Rethinking Modern Financial Ecology and Its Regulatory Implications

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Our understanding of the modern financial market significantly shapes the way we regulate it. Sensible and effective regulation will not be achieved if that understanding is misplaced or premised on faulty assumptions. All three mainstream market theories, Efficient Market Hypothesis, Behavioural Finance and Adaptive Market Hypothesis, fail, to some extent, to accurately reflect the complete features of modern financial ecology, and they overlook the unique roles played by regulators, the financial market infrastructures, and the financial gatekeepers. This paper views financial markets as an adaptive, complex ecosystem, and re-explores the distinctive roles played by the various groups of market participant. It re-conceptualizes the comprehensive landscape of modern financial ecology by exploring the mainstream market hypotheses, and by adapting, and applying, to them the insights of complexity science.

Notre compréhension des marchés de capitaux modernes influence considérablement l'approche que nous adoptons pour en assurer la règlementation. Or, du moment que cette compréhension repose sur des hypothèses erronées ou bancales, il en résulte qu'il est impossible de mettre en place des règlements raisonnables et efficaces. À cet égard, aucune des trois théories classiques des marchés, soit l'hypothèse du marché efficient, la finance comportementale et l'hypothèse du marché adaptatif ne reflète avec exactitude toutes les caractéristiques de l'écologie financière moderne; ces théories négligent par le fait même le rôle unique qu'y jouent les organismes de réglementation, les infrastructures des marchés de capitaux et les organismes qui en contrôlent l'accès. Cet article présente les marchés de capitaux comme un écosystème complexe et adaptatif, et explore de nouveau les rôles distinctifs de ses divers participants. En outre, il réexamine le paysage global de la finance moderne en explorant les hypothèses des

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marchés traditionnels, et ce, en les adaptant et en les appliquant selon les préceptes de la science de la complexité.

1. INTRODUCTION

A clear understanding of modern financial ecology is fundamental to the achievement of effective financial regulation. We will not be able to grasp the exact nature of modern financial markets unless we begin to view them as an adaptive, complex ecosystem. The evolution of this ecosystem is not theoretically predictable, nor empirically testable. What we can do, at most, is learn from the wisdom of different market hypotheses, then apply our firsthand observations and experiences to make sense of them. Rather than theorize about how the ecosystem might respond to regulatory changes, this author believes that a more sensible approach is to depict the system's main characteristics clearly, note how these characteristics have shaped the system's evolution, then proceed to estimate its sensitivity to ecological transformation.

To this end, this article re-conceptualizes then portrays the comprehensive landscape of modern financial ecology by exploring the mainstream market theories, and by adapting and applying certain insights of complexity science. Part 2 briefly reviews the Efficient Market Hypothesis, Behavioural Finance Hypothesis and Adaptive Market Hypothesis, highlighting the insufficiencies of each, and underscoring the need to view today's financial markets as an adaptive and complex ecosystem. Part 3 goes further to explore the ecosystem's primary characteristics, first by identifying the primary groups of agents that operate within the ecosystem, then by analyzing the laws that govern the evolution and order of the ecosystem through the lens of complexity science. Part 4 concludes by summarizing the set of regulatory implications that arises from the analysis in Part 3.

2. FINANCIAL MARKET AS AN ADAPTIVE, COMPLEX ECOSYSTEM

(a) Hypotheses and Realities of Market Nature

Analyzing different academic hypotheses about the nature of the market, then arguing a case for which of these hypotheses makes most sense, seems a good place to start rethinking the nature of the contemporary financial market. But that is an approach this article declines to adopt. Hypotheses of any kind are often imaginative constructs meant to serve as approximations, not as the crystallizations of a far more complex reality. Market hypotheses are very helpful in individual and institutional decision-making and scholarly discussions, and even in economic projections, but they are by no means a compendium of the immutable laws of the financial market's nature.

Even the most appealing hypothesis has its own deficiencies. Any policy recommendation based exclusively on a particular market hypothesis or theory puts its efficacy in jeopardy, because every hypothesis is actually ready to be

proven obsolete by empirical evidence. Accordingly, this article adopts another approach — to discover as many *realities* of the contemporary financial markets as the author can, and to depict the market's nature very carefully through them. This approach does not suggest none of the major market hypotheses are valuable. Rather, to the author's mind, the converse is true, for each market-regarding hypothesis from the academic mainstream offers important, noteworthy observations.

(b) Efficient Market Hypothesis and Behavioural Finance Hypothesis

Economists attempt to explain the market's nature with various hypotheses and many simplified assumptions. Many of those assumptions build on economists' perceptions of human nature, that is, of that mysterious puzzle that renders our understanding of the nature of financial market more complex and tangled. Two competing theories that aim to explain the price-formation mechanism and the rationales of investor behaviours are basically the products of different perceptions of human nature. For instance, an "efficient" market, in the Efficient Market Hypothesis[1] (EMH) sense, is defined by Nobel Laureate Eugene Fama, as "a market where there are large numbers of rational, profit-maximizers actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants."[2] Furthermore, EMH assumes that "market prices reflect fundamental value and change on the basis of new information,"[3] and "no investment strategy can yield average returns higher than the risk assumed and no trader can consistently outperform the market or accurately predict future price level, as new information is instantly absorbed by market prices."[4]

Such assumptions about efficiency and rationality do not stand immune from attack. Behavioural economists[5] and psychologists have shown that collective human decision-making does not always conform to rationality, but "exhibits certain behavioural biases that are clearly counterproductive from the

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1 For a classical paper on EMH, see Burton G. Malkiel & Eugene F. Fama, "Efficient Capital Markets: A Review of Theory and Empirical Work", 25 J. Fin. 383 (1970). For the debate over whether the financial market is rational or not, see Mark Rubinstein, "Rational Markets: Yes or No? The Affirmative Case", 57 Fin. Analysts J. 15 (2001); EMH, as observed by Professor Cox, can be broadly stated as holding that "publicly available information is rapidly incorporated in the price of publicly traded securities." James D. Cox, "Fraud on the Market after Amgen", 9 Duke J. Const. L. & Pub. Pol'y 1, 11 (2013).

2 Eugene F. Fama, "Random Walks in Stock Market Prices", 21 Fin. Analysts J. 56 (1965).

3 Emilios Avgouleas, *Governance of Global Financial Markets: The Law, the Economics, the Politics* (Cambridge: Cambridge University Press, 2012), 57 [Avgouleas].

4 *Ibid.*

5 For an overview of mainstream behavioural finance theory, see Meir Statman, "Behavioral Finance: Past Battles and Future Engagements", 55 Fin. Analysts J. 18 (1999).

financial perspective."[6] A number of behavioural biases have been well documented[7] and empirically supported. Overconfidence Bias, for example, indicates that a trader or an investor tends to take too much credit of his success, and therefore places undue confidence in his future investment decisions.[8] Overreaction Bias indicates that investors tend to overreact to both bad and good news (especially those unexpected and dramatic news events) about the stock market, and therefore drive the share prices of stock up and down disproportionately.[9] Optimal Bias, on the other hand, refers to people's tendency to unrealistic optimism about the outcomes of uncertain events.[10] Availability Bias sees that people rely upon information that is readily available to make decision, rather than examine all available possibilities.[11] Accordingly, people tend to "discount the probability of an event's occurrence based on the length of time since it last occurred or how extreme it was."[12] Finally, "herding behaviour"[13] is the tendency that investors "charge into risky ventures without adequate information and appreciation of the risk-reward trade-offs."[14] In addition to the above, certain studies even observe behaviour biases from the physiologic and neuroscientific perspectives to indicate that hormone levels can affect market participants' risk appetite and investment decision-making.[15]

Although two competing theories have presented conflicting views about, and evidence for, how market participants respond to prices and information in the financial markets, that does not necessarily mean that one of them is inherently false, or that neither has practical value. EMH helps us understand the price-information mechanism better, and underscores the paramount importance of information transparency. The assumption of rationality rooted in EMH may

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6 Andrew W. Lo, "Reconciling Efficient Markets with Behavioral Finance: The Adaptive Market Hypothesis" (2005) 7 J. Inv. Consulting 21 at 25 [Lo].

7 Thomas Gilovich, *How We Know What Isn't So: The Fallibility of Human Reason in Everyday Life* (USA: Free Press,1993); see also Robyn M. Dawes, *Everyday Irrationality: How Pseudo-Scientists, Lunatics, and the Rest of Us Systematically Fail to Think Rationally* (USA: Avalon Publishing, 2001).

8 Simon Gervais & Terrance Oden, "Learning to Be Overconfident", 14 Rev. Fin. Stud. 1, 19 (2001).

9 Werner M. De Bondt & Richard Thaler, "Does the Stock Market Overreact?" (1985) 40 J. Fin. 793, 804 .

10 Iman Anabtawi & Steven L. Schwarcz, "Regulating Systemic Risk: Towards An Analytical Framework" (2011) 86 Notre Dame L. Rev. 1349, 1366.

11 *Ibid.* at 1367.

12 *Ibid.*

13 For an overview of theoretical and empirical research on herd behaviour in finance, see Sushil Bikhchandani & Sunil Sharma, "Herd Behavior in Financial Markets" (2000) 47 Int'L Monetary Fund Staff Papers 279.

14 *Ibid.*

15 John Coates, *The Hour between Dog and Wolf: Risk-Taking, Gut Feelings and the Biology of Boom and Bust* (Canada: Random House, 2012) (arguing that financial markets can be made more stable by having a greater endocrine diversity in the financial industry).

not be entirely wrong if we see the dynamics of financial markets as long-term learning processes.

Generally speaking, though sometimes affected by cognitive biases, human beings basically act in their own interests, and demonstrate at least "bounded rationality,"[16] if not unbounded rationality. Although market participants seem to be subject to behavioural biases, EMH proponents argue that market forces will always bring prices back to rational levels, as market participants are also strongly incentivized to identify and arbitrage from such biases if a sufficient period of time is given to them.[17] Such a view offers financial policymakers strong confidence in the likelihood that, if information is generally accessible to market participants, a certain degree of market efficiency should not be hard to achieve, as well-communicated information will naturally incentivize market participants to act in a way that offsets biases.

Behavioural finance hypothesis, on the other hand, gives us a deeper understanding of individual investment behaviour, and sheds light on how regulators and the managements of financial institutions can redirect irrational behaviours to serve rational objectives. More importantly, behavioural finance reminds us that any effort aimed at pursuing the optimal efficiency of financial markets will be unrealistic if behavioural biases are not fully appreciated.

