Mechanisms of social value creation: extending financial modelling to social entrepreneurship and social innovation

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Abstract: We focus on the identification and selection of innovation initiatives that are intended to create cumulative social value. We suggest that a process like discounted cash flow (DCF) is needed, but developing such a process is complicated in the social value context due to a lack of metrics and consistent social value constructs. Taking a dynamical systems perspective and using economic modelling as a guide, we argue that access to resources and information about their future use represent measurable social value. Further, we describe innovation as the recognition and exploitation of patterns in the environment that create social value.

Keywords: social value creation; entrepreneurship; social innovation; discounted cash flow analysis; dynamical systems; access to resources.

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1 Introduction

Social entrepreneurship has become an area of increasing interest in both practice and academia. The diversity of specific implementations and the variety in their objectives (Massetti, 2008) make it a difficult subject to develop theoretically. As Goldstein et al. (2008) point out, one of the challenges facing those interested in a theory of social entrepreneurship is determining the constructs, relationships and metrics for social value creation. To pursue this question, we will define the social value created by an organised activity as the net benefit that accrues to all stakeholders including those in future generations. Of course, what is meant by 'benefit' and how it is measured, just who the 'stakeholders' are and how we determine impacts on them, and how one anticipates the desires of 'future generations' and determines the benefits they receive as balanced against the current situation, are the hard questions.

One might argue that the meaning of social value is so apparent that it need not be defined. For example, when one feeds the hungry, social value is created. But such thinking is erroneous. Despite being a kind act, feeding a hungry child only creates lasting social value if some broader social benefit is achieved. In theory, one of the advantages that economics has over the other social sciences is that, in addition to offering a more broad-based perspective than finance and accounting, it offers tools and methods with which value can be expressed quantitatively. Economic value is a simple matter, since we might argue that individual wealth, aggregated across all individuals, sums to national wealth. But because social value involves stakeholders other than shareholders, and often what they value is non-monetary, the problem is far more difficult.

Complexity science and in particular, dynamical systems theory, provide a broad mathematical and philosophical framework that connects the physical sciences – and therefore physical resources and environmental effects – with the social sciences and our understanding of human experience. It is a quantitative approach to modelling phenomena that if aptly applied may further our understanding of social value creation. This article will elaborate a means through which complexity can be utilised to develop a more rigorous definition of social value (Emtairah and Mont, 2008).

In order to quantify social value, we must establish a unit of measure (Lempert and Nguyen, 2008; Mayer, 2008). We argue that any measure of this type should reflect two elements:

1 a system's potential for continued access to necessary resources of various types including social resources such as community

2 the acquisition and use of information that increases the potential for the use of those resources in the future, what Hazy et al. (2008) called technology leverage.

The first is important because physical and biological systems require continued access to resources; access to them thus implies that value is created (Jackson et al., 2008; Hajeeh, 2008) in both a social and economic context. The second is important because information about the resources and how to obtain them, as well as how to use them efficiently increases the value of the resources that are being used; this notion of resource productivity is particularly important when resources are limited. This later aspect of social value creation is directly linked to innovation. The convergence of business and social practices (Ramirez and Janiga, 2009) support the approach we describe and the need for a common analysis method.

We begin with a discussion of dynamical systems theory and how it might help us understand the dynamics of innovation in the context of economic and social value creation. Because the creation of economic value leads to wealth and prosperity, it may also create social value depending upon the impact the activity has on other stakeholders, including those in future generations. We therefore posit that any definition of social value creation must encompass economic value creation. More precisely, we posit that economic value creation is a special case of social value creation. *Ceteris paribus,* economic value creation creates a like amount of social value. However, when non-shareholder stakeholders are also affected, economic value is in general not equal to social value. We seek to broaden the economic approach that is commonly used in finance – discounted cash flow (DCF) analysis – to include other constituencies and thus to enable the analytical evaluation of the social value created through innovation. To do this, we frame both economic and social value in a dynamical systems context.

2 Nested dynamical systems and information

Dynamical systems, like those used to describe social and economic systems, are highly interactive and non-linear, and therefore often defy the use of simplified analytical models that clearly predict outcomes. Some aspects of these systems can be idealised so that simplified models can be created and solutions found. This is what is done in economic modelling in the case of the 'profit maximising firm' for example, but it is also a common strategy for modelling social systems with respect to demographics, game theory studies and epidemiology to name a few. However, many important problems cannot easily be reduced in this way.

