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DISCUSSION PAPER SERIES

3 – 2012/I

COMPLEXITY AND ENDOGENOUS INSTABILITY

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JANUARY 2012

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Abstract

The global financial crisis proved the critical impact of the gap between individual rationality and group rationality. This gap is not supposed to arise in a Neoclassical world, but it frequently arises in a world as complex as ours. The paper explores how endogenous instability might arise due to such a gap, and what behavioral rules might help to mitigate its impact.

JEL codes: C70, D03, D87, G01

Keywords: fallacy of composition, empathy, *n*-person prisoner's dilemma games, *n*-person zero-sum games, symmetry, the golden rule.

1 Introduction

In November, 2008, shortly after the collapse of Lehman Brothers and the outbreak of the global financial crisis, Queen Elizabeth II of England was visiting London School of Economics. She asked the group of eminent economists attending: "Why nobody noticed that the credit crunch was on its way?" Later, in June, 2009, the British Academy organized a forum to discuss the subject, and based on that, British Academy Fellows, Tim Besley and Peter Hennessy, prepared a letter to the Queen to provide the answer (Besley and Hennessy, 2009). Towards the end of the letter, the authors note:

> So where was the problem? Everyone seemed to be doing their own job properly on its own merit. And according to standard measures of success, they were often doing it well. The failure was to see how *collectively* this added up to a series of interconnected imbalances over which no single authority had jurisdiction. This, combined with the psychology of herding and the mantra of financial and policy gurus, lead to a dangerous recipe. *Individual risks may rightly have been viewed as small, but the risk to the system as a whole was vast.* (Emphasis added.)

The letter concludes:

> In summary, Your Majesty, the failure to foresee the timing, extent and severity of the crisis and to head it off, while it had many causes, was principally a *failure of the collective imagination* of many bright people, both in this country and internationally, to understand the *risks to the system as a whole*. (Emphasis added).

So one main reason behind the crisis was the well known "fallacy of composition:" to infer that what is true for an individual bank or institution is also true for the whole market or economy. The fallacy arises due to failure to understand "the fact that the way the parts relate, interact, or affect each other often changes the character of the whole" (Damer, 2009, p. 140). Early economics textbooks used to illustrate the fallacy, mainly through the paradox of thrift. But it has been gradually de-emphasized in later texts (Lutz, 1999, p. 7).

In Neoclassical theory, such fallacy is not supposed to arise, at least not seriously. The "invisible hand" is supposed to coordinate self-interested agents and produce the good for the whole group. Self-interest is sufficient to satisfy group-interest. But we know that this is frequently not the case, the crisis being the most visible example. The fallacy has many applications in various economic activities, including growth, development, and trade (e.g. Mayer, 2003). It shows that the representative agent model cannot be warranted due to divergence of macro phenomena from micro behavior (Caballero, 1992). The fact that the whole in many ways differs from the parts is a major point of departure of Complexity Economics from Neoclassical theory (Al-Suwailem, 2010).

Standard macroeconomic models assume that the source of variability is exogenous; endogenous instability is assumed out (Buiter, 2009). Prior to the crisis, economic models assumed "crash-free" markets, which itself contributed to the crash (Bouchaud, 2008). Not only did these models fail to provide answers to questions of insolvency and illiquidity, they did not allow these questions to be asked in the first place (Buiter, 2009).

The crisis proved how volatility could arise endogenously from traders' and bankers' actions. Adrian Turner (2009), governor of Financial Services Authority, UK, remarks:

> … indeed, there are good reasons for believing that the financial industry, more than any other sector of the economy, has an ability to generate unnecessary demand for its own services—that more trading and more financial innovation can under some circumstances create harmful volatility against which customers have to hedge, creating more demand for trading liquidity and innovative products; that parts of the financial services industry have a unique ability to attract to themselves unnecessarily high returns and create instability which harms the rest of society.

This paper aims to examine how fallacy of composition in financial markets may lead to endogenous instability. Section 2 documents the endogenous volatility of financial markets. Section 3 presents game-theoretic models of fallacy of composition, and discusses some examples of fallacious behavior, particularly in the run up to the financial crisis. Section 4 discusses roots of fallacious behavior and related remedies. The conclusion is presented in section 5.

2 Endogenous Instability

It has been long-observed that financial markets show "excess volatility", as demonstrated by Robert Shiller (1989) and others. Shiller finds that volatility of stock market (S&P 500) is much higher than would have been predicted by efficient market hypothesis, particularly for the latest part of the twentieth century.

Campbell and Ammer (1993) find that, for postwar data, 55-70% of variance of excess stock returns is attributed to changes of expectations of future returns, and only 15-20% is attributed to changes in expected future dividends. Nardari and Scruggs (2005) find that most changes (87%) in stock market volatility over time are explained by variations in volatility of expected returns. These results show how excess volatility of financial markets arises largely from within the market, i.e endogenously.

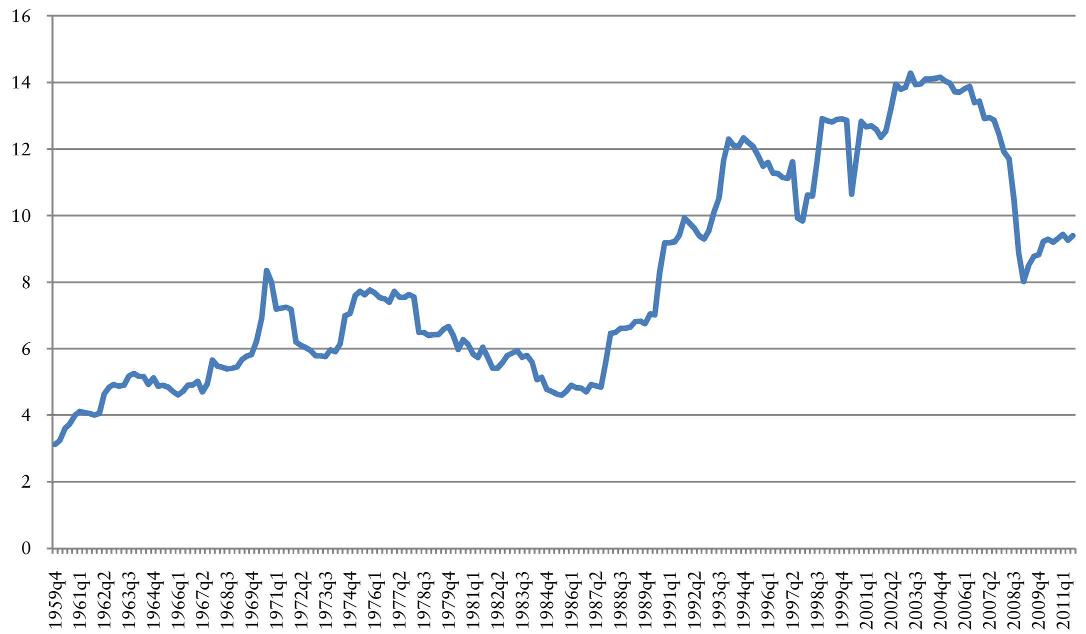
Anders Johansen and Didier Sornette (2006) examine crashes in financial markets, and distinguish between crashes resulting from endogenous speculative behavior and those resulting from exogenous shocks like declaration of war. They find that endogenous crashes are preceded by super-exponential power law price appreciation, or what they call "log-periodic power law signature (LPPS)," which is consistent with rational speculative bubbles. By examining financial markets worldwide (stocks, currency, bonds) during the past century, 49 crashes are identified, 25 of which are found to be endogenous, 22 exogenous, and 2 are associated with the Japanese anti-bubble.

