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Perspective

A Proposal for Integrating Theories of Complexity for Better Understanding Global Systemic Risks

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The global financial crisis of 2008 has shown that the present financial system involves global systemic risks. The dimension of these risks is hard to grasp with the conceptual tools that have been developed to tackle conventional risks like fire or car accidents. While modern societies know quite well how to deal with conventional risks, we have not yet been equally successful at dealing with global systemic risks. For managing this kind of risks, one needs to understand critical features of specific global systems where many human agents interact in ever changing complex networks. Here we apply two specific dimensions of complexity theory for dealing with global systemic risk in an integrated fashion: normal accidents and extended evolution. Both of them have successfully been applied to the analysis of systemic risks. As a paradigmatic example of global systemic risks, we focus on the global financial crisis that began in 2008, and suggest that the future evolution of the financial system could either see a further increase in complexity, or a reversal to a less complex system. We explore and contrast the implications of normal accident theory and extended evolution perspectives and suggest a four-point research strategy informed by complexity theory for better understanding global systemic risks in financial systems.

KEY WORDS: Extended evolution; global financial crisis; global systemic risks; key currency; normal accidents

1. INTRODUCTION

It is widely understood that today's financial system involves many global systemic risks. To understand such risks in the financial, but also in other domains will require different perspectives and additional research. Here complexity theory will play a key role. In this article we introduce two specific dimensions of complexity theory, *extended evolution* and *normal accidents*, as illustrations of what can be gained by such a perspective. Specifically, we use these two concepts to look beyond the financial crisis of 2008 and to imagine possible future evolutionary trajectories of the global financial system. We argue that the financial crisis of 2008 can be understood as a first warning sign of a transition beyond the present dollar-centered financial order. Such a transition presents important opportunities, but also severe risks to the global socioeconomic system.

We first introduce the concept of global systemic risks. Next, we look into the global financial crisis that began in 2008 as a paradigmatic example of such risks. We suggest that the future evolution of the financial system could either see a further increase in complexity, or a reversal to a less complex system. We explore the implications of normal

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accident theory and extended evolution perspectives and suggest four specific research needs to better understand the complexity of global systemic risks in general, and global systemic financial risks in particular.

2. GLOBAL SYSTEMIC RISKS

Renn et al. (forthcoming) distinguish *global systemic risks* and *conventional risks* as two contrasting subcategories of the general category *risk* (Renn, Lucas, Haas, & Jaeger, 2017). Risk refers to the uncertainty and severity of the outcomes of an activity with respect to something that some agents value (Aven & Renn, 2009), a definition that is deliberately general. Probability and utility functions are key tools that help to insure and regulate conventional risks. We define conventional risks as risks that can be made acceptable to the relevant agents through combinations of insurance markets with regulations developed within the framework of nation states.

For global systemic risks, in contrast, relevant concepts for comprehending them as well as institutions for dealing with them are lacking, and innovative approaches are called for. Jaeger (2016) shows that the concepts of probability and utility are still necessary, but not sufficient to deal with global systemic risks. It is not possible to control these risks by identifying and implementing a globally optimal strategy. Rather one needs to understand critical features of specific global systems where many human agents interact in ever changing complex networks. Even the most powerful agent cannot do better than engage in a coevolutionary process with other agents in such a way as to create win–win opportunities in expanding networks (Jaeger, 2016). Given this challenge, it is not surprising that no canonical definition of global systemic risks has emerged as of yet.

We argue that to begin to understand systemic risk and its consequences it is necessary, although still not sufficient, to combine the concepts of *extended evolution* and *normal accidents*, so as to develop a comprehensive way to think about global risks and societal responses.

To our knowledge, it was William Cline who coined the term *systemic risk* in his study of international debt in 1984 (Cline, 1984). In 2003, the Organization for Economic Cooperation and Development (OECD, 2003) broadened the discussion and applied the concept of systemic risks to other domains like climate change, international terrorism, and pandemics. The global financial crisis has given a push to systemic risk research. In 2009, building on the work of the International Monetary Fund, the Financial Stability Board, and the Bank for International Settlements, the G20 offered a definition of *financial* systemic risk as

> "A risk of disruption to financial services that is caused by an impairment of all or parts of the financial system and has the potential to have serious negative consequences for the real economy." (G20, 2009).

