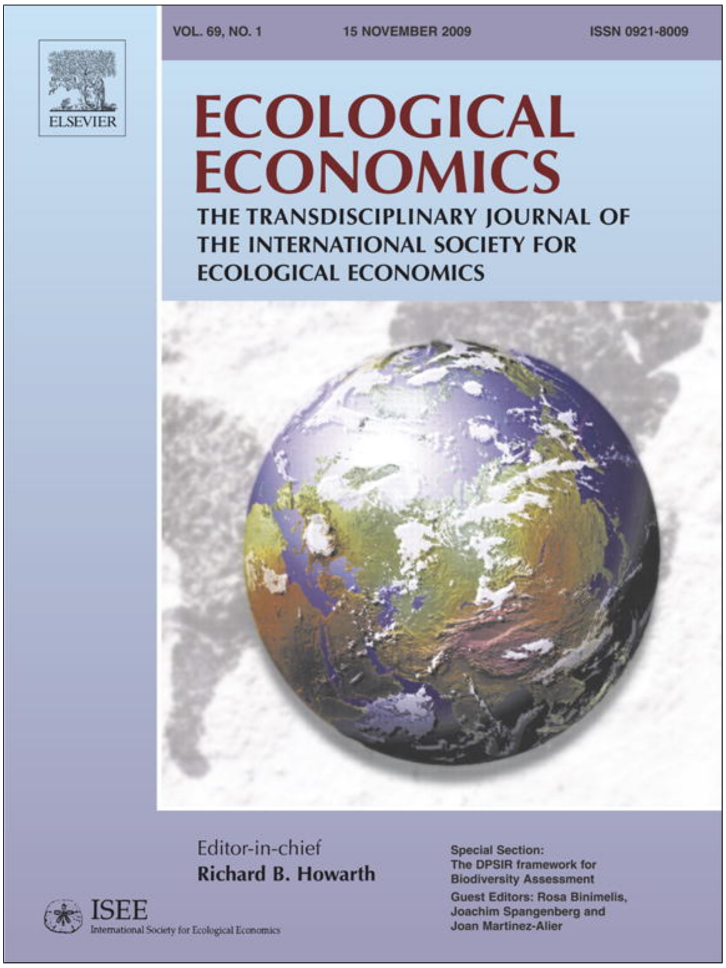
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Methods

# Quantifying economic sustainability: Implications for free-enterprise theory, policy and practice

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ABSTRACT

In a previous paper (Ulanowicz, Goerner, Lietaer, and Gomez, 2009), we combined thermodynamic, network, and information theoretic measures with research on real-life ecosystems to create a generalized, quantitative measure of sustainability for any complex, matter/energy flow system. The current paper explores how this metric and its related concepts can be used to provide a new narrative for long-term economic health and sustainability. Based on a system's ability to maintain a crucial balance between two equally essential, but complementary factors, resilience and efficiency, this generic explanation of the network structure needed to maintain long-term robustness provides the missing theoretical explanation for what constitutes healthy development and the mathematical means to differentiate it quantitatively from mere growth. Matching long-standing observations of sustainable vitality in natural ecosystems and living organisms, the result is a much clearer, more accurate understanding of the conditions needed for free-enterprise networks to produce the kind of sustainable vitality everyone desires, one which enhances and reliably maintains the health and well-being of all levels of global civilization as well as the planet.


## 1. Creating a sustainable economy: a new empirical narrative

The trickledown narrative of economic health appears to be collapsing. In his October 23rd testimony to Congress, even Alan Greenspan admitted that the banking crisis which broke in September, 2008 had demolished his confidence in the reigning neoliberal orthodoxy and opened a vacuum in economic policy direction worldwide. The lead story of the October 11, 2008 issue of *The Economist* summed up the impact: “With a flawed diagnosis of the causes of the crisis, it is hardly surprising that many policymakers have failed to understand its progression.”[1]

It is our hope that the new ability to define and measure healthy development in complex flow systems, hereafter called Quantitative Economic Development (QED), can help provide a solid empirical/mathematical basis for the more accurate diagnosis of how to build and maintain economic vitality being advanced by a wide array of activists, from micro-credit banker Mohammed Yunus to *Natural Capitalism* economist Paul Hawkins. The result is both greater validation for the Triple Bottom Line (Elkington, 1998) approach to building social, economic and environmental health in tandem, and a rediscovery of Adam Smith's original vision of free-enterprise networks backed by a new clarity on the critical conditions needed to keep them strong.

