Why an Economy needs more than one Currency: the Scientific Evidence

Bernard Lietaer

Abstract - The paradigm of a single currency per country which has been prevailing in the entire field of economics for centuries needs to be challenged if we want to achieve a more resilient economic system. This finding is based on the recent discovery of a general law that determines the structural conditions of stability of any complex flow network. This law applies equally to all natural ecosystems because they are complex flow networks in which biomass circulates; and to economies because they are complex flow networks in which money circulates. Graphics provide illustrations to this argument.

Keywords - resilience vs efficiency, monetary ecosystems, complementary currencies

I. INTRODUCTION

A complementary currency is any standardized medium of exchange used in an economy other than the official legal tender. Examples include commercial loyalty currencies such as airline miles; local and regional currencies of which several thousands small-scale systems have emerged in many countries around the world such as Time Banks or Local exchange trading systems (LETS); and Business-to-Business systems such as the WIR in Switzerland. Conventional economists tend to regard all such complementary currencies as an anomaly, to be dismissed as an irrelevant or romantic distraction. Regulators tolerate them, as long as they remain marginal. If ever any were to grow to a relevant size, they believe such monetary innovations should be suppressed because of concerns that they might disturb monetary policy or reduce economic efficiency (Rösl, 2006).

A recent scientific breakthrough provides the evidence that a systemic cause for the prevailing monetary and financial instability happens to be the monopoly of one single type of currency. In fact, it will be shown that, far from being a disturbance, a minimum variety of monetary media is a *necessary condition* for sustainable economic and financial stability in a society. Furthermore, this isn't a conclusion based on some personal preferences or opinions, but is backed by a law that is as universal as gravity!

Indeed, there exists a structural flaw in our Modern monetary system, a flaw that has been with us for centuries. Actually, it was already "doing its thing" when the Dutch tulip bubble burst in 1637, and it played an unacknowledged role in every crash since that time, including the one whose fallout we are still experiencing now! The proof for this claim comes from a fundamental law that governs all complex flow systems, including all natural ecosystems, as well as economic and financial systems. It is based on a recent theoretical breakthrough which makes it possible to measure quantitatively with a single metric the sustainability of any complex flow system as an emergent property of its structural diversity and interconnectivity. Furthermore, it is revealed that whenever diversity in a complex flow network is being sacrificed because of too much emphasis on efficiency, structural collapses are a totally predictable consequence.

From this perspective, it is obvious that we have been living worldwide with a monoculture of the same type of media of exchange, in the form of a single national currency monopoly in each country, created everywhere through bank-debt. Both the Marxist and the various capitalist schools of economic thought have been blind to this issue: they all presuppose as self-evident a monopoly of a single national currency. The main difference in this respect between communism of the Marxist-Leninist variety on the one side, and capitalism on the other, was that in the former governments were the owners of the banks all the time, while in the capitalist system this is the case only for banks that have dramatically failed. But the money system itself is in fact the same: a single national currency created through bank-debt…The structural solution to economic and financial sustainability becomes also clear: we need to diversify the types of currencies available in a society and the types of agents that are creating them, specifically through complementary currencies.

II. SUSTAINABILITY OF COMPLEX FLOW SYSTEMS

For those desiring a fully documented step by step mathematical evidence of what is being claimed here, please refer to the seminal paper (Ulanowicz, Goerner, Lietaer and Gomez, 2009).[i] Only the most relevant points can be summarized here.

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

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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 has two components: order and the absence of order. The first component, called "mutual constraint", quantifies all that is regular, orderly, coherent and efficient. It encompasses basically all the concerns of conventional science. This first component is an analogue of Newton's Third Law of motion, or of the *Yang* construct familiar in Chinese philosophy.[ii] By contrast, the second component represents the lack of those same attributes, or the irregular, disorderly, incoherent and potentially inefficient 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. It corresponds to the Chinese *Yin.*

In the jargon of IT, this second, usually 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 a changing environment, or survive unexpected challenges. It will be shown next why this absence of order happens to be even more significant than the first variable, order, if we are to understand sustainability.

