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BEHIND THE 2008 CAPITAL MARKET COLLAPSE

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SUMMARY:

Greed and the unethical behavior of financial institutions obviously played a part in the collapse of the world capital market in 2008. But, this paper argues that the main culprits are the neo-liberal ideology (requiring ever smaller governments and privatization) and the flawed theories of risk assessment. It also finds that given the fact that market economies are fractal structures, the objective assessment and / or the quantification of risks is not even possible. It concludes with some recommendations as to how to avoid future collapses.

Key Words: Efficiency and self-correction in market economies; Linear-positive and non-linear modelings; creative destruction of coefficients; determinism and randomness, and risk assessment.

I - INTRODUCTION

The latter part of 2008 was a period of reckoning for the freewheeling and free-market practices of Wall Street. The highly leveraged securities linked to US mortgages that banks around the world had and still have on their books were at the root of the near collapse of the capital market. These fast-and-loose mortgage lending decisions of these financial institutions have metaphorically caused a shock wave that quickly propagated around the world. Stock markets nose-dived and paper losses amounted to trillions of dollars.

More explicitly, financial institutions in the US packaged non viable mortgages debts into investment instruments that were bought by other institutions. European banks followed their US counterparts in buying these toxic instruments dressed up to look more secured than they actually were. That was the first stage. In the mean time, the buyers of these securities did attempt to insure themselves against the risk of default by buying credit swaps in the second stage. A credit default swap is a non-tradable contract between two investors that insures them against the potential default of some party. Such a contract obviously reflects the fact that participants were well aware that markets were unregulated and non-transparent, and that if a party were to fail to meet his obligations, somebody would have to pay up. When it became clear that these mortgages were not viable, both the buyers of these hybrid instruments and the sellers of insurance against defaults panicked, sending out the first shock wave. The Credit Default Swaps market is huge. Over the years, it has grown to $55 trillion in notional values. Because buying these contracts was the best way of spreading one's risks; hence the more defaults there are, the more exposed some party is. Then beside mortgage debts, all instruments heretofore protected by swaps appeared risky (1). But that was not all. It soon became clear that banks around the world were also tied up in a tattered web of loans and other shenanigans. As it was not known who was holding toxic instruments and, therefore, who stood to bear sizable losses, the banks simply closed down the credit market, sending out a second shock wave. That second shock wave has caused and continues causing solvency problems for the financial institutions that rely on short term loans to finance their operations. By October 2008, it had reached both industrial and emergent economies, threatening their currency, labor, and commodity markets, which in turn risk sending the whole world into a recession.

Neo-liberal governments around the world became petrified with fear and suddenly switched their allegiance to Keynesianism, as they came to realize that the only way out of that mess was for them to prime the credit market with public funds. So far, the US Government has distributed close to $1.0 trillion (when what the Federal Reserve has pumped in and other little give-a-ways from the government are tallied, the total comes close to $4.0 trillion (tn)). Elsewhere, the European Union promised $3.85 tn. China is to make available some $586 billion (bn), and likewise for other countries such as Russia ($200 bn), South Korea ($150 bn), Switzerland ($57.0 bn), Australia ($ 7.3 bn), Qatar ($5.3 bn), etc. The less well endowed countries such as the Ukraine, Belarus, Hungary, Romania, Kazakhstan, Bulgaria, Turkey, Pakistan, Iceland, etc., are now in negotiation with the International Monetary Fund (IMF), seeking urgent help to prevent a meltdown. Meanwhile, the Federal Reserve in the US, for its part, is now engaged in dollar swaps with emergent countries such as Brazil, Mexico, Singapore, etc. As far as individuals are concerned, besides fearing the loss of their savings and livelihood, they are at a loss to figure out the double standard of their governments with regard to the use of public funds to rescue the very same authors of the crisis.

This fiasco seems to be due to three reasons. First, packaging toxic mortgages debts into viable investment instruments reflects excessive greed and unethical behavior. The banks, pension funds and hedge funds who risked other people money in bets in highly leveraged securities reflect the fact that they were unsupervised, unregulated, over-leveraged; this in turn is a direct consequence of the prevailing neo-liberal philosophy. The credit agencies, in particular the financial engineers, a. k. as "quants", that supposedly had evaluated the risk associated with these securities were either callously indifferent to the consequences or were using a flawed theory of risk assessment. All of these factors must be brought to bear on a reasonable explanation. This is the main purpose of this paper.