In 2017, the European Central Bank (ECB) suggested a vaguely similar but not identical definition:

> "Systemic risk can be best described as the risk that the provision of necessary financial products and services by the financial system will be impaired to the point where economic growth and welfare may be materially affected." (ECB, 2017).

We think that it is too early to offer a general definition of global systemic risks because we believe that further research is needed for better understanding those risks. Rather, we want to highlight features common to paradigmatic examples of global systemic risks. In particular, we think about the risks of the 2008 financial crisis, of pandemics, and of climate change. Again building on Renn et al. (2017), and Renn et al. (forthcoming) in the introduction to this special issue, we want to emphasize four features of global systemic risks. They are:

- Transboundary and cross-sectoral in their consequences.
- Highly interconnected and intertwined, leading to complex causal structures and evolutions.
- Nonlinear in the cause–effect relationships, often involving unknown tipping points or tipping areas.
- Nondeterministic in their effect structure, which leads to poorly known possible futures.

Actual global systemic risks show all of these features, but we are not comfortable to accept these as a general definition without further exploration.

3. THE GLOBAL FINANCIAL CRISIS

In August 2018, Adam Tooze published a history of the decade of financial crises that started in 2007 (Tooze, 2018). His study strongly suggests that the financial crisis marks the beginning of one of the biggest challenges of globalization in history. The crisis erupted with full force when Lehman Brothers went bankrupt on September 15, 2008. U.S.

authorities, especially the Fed and the Treasury, considered rescuing Lehman Brothers, but decided otherwise. To the surprise of most experts and policymakers, the bankruptcy of Lehman triggered something that almost no one thought possible: A complete freezing of the most important credit markets, foremost the markets for interbank credit. Subsequently, a cascade of credit tightening endangered financial firms throughout the whole OECD.

The U.S. government reacted with unprecedented emergency measures. Its *Troubled Asset Relief Program* (TARP) mobilized funds on the order of 5% of U.S. gross domestic product for stabilizing U.S. financial institutions. The Fed avoided the worst by expanding its asset book and injecting vast amounts of dollars into the United States and—via swap lines with other central banks—the global economy.

Nevertheless, industrialized countries experienced a severe recession. While banks were rescued by governments, large parts of the population were hit hard by the recession. In the Eurozone, the recession was amplified by the mistaken belief that public debt, not bank overexposure, was the main problem.

After the ECB hesitated to act, with damaging consequences, under the leadership of Jean-Claude Trichet, it eventually safeguarded the Eurozone. The decisive moment was Mario Draghi's famous speech culminating in the statement

> "Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough." (Draghi, 2012).

China also played a stabilizing role with a massive stimulus program (and purchase of European bonds) which complemented, and supported, the ECB's *whatever it takes* approach. All these coordinated responses represented a remarkable global effort.

Meanwhile, a decade since the global financial crisis first erupted, "America first" became the declared strategy of U.S. president Donald Trump, while China's president Xi Jinping has discarded the previous Chinese strategy of keeping a low profile. In addition, despite the many changes in financial regulation, it is hard to see how the next crisis could be avoided and, once happening, managed without catastrophic damages. Even more so, largely due to the financial crisis and its ramifications, the social, political, economic, and military order that has supported globalization has now been superseded by antagonistic attitudes and perceived zero-sum situations. Evidence for this trend are the popularity of tariffs, the emerging nationalistic movements with their fondness for protectionism and strong borders, and a worldwide backlash against the global elites.