Fortunately, over the last 50 years a robust mathematics of dynamical systems has been developed to describe the behaviour of non-linear systems, albeit without the same level of apparent certainty that idealised linear models falsely imply. According to Hirsch et al. (2004), a dynamical system is a way of describing the passage of time through all points of a given space. For our purposes, 'space' is not necessarily (nor is it usually) limited to the three-dimensional physical space in which we live. Rather, it is an abstraction that represents the space of all possible states of an organisation, or of a group or even an institutional field, even when those 'states' are represented by a set of variables such as personnel engagement, client satisfaction or profitability.[1]

A combination of values for these sets of variables is called a *point* and the set of all possible points forms what is called a *state space*. Mathematically, an organisation is assumed to reside at a single point in this space at a particular time. The question to be answered is not necessarily how one maximises a single variable – profits for example – but rather where the system will be among all of it possible configurations at a point in the future. In practice, not all points in state space can be occupied by the system. When initial conditions are known, the subset of points in space that the system can occupy is called its *orbit*, just as the path that the planet Mars sweeps around the sun is its orbit.[2] Such a model can be compared to empirical evidence, and indeed, in the case of even very complex physical systems, the models that have been developed by science are remarkably accurate.[3] It is an open question whether anything like this precision is possible for social systems. Indeed, in a sense, all of organisational life – and the study of it – are constant searches for an answer to this question.

An example of the complexity of the challenge can be seen in a social entrepreneurship venture in Croatia (Odinsky-Zec and Stubbs, 2009), where former boxer has developed an organic farming venture to make money, indeed, but also to further his own perspective on social value, a benefit that is more difficult to measure. The entrepreneur believes that his personal success initially as a professional boxer and then as a businessman was enhanced in part by his discipline and healthy eating habits. For his ventures, his drive comes in part from his desire to spread what he perceives to be his healthy lifestyle. These ideals are embodied in a set of principles that he will not compromise and he believes these are key to his continued profits. Profits are important, yes, but so is social change. His is not solely a profit maximisation strategy all; it includes something else, something different. In his case, the trade-off between economic value and social value is made implicitly by him, based upon his intuition. For those interested in studying the social entrepreneurship phenomenon, however, a more disciplined approach to predicting and evaluating social value creation is needed. When the future state of the social enterprise within its environment can be modelled as a dynamical system, in a way that includes social benefits, its potential to create value can be calculated but only if the future state can be predicted with confidence. This is not always easy (Uskokovic, 2008).

2.1 Convergence toward attractors

Attractors within a dynamical system are defined as subsets of state space, such that when the orbit of the system enters the subspace, it does not exit. In a sense, then, a dynamical system with an attractor is predictable. The capital constrained firm cannot experience growth that would cause it to run out of cash. At the same time, effective management and shareholder oversight would apply pressure for the firm to maximise its growth path for its self-funding trajectory. In other words, an attractor is a set of possible organisational states that in some sense 'attracts' all of the system's nearby configurations and draws them toward the attractor states. In the example above, the regulating mechanism goes like this: If growth is too fast, the firm will become low on cash and this implies the need to apply the brakes to growth. If growth is too slow, investors will seek to take their capital elsewhere, a reality that can drive management to push the system to grow as fast as it can. The parameters and their specific settings are important in this process as they determine the attractor.

Each combination of constraints on the system implies an underlying set of mathematical parameters that establish a potentially different attractor cage. If constraints change, (a capital infusion, for example) so too does the attractor cage. By adjusting constraints and implicitly, the appropriate parameters (Haken, 2006), the system's behaviour can be changed from dynamics that are drawn to a simple point attractor, to those moving to an attractor that oscillates between states, or even toward a more complex attractor that does not reach a single point of stability, or even an oscillating configuration, but one that is still contained within an *attractor cage,* a state that is not always precisely predictable but remains contained in a subset of state space. In dynamical systems, parameters make a huge difference. What these constraints are, how they can be influenced and how changes impact the implicit dynamical system parameters are undeveloped areas of organisation theory. Most models currently used in social science implicitly assume that these important parameters remain constant and further they are assumed to be set at a level such that they approach a point attractor or at best an oscillating or periodic one.

2.2 Fluctuations and divergence within attractors

Up to now, we have assumed that the dynamical systems in use to describe organisations of interest are deterministic. Once initial conditions are known, in other words, information about the current state is all that is needed to determine its state at some future point. Yet surprises happen all the time in organisational systems. The invention of the microprocessor by Intel was serendipitous and unplanned, and it fundamentally changed the operating environment both within the company and beyond it (Hazy, 2008). Not only was this significant event not predictable or deterministic, it introduced divergence and instability into the system with dramatic long-term effects.[4]

To understand why this occurred, it is useful to look at Haken's (2006) synergetics model. Haken generalises Ginzburg-Landau theory that describes chemical state changes (Guastello, 2002) and argues that fluctuations which introduce divergence into a system's dynamics have the potential to reorder the system according to new attractors. By divergence, we mean that along some dimension, the observed effect grows exponentially (with a positive exponent). Fluctuations or 'experiments' that occur in the system, either by random events or intent, can have certain components – those that are not dampened by balancing feedback – that tend to diverge in this way.[5] Mathematically, this also means that along some dimension new information is being uncovered (Ruelle, 1989). This was the case when an 'experiment' at Intel led to the microprocessor industry (Hazy, 2008). As new uses and technologies were discovered, new information about the marketplace for microprocessors was uncovered. As microprocessors were used for more and for more new things, for a while the market opportunity expanded exponentially, an example of a divergent component in Intel's attractor cage.