However, both these two mainstream theories have failed to accurately reflect the real features of financial markets. Traditional EMH fails to appreciate the fact that humans are inherently limited in their computational abilities, for psychological, emotional and/or physiological reasons. Although bounded rationality may in the long run be redirected to the "rational" level in the process of learning, it still greatly undermines the predictive power of EMH in the short term. In addition, EMH assumes that market participants are motivated by the pursuit of optimal returns, but such an assumption overlooks the fact that there are various distinct groups of market participant in the financial markets, and each group may hold a different definition of "optimal returns."

EMH supporters focus their discussions mainly on retail or institutional investors of certain types of security, rather than expand their explorations to market infrastructures or traders who are empowered to make gigantic bets without first seeking consent from their institutions. Likewise, behavioural finance hypothesis reflects the real market's nature only partially. EMH proponents have criticized the behavioural literature as "primarily

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[16] For a good overview of the theory of bounded rationality, see Herbert A. Simon, "Bounded Rationality and Organizational Learning", (1991) 2 Org. Sci. 125.

[17] As noted by Emilios Avgouleas, "the actions of "noise traders" alone are not sufficient to distort price efficiency. Any price inefficiencies created by "noise trading" would be exploited by arbitrageurs (so called "smart money")", Avgouleas, *supra* note 3, at 58. For how EMH proponents respond to critics made by behavioural finance theorists, see Burton G. Malkiel, "The Efficient Market Hypothesis and Its Critics" (2003) 17 J. Econ. Pers. 59.

observational, an intriguing collection of counterexamples without any unifying principles to explain their origins."[18] Unsurprisingly, behavioural finance focuses its studies mainly on individual investors, namely, retail investors and traders, because the fundamentals of the theory are built principally on the cognitive biases of human beings. This approach reduces organizational decision-making to individual decision-making, and fails to appreciate how organizational dynamics may cure the behavioural biases that are often an individual's bias, not the organization's bias. Finally, one cannot but conclude that behavioural finance fails to offer a coherent and plausible explanation of what really motivates market participants' behaviours.

(c) Adaptive Market Hypothesis

In an effort to reconcile the EMH with behavioural biases in a theoretically consistent manner, and to offer a more inclusive market theory, Professor Andrew Lo proposes the Adaptive Market Hypothesis (AMH), based on evolutionary perspectives. It is a theory that incorporates several assumptions of both EMH and behavioural finance, and, in this author's opinion, offers a superior overview of market realities. The theoretical root of AMH might be traced back to an article authored by complexity economist W. Brian Arthur, in which he synthesizes the *rational* and the *psychological* perspectives of the financial market and declares that market reducible to a "co-evolving ecology of beliefs."[19] That ecology, according to Arthur, is a vast collection of economic agents' subjective beliefs or hypotheses, and is therefore open to the constant formulation and evolution that eventually makes of it an ocean ever-changing.[20]

In line with Arthur's observation, the AMH "implies that the degree of market efficiency is related to environmental factors characterizing market ecology such as the number of competitors in the market, the magnitude of profit opportunities available, and the adaptability of the market participants."[21] In his view, behavioural biases cited as deviations from rationality are in fact in line with an evolutionary model under which individuals adapt to "a changing environment via simple heuristics."[22] Lo views the financial markets as an adaptive ecosystem wherein distinct groups of "species"[23] (retail investors,

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[18] Lo, *supra* note 6, at 21, 22.

[19] W. Brian Arthur, "Complexity in Economic and Financial Markets" (1995) 1 Complexity 20.

[20] *Ibid.*

[21] Lo, *supra* note 6 at 21.

[22] *Ibid.* Major new studies are now also reflecting the strength of the alternative views to EMH. See Andrew W. Lo, *Adaptive Markets: Financial Evolution at the Speed of Thought* (Princeton: Princeton University Press, 2017); Richard Bookstaber, *The End of Theory: Financial Crises, the Failure of Economics, and the Sweep of Human Interaction* (Princeton: Princeton University Press, 2017).

[23] *Ibid.* at 31.

pension funds, hedge funds and market makers) compete for scarce financial resources, in order to survive.[24]

Contrary to the assumptions that market participants are motivated to reach optimal return, the evolutionary perspective that Lo adopts claims that individuals in the market are like organisms that "have been honed — through generations of natural selection — to maximize the survival of their genetic materials."[25]

Lo developed his hypothesis upon revisiting the theory of bounded rationality promoted by Nobel Laureate Herbert Simon.[26] Simon argued that individuals can hardly reach the kind of optimization of choices that neoclassical economists have envisaged, because "optimization is costly and humans are naturally limited in their computational abilities."[27] Instead, individuals, their degree of rationality being bounded, make choices that are simply satisfactory.[28] Such a theory naturally raises the following question: how do individuals determine the point at which their optimizing behaviour is satisfactory? Lo believes that "such points are determined not analytically, but through trial and error and, of course, natural selection."[29] He further claims that "individuals based on their past experience and their "best guess" as to what might be optimal, and they learn by receiving positive or negative reinforcement from the outcomes."[30] Accordingly, Lo argues that heuristics or behavioural biases are actually developed by individuals to solve economic challenges, and once the challenges have been resolved, the heuristics will adapt to meet future environmental changes, and eventually return to approximate optimal solutions.[31]

AMH becomes so attractive because it provides us with a persuasively comprehensive picture of the contemporary financial market. It does not just tell us that market participants act in their own self-interests; it tells us also that

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[24] *Ibid.*; W. Brian Arthur also views today's economy as an ecology in which non-equilibrium is the natural state. See W. Brian Arthur, "Complexity Economics: A Different Framework for Economic Thought" (2013) Santa Fe Inst. Working Paper, at 3, 5, (observing that "[w]e are in a world where beliefs, strategies, and actions of agents are being "tested" for survival within a situation or outcome or "ecology" that these beliefs, strategies and actions together create. Further, and more subtly, these very explorations alter the economy itself and the situation agents encounter. . . . We are, in other words, in a world of complexity, a complexity closely associated with non-equilibrium."). For a systematic analysis of Brain Arthur's theory of complexity economics, see W. Brian Arthur, *Complexity and the Economy* (Oxford: Oxford University Press, 2014) [Arthur].

[25] Lo, *supra* note 6 at 30.

[26] See *ibid.*

[27] *Ibid.*

[28] *Ibid.*

[29] *Ibid.* at 30-31.

[30] *Ibid.*

[31] *Ibid.* at 31.

behavioural biases are actually the products of human optimization and rationalization processes, and can be cured and adapted to new environments through learning. It attempts also to offer an inclusive conclusion about what really motivates market participants. On this framework, market participants are motivated simply by the desire for survival,[32] and are willing to engage in endless and fierce competition.

While profits and utilities maximization are all relevant aspects of market ecology, the key to determining the evolution of the financial market is survival.[33] AMH offers a satisfying explanation of why *innovation* and *arbitrage* have long been the dominating forces that drive the evolution of financial markets.[34] To survive better and longer, innovation and arbitrage are ways that market participants utilize to create their own competitive edges over others. In addition, AMH advises us that the current market environment is a product of the natural selection process,[35] and thus the development and evolution of the market is without central direction.

The assumption of AMH is that market dynamics are extremely complex and adaptive, as too many components — such as individuals' selfishness, competition, and other environmental conditions — operate and affect one another. As a result, "convergence to equilibrium is neither guaranteed nor likely to occur at any point in time."[36] Last but not least, AMH fits our presumption that the nature of financial markets should not be simplified to reductionist claims; rather, we tend to believe that there must be multifaceted features to be fully appreciated before we can claim a comprehensive understanding of the market.

AMH is tremendously helpful for the purpose of identifying the key features of today's financial market, but it is not without limitations or inaccurate assumptions. At least one shortcoming can be found in AMH: although Lo has identified several distinct groups of market participants, he assumes that all groups behave in a common manner,[37] and that all are competing for the purpose of surviving. This relatively narrow perspective seems to have emerged from the commonsense-biased view of how we define market participants.

Of course, the financial market is where participants exchange and trade in order to pursue the maximization of profits, but it certainly should not exclude those who take part in the market mainly to *facilitate* exchange and trading functions. Central counterparties, for example, have been an indispensable part of today's market, and have long been utilized by derivatives exchanges, and by quite a few securities exchanges and trading systems.[38] Serving as an entity that

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32 *Ibid.*

33 *Ibid.* at 37.

34 *Ibid.*

35 *Ibid.* at 34-7.

36 *Ibid.* at 32.

37 As shown in *ibid.* at 31.

"interposes itself between counterparties to financial contracts in one or more [financial] markets,"[39] a central counterparty (CCP) has the potential to reduce risk to market participants by imposing vigorous risk control regimes, such as margin requirements or multilateral netting of trades.[40] On the other hand, a risk-management failure by a CCP has also the potential to disrupt markets, and that disruptions may spill over to payment systems, as well as to other settlement systems.[41]

If an analysis of the market's nature takes into account only those participants whose mission is to trade to maximize trading profits, it unduly restricts the uses to which it might have been put. In the context of financial regulation, the reason we need a better grasp of the market's nature is surely to enhance the resilience of the market, not just to cultivate an intellectually consistent hypothesis. Along with its oversight of the roles of CCPs and of other types of financial market infrastructures (FMIs), AMH does not seem to appreciate the unique roles of rating agencies and regulators[42] in facilitating and gatekeeping the order of financial markets either. A series of questions one would naturally raise are these: are FMIs, rating agencies, and regulators all motivated by the desire for survival, and competing for the same kind of scarce financial resources? If not, what are their roles in this adaptive financial ecosystem? And what motivates them to behave as they do?

The fact that AMH did not include and consider FMIs, gatekeepers and regulators as distinct groups of marker participants has shown that even the best available theory of the market does not necessarily offer a precise and impartial view of the market's nature. And this is probably the destiny that most efforts that aim to theorize the financial market eventually reach. Again, market hypotheses serve basically as approximations. If the complexity of market realities is to be really understood, observation and inductive reasoning might be the best approaches to adopt.

3. MAIN CHARACTERISTICS OF COMPLEX FINANCIAL ECOSYSTEMS

Based on what we have learned from the AMH, we now understand that the financial market is in fact a complex, adaptive ecosystem.[43] Given the

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[38] Bank of Int'l Settlements & Int'l Org. of Sec. Comm., Recommendations for Central Counterparties 1 (2004), online: < http://www.bis.org/cpmi/publ/d61.pdf > .

[39] *Ibid.*

[40] *Ibid.*

[41] *Ibid.*

[42] See Lawrence G. Baxter, "Betting Big: Value, Cautions and Accountability in An Era of Larger Banks and Complex Finance" (2012) 31 Rev. Banking & Fin. L. 765, 857 (observing that "[d]omestic and transnational regulators are themselves a part of this ecology") [Baxter, "Betting Big"].