QED's support for Triple Bottom Line thinking and Smith's original vision comes from an assessment of long-term economic vitality that rests entirely on the health of the multi-scale business networks and human capital that make up the real economy. This structural approach to economic sustainability adds mathematical precision to Daly's (1997) contention that one of today's key problems is that current theory fails to differentiate healthy development from mere growth in GDP monetary exchange volume. It also helps explain where neoliberalism went wrong.

## 2. QED's approach to quantifying sustainable economic development

The basic idea behind QED is that the same laws of growth and development apply both to natural flow systems and economic ones. This notion rests on a thermodynamic hypothesis with long historical roots in ecological economics,[2] namely, that similar energy concepts and network analysis methods can be applied to all matter–energy–information flow systems because, as Systems Science has long observed and Prigogine's

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[1] *The Economist*, October 11, 2008, pg. 13.

[2] Odum (1971), Hannon (1973), and Costanza (1981), for example, have all used energy theory as the basis for understanding economic operation. Georgescu-Roegen (1971) used it to create a thermodynamic theory of economics while Daly (1973) used it to urge a steady-state view and a focus on the socio-economic infrastructure needed to undergird structurally stable growth (Daly, 1997). In fact, according to Kenneth Boulding (1981), many early economists held energy views, until those who favored Newtonian mechanics channeled economics towards today's familiar mechanics of rational actors and the reliable self-restraint of General Equilibrium Theory, which now dominate the academic literature as well as the boardrooms and political venues of the world.

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(1967) work in Self-organizing Systems confirms, such systems exhibit strong parallels in behavioral patterns and developmental dynamics.

QED's assessment of sustainable development grows out of energy flow's natural connection to network structure. Ecologists, for example, have long known that an ecosystem's ability to maintain its own vitality over long periods—that is, its "sustainability"—depends largely on the layout and magnitudes of the trophic pathways by which energy, information and resources are circulated. As early as 1951, Leontief showed that economic structure can be effectively modeled as a similar flow-map (input–output map) of goods, services, money or value circulating across a network of businesses (Leontief, 1951). QED's measures, therefore, are based on the layout and magnitudes of flows ($T$) from any node $i$ to node $j$ ($T_{ij}$), where flows can represent biomass going from prey $i$ to predator $j$ (see Fig. 2), or money or materials going from business sector $i$ to sector $j$ or from country $i$ to country $j$. This approach adds a structural specificity lacking in earlier thermodynamic measures such as emergy (Odum, 1996) and exergy (Dincer and Cengel, 2001) which look at the level of free energy embodied in the organization, not how the organization's structure must be laid out for optimal longevity and work.[3]

The long-term maintenance of vitality appears to rest heavily on two structure-related attributes: 1) *efficiency*: the network's capacity to perform in a sufficiently organized and efficient manner as to maintain its integrity over time (May, 1972); and, 2) *resilience*: its reserve of flexible fall-back positions and diversity of actions that can be used to meet the exigencies of novel disturbances and the novelty needed for on-going development and evolution (Holling, 1973, 1986; Walker et al., 2006).

Both resilience and efficiency are related to the levels of diversity and connectivity found in the network, but in opposite directions. A well-woven multiplicity of connections and diversity plays a positive role in resilience, for example, because additional options help the system rebound from the loss or disruption of one or more pathways or nodes. Yet, flow systems also require efficient end-to-end circulation of products in order to properly catalyze crucial processes at all levels of the whole. Redundant pathways and excess diversity hinder such throughput efficiency, leading to stagnation that erodes vitality by dissipating weak throughput via various inefficient sectors. In short, resilience and efficiency are essentially complementary because the streamlining that increases efficiency automatically reduces resilience. In general, greater efficiency means less resilience, and, conversely, greater resilience means less efficiency.

This inherent push–pull tradeoff explains why, after a certain point, increasing a system's efficiency makes it more brittle even as it grows bigger and more directed. Conversely, while increasing diversity and connectivity makes the system technically more resilient, beyond a certain point the loss of efficiency also makes it more stagnant. The upshot is that systems become *un*sustainable whenever they have either too much or too little diversity/connectivity (or too much or too little efficiency).