If and when divergent components like the microprocessor encounter opportunity potential in the environment, external forces reinforce internal activities – as the expanding marketplace did for the microprocessor. Under these circumstances, a divergent component can be sustained over a long time span. Its influence can exceed the time required for local interactions, such as production cycles, annual budgets, etc., in a firm like Intel and influence those cycles. In such cases, the longer term trends eventually come to dominate the microdynamics of daily activities, constraining them and gradually redefining the operation of the system. In other words, the organisational system may come to be dominated by divergences that originally arose from local experiments. When outside forces amplify the divergent component, however, it may become the core element of an innovation that completely transforms the organisation of society. This process happens in business, but it can also happen on a larger scale and even change society. This is the potential that social entrepreneurship offers.

Reordering events such as these are somewhat rare. Most often experiments remain local and dissipate without effect or they have divergence that distracts but is not amplified by reordering forces in the environment. However, when divergent aspects come under the influence of new and potentially stronger forces in the environment – the broader economic and political system in the case of social systems – reordering of the entire society becomes possible (Nadler and Kros, 2009). Futurists sometimes refer to the divergent micro level fluctuations that might signal larger scale changes as the 'weak signals', the 'long waves' or the 'mega trends'. Sorting through these 'projects' to identify those that reflect weak signals from ordering forces in the environment is a key challenge for management.

According to dynamical systems theory (Haken, 2006), the issue of whether weak signals rise above the background noise depends critically on the values of the parameters that are constraining the system and on the specific nature of the attractor cage that contains the system. A system that tends toward a single state and thus has a point attractor, for example, would tolerate little divergence during experimentation even within random events or fluctuations. It would therefore tend to dampen any and all distracting fluctuations to quickly drown out the presence of weak signals. For example, a focused sports team has the capacity to ignore the effects of injuries or officiating inconsistencies that might distract another team. A single-minded attraction toward winning drives the team forward to its goal even against the odds and even as the team is buffeted by random events.

When a social system does not have a single point of focus but instead is more loosely constrained and may move in more than one direction, it is said to exhibit *dynamics of requisite complexity* (Goldstein et al., 2008). Under these conditions, experimentation occurs and new information is gathered. When this occurs in the context of an opportunity potential in the environment, those involved may recognise the potential and adapt into a new organising pattern in the firm. They do this as local fluctuations respond consistently to the forces in the environment. When these forces dominate local interactions, the system experiences a *structural reordering* as local interaction dynamics become less significant than the large scale impacts.

Political systems likewise experience structural reordering. This is what occurred and continues to occur across Eastern Europe after the fall of the Soviet Union. Europe is reordering with the adoption of the European Union and South Africa realigned at the end of Apartheid. It is what the members of the US Government and its allies hope will occur in Iraq, Afghanistan and across the Middle East. As we write, the USA is in the midst of a structural reordering of its political system as a new democratic administration took office is January 2009[6]. The relationship between political and cultural systems that operate on a large scale and smaller scale innovation and the social entrepreneurship initiatives that operate in the environment is the subject of this paper (Sangle, 2008).

When external forces, represented mathematically as opportunity potential functions, act on the system and imply new ordering of its structure, we call them *ordering forces*. Haken (2006) shows that as these ordering forces change over time, they can sometimes be represented as dynamical systems in their own right. In other words, to the extent that a system under the sway of ordering forces it is predictable. However, that 'sway' or force is still constrained within its own attractor cage. For example, the technological and market conditions that led to the launch of the Intel microprocessor business and the subsequent reordering of Intel (Hazy, 2008) can be thought of as a dynamical system sweeping out an orbit in its state space. To the extent that the larger scale system can be modelled, its dynamics (the technological development and market opportunities for microprocessors) eventually dominated the day-to-day activities within Intel. In other words, the dynamics with the longer time scale can *take off* and even *take over* the system as it resonates in the broader opportunity potential field at work in the organisation's environment. When this occurs, there is a tremendous decrease in complexity as the intricately detailed microdynamics of stability in the previous regime become dominated (and essentially irrelevant) within the context of the sometimes simpler but more powerful dynamics of the larger scale. Regardless of the content of discourse, day-to-day activity and decision-making within Intel, the firm became a microprocessor company because a few key events in the company interacted with powerful forces in the environment.

Note that this reordering is possible because there is new information becoming available within the fluctuations or experiments. When fluctuations occur in a system with dynamics of requisite complexity, the information that is created might not be related to the prior attractor. Rather, it can be indicative of other possible but as yet unrecognised forces in the environment that might present opportunities. When an organisation's members are able to recognise these patterns, they can ride the trend to new possibilities for continued stability and successful growth.

3 Social system innovation

Before describing the process of innovation in dynamical system terms, it is useful to step back and think about the predicament that individuals face in organisations and the important role played by information.

3.1 Information and an organisation's future prospects

In organisational life, each individual makes use of the information that becomes available about the workings of the systems and the environment in which they participate. Each system has stochastic elements (so that the relevant quantities are random variables) and so the information available to each individual is not only the expected value of the system's state (whether profits meet forecasts each quarter, for example), but also the higher order moments of probability distributions that arise from these observations such as the variance, skewness, etc., of these outcomes. Individuals use this information (most often implicitly) to further their understanding of the environment, make choices and take action within these systems. Information about resource flows and the organisational system itself are used to frame individual choices that define their level of participation in relation to their own self-interest (Hazy and Silberstang, 2009b).