According to Jean-Philippe Bouchaud (2010), news plays a minor role in financial market volatility; most jumps appear to be unrelated to news, but seem to appear spontaneously as a result of the market activity itself. Further, the stylized facts of price statistics (fat-tails in the distribution of returns, long-memory of the volatility) are to a large extent universal, independent of the particular nature of the traded asset, and very reminiscent of endogenous noise in other complex systems (turbulence, earthquakes, etc.). In all these examples, the intermittent, avalanche nature of the dynamics is an emergent property, unrelated to the exogenous drive which is slow and regular.

Remarkably, the volatility of the real sector has been declining in the second half of the twentieth century (Kahn et al., 2002; Davis and Kahn, 2008). Yet, financial markets during the same period have shown no sign of reduced volatility (Brock, 2002). In fact, the evidence is mounting that they became increasingly volatile (World Bank, 2001; Bordo et al., 2001). According to Reinhart and Rogoff (2009, pp. 344-347), from 1930 till 1969, there were around 31 banking crises worldwide. From 1970 till 2007, the number jumps to 167. "The fact that the total risk of the financial markets has grown in spite of a marked decline in exogenous economic risk to the country is a key symptom of the design flaws within the system" (Bookstaber, 2007, p. 5).

Figure 1 compares volatility of the growth rate of GDP of the US to that of S&P500. Volatility is calculated as standard deviations for a 10-year window. The ratio of S&P500 volatility to that of GDP is plotted. It can be seen that, starting from early 1980s, there was an upward trend in S&P500 volatility relative to that of GDP. The average ratio of volatilities for 1959-1980 is 5.8, but 9.8 for 1980-2010. As Table 1 shows, while volatility of GDP has dropped by about 35% in 1981-2010, volatility of S&P500 for the same period has risen by about 21%.

Figure 1: Ratio of Volatility of SP500 to Volatility of GDP



Standard deviation of growth rate of S&P500, divided by the standard deviation of growth of GDP. S&P500 monthly data are averaged quarterly to match the frequency of GDP. Both S&P500 and GDP levels are in current dollars and are indexed so that 1950q1 = 100. Standard deviation is computed for a 10-year (40 quarters) window.

Source: finance.yahoo.com and www.bea.gov.

Table 1

Volatility of GDP and S&P500

	GDP	S&P500	Ratio
1950q1-1980q4	1.3%	5.8%	4.5
1981q1-2010q4	0.8%	7%	8.5
Change, %	-35%	+21%	88%

3 Financial Fallacies

There are two ways to model fallacy of composition: *n*-person zero-sum game, and *n*-person Prisoner's Dilemma game.

3.1 *n-Person Zero-sum Games*

A zero-sum game is a game in which payoffs of players always add to zero. To win in a zero-sum game is not impossible for any individual player per se. But it is impossible for *all* players to win simultaneously.

One way to model *n*-person zero-sum games is through the "minority game." Minority games (e.g. Challet et al., 2005) are games in which players have two choices. After choice is made, those who are in the minority win, while the majority loses. By design, there is no outcome that satisfies all players. Since it is in the interest of each player to win, each player wants to be in the minority, which is impossible to be achieved. To be in the minority therefore is self-defeating, and thus generates fluctuations endogenously (Batten, 2006, 2007). Each player is trying to predict the choice of others. Outguessing creates self-referential loop that makes the game inherently unstable.

(J.M. Keynes's (1936) "beauty contest" is a guessing game, but it is not an *outguessing* game. It is a *majority* game, not a minority game. That is, players need to guess the guesses of others, but need not prevent others from guessing theirs, and thus players' guesses might possibly converge. Outguessing however cannot converge by construction.)

Foster and Young (2001) argue that there is an inherent tension between rationality of players and their abilities to predict the behavior of their opponents when payoffs are uncertain. Specifically, there are games in which it is impossible for perfectly rational players to learn to predict the future behavior of their opponents (even approximately), no matter what learning rule they use. The reason is that in trying to predict the next-period behavior of an opponent, a rational player must take an action this period that the opponent can observe. This observation may cause the opponent to alter his next-period behavior, thus invalidating the first player's prediction. The authors argue that there are strategic situations in which it is impossible *in principle* for perfectly rational agents to learn to predict the future behavior of other perfectly rational agents based solely on their observed actions (see also Nachbar, 2005). It should be noted that this impossibility result holds for the players themselves. For outside observers, the authors note, it is possible to recognize certain patterns in players' behavior. This reflects the divergence of individual agents from the system as a whole. So while individual agents are unable to predict the behavior of their opponents, it is possible for an outside observer to some extent to predict the behavior of the whole system.

The impossibility of predicting opponents' behavior by competing agents was envisioned long before (see Koppl and Rosser, 2002). Herbert Simon (1978*a*, p. 9; 1978*b*, p. 360) considers the problem of "outguessing" in an imperfect-competition environment as "the permanent and ineradicable scandal of economic theory." He points out that "the whole concept of rationality became irremediably ill-defined when the possibility of outguessing was introduced," and that a different framework and methodology must be adopted to understand economic behavior in such conditions (cited in Rubinstein, 1998, p. 188).