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 or energy resource. Rather, it is a characteristic of the system structure that reflects its flexibility both to survive change and to adapt to new circumstances – and it usually requires some loss of efficient performance (Ulanowicz, 2009, 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.

Let us now define more precisely our terminology:

- *Efficiency* is defined as the capacity of a complex flow network to process volume of whatever flows through it, per unit of time (e.g. grams of biomass per square meter per year for a natural ecosystem; GNP per capita in an economy; billions of dollars per day in an electronic payment system; or KWh in an electrical distribution network).
- *Resilience* is the capacity of a complex flow network to survive an attack, a disease, or adapt to a change in the environment.

So crucially, efficiency is definitely not a sufficient metric for sustainability. This confirms the often repeated point that GNP/capita is not sufficient to assess economic sustainability. Indeed, this metric cannot distinguish between a healthy sustainable growth and a short-term bubble doomed to collapse. For a complex flow system to be sustainable, it is also necessary that it possesses enough resilience, an undefined and contingent responsiveness to the unpredictable challenges thrown up by its own workings or its environment. It is thanks to this feature that a resilient flow network of any kind can withstand shocks and adapt itself when necessary.

In summary, natural ecosystems exist because they have *both* sufficient self-directed identity *and* flexibility to change. 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 exist today. They are our best living examples of large scale and long-term sustainability in action.

Furthermore, it has been shown that the driving force behind this evolution happens to be entropy, which is generally accepted as the most universal law in our universe. It is even more fundamental than gravity, given that modern thermodynamics have proven that gravity is one of its consequences! (Dewar, 2003) (Chaison, 2003) (Roddier, 2012)

III. EMPIRICAL ECOLOGICAL EVIDENCE

The key observation is that nature does not select for maximum efficiency, but for a balance between these 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 structural instability. Too much efficiency (excess Yang) leads to brittleness and too much resilience (excess Yin) 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 were now able to define and precisely quantify a complex system's sustainability in a single metric. However, the object of our interest involves in reality four dimensions, and is therefore hard to visualize mentally or graphically.

The following 3 dimensional graphic analysis provides an insight into the shape of this 4 dimensional object.[iii]

The vertical axis represents the sustainability F of a complex flow network. The two horizontal axes are respectively the interconnectivity and the diversity of the same complex network. In natural ecosystems the weight on efficiency has empirically been determined from a regression analysis using actual data from a wide variety of ecosystems to have a value of beta = 1.288. Fig. 1 illustrates the conditions where natural

ecosystems seen as complex flow networks are the most sustainable (color yellow).
What the graph shows is that a natural ecosystem will tend to evolve towards sustainability preferably by increasing diversity, and secondarily through increasing interconnectivity. For instance, a forest will tend to become more sustainable by multiplying the diversity of fauna and flora that can survive in the environmental conditions of the area. To a lesser extent will it encourage animals to feed on other plants and prey than what they had evolved to feed from in their specific ecological niche (e.g. by having rabbits become carnivores, or pandas learn to eat something else than their usual specific type of bamboo).

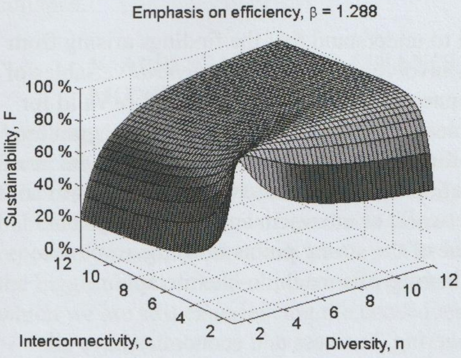

Fig. 1 : Sustainability as a function of diversity and interconnectivity in natural ecosystems (with beta = 1.288 determined empirically). The shape of the highest sustainability zones (colored in yellow) shows that a natural ecosystem will tend to evolve towards sustainability primarily by increasing diversity, and secondarily through increasing interconnectivity.