[43] Another way to observe the financial system is to view it as "law-related systems". As

complexities and rapidly changing dynamics within this ecosystem, it would be naïve to attempt to list exhaustively *all* the characteristics of the system. The most important and direct questions with regard to our understanding of the market's nature, as the author believes, are: (1) What are the laws that govern the evolution of the financial ecosystem, and to what extent do those laws affect the communication of information, and the efficacy of regulatory interventions? (2) Who are those "major participants" of this ecosystem, and what elements motivate and incentivize their behaviours? (3) What are the forces that shape the order of the system, and does their identification hold any suggestions for how a better market order can be achieved?

To answer the questions above, this author found it is extremely helpful to observe the financial market through the lens of complexity science.[44] Treating the financial market as a complex system is by no means a novel idea.[45] Indeed, such an analogy has been gaining popularity in the aftermath of the 2008 Crisis.[46] For instance, the British Government Office for Science in 2010 published a review that observes that "the global financial markets have become a complex adaptive ultra-large-scale socio-technical system-of-systems."[47]

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observed by Anabtawi and Schwarcz based on the systems theory, "a system incorporates elements, interconnections, and functions. Further, a law-related system is a particular type of system in which law is an integral element." Iman Anabtawi & Steven L. Schwarcz, "Regulating Ex Post: How Law Can Address the Inevitability of Financial Failure" (2013) 92 Texas L. Rev. 75, 75-86 (noting that "the financial system consists of three principal elements — firms, markets, and legal rules").

[44] For an introductory review of how complexity theory is being applied to the understanding of financial systems, see for example, Baxter, "Betting Big", *supra* note 42 (Part III and the references cited therein).

[45] For the idea of viewing global financial markets as complex adaptive systems, see Lawrence G. Baxter, "Internationalisation of Law — The 'Complex' Case of Bank Regulation", in Mary Hiscock & William van Caenegem eds., *The Internationalisation Of Law: Legislating, Decision-Making, Practice and Education* 3 (2010) [Baxter, "Complex Case"]; see also, Andrew G. Haldane & Robert M. May, "Systemic Risk in Banking Ecosystems" (2011) 469 Nature 351, 351-55 [Haldane & May]. The complexity economics, an emerging scholarship that is getting traction recently, also views the economy (which conceptually includes financial markets) as a system where "agents are constantly creating an "ecology" of behaviours they must mutually adapt to." Arthur, *supra* note 24, at Preface.

[46] For relevant commentaries, see e.g., Debora MacKenzie, "Why the Financial System Is Like An Ecosystem" *New Scientist* (22 October 2008), online: < http://www.newscientist.com/article/mg20026794.600-why-the-financial-system-is-like-an-ecosystem.html > ; Gary Stix, "The Science of Bubbles and Busts" (2009) 301 Sci. Am. 78, 78; John Kay, "Barbarians at the Gates of Complexity" *Financial Times* (5 October 2010), online: < http://www.ft.com/intl/cms/s/0/902fc3d8-d0b0-11df-8667-00144feabdc0.html#axzz1ounhwDou > .

[47] Dave Cliff & Linda Northrop, "The Global Financial Markets: An Ultra-Large Scale Systems Perspective" in R. Calinescu & D. Garlan, eds., *Large-Scale Complex IT Systems. Development, Operation and Management*. (2012), online: < http://www.bis.-

Analogizing "the financial market" and "complex system" is sensible and attractive for at least the following reasons:

- First, the massive interconnectedness that manifested in the run-up to the 2008 Crisis did speed up the contagion of default risk, and did drive the bankruptcy of an investment bank into a world-wide systemic event.[48] The seemingly disproportionate market reactions had, to a certain extent, demonstrated the phenomena called "Power Laws" and "Non-linearity" by complexity theorists.[49]

- Second, the continuous occurrences of the so-called "glitches" in trading systems[50] around the world could generally be attributed to the immense technological complexities within the contemporary trading and exchange systems.[51] Furthermore, the sudden irrational collapses of stock markets caused by these glitches are also examples of "Power Laws" and "Emergence" in complexity science.

- Third, the sheer volume of rules and regulations aimed at reforming the financial system has been growing to an unmanageable and complex peak, either domestically or internationally.[52] This huge regulatory complexity not only makes the outcomes of every single regulation

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gov.uk/assets/bispartners/foresight/docs/computertrading/11-1223-dr4-global-financial-markets-systems-perspective.pdf > .

48 Nevertheless, the failure of Lehman Brothers was by no means the direct cause of the 2008 Crisis. Rather the event was just the last straw that broke the camel's back. See John H. Cochrane & Luigi Zingales, "Lehman and the Financial Crisis" *Wall Street Journal* (15 September 2009), online: < http://online.wsj.com/news/articles/SB10001424052970203440104574403144004792338 > .

49 See Helbing, *infra* note 151 at 3-4.

50 When interviewed by the CNN Money, a trader and market structure consultant observed that "[t]he market has become so complex and so intertwined. "One little hiccup and everything goes down." Maureen Farrell, *Trading Glitches a Sad New Market Reality*, CNN Money (22 August 2013), online: < http://money.cnn.com/2013/08/22/investing/nasdaq-trading-glitch/index.html > .

51 The root cause of trading abruption could be traced to complexity issue. See E.S. Browning & Scott Patterson, "Market Size + Complex Systems = More Glitches" *Wall Street Journal* (22 August 2013), online: < http://www.wsj.com/articles/SB10001424127887323980604579029342001534148 > .

52 For how complex rules and regulatory complexity adversely affect the robustness of the global regulatory framework, see Andrew G. Haldane & Vasileios Madouros, "The Dog and the Frisbee" (Speech delivered at the Federal Reserve Bank of Kansas City's 366th economic policy symposium, Jackson Hole, Wyoming, 31 August 2012), transcript online: < http://www.bis.org/review/r120905a.pdf > ; the term "complexity risk" has also been used to denote risks as a result of convoluted and complex regulations, see Karen Shaw Petrou, "The Complexity-Risk Conundrum: Why SIFIs Can't Be Both Bullet-Proof and Profit-Making" (Remarks prepared for the Securities Industry & Financial Markets Ass'n., 10 January 2012), transcript online: < http://www.fedfin.com/images/stories/press_center/speeches/SIFMA_Sp > .

unpredictable, but also dramatically complicates the "cat-and-mouse" games between regulators and the regulated.

The fact that regulatory outcomes do not equal the sum of every regulatory input has proven that the financial market is in fact a non-linear system, where "one cannot reduce causes and effects into simple . . . reductionist relationships."[53] Lastly, part of the attraction of complexity theory is that "it operates on a very high level of generality."[54] Such a level of generality makes it fairly easy to apply complexity science to both natural evolutionary systems as well as to artificial systems such as computer networks, transnational regulatory networks, and even to the wider economy.[55]

There is a set of elements of complexity science that is particularly relevant to our observation of the contemporary financial market. This set of elements, together with other features of market realities this author has observed, as well as the current literature,[56] constitute the key characteristics of the complex financial ecosystem this article envisages. Below is the analysis of the main features of today's adaptive, complex financial ecosystem.

(a) The Overall Picture of Today's Ecosystem: System-of-Systems and Network Architectures

The financial ecosystem is a system-of-systems,[57] in which every sub-system has its own sub-systems. Species of all kinds act as "agents" within each sub-system, and their relationships with one another constitute countless networks of different sizes. Each sub-system has self-similar patterns with other micro-level systems, and with the macro-level system.[58] Given the nature of the ecosystem, the sheer volume of complexities and interconnectedness has made the evolution of the system such that it is without a central direction, and is intrinsically unpredictable.

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[53] Baxter, "Betting Big", *supra* note 42, at 20.

[54] Donald Hornstein, "Complexity Theory, Adaptation, and Administrative Law" (2005) 54 Duke L. J. 913, 917.

[55] *Ibid.*

[56] For a comprehensive summary of the key elements of complexity systems, see Baxter, *supra* note 42; see also, Dirk Helbing *et al.*, *Managing Complexity: Insights, Concept, Applications* (Springer-Verlag Berlin Heidelberg, 2008).

[57] For the characteristics of such a system-of-systems, see Baxter, "Betting Big", *supra* note 42 at 854-861.

[58] Yet the functioning of the system "as a whole is distinct from the functioning of its component parts." Steven L. Schwarcz, "Regulating Financial Change: A Functional Approach," 100 Minn. L. Rev. 25-32, online: <http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=5995&context=faculty_scholarship>, at 32. (observing that "[t]he function of the financial system as a whole is to serve as a network within which its component elements, firms and markets, can achieve the economic functions previously identified and discussed.").

Nonetheless, this feature does not necessarily suggest that there is nothing policymakers can do in terms of making this system more resilient. First, because the overall system demonstrates self-similarity on every level, sometimes what works in the sub-system may work in the upper-level system too. For instance, the overall stock-trading system in the US can be viewed as such a system, wherein 13 exchanges and about 40 dark pools operate as sub-systems, together with countless interacting human agents and computer systems. Although the communication and information-transmission of the inter-exchanges is of paramount importance for the stability of such a system, this does not mean that the rules or the governing regime of the individual exchange cannot be applied to other exchanges. On the contrary, certain mechanisms, such as the circuit break program, and Rules for Breaking Clearly Erroneous Trades,[59] can be universally applied to all exchanges, as those mechanisms aim to tackle problems that result from the same pattern that every individual exchange shares.

Second, some nodes in the network are very large and concentrated, and thus would affect the overall system adversely and disproportionately. Overseeing *all* nodes in the system is simply unrealistic, as it would require indefinite input from regulators, either in fiscal resources or work hours. Nevertheless, injecting regulatory resources only into the oversight of large and concentrated nodes could be a relatively sensible approach. Large and concentrated nodes are usually multinational, ultra-large financial institutions that are immensely interconnected to other nodes in the network. This nature makes those financial conglomerates "super spreaders"[60] of potential systemic risk because a single failure within one node will trigger a series of failures of its successive nodes and sub-systems. Such a phenomenon, referred to as "cascading failures"[61] by network scientists, was exactly the kind of failure that made the 2008 Crisis an uncontrollable systemic event. If complexity science is to lend any support to the post-Crisis regulatory reforms, regulating "super spreaders" to

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[59] For a quick but comprehensive introduction of the new SEC circuit breaker program and erroneous trades breaking rules, see Deborah L. Jacobs, "Why We Could Easily Have Another Flash Crash" *Forbes* (9 August 2013), online: < http://www.forbes.com/sites/deborahljacobs/2013/08/09/why-we-could-easily-have-another-flash-crash/ > .

[60] Haldane & May, *supra* note 45, at 354.