The problem of "outguessing" is most acute in speculative markets. J.M. Keynes (1936, pp. 154-155) describes speculation as a "battle of wits," and the objective is to "outwit the crowd". Speculators are not concerned with valuing the long term yield of an investment, but rather with foreseeing changes in conventional valuation of the asset "a short time ahead of the general public." Similarly, Warren Buffet (2000, p. 14) points out that speculation is not about predicting what an asset will produce, but rather about what other market players will do in order to be ahead of the them. Speculators "spent their time chasing one another's tails," as Krugman (2009*a*) remarks. So it is an outguessing, minority game. Each player is trying to decide to buy or to sell ahead of the majority. But if everyone is trying to do the same, it is impossible to reach a mutually satisfying outcome. Speculative markets therefore become inherently unstable.

Lux and Marchesi (1999) model financial markets as consisting of "chartists," those who seek to predict the behavior of other players, and of "fundamentalists," those who seek to predict the value of the asset based on its fundamentals. The probability that a given trader switches from one group to the other evolves endogenously based on profits made. The model shows that, when chartists dominate the market, it becomes highly volatile, but reverts to stability when the number of fundamentalists recovers back. Thus, speculative behavior tends to be destabilizing and endogenously generates turbulence.

Markose at al. (2004) model a financial market as a network of agents. The network evolves endogenously by agents changing the weights of their links to neighbors based on performance. When returns are generated endogenously through minority game structure, the network becomes highly clustered with fat tails and thus higher likelihood of extreme events.

Ponzi Schemes

One obvious example of *n*-person zero sum games is Ponzi schemes. A Ponzi scheme is a system in which a participant pays a fee to *A* in order to be able to collect more fees from *B* and *C*, and each of these two repeats the process creating an ever-growing pyramid. Because Ponzi schemes are illegal in many countries, proponents of such schemes invented "pyramid schemes" or "multi-layer marketing schemes." These are Ponzi schemes but the fee now is presented as a price for a certain product or merchandise. The scheme promises participants high returns based primarily on recruiting others to join the program, not based on profits from selling the product to consumers. The product is not sold to consumers, but rather sold to other recruiters, who in turn sell to yet more recruiters, ad infinitum. Regulators still take strong stance against such schemes (Valentine, 1998). It should be noted that while a pyramid scheme is a multi-person zero-sum game, new participants (those at the bottom of the pyramid) do not consider themselves losers. Individually, each hopes or expects to make profits in the near future, but this is impossible for all participants.

Ponzi and pyramid schemes illustrate the characteristic fragility of finance, and may arise in various environments including banking and financial bubbles (World Bank, 2001, pp. 10, 79, 145).

Bubbles

It is not difficult to see that a speculative bubble is a kind of a Ponzi scheme: investors win only if there are enough newcomers to buy and keep prices up, and those in turn win only if more investors join, and so on. Unless there is an infinite stream of capital flowing into the market, it is impossible for all investors to win. Holding the intrinsic value of traded assets constant, a speculative bubble is a multi-person zero-sum game. Since such bubbles are usually not deliberately organized by specific persons, Shiller (2000, ch. 3) calls them "naturally occurring Ponzi processes." For each individual investor, it is profitable to join the rising market with the expectation that the "greater fool" or the "sucker" will absorb the losses. But as each investor behaves in this manner, the divergence between asset price and the fundamentals widens, and thus the likelihood and magnitude of a crash rises substantially. The initial driver of market rise could be a general belief that assets are undervalued, introduction of new technologies or innovations that could open new opportunities, deregulation, easy credit and excess money supply, etc. (Kindleberger and Aliber, 2005). But once the market starts rising, it might transform into a Ponzi process and generate self-fulfilling, but unsustainable, expectations.

The mechanism of bubble formation can be further clarified using the "Dollar Auction game." The game, introduced by Shubik (1971), works as follows: A dollar bill is auctioned off, such that the highest bidder wins the dollar, but the second-highest bidder pays his bid to the auctioneer for nothing. Essentially, it is a zero-sum game including the two bidders and the auctioneer. In experiments, a dollar bill is eventually sold for more than one dollar in most cases (Colman, 1999, pp. 196-199). This seems quite strange, but the explanation lies in the rule that the second-highest bidder stands to lose. Since neither bidder wants to be the second-highest bidder, he keeps bidding. Before bidding reaches $1, there is a chance for the winner to make a profit. Afterwards, each bidder is trying to minimize losses. At each bidding round, each player considers raising the bid a little more will not cause much additional loss. However, as the bidding war escalates, losses accumulate and bidding value goes way beyond the value of the auctioned dollar.

The game models the problem of self-reinforcing escalation. It provides insights on how in reality investors might keep throwing "good money after bad." But it is not only the problem of "sunk costs" that causes the escalation. More important, it is the zero-sum structure of payoffs that breeds the competition and the psychology of conflict. In a zero-sum game, "players are forever at each other's throat" (Gardner, 1995, p. 37). As detailed experiments show, the Dollar Auction game starts with incentives to make profits, and then develops into a conflict in which each bidder wants to "prove himself" and refuses to give up (Colman, 1999, pp. 197-198).

When trading in financial markets becomes mostly speculative, zero-sum game, there is a good chance that it transforms into a kind of Dollar Auction game. For each financial asset, there are many side-bets; each involves a winner and a loser. Each bet can be viewed as a Dollar Auction game, with brokers playing partly the role of the auctioneer. No trader wants to be a loser, so they keep betting greater amounts, leading to higher values of the bet. This reflects back on the value of the underlying asset, leading to a second round of betting, and so on. Each wants to avoid the losses and thus wants to shift the "hot potato" to the other, and by doing so, the market keeps rising to unrealistic levels. The game harbors its own self-escalating mechanism, leading to bubbles and, subsequently, crashes.

This is confirmed by what Brunnermeier and Pedersen (2005) call "predatory trading": trading that exploits the need of other investors. If an investor needs to liquidate, other traders sell to push the price of the asset downward, and then they buy back to profit from the swing. This leads to price overshooting, thus endogenously generating fluctuations. Further, a trader profits from another trader's crisis, and the crisis can spell over across traders and across markets.

Shadow Banking

Historically, commercial banks have frequently suffered runs on their demand deposits. The reason is the fractional reserve structure whereby depositors are guaranteed the nominal value of their deposits on demand, while in reality only a fraction of these deposits is available for withdrawal. Fragility of banks led to creation of a whole spectrum of institutions, including central banks and deposit insurance, together with tight regulations of commercial banks, to minimize bank runs.