Greed is natural and hence has few remedies in the short run. Amoral and unethical behaviors are to be expected in unsupervised settings, while flawed theories do have long lasting consequences. I will focus on the last two. For, the neo-liberal economic philosophy that was officially shaping world attitude for the last twenty-two years, was presented as the passport to affluence; its obvious and, now undeniable, negative impacts were never mentioned. As far as flawed scientific theories are concerned, as their negative consequences are quite enduring, they must be deconstructed at the first opportunity.

II – THE NEO-LIBERAL PHILOSOPHY

The neo-liberal philosophy finds its underpinning in the so-called neo-classical economic theory. Although the forefathers of that theory were not scientists, they nevertheless attempted to construct a psycho-mathematical structure, based on unproven heuristics, but akin to Newtonian mechanics. It rests on two fundamental assumptions. Namely, the well-informed and far-sighted consumer is rational in the Boolean sense, and the producer of goods and services is always technically efficient. Therefore, the rational consumer will maximize his or her utility, while the efficient producer will maximize his or her profits. Hence, society as a whole may rest assured that the uses of its resources will always be optimal, meaning that markets will be efficient and self-correcting under minor disturbances.

After the debacle of the 1930s, the British economist and statesman, John Maynard Keynes, had argued that markets were neither efficient nor self-correcting. On the contrary, he thought that the underlying forces working toward the establishment of market equilibria are often weakly felt. Hence, markets may become stuck in situations where friction and rigidities prevent these underlying forces from producing their effects. Hence, economies may become trapped in disequilibria. That is to say that he downplayed the role of self-correction, and upheld that of income effects in the determination of output and employment and the interventionist role of governments in the formulation of policies. To finance the provision of public goods and the management of economic growth, governments will have to rely on progressive taxation measures. Effectively, the period during which these ideas held sway was the most prosperous of the entire 20th century, but the power elite never accepted them due mainly to their subtle redistributive impacts.

Approximately ten years after Keynes' ideas were aired, the power elite financed the creation of the Mont Pelerin Society, under the guidance of the Austrian neo-liberal economist, Friedrich von Hayek, assisted by his faithful student, Milton Friedman. According to the philosophy put forward by the Society, all contemporary economic ills are due to governments' interventions. And that society is best served by maximum market freedom. Therefore, the role of governments should be restricted to the creation of markets and to the protection of private property; all other economic functions should be left to the private sector. Friedman and other academics, oligarchs, rightwing think-tanks, and a collaborative press became the main proponents of the liberal philosophy in the US. During the later part of the 1980s, the Reagan Administration extended the timid efforts that began under the previous administration by hastening the deregulation trends via the so-called 'Washington Consensus' (WC); that is, governments in the US and in England made the WC official policy. The European Union followed suit, while the international economic institutions, such as the IMF and the World Bank, were enlisted to spread the WC abroad, thereby forcing other governments in financial need of help to become unwilling adherents. The deregulation fever continued under the Clinton Administration. The latter deregulated agriculture, telecommunications, and financial services, accompanied by tax cuts (capital gain and estate taxes), and pushed the free trade agenda as dictated by the WC.

Animated by the neo-liberal philosophy, governments around the world removed all regulations on capital and labor markets, while "dis-investing" in their respective economies by selling all heretofore public enterprises to their cronies. Everything was done quietly and quickly, and in the name of efficiency. Undoubtedly, regulations may become excessive and even counter-productive in some instances. But to think that an economy can function in the total absence of regulations is to deliberately ignore some basics facts in nature. This author, among others, has warned against the dangers of unregulated markets (Dominique, 1999), but to no avail; greed over-powered all cautions. In fact, it is reasonable to suppose that the repeal of the Glass-Stegall Act and the passage of the Commodity Futures Modernization Act of 2000 in the US are in line with that philosophy but, at the same time, they spurred on the speculative fever leading to the present crisis. To go beyond the sub-prime mortgage debacle and to understand how a crisis of bigger magnitude than the one of 1929 (or 1933) could come about, and why it may happen again, we must make a slight digression into the neo-classical theory that underpins the neo-liberal philosophy.