Stability in dynamical systems in one form or another makes some predictability possible. Stability of physical and biological systems is certainly evident in the case of daily or seasonal cycles and consistency within the environment. Tomorrow, corn will provide nutrition just as it does today. Economic and social systems have predictable markets and legal constraints as well. Conditions of stability and near stability are characterised by convergence of the relevant dynamical systems toward *attractors* in state space. For individuals within the system, 'predictability' is based upon the presence of information within the system that enables appropriate choices and actions with predictable results. If there were no attractors and attractor cages, or if there is no way to recognise information available about them, reasoned action would not be based on facts and therefore would have no fitness-enhancing value. As a general matter, therefore, it is important to know when stable dynamical systems are present in the environment and what their attractor cages look like. In particular, it would be useful to glean from observation and interventions, if and when new attractors are possible. It would also be helpful if individuals could enact their reality.

3.2 Constraints, parameters, bifurcation and system behaviour

The behaviour of a dynamical system, for example, whether it approaches an attractor, and if it does, the nature of the attractor, is determined in part by the value of the parameters that define its differential equations. When changes to a particular parameter, for example the coefficient of the x term in the equation, cause the system under study to change its dynamics from one attractor cage to another, the system's dynamic behaviour changes qualitatively. The parameter that determines the system's behaviour in this way is called a *bifurcation parameter* and the point of change is called a *bifurcation point*. It is called this because when the value of the parameter passes a certain threshold value, the bifurcation point, the behaviour of the system suddenly changes such that it can occupy one of two (or sometimes more) states.

Although there are many examples in the physical and life sciences (for examples see Nicolis, 1989), examples in the social sciences have only recently been identified. One example was identified in youth groups. The phenomenon studied was the gathering of young people around individual leaders (Phelps and Hubler, 2006). Although initially individuals acted autonomously (an attractor state characterised by low correlation among individual actions), they suddenly shifted to highly correlated action when one individual expressed a direction for the group. In this case, the parameter measured was 'peer pressure' driving individuals to conform to group decisions. In other words, when there was enough social pressure to stay with the group, a qualitatively different state, correlated activity, could result if there was a collective goal to be achieved by cooperation. When peer pressure was low, individuals continued to act for themselves with little or no correlation regardless of whether there was a cooperative opportunity. The dynamics of the group had two possible distinct states when peer pressure was high, but only one when it was low. The dynamics depended on the value of the parameter.

To understand how this process works in general, let us look first at the case where the bifurcation parameter is below the critical threshold. In this case, the agent is highly confident in the information (or value of the coefficient, mathematically speaking) it has about the expected outcome of a particular action or choice to be taken locally – for example, an agent's expectation about his or her personal benefit from taking a particular action. At the same time, agent has little information about the variance or skew in the result that might be due to interaction effects as others play out their own self-interested strategies. For example, an agent has little knowledge or expectation about possible negative interaction effects or what might even be a greater benefit to be gained from cooperating with others. In the above example, each young person knows what to expect from his or her own individual action and has little information about the benefits of cooperating. Nor does he/she have information about the negative consequences that might spring from the actions of others. The signal about 'what is in it for me' is strong enough to block out the possibility that individuals might recognise weak signals about possible external effects. In the youth group example above, conversations among the young people about cooperating on a project are unconvincing when individuals are preoccupied with thoughts about what they would rather be doing elsewhere.

To the extent, these signals about the benefits of cooperation are emitted, they go unrecognised. They are treated as noise and are intentionally extinguished as distraction along with other noise in the environment (Hazy and Silberstang, 2009a). Essentially, although these signals would imply the system is complex with more than one possible future, the actors treat the system as deterministic, choosing to follow what they perceive to be a deterministic path along which they are heading. Implicitly there is an assumption that random fluctuations can be quickly dampened, that divergence does not reflect unrecognised forces and potential opportunities in the market, and there is no acknowledgement that this information must be incorporated into their system of action. The actors attempt to manage action within the system using linear approximation assumptions, simply waiting for the youth group meeting to end, or more generally, using budgets, management by objectives and sales targets.

Above the threshold, the bifurcation point, the situation is quite different. In this case, confidence in information about expected value of individual action is weakened (mathematically the coefficient of that term is near zero). The clearest path to individual self-interest is blocked; the youth group is away on retreat, for example. Without preoccupation over the expected value of the outcome ('what is in it for me?') weak patterns in the interaction background become apparent in the variance, skew and kurtosis of the interactions, hinting at possibilities opening up in the environment, so that these become easier to recognise. Patterns become recognisable; a game of 'capture the flag' or some other group activity might begin, for example. Under conditions like these, ones with the dynamics of requisite complexity, the system might bifurcate and take on qualitatively different dynamics. Under these conditions, *innovation* can occur as individuals quite suddenly change their focus to engage in a new thing, a kind of coordinated action (Hazy and Silberstang, 2009a). This leap can only happen when constraints that had provided clarity toward the expected value of the old path are relaxed so that weak signals about new possibilities are heard. And, of course, ordering forces in the environment have to provide new possibilities.

