Is Our Monetary Structure a Systemic Cause for Financial Instability? Evidence and Remedies from Nature

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Abstract

Fundamental laws govern all complex flow systems, including natural ecosystems, economic and financial systems. Natural ecosystems are practical exemplars of sustainability: enduring, vital, adaptive. The sustainability of any complex flow system can be measured with a single metric as an emergent property of its structural diversity and interconnectivity; it requires a balance in emphasis between efficiency and resilience. The urgent message for economics from nature is that the monoculture of national currencies, justified on the basis of market efficiency, generates structural instability in our global financial system. Economic sustainability therefore requires diversification in types of currencies, specifically through complementary currencies.

Keywords: sustainability, efficiency, resilience, biodiversity, ecosystems, complexity theory, financial instability, economic sustainability, complementary currencies

Why is the financial crisis of 2008 treated as if it were the first? The World Bank has identified more than 96 previous banking crises and 176 monetary crises since President Nixon introduced the floating exchange regime in the early 1970s (Caprio & Klingebiel, 1996). Even before this period, financial booms and bust cycles were, in Kindleberger's words, a remarkably "hardy perennial" (Kindleberger, 1978); he inventories no less than 48 massive crashes between the 1637 tulip mania in Holland and the 1929 crash on Wall Street. In short, it may be tempting to consider financial and monetary instability as a given, as part of Schumpeter's "creative destruction" of capitalism. But Schumpeter was referring mainly to the rise and fall of business units, not the monetary system. Could it be that a bug in the monetary system keeps crashing the operating system of capitalism, and that this has generated financial instability during the entire Modern capitalist era?

Our view is that such repeated breakdowns, in very different countries and times, under different regulatory environments, and in economies with very different degrees of development, signal some underlying structural problem. If such a deeper mechanism is involved, it could explain why each new set of regulations achieves, at best, only a reduction in the frequency of banking and monetary crises, without getting rid of them and their horrific economic and socio-political consequences.

Here is a metaphor. You are given a car without brakes and with an unreliable steering wheel. And you are sent across the Alps or the Rockies. When you crash, you are told that you are a bad driver; or that your road maps are out of date. And everybody is endeavouring to get that same car back on the road, with as little change as possible...predictably until the next crash. Indeed, such a car is not fit for driving; it has structural problems which, if not fixed, will predictably cause other crashes. Extending the metaphor, and assuming that only structural solutions can genuinely address structural problems, a helpful starting point would be to identify the nature of the structural problem that is plaguing our financial and monetary system.

Sustainability of Complex Flow Systems

We now have scientific evidence that a structural fault is indeed involved in generating financial crashes. The theoretical breakthrough is the capacity to measure with a single metric the sustainability of complex flow systems, which include natural ecosystems and economic or financial systems. Understanding and empirical substantiation of this mechanism has arisen from quantitative ecological research. For those desiring full technical and mathematical proof of what will be claimed here, please refer to the relevant paper (Ulanowicz, Goerner, Lietaer, & Gomez, 2009). The most relevant points are summarized hereafter.

A recent and surprising insight from systems ecology is that sustainability is as much about "what is not" as "what is". How can this be?

Conventional science investigates what is apparent – the things that are present in our world; it ignores or understates the absence of things. This seems hardly surprising and, on the face of it, of no consequence. Even if absence can make the heart grow fonder, this surely has nothing to do with the real world. Or does it?

Information is any "difference that makes the difference" (Gregory Bateson) and, as the binary logic of the digital age has popularized, such difference almost always involves the absence of something. In coming to terms with the working of whole systems, information theory (IT) is a means for apprehending and quantifying what is missing. The key point is that if one is to address the issue of sustainability, then the inchoate, undetermined "potentiality" of a system also becomes an indispensable focus of inquiry, because it is the source of the resilience that allows the system to persist (Conrad, 1983).

What IT tells us is that a system's capacity to undergo change (H) has two components: order and the absence of order ($H = X +$ ˜ The first component, called "mutual constraint" (X, an analogue of Newton's Third Law of motion), quantifies all that is regular, orderly, coherent and efficient. It encompasses basically all the concerns of conventional science. By contrast, the second component (..represents the lack of those same attributes, or the irregular, disorderly, incoherent and inefficient potential behaviours that have escaped the scrutiny of science mainly because they cannot easily be described, and even less readily repeated or measured, or all of the above.

In the jargon of IT, this second, overlooked component of system change is called "conditional entropy"; it can also be thought of as uncommitted potential. Critically what this says is that the very absence of order (even if its potential is never activated, and therefore unnoticed and unmeasured) plays the key role for a system to persist over the long run, to adapt to changing environment, or survive unexpected challenges. We know this intuitively and also from our experience of day to day living, exemplified in the familiar expressions "laid-back", "I can cope with that" and "slack in the system"; but we rarely recognize it in our collective affairs, much less acknowledge its importance for sustainability. We will next show why this happens to be even more significant than the first variable, order, if we are to understand sustainability.

Separately, order (mutual constraint) and disorder (conditional entropy) tell us nothing about the vitality of a system. Is it healthily working, furiously spreading a cancer, moribund or even dead?