[61] For the use of the term "cascading failures" in the context of financial crisis, see Jeffrey D. Sachs, "Blackouts and Cascading Failures of the Global Markets", *Scientific American* (15 December 2008), online: < http://www.scientificamerican.com/article.cfm?id = blackouts-and-cascading-failures > (noting that "[c]ascading failures are an emergent phenomenon of a network, rather than the independent and coincidental failures of its individual components." "Bank regulators and macroeconomic policymakers have focused too much attention on the individual nodes of the network (that is, on each bank, and each national economy) without proper regard for the system-wide amplification."). For the cause and mechanism of cascading failures, see Helbing, *infra* note 151, at 5-8.

ensure their resolvability is definitely the first lesson learnt by worldwide policymakers.

(b) Primary Groups of Agents Operating within the Ecosystem

Distinct groups of market participant in the financial ecosystem can be observed as different "agents" within a complex system. An agent is generally an entity that acts consciously to meet certain desirable outcomes. Agents are the minimum comprising units within a complex system, and the interactions among them constitute networks and sub-systems, and in turn, define the scope of the overall complex ecology. The taxonomy of agents in the financial ecosystem varies, but this author finds it helpful to classify all agents into five major categories: *Retail Investors*, *Institutional Investors*, *Financial Market Infrastructures*, *Financial Gatekeepers* and *Regulators*. The reason this classification is adopted is that it clearly identifies and differentiates the groups of agent whose actions are driven by distinct motivations, and those governed by divergent interests.

(i) Retail investors

Generally speaking, most market hypotheses are built on scholars' understandings of retail investors. Every retail investor, be it a consumer (investor) of a specific type of financial product or an individual shareholder of a public company, is a human being. No matter that we believe that humans make their decisions according to their bounded or unbounded rationality, our beliefs basically reflect nothing but our own imaginations about, and understandings of, human nature. (It is as well to remember that the exploration of human nature had provoked fierce debates between the neoclassical and behavioural economists.)

Scholarly debates aside, there is little dispute on the point that retail investors generally act to pursue maximized monetary gains. Motivated mostly by the maximization of investing profits, retail investors engage in the ecosystem by buying and selling particular financial products. Timing, quantity and price are the three decisive factors that govern their every trading decision, and these decisions can be evaluated thoroughly only on the presentation of sufficient market information. Retail investors factor as much relevant information as possible into their decision-making, and sometimes compete fiercely with one another for scarce financial resources, such as credits — the right or chance to buy certain types of securities. A timely, fully transparent disclosure regime may be of collective interest for retail investors, but might sometimes be undesirable for a single individual retail investor, as it forbids the investor to himself take advantage of undisclosed proprietary information.

Retail investors are usually not very large "nodes" in the ecosystem, unless a concerted action is adopted collectively by consumer groups, or some individual investors are wealthy enough to affect the up-and-down market wave.[62] In most

cases, retail investors are inferior in terms of their competition with institutional investors, and thus are deserving of more regulatory protection.[63]

(ii) Institutional investors (financial institutions)

Institutional Investors constitute the core of the financial ecology. Commercial banks, investment banks, insurance companies, hedge funds, private equity funds, and pension funds are all various forms of institutional investor. Similar to retail investors, they are all more or less motivated to generate maximized investing profits, or, to be precise, maximized profits for their shareholders and primary beneficiaries. Despite their status as "legal persons", the motivation and rationale that affect institutional investors' actions and decision-making should not be seen simplistically as the same as the motivation and rationale of retail investors, who are real human beings.

First, the assumptions about rationality that the neoclassical economists made can apply to an organization only when there is no doubt that the decision-making process in that organization is a process powered by human brains. Nonetheless, the literature has all too often suggested otherwise. There are plenty of discussions of models of organizational decision-making, but the classic and most comprehensive model is in international politics, in the work of highly-regarded political scientist, Graham Allison, who introduced three models of governmental decision-making in his well-known book, *Essence of Decision: Explaining the Cuban Missile Crisis*.[64] Although the three distinct models: *Rational Model*, *Organizational Process Model* and *Bureaucratic Bargaining Model*,[65] were derived from the context of a government's foreign policy decision-making process, they are a surprisingly valid fit in almost all kinds of organizational decision-making contexts.

Only when the Rational Model applies can an institutional investor's decision-making be considered "rational" in the EMH sense. Where a financial institution is in fact governed by the Organization Model, it is the set of stringent standard-operation procedures (SOPs) that are being followed in the decision-reaching process, rather than the thorough examination of all available options before the final decision is made. In most situations, nevertheless, financial institutions follow the pattern depicted in the Bureaucratic Bargaining Model. On this model, decisions are in fact reached through the bargaining process in which representatives of different interests within the organization negotiate,

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[62] It is noteworthy, though, that before the deposit insurance was launched, retail investors used to be very large "nodes" when they engaged in runs on banks.

[63] This is the exact reason that consumer financial protection has become one of the most important and urgent issues for financial regulators. The awareness of the importance of consumer financial protection has pushed for the creation of the Consumer Financial Protection Bureau in the US.

[64] Graham T. Allison & Philip Zelikow, *Essence of Decision: Explaining the Cuban Missile Crisis* (1999).

[65] *Ibid.*

then reach a compromise. For instance, traders and their immediate direct supervisors may push for more risky investments than do the other departments of the firm, as traders are strongly driven by the desire to earn handsome bonuses. If a firm is dominated by a culture that encourages traders to bet as high as they can, the firm may overlook some healthier, more rational investment options, and end up making harmful, biased investing decisions.

Second, unlike retail investors, who are motivated mainly to maximize their investing profits, financial institutions are also driven by the desire for *survival* and *growth*. The survival of a financial institution does not always equal to the pursuit of maximized profits within a fiscal year. Sometimes it is all about gaining long-term competitive advantages by entering an underserved market first, cultivating unique niche products, or building networks effects. Such a reality greatly affects the dynamic games within the ecosystem, because it makes the prediction of a counterparty's *short-term* behaviour extremely unlikely. Pursuing growth in size, through either organic growth or mergers and acquisitions, is also a very important objective for contemporary financial institutions. Such a thrust can be explained in part by the expected advantages of being a "too-big-to-fail" firm, but is driven mostly by the endless pursuit of *efficiencies of scale*.[66] Despite the unsettled empirical evidence on whether bigger banks really gain in efficiency and economies of scale,[67] there seems to be an undisputed consensus among bankers that "*larger* and *more diversified* financial institutions outperform their smaller counterparts."[68] Furthermore, scale enables larger financial institutions to maintain growing profitability through increasing *leverage*.[69] This can be inferred from the fact that the leverage of banks has increased significantly from approximately 10-to-1 to as much as 75-to-1 or more[70] in the past century.

In addition to the dissimilar motivations and processes of decision-making, institutional investors differ greatly from retail investors on another important dimension. Financial institutions can often be very large nodes, and they wield the power of being able to spread the *risk of failure* in the ecosystem rapidly.[71] Furthermore, the interconnections among large financial institutions can sometimes constitute vast networks, and even sub-systems, and thus contribute further great instability to the overall system.[72] Such a feature naturally lends

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66 Baxter, "Betting Big", *supra* note 42 at 786-87.

67 For a good overview of evidence for efficiencies of scale and scope, *see Id.* at 807-11. See also The Eur. Comm., High-level Expert Group on Reforming the Structure of the EU Banking Sector: Final Report ["Liikanen Report"], appendix 4 (2012), online: < http://ec.europa.eu/internal_market/bank/docs/high-level_expert_group/report_en.pdf > .

68 Baxter, "Betting Big", *supra* note 42 at 803.

69 *Ibid* at 804.

70 *Ibid.*

71 *Ibid.* at 850.

72 See *ibid.* at 857-61.

support to regulatory proposals that aspire to enhance the regulation of ultra-large financial institutions, either in *ex ante* supervision or *ex post* resolution. A view among commentators that has gained a growing popularity is that an enhanced regulatory regime for financial conglomerates can effectively increase the resilience of the financial system.

(iii) Financial market infrastructures

A financial market infrastructure (FMI) "is defined as a multilateral system among participating institutions, including the operator of the system, used for the purposes of clearing, settling, or recording payments, securities, derivatives, or other financial transactions."[73] Such a definition includes five major types of FMI: payment systems, Central Securities Depositories (CSDs), Securities Settlement Systems (SSS), Central Counterparties (CCPs), and Trade Repositories (TRs).[74] Trading exchanges, trade execution facilities, and multilateral trade-compression systems can also be included if a broader definition is adopted.[75] FMIs are dramatically different from institutional investors. Unlike traditional financial institutions, FMIs do not ordinarily create risks, but are thought to "reduce risks that arise as part of the transaction process, and to enable the better management of [a variety of] risks."[76] For instance, CCPs and payment systems aim to "reduce credit and liquidity risk by enabling the multilateral netting of financial exposures."[77] Furthermore, CCPs, help also by injecting transparency into the "complex networks of bilateral exposures, and . . . [by] mitigat[ing] credit risk by collecting margin from all counterparties."[78]

The rationales behind the decision-makings of FMIs, like those of institutional investors, differ in accordance with what organizational form an FMI adopts. Modern FMIs are legally organized as a number of forms, including "associations of financial institutions, nonbank clearing corporations, and specialized banking organizations."[79] Some FMIs are operated by a central bank, whereas others are owned by the private sector.[80] Besides, not all FMIs operate as for-profit entities. The *rationales* of FMIs' actions are subject also to the three models of organizational decision-making described above, and are surely not entirely rational in any sense.

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[73] Bank for Int'l Settlements & Int'l Org. of Sec. Comm., Principles for Financial Market Infrastructures 7 (2012), online: <http://www.bis.org/publ/cpss101a.pdf>.

[74] *Ibid.*

[75] *Ibid.*

[76] Bank of England, *infra* note 81, at 1.

[77] *Ibid.*

[78] *Ibid.* at 1-2.

[79] Bank for Int'l Settlements & Int'l Org. of Sec. Comm., *supra* note 73, at 7.

[80] *Ibid.*

Motivations that drive FMIs' actions are nonetheless worth noting. For those for-profit entities, maximizing monetary gain is no doubt a key motivating force. Non-profiting FMIs (and *theoretically all* FMIs) should, nonetheless, also be motivated to mitigate risk and enhance stability in the wider financial system. That is, they should be inspired to pursue the social optimum. As correctly observed in a report by the Bank of England, FMIs are "in essence, sets of rules, contracts, processes and operational arrangements for managing, reducing and allocating risk arising from transactions between market participants."[81] Therefore, "monitoring, managing and mitigating risk, including systemic risk, is, then, a primary responsibility for the operators of Financial Market Infrastructures."[82]

It is very important, especially for the purposes of this article, to recognize the residual fact that certain groups of market participant are in fact motivated or equipped to *realize the social optimum*. Policy measures premised on the neoclassical economic assumption that market participants are only motivated to pursue optimal returns may mislead us to believe that the incentives of certain individual market actors can never be aligned with the incentive to achieve the collective good. Furthermore, misled thus, we are made to ignore the possible roles FMIs perform in the enhancing of the disciplinary power of the financial market.