With the growth of financial and money markets, financial institutions (including commercial banks) were able to find alternative sources of funding: short-term borrowing through short-term papers. By borrowing short-term and lending long-term, non-bank financial institutions were able to replicate the banking model, as short-term and overnight loans (repos) replace deposits. However, there is no safety net and regulatory structure to protect such "shadow banks" from classical, century old, bank-type runs. The sizable growth of shadow banking made the financial system greatly vulnerable and fragile. In 2007, size of the shadow system was $10.5 trillion, while that of commercial banks was $10 trillion (Geithner, 2008). By the end of 2006, investment banks in the US were rolling more than 25% of their liabilities on daily basis (Baily et al., 2008). The financial crisis thus was precipitated by a classical run (Brunnermeier, 2009; Krugman, 2009*b*, ch. 8).

Borrowing short and lending long create a fallacious structure. It is possible for some depositors to withdraw (or for some overnight lenders to stop rolling over), without affecting the solvency of the bank. But many depositors or lenders cannot do the same without the bank collapsing. Those who are able to withdraw do so only at the expense of others being less likely able to withdraw. As long as remaining depositors or lenders do not withdraw, the problem is not visible. But the moment their confidence is slightly shaken, a run is enacted. As Chuck Prince, then CEO of Citigroup, remarked in summer of 2007: "When the music stops, in terms of liquidity, things will be complicated. But as long as the music is playing, you've got to get up and dance. We're still dancing" (*Financial Times*, 10.07.2007). So, as long as house prices were rising, lenders were happy to roll over trillions of short-term debt used to finance 20 or 30 years mortgages. But when prices started to flatter, creditors rushed out of the doors, leading to "the mother of all bank runs" (Roubini and Mihm, 2010, p. 80).

Although maturity mismatching creates liquidity at the micro level (i.e. for an individual lender or depositor), at the macro level it creates systemic risks. A run on a given bank will not be limited to that bank. Because banks are inter-connected, other banks may also suffer runs on their deposits, creating a contagion that threatens the system as a whole. The same is true for shadow banks, with greater risks arising from the sensitivity of financial markets.

Banks use short-term debt because it has lower costs than medium or long-term loans. Lenders who are able to get their money ahead of other creditors face fewer risks; hence, they charge lower premiums. As long as money markets are functioning normally and thus very unlikely to dry up suddenly, this seems like a good opportunity for banks to make additional profits. Other banks naturally would follow the same strategy. However, medium or longer-term creditors of these banks will be at a disadvantage if any bank faces any kind of difficulty. These creditors therefore might start to switch to a shorter time horizon. Gradually, more and more creditors insist on shorter and shorter time horizons for repayment. The result is that a majority of banks and creditors are rolling trillions of debt on daily or weekly basis. The market becomes extremely fragile, and a few creditors who refuse to roll over can trigger a massive run. This analysis is consistent with the trend in Asset-backed Commercial Papers (ABCP), whereby the rising size and shrinking maturity increased rapidly in the run up to the crisis (Baily et al., 2008, p. 30; Rajan, 2010, p. 151). Thus, what starts as a remote possibility develops through the fallacy of composition into a highly probable event.

Complex Derivatives

Life would have been much different if it were risk-free. Unfortunately, uncertainty is deeply ingrained in our universe even at the most elementary level (as indicated by Heisenberg's "uncertainty principle"). Thus there is no way to entirely eliminate risk from economic activities. While some may be able to avoid risk for some time by shifting it to others, if everyone decided to do the same, the economy simply would collapse. It is a perfect example of a fallacy of composition. It might be insightful however to see what would happen before reaching that end.

Suppose that, while the majority of agents want to avoid risk, a few are willing to take them. Then risks that were scattered and diversified become concentrated and correlated. Those risk takers become "systemically important," since a failure of one might bring down the whole economy. What might appear for an individual agent as reduction of risk, ends up making the whole economy more risky.

During the subprime bubble before the recent crisis, banks felt more secure by shifting the risks of their mortgage borrowers, through structured finance like CDOs and CDS, to risk takers like AIG, Lehman Brothers, and others. This encouraged banks to extend lending further to riskier borrowers, feeding the housing bubble. Further, banks were able to shift standard risks that can be easily assessed. Non-standard risks were retained. Thus, banks replaced simple and "vanilla" risks with more complicated and more paying risks (Rajan, 2005, p. 317). This means that risk transfer did not make banks less risky; in fact, they became more risky. But because of the way structured finance worked, these two types of risk, transferred and retained, were ultimately linked. With the accumulation and build up of huge risks by banks and AIG, both became more risky. According to FSA (2009, p. 16), most of securitized credit ended up not with end investors, but rather with banks. Through structured finance and complex derivatives, most of risk was left on banks' balance sheets.

Risk takers like AIG were happy with the upfront fees that they were getting and the resulting bounces in the short run. But as these institutions were building up risks, banks became in fact less secure than they perceived. The more debts AIG and Lehman were "insuring," the more risk was being built up, the more the housing bubble was inflating, and thus the more the system became fragile and interconnected. A slight slowdown of house prices therefore caused waves of defaults and subsequent market meltdown.

Informational Asymmetry

Risk-shifting yields additional forms of fallacy of composition. Derivatives, the common means for shifting risks, are zero-sum contracts (Greenspan, 1999). Since the objective is to shift risk, but not the ownership of the underlying asset, the contract ends up with a gain to one party and a loss to the other. In theory, derivatives are supposed to shift risk to those who are more *able* to bear it, thus making the two parties, ex ante (in contrast to their ex post zero-sum nature), better off. In reality, though, risk is shifted to those who are more *willing* to bear the risk. Due to asymmetric information, those who are more willing to take risks are frequently those who are less able to bear them. Because derivatives are zero-sum contracts by nature, there will be a feedback from payoff structure to informational asymmetry: Since players are in direct conflict, they have every incentive to hide information and misrepresent their choices, to the extent of adopting randomized strategies (Schelling, 1960). Informational asymmetry, therefore, is likely to rise, leading to greater distortions of the distribution of risk being born by the less able but more willing. This further intensifies conflict of interest, worsening informational asymmetry, deteriorating risk distribution, and so on.

Arora et al. (2010) argue that financial derivatives (like CDOs and CDS) can worsen informational asymmetry and amplify the associated costs. The reason is that, due to computational complexity, the seller is able to rely on computational intractability to disguise their information via "cherry picking." Using input information that is available to all parties, the derivative can be structured in a manner that cannot be understood or priced with any foreseeable amount of computational effort, and this is true even for very simple models of asset yields. The incentive for this "cryptography" is not difficult to see: the inherent conflict of interest in zero-sum games. This explains how financial derivatives became increasingly complex, and thus more risky, particularly in the run up to the crisis.