Since resilience and efficiency are both necessary, but pull in opposite directions, nature tends to favor those systems that achieve an optimal mix of the two. Furthermore, a system's balance of efficiency and resilience can be calculated via its configuration of diversity and connectivity. This allows the system's sustainability to be captured in a single metric that establishes its place in the continuum from brittle (insufficiently diverse) to stagnant (insufficiently efficient).

[3] It has been suggested (Christensen, 1994) that exergy or emergy could serve as alternative mediums to quantify each flow, such that one retains the flow structure in the consequent measure. Those who suggest this (Brown, 2005) feel that it would improve upon Ascendency calculated using conventional energy or carbon. This proposition, while intriguing, remains to be seen since it has not been correlated with actual organizational longevity as QED's measure of Sustainability has in ecosystems.

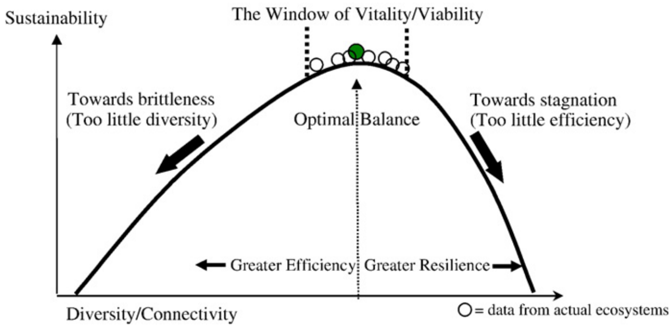


**Fig. 1.** Sustainability as a function of efficiency and resilience.

Consequently, in our previous paper (Ulanowicz et al., 2009), we argued that flow-network sustainability can reasonably be defined as *the optimal balance of efficiency and resilience* as determined by nature[4] and measured by system structure. The underlying mathematics are sufficiently well-behaved that there exists only a single maximum for any given network system, as shown in Fig. 1. Interestingly enough, since optimal sustainability is situated slightly toward the resilience side, the resulting asymmetry suggests that resilience plays a greater role in optimal sustainability than does efficiency.

Data from natural ecosystems appear to confirm the mathematics of this Sustainability measure in that they match Zorach and Ulanowicz's (2003) Window of Vitality, a narrow range of health situated around peak Sustainability that delimits long-term viability in natural systems. These data, however, are not sufficient to determine the exact optimum of Sustainability (Ulanowicz, 1997).

Readers desiring a full technical and mathematical derivation this single metric of Sustainability are referred to our earlier paper. The next section explores some of its practical implications for economic health.

## 3. Tradeoffs among resilience, efficiency, size and long-term health

Much as Daly (1997) argued in economics, theoretical ecologist Ulanowicz (1980) has observed that a flow system's long-term sustainability depends on a judicious balance of size and internal structure (development). In ecosystems as in economies, size is generally measured as the total volume of system throughput: Total System Throughput (TST) in ecosystems and Gross Domestic Product (GDP) in economies. Both GDP and TST are poor measures of sustainability, however, because they measure volume, while ignoring the network structure needed to process resources and circulate energy to all parts of the whole. This leaves them unable to distinguish between growth and development or between a bubble economy and a resilient one.

Since sustainable development requires a balance of efficiency and resilience, Ulanowicz (1980) used configurations of flow pathways and magnitudes in natural ecosystems to develop a measure of network efficiency called the Systemic Efficiency (SE or $E$), which gauges overall system performance as well as its ability to pull more and more energy into its sway, while reducing extraneous diversity/connectivity.[5] Ulanowicz and Norden (1990) also used network characteristics to create a measure of resilience, called Resilience Capacity (RC or $R$), that takes into account the system's average

[4] Presumably, the balance found in nature also reflects underlying physical laws of structural stability and optimal flow, such as those seen in power laws and fractal development.

[5] Systemic Efficiency, called Ascendency in earlier literature, is defined mathematically as:

$$SE = T_{..} \cdot X = \sum_{i,j} T_{ij} \log\left(\frac{T_{ij}T_{..}}{T_{i.}T_{.j}}\right)$$

The log is the natural logarithm of base $e$, and, as in the normal convention, a dot as subscript means that the index it replaces has been summed over all components.