The idea here is similar to how new sounds come alive when one retreats from the city. Patterns that were previously undetectable become obvious. Many of these are common sounds, insect or night animals, and these are easily recognised and dismissed. These 'fluctuations or novelty' in the otherwise perfect quiet or white noise have all convergent components. Each is clearly contained within the moment and does not represent longer term effects, and so they can be set aside, extinguished and forgotten. But occasionally, there is a sound that might signal the onset of a larger phenomenon. For example, the nearly inaudible rumble of an oncoming train or the not so random explorations of an approaching black bear.

By 'lowering the relative amplitude' of signals that define the accepted norms for local action, other signals, less powerful, perhaps, can be heard. These are weak signals now, but as the illustration shows, what was once a weak signal can become a strong one.

Recognising such signals early brings considerable evolutionary advantage. These conditions force a more probabilistic view of the future. In other words, they introduce the need to incorporate risk into models used to evaluate the signals being perceived and whether they will actually develop along the pattern that is recognised or hypothesised.

The challenge for individuals processing information within such a complex environment is following strong signals that enable convergence to some attractors while at the same time parsing the various weak signals, making choices and engaging in action given the probabilistic trajectories of the ordering forces that are recognised as operating in their environment. Success in the former is performance. Success at the latter process is innovation. To succeed at this systematically, an analytical approach for evaluating alternatives and consistent metrics that allow comparison among alternatives are needed. The success of economics and finance as cumulative social sciences comes from the existence of such techniques and metrics. For positive action to develop in the other social sciences, something similar is needed.

4 Economic value creation as a model

To begin to develop a method for evaluating how social value might be created through social innovation and entrepreneurship, it is useful to look at how economists evaluate the creation of economic value by entrepreneurs. The model we use is *DCF* analysis, the single most important technique in corporate finance. It provides a clear description of what a value creation formula might look like, albeit one with a single dimension, economic value creation for current shareholders. Although it is exclusively current shareholders whose benefit is considered, it is important to note that this technique does include the current or present value of the future value that is created for them.

We take it as axiomatic that economic value creation is a special type of social value creation. Economic value implies wealth. If there are no counter-balancing negative effects from these activities in other relevant spheres of interest for other stakeholders, current and future, then social value has been created (Sangle, 2008). In fact, in finance it is recognised that managers do not always maximise shareholder wealth because they must please other stakeholders (i.e., government bureaucrats, clients, customers, employees, community activists, etc.) as well. Shareholder value maximisation may be an ideal concept in economics. However, this ideal is often modified in practice. It seems therefore that social value creation does in fact go hand in hand with economic value creation. A practical problem remains, however. With the current state of knowledge, it is not possible to objectively compare one alternative to another unless all values are reduced to comparable units of measure.

4.1 The nature of a cash flow

In economics and finance, net cash flow is the flow of cash into an entity minus the cash that flows out. Formally, this cash position is defined as the 'free cash flow' (FCF) to the firm. It is the amount of cash left to the firm after it paid for everything it had to pay for and invested in everything it had to invest in. The former is needed in order to fund the firm's current operations. The latter is needed in order to guarantee the firm's future growth and survival *vis-à-vis* competition.

The FCF belongs to the firm's various security holders and represents the return on their investment in the firm. It is available for distribution based on the nature of their claims, for example as a dividend or an interest payment[7]. It does not capture the value implications for other stakeholders except to the extent their interests influence the cash flow that creates value for security holders.

4.2 Discounting for present versus future value

The fundamental question that DCF analysis attempts to answer is how one evaluates the current value of future cash flows to compare with the value of having cash in one's pocket today – present value. As we describe later, this can only be done because the organisation exists within a well-defined and stable, larger-scale dynamical system, the capital markets.

Value is said to be created when the activities within an organisation generate projects (experiments) that have rates of return exceeding the costs incurred while also acquiring the capital needed to fund these projects. In other words, value is created when one can assume that a firm's activities can earn profits in excess of financing costs now and additional value is created when one can assume that the firm will continue to operate profitably into the future at levels in excess of the firm's cost of capital. In more general terms, the firm has value when there is credible information available within the system implying that the firm will continue to have access to, and the means to acquire and use, the resources that it will need (particularly financial capital, but also human, raw materials, technology, etc., which are acquired using capital) to operate profitably into the future.

Since an organisation obtains various types of capital from multiple sources on varying terms, the weighted average cost of capital (WACC) is utilised as a benchmark to determine a project's value contribution to security holders. Future returns that are assumed to be in excess of the WACC imply value is created. A firm's WACC depends upon the level of risk of expected FCFs – the greater the likelihood of missing the expected FCFs the greater the cost of capital. In other words, uncertainty with respect to future cash flows implies a higher cost of capital and this in turn implies that money today is worth relatively more that is the risky prospect of having money in the future.