In many of our human designed systems, there is a tendency to over-emphasize growth of volume, at the expense of resilience. In short, to emphasize efficiency more than resilience. As we saw earlier, the key technical argument from conventional economists against multiple currencies is that it would decrease efficiency.

One consequence is the unleashing of autocatalytic forces that the theory warns can be problematic for the sustainability of the whole network. In an economy, that takes the form for instance of the larger economic actors that succeed through lobbying to obtain laws and rules that favor their growth at the expense of the smaller ones. In the financial domain, it takes the form of banks that become "too big to fail", and thereby obtain implicit guarantees from governments that they will be bailed out in case of trouble.

Fig. 2 shows what tends to happen when such a bias towards efficiency is introduced. The sustainability is dramatically reduced. Only a narrow zone, requiring a lot of diversity remains sustainable. However, in the monetary domain, as long as we remain stuck with the idea of a single national currency, this diversity is systematically eliminated. Such a system will predictably collapse, and if it is restored to "normal" will collapse again and again.

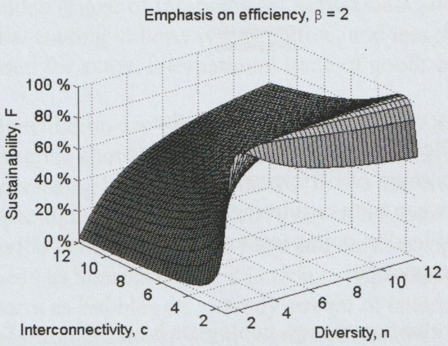

Fig. 2 Reduction of sustainability when efficiency is overemphasized (beta = 2). Sustainability is reduced to a narrow band requiring a lot of diversity.

When this bias towards favoring efficiency is pushed still further, the collapse of interconnectivity and sustainability gets still more accentuated, as illustrated in Fig. 3. In other words, the more the bias towards efficiency prevails, the quicker the system will collapse.

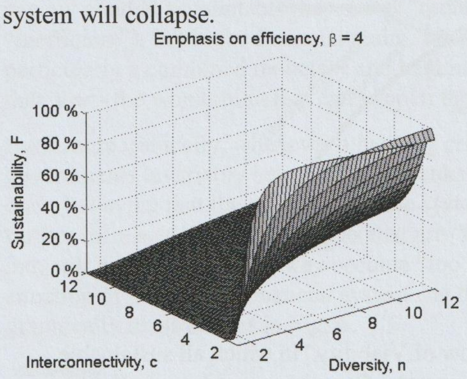

Fig. 3 When overemphasis on efficiency is pushed still further (beta = 4), a complex flow network becomes a totally unsustainable system.

Fig. 4 is a two dimensional graph of Sustainability as a function of Efficiency and Resilience in complex flow networks.

Observe that there is an asymmetry: in natural ecosystems optimality requires more resilience than efficiency! (The optimal point lies closer to resilience than efficiency on the horizontal axis).

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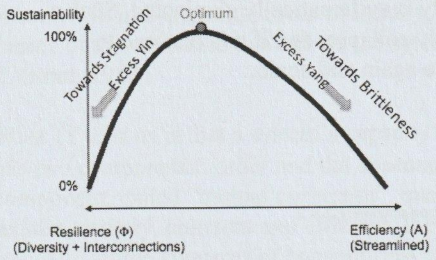

Fig. 4: Sustainability curve mapped between the two polarities of Efficiency and Resilience. Nature selects not for a maximum of Efficiency, but for an optimal balance between both requirements. Too much efficiency will lead to collapses, too much resilience leads to stagnation.

Moving beyond information theory, ecologists have empirically measured the transfer of biomass and energy ("trophic exchanges") within ecosystems. They 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 the two structural variables: diversity and interconnectivity. 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" (in ecological literature the "window of vitality").
(See Fig. 5).