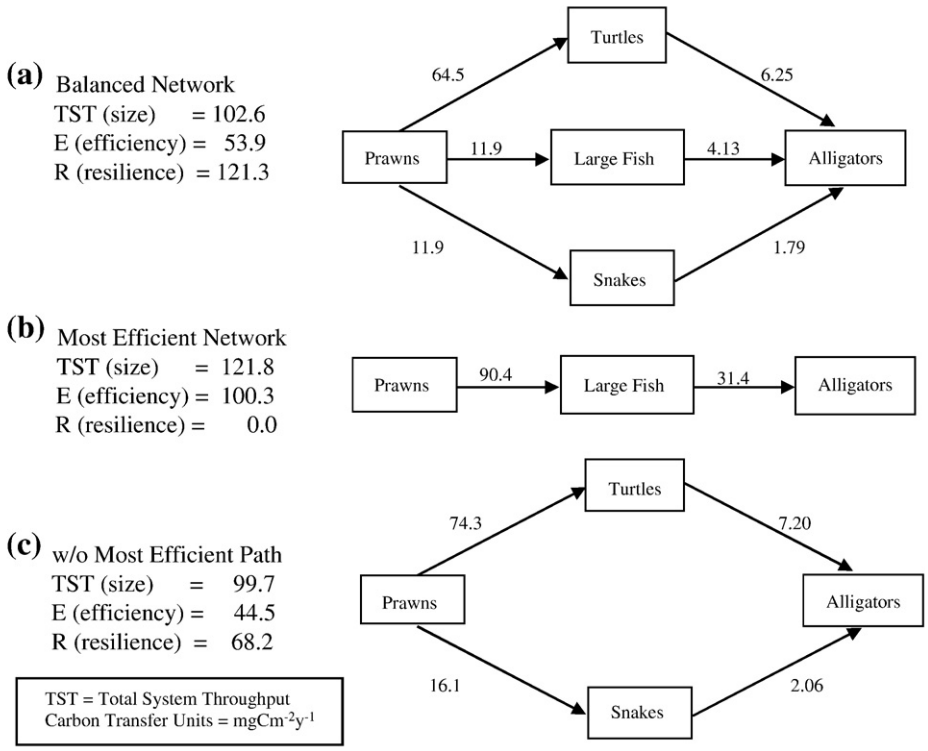


**Fig. 2.** (a, b, c) Size, Efficiency and Resilience Tradeoff in Carbon transfer in the Cypress wetland ecosystem of south Florida (Ulanowicz et al., 1996).

number of connections and its levels of diversity to gauge its likelihood of being adaptable in the face of perturbations.[6] A further metric, Developmental Capacity ($C$) combines Systemic Efficiency and Resilience Capacity to measure the system's balance of the two factors. Developmental Capacity, defined as $E+R$, serves as an effective measure of Sustainability ($S$); it is a single metric of overall health that 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.[7]

The simple ecosystem example shown in Fig. 2a–c clarifies how tradeoffs among efficiency, resilience and growth affect a flow system's long-term health. Fig. 2a depicts pathways of carbon flow in the Cypress wetlands of South Florida leading from freshwater prawns to the American alligator, via three intermediate predators: turtles, large fish, and snakes (Ulanowicz et al., 1996). (These species are, of course, entwined in a myriad of relationships with other populations, but for the purposes of illustrating our point, this sub-network will be considered here as if it were in isolation.) The total throughput volume (TST) per year for the relatively balanced prawn-alligator ecosystem is measured as 102.6 mg of carbon per square meter (mg C $m^{-2}$ $year^{-1}$) of that wetland ecosystem. Its Systemic Efficiency ($E$) works out to 53.9 mg and its Resilience Capacity ($R$) is 121.3 mg.

In this example, the most efficient pathway between prawns and alligators is via the large fishes. If, as is often the case in economics, efficiency was taken as the sole criterion for vitality, then the flow path through large fish would grow at the expense of the less efficient routes until it completely dominated the transfer. As Fig. 2b shows, efficiency increases dramatically in this scenario, and creates an equally impressive jump in volume: $E$ almost doubles from 53.9 to 100.3 mg, while TST leaps from 102.6 to 121.8 mg. The parallel economic event would be a massive increase in productivity/efficiency that produces a dramatic leap in GDP. On the other hand, resilience for this highly efficient system vanishes completely ($R=0$). Should some catastrophe occur, like a virus wiping out the fish population, all transfer from prawns to alligators would cease, with potentially cataclysmic results. An economic parallel can be seen in the U.S. government's attempt to prop up massive banks in order to avoid losing the central monetary flow path.