Almost every FMI represents a fairly large network in the ecosystem, because most FMIs enjoy monopoly or oligopoly status in their respective business or service line. This structure can sometimes unduly concentrate risk of failure on a single large FMI, and therefore make the disorderly insolvency or operational failure of an FMI a severe systemic disruption.[83]

(iv) Financial gatekeepers

In addition to the abovementioned groups, there are many other actors/agents who undertake various secondary roles in the market, such as gatekeeping and transaction facilitating. Among those agents, rating agencies, auditors and transactional attorneys are probably the most active ones. Being recognized as "gatekeepers" in a broad sense, these agents usually receive smaller payoffs for their agency in the approval, certification, or verification of information than

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[81] Bank of England, The Bank of England's Approach to the Supervision of Financial Market Infrastructures 3 (2013), online: <http://www.bankofengland.co.uk/financialstability/Documents/fmi/fmisupervision.pdf>.

[82] *Ibid.*

[83] As pointed out by the BCBS, although "FMIs are unlike most other forms of financial institution in that they will typically have rules and procedures which are binding on their participants and which can enable them to establish arrangements to recover from financial shocks. An FMI is therefore less likely to reach the point where it needs to be resolved by the relevant authorities." However, "the possibility of it reaching such a point cannot be ruled out." Bank for Int'l Settlement & Int'l Org. Sec. Comm., Recovery and Resolution of Financial Market Infrastructures 2 (2012), online: <http://www.bis.org/publ/cpss103.pdf>.

does the principal in the transaction that the gatekeeper facilitates.[84] Furthermore, these agents are primarily persons who command substantial reputational capital, which they pledge as assurance of the accuracy of statements or representations, and verify them thereby.[85]

Because the payoffs of financial gatekeepers are relatively small, and what keeps the long-term profitability of their businesses is in fact their reputation, they are generally motivated to pursue *the long-term accumulation of reputational capital*,[86] rather than pursue short-term monetary gains. Nonetheless, the current business models and industrial structure indeed make financial gatekeepers and rating agencies (particularly auditors) rather dependent on their clients, and in turn, less disposed to apply the highest professional standards in their gatekeeping activities.[87] Rating agencies, for example, were heavily criticized for failing to provide impartial ratings, because their ratings are influenced by their issuer-pay model.[88] For the purposes of this article, a key implication one must take into account when recognizing financial gatekeepers as major market participants is that these gatekeepers not only facilitate the communication of information to the market, but also equip other market participants with *capacity* to exercise disciplinary power.

Financial gatekeepers are ubiquitous, and play a very active role in every "linkage" that connects the nodes of the ecosystem. A malfunctioning of their gatekeeping mechanism, although it may not immediately contribute to a direct chain-reaction, will imperceptibly alter the shared *culture* or *behavioural patterns* of market participants in a negative way. Conversely, the well-functioning role of a financial gatekeeper can not only advance the accuracy, sophistication and transparency of the circulation of market information, but it can also restore the trustworthiness and integrity of the market participants in the ecosystem. The awareness of the importance of the trustworthiness by market actors is remarkable because it will, on the one hand, increase the actors' *willingness* to exercise disciplinary power, and will make market participants less likely to deviate from their ethical or professional standards.

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[84] John C. Coffee, Jr., "Gatekeeper Failure and Reform: The Challenge of Fashioning Relevant Reforms" 84 B.U. L. Rev. 301, 308-09 (2004).

[85] *Ibid.*

[86] See John C. Coffee Jr., *Gatekeepers: The Professions and Corporate Governance* (Oxford: Oxford University Press, 2006) 2-3.

[87] See Ross Buckley, "Reconceptualizing the Regulation of Global Finance" 36 Oxford J. of Legal Studies, 242, 252-254, 269-270 (explaining the changes in the business models of rating agencies and how does such changes subject rating agencies to major conflicts of interest).

[88] Han Xia & Günter Strobl, *The Issuer-Pays Rating Model and Ratings Inflation: Evidence from Corporate Credit Ratings* (Soc. Sci. Res. Network Working Paper, 2012), online: < http://papers.ssrn.com/abstract = 2002186 > (concluding that "the conflict of interest caused by the issuer-pays rating model leads to inflated corporate credit ratings").

(v) Financial regulators

Financial regulators, domestically or transnationally, are no doubt a part of this ecology. The definition of financial regulators encompasses a variety of groups. Central banks, financial supervisory agencies of all kinds, bank examiners, self-regulatory organizations, and various transnational/transgovernmental regulatory networks (TRNs)[89] are all important components of the financial-regulators domain.

Most discussions of the market's nature tend to overlook the very status as *fact*, whether one likes it or not, of regulators' being very important participants in financial markets.[90] A picture that aims to portray the financial market without painting in the regulators would simply be an incomplete and inaccurate one. Traditional market theories suggest that regulatory interventions are mainly created, and should only be adopted, for correcting market failures or externalities problems.[91] Some extreme views even hold that the invisible hand of the market itself will fix every glitch, given a sufficiently long period of time. Nevertheless, none of these views reflects accurately the realities that we have been witnessing and experiencing since the inception of modern financial markets.

The fact is that we are becoming more dependent on heavy regulation as the primary response to repeated occurrences of financial crisis. The hands of domestic regulators and TRNs are reaching into almost every function and dimension of financial markets, and these regulatory hands themselves have constituted a complex web in which full compliance with regulations looks like an unmanageable mission for financial institutions.[92] It is no longer a need to respond to certain market failures as occasions that warrant regulators' intervention. Rather, regulators now choose to adopt preventive approaches extensively, in order to mitigate systemic risk and maintain financial stability *beforehand*. The growing importance and vigorousness of regulatory actions has made us curious about how the best balance of regulatory intervention and market solutions can be reached, and what other undertakings might become possible roles of regulators.

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89 See Anne-Marie Slaughter, *A New World Order* (Princeton: Princeton University Press, 2004). See also Pierre-Hugues Verdier, "Transnational Regulatory Networks and Their Limits", 34 Yale J. Int'l L. 113 (2009); Kal Raustiala, "The Architecture of International Cooperation: Transgovernmental Networks and the Future of International Law," 43 Va. J. Int'l L. 1 (2002).

90 Baxter, "Betting Big", *supra* note 42, at 866 (observing that "[t]he situation presents a classic example of how the regulators themselves are important interactive agents within the overall complex adaptive system of systems.").

91 See David Gowland, *The Regulation of Financial Markets in the 1990s* (Aldershot, Hants, England: E. Elgar,1990) 21 (recognizing that one of the primary justifications of financial regulation is to correct market failure).

92 For the causes of regulatory complexity, see Baxter, "Betting Big", *supra* note 42 at 863-66.

Although financial regulators generally follow the patterns demonstrated by the three models of institutional decision-making, their decision-making is also heavily affected by issue-relevant interests groups and constituents. Interest groups and their constituencies are vocal in the decision-making processes of financial regulators for two reasons. First, financial markets are relatively mature and sophisticated in western developed countries, as distinct from those of emerging economies. These western countries all live to some extent in the shadow of political pluralism[93] (a concept with multiple meanings), but basically envisage the just political decision-making process as the endless bargaining process among different interest groups.

Under political pluralism, many non-governmental groups use their resources to exert influence, and eventually, consensuses on particular issues are reached. This naturally encourages regulatory agencies to be as responsive to their constituency and relevant interest groups as they can. Second, rapidly-changing financial innovation makes the industry, rather than the regulators, the expert on novel products or services. Such an asymmetry in expertise has in fact forced regulators to be deferential to industrial groups on a variety of issues.[94]

Financial regulators are motivated to achieve a range of different objectives, despite the fact that all intended objectives aim to enhance the social optimum. The heterogeneity of motivations would sometimes subject financial regulators to conflicts of interests in the context of transnational policy-making and supervision. Although a TRN is meant to serve the collective interests of its members, technocrats and representatives of different member countries are usually tied to, or captured by, domestic interests, as they are accountable *de jure* to their respective constituencies.[95]

In certain cases, inter-agency conflicts occur also on the domestic level, especially when a new business line or practice is emerging, and more than one agency is competing to expand its own regulatory power.[96] It is important to understand that financial regulators are motivated by diverse objectives, and that

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[93] For a good overview of political pluralism in the context of western countries, see Darryl Baskin, "American Pluralism: Theory, Practice, and Ideology", 32 J. Pol. 71 (1970).

[94] Some commentators even claim that regulators are in fact "captured" by the financial industry. On the other hand, some scholars have made powerful argument asserting that even though the appearance of undue industry influence seems great, it could be too facile to assert that financial agencies are simply "captured". See, for example, Lawrence G. Baxter, "Capture Nuances in Financial Regulation", 47 Wake Forest L. Rev. 537 (2012).

[95] One of the primary values of the theory of TRNs, as its proponents claimed, is to resolve the "global paradox". Slaughter, *supra* note 89, at 8 (explaining that "[w]e need more government on a global or regional scale, but we don't want the centralization of decision-making power and coercive authority so far from the people actually to be governed.").

[96] The dispute over who should regulate and oversee financial derivatives among agencies is exactly the kind of example. See Roberta Romano, "The Political Dynamics of Derivative Securities Regulation", 14 Yale J. on Reg. 279 (1997).

this diversity dramatically affects the interactive games of regulators and the regulated. Regulatory arbitrage and regulatory capture[97] are the two most salient examples of the industry trying to harness and profit from diversity.

(b) Laws Governing the Evolution of the Ecosystem

Although the financial ecosystem is a complex system without central control or specific direction of development, this does not necessarily mean that there is no equivalent of "law of physics" that *governs* or *affects* the overall evolution of the system.[98] On the contrary, complexity theorists have considered a set of elements[99] that not only serve the purpose of characterizing complex adaptive systems, but also offer great insights to help us understand how these systems are shaped. There are three elements that this author believes best depict the laws governing the system-wide evolution: *Non-linearity, Power Laws,* and *Path Dependency*. Each will be analyzed, and used to explain why the contemporary financial ecosystem evolves the way it does.