III – THEORETICAL CONSIDERATIONS

As indicated, the assumptions that markets are efficient and stable, and the fact that prices and quantities take on only positive values have led economists to favor positive linear models as representations of economies as a whole. This orientation was reinforced by a mathematical fact to the effect that the system matrices of positive linear systems are Metzlerian. In other words, a real square matrix **M** with i rows, j columns, and m_{ij} elements is Metzlerian if $m_{ij} \geq 0, \forall i, \neq j$. If the model is specified in discrete time, the existence and the stability of its positive solution are guaranteed by a famous theorem due to G. Frobenius (1908) and O. Perron (1907). According to the Frobenius-Perron Theorem, a positive matrix such **M** has a single positive dominant eigenvalue. Regardless of the dimensions and the time of convergence, starting from any positive initial conditions, the solution to the system tends to align itself to the eigenvector associated with the positive dominant eigenvalue. A second property is that as the equilibrium point is positive, it is also stable. That appears to be the case in economics where the state vector is the equilibrium price vector **p***which must be positive [(2)].

If the system matrix of the economy is Metzlerian, its equilibrium is a fixed-point, **p***. Any deviation from this fixed-point equilibrium must be due to errors of specification, sampling and measurements. Economists further posit that such errors are randomly distributed about **p*** with zero *mean* and constant variance, σ^2. The square root of the variance, σ, is the *standard deviation* of the disturbances about **p***.

In the economic world, an outcome is said to be *risky* whenever the randomness associated with that outcome can be quantified with numerical probabilities. When it is not possible to assign numerical probabilities to all possible outcomes, the situation is then termed *uncertain*. As it turns out, common sense associates risks and future returns. Thus, to determine the price of a security, say, that promises a given returns in the future, one must have an idea of the risk associated with that returns at the time of the pricing. During the 1960s, the security market was growing at an impressive rate. That opened the way for a whole new kind of experts, known as financial engineers or 'quants', specialized in risk assessment.

The quants have played with various measures of riskiness over the years since. During the 1960s, the *mean-standard deviation* measure was widely used in portfolio theory and in the so-called Capital Asset Pricing Model. It quickly became very unsatisfactory as it was routinely used in conjunction with consumer preferences and quadratic utility functions. I can think of three reasons why that measure would not do the trick: i) consumers' preference is still assumed to be a two-place relation in economic analysis, when greater knowledge about the human brain suggests that it is in fact a multi-place relation; ii) utility functions are unobservable, and; iii) the distribution of probable economic events does not follow the Gaussian distribution; I will return to that point later on. During the 1970s, economists switched to the so-called *mean-preserving spread*, proposed by Rothschild and Stiglitz (1971). Though it was routinely used for a while, it too was dependent on utility functions whose existence and properties are nothing but guess-work of economists. Still later on, the analysis of risky outcomes made wide use of other measures, such as *stochastic dominance* (see, Fishburn, 1982)), *mean-absolute deviation*, *interquartile range*, and even the classical statistical measure of *entropy*; in information theory, entropy is a measure of uncertainty, but in this case it has proven to be unresponsive to the different values that the random variable may take. Thus, every one of these measures exhibits one shortcoming or another. To grasp the difficult of finding a satisfactory measure of riskiness, it would useful to begin with the notion of randomness itself.

The world random is a substitute for 'aleatory' that comes from the Latin root 'alea', meaning 'dice'. A formal definition of aleatory is really independence from initial conditions, or the impossibility of predicting the future. Put differently, even though initial conditions may be known, they may not be repeatable, and the outcome can not be predicted. To know the outcome, one must throw the dice, but a second throw may give a different outcome. The reason for this is that some conditions or information is missing. Let us examine this more closely. The physical laws regulating the dice's motion are deterministic. Once the dice is thrown, it is subject to the gravitational pulls of the earth and that of the experimenter, to the potential energy, to the torque (if any), and to the elasticities of both dice and the surface on which the dice falls. If the experimenter could account for all of these *ex ante*, the outcome could be predicted. In other words, the dice thrower could predict the future, but until a human is able to carry out the required calculations and abide by them, dice throwing will remain the symbol of randomness.