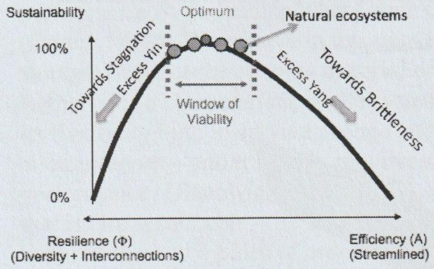

Fig. 5: The "Window of Viability" in which all sustainable natural ecosystems operate. Complex natural ecosystems invariably operate within a specific range on each side of the Optimum point.

IV. APPLICATION TO OTHER COMPLEX FLOW SYSTEMS

The question will undoubtedly be raised whether what we learn from ecosystems still is relevant when applied to other complex flow systems, such as economic or financial systems. This question is typically the result of the interpretation that natural ecosystems are used here as a metaphor for economies.

We can't emphasize enough that the relevant link is *not* a metaphor! Instead, what applies is a specific universal law that happens to apply to the structure of *all* complex flow network systems, independently of the nature of what flows in the network. Just as Newton's discovery was that the same law of gravity applies to both the moon and an apple falling in his garden! In our particular case, this is even literally true, because the driving force behind our theoretical framework is entropy, which happens to be at the origin of gravity itself. In other words, we were conservative at the beginning of this paper when stating that the law backing our claims is as fundamental as gravity. It is in fact even more fundamental than gravity!

It is indeed critical to understand that the findings arising from natural ecosystems involve only the two *structural* variables of variety and interconnectivity. They remain therefore valid for any complex flow network with the same structure, regardless of what is flowing through the network. It can be biomass in an ecosystem, information in a biological system, electrons in an electrical power network, or money in an economic system. [iv] This is precisely one of the strong points of using a web-like network approach instead of a 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 had 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. In contrast, conventional engineering, economics and finance assumes invariably assumes that more efficiency is always better!

Until this finding, 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. Total System

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Throughput (TST) measures size in this way for ecosystems, exactly as Gross Domestic Product (GDP) does in economies . Many economists urge endless growth in size (GDP) because they assume that growth in size is a sufficient measure of health. TST and GDP, however, are both poor measures of sustainability because *they ignore network structure*. They cannot, for example, distinguish between a healthily thriving resilient economy; and a bubble that is doomed to burst. Or between healthy "development," as Herman Daly (1997) describes it, and 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.

V. APPLICATION TO FINANCIAL AND MONETARY SYSTEMS

Applying the above complex flow framework specifically to financial and monetary systems, we can predict that excessive focus on efficiency will 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 triggered in 2007-8 from which we are still experiencing the consequences today.

If we view economies as flow systems, this ties directly into money's primary function as medium of exchange. In this view, money is playing in the real economy the identical role of 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 regulations further ensure that banks tend to be institutional 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 crash of 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 August 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 $5.3 trillion *per day* in 2013, to which trillions of currency derivatives should be added (Bank of International Settlements, 2013). 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[v] 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)

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 therefore dangerously brittle system. This system's lack of resilience shows up not in the technical field of the computer networks (which all have backups which too narrow minded accountants may see as "redundant" or "inefficient"), but in the financial realm. 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 smaller ones, believing that the efficiency of the system is thereby further increased. This make banks that are "too big to fail" into still bigger ones, until they become "too big to bail". This situation of the current financial system can therefore be graphically illustrated as in Fig. 6.