4. THE IMPLICATIONS OF COMPLEXITY

Today, the global financial order is structured around the United States, with the U.S. dollar as its key currency[1] (Mehrling, 2016; Tooze, 2018). Right now, we can only speculate when this regime will give way to a new global financial order and what this order will look like. Murau, Rini, and Haas (2020), for example, present alternate evolutionary trajectories for the future of the global financial system. They present trajectories with a single key currency, with multiple key currencies, or without any key currency.

Some of these scenarios imply that the complexity of the financial system will rise, whereas in one scenario, the complexity is drastically reduced. We want to complement the work of Murau et al. (2020) and explore the role of complexity theory for discussing possible futures of the financial system. For this conceptual article, we focus on two specific strands of complexity theory, the notions of extended evolution and normal accidents. As we will see, these two concepts come to rather different conclusions how to deal with the complexity of complex global systems.

5. THE FINANCIAL CRISIS AS A NORMAL ACCIDENT

In 1984, Charles Perrow published his monograph on *normal accidents* (Perrow, 1984). He argued that tightly coupled complex systems in modern organizations produce normal accidents, that is, accidents that result from small random fluctuations in the normal operation of these systems. In a tightly coupled complex system, failure of a specific component will impact the functioning of other components and propagate through the system, causing the overall system to malfunction. Subsequent research on high reliability organizations (HROs), however, suggests that in some cases a safety culture supported by a suitable fabric of organizational practices allows

[1] In a specific period, key currencies are the currencies that are most widely used as *unit of accounts* for denominating debt contracts in international transactions—irrespective of whether these contracts originate from the private or public sphere. For the origin of the concept, cf. Asso and Fiorito (2009) and Mehrling (forthcoming).

to run a tightly coupled complex organization in a highly reliable way (Klein, Bigley, & Roberts, 1995; Weick & Sutcliffe, 2015).

Today's global financial markets form a tightly coupled complex system prone to normal accidents, and the global financial crisis shows many features of such an accident (Guillén, 2015). Had the safety culture of the global financial system been up to the challenge, the crisis might have been avoided. This safety culture, however, was jeopardized by the behavior of elite agents who, for their own gains, exposed other agents and ultimately world society to global systemic risks (Perrow, 2010).

Managing these risks thus calls for two kinds of institutional innovations. The first is loosening the tight coupling and/or reducing the complexity of the system in order to reduce the probability of normal accidents. The second is overcoming forms of social inequality that enable privileged agents to erode the necessary safety culture to their own advantage. These innovations will need to be effective at the global scale. Unfortunately, as Scheffer et al. remark, it remains unclear "whether scaling up of effective governance can now be done at the global level and, if so, what this new form of governance might look like" (Scheffer, van Bavel, van de Leemputa, & Nes, 2018).

6. EXTENDED EVOLUTION

The study of major transitions in biological evolution has spurred work on extended evolution theory that is highly relevant for sociocultural evolution, including understanding the financial system. A key reason is that extended evolution is not based on finding an analog of biological genes in order to model sociocultural evolution, but rather stresses the role of regulatory networks and niche construction (Laubichler & Renn, 2015). Regulatory networks are structures that govern the behavior of systems, while niche construction describes the fact that these systems actively construct their relevant environments. Both processes are linked by continuous feedback relations, which determine the outcome of their evolutionary dynamics.

Biological selection generally does not operate on single genes, but on network of genes, their regulatory structures, and the nested layers of phenotypes in which the genes and their regulatory networks are embedded. Furthermore, the selecting environment or niche is not external to the actions of organisms, but rather is the product of complex interactions among organisms and between organisms and their surroundings. The resulting coevolutionary dynamics therefore involve large numbers of complex feedback loops, which lead to implicit systemic risks—in a biological sense—that organisms, species, and ecosystems have to deal with. Seen from this evolutionary perspective, systemic risks are unavoidable and many features that emerged in the course of evolution are attempts to manage systemic risks.