When scaled by the activity of the system – quantified as its total system throughput (TST) – the property of mutual constraint converts into the measure of a system's "throughput efficiency" [1] (A), so-called because it measures the capacity of a system to process volumes of whatever that particular system deals with (e.g. biomass in an ecosystem, electrons in an electrical distribution system, or money in an economy). On the other hand, scaled conditional entropy becomes a measure of a system's resilience (ϕ), because it captures the capacity of a system to change and adapt. Thus the total capacity for system development (C) can be expressed as both order and disorder, or $C = A + \phi$ (Ulanowicz, Bondavalli & Egnotovich, 1996).

A living system adapts in homeostatic fashion to buffer performance by expending what Odum called "reserves" (Odum, 1953). The reserve in this case is not some palpable storage, like a cache of some material resource. Rather, this second variable ϕ is a characteristic of the system structure that reflects its capacity both to survive change and adapt to new circumstances – and it usually requires some loss of efficient performance (Ulanowicz, 2010). Systems that endure – that is, are sustainable – lie in dynamic balance somewhere between these two poles of order and disorder, efficient performance and adaptive resilience.

We now have the basic elements for a more complete description of complex living systems. That it possesses throughput efficiency, *A*, means that the system is capable of exercising sufficient directed power to maintain its integrity and growth over time. Autocatalysis plays a key role among those processes: autocatalysis is a type of self-perpetuating (positive) feedback process capable of exerting a centripetal pull upon materials and energy, drawing more and more resources into its orbit.

So crucially, as we have seen, throughput efficiency is definitely not sufficient for sustainability. Also necessary is that it possesses a resilience, ϕ of undefined and contingent responsiveness to the unpredictable challenges thrown up by its own workings and its environment. It is thanks to this ϕ that a resilient ecosystem can withstand shocks and adapt itself when necessary.

This dialectic between efficiency and resilience is the "go and get" and the "let go and give" of life. In the Chinese philosophical tradition, they are called respectively the *yang* and the *yin*, characteristics which they assigned to all natural systems. The poet John Keats coined the term "negative capability" for the often overlooked *yin* trait of human personality and experience: the capacity to hold uncertainty without angst – the capacity to live with the unknown as an ally rather than something to be eliminated. Such "undecideness" is not hesitant fence-sitting, indifference or laziness; nor is it a skill in the usual sense of the word, although it can be cultivated. It is more like a connection to an undifferentiated ground that resists form, which continually invokes questions and reflection and is potentially multi-dimensional, a space of "both-and" and *neti-neti*, the Hindu concept literally meaning "neither this, nor that".

In summary, natural ecosystems exist because they have *both* sufficient self-directed identity *and* flexibility to change. This is what the Chinese refer to as *yin-yang*, two ideograms joined as a single concept, where the polarities necessitate each other in an appropriate balance in harmonious complementarity. Over time nature must have solved many of the structural problems in ecosystems (otherwise, these ecosystems simply wouldn't still exist today). They are our best living examples of large scale sustainability in action.

Moving beyond information theory, ecologists have measured the transfer of biomass and energy ("trophic exchanges") within ecosystems. For example, using a web-like network approach, they have estimated the magnitude of carbon transfers within a freshwater cypress wetland community leading from prawns to the American alligator via three intermediate predators: turtles, large fish, and snakes (Ulanowicz, Bondavalli, & Egnotovich, 1996); or estimated the trophic (nutritional) transfers of energy in the Cone Spring community, a small freshwater ecosystem comprising primary producers (algae and higher plants), detritus, bacteria, detritivores (annelids and molluscs) and carnivores (insects) (Tilly, 1968).

Ecologists have also found ways to derive values for an ecosystem's throughput efficiency and resilience by estimating network size and network connectedness in terms of two variables: (1) node to node pathway steps (n, which gauges the effective number of trophic levels in the system and is directly related to throughput efficiency and (2) links per node (c, which measures the effective connectivity of the system in terms of links per node which is directly related to resilience).[2] It turns out that there is a specific zone of optimal robustness, into which all observed natural ecosystems fall. This zone has been named the "window of viability" (also in ecological literature the "window of vitality").[3]

The key conclusion is that nature does not select for maximum efficiency, but for a balance between the two opposing poles of efficiency and resilience. Because both are indispensable for long-term sustainability and health, the healthiest flow systems are those that are closest to an optimal balance between these two opposing pulls. Conversely, an excess of either attribute leads to systemic instability. Too much efficiency leads to brittleness and too much resilience leads to stagnation: the former is caused by too little diversity and connectivity and the latter by too much diversity and connectivity.

Sustainability of a complex flow system can therefore be defined as the optimal balance between efficiency and resilience of its network. With these distinctions we are able to define and precisely quantify a complex system's sustainability in a single metric. The generic shape of the relationships between sustainability and its constituent elements is shown in Figure 1. Observe that there is an asymmetry: optimality requires more resilience than efficiency! (The optimal point lies closer to resilience than efficiency on the horizontal axis).

