesel
- The retailer makes no changes

Closest to raw materials

 Farthest from raw materials



#### Sweden's "stranding cascade"



- Multiple pathways
- More or less easy to modify
  - Electricity, gas, steam: Renewable electricity sources
  - Basic metals: No change, not a petroleum input
  - Road transport: Biofuels, electric vehicles



#### **Complete decarbonization and capital at risk**

|          | Total capital |        | Mining (B) |         | Manufacturing (C) |        | Electricity/gas (D) |         |
|----------|---------------|--------|------------|---------|-------------------|--------|---------------------|---------|
| Austria  | $5,\!689$     | (0.8%) | 431        | (16.0%) | 1,706             | (2.4%) | $3,\!315$           | (12.5%) |
| Belgium  | $3,\!181$     | (0.6%) | 1          | (0.1%)  | $2,\!692$         | (3.0%) | 285                 | (1.2%)  |
| Czechia  | $17,\!536$    | (3.7%) | $4,\!075$  | (60.9%) | 2,772             | (3.3%) | 6,718               | (25.7%) |
| Germany  | 40,752        | (1.0%) | $3,\!629$  | (29.6%) | 12,702            | (2.8%) | $21,\!627$          | (12.2%) |
| Greece   | 8,774         | (2.7%) | $1,\!313$  | (48.7%) | $1,\!800$         | (8.1%) | $2,\!683$           | (17.1%) |
| France   | $35,\!514$    | (1.4%) | 3,644      | (21.4%) | $3,\!877$         | (2.1%) | $21,\!913$          | (23.3%) |
| Italy    | $58,\!589$    | (2.1%) | 2,252      | (10.7%) | 19,776            | (4.9%) | $30,\!565$          | (14.0%) |
| Sweden   | $3,\!970$     | (0.8%) | 55         | (1.4%)  | 1,762             | (2.2%) | 1,856               | (3.1%)  |
| Slovakia | 18,749        | (8.2%) | 473        | (15.1%) | $3,\!220$         | (7.7%) | $13,\!458$          | (35.1%) |
| UK       | $84,\!678$    | (3.6%) | 45,900     | (69.3%) | $7,\!385$         | (2.9%) | $28,\!384$          | (35.7%) |

Productive capital stock at risk of stranding (million € at current prices in 2010 and share of total/sectoral capital stocks)



## A two-sector greenbrown capital model

#### Sectors

- Unaffected: Relatively insensitive to the amount of green capital in the economy because of network effects and forward-backward linkages
- Farther from raw materials
- Affected: Sensitive to the amount of green capital in the economy because of network effects and forward-backward linkages
- Closer to raw materials



#### **Balance sheet**

|          |            | Unaffected s                   | sector firms                   | Affected se                    |                             |       |          |
|----------|------------|--------------------------------|--------------------------------|--------------------------------|-----------------------------|-------|----------|
|          | Households | Brown                          | Green                          | Brown                          | Green                       | Banks |          |
| Money    | +M         |                                |                                |                                |                             | -M    | 0        |
| Loans    |            | $-L_{ub}$                      | $-L_{ug}$                      | $-L_{ab}$                      | $-L_{ag}$                   | +L    | 0        |
| Equities | +E         | $-E_{ub}$                      | $-E_{ug}$                      | $-E_{ab}$                      | $-E_{ag}$                   |       | 0        |
| Capital  |            | $+p_{u}K_{ub}$                 | $+p_{u}K_{ug}$                 | $+p_{u}K_{ab}$                 | $+p_{u}K_{ag}$              |       | $p_{u}K$ |
| Total    | Ω          | $p_u K_{ub} - L_{ub} - E_{ub}$ | $p_u K_{ug} - L_{ug} - E_{ug}$ | $p_u K_{ab} - L_{ab} - E_{ab}$ | $p_{u}K_{ag}-L_{ag}-E_{ag}$ | 0     | $p_{u}K$ |



### Firm (model) behavior

- Firms invest in anticipation of demand
- Their demand expectations are always satisfied\*
- They successfully target a loan-to-equity ratio
- They allocate investment funds to green or brown capital depending on
  - Profitability
  - Market valuation (as a "window of opportunity")
  - Risk management (for affected firms only) : hedge against uncertainty over green capital penetration in the rest of the economy

\* This is a "classical" assumption. The model is closed through forced saving by households.



#### Shares of fixed capital by sector and type



#### Reflections

- A sustainability transition will require deep structural change
- One complex system (the economy) is transforming with funding from another complex system (finance), with implications for yet other complex systems (society and ecosystems)
- Because economies operate as "going concerns", transformation means relearning by workers, consumers, managers, investors, and government
- How much one sector has to change depends on choices made in other sectors (e.g., the available platform chemicals)
- The abstraction that makes finance so flexible and responsive may obscure what is happening in the "real" economy, with potential for surprise