From the point of view of extended evolution, it is still an open question whether the necessary strong regulatory networks that could manage systemic risks will emerge within the financial system in time to prevent dramatic system failure. In particular, it remains unclear whether adding more complexity, or regulatory layers, might actually help to keep systemic risks in check, or whether this needs a reduction in the complexity of these systems, something that, in any case, is very difficult to achieve. In the course of evolution, biological systems rarely reduced complexity. In economic history, the financial system saw complexity reduction only in the context of large-scale historical crises. The de facto nationalization of finance at the beginning of World War I is one historical example. The substantial endogenous scale back of financial activity during the Great Depression and its connected regulations—with the landmark Glass–Steagall act that ended universal banking in the United States—is another one. The two big open questions from the perspective of extended evolution are whether it is possible and whether it is advisable to reduce the complexity of the financial system in the absence of impending major systemic crises.

7. AN EXTENDED EVOLUTION EXERCISE

Here we want to briefly illustrate what it could mean to analyze the global financial crisis from a viewpoint of extended evolution. Focusing on populations of banks, firms, households, and nations as well as their network connections we need to identify the regulatory structures governing the financial system as well as the various niches that the actors in these systems have constructed for themselves. The compound of these populations faces the challenge of monetary coordination, which—to use biological terminology—represents a complex problem of regulation. Historically, this challenge has been met by having a *key currency*, which is one of the defining features of a constructed niche for the financial

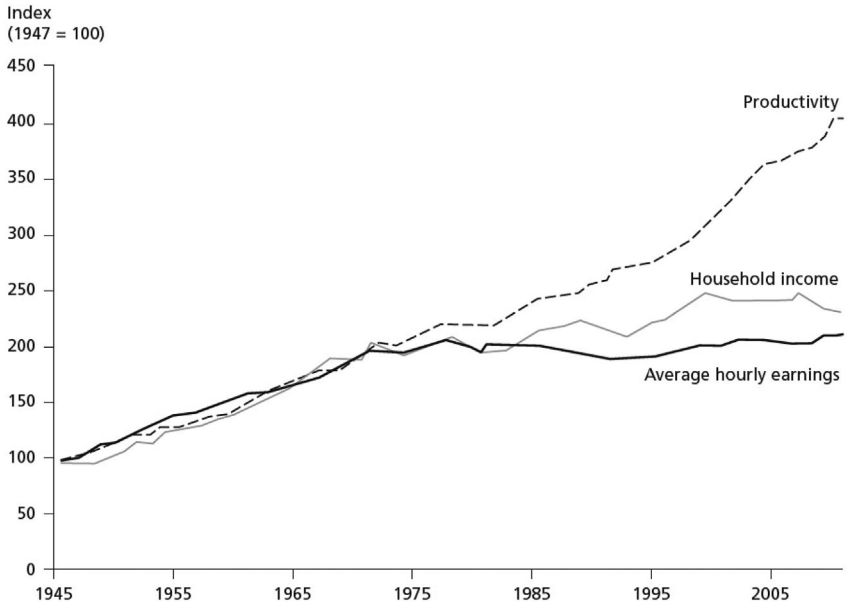

Fig 1. U.S. productivity, household income, and average hourly earnings 1947—2011.

system. Historically, we have seen a sequence of key currencies from the Spanish dollar, the British pound, to the U.S. dollar. Such arrangements are maintained by tangible benefits for a sufficiently influential part of the population of the *key country* that issues the key currency, along with the options provided to other countries through the existence of a sufficiently large amount of a sufficiently stable key currency.

Robust social cohesion and stable and strong institutions (i.e., regulatory networks) within the key country are thus a precondition for sustaining the role of its key currency, as only a functioning system can construct and maintain a global niche for the financial systems that can absorb regular perturbations.

Today this social cohesion is at risk. Fig. 1 shows the decoupling of household income and average hourly wages from productivity growth in the United States (Kochan, 2013, via Streeck, 2013). In the 1950s and 1960s, U.S. household incomes and average hourly wages increased with productivity. By and large, this pattern was shared across industrialized societies (Nordhaus, 1972). It is best understood as the result of a social norm broadly accepted by employers, trade unions, governments, and central banks—a cornerstone of the social regulatory network that maintained the niche of the global financial system after World War II. As a result, during this period U.S. inflation fluctuated in a manageable bandwidth between 6% and −1%, and the Bretton Woods architecture of the global financial system worked reasonably well.