Informational asymmetry also leads to higher risks taken by banks, as pointed out earlier (Rajan, 2005). Banks are able to transfer plain vanilla risks for which enough symmetric information is available to risk takers. More complicated risks, with less symmetric information, are kept on the books of banks. As banks expand their business and take more risks, the distribution of risk on their books deteriorates. The result is that banks become more, not less, risky.

3.2 *n-Person Prisoner's Dilemma Game*

Multi-person Prisoner's dilemma (PD) game is a model of "social dilemmas," in which individual rationality leads to collective irrationality (Rapoport, 1987; Colman, 1999, pp. 201-223; Kollock, 1998). It is a classical example of the fallacy of composition: if each agent acts selfishly hoping to be ahead of others, they all end up in the worst possible position. Interestingly, according to Peter Nonacs (2011), Prisoner's Dilemma arises only in human society. "There is simply no conclusive evidence that a Prisoner's Dilemma applies anywhere in nature apart from human interactions" (p. 423).

Prisoner's Dilemma game may endogenously generate instability. Nowak and May (1992) examine a simple PD game played on 2-dimension spatial arrays. In each round, every individual 'plays the game' with immediate neighbors; after this, each site is occupied either by its original owner or by one of the neighbors, depending on who scores the highest total in that round. Despite its simplicity (no strategies and no memories), the game can generate chaotically changing spatial patterns, in which cooperators and defectors both persist indefinitely (in fluctuating proportions about predictable long-term averages).

Nowak and Sigmund (1993) examine iterated PD with heterogeneous population of simple strategies, whose behavior is totally specified by the outcome of the previous round. They show that the game can lead to persistent periodic or highly irregular, chaotic oscillations in the frequencies of the strategies and the overall level of cooperation.

The reason behind endogenous instability in PD game is simple: Defection doesn't pay unless there are (enough) cooperators. To defect amongst defectors doesn't pay. The relation between defectors and cooperators is to some extent similar to that between predators and preys. Too many predators will make them lose and vanish. Too many cooperators invite predators to multiply.

The PD framework can explain many aspects of financial behaviors and its relation to economic phenomena.

<u>PD and Financial Fallacies</u>

There are many ways in which financial instability arises endogenously through PD-like interactions. One aspect is the choice of debt versus equity in financing economic activities. In a non-cooperative setting (i.e. without binding agreements), the choice of debt vs. equity between a banker and a business owner, can be modeled as a PD game: Equity, the cooperative choice, is Pareto-optimal; yet, each has the opportunity to take advantage of the other. The business owner can misreport profits in case of success, while the banker can blame the owner in case of failure, and thus refuses to bear the losses. With mutual distrust, the two ends up in choosing debt over equity, although they are both better off choosing equity (Al-Suwailem, 2005).

The trend in increasing leverage in many economies can, at least in part, be explained through *n*-person PD framework. On the aggregate level, everyone is better off in an economy with high level of equity and low level of debt. If most banks and corporations follow this conservative strategy, the company that deviates and increases its leverage will enjoy higher returns on equity (ROE) and thus higher share value and larger bonuses. Others will be in a disadvantaged position, and thus follow en suite. The result is a "leverage race," with ever-increasing fragility and, eventually, instability. Although collectively, they are better off with lower leverage, individualistic evaluation makes every on worse off.

		Majority	
		High equity	High leverage
Minority	High equity	*a*	*c*
	High leverage	*b*	*d*

Minority Payoff: $b > a > d > c$

The table above represents an *n*-person PD game. Firms have two choices: high equity and low leverage (the cooperative choice), or low equity and high leverage (competitive choice). The game is played between the "majority" and the "minority". Numbers in cells are the payoffs of the minority. If the majority of firms choose to have high equity, it pays to the minority to choose high leverage because this will make them more profitable while the system is still stable since the majority has low leverage. But if everyone chooses high leverage, the system becomes highly fragile and all are exposed to higher risks.

This might explain the "thrust towards fragility" that Hyman Minsky characterized of capitalist economies, as part of his "financial instability hypothesis" (Minsky, 1982, 1986).

A similar race, but in the opposite direction, happens when deleveraging in economic downturns. As market demand slows down, creditors demand higher collateral and/or force foreclosure of assets or properties, as happened in the recent crisis. The negative impact of foreclosure of properties extends beyond direct borrowers and lenders, increasing the downward pressure of prices, leading to another wave of defaults due to inability to refinance. The downward spiral can be avoided if creditors give respite to borrowers and allow forbearance; in this case every one is better off as assets and properties preserve their values with minimum collateral damage. But if most creditors follow this strategy, some would be better off to deviate and force foreclosure, because they will be able to auction off the property at reasonable prices. It is the same n-PD problem.

The race for leverage and deleverage is even worse in financial markets. Thurner et al. (2010) analyze collateralized short-term debt with margin calls, widely practiced in financial markets. In this environment, funds that use higher leverage are able to generate higher profits, and thus attract more investors. As other investment funds follow, average leverage increases. Thurner et al. also show how such leverage causes endogenous volatility. Without leverage, investors' strategy is stabilizing: to buy in falling market where price is below fundamental value, and sell when market is booming. But with leverage, a price drop causes margin calls, which makes investment funds sell assets that they would otherwise be buying. When many funds sell, price drops further, causing another round of feedback. The authors show how such nonlinear dynamics lead to fat tails and clustered volatility. This supports the argument that market volatility is caused by endogenous dynamics rather than the nature of exogenous information.

Speculative Pressure

The trend in increasing speculative activities can also be explained, again at least in part, using the PD framework.

Consider a real trade transaction, in which a supplier has to deliver a certain good or commodity to the client, and the latter has to pay the full price. This mutually beneficial transaction is essential for productive economies. Now consider an agreement between two parties to trade the same good or commodity at a future date, but instead of delivering the commodity, the two parties simply settle the deal through paying the change in price at maturity compared with the agreed price. If market price at maturity is higher, the seller pays the difference; if lower, the buyer pays the difference. This is simply a forward derivative contract.