4.3 Uncertainty, weak signals and risk

The mobility of capital and the search by agents who have it for high returns with minimal risk can create a problem for firms operating in a marketplace with a high degree of uncertainty. An example was described by Friedman (2008) in his book *Hot, Flat and Crowded*. He describes a conversation he had with Jeffrey Immelt, the Chairman and CEO of General Electric, about the problem large firms face in trying to react to global climate change. He quotes Immelt:

> "Big energy companies won't make 'a multibillion-dollar, forty-year bet on a fifteen-minute market signal. That doesn't work'. Big industry players like GE need some price certainty if they are going to make long-term bets on clean power, and to those market dogmatists who say that government should not be in the business of fixing floor prices or other incentives to stimulate clean power, Immelt says: Get Real. 'Don't worship false idols. The government has its hand in every industry. If they have to be then I'd prefer they were productive rather than destructive." (pp.255–256)

Using complexity terms, what Immelt was saying was that the models that forecast FCFs are based on information that can be confidently associated with convergence to an attractor like a fixed $100 per barrel floor-price for oil. We call information of this type 'strong signals' because when it is detected it has a clear expected value with low variance. Analysts can therefore be confident in their forecasts. In contrast, weak signals, like the vague concerns about long-term global warming, can be detected as a pattern, but the expected values of the various variables in the attractor are not yet understood well enough to be included in planning models – except as increased risk. Weak signals are therefore difficult to use in resource allocation decisions and are sometimes even consciously ignored, as GE is doing in some cases with global climate change. Acknowledging the risk inherent in this uncertainty would actually increase their cost of capital, a situation that managers seek to avoid.

If weak signals are considered, the models will necessarily include considerable risk with respect to predictability. As a result, providers of capital will be less willing to assume the implicit uncertainty even if all parties acknowledge that a weak signal is present. This is because greater uncertainty increases the likelihood that the investors will never achieve acceptable returns. If weak signals do not imply convergence to a planning value of any kind, even the possibilities (and their implied probabilities) cannot be modelled. Thus, there is a point when the level of uncertainty inherent in a particular project exceeds investors' collective appetite for accepting risk even though they are chasing high returns. Projects that lack clearly identifiable attractors are not funded by capital markets, even those investing risk capital. Information from which convergence to an attractor can be inferred is needed because it is how risk is assessed. These ideas imply a proposition.

Proposition 1 A necessary (but not sufficient) condition for capital markets to allocate funding to a project is that there must be information available that can be interpreted as supporting convergence to an attractor.

The existence of the alternative investments is a key institutional factor explaining why the capital markets work to allocate capital resources efficiently. If a business is not creating adequate value for the level of risk assumed, or if information about the firm is not convincing, the money can be taken out of the firm and invested elsewhere. Just as firms allocate capital internally in an effort to accommodate their WACC, capital markets allocate resources to firms who succeed in doing so as investors seek to maximise returns. This is why we said earlier that DCF analysis of economic value creation *within a firm* only works when organisations are considered in a broader capital markets context that allocates resources efficiently *to firms that succeed* in doing so. Capital markets are where the financial securities of these organisations (i.e., claims on their FCFs) are traded, creating a process of efficient capital allocation.

4.4 Fluctuations complicate the calculations

A large number of events affect the firm's FCF, and their arrival can be very difficult to predict. The 2008 financial crisis is only one example. One obvious source of fluctuations would be changing prices for inputs – oil, for example, or agricultural commodities for which prices fluctuate due to weather conditions. Because such fluctuations impact the firm, they impact cash flows and cash flow forecasts. They in turn cause the imputed enterprise value that is based upon the changing information to fluctuate. The value per share likewise fluctuates with the anticipation or arrival of these events.

Most of the time, the fluctuations are inconsequential. In fact, organisations are often designed with the explicit purpose of absorbing fluctuations in inputs as well as those inside the company and dampening their effects. Management is often judged based upon its ability to deliver consistent, stable outputs such as earnings and revenue growth. Vertical integration to stabilise access to inputs and employee cross-training programmes together with clearly documented policies, procedures and work rules are just examples of tactical initiatives that do just this.

On the other hand, at times, aspects of these fluctuations might be more difficult or impossible to contain. This occurs when variance in the microdynamics of internal interactions is driven by a consistent force arising from an opportunity potential in the economy or the broader society. When weak signals of an apparent trend are observed but their implications are not yet recognised or understood, the information is embedded in observed variance, skew or higher order moments. For example, increased absenteeism among employees might be caused by a growing influenza epidemic that has not yet reached a threshold level to be recognised but that might eventually destabilise a firm to the point that it can no longer operate its factories. The trend is first recognised as higher than anticipated variance, etc., and this is interpreted as increases risk.

On the positive side, fluctuations can also lead to innovations. This happened at Intel in the 1960's when engineers were working on various new projects. One of the projects led to the invention of the microprocessor. A general industry trend, a weak signal, involved improvements in microelectronics process technology, a trend that came together to influence one such team. It was a local fluctuation that enabled a single chip design for the world's first microprocessor at Intel. Ultimately, sales of this new invention outpaced the firm's core business in dynamic random access memory or DRAM (Hazy, 2008).