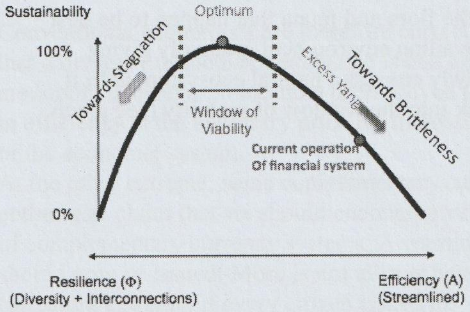

Fig. 6: Today's global monetary ecosystem is significantly overshooting the Window of Viability because of its exclusive emphasis on efficiency. It is careening toward brittleness and

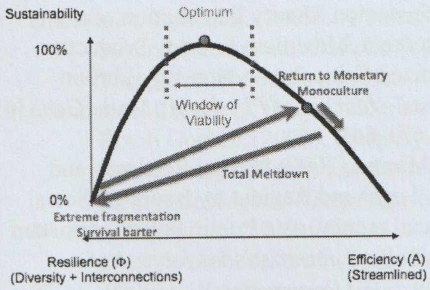

Fig. 8: Under the pressure of the monetary orthodoxy and powerful lobbies, the monopoly of bank-debt money as medium of exchange is re-established after a meltdown. This brings the system back to the situation described in Fig. 6. The autocatalytic pressures in such a monoculture will tend to gradually push the system towards more excessive efficiency and therefore its next crisis. As soon as memories of the previous one has started to fade…
Of course, in natural ecosystems, such a systematic, repetitive and artificial human intervention isn't taking place, and natural systems follow normally the dynamic of the green arrow in Fig. 7.

Fortunately, most crises are less extreme than total financial and monetary meltdowns. However, the exercise of exploring "pure" extremes gives some ideas of the power and nature of the dynamics that are involved. Less extreme crises simply manifest only some of the features of the process. Just like a partial forest fire, one that doesn't reduce everything to ashes, manifests only some of the attributes of a total burnout.

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 same theoretical framework applies to both natural and man-made complex systems...

We have been going through this loop many times by now. To be precise, according to IMF data, between 1970 and 2010, there have been no less than 145 countries experiencing a banking crises, 208 monetary crashes and 72 sovereign debt crises: a staggering total of 425 systemic crises, an average of more than ten per year! (Capri & Klingebiel,1996; Laevan & Valencia, 2010). The Greek crisis increases the number of sovereign debt crisis from 72 to 73…
How many more crises do we want to undergo? Lots of countries in Europe are now candidates for being considered "overendebted"…

These crises have hit more than three-quarters of the 180 countries that are members of the IMF, many of them several times. How many more crises do we need before humanity is willing to learn that this is a structural issue, and that only structural changes will avoid repeating the same patterns?

It may be useful to remember during the next monetary or financial crisis that Albert Einstein defined insanity as doing the same thing over and over again and expecting different result…

VI. A STRUCTURAL MONETARY SOLUTION

Conventional economic thinking assumes the *de facto* monopolies of national moneys as an unquestionable given. In contrast, the clear lesson from nature is that systemic monetary sustainability requires a diversity of currency systems, so that multiple and more diverse agents and channels can emerge for a richer range of exchanges to emerge.

It is important to realize that another way than waiting for a total meltdown is available now to get back towards the window of vitality. That other way is to let complementary currency system grow, or even encourage the soundest of them to blossom, and gradually and gently push back the excesses of the monoculture, as seen in Fig. 9. There is an complementary currency movement slowly gathering steam which should be encouraged as it is a gradual way to bring our economy into more stability.

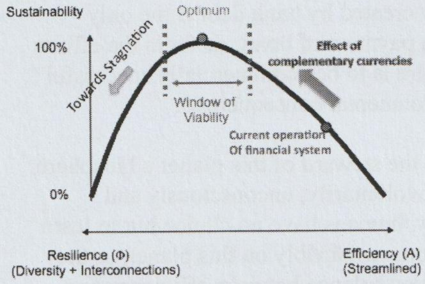

Fig. 9: The Effect of Complementary Currencies

The operation of complementary currencies of diverse types enables the economy to flow back towards greater sustainability (thick upward green arrow). While it is true that this 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.