This example helps clarify why maximizing efficiency leads, to use a cliché, to putting all of one's eggs in a single basket: it courts disaster because it eliminates resilience. Similarly, instead of signaling economic vitality, the surge in GDP growth that often accompanies increasing efficiency may actually mask increasing brittleness. Events such as Hurricane Katrina and the Iraq war show how global dependence on oil as a primary energy source provided by a few, large corporate suppliers makes the energy sector an obvious example of such systemic brittleness. Yet, since a mere ten to twelve companies now control over 80% of the world's food supply of cereals, grains, meat, dairy, edible oils, fats, and fruits (Goldsmith and Mander, 1997), global dependence for food supplies on a few large agribusinesses presents a similarly serious threat. While this consolidated corporate system may, as many economists claim, represent the most efficient path from resource to consumer, it also puts the global food system in the same situation shown in Fig. 2b, with few options should economic, political, or environmental events disrupt one or more of these major pathways.

In contrast, systems that maintain proper resilience during growth are more likely to adapt to crises in ways that largely protect total throughput (size), while expending some resilience and modestly reducing efficiency. For instance, in our carbon transfer example, if healthy populations of turtles and snakes were still present after our hypothetical fish virus, these additional pathways would allow the system to adapt while maintaining flow as shown in Fig. 2c. In this case, rather than total system collapse, TST volume drops modestly from 102.6 to 99.7 mg and Systemic Efficiency falls back slightly from its previous level of 53.9 to 44.5 mg. The loss of the large fish, however, also causes Resilience Capacity to drop by almost half to 68.2 mg.

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[6] Resilience Capacity, called Reserve Capacity or Overhead in earlier literature, is defined mathematically as: $RC = -\sum_{i,j} T_{ij} \log\left(\frac{T_{ij}^2}{T_{i.}T_{.j}}\right)$.

[7] Sustainability is defined mathematically as: $S = C = SE + RC = -\sum_{i,j} T_{ij} \log\left(\frac{T_{ij}}{T_{..}}\right)$.

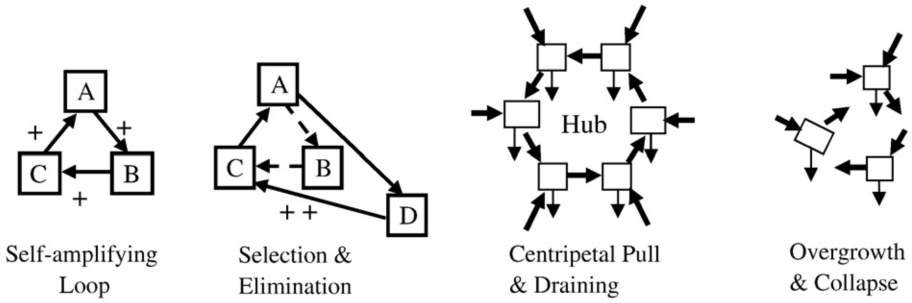


**Fig. 3.** Centripetal pull and erosion in autocatalytic circuits.

Such numbers substantiate diversity/connectivity's role in supporting a soft-landing response to the kind of overgrowth seen, for instance, in the dot.com bubble, as well as to the periodic disturbances from environmental events and localized business irresponsibility that inevitably befall an economy. The ability to quantify resilience also provides an empirical basis for concern about, for example, the loss of small farms, which provide alternate food-supply pathways for the global food-security crisis that many scholars (e.g., Von Braun et al., 2004) argue lies on the horizon. The result is a new appreciation of the small, diverse economic networks that make up the bulk of any economy, as well as a discrediting of the idea that highly efficient big-fish businesses are the surest path to economic health.