In the late 1960s, however, in the United States as in most industrialized countries workers started to increase the pressure for higher wages as a response to increasingly alienating working conditions (and in the United States racist discrimination), increasing income taxes, and favorable labor market conditions (in the United States due in part to the government deficit used to finance the Vietnam war) (Jaeger & Weber, 1988). Employers reacted by increasing prices, driving inflation to 10% and above. Central banks and governments brought inflation down again by increasing unemployment and weakening trade unions. Decades of increasing inequality followed as productivity kept increasing while hourly wages and household incomes stagnated (Fig. 1).

These dynamics threatened social cohesion—and electoral successes—again. Several U.S. administrations tried to comfort large parts of the population by engineering easy access to mortgages and thus homeownership in order to make rising inequality bearable. This, however, paved the way to the subprime crisis, the key trigger of the global financial crisis.

It is an open but crucial question whether the overall population of the key country (the United States) will be willing to sustain the current social and financial order with the U.S. dollar as key currency in the long run. As the current arrangement benefits mostly the elites, support depends on a renewal of

the normative fabric within the United States. Key elements of this regulatory network—comprising both legal regulations and often highly effective social rules—are norms of fairness relating to distribution of wealth, income, risks and opportunities between social classes and racially defined groups.

The increasing inequality and related political polarization make this, at the very least, doubtful. The outcome of the internal socioeconomic and political development of the United States in conjunction with global developments thus might decide which of the scenarios presented in Murau et al. (2020) will actually unfold. Whatever transitions will eventually take place, narrowing the analysis to economic variables in the usual sense will miss key dynamics. The future of global systemic risks in the financial domain will depend to a large extent on the interactions between regulatory networks and the institutional niches in which the financial system is embedded.

8. CONCLUSION

Concepts and knowledge from extended evolution theory and the normal accident approach provide relevant insights for managing global systemic risks. Increasing redundancy within systems and constructing strong external regulatory niches for those systems are strategies that have worked throughout biological evolution. Likewise, the normal accident approach considers increasing redundancy as a key strategy for fostering the resilience of systems. Finally, HRO research complements these strategies with the establishment and institutional support of global safety cultures adequate to contain the relevant systemic risks.

Combining the perspective of extended evolution and normal accidents leads to the question whether reducing complexity is a possibility. It is a standard recommendation to manage normal accidents in sociotechnical systems. In the course of evolution, however, biological systems rarely reduced complexity in the absence of systemic crisis. So far globalization has followed the dynamics of biological evolution, including a build-up of global systemic risks. Can this trend be reversed, and systemic risk be reduced by reducing complexity? Currently, we just do not know.

Against this backdrop, we suggest advancing complexity theory with the goal of integrating the perspectives of extended evolution and normal accidents into a comprehensive approach via researching highly relevant real-world examples of global systemic risks. In particular we suggest a multipronged research strategy with four parallel exercises: Firstly, analyzing global institutional designs with regard to global systemic risks. This should include an analysis of seemingly promising designs that never saw the light of day.[2] Secondly, we need to better understand the past transitions between global financial orders and their respective key currencies. This exercise will hopefully help us prepare for the next transition, which has possibly started with the 2008 crisis. Thirdly, we should investigate specific aspects of the evolution of the global financial order. Important examples are the emergence of the Eurodollar market, the development of the Eurozone, and the role of Asia in the changing topology of the global financial system. Last but not least, there is a rather urgent research need to identify early warning signals that indicate a major transition within the present global financial system.

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[2]For example, in 2009, Zhou Xiaochuan, the governor of the People's Bank of China, stated that it was unfortunate that Keynes' plan for a postwar international financial order was rejected, as in hindsight Keynes' approach might seem more farsighted than the actual Bretton Woods system (Zhou, 2009).

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