Obviously, this contract is a bet against the good's price. It is much less costly than the real trade transaction: No delivery and no full price payment. All they have to pay is price difference at maturity (plus a small down payment at contract time). Thus, other things constant, the winner in the bet is able to make more money than in case of the real trade transaction. The loser, however, does not necessarily consider himself a net loser: He reverses the bet with other parties, so the loss is born by another bettor, who in turn also reverses the bet, etc. Speculators are playing an *n*-person zero-sum game in which loss is pushed to the "greater fool," as discussed earlier. From speculators' point of view, they expect to make more money than those in the real sector, and in fact, in the short run, they might very well be doing so. Just like a bubble, however, it must come to a halt whereby the "greater fools" are unable to offload the risks, and the bubble explodes in their hands. Unfortunately, at that stage, losses are so huge that even the real sector suffers.

Thus, overall, speculators perceive that they will make more money in good times, and, in bad times, will suffer comparable losses with the real sector. There is an incentive, therefore, to switch from real trade to betting, just like there is an incentive to defect in a PD game. This incentive though holds as long as the real sector is doing its job. Otherwise, if most economic agents decide to bet rather than trade and produce real goods and services, the economy simply collapses.

		Majority	
		Trade	Bet
Minority	Trade	*a*	*c*
	Bet	*b*	*d*

Minority Payoff: $b > a > d > c$

Accordingly, the relationship between the speculative sector and the real sector becomes an *n*-PD relationship: As long as the real sector is producing, it pays for speculators to bet; but if everyone becomes a bettor, they all lose. This is represented in the table above.

But the problem does not stop here. As the speculative industry grows and expands, bettors keep looking for new ways to earn extra returns. The most natural way is to extend the previous trend: Instead of betting on real goods or commodities, why not bet on bets? The second level of betting has similar incentives of the first level: lower costs and easier means to make money. The first level of betting is "covered" betting, when the seller owns the underlying commodity. The second level is "naked" betting: the seller does not own the commodity; it becomes a purely side-bet. At another level, speculators bet on an "index" of commodities that simply does not physically exist. At even a higher level, speculators bet on an index of bets, and so on. In derivatives markets, there are futures on futures, futures on options, options on futures, etc. In the recent crisis, mortgage debt was securitized through several levels: it starts with MBS, then CDO, and then synthetic CDOs, CDO squared, CDO cubed, etc.

Financial Decoupling

Financial fallacies cause financial markets to grow on their own. This results in disconnection of the financial sector from the real sector, where financial markets "seem to develop a life of their own, and at times appear entirely disconnected from their underlying economic fundamentals" (Lux, 2009, p. 218). Unfortunately, this disconnection is unsustainable, and correction has to take place, sooner or later. The cost of this divergence ultimately is paid by ordinary citizens in the real sector.

3.3 *Lucas Critique, Tail Risk and Black Swans*

In *n*-person zero-sum games and *n*-Prisoner's Dilemma games, the fallacy of composition transforms an unlikely event into a reality. What starts as a "tail risk," a low-probability event of loss or default, becomes by the actions of agents, a highly likely event.

When agents behave and interact in a certain manner, it becomes a relatively stable regularity. The probability that this regularity fails becomes small or distant. Taking this regularity as given, an opportunity arises for some agents to take advantage of it. But as soon as others start to realize this opportunity, this "regularity" loses stability, and probability that it fails becomes very high.

This is consistent with the "Lucas Critique". A model may not be stable if it is used to recommend actions or behaviors that are not accounted for in the model itself (see Savin and Whitman, 1992). According to U. Rajan et al. (2010), models used to predict risk and probability of defaults are subject to Lucas critique: As agents (banks and others) know the models used for prediction, they will adapt their behavior accordingly. This makes banks take additional risks assuming that probability of defaults overall are constant as determined by these models. U. Rajan et al. (2010) describe the result as "Failure of Models that Predict Failures". As Stiglitz (2010, p. 95) rightly point out, models based on data from pre-securitization era were used to create financial instruments, like CDOs and CDSs, that alter the data-generating processes, which makes these models invalid. The models assumed "crash-free" markets, which itself contributed to the crash, as Bouchaud (2008) points out.

But the Lucas Critique does not necessarily imply that, by utilizing such models, the tail risk becomes materialized. The latter is likely to happen only when agents are in conflict; in this case that utilizing the model to take advantage of other agents would lead them to react in the opposite direction, just as in a minority game or *n*-PD game. It is not difficult to see that that this result is consistent with the impossibility result of predicting the behavior of rational opponents, established by Foster and Young (2001) and Nachbar (2005), among others.

This was the case with traders and bankers who were trying to maximize their returns by exploiting regularities detected by their models. As R. Rajan (2010, p. 146) points out, "their own collective actions precipitated the events they should have feared". Mainelli and Giffords (2009, pp. 18-19) note that herd behavior combined with unending search for "alpha" (or excess returns) will eventually undermine any risk-mitigation structure, and create discontinuities and inevitable tail risks. So what was considered a "black swan" has been transformed into a "white swan" (Roubini and Mihm, 2010, p. 300).

4 Roots of Fallacious Behavior

Raghuram Rajan, University of Chicago professor of finance and former chief economist at IMF, writes in his book, *Fault Lines* (2010, p. 126):

> In sum, bankers are not the horned, greedy villains the public now sees them to be. In the classes I have taught over the years, the future bankers were as eager, friendly, and ready to share as the other students in class … I have no doubt they continue to be decent, caring human beings. But *because their business typically offers few pillars to which they can anchor their morality, their primary compass becomes how much money they make*. The picture of bankers slavering after bonuses soon after they had been rescued by government bailouts was not only outrageous but also pitiable—pitiable because they were clamoring for their primary measure of self-worth and status to be restored. (Emphasis added.)

John Bogle, former CEO of Vanguard Group, in his book *Enough* (2010, p. xxiv) describes the financial crisis as an "ethical crisis". He cites Reuter's economics editor Edward Hadas (2008) saying:

> A distressingly large portion of activity in the financial world is little more than gambling. When shares and bonds, or derivatives based on them, are bought and sold, the gains and losses almost cancel each other out. Such trading may be fun — portfolio management is a common hobby — but it does almost nothing for the nonfinancial economy … There is a psychological, even a moral, problem with finance. A country gets rich by making stuff, not by seeming to make money from money … The economically illusory gains of finance distract people from more valuable tasks.

Economics, from Adam Smith until J.M. Keynes, was understood to be a moral science (Staveren and Peil, 2011). Yet, virtually alone among the major professions, economics lacks a body of professional ethics to guide its practitioners (DeMartino, 2011). In the classification system of economic literature by American Economic Association, there is no entry for "ethics" or "morality", although it mentions "social values". The stories reported by industry experts, years before the crisis, show consequences of the steady decline of ethical and moral principles (Partnoy, 1997, 2003; Das, 2006; Ferguson and Marrs, 2010).