(i) Non-linearity

Complex adaptive systems are non-linear systems. This fundamental feature denotes that the behaviour of these systems cannot be explained in the mechanical, reductionist linear manner; rather, these systems are non-linear ones in which "the whole is different from the sum of its parts."[100] As correctly observed by environmental law scholars, and nicely put by Professor Hornstein, ecosystems "are no longer modeled simply as reflecting the balance of nature or as reflecting the predictable, evolutionary succession of stages of ecological development."[101] This teaches us that the evolution of ecosystems is generally unpredictable, and constantly inconstant. The overall ecosystem is in fact governed by the Law of Constant Change and Instability, the very essence of non-linearity.

This particular law of physics holds at least three implications for the contemporary financial system. First, the consequence of imposing a specific set

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[97] For a novel approach to observe the complicated embrace between regulators and the financial industry, see Baxter, *supra* note 94.

[98] Scholars who draw on chaos theory and the "law and engineering" approach to analyze modern financial markets may observe that there are no general laws for complexity. Under this law-and-engineering approach, "failures are almost inevitable in complex systems and that successful systems are those in which the consequences of a failure are limited." So the most sensible way to regulate complexity in financial markets is to limit the consequences of inevitable financial-market failures, such as with the use of a "market liquidity provider of last resort". See Steven L. Schwarcz, "Regulating Complexity in Financial Markets", 87 Wash. U. L. Rev. 211, 265-266 (2009).

[99] For a good overview of the commonly referred elements in complexity science, see Baxter, "Complex Case", *supra* note 45 at 14-20.

[100] *Supra* note 95 at 14.

[101] Hornstein, *supra* note 54 at 931.

of regulations or laws may not be the intended one, and the outcomes are highly subject to the interactive dynamics of the agents within the financial ecosystem.[102] The risk-weighting regime adopted in calculating a bank's capital is probably the best example of this phenomenon. In order to "harness the perceived advantages of internal models for the measurement of credit risk",[103] Basel II allows banks to calculate regulatory capital requirements with their own estimated risk parameters. This Internal Ratings-Based (IRB) approach was envisaged to achieve two major goals: the enhancement of risk sensitivity, and the promotion of incentive compatibility.[104] Nevertheless, in hindsight, neither of these intended objectives has materialized. The pursuit of "risk sensitivity", a mission accomplished by banks mainly by their pushing out of assets into off-balance sheets, leads to a false sense of security. To boot, banks were hardly incentivized to perfect or improve their risk management; in fact, they were instead encouraged to take greater risks, because they now have the "best" risk model — the so-called Value at Risk (VaR) — to justify their risk-taking decisions. The VaR model lets banks stay in their comfort zones, and make decisions without taking into consideration the consequences of extreme events.[105] The outcomes of the adoption of the IRB capital regime are largely unpredictable, and almost directly contradict the original regulatory intents. These consequences are vivid demonstrations of non-linearity, and were aroused mainly in the complex dynamics of regulators and the regulated.

Second, the consequences of or system-wide reactions to the failure or major default of a highly interconnected financial institution may become an unexpected or seemingly irrational systemic-crunch of liquidity.[106] Salient examples are the failure of Bank Herstatt and Lehman Brothers:[107] both contributed to a system-wide banking crisis that perhaps no one had ever expected. Furthermore, both failures introduced landmark regulatory reforms that eventually drove the evolution of financial markets to another level.[108] The

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[102] Baxter, "Complex Case", *supra* note 45 at 20.

[103] Basel Comm. on Banking Supervision, "The Regulatory Framework: Balancing Risk Sensitivity" Simplicity and Comparability 6 (2013), available at <http://www.bis.org/publ/bcbs258.pdf>.

[104] Basel Comm. on Banking Supervision, The Internal Ratings-Based Approach 1 (2001), available at <http://www.fsa.go.jp/inter/bis/bj_20010117_1/1l.pdf>. See also, *ibid.*

[105] For an empirical study on the limitations of the VaR model, see Andreas Krause, "Exploring the Limitations of Value at Risk: How Good Is It in Practice?", 4 J. of Risk Fin. 19 (2003); VaR is often estimated through the use of Gaussian copula function, a formula that was criticized as a devastating punch that "killed Wall Street". Felix Salmon, "The Formula that Killed Wall Street" 9 Significance 16 (2012).

[106] Baxter, "Complex Case", *supra* note 45 at 18

[107] *Ibid.*

[108] The failure of Herstatt Bank led to the worldwide implementation of Real Time Gross Settlement Systems (RTGSes), which ensures that payments between one bank and another are executed in real-time.

US Dodd-Frank Reform, for instance, has not only introduced endless debates over how to make the financial ecology more resilient, but also dramatically changed both the industrial and regulatory landscapes in the US. Non-linearity, again, shows its ability to drive the evolution of our financial ecosystem.

Third, market solutions that rely on best practices may turn out to be useless, or lose applicability after the market has reached another level of evolution. The growing complexity in market transactions and trading technology lets the so-called "fat tail" or "black swan"[109] events happen more frequently than ordinary human wisdom would expect. If an industrial best practice fails to appreciate the fact that this complexity has sent the evolution of the market into another universe, then this practice will soon become valueless, as it is premised on obsolete assumptions about the market. The wide industrial adoption of VaR is one of the best illustrations of this phenomenon.[110] VaR was developed and popularized in the early 1990s by a handful of scientists and mathematicians,[111] and became dominant on the strength of its promotion by the US Securities Exchange Commission (SEC) [112] and the BCBS.[113]

Generally speaking, VaR measures the boundaries of risk in a portfolio over a short duration, on the assumption that a market is "normal".[114] VaR, however, fails to factor in the possibility of the occurrence of a black-swan event. This omission might not be a severe and dangerous one if we were still living in a financial ecology where black-swan events rarely happen.[115] Nonetheless, we are now actually living in an ecology where "Power Laws" determine the frequency of the occurrences of highly unlikely events.[116] Now, the "once-in-a-lifetime" systemic crisis happens more often than the VaR model had assumed. This feature makes the predictive power of VaR fairly unreliable,[117] and makes it no longer the most desirable risk management model.

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[109] For a readable and classical book on the theory of the Black Swan, see Nassim Nicholas Taleb, *The Black Swan: The Impact of the Highly Improbable* (Revised edition, London: Penguin, 2010) .

[110] The pervasive use of the VaR model is also viewed as a result of reliance on heuristics. *See* Steven L. Schwarcz & Lucy Chang "The Custom-to-Failure Circle", 62 Duke L. J. 767, 772-777 (2012).

[111] *See* Joe Nocera, "RISK Mismanagement - What Led to the Financial Meltdown" *N. Y. Times* (2 January 2009), online: < http://www.nytimes.com/2009/01/04/magazine/04risk-t.html > .

[112] *Ibid.*

[113] VaR models are also used "to generate bases for compensating [bank] employees and managers, such as adopting compensation systems that reward profit generation with "low risks" as indicated by VaR statistics." Schwarcz & Chang, *supra* note 110, at 773.

[114] Nocera, *supra* note 111.

[115] *Ibid.*

[116] Larry Elliott & Mark Milner, "Age of Anxiety", *The Guardian*, (10 July 2001), online: < http://www.theguardian.com/business/2001/jul/10/globalrecession > (reporting the fact that "[t]he frequency of financial crises has doubled since the Bretton Woods fixed exchange rate system collapsed in the 1970s.").

Non-linearity, in summary, subjects the entire financial ecosystem to a highly unpredictable dynamic game. In this game, everything is constantly changing, and there is no central direction. Every effort exerted to affect other agents' behaviours may very easily fare into a totally unexpected outcome and direction, regardless of whether the effort is made by a regulatory agency or by an influential bank. Non-linearity also makes the overall financial ecology a very unstable one. The entire financial industry is susceptible to unexpected extreme events, and worse, the regulatory landscape, envisioned to reduce susceptibility, is itself susceptible to ineffectuality or complex regulations. In the aftermath of the 2008 Crisis, the various reform efforts around the world were made to mitigate systemic risk, or to reduce the likelihood of systemic events. Nonetheless, we learned to our surprise that most of these efforts were conditioned upon the successful implementation of a myriad of complex regulations and rules. An inevitable question one must ask oneself is that if the overall system we are dealing with is already so unpredictable and non-linear, why do we push for more complex regulations, and wait for more unpredictable outcomes to be introduced by the implementation of these regulations?

Although the lesson learned from the non-linear feature of the financial ecology indeed looks very discouraging, we now at least know that there are two important mistakes policymakers should avoid making: first, policymakers should not escalate unduly the complexity of their proposed legislations or regulations with endless rulemaking; second, whenever a policy or a set of rules is adopted, policymakers should be prepared to change the policy or rule in response to the evolution of the financial ecology. In other words, policymakers should not refuse to adapt themselves to new changes introduced by the market, and should avoid sticking to any principles, rules or heuristics, no matter how persuasive and useful they might look.

(ii) Power laws

Another law of physics that governs the evolution of the financial ecosystem is Power Laws.[118] Power Laws can be understood as a sub-concept of non-

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[117] The VaR model is unreliable in many ways. *See* Simon Johnson & James Kwak, "Seduced by A Model" N.Y Times Economix Blog (1 October 2009), online: < http://economix.blogs.nytimes.com/2009/10/01/seduced-by-a-model/ > (summarizing that "VAR depends on three assumptions that are generally false: not all assets, particularly illiquid ones, are included in the VAR calculation; estimates are based on past data that is unrepresentative of the future; and because financial returns exhibit "fat tails" (extreme outcomes are more likely than you would expect), VAR estimates tell you very little about how bad things can get that last 1% of the time.").

[118] For a classical explanation of Power Laws, including their real-world examples and mathematics, see Mark EJ. Newman, "Power Laws, Pareto Distributions and Zipf's Law", 46 Contemporary Physics 323, 323 (2005) (defining Power Laws as that "[w]hen the probability of measuring a particular value of some quantity varies inversely as a power of that value, the quantity is said to follow a power law, also known variously as Zipf's law or the Pareto distribution.").

linearity, but they capture another very important dimension that non-linearity fails to cover. (Although the concept of power laws can be accurately described only in the language of mathematics, knowing only some key features of how it functions is sufficient for the purposes of this article.) A power-law distribution[119] has a so-called "heavy tail" or "fat tail", therefore extreme events are far more likely than they would be in a traditional Gaussian distribution. For instance, in the context of finance, try to imagine that you plot the severity of a financial crisis on the Y-axis, and the probability of the occurrence of such a crisis on the X-axis. The curve depicted in this coordinate system will be a long tail-shape rather than a U shape or a straight line. That means that the lower the possibility of a crisis, the greater its severity will be if it happens, and vice versa. Power Laws distribution can explain also the so-called 80-20 Rule,[120] a rule that claims that roughly 80% of effects come from 20% of causes. According to that Rule, 80% of market shares may be controlled by 20% of market participants, or 80% of wealth within an economy may be enjoyed by 20% of a population, the social elites. In a nutshell, Power Laws suggest that complex ecosystems are often "defined" by extreme events or dominated by a small number of large agents or nodes.