## 4. How positive-feedback growth erodes systemic sustainability

Understanding the tradeoffs required for long-term economic vitality helps us aim our policies toward a more appropriate balance, but it does not explain the origins of bubbles or brittleness per se. For this we turn to the phenomenon of centripetal pull resulting from autocatalytic growth. Flow circuits often fall into positive-feedback arrangements in which each node has an amplifying effect on its downstream neighbor in the loop. As Fig. 3 shows, such autocatalytic loops often create *centripetal pull*, a self-reinforcing momentum that draws progressively more resources into their sway, making the circuit a centralizing hub for surrounding flows (Matutinović, 2005). A number of natural processes cause this vortex to accelerate its own efficiency and growth in a way that actively drains the broader system (Ulanowicz, 1995). These easily recognized processes include:

1. *Selection*, a natural tendency to augment elements that increase flow through the epicenter circuit and to eliminate elements which do not
2. *Increasing efficiency* honed by this selection and elimination
3. *Self-amplifying growth* created by increasing efficiency, influx and pull
4. *Erosion* of the surrounding network caused by the massive draw of resources into the epicenter hub
5. *Brittleness* caused by the elimination of backup resilience
6. *Rigidity* cause by increasing constraints on options and behavior.

Today's massive algae bloom in the Gulf of Mexico shows what happens when unchecked growth in one circuit creates a resource-concentrating vortex that actively erodes the broader network upon which systemic health ultimately depends. Fertilizer and agricultural wastes flowing down the Mississippi River triggered massive algae growth that has depleted nearly all the oxygen in over 8500 mi$^2$ of water, which caused an equally massive die-off of marine life, notably fish, shrimp and shellfish.[8]

Policies that promote positive-feedback growth in an economy may result in a wealth-concentrating vortex that breeds similar brittleness and bubbles at the same time. The current banking/financial crisis initially precipitated by the mortgage derivative bubble shows how this process works. 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. 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 epicenter banking/financial circuit as well.

The innocence with which this process proceeds explains why a number of strategies intended to increase economic health actually erode it. The classic example is the "Walmart Effect": the perplexing observation that the large, highly efficient companies supported by local economic development offices tend to erode surrounding economic networks even as they increase GDP. For decades now, most economic development offices have focused on creating incentives to lure big corporations to setup shop in their locale in hopes that jobs and taxes would trickledown best from there. This approach skyrocketed under neoliberal rule because emphasis on GDP growth and the giant, deregulated corporations that most increase it, tended to promote mutual-benefit arrangements between big corporations, media and the economic development officers, academics, and politicians that espoused neoliberal beliefs. Selecting for ability to bring in big-box retailers made sense because greater size generally meant greater GDP growth, while greater economies of scale (i.e., efficiency) meant lower prices. Lower prices naturally pulled more consumers and money into the corporate system causing corporate and government coffers to swell along with the GDP. Since the benefits of this circuit seemed undeniable, those who supported the "elephant hunting" process were rewarded, while those who did not were eliminated.

Unfortunately, neoliberal theorists discounted the erosion that came too. As the movie, *Walmart: The High Cost of Low Prices* (Brave New Films, 2005) documents, support from local government and head-to-head competition over price allowed the more efficient big-box retailer to drive the smaller, more diverse local enterprises out of business. Walmart then takes advantage of this situation to increase its profits by lowering wages, removing benefits and often increasing prices as well. Burdens on public coffers increase, and brittleness sets in because worker and community options have been eliminated along with local business diversity. At the same time, instead of building a strong local network by catalyzing local business processes, much of the money and benefit of large-scale efficiency is drained from the local economy and siphoned off to distant headquarters. A 2002 study[9] in Austin, Texas, for instance, showed that for every $100 local consumers spent at a national

[8] See U.S. Environmental Protection Agency, NOAA, www.gulfhypoxia.net.

[9] "Civic Economics," Austin Unchained, Austin, Texas, October 2003.

bookstore, the local economy received only $13, whereas the same amount spent at local bookstores yielded $45. A 2003 study[10] of Midcoast Maine expanded this finding showing that local businesses spent 54% of their revenue (goods, professional services, wages, benefits, etc.) within Maine, while big-box retailers returned just 14% of their revenue, mostly in the form of payroll. Local resilience declines along with local circulation; local wages decrease with employment options; and the local governments that supported the big box find that the costs of incentives and infrastructure expansion outweigh the taxes that the big retailer adds. Shuman (2006) documents the overall impact in lost jobs, lower wages, over-extended infrastructure and eroded community well-being.