The lesson here is that randomness does not seem to exist in the universe. If outcomes appear random, it is because either the deterministic mechanism generating the outcomes is hidden from observation or initial conditions are unrepeatable. That affirmation is supported by numerous examples and thought experiments. For example, the famous 'baker's transformation' shows that once the rules producing the outcome are known, the present contains both the past and the future. On the other hand, when the rules are hidden from view, determinist outcomes may appear random. For example, the computer is a deterministic machine par excellence, yet it can generate a random number table. Dice throwing, the computer, and the logistic map, (about which I will have to say in a moment), etc., are examples of how randomness can appear in deterministic mechanism in the microscopic realm. The 'twin-star' thought experiment and the trajectories of our earth around the sun show that when the deterministic mechanism is hidden from view, randomness may appear even in the macroscopic realm. The same phenomenon appears in mathematics, as evidenced by the so-called 'Bernoulli shift' that demonstrates how randomness may appear due to the inability to observe the hidden mechanism. I will not go into the details of these cases; the interested reader should consult Ekland (1988) for more. However, I think that it would be instructive to show the workings of the logistic map, as that case is more helpful for the present purpose.

Consider the logistic map:

$$x_{t+1} = c\, x_t (1 - x_t), \tag{1}$$

where the slope is given by $\Delta x_{t+1} / \Delta x_t = c\,(1 - 2x_t)$ and c is the tuning coefficient. For values of $c < 1$, there is no equilibrium, defined as $x_{t+1} = x_t$. For values $1 < c \leq 3$, equilibria are fixed-points that are unique and stable. For values $c > 3$, equilibria start doubling in what has come to be known as period-doubling bifurcation. At values $c = 3.4495$, there are four equilibria. The period doubling, or the Feigenbaum cascade, continues with increasing values of c. At values of $c \geq 3.8284$, a region called *strange* or *fractal attractor* appears in the phase space of the map. A strange attractor is a set of points toward which very complicated trajectories are attracted. Within that set there are orbits of very large periods and an uncountable set of aperiodic orbits, meaning that a particle, say, on an aperiodic orbit will never return to a point it had previously visited [(3)]. Strange attractors are often referred to a *chaotic deterministic* or simply *fractal attractors*; I may, later on, use these terms interchangeably.

Again, we should notice that the mechanism given in equation (1) is perfectly deterministic. For values of $1 < c \leq 3$, predictions or forecasts are accurate. For values of $c > 3$, forecasts become increasingly inaccurate. For values of $c \geq 3.8284$, forecasts are impossible, yet the mechanism generating this apparent randomness remains perfectly deterministic. All of the above examples teach the same lesson. That is, randomness may appear when the information set of the observer is incomplete.

In the matter that concerns us here, I should point out that first, a substantial portion of economic modeling rests on utility functions, yet economists do not know what a utility function may look like; indeed, we have shown elsewhere (Dominique, 2008) that utility functions may even be a superfluous paraphernalia. Second, the equilibrium price vector is attainable only when adjustments in supply and demand cease, but they never do. As long as adjustments are continuous and hidden from view (the economist is unable to observe them in real time), the equilibrium price vector is wobbling within the attracting region. Hence, the difficulty of quantifying risks. In the next section, I will more explicit about this last point.

IV - FURTHER CONSIDERATIONS

The above discussion shows that determinism is a property of the universe as a whole, but randomness may appear in any part of it that is observed in isolation. It also seems to vindicate Einstein's famous dictum: "God does not use dice."

The difficulty of quantifying risks in a market economy may be demonstrated in a more explicit way. That is, in taking the simplest of all economic models, a pure exchange model. It abstracts from problems related to fiat money, inflation and time-to-build; it is pure. But, it unambiguously shows that it might not even be possible to determine the equilibrium price vector, **p***, before an equilibrium is actually reached. The model is developed elsewhere (Dominique, 2008), but only a section is reproduced here in order to guide the discussion. In a pure exchange market with i = 1, 2, …, m consumers and j = 1, 2, …, n producers may be written as:

$$\dot{\mathbf{p}} = \mathbf{dg}\,(1/p_j)\,[\,\mathbf{M} - \mathbf{dg}\,(\textstyle\sum_i \omega^i_j)]\,\mathbf{P}, \qquad (2)$$