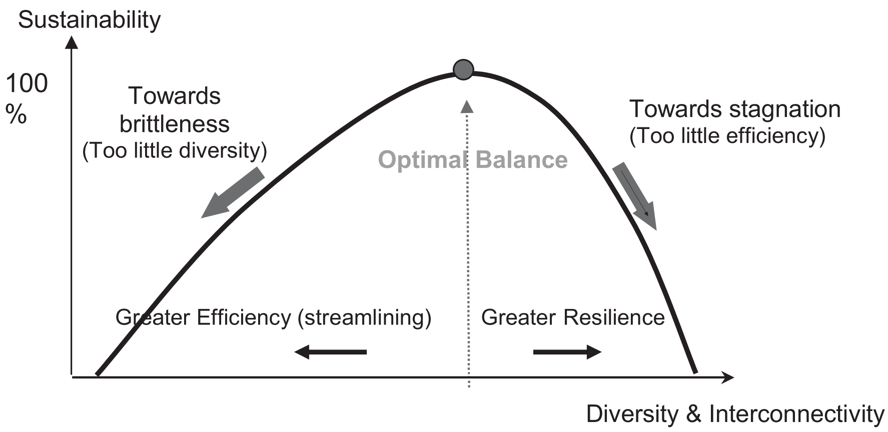

Figure 1. Sustainability curve mapped between the two polarities of efficiency and resilience. Nature selects not for a maximum of efficiency, but for an optimal balance between these two requirements. Notice that resilience is roughly two times more important than efficiency at the optimum.

Until recently, total throughput and efficiency have been the only means for us to identify the relative success of a system, whether in nature or in economics. For example, in ecosystems, as in economies, size is generally measured as the total volume of system throughput/activity. Gross Domestic Product (GDP) measures size this way in economies and Total System Throughput (TST) does so in ecosystems. Many economists urge endless growth in size (GDP) because they assume that growth in size is a sufficient measure of health. GDP and TST, however, are both poor measures of sustainable viability because *they ignore network structure*. They cannot, for example, distinguish between a resilient economy and a bubble that is doomed to burst; or between healthy "development," as Herman Daly (1997) describes it, or explosive growth in monetary exchanges simply due to runaway speculation.

Now, however, we can distinguish whether a particular increase in throughput and efficiency is a sign of healthy growth or just a relatively short-term bubble that is doomed to collapse.

As explained above, it is also interesting that ecosystems have their most critical parameters within a very specific and narrow range, which can be computed empirically with precision and which we call the "Window of Viability" (See Figure 2).

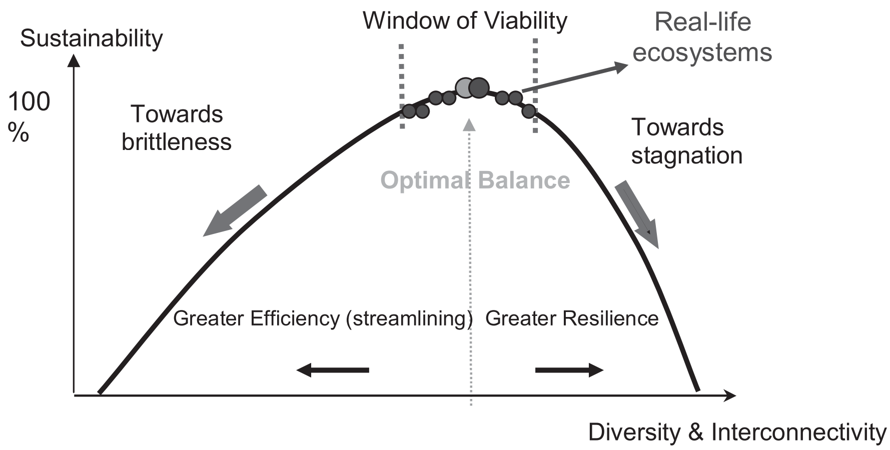

Figure 2. The "Window of Viability" in which all sustainable natural ecosystems operate. Complex natural ecosystems invariably operate within a fairly narrow range on each side of the Optimum point.

Application to Other Complex Systems

The question will undoubtedly be raised whether what we learn from ecosystems still makes sense when applied to other systems, such as economic or financial systems.

It is critical to understand that the findings described in natural ecosystems arise from the very *structure of a complex flow system*, and therefore that they remain valid for any complex flow network with a similar structure, regardless of what is being processed in the system: it can be biomass in an ecosystem, information in a biological system, electrons in an electrical power network, or money in an economic system. This is precisely one of the strong points of using a web-like network approach instead of machine-like metaphor.

The fields of engineering, business and economics have all been focusing almost exclusively on efficiency, and therefore constitute a wide-open field to explore the validity of the proposed metrics to improve sustainability. For example, electrical power grids have been systematically optimized for decades towards ever greater technical and economic efficiency. It has come as a surprise to many engineers that, as they have approached higher efficiencies, suddenly large-scale blackouts have been breaking out with a vengeance "out of nowhere". For instance, a few decades ago several blackouts hit large areas of the United States and Northern Germany. The data should be available to model these systems as flow networks, because that is what they literally are. One could then quantify their efficiency and resilience, and their Window of Viability. The solution on how to rebalance such a system to make it less brittle, and to determine its optimal sustainability, would be an obvious "hard science" test application of the concepts and metrics described here.