The appreciation of how Power Laws function to affect the financial ecology has two significant regulatory ramifications. First, although monitoring idiosyncratic risk introduced by financial institutions is surely important, keeping a close eye on extreme, systemic risk is nonetheless much more seriously necessary.[121] Over the past century, financial regulation has been dominated by the idea that ensuring the safety and soundness of every individual financial institution is the vital, if not only, mission. The Deposit Insurance Scheme, for example, has been widely regarded as the most successful mechanism to deliver this micro-prudential mission. Yet the consequences that came in the wake of the 2008 Crisis have taught us that a mere reliance on micro-prudential regulation is far from sufficient. More attention has to be paid to macro-prudential regulation, a policy-set that takes into account risk factors that "go beyond individual financial institutions, including shock correlations and interactions between institutions in their response to shocks."[122] Redirecting regulatory energy into macro-prudential policymaking helps remind us of the

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[119] For how power laws manifest itself in financial markets, see Xavier Gabaix *et al*., "A Theory of Power-Law Distributions in Financial Market Fluctuations", 423 Nature 262, 267—270 (2003).

[120] For an overview and applications of the 80-20 Rule, see Richard Koch, *The 80/20 Principle The Secret of Achieving More With Less*. (Bolinda Audio) (2012).

[121] Baxter, "Complex Case", *supra* note 45 at 15.

[122] Maria J. Nieto, "What Role, If Any, Can Market Discipline Play in Supporting Macroprudential Policy?", Banco de Espana Occasional Paper No. 1202 (16 March 2012), online: < https://ssrn.com/abstract = 2024918 > or < http://dx.doi.org/10.2139/ssrn.2024918 > .

severe consequences of highly unlikely systemic events, and of the urgent need to prevent those events from happening again.

The second implication we note once we understand Power Laws is that regulators should put more emphasis on the supervision of ultra-large financial institutions. There are thousands of financial institutions across the globe, but not all have the ability to drag the wider economy into disastrous meltdown. Power Laws have taught us that a few of the larger financial institutions in fact dominate most of the world's financial resources, and therefore the failure of these institutions can easily impose vast, disproportionate consequence on our economy. Fortunately, the FSB and BCBS have recognized the paramount importance of Systemically Important Banks (SIBs) and Systemically Important Insurers (SIIs), and have been pushing for various reforms in the system that effects their supervision.[123]

Power Laws, in short, subject the overall financial ecosystem to the dominance of extreme events and the few ultra-large financial institutions. Extreme events and the few super-large agents not only define the major landscape of the financial ecology, but also the success of regulatory interventions as being capable of detecting and mitigating systemic risk, and being able to contain the spread of risk through effectively-supervising SIFIs. This is the very essence of the explanation of why macro-prudential policy has become the key factor that dramatically shapes the regulatory landscape, and of why this policy has become the central focus of regulatory inputs in the aftermath of the 2008 Crisis.

(iii) Path dependency

Path dependency suggests that outcomes in complex systems are extremely sensitive to initial conditions.[124] This law of physics affects the evolution of complex systems in two general ways. First, small change in input can have large and dramatic impact on output, a phenomenon usually referred to as the "butterfly effect". Therefore it is important to understand the path from which change emanates before reaching any policy decisions. Second, the set of decisions one faces in any given circumstance is limited by the decisions one has made in the past.[125] This tendency of decision-making subjects each individual

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[123] See Fin. Stability Board, Policy Measures to Address Systemically Important Financial Institutions (2011), online: <http://www.financialstabilityboard.org/publications/r_111104bb.pdf>. See also Basel Comm. on Banking Supervision, Global systemically important banks: Assessment methodology and the additional loss absorbency requirement — final document (2011), online: <http://www.bis.org/publ/bcbs207.pdf>.

[124] See e.g., Hornstein, *supra* note 54, at 924-27; Roe, *infra* note 131. For an overview of path dependency theory and its application in the common law system, see Oona A. Hathaway, "Path Dependence in the Law: The Course and Pattern of Legal Change in a Common Law System", 86 Iowa L. Rev. 601 (2001).

[125] See Hornstein, *ibid*; see also Roe, *infra* note 131 at 643-53.

agent, as well as the nodes within complex systems, to a pattern in which the "first mover" and the "first established order" discourage evolution.

There are several financial regulatory inferences one can draw once one understands path dependency. First, it is important to thoroughly evaluate and observe the cultural roots of a given market or jurisdiction before proposing any regulatory measures.[126] Even if we view today's financial markets as an adaptive ecosystem, this does not necessarily entail that "the survival of the fittest" is always the rule that governs ecological adaption. Market theory such as AMH assumes that the survivor is the key determiner of the evolution of the financial market,[127] and the core driving force of adaption. Yet, this kind of "adaptationist fallacy"[128]— the idea that everything that survives must have been distinguished as the fittest — may simply fail to reflect reality.[129]

Sometimes, survivors of the competition and evolution of the ecosystem are in fact "inefficient" institutions, rules, regimes and systems.[130] And the reason these inefficient agents or paradigms survive is that the overall ecosystem follows the path shaped by its political and cultural institutions, or by mere chaotic events.[131] As Roe seems to suggest, the regulatory structure in the US, where financial regulation is carried out by an "institutionally based functional system,"[132] can be explained only by the path dependency set by embedded institutions.[133]

Drastic reform on redesigning of the US regulatory structure, such as the integrating of all financial regulators on the federal level as one consolidated regulator, is unlikely to happen, as an institutional path has been established for a long time. Because of path dependency, regulatory reform is made sensible and "rational" only if policymakers are fully aware that this path dependency exists in today's financial systems.[134] Regulatory resources, therefore, should be

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[126] See Hornstein, *ibid.*

[127] See Lo, *supra* note 18 at 30.

[128] For an overview of the idea of "adaptationist fallacy", see E. Donald Elliott, "Law and Biology: The New Synthesis?", 41 St. Louis U. L.J. 595, 598-99 (1997).

[129] The adaptationist fallacy seems more awkward in the context of financial ecosystems. See Haldane & May, *supra* note 45 at 351-55 (observing that "[i]n financial ecosystems, evolutionary forces have often been survival of the fattest rather than the fittest.").

[130] See Hornstein, *supra* note 54 at 924-27.

[131] See, e.g., Mark J. Roe, "Chaos and Evolution in Law and Economics", 109 Harv. L. Rev. 641, 646-53 (1996) [Roe]; Lucien Arye Bebchuk & Mark. J. Roe, "A Theory of Path Dependence in Corporate Ownership and Governance", 52 Stan. L. Rev. 127 (1999) (discussing the role of path dependence in corporate ownership structures); Steven L. Schwarcz & Ori Sharon, "The Bankruptcy-Law Safe Harbor for Derivatives: A Path-Dependence Analysis", 71 Wash & Lee L. Rev. 1715 (2014).

[132] U.S. Treas., Blueprint For A Modernized Financial Regulatory Structure, 137-47, 139 (2008), online: < http://fic.wharton.upenn.edu/fic/Policy%20page/Blueprint.pdf > .

[133] See Roe, *supra* note 131 at 646-52.

[134] Sometimes such an inquiry could be very hard as there are also very weak forms of path dependency that are difficult to detect. See Roe, *supra* note 131.

deployed into developing innovative measures, as well as into exploring the historical, cultural and institutional roots of each regulatory objective.

The second inference one can draw upon appreciation of the path-dependency concept is that market participants make path-dependent decisions, whether that path is set by shared values, heuristics, first movers in the market, or even by sunk costs already spent.[135] Those paths are barely rational in the minds of neoclassical economists, but they are very decisive in the efficacy of any proposed regulatory measure or market mechanism. Recognition of this prompts us to rethink the behaviours of market participants by revisiting behavioural finance, and to remind ourselves repeatedly of the significant role played by cognitive bias in shaping financial regulation.

To sum up: Path dependency confines all financial reform efforts to paths on which *historical*, *cultural* or *political* factors direct the outcomes of measures adopted. This renders the existing regulatory structures and market mechanisms very unlikely to undergo significant change. Therefore it would be sensible to launch reforms that are *culturally* and *politically* compatible with the entrenched institutional paths, rather than push for ones that *deviate radically* from them.[136] In addition, it is helpful to find out what is the decision-making path-dependency of individual market participants, and to use the information we glean to cultivate sensible approaches to implementing regulatory reforms.

(d) Emergence: The Order of the Ecosystem

Discussion in the previous section focused on what kinds of "laws of physics" may govern the system-wide *evolution* of today's financial ecology. That exploration helps us understand the key characteristics of the financial ecosystem, and what might be the plausible outcomes of regulatory interventions that are cognizant of those key characteristics. But that discussion did not fully answer the question about how policymakers can deal with mechanisms that *grow endogenously* within the market, and harness them to direct the overall ecology to the common good. Questions like this naturally lead us to inquire what shapes the order of the financial ecosystem, and how such an inquiry might hold ramifications for financial regulation. Perhaps the concept of "emergence" in the field of complexity science can help explain how the system-wide order of the contemporary financial ecosystem is formed.

According to Baxter, the concept "emergence" is highly controversial, and has been criticized as offering "only smoke and mirrors, functioning merely to provide names for what we can't explain."[137] Nonetheless, as accurately pointed out by Baxter, "emergence has become a central element of complexity theory and the idea, even when not so termed, has played a fundamental role in

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[135] Roe, *supra* note 131 at 646-53; Hornstein, *supra* note 54 at 927.

[136] Bebchuk & Roe, *supra* note 131 and accompanying text.