where the dot refers to differentiation with respect to time, **dg** $(1/p_j)$ and **dg** $(\sum_i \omega^i_j)$ are diagonal matrices, **P** is a column vector of prices, and $\mathbf{M}_{(n \times n)}$ is the system matrix, written in full as :

$$(3)\quad \mathbf{M} = \begin{bmatrix} (\alpha^1_1\,\omega^1_1 + \alpha^2_1\,\omega^2_1 +,\ldots,+ \alpha^m_1\,\omega^m_1) & (\alpha^1_1\,\omega^1_2 +,\ldots,+ \alpha^m_1\,\omega^m_2) & \ldots & (\alpha^1_1\,\omega^1_n +,\ldots,+ \alpha^m_1\,\omega^m_n) \\ (\alpha^1_2\,\omega^1_1 +,\ldots,+ \alpha^m_2\,\omega^m_2) & (\alpha^1_2\,\omega^1_2 +, \ldots, + \alpha^m_2\,\omega^m_2) & \ldots & (\alpha^1_2\,\omega^1_n +,\ldots,+ \alpha^m_2\,\omega^m_n) \\ \vdots & \vdots & & \vdots \\ \ldots & \ldots & \ldots & \ldots \\ \vdots & \vdots & & \vdots \\ (\alpha^1_n\,\omega^1_1 +,\ldots,+ \alpha^m_n\,\omega^m_1) & (\alpha^1_n\,\omega^1_2 +,\ldots,+ \alpha^m_n\,\omega^m_2) & \ldots & (\alpha^1_n\,\omega^1_n +,\ldots,+ \alpha^m_n\,\omega^m_n) \end{bmatrix}$$

In matrix **M,** the α's are the budget shares ($\sum_i \alpha_i = 1$) and the ω's are the initial endowments of the agents. What is important to notice is that the elements of **M** are products of the α's and the ω's. Previously, economists had always assumed that the coefficients of **M** were constants. Matrix **M** shows that it was never so. The difference here is that the state variable or the equilibrium price vector is actually determined by the coefficients of the system, which are not constants as long as the system is in transition toward the equilibrium. That makes the system non linear.

Differential equations with non-constant coefficients are always difficult to solve, as their solutions consist of a complementary part and a characteristic part. For non-linear systems in general, mathematicians recommend qualitative solutions or the general behavior of the system rather than quantitative solutions. The reason for that is that there might be a fractal attractor sitting at the heart of the system. But before I can show why fractal attractors may be the root cause of the inability to quantify state variables in economic analysis as well as the other social sciences, I must make another digression into fractal geometry.

Most people would agree that they live in 4-dimentional universe, i. e., the 3 Euclidean dimensions of space and one of time, giving us a 4-D universe. Four is an integer, and a member of the set of whole numbers as -3, - 2, - 1, 0, 1, 2, 3, etc. But fractal systems, on the other hand, live in a non-integer universe. The German mathematician, Felix Hausdorff (1848- 1942) was perhaps the first to notice that the true dimensions of all the irregular shapes found in nature may not be Euclidean. He further noticed that for certain curves, such as the Koch snow flake, an infinite length may be surrounded by a finite area. He then devised a measure that is now routinely used as an index of irregularity. That measure is in essence *the logarithm of the increase in the length of the curve to the logarithm of the decrease in the scale, or the decrease of the unit of measurement used to measure the curve.* For a smooth manifold, the Hausdorff dimensions coincide with the Euclidean dimensions, which it will be recalled are always an integer values. However, for irregular shapes, such as that of trees, clouds, mountains ranges, etc, their Hausdorff dimensions are fractional. Since then, Hausdorff dimensions, being indices of irregularity, have become the focus of the fractal geometry developed by Benoit Mandelbrot (1983). Naturally, the concept was later expanded to the estimation of the strangeness of strange attractors. I will shortly connect fractal attractors to the determination of market prices. For now, the important lesson is that Mandelbrot has uncovered the geometry used by nature itself to create patterns and novelties. Let me first show how nature proceeds and next I will argue that the whole visible universe might be using the same geometry.