The links between erosion, bubbles and autocatalytic growth also explain why neoliberal policies that over emphasized efficiencies, consolidation, deregulation, and GDP growth created widespread brittleness during a period of unprecedented worker productivity and owner profits. The observed effects of NAFTA are a case in point. Conventional economic wisdom erred grievously in predicting NAFTA would increase vitality for the entire economic network, as opposed to just a few epicenter circuits. In contrast, QED would have correctly predicted that the accelerated growth in the large-scale circuit's power and efficiency would be accompanied by the widespread loss of jobs and erosion of surrounding networks—just as Ross Perot argued it would. In essence, neoliberal policies are *economically* unsustainable because their exaggerated support for large-scale organizations leads to imbalance. Much as an overly large canal erodes surrounding wetlands by funneling soil and nutrients out to sea, so domination by a few high-capacity organizations tends to drain the broader networks upon which long-term vitality depends.

Autocatalysis, therefore, also explains why over-fueling dominant circuits or having insufficient constrains on them often leads to catastrophic boom-bust cycles, instead of the healthy equilibrium that some theorists predict. In nature, self-amplifying (positive-feedback) loops do eventually provoke their opposite: decelerating (negative feedback) loops that move back toward *balance* (which is often mistakenly described as "equilibrium"). However, most economists fail to mention that these downward adjustments can also trigger autocatalytic over-shoot, causing recessions, depressions, panics and possibly even monetary, banking or economic collapse if resilience is low or the downward spiral is left unchecked.

Consequently, as Tainter (1988) shows, autocatalytic economic circuits follow a path similar to that of the Roman Empire: they grow; dominate their surroundings; reach their limits; and, if unchecked, end in collapse due largely to erosion of non-epicenter networks, such as small farmers, local governments and the public at large. Understanding this process empirically grounds the age-old claims that monopolistic concentration, insider trading, speculation and sheer greed are all bad for economic health because they cause erosion, bubbles and crashes. Similarly, regulations like the Glass–Steagall Act of 1933, which effectively barred Wall Street investment banks from owning community savings banks, were effective because they blocked autocatalytic alignment.

## 5. Rethinking where current theory and practice went wrong

A great deal of current economic theory rests on the assumption that economic laws, such as standard supply-and-demand dynamics for example, hold *regardless* of the resilience of the underlying networks. Similarly, as Cobb et al. (1995) and others have pointed out, today's primary measure of economic health, GDP growth, only counts the volume of monetary exchanges and ignores whether such exchanges go toward building economic capacity or paying for damages, liabilities and unproductive debt. GDP growth actually masks declines taking place in various parts of the economic web by allowing massive gains in one sector, such as hedge funds, to be conflated with health for the whole. In retrospect, this blindness to network health rendered much of classical theory incapable of understanding, much less predicting either bubbles or the kind of widespread economic instability that now threatens the world.

This lack of visibility and concern for the erosion of lower scale networks opened the door to policies that accelerated their destruction. From NAFTA to the WTO, neoliberal devotion to deregulating capital removed many of the obstacles to concentration long known to create harm. Blind faith in market efficiency and the correctness of maximizing profits regardless of the costs to anyone or anything else created disdain for such moral concerns as harm to smaller economic actors: consumers, labor, and small businesses. These and the damage to the environment caused by toxic products, externalized costs and predatory practices were rationalized as collateral damage and creative destruction. Consequently, a long list of critics (e.g., Stiglitz, 2002; Pollin, 2003; Saul, 2004) point to the increasing concentration of wealth and power,[11] the elimination of good jobs,[12] the erosion of civil liberties, public health and democracy,[13] and the other 96 major banking crises that have occurred between neoliberalism's rise in 1980 and 1996,[14] as evidence of its inherent *un*sustainability. Yet, without effective measures, unshaken belief in the trickledown benefits of consolidation, labor restrictions, and tax cuts on capital still drives many policymakers to advocate largesse for large-scale business and disregard for small businesses and the human scale.