[137] Melanie Mitchell, *Complexity: A Guided Tour* (Oxford: Oxford University Press, 2011) 294 (quoting Debra Gordan); Baxter, "Complex Case", *supra* note 45 at 16.

jurisprudence, from natural law to common law and the jus commune and lex mercatoria."[138] Therefore it is very unlikely that one can fully understand today's complex financial ecosystem without a better grasp of the term "emergence". But what exactly does the term "emergence" connote? An English philosopher has tendered a definition, albeit somewhat less than a lucid one:

> Every resultant is either a sum or a difference of the co-operant forces; their sum, when their directions are the same – their difference, when their directions are contrary. Further, every resultant is clearly traceable in its components, because these are homogeneous and commensurable. It is otherwise with emergents, when, instead of adding measurable motion to measurable motion, or things of one kind to other individuals of their kind, there is a co-operation of things of unlike kinds. The emergent is unlike its components insofar as these are incommensurable, and it cannot be reduced to their sum or their difference.[139]

This philosophical definition justifies to a certain extent the assertion that the concept "emergence" indeed provides only a name for things we cannot explain, and is thus not available as an operable definition in the context of this author's discussion. A more operable definition would be the one proposed by economist Jeffery Goldstein. He defines "emergence" as a reference to "the arising of novel and coherent structures, patterns, and properties during the process of self-organization in complex systems."[140] He proposes that features of emergents are not previously observed in the complex system. And their radical novelty renders emergents neither predictable nor deducible from other components.[141] That is to say, emergents cannot "be anticipated in their full richness before they actually show themselves."[142] As Goldstein argues, emergents appear as "integrated wholes that tend to maintain some sense of identity over time,"[143] and this coherence "spans and correlates the separate lower-level components into a higher-level unity."[144]

Goldstein's observations point out two important features of emergence. One is the pattern, structure, and regularity that "suddenly and unexpectedly" emerges in a complex system. The other is that there is certain degree of homogeneity between this macro-level order and each micro-level pattern in sub-systems. In other words, it is posited than an order was formed unpredictably, but is traceable in every sub-system once it is manifest. If we observe such an

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[138] Baxter, "Complex Case", *supra* note 45 at 16-7.

[139] George Henry Lewes, *Problems of Life and Mind* (1875) 359 .

[140] Jeffery Goldstein, "Emergence as A Construct: History and Issues" (1999) 1 Emergence 49, 49, online: <http://www.anecdote.com.au/papers/EmergenceAsAConsutructIssue1_1_3.pdf>.

[141] *Ibid.* at 50.

[142] *Ibid.*

[143] *Ibid.*

[144] *Ibid.*

order/emergence in market participants' points of view, we would realize that the final layout of the system-wide order is not what we intended it to be when we initiated a purposeful action. It turns out that we, as market participants, are affected imperceptibly by an invisible hand, a process by which a "man is led to promote an end which was no part of his intention."[145]

The order that emerges from a complex system can be understood also as the "spontaneous order"[146] proposed by many well-known philosophers and economists, such as Adam Ferguson[147] and Friedrich Hayek.[148] A simple way to explain "spontaneous order" is to quote political philosopher Norman Barry:

> What is important about the theory of spontaneous order is that institutions and practices reveal well-structured social patterns, which appear to be a product of some omniscient designing mind, yet which are in reality the spontaneous co-ordinated outcomes of the actions of, possibly, millions of individuals who had no intention of effecting such overall aggregate orders.[149]

Spontaneous order, therefore, is not a product of human rationality. Rather, it is a product of the natural processes that coordinate human activities.

The next question one would ask is about how an understanding of emergence/spontaneous order as facts about today's complex financial ecosystem might advise policymakers about the role of regulation. There are two important leads here. First, the role of regulation should be to help *facilitate the coordination* of market participants' activities, instead of attempting to direct their outcomes by imposing a commanding intelligence. There are some mechanisms that are particularly helpful to achieve optimal co-ordination of the aims and purposes of countless market actors. The mechanism of price is one of the best examples. As Norman Barry observes, "a change in the price of a commodity is simply a signal which feeds back information into the system enabling actors to "automatically" produce that spontaneous co-ordination which *appears* to be the product of an omniscient mind."[150] If this is indeed the case, then the most important job for regulators is to ensure accuracy and fairness price for all commodities, and do everything to prevent price distortions.

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[145] Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations,* R. H. Campbell and A. S. Skinner, eds., (Indiana: Liberty Classics, 1981) at 456. The reference to the "invisible hand" occurs also in Smith's *Theory of Moral Sentiments,* D. D. Raphael and A. Macfie, eds., (USA: Liberty Fund, 1985) at 58.

[146] For a comprehensive and thorough analysis of the origin of "Spontaneous Order", see Norman Barry, "The Tradition of Spontaneous Order" (1982) 5 Literature of Liberty 7, online: < http://www.econlib.org/library/Essays/LtrLbrty/bryTSO.html > .

[147] See Adam Ferguson, *An Essay on the History of Civil Society*, Fania Oz-Salzberger, ed., (Cambridge: Cambridge University Press, 1996) at 118-131.

[148] See Friedrich Hayek, *Law, Legislation and Liberty: Vol. 1, Rule and Order* (Chicago: University of Chicago Press, 1973) at 35-54.

[149] Barry, *supra* note 146 at 10.

[150] *Ibid.*

The same principle applies to financial regulation. Because the display of emergence renders the order of today's financial ecology a spontaneous and unpredictable one, any "rational" human-planned regulatory measures will lead the overall system to an unexpected outcome. The safest and more efficient way forward would be to identify and develop mechanisms that have the potential to automatically co-ordinate the interests, purposes and actions of market participants. The well-regarded complexity scientist, Dirk Helbing, takes a similar perspective. In his view, "the right approach to influencing complex systems is to support and strengthen the self-organization and self-control of the system by mechanism design."[151] Therefore, "regulations should not specify what exactly the system elements should do, but set bounds to actions (define "rules of the game"), which give the system elements enough degrees of freedom to self-organize good solutions."[152] This proposition implies that harnessing the self-disciplinary power of the market to help regulate the complex financial ecosystem might be a more sensible approach to safeguarding today's complex financial ecosystem.

The second available inference is that "[r]ules appropriate for a spontaneous order . . . are more likely to be discovered than deliberately created."[153] This seems to lend support to the regulatory approach in which best practice is highly valued in the industry, and commended to all industry members. Yet this is not to say that the regulators' job is merely to promote the wider adoption of the industry's best practices. Our discussion of non-linearity should have warned that reliance on best practices may turn out to be useless, or to be losing applicability because the market has evolved to different level. Therefore, the appropriate response is to remind ourselves not to underestimate the importance and usefulness of industrial best practices. On the other hand, those best practices should not be trusted blindly. Rather, policymakers should work hard on how to initiate their adaptation to that which is socially desirable.

4. CONCLUSION

All three mainstream market theories fail, to some extent, to accurately reflect the real features of modern financial ecology. Traditional EMH fails to appreciate the fact that humans are inherently limited in their computational abilities, for psychological, emotional and physiological reasons. Although bounded rationality may in the long run be redirected to the "rational" level in the process of learning, it still greatly undermines the predictive power of EMH in the short term. In addition, the EMH's assumption that market participants are motivated by the pursuit of optimal returns overlooks the fact that there are

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[151] Dirk Helbing (ed.), Social Self-Organization - Agent-Based Simulations and Experiments to Study Emergent Social Behavior 271 (Springer-Verlag Berlin Heidelberg, 2012).

[152] *Ibid.*

[153] Barry, *supra* note 146 at 11.

various distinct groups of market participant in the financial markets, and each group may hold a different definition of optimal returns.

Similarly, behavioural finance hypothesis reflects the real market's nature only partially. It focuses its studies mainly on individual investors, namely, retail investors and traders, because the fundamentals of the theory are built principally on the cognitive biases of human beings. This approach reduces organizational decision-making to individual decision-making, and fails to appreciate how organizational dynamics may cure the behavioural biases that are often an individual's bias, not the organization's bias. Finally, behavioural finance fails to offer a coherent and plausible explanation of what really motivates market participants' behaviours.

Even the best available market theory like AMH is unable to offer an impartial view of the modern financial market's nature, as it does not appreciate the unique roles of FMIs, rating agencies and regulators in facilitating and gatekeeping the order of today's financial markets.

With the above in mind, this paper proposes a more sensible approach to understanding today's financial market. That approach is to depict its characteristics clearly, note how those characteristics have shaped its evolution, then proceed to estimate its sensitivity to ecological transformation. Complexity theory, this author believes, is exactly the tool that can help us achieve the objectives of foregoing missions, and thus to rethink modern financial ecology and its regulatory implications.

As informed by complexity science, *Non-linearity*, *Power Laws*, *Path Dependency* and *Emergence* are the four key elements that best depict the laws governing the market-wide evolution and order. Non-linearity characterizes the financial ecosystem as the product of a highly unpredictable dynamic game. The consequence of imposing on it a specific set of regulations or laws may not be the intended one, and the outcomes are highly subject to the interactive dynamics at play among the agents within it. In addition, the consequence or system-wide reactions to the failure or major default of a highly interconnected financial institution may fare into an unexpected or seemingly irrational systemic crunch of liquidity. These features hold three major regulatory implications: first, policymakers should not unduly escalate, by endless rulemaking, the complexity of their proposed legislations or regulations; second, whenever a policy or a set of rules is adopted, policymakers should be prepared to change that policy or rule in response to the evolution of the financial ecology; third, market solutions that rely on best practices may turn out to be useless or lose applicability because the market has evolved to another, different level.

Power Laws show the overall financial ecosystem to be subject to dominance by extreme events, and by the few ultra-large financial institutions. These dominators define not only the major landscape of the financial ecology, but they also define successful regulatory intervention as the capacity that detects and mitigates accruing systemic risk, and contains the spread of risk by supervising SIFIs effectively. Therefore, two major implications for policymakers are: first,

although monitoring idiosyncratic risk introduced by financial institutions is surely important, keeping a close eye on extreme systemic risk is nonetheless far more urgent; second, regulators should put more emphasis on the supervision of ultra-large financial institutions.

Path dependency makes efforts to introduce radical change to the existing regulatory structures and market mechanisms unlikely to be successful. So two important lessons for policymakers are, first, that it is important to thoroughly evaluate and observe the cultural roots of a given market or jurisdiction before proposing regulatory measures. It would be more sensible to launch reforms that are culturally and politically compatible with the entrenched institutional paths than to push ones that are radically unlike them. And second, market participants' decisions are path dependent, that is, their procedures and attitudes are set by shared values, heuristics, first movers in the market, or even by sunk costs spent previously. Therefore, it is helpful to find out what the decision-making path is, and to use the discovered information to cultivate sensible approaches to implementing the desired regulatory reforms.

Emergence renders the order of today's financial ecology a spontaneous and unpredictable one, so any human-planned regulatory measures may produce unexpected outcomes in the overall system. Therefore, two major implications stand out:

- First, rules appropriate to a spontaneous order are more likely to be uncovered than intentionally created. Therefore, policymakers should avoid the underestimation of industrial best practices while eschewing a blind trust in them. Policymakers should concentrate on working out how to direct best practices to the pursuit of socially desirable outcomes.

- Second and most importantly, the role of regulation is to help facilitate the coordination of market participants' activities, not to direct outcomes by imposing a commanding intelligence. The most effective procedure is to detect and develop the mechanisms that have the potential to automatically co-ordinate the interests and purposes of market participants. That is to say, harnessing the self-disciplinary power of the market to help regulate the complex financial ecosystem might be a more sensible approach to safeguarding today's complex financial ecosystem.