As R. Rajan rightly notes, bankers and traders are not intrinsically villains; it is the nature of the environment they operate in and the game they keep playing. As we have seen in the Dollar Auction game, good, ordinary people suddenly may behave aggressively and violently due to the rules of the game. If we want people to preserve their good nature, then we need to modify the rules of the game. In particular, fallacies of composition need to be circumvented in order to dampen the incentive for exploiting others and taking advantage of them. To reach that, not only regulatory measures are needed, but also, and as a prerequisite, ethical pillars need to be in place to which bankers and market players would anchor their morality. Below we discuss some essential aspects of ethics, and how they, by nature, could contain and circumvent financial fallacies.

4.1 *Universalizability*

Universalizability is a basic property of ethical statements. It means that "whatever is right (or wrong) in one situation, then it is right (or wrong) in any relevantly similar situation" (Singer, 1999; Harris et al., 2008, pp. 57, 64). This principle is common to moral theories of Kant (1785), Rawls (1971), and other moral philosophers (Barry, 1989, pp. 196-197). According to Richard Hare (1977), universalizability is common to all judgments, not only normative. Hence, offense against universalizability is *logical*, not (only) moral (Singer, 1999).

It is not difficult to see the moral appeal of this principle. It rests on the basic premise that humans are essentially equal: One cannot give himself privileges that others, sharing similar attributes and in comparable situations, shall not have. It reflects fairness and justice in treating self and others. Obviously, this principle does not allow for fallacies of composition to arise. In case of zeros-sum games, each player will do its best not to allow others to win, because if they do, he or she must lose. In a Prisoner's Dilemma game, the defector never wants others to defect. The dilemma therefore can be avoided if players adopt universalizable rules of behavior.

Amartya Sen (1974) argues that the "categorical imperative" would eliminate the dilemma in PD game, since defection is not universalizable. So does Anatol Rapoport (1987, pp. 975-976), who points out that Prisoner's Dilemma game, and public good games in general, "provide a rigorous rationale for Kant's Categorical Imperative: act in the way you wish others to act. Acting on this principle reflects more than altruism. It reflects a form of rationality which takes into account the circumstance that the effectiveness of a strategy may depend crucially on how many others adopt it". It is not difficult to see how deviation in a PD is logically inconsistent: The reason to deviate is to gain, not to lose. But if deviation is universalized, all players stand to lose. This defeats the primary reason for deviation. Deviation in PD therefore is self-defeating, as previously pointed out (see White, 2009, for a counter argument).

This kind of "rationality" that Rapoport refers to is close to "ecological rationality" advanced by Gigerenzer et al. (1999) and Vernon Smith (2008). According to

Smith, a behavior is ecologically rational if it is adapted to the structure of its environment (p. 36). He cites Hayek (1973) that this concept of rationality leads to the insight that orderliness of society preserved practices that enabled the group to prevail (p. 37). Ecological rationality therefore extends individual rationality to group rationality.

According to Nowak (2011, ch. 4), evolutionary models show how cooperation at the group level allows the group to survive and surpass groups which give individual rationality a priority over group rationality. Groups of cooperators tend to win and triumph over groups of defectors.

Coleman et al. (2008) provide experimental evidence that humans favor group rationality over individual rationality, despite that the latter is the Nash equilibrium of the game. Most subjects expected their partners to cooperate and thus follow the same collective choice approach. Coleman et al. argue that "team reasoning" is not equivalent to a weighted average of self and the other player. Rather, it is to maximize the collective payoff, even though the outcome is inconsistent with Nash equilibrium.

Overall, "ecological rationality," "collective rationality," or "team reasoning," is consistent with human behavior. "Universalizability", therefore, gains support not only from fairness and justice, but also from evolutionary dynamics and experimental evidence.

4.2 *Reversibility*

"Reversibility" is a local ethical property: It says that, in a bilateral interaction, one should choose an action that would be acceptable to him if he were in the other's shoes. If each party follows the same rule, the set of actions they converge unto would be morally acceptable. The reason is that, in this manner, each treats the other equally to himself. Thus, "equilibrium" actions are fair to each other. When more than two parties are involved, reversibility pair wise may allow the group to reach mutually satisfying set of actions. The "reversible solution" could be reached as right from anyone's perspective, given that each puts himself in the shoes of the other (Kohlberg, 1973).

From economics point of view, this sounds much like solving simultaneous equations. Role-taking can be thought of as substituting choice function of each party into that of others. The “reversible solution” is equivalent to the solution of the equations or the “fixed point” of the system.

Reversibility can be extended from a (small) group of agents to larger groups by repeatedly applying the same rule. The “reversible solution” therefore becomes universalizable. Hence, local reversibility may lead to global universalizability (see Wattles, 1996, pp. 124-125). This resonates well with complexity approach whereby global order is reached through local interactions. Reversibility therefore can be viewed as a decision process towards reaching universalizability. Further, the reversibility process itself is universalizable.

A zero-sum game cannot be admissible by the reversibility criterion: Given the outcome of the game (i.e. ex post), the winner would not hold to his choice if he puts himself in the loser’s shoes. Conflict of interests does not allow the two parties to reach mutually satisfying decisions. Similarly, in a Prisoner’s Dilemma game, the defector strictly prefers the other player to cooperate; if he puts himself in the cooperator’s shoes, defection will not be admissible. Reversibility might find empirical support in the growing research in neuroscience of empathy.

4.3 *Empathy*

Role-taking is supported by recent neuroscience research on empathy. There is mounting evidence that observing a person performing a certain action activates a set of neurons in the observer’s brain that includes the same neurons responsible for performing that action by the observer himself. “Mirror neurons” work more or less as mirrors: to project the observed person’s activity onto the observer’s own mind, as if he is performing the action. This is true not only for actions, but also emotions (Rizzolatti and Sinigaglia, 2008). In this manner, one is able to temporary put himself in the other’s shoes. Research further shows that such process takes place non-consciously. Feelings and emotions resonate spontaneously, although it might be complemented by cognitive inference. “Emotional resonance” helps coordinate behavior and harmonize actions. Since it is to a substantial degree spontaneous, empathy is the default state of nature (Baaren et al., 2009; Pfeifer and Dapretto, 2009).

Donald Pfaff (2007) argues that it is more costly for the neural system to isolate the feelings of the self from the interacting party than to resonate with him. The temporary blur of the barrier between identities induces empathy and shared feelings. It is not difficult to see how shared feelings induces "collective rationality" or "team reasoning" that is at odds with the fallacy of composition.