In contrast, QED's structural approach provides a detailed empirical explanation for why this combination of largesse and disregard leads to the widespread brittleness that, as the current crisis shows, threatens big and small alike. It also reveals the fallacy of other assumptions, such as: 1) increasing efficiency always improves economic health regardless of the harm that labor, material and environmental "efficiencies" often cause to people, planet and communities; 2) highly skewed distributions of wealth, power and size do not affect economic health; and 3) markets always move towards optimal equilibrium, not collapse, because positive-feedback growth will always be restrained by a timely negative feedback response. The result is a clearer view of the road to sustainable socio-economic vitality with direct implications for how we conceptualize and promote "sustainable" economic development.

Because we have over emphasized large-scale organizations, the best way to restore robustness today would be to revitalize our small-scale fair-enterprise root system with an eye to restoring the requisite diversity, intricacy and resilience. Economic development must become more focused on developing human, community, and small-business capital because long-term, cross-scale vitality depends on these. Micro-credit institutions, small enterprise incubators, and local network facilitations groups such as the Business Alliance for Local Living Economies (BALLE) and the New Economics Foundation (NEF) are already cultivating this type of sustainable development. They work because Triple Bottom Line combinations of community development, small-scale economic development, and Green jobs/infrastructure development tend to produce more socially, economically and environmentally sustainable wholes.

[10] "The Economic Impact of Locally Owned Business vs Chains: A Case Study in Midcoast Maine," New Rules Project, Institute for Local Self-Reliance (ILSR), Minneapolis, Minnesota. September 2003.

[11] See Culpeper, 2005, for data on the growing disparity between rich and poor nations and individuals.

[12] Accompanied by "jobless growth," meaning an increase in GDP growth that is accompanied by a decrease in living-wage jobs. By 1995, for example, almost a third of the world's 2.8-billion person workforce was either jobless or working for such low wages that they faced a life with little chance for advancement. For rates of jobless growth see Jeremy Rifkin, 1995, *The End of Work: The Decline of the Global Labor Force and the Dawn of the Post-Market Era*. New York: Jeremy P. Tarcher.

[13] See Klein, 2008, for details on these.

[14] Caprio and Klingelbiel, 1996, "Bank Insolvencies: Cross Country Experience," *Policy Research Working Papers No.1620* (Washington, DC: World Bank, Policy and Research Department, 1996).

The new measure of economic sustainability supports these efforts by turning today's inexact ideal of equity into a precise picture of the balance needed between big and small, diverse and constrained. Our hope is that, by showing where a more reliable path to prosperity might lie, the new narrative will offer a powerful alternative to policymakers who presently see no choice but to continue down the current path.

## 6. Conclusion: systemic sustainability and free enterprise, rightly understood

For years critics have argued that environmental sustainability was at best a luxury and at worst a detriment to economic health, but now we have a new lens. Blind obsession with GDP growth, efficiency and maximizing profit for owners regardless of the costs to anyone or anything else set neoliberal economics at odds with workers, consumers, small business and the environment. QED's ability to incorporate all externalities helps us see why these over-emphases also set it at odds with long-term economic health and the proper functioning of markets as well. The result, however, is not a rebuke of free enterprise, but a clearer picture of how to preserve its best principles while progressing past current excesses.

The new science of sustainability described here focuses our common concerns about jobs, education, healthcare and prosperity on a new understanding of why “it is not how big you grow, but *how* you grow big” that matters. In this view, durable economic vitality requires exchange networks that exhibit the same balance of hardy weave, diverse alternatives, and efficient throughput performance that produces long-term vitality in all flow systems. On the progress side, the role diversity and intricate connectivity play in supporting vitality and averting disaster gives them a new status not visible in current theory. Yet, paradoxically, validating the importance of diverse, well-knit enterprise networks brings us back to our grassroots, *fair*-enterprise origins, now armed with an empirical understanding of why protective anti-trust laws are necessary because excess size and pull can be deadly to the economic whole upon which we all depend.

The narrative that emerges retains the main touchstones of traditional free-enterprise theory, such as the importance of diversity and freedom, while neatly integrating social justice concerns, outsourcing unease, corporate abuse allegations, and well-documented observations about the dangers of excess concentration into a more balanced unity. Balance, of course, is the key. Here, for example, efficiency, GDP growth and other mainstays of current thought remain valid concerns, but excessive, single-minded pursuit of them is tempered by the realization that they are neither always good, nor a sure route to economic health.

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