The point being made here is truly profound and has wide-reaching implications for all complex systems, natural or human-made. Placing too much emphasis on efficiency tends to automatically maximize flows, size and consolidation at the expense of choice, connectivity and resilience until the entire system becomes unstable and collapses.

Application to Financial and Monetary Systems

Applying the above complex flow framework to financial and monetary systems, we can predict that excessive focus on efficiency would tend to create exactly the kind of bubble economy which we have been able to observe repeatedly in every boom and bust cycle in history, including the biggest bust of them all, the one that we are experiencing today.

Viewing economies as flow systems ties directly into money's primary function as medium of exchange. In this view, money is to the real economy like biomass in an ecosystem: it is an essential vehicle for catalyzing processes, allocating resources, and generally allowing the exchange system to work as a synergetic whole. The connection to structure is immediately apparent. In economies, as in ecosystems and living organisms, the health of the whole depends heavily on the structure by which the catalyzing medium, in this case, money, circulates among businesses and individuals. Money must continue to circulate in sufficiency to all corners of the whole because poor circulation will strangle either the supply side or the demand side of the economy, or both.

Our global monetary system is itself an obvious flow network structure, in which monopolistic national currencies flow within each country (or group of countries in the case of the Euro), and interconnect on a global level. The technical justification for enforcing a monopoly of a single currency within each country is to optimize the efficiency of price formation and exchanges in national markets. Tight regulations are in place in every country to maintain these monopolies. Banking institutional regulations further ensure that banks tend to be carbon copies of each other both in terms of their structure and behaviour. This was demonstrated among the world's bigger banks, most recently and with a vengeance, with the simultaneous crisis in 2008.

Furthermore, in a seminal 1953 paper, Milton Friedman proposed that letting markets determine the value of each national currency would further improve the overall efficiency of the global monetary system (Friedman, 1953). This idea was actually implemented by President Nixon in 1971, to avoid a run on the dollar at that time. Since then, an extraordinarily efficient and sophisticated global communications infrastructure has been built to link and trade these national currencies. The trading volume in the foreign exchange markets reached an impressive $3.2 trillion *per day* in 2007, to which another daily $2.1 trillion of currency derivatives should be added (Bank of International Settlements, 2008). Over 95% of that trading volume is speculative, and less than 5% is in fact used for actual international trade of goods and services.

Speculation can play a positive role in any market: theory and practice show that it can improve market efficiency by increasing liquidity and depth[4] in the market. But current speculative levels are clearly out of balance. Although over half a century old, John Maynard Keynes' opinion has never been as appropriate as it is today. "Speculators may do no harm as bubbles on a steady stream of enterprise. But the position is serious when enterprise becomes the bubble on a whirlpool of speculation. When the capital development of a country becomes a by-product of the activities of a casino, the job is likely to be ill-done." (Keynes, 1936, p.159)

Nobody questions the efficiency of these huge markets; but their lack of resilience has also been amply demonstrated, for instance during the Asian crisis of the late 1990s, and dozens of other monetary crashes. In short, our global network of monopolistic national moneys has evolved into an overly efficient and dangerously brittle system. This system's lack of resilience shows up not in the technical field of the computer networks (which all have backups), but in the financial realm, as has been spectacularly demonstrated by the large number of monetary and banking crashes over the past thirty years. Such a crisis, particularly a combined monetary and banking crash, is - other than war - the worst thing that can happen to a country.

Even more ironically, whenever a banking crisis unfolds, governments invariably help the larger banks to absorb the smaller ones, under the logic that the efficiency of the system is thereby further increased. When a failing bank has proven to be "too big to fail", why not consider the option to break it up into smaller units that can be made to compete with each other? This was done in the US, for instance, with the break up of the Bell telephone monopoly into competing "Baby Bells". Instead, what tends to be done is to make banks that are "too big to fail" into still bigger ones, until they become "too big to bail". This whole process is illustrated in Figure 3.[5]

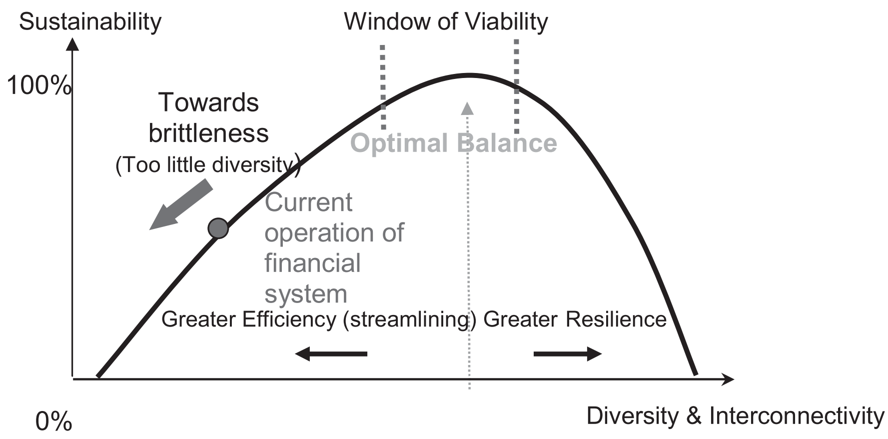

Figure 3. Today's global monetary ecosystem is significantly overshooting the optimal balance - the Window of Viability - because of its exclusive emphasis on efficiency. It is careening toward brittleness and collapse because a general belief prevails that all improvements need to go further in that the same direction (thick downward arrow) of increasing growth and efficiency. For instance, the global monoculture of bank-debt money as legal tender is technically justified on the basis of efficiency of price formation and exchanges within each country. Internationally, floating exchanges were also justified because they are "more efficient".