Conventional economists are therefore correct when they claim that a diversity of media of exchange is less *efficient* than a monopoly. However, it has now been proven that such a drop in efficiency is the necessary price for increasing the *resilience* of the economic system.
At the other extreme, some complementary currency enthusiasts claim that we should encourage very large numbers of complementary currency systems. A warning can and should now be issued: More is not always better…At a caricature extreme, if every citizen issued his or her currency, the result would predictably be total stagnation!

Furthermore, we now have also empirical proof from 75 years of data from the WIR system in Switzerland that business-to-

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business complementary currencies actually help central banks in their task of stabilizing the national economy in terms of employment and in smoothing the swings in the business cycle (Stodder, 1998, 2008, 2010). In a period when unemployment, poverty and economic exclusion are all increasing in the developed world, it would be important that central banks revisit this issue with a more open mind than has been the case so far...

VII. CONCLUSION

A monetary monoculture has been legally imposed for centuries in the name of market efficiency. Furthermore, governments everywhere enforce this monopoly most importantly by requiring that all taxes be paid exclusively with conventional bank-debt money.

It is important to understand that the only real power and leverage that governments have in the monetary domain is the capacity to specify the kind of currency or currencies it accepts in payment of fees and taxes. This is critically important because the choice of that currency also dictates the kind of efforts that governments require from businesses and citizens. If conventional money created by bank debt is the only currency acceptable in payment of taxes, de facto the efforts that governments require is to be "commercially successful" regardless of the environmental consequences.

Humanity has become the steward of this planet's biosphere. This has become so, involuntarily, unconsciously and reluctantly. Ultimately, humans have no choice but to learn how to learn to live more sustainably on this planet, or they will cease to exist. A new balance between efficiency and resilience is needed to attain that. Nature has shown us how this can be achieved. Why not listen?

REFERENCES

Bank of International Settlements (BIS) (2010) Stephen G. Cecchetti, Madhusudan S. Mohanty and Fabrizio Zampolli, *The Future of Public Debt: Prospects and Implications*

Bank of International Settlements (BIS). (2013) *Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity 2013*

Caprio, Gerard Jr, and Daniela Klingebiel. (1996). *Bank Insolvencies: Cross Country Experience* Policy Research Working Papers No.1620. Washington, DC, World Bank, Policy and Research Department.

Chaisson, Eric "Non-equilibrium Thermodynamics in an Energy-Rich Universe", in A. Kleidon and R.D. Lorenz (eds), *Non-Equilibrium Thermodynamics and the Production of Entropy: Life, Earth, and Beyond* (Berlin/ New York: Springer, 2005), pp. 21-33.

Conrad, Michael. (1983). *Adaptability: The Significance of Variability from Molecule to Ecosystem.* New York, Plenum Press.

Daly, Herman. E. (1997). *Beyond Growth: The Economics of Sustainable Development.* Boston, Beacon

Dewar, Roderick "Information Theory Explanation of the Fluctuation Theorem, Maximum Entropy Production and Self-Organized Criticality in Non-Equilibrium Stationary States", *Journal of Physics A: Math. Gen. 36 #3* (2003), pp. 631-641.

Freire Vasconcellos, Marusa (2009) "Social Economy and Central Banks: Legal and Regulatory Issues on Social Currencies (social money) as a Public Policy consistant with Monetary Policy" *International Journal of Community Currency Research* Vol 13 (2009) pp.76 – 94

Friedman, Milton (1953). "The Case for Flexible Exchange Rates". In *Essays in Positive Economics* (pp.157-203). Chicago: University of Chicago Press.

Goerner, Sally J., Bernard Lietaer, and Robert E. Ulanowicz. (2009). Quantifying Economic Sustainability: Implications for free enterprise theory, policy and practice. *Ecological Economics*, 69(1), 76-81.

IMF (2012) Jaromir Benes and Michael Kumhof *The Chicago Plan Revisited* (IMF Working paper 12/202 (August 2012).