The presence of fluctuations and experiments within the organisation and the resulting recognition by some of weak signals that influence these experiments is the starting point of innovation. If the weak signals are found to reflect the influence of an opportunity potential function within a larger scale dynamical system, that new system can be modelled and a new path that exploits the new opportunity may become apparent. The process of bifurcation to this new path is what is meant by the term 'innovation'.

4.5 *Economic value creation in dynamical systems*

The above can be generalised so that economic value creation might be seen in the context of the process where individuals, managers and investors gather, share and use information to make choices and act within a dynamical system. The forecasted cash flows that sum to PV represent a way to gather and use information about the system and the environment to inform actors within the organisation and in financial markets about the organisation's prospects for acquiring and processing needed resources in the short and the long-term (Helfat et al., 2006).

In what follows, we argue that the relationship between FCF and forecasting access to resources of all types is a fundamental one. The ongoing need to evaluate current operations in detail and then use the information that is available to assess an organisation's current and continuing prospects for acquiring and processing needed resources logically implies that an analysis technique like DCF would be needed in any case. A DCF analysis includes predicted access to resources of all types, assumes price levels for factors of production and evaluates how this access might change in the future. A positive net present value (NPV) (the present value of future cash flows net of the cost of the project) at the end of DCF analysis process – where all of the terms added together are greater than zero – implies that value has been created.

We suggest that an analytical technique like DCF is necessary for evaluating innovation and social entrepreneurship in the context of social value creation. We argue that an approach that mimics DCF but that explicitly addresses an organisation's value creation potential in the context of both resources and information is what is needed. In particular, an organisation's value creation should be described according to the:

1 level of access the organisation has to necessary resources, both that it needs to operate and that are consumed or appropriated by its stakeholders

2 information about those resources and their likely availability in the future

3 knowledge about how to use resources with maximum productivity.

As we describe in the following sections, a modelling approach that uses a dynamical systems perspective would represent a more general and theoretically complete rendering of economic value because it could be modified to include the impact to other stakeholders and the potential for technology leverage (Hazy et al., 2008) to increase the value of the resources.

4.6 DCF and dynamical systems

Traditional DCF analysis is actually a model of the firm as a dynamical system with cash flow as the variable of interest (Henderson and Quandt, 1980). Over time, the system's state – as reflected in its FCFs – changes. The value of cash flows is a function of a number of variables and is constrained by certain parameters. Traditionally, in the explicit calculation of cash flows, the availability of raw materials, human resources and financial capital are implicitly assumed as being fully reflected in market pricing mechanisms and in the process of estimating risk. As such, prices are included as variables in the firm's production function, and thus the prices are variables in the dynamical system reflecting the firm's FCF. Most often simplified linear models are used to estimate prices, however, such as a 5% per year price increase in raw materials. This is obviously oversimplified, in particular when resources are scarce. During the financial crisis of 2008, business and consumer credit (that is, financial resources) became unavailable, conditions where capital pricing models are irrelevant. Dynamical systems models that only having pricing inputs can become useless if they ignore non-linear constraining effects such as credit rationing. Firms dependent on credit such as The Big Three US automobile makers were caught off guard by these non-linearities and were threatened with collapse.

4.7 Bifurcation and qualitative change

In contrast, although we agree that resources – land and raw material, labour and human resources/skills, financial capital and knowledge/technology including entrepreneurship – are critical to an organisation's functioning, we argue that the *level of resources* available to the organisation acts as an external constraint on the system, implicitly serving as a bifurcation parameter for the system's dynamics. This is a decidedly different approach than the one implicit in the linear assumptions that characterise traditional models. In addition to looking for correlations among independent and dependent variables, parameters are also included and their values are assumed to qualitatively change the relationships among the other variables. Because changes to the parameters do not necessarily have a linear effect on the system's response, traditional sensitivity analyses that selects a best, worst and expected case, are unlikely to capture the essential non-linear dynamics that determine the FCF stream. This is because resource constraints, or lack there of, implicitly determine the system's internal dynamics and thus the nature of the attractor cage within which the system operates. Such dynamics may be sensitive to small changes in input.

An example of the bifurcation dynamic is the impact that access to financial capital has on a firm's FCF growth curve. An expansion stage company is often capital constrained and as a result pursues a self-funding operating plan. An injection of incremental funds from a venture capitalist might, if it crosses the threshold point, operate as a bifurcation parameter enabling innovation. Excess funds allow for choices that include funding a portfolio of projects including risky experiments that might reflect ordering forces from opportunity potential in the environment. A portfolio of 'experiments' in turn generates information about those forces for the firm's use. Analysis of this information from all of these experiments might allow managers to infer the presence of an opportunity and target innovation toward the opportunity. Thus, either the firm's management processes effectively channel excess funds to a set of value-creating projects that accelerate FCF growth, or the funds are squandered on unsuccessful projects where growth does not materialise and a lower performance path results. This is a bifurcation.