Similarly, the substance that circulates in our global economic network – money – is also maintained as a monopoly of a single type of currency – bank-debt money, created with interest. Imagine a planetary ecosystem where only one single type of plant or animal is tolerated and artificially maintained, and where any manifestation of diversity is eradicated as an inappropriate "competitor" because it would reduce the efficiency of the whole.

An overly efficient system as the one described in Figure 3 is "an accident waiting to happen", condemned to crash and collapse however many competent people dedicate time and heroic efforts to try to manage it. Graphically, this is illustrated in the next illustration (Figure 4).

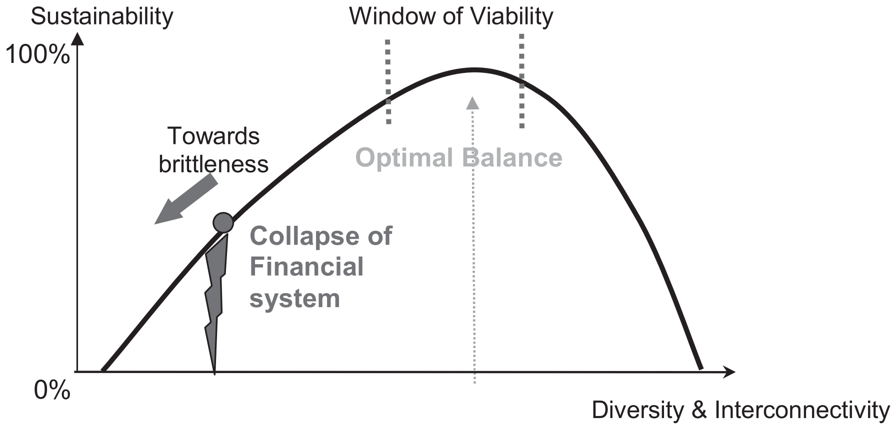

Figure 4. The dynamics of an artificially enforced monoculture of currencies and banks in a complex system where efficiency is the only criterion considered relevant. The only possible outcome is systemic financial collapse.

As stated earlier, nature has over billions of years selected the conditions under which complex ecosystems are sustainable, otherwise they wouldn't exist today. In contrast, humanity still struggles with the issue of how to create sustainable economies. We know that the theoretical framework applies to both natural and man-made complex systems. Has the time not come to learn in this domain from nature?

A Structural Monetary Solution

A full inventory of the options on how to deal with a systemic banking crisis has been explained in another paper (Lietaer, Ulanowicz & Goerner, 2009). Here we will focus only on the solution which aims at increasing structurally the resilience of the monetary system, even if at first sight that may be less efficient.

Conventional economic thinking assumes the *de facto* monopolies of national moneys as an unquestionable given. The logical lesson from nature is that systemic monetary sustainability requires a diversity of currency systems, so that multiple and more diverse agents and channels of monetary links and exchanges can emerge, as seen in Figure 5.

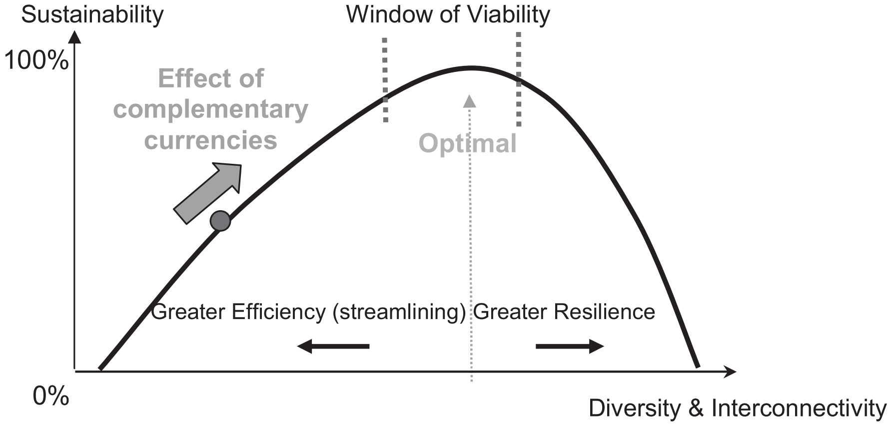

Figure 5. The Effect of Diverse Complementary Currencies
The operation of complementary currencies of diverse types enables the economy to flow back towards greater sustainability (thick upward arrow). While this process clearly reduces efficiency, that is the price to pay for increased resilience of the whole. Complementary currencies facilitate transactions that otherwise wouldn't occur, linking otherwise unused resources to unmet needs, and encouraging diversity and interconnections that otherwise wouldn't exist.