Keynes, John Maynard. (1936). *The General Theory of Employment, Interest and Money* London: Macmillan. P. 159.

Laevan, Luc and Valencia, Fabian, 2010, Resolution of Banking Crises: The Good, the Bad, and the Ugly, IMF Working Paper 10/146 (Washington: International Monetary Fund).

Lietaer, Bernard, Robert E.Ulanowicz, and Sally J.Goerner. (2009). Options for Managing a Systemic Bank Crisis. *Sapiens*, 2 (1). Available online at http://sapiens.revues.org/index747.html

Odum, Eugene. P. (1953). *Fundamentals of Ecology.* Philadelphia: Saunders.

Roddier, Francois *Thermodynamique de l'Evolution: un Essai de Thermo-bio-sociologie* (Editions Parole, 2012)

Rösl, Gerhard. (2006) *Regional Currencies in Germany: Local Competition for the Euro?*. Discussion Paper, Series 1: Economic Studies, No 43/2006, Deutsche Bundesbank Eurosystem. Available for download at http://www.bundesbank.de/download/volkswirtschaft/dkp/2006/200643dkp_en.pdf

Stodder, James. (1998). Corporate Barter and Economic Stabilization. *International Journal of Community Currency Research*, 2.

Stodder, James. (2000). "Reciprocal Exchange Networks: Implications for Macroeconomic Stability". *Conference Proceedings, International Electronic and Electrical Engineering (IEEE)*, Engineering Management Society (EMS), Albuquerque, New Mexico. An updated version (2005) is available at http://www.rh.edu/~stodder/Stodder_WIR3.htm

Stodder, James. (2009). Complementary Credit Networks and Macro-Economic Stability: Switzerland's *Wirtschaftsring. Journal of Economic Behavior and Organization*, 72, 79–95. Available for download at http://www.rh.edu/~stodder/BE/WIR_Update.pdf

Ulanowicz, Robert E. (2009). A Third Window: Natural Life beyond Newton and Darwin. West Conshohocken, PA: Templeton Foundation Press.

Ulanowicz, Robert.E., Sally J. Goerner, Bernard Lietaer, and Rocio Gomez. (2009). Quantifying sustainability: Resilience, efficiency and the return of information theory. *Ecological Complexity* 6(1):27-36.

Werner, Richard A. (2012) *How to end the European crisis – at no further cost and without the need for political changes.* Southampton, GB, University of Southampton, 12pp. (Centre for Banking, Finance and Sustainable Development Policy Discussion Paper, 2-12).

Werner, Richard A. (2014) Enhanced Debt Management: solving the eurozone crisis by linking debt management with fiscal and monetary policy. *Journal of International Money and Finance*, 1-27. (doi:10.1016/j.jimonfin.2014.06.007).

NOTES

[ii] Available for download on https://www.researchgate.net/publication/222401950_Quantifying_sustainability_Resilience_efficiency_and_the_return_of_information_theory

[ii] What we have defined here as "Efficiency" is a quantitative measure of Yang; and "Resilience" is a quantitative measure of Yin. As far as we know, this is the first time that Western science is proving the validity of the Chinese insight about the need for a balance between Yin-Yang polarities. The origin of this insight has been traced back to prehistoric Siberian shamanism, and was fully developed by Lao Tse in the 5th century BC. If we are using this Yin-Yang vocabulary, at the risk of appearing exotic, it is simply because we don't have any equivalent words in any of our Western languages.

[iii] The 4 dimensions are identified in the graphs as respectively: sustainability (F) , diversity (n), interconnectivity (c) and relative emphasis on efficiency (beta). These 3D graphs were graciously provided by Maria-Lovisa Amundadotir

[iv] The type of dynamics are indeed universal for any complex flow network. However, it is possible that the parameters of the window of viability may be different depending on what flows in the system. If we could have access to real-life data, these parameters would be able to be determined empirically. The necessary data exist in both electrical distribution systems and in the banking system. Because of their competitive relevance, we have not been able to obtain such data. We would be happy to collaborate with anybody who has access to such information...