In Euclidean geometry, a point has zero dimension (0-D). A straight line has 1-D, a square has 2-D, a cube has 3-D, etc. With this in mind, let us examine an object such as the *Cantor set*. Its dimension is not zero (not a point), nor it is a line (1-D). How could such a creature come to be? Very simple. Take a line of unit length, remove the middle third and throw it away, and repeat the procedure until the limit. The resulting fractal is larger than a point and less than a line; its fractal or Hausdorff dimension is 0.6309, exactly the ln 2 / ln 3 [(4)]. Another example is the *Sierpinski Gasket* which is a square with an inscribed triangle from which ever smaller triangles have been cut away; its fractal dimension is 1.5850, between a line and a surface. The *von Koch snow flake* is an equilateral triangle, inscribed within a circle of finite length, out of which the middle third has been removed from each side, followed by other removals *ad infinitum*. In the limit, a curve of infinite length is confined within a circle of finite length; its fractal dimension is 1.2618 [(5)]. The *Menger Sponge* is a cube in Euclidean dimensions from which sub-cubes have been cut away; its fractal dimension is 2.7268. In short, fractal geometry drives most, if not all, processes in nature, i. e., from geology to biological processes. That is, nature uses the same procedure over and over again. The secret is *creative destruction according to simple determinism or rules.*

Fractal structures are per force everywhere in nature, but one of their most important characteristics is that they are invariant to scales. Another way of saying the same thing is that each fraction of a fractal object contains the whole object. For that reason, scientists refer to them as *self-similar systems*, because they produce similar patterns at all scales; and so it is in nature, from galaxies to the atomic structure, from mountain ranges to the coast lines, from the shapes of trees to the whole forests, and on to the human brain (whose fractal dimension is also 2.7268). Another important characteristic of fractal systems is that probability distributions in these systems differ from the normal curve or the Gaussian distribution. In particular, low probability events according to the normal curve are much more likely in self-similar systems; this is another reason why normal standard deviations failed to capture the risks associated with derivatives. Moreover, since the economy is also a fractal, one would expect that the household's economy to be similar to the regional, to the national, and to the international economy; and so it is. By the same reasoning, we should not be surprised to learn that the human brain uses the same geometry as nature to build constructs such as the economy. And here is an even more compelling reason why.

As is now well known, the Theory of General Relativity and the Quantum Theory, two extremely successful theories of physics, are at loggerheads. In an attempt to unite them, many quantum gravity theories have been developed over the years. Most of them present some drawbacks. The how and why are not important for the present purpose, but one of these theories is and it should engage our attention for a brief moment. It is known as the Causal Dynamical Triangulations of Quantum Gravity or (CDT) [(6)] for short. The reason for the apparent success of CDT comes from its assumption to the effect that at distances 10^{-34} meter or smaller, space-time is made out of tiny 2-D triangular fractals, oriented from the past to the future. When they are assembled according to the rules of both General Relativity and Quantum Theories, simulations on powerful computers result in a smooth space-time, and a stable universe whose fractal dimensions lie between 3.92-D and 4.02-D, with an average of 4.02-D. Up to now, CDT is the only quantum gravity theory that produces, under simulations, a universe with realistic and observable properties, and it confirms that the universe we inhabit is a huge fractal.

The idea that the economy is a fractal is a compelling one. The human brain, being a product of nature, is also a fractal; hence, all its constructs, such as the organization of society, modes of governance, our general behavior, our economies, etc., are bound to be fractal structures too. And the main lesson from the story of fractals is how the secret of nature has been uncovered. That is, how it proceeds to create these similar pattern-like emergent novelties? From the story, it is clear that it is through destructions and creations, as in the Cantor set. With this in mind, we can return to eq. (3) to verify that the equilibrium price vector of the economy is produced or created through adjustments of demand, "proxied" by the budget shares (α's) and supply, "proxied" by initial endowments (ω's). Another way of saying the same thing is through creations and destructions of excess demands, *a law of motion that is hidden from view*. The equilibrium would be reached when adjustments cease. However, the market is a continuous process, and no one can observe these micro adjustments in real time. The only way we could compute an equilibrium price vector is for supply and demand to be exactly the same in each market period. That not being so, then the equilibrium is never attained, because the economy is always on a trajectory; some might prefer to say that it lives in disequilibrium. In such a system, as in the twin-star experiment, only the past is open to view. This seems to be the main reason why uniqueness and stability could never be demonstrated in general equilibrium analysis. If we want to be serious about understanding the nature of a market economy, the only alternative is to focus on the data it leaves behind.