This is the practical lesson from nature: allow several *types* of currencies to circulate among people and businesses to facilitate their exchanges, through the implementation of complementary currencies. Let us start by defining a currency as whatever a community is accepting as medium of exchange. A complementary currency is therefore any standardized instrument, other than national money, that is actually used in exchanges. These different types of currencies are called "complementary" because they are designed to operate in parallel with, as complements to, conventional national moneys.

What is most surprising and interesting is that, below the radar beams of officialdom and most academics, there has been a spontaneous emergence over the past decades of precisely the kind of instruments that would be relevant to correct the problem of currency monopoly.

Notice that if the problem is the monopoly of one type of currency; replacing one monopoly with another isn't the solution. Monetary reforms which aim at substituting one monopoly by another would therefore be insufficient.

The very idea of allowing different types of currencies co-exist will certainly appear shockingly unorthodox to conventional monetary thinking, but in fact there are already hundreds of thousands. By far the most common are commercial complementary currencies, such as Airline Miles, or the many thousands of other loyalty currencies issued by companies, chains and individual shops at different scales around the world. They have demonstrated that people are willing to change behaviour (e.g. return to the same vendor) in order to obtain and use them. If that weren't true, businesses wouldn't continue to issue them.

However, the more interesting behaviour changes can be found in the so-called social purpose complementary currencies. They are much less common than the commercial loyalty systems, but they have grown in number to total several thousand in a dozen countries.

Just in the social domain, a wide variety of complementary currencies have become operational, as shown in the following graph. Such systems have been described extensively (Greco, 2003; Kent, 2005; Lietaer, 2001) and the *Journal of Community Currency Research* a specialized peer-reviewed journal has emerged to track academic research in this burgeoning field (see www.uea.ac.uk/env/ijccr/)

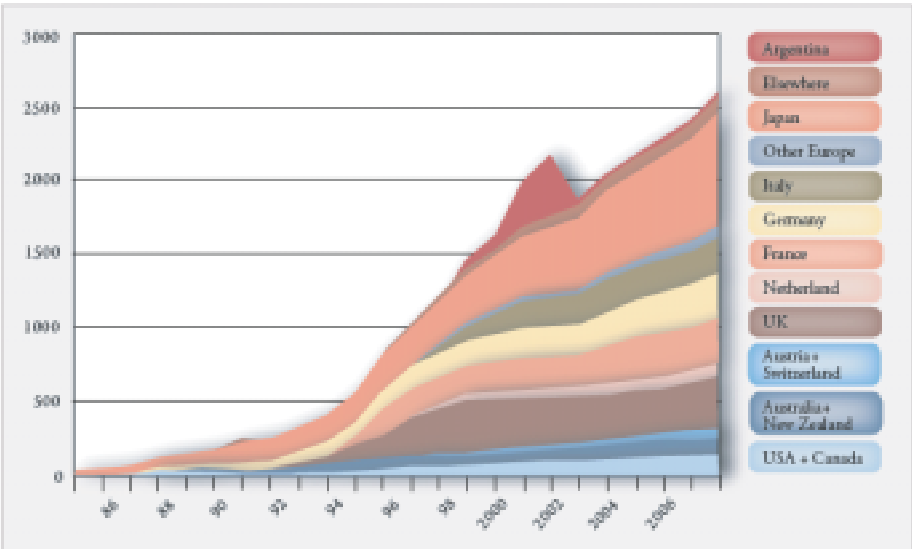

Figure 6. Number of Social Purpose Complementary Currencies Operational in a Dozen Countries (1984-2007).

These estimates are purposely very conservative. They include only systems that were operational during the corresponding year and whose existence was verified by one of the authors through the net or in personal contact. Many more systems exist that don't feel the need to advertise their existence.

All this research has documented that people have significantly different attitudes towards different types of currencies. Even more importantly, it has proven that behaviour change can be generated systematically when incentive schemes are designed involving specialized currencies circulating in parallel with the flow of conventional national money. Evidence has accumulated in dozens of countries that complementary currency systems can be designed, for instance, to successfully improve solidarity among neighbours; to support cooperation rather than competition in a community; to encourage inter-generational elderly care; or to induce a consumer life-style that reduces carbon emissions.

As Edgar Cahn's work in Time Dollars demonstrates, whenever complementary currencies begin flowing through a community, there is an increase in the degree of diversity and interconnectivity in the system. This is due to the ability of complementary currencies to catalyze business processes and individual efforts that are too small or inefficient to compete for national currencies in a global market place (Cahn, 2004).

In short, both in the commercial and the social domains, the monopoly of conventional money as medium of exchange has already technically died without most people taking notice. But most of this has been happening on too marginal a scale to make policy makers aware of the potential of such tools to address the huge breakdowns that we know we will have to face in the 21st century.