[v] "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 sufficiently large transaction could significantly affect prices.

collapse because a general belief prevails that all improvements need to go further in that the direction of increasing growth and efficiency (red downward arrow on the right). 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". This is part and parcel of how we are building up an "Excess Yang" unbalance.

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 successful diversity is eradicated as an inappropriate "competitor" because it would reduce the efficiency of the whole.

Such an overly efficient system - as described in Fig. 6 - is "an accident waiting to happen". It is condemned to a sudden crash and collapse whatever heroic efforts will be made even by competent people who try to manage it. What happens after a collapse? Let us take as example the most extreme cases of total systemic meltdown. For instance: an atomic bomb burns a forest down to ashes; or a complete meltdown of a financial system.
As examples in the monetary domain, total collapses happened in Germany in the 1920s, in the United States during the "bank holidays" of the Great Depression, in Russia in the 1990s and in Argentina in 1999-2002. All these cases have in common to be simultaneous monetary and banking crisis. A dollar or a Euro crisis could again make this phenomenon part of our near future.

The process of a collapse shows up graphically with a drop of sustainability to close to 0%. (see Fig. 7) and an extreme fragmentation, without any efficiency at all. In a forest, this takes the form of seedlings of any type trying to sprout randomly. This is gradually followed by the successful multiplication of the flora and fauna that happen to be best adapted to the prevailing environment gradually giving structure to the newly emergent natural ecosystem until it slowly climbs back into the window of viability (see green arrow in Fig. 7).

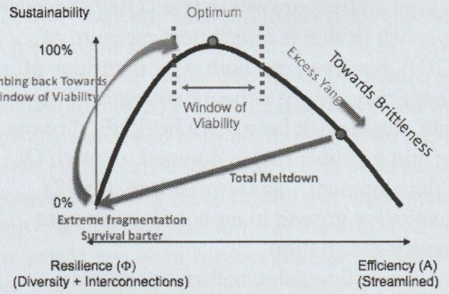

Fig. 7: Dynamics of a total collapse and recovery of a complex flow-network in natural ecosystems. First, extreme fragmentation takes places, without any efficiency. All kinds of species try to emerge. In the case of an economy, this takes the form of survival barter where everything is potentially used as currency. In natural ecosystems, the recovery sees the less inefficient species starting to thrive, and together they generate an ecosystem operating within the Window of Viability.

The same Fig. 7 can be used to explain what could happen in a total collapse of the monetary and banking system. After a period of total fragmentation in the form of survival barter, some standards and some informal agreements would start to emerge. In Argentina this took the form of the multiplication of local exchange mechanisms, under the names of *"ruedes de trueque"* in which locally issued *creditos* currencies were used as medium of exchange in weekly neighbourhood markets. Assuming that the designs of these emergency systems had been sound (which unfortunately wasn't the case in Argentina!), then the better systems would have had a chance to emerge as models for others, and gradually more efficient exchange systems could have evolved. Over time, a more diversified and more interconnected economy would rebuild, which would return the system back into the Window of Viability.

In Modern monetary practice, however, what has invariably happened until now is that as soon as possible, under the ideology of monetary orthodoxy and as a result from bank lobbying, a monopoly of bank debt money as the only medium of exchange is re-established back as before. This took place for instance in Germany in the 1920s and in the US in the 1930s, when all the "emergency currencies" were outlawed; or in Argentina through a massive falsification of *credito* paper currencies.
However, we now know that such a monoculture is not a sustainable structure in the long run, so that such a return to "normalcy" is in fact missing the window of sustainability. As a consequence, we are getting back on the next cycle of pushing for more efficiency within a monoculture environment, which will lead to the next crash a few decades later.
This process is illustrated in Fig. 8.

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