I can conclude this section with the following observation. Risks can not formally be quantified, and the equilibrium price vector around which risks are supposedly assessed is never attained in a market economy. Thus, risk assessments carried out on Wall Street by the "quants" are nothing but an exercise in quantifying subjective probabilities. The Efficient Market Hypothesis, which asserts that all the pertinent information about the security is fully embedded in its price, is vacuous; the underpinning of that belief is the assumption price fluctuations in the short run are random until the fixed point equilibrium is reached. The so-called mark-to-market practice, an offshoot of the Capital Asset Pricing Model, is also a futile exercise, because the equilibrium price of capital is not knowable; we can only known an *ex post* price, i. e., a disequilibrium price at that. It should now be clear that besides greed and the lack of regulations and supervision, flawed theories have, once again, led to the collapse of the capital market.

V – REMEDIES

Having shown that the economic system described by equation (2) approaches its equilibria by the natural method of creative destructions in the sense of Schumpeter, it remains now to examine the evidence. We have already discussed the fact that all market economies, be they be familial, regional or international, are similar, regardless of the differences in scales. But, there are many more scale-invariant patterns. The most prevalent sort of such patterns we can systematically see is boom-and-bursts, which appear as fluctuations to the naked eyes. That means that we would expect market economies to be continuously fluctuating. Low and behold, that is what we observe. For example, during the 1920s, Mitchell and Torpe (1926) had found that fluctuations in European economies numbered in the hundreds. From 1887 to 1990, the economist

Christine Romer (1999) identified some 24 peaks in the US economy. Sheffrin (1998) examined output series from six European countries and concluded that there has been little difference in volatility between the pre-World War I period and the post-world War II era. More recent examples are to be found in the Japanese economy during the 1990s, in the Asian economies in the mid-1990s, and in the US economy since 2000. The evidence of fluctuating patterns is undeniable.

More compelling evidence is to be found in the data the economy leaves behind. It so happens that physicists have developed a number of statistical techniques of estimation of systems' fractal dimensions. This is not the place to describe these techniques, except to say that the easiest approach is to reconstruct the phase space of the whole economy from the plot of, say, the price variable in any sub-market with different lags (see, Packard *et al*., 1980)). From just one observable, it is possible to construct a phase space that nicely yields the fractal dimension of the variable, as well as its sensitivity to initial conditions. There exist already a number of studies that show that the capital market is characterized by low dimensional attractors (see, Peters, 1989, 1991). These dimensions are of course non integers, and they are the same that Grassberger and Procaccia, 1983) refer to as *correlation dimensions.*

That being so, the conclusions that can be drawn are as follows: First, the neo-liberal philosophy requiring ever smaller governments and the absence of stabilization policies is nothing but a flawed ideology. Obviously, I am not arguing for bigger and bigger governments, but as Karl Polanyi observed in 1944 in *The Great Transformation*, a global economic or financial system that does not have a global institution to regulate and stabilize it will lead to unacceptable levels of social disruption. How perceptive!

Second, it follows from the previous discussion that long term forecasts in fractal systems such as the weather or the economy are futile exercises.

Third, the collapse of financial markets during the latter part of 2008 is a warning event signaling to governments in industrial countries the need to regulate all hybrid instruments, a. k. as derivatives or, at the very least, establish a clearinghouse for their trade. To the other governments in emerging countries that are now seeking help from the IMF, the same applies; they should, in addition, be aware of the dangers implicit in the stringent conditions that the IMF usually imposes. It might ask them to do the exact opposite of what industrial countries are now doing to avoid a recession; that is, to raise interest rates, to remove social nets, and to privatize their banks, etc.

Fourth, the present debacle is also a blow to many egos. Ideologues are expected to counterattack by asking for more deregulations. The quants might offer some self-serving excuses for their models with arguments centered on the complexity of derivative markets or the human factor; society must turn off their microphones.