Most of those systems are too small and/or too recent for us to be able to empirically measure their macro-economic impact. One important exception is the WIR, which has been operational since 1934, involves today about 70,000 Swiss businesses, and has an annual volume of over US$2 billion (Studer, 1998). Because of its 75 year history and the quality of the data gathered over this time, the stabilization effect of this system on the mainstream economy has been able to be proven quantitatively (Stodder, 1998, 2000 & 2009). Exactly as our theoretical framework would forecast, the Stodder studies empirically demonstrate that the WIR system spontaneously behaves counter-cyclically with the mainstream economy, and thereby helps rather than hinders the efforts of the central bank to stabilize the economy. However, both conventional monetary theory and central banking practice still consider such "unorthodox" commercial currency systems as either irrelevant as long as they remain small; or as a nuisance that could perturb monetary policy if they were to grow to any significant size (Rösl, 2006).

Application to Economic Theory

The issue of diversity matters not only in types of money, but also in economic agents. Too little diversity, or too much, can precipitate instability. For example, a town that has but one very large employer will find it harder to adapt if that company goes under, than a town with several medium size employers and many more small ones.

Theoretical ecology has shown us that the dynamic balance between an efficient (streamlined, compact) network and a resilient network (looser, more diverse, with redundant pathways) provides a measure of sustainability for any complex flow system. It provides a single metric of overall system health, which reflects how efficiently the network circulates materials and energy throughout the system, while simultaneously staying resilient enough to survive normal vicissitudes and flexible enough to adapt, develop and evolve. More efficient performance implies less latent potential, and a rather fixed structure with little scope to innovate and adapt when challenged by novel disturbances. At the other extreme, a system with too much slack and diversity may possess ample buffers, but lack the coherence and purpose to grow. Somewhere in between these extremes lies healthy sustainable development.

Current economic theory fails to differentiate healthy development from cancerous growth. Policies that promote positive-feedback growth in an economy may result in a wealth-concentrating vortex that breeds brittleness and bubbles in the same process.

The most recent banking/financial crisis shows how this works in practice. It was initially precipitated by the mortgage derivative bubble, the latest of many bubbles in a supersaturated, force-fed economy. Deregulated bankers in search of new sources of income, stockbrokers in search of hot new products to sell, and big financial investors in search of higher gains, formed a self-amplifying circuit in which gains in any segment naturally fed gains in the others. This autocatalytic loop grew rapidly by pulling in resources from the broader economic network and concentrating wealth in the hub. The result in the major economies was that, during the two decades leading up to the crash of 2008, profits in the financial sector roughly doubled as a percent of total corporate profits. It also evolved ever more efficient (if dangerous) "pull" techniques and a kind of rigid group-think that dismissed traditional risk assessments precisely because selection pressures were intense, with those who increased gains being lavishly rewarded, and those who didn't being out of a job. While the derivative bubble triggered the crisis, the erosion of other sectors created an underlying brittleness (from debt burden, for instance) that made the broader economy susceptible along with the epicentre banking/financial circuit as well (Goerner, Bernard, & Ulanowicz, 2009).

Hence the mantra of forever increasing efficiency has become misguided and counterproductive. The quest for greater economic efficiency, for example by downsizing or by "just in time" deliveries or other ways to continually increase the efficiency of value chains, has reduced the stability of the overall economic system. This phenomenon of autocatalysis can also precipitate system collapse through implosion. Examples are the dot .com bubble and the hollowing-out of small town high streets and urban neighbourhoods by "big-box" retailers (Goerner *et al*., 2009).

The message is we must rebalance. We now have scientific proof of why a single-minded push for greater efficiency will predictably generate systemic inflexibility to the point of brittleness and failure. Equally, policies that only tweak at the edges of a senescent system do not address the structural flaws of the current system. We must understand, cultivate and nurture the complex and adaptive components of our economic system.

Complementary Currencies for Meeting the Challenges of the 21st Century

The end of the Industrial Era is coinciding with a convergence of unprecedented challenges. Global issues such as climate change, energy and resource supply squeezes, rising underemployment and a rapidly aging population come to mind. The expectation with the dawning of an Information Age is that just about everything will change in our society, but with one critical exception; that is, we are supposed to meet those challenges with the monetary tools that were designed several centuries ago: a monopoly of bank-debt money.

We could provide many examples to give a sense of what the future could hold with a new, diversified monetary structure. To just take one, there is now almost universal consensus that we will need to massively shift to a lower carbon economy worldwide. The favoured instrument to achieve this is a market in carbon emission rights (traded in US$ or Euros). This is an indirect, hence a somewhat blunt and unreliable means, to achieve this aim. Specialized complementary currencies can function more directly and in a fully guaranteed way. For example, a UK proposal uses a complementary currency called a Tradable Energy Quota (TEQs). A given quantity of TEQs is created, corresponding to the maximum emissions for that year and country, or region. When an individual, business or government entity buys energy, such as petrol for your car or electricity for a business, payments occur in two currencies: the cost in conventional money (as today) and a quantity of TEQs corresponding to the corresponding carbon content. Those who spend more than their quota have to obtain other people's surplus TEQs through an electronic auction system. Such dual currency payments would be completely electronic and automatic, typically using direct-debit technology (see details on www.teqs.net).