Pfaff also argues that our brains are equipped will all mechanisms needed for cooperative tendencies. Noam Chomsky proposed that humans are born with inherent capacity to learn language. Similarly, Pfaff argues, humans are born with inherent capacity for fair play and ethical behavior.

4.4 *Reciprocity and the Gulden Rule*

Role-taking might explain the natural and widely documented tendency for reciprocity. Reciprocity means that, in response to friendly actions, people usually respond nicely and favorably; conversely, in response to hostile actions, they are frequently nasty and even brutal. This is true even with strangers, even when it is costly to do so and yields no material reward (Fehr and Gächter, 2000). Reciprocity implies that one is able to play the same role of the counterparty in order to treat him in the same manner he was treated. But this requires that one is able to envisage the role of the other party. The mirror neural system enables us to perform this process.

The Golden rule, "Do unto others what you want others do unto you," is a near universal ethical rule (Wattles, 1996). It can be seen as a normative extension of reciprocity: Given that people will reciprocate the way you treat them, then it is better to treat them nicely so that they are likely to treat you nicely as well. "Tit for Tat" strategy is an obvious application: It starts with cooperation (being nice), which is the normative part; it reciprocates afterwards, which is the positive part. Not surprisingly, Tit for Tat is able to elicit cooperation very well (Axelrod, 1984). But the Golden Rule allows for a variety of other strategies, like Tit for 2 Tat and Generous Tit for Tat (Nowak, 2011). These strategies are based on reciprocity and aim at eliciting cooperation rather than defection, and that is the essence of the Golden Rule.

The logic of the Golden Rule is deeply ingrained in human judgments. When a bank sells a security to its clients, at the same time when the bank is betting against this security, it immediately becomes obvious that the bank is not behaving properly. The bank is not fair in treating its clients since it is recommending a security that it would not have accepted for itself, despite the fact that both the client and the bank have the same objective of making positive returns. Many governance issues, like conflict of interest and inside information, can be traced back, ultimately, to the logic of the Golden Rule.

4.5 *Symmetry*

Symmetry is defined as immunity to a possible change. It had played a crucial role in the progress of science, and in recent times, it is considered as the foundation of science (Rosen, 2010).

Stanford University professor Roger Shepard (2001, 2008) argues that, just as symmetry is so fundamental to universal principles of science and physics, like the principle of least action, symmetry may be equally basic to universal principles of ethics. He argues that the "categorical imperative" of Kant (1785), and "the veil of ignorance" of Rawls (1971), and other moral theories, have as common the "symmetry of invariance under permutation of individuals" (2008, p. 28).

Shepard goes further to point out that a candidate for a universal moral principle is the Golden Rule, which is endorsed by most religions. Symmetry is deeply internalized in human beings, and thus serves as a basis for universal ethical principles. Just as all human beings have unique potential for learning a fully expressive natural language, all human beings have the latent potential for achieving rational, self-consistent, moral principles (*ibid*, p. 26).

Robert Nozick (2001) examines the nature of "the objective world". A phenomenon is objective if it is invariant under a certain range of possible transformations. Nozick extends the discussion to ethics, examining objectivity of the process for reaching ethical and moral judgments, and objectivity of ethical statements themselves. For the process to be objective, one has to be impartial, lack personal involvement that might bias the result. The "ideal observer" of Adam Smith, and "veil of ignorance" of Rawls, among others, reflect this requirement (p. 288). Objectivity of ethical statements involves certain symmetry, and he cites the Golden Rule as an example (p. 289). He then cites several theories of justice, which require symmetry or similarity in treatment, like those of Kant, Sedgwick, and Hare. Nozick points out that "similarity in treatment stems from impartiality". This means symmetry is required for both: process and judgment.

Both Nozick and Shepard, therefore, make parallels between ethics and science, whereby symmetry is the common criterion for objectivity and consistency.

4.6 *Symmetry, Complexity, and Stability*

Hermann Weyl (1983, p. 3) notes that, in one sense, "symmetry denotes that sort of concordance of several parts by which they integrate into a whole" (cited in Stewart and Golubitsky, 1992, p. 27). When parts integrate into a whole, the whole would possess properties invariant under certain transformations, the parts fail independently to maintain. For example, space-time shows invariant properties that space and time, independently, do not preserve under transformation (Nozick, 2001, p. 77).

The fallacy of composition arises in complex systems in which invariances of the part or the individual are not identical to those of the whole or the group. This means that, when agents behave ethically, they are able to gain, as a group, invariances absent from individuals. By definition, invariance implies conserved properties under a range of possible transformations, and thus a minimum degree of stability of the system. The link between symmetry and stability therefore is not hard to see.

Putting the above discussions into perspective, it becomes clear that ethics are not purely personal or subjective, with negligible impact on markets. Ethics might be as objective as pure science, and are essential for stability and resilience of the economy.

4.7 *Ethics and Economics*

According to Nozick (2001, pp. 240-242), the function of ethics is to coordinate on mutual benefits. But that is what we learn in elementary economics about "gains from trade." Both ethics and trade, therefore, have the same function: to reach mutual gain. So how come they diverge and move apart? The answer lies in complexity: When the whole behaves differently from the parts, fallacy of composition arises, and thus self-interested trade would diverge from ethics. To bring them back, we don't need to give up on trade. It is exactly the opposite: To preserve gains from trade we need to give up on zero-sum and opportunistic interactions. These interactions defeat the objective of trade that economists analyze, and thus become ethically questionable. This confirms that economics, in essence, is a moral science.

Adam Smith was right about the market's invisible hand. He only failed to mention that there is another invisible hand; a hand that coordinates individual's rationality with that of the group. Market's hand works through material interest; the social hand works through the moral sense. The two hands are not supposed to miss with each other; rather, together, they can make a much more creative and interesting systems.

5 Conclusions

We live in a complex world whereby properties and behavior of the whole diverge significantly from those of the parts. "Methodological individualism" cannot as such be taken for granted any more, particularly after the global financial crisis. Regulators and policy makers became well aware of this divergence, and accordingly, they are developing "macro-prudential" regulations in contrast to the previously adopted "micro-prudential" ones. But regulations, although necessary, are not sufficient. We need to re-examine the underlying principles guiding economic behavior. Economics and finance need to be redesigned to reflect modern developments in science of symmetry and complexity. Interestingly, but not surprisingly, in this manner economics is able to reclaim its position as a moral science.

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