Fifth, instead of pumping public funds into private enterprises, it might be better to let them file for bankruptcy; this would give them an opportunity to reorganize themselves, and let shareholders bear a part of the burden.

Finally, with bail-outs after bail-outs, national debts and governments' deficits are on the increase. Soon governments will start shunning social programs for the lack of funds. The present debacle might just be a golden opportunity for all, governments included, to move away from the neo-liberal ideology, to seriously consider a negligible Tobin tax on speculative currency transfers, to abrogate a few insane legislations such the Commodity Futures Modernization Act of 2000, and to learn the lesson we should have learnt since the debacle of 1929.

NOTES

(1) The American International Group had a portfolio of \$400 bn in CDSs. The Lehman Brothers had a portfolio of \$110 bn in bonds and \$440 bn in CDSs. Fannie Mae had \$748 bn of loans and securities. The collapse of three Icelandic banks has put at risk some \$50 bn in bonds and \$200 bn in CDSs. Barclays and RBS together had some \$2.4 tn tied up in CDSs, etc.

(2) Let **M** be the system matrix with elements $m_{ij} \geq 0$, for $\forall$ i $\neq$j, and i, j $\in$ n and let the dominant positive eigen value of **M** be λ. If the system is specified in continuous time, one begins by specifying the matrix **A** as **A =** b **I** + **M**, where **I** is the identity matrix, and b is a suitable constant. **A** has a positive dominant eigenvalue $\sigma \geq 0$ and a corresponding eigenvector ν, according to the theorem. It follows that $\lambda = \sigma - b$ is the dominant ei genvalue of **M**.

(3) Let there be a state variable p (t) and a mapping $E(p(t)) \in R^n$, where t is one of the n dimensions. Then a closed set $S \in R^n$ is an attractor if there exists a neighborhood N of S such that if E(p(t)) is in N at $t \geq 0$, then $E(p(t)) \rightarrow S$ as $t \rightarrow \infty$. The attractor may have more than one branched surfaces which are interleaved and which intersect. If the attractor is strange, trajectories never intersect, but move from one branched surface to another as they circulate through the apparent branches such that S contains i) a countable set of periodic orbits of arbitrarily large periods; ii) an uncountable set of aperiodic orbits, and; iii) a dense orbit.

(4) Notice that the length of the Cantor set should be zero, because the total lengths thrown away is the infinite sum of the geometric progression of lengths. That is,

$$1/3 + (2 \times 1/9) + (4 \times 1/27) + (8 \times 1/81) + \ldots = 1.$$

Yet, the set contains an uncountable infinity of points of 0-D.

(5) To construct the von Koch curve, first inscribe an equilateral triangle of side of unit length in a circle of finite circumference. Then cut the middle third on one side, pivot the cut piece 60 degrees and add one third of unit length to form a smaller equilateral triangle. Do the same on the other two sides, to add three additional triangles of 1/ 3 length to the length of the curve. In the second iteration, add 12 triangles of 1/ 9 length; the third iteration adds 48 triangles of 1/ 27 length, 192 triangles of 1/ 81 length in the forth iterate, and so on until the limit. The total addition to the perimeter of the initial triangle is the sum of the series:

$$3/3 + (3/3 \times 4/3) + (3/3 \times 4/3 \times 4/3) + (3/3 \times 4/3 \times 4/3 \times 4/3) + \ldots + \rightarrow \infty .$$

(6) he quantum gravity theories are all efforts to unite the theory of general relativity and the quantum theory. They may be divided into two main categories. One is String Theory whose predictions can not be tested experimentally, because science does not have at this point in time any technology that would permit scientists to examine space-time at distances of 10^{-34} meter or less. The other research program, initiated by Stephen Hauking, has produced the Loop Quantum Gravity, the Euclidean Quantum Gravity (EQG), and the Causal Dynamical Triangulations (CDT). The latter is a modern version of Hauking's EQG, due to Jan Ambjorn, Jerzy Jurkiewicz, and Renate Loll. Its advantage and success is due to the fact that it approaches space-time

as a mosaic of triangles with a built-in distinction between space and time, and it starts with fractals on small scales. These tiny fractals are assembled according to the rules of both General Relativity and Quantum Theory. Simulations produce a stable universe with all the properties of the actual observed universe.

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