A completely different complementary currency approach is a voluntary citizen-based experiment in the Netherlands with a carbon-reducing complementary currency. It can be seen as a loyalty currency for rewarding green behaviour. Credits are earned when a carbon-reducing activity is performed by a consumer (e.g. investing in solar panels). These credits can then be spent to purchase other carbon-reducing services or products (e.g. paying for public transport), thereby creating an economy with a virtuous loop of carbon reductions (see details in www.nu-kaart.nl). If a city, region or national government wanted to make such behaviour compulsory, it could raise a tax payable in such a currency. This is, after all, the mechanism by which the demand for conventional bank-debt money is made compulsory by governments (Wray, 1998).

Conclusions

Ironically, our financial system is so fragile because it has become too efficient. Our modern monetary system is based on a monoculture of a single type of money (all our national currencies have in common to be generated as bank-debt money). This monoculture is legally imposed in the name of market efficiency. Furthermore, governments enforce this monopoly by requiring that all taxes be paid exclusively in this particular type of currency.

Unlike natural systems ("you cannot negotiate with a living cell..."), economic systems are completely manageable because we built them. But "manageable changes" like new regulations, or changed personnel at the top of our financial institutions, will at best only reduce the frequency of the crashes, not eliminate them. This doesn't mean that managerial changes are not justified, useful and necessary; but we claim that whatever is done at that level will, in the end, reveal itself to be insufficient. This is *not* a management problem, it's a *structural* problem.

So the good news is that the repeated financial and monetary crises are avoidable. However, that will happen if, and only if, we are willing to revisit the structure of our money system. Specifically, different types of currencies issued by different types of institutions would provide the diversity and the higher interconnectivity that a resilient financial system would require.

The most valuable role for government in implementing our proposed approach could limit itself to specifying the kind of currency other than conventional bank-debt national money it would accept in payment of fees and taxes. Interestingly, Uruguay has been the first country to follow precisely such a strategy by accepting an electronic business-to-business generated currency called C3 (for Commercial Credit Circuit) for all payments of fees and taxes, in addition to the conventional national money. Their reason: it is a very effective way to increase employment through the small and medium-sized enterprises (which represent over 90% of private employment in that country), because it provides working capital to the participating businesses without costing anything to the government. A bank plays the role of converting the C3 units into national currency when requested, at a cost borne by the participating business making that request (see details on www.lietaer.com).

So why is such an approach not generalized? It may still be too new for the worldwide institutional framework – including global organizations such as the IMF and the World Bank, and each country's central bank – that has as crucial mandate to ensure the stability of the monetary and financial environment. Monetary orthodoxy continues to prevail: achieving the objective of monetary stability requires the safeguarding of the monopoly of the existing money creation process. This orthodoxy is part of the powerful auto-catalytic forces that engender and protect banks that become "too big to fail". As a consequence, some of the remedies that are now being applied are actually worsening the structural problem.

What governments learned in the 1930s is that they can't let the banking system sink, without risking a collapse of the entire economy. Unfortunately, governments may learn in the on-going crisis that they can't afford to save the banking system.

Financial regulators and policy makers, on their side, are in the uncomfortable role of trying to control the defective car sent over a mountain range described as a metaphor at the beginning of this paper. Alan Greenspan, former governor of the Federal Reserve, now admits that "the world will suffer another financial crisis" but blames "human nature" for this state of affairs[6]. The problem with this interpretation is that changing human nature isn't a very realistic basis for attaining global financial stability any time soon.

If this crisis is structural, as we have argued, then only a structural solution will actually achieve the regulators' aim. At this point, however, the prevailing orthodox idea that we need to enforce a monopoly of a single national currency, one in each country or group of countries, remains firmly in place, despite the massive systemic collapse in 2008. Let us please remember that it is orthodoxy that got us into this trouble...

Maybe, after all, it is part of human nature to refuse to learn from nature in the monetary domain? The trillion dollar question becomes therefore: how many more banking and monetary crashes do we have to live through before we have the humility to learn from nature in this domain?

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Notes

1. We will abbreviate this variable simply as efficiency. The original ecological literature refers to this variable as "ascendency".
2. Mathematically $n = 2^{A}$ and $c = 2^{\Phi/2}$
3. The zone of viability is defined on one axis by a measure of path length of between 2 and 5 nodes (with optimum performance at around 3) and on the other by a node/link density of between 1 and 3. The geometric center of the window (n = 3.25 and c = 1.25) suggests the best possible configuration for sustainability under the information currently available. In essence, this says that systems can be either strongly connected across a few links or weakly connected across many links, but configurations of strong connections across many links and weak connections across a few links tend to break up or fall apart, respectively (Zorach & Ulanowicz, 2003).
4. "Liquidity" and "Depth" of a financial market refers to the possibility of moving large volumes of money without significantly affecting prices. In a deep market, a lot of people are buying and selling. By contrast, in a thin market, because fewer people are trading, even one single large transaction could significantly affect prices.

5. We have not yet been able to formally quantify the window of viability of the global monetary system, although such an exercise would be achievable if the data about global flows by currency and institution are available. However, we are clearly dealing with a monoculture of bank-debt money worldwide. A monoculture is by definition lacking the diversity of any natural ecosystem, and pushes us away from the resilience pole. The institutional pressure on efficiency further pushes in the same direction.
6. Interview of September 8, 2009 on BBC2 http://news.bbc.co.uk/2/hi/8244600.stm

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