On the other hand, if the value creating projects are funded, incremental funding above and beyond these successful projects might do little or nothing. The number of value creating projects that are available to a firm is limited by the opportunity potential in the environment; if there are no more opportunities, incremental funding will not drive additional growth. There is an optimal funding level and even though additional funding above that level does not appreciably change the result, it is also true that a certain minimal level of funding is still needed to allow the firm to find the high growth path. Absent a cash injection this bifurcation in FCF growth would not occur; incremental cash, but not too much, enables the firm to either grow more rapidly of fail to capitalise on the opportunity. This non-linear bifurcation description is consistent with empirical results developed by Nohria and Gulati (1996) who found a non-linear relationship between organisational slack and innovation.

4.8 Ordering forces in the environment

Organisations do not exist in isolation. Often, the environment is benign, but at times, a consistent pressure, an adaptive tension (Uhl-Bien et al., 2007), is placed on the system. For reasons described earlier, when adaptive tension originates as a consistent flow or force in the environment that is reshaping industries or societies – for example, the flow of manufacturing from the USA to China due to wage differences – we call these 'ordering forces' and represent them as a potential function acting on the units of the system as well as the system itself. It can be understood in part as a dynamical system in which the organisation is nested.

Ordering forces in this larger system operate on the nested system because they impact its ability to maintain its access to the resources it needs; new markets or new technologies can all be relevant variables in this potential function. Dramatic changes in the dynamical systems within the environment can therefore set off a structural reordering of nested organisations if their agents are in a position to recognise weak signals associated with the ordering forces. For example, in the late 1990s and early 2000s, US information technology (IT) jobs were increasingly outsourced to India. This trend was driven by several factors – wage differences, educational achievement in India and the adoption of total quality management processes – that could have been modelled using dynamical systems techniques. Experiments within US companies that made use of these offshore services allowed those companies to detect the weak signals and potentially recognise a pattern that reflected the dynamical system that was driving the trend. These experiments allowed participating companies to see the new pattern that in turn implied a new emerging attractor (off-shoring of IT) as an alternative to the one (local IT staff) that had previously governed the dynamics within the nested system.

4.9 Variance and discount rates

Organisations are always subject to uncertainties in their cash flow forecasts. When the variance is random, however, some of the components of random fluctuations cancel each other to maintain the expected value. Further, with improved forecasting techniques, some additional error can be eliminated which would reduce the variance.

When an organisation is subject to ordering forces in the environment, however, individuals and subunits of the organisation may be affected, and if they are, the fluctuations at the micro level could be intercorrelated and also correlated with the ordering force. These are the trends to identify, the weak signals. This may be translated into increased variance, skew or other higher order moments in microdynamics in the organisation. Even though forces are being observed in the environment, what we observe is instability and uncertainty as the system is subjected to external forces in the environment, like the off-shoring of IT resources in the industry. The divergent components of fluctuation and experimentation in the system – like individual learning about the skills and processes needed for off-shoring – are observed as uncertainty and translated into a measure of risk. Even though opportunity is present, the selection of a higher discount rate is likely.

5 Social value creation

How can the DCF approach be translated into an analytical technique for the calculation of social value? First, it is necessary to define a single metric for the social value that is created regardless of nature of the value. It would likewise be helpful if the metric is analogous to FCF and that all flows into and out of the system are considered. Next, a method comparable to discounting that can be used for comparing future value created to current value created must be identified. Finally, market mechanisms analogous to capital markets are needed to determine the discount rate.

5.1 Social value as ensuring continuing access to necessary resources

It is necessary to identify a single metric for purposes of a general approach for comparing projects across sectors (Jackson et al., 2008; Emtairah and Mont, 2008). This does not mean that this new quantity would be the only metric. Rather, once such a metric was developed, it could be used to compare different projects against an objective scale. Other factors could also be considered as alternatives are evaluated.

We recognise that all of the inputs and desired outcomes of various and unrelated social projects cannot always be easily reduced to a dollars and cents calculation in a manner that would be internally consistent and acceptable to all stakeholders. However, we do see a dynamic that seems to be common across many types of social projects. It also might imply a common metric, particularly if units in this metric can be traded in markets. Embedded in the objectives of projects as varied as healthcare, literacy, education, family planning, disaster relief and climate change is what amounts to a generalisation of the adage: 'if one gives man a fish, he eats for a day; but if you teach a man to fish, he eats for a lifetime'. In other words, a certain type of social value is created when the target groups gain access to resources ('the fish') 'and also when they are given access to information' or knowledge about how to continue to gain access to resources and use them efficiently ('knowing how to fish'). This adage can be interpreted in DCF terms.

Access to and use of resources in the current period (if this could be measured) is comparable to business activities that result in FCF in the current period. Because the relevant target groups have access to information and know how to use it – they know how to fish – they have the relevant capabilities to continue to have access to resources. As a result, using only information in the current period, but because some aspects of dynamical systems are stable and can be predicted, their ability to access fish in future time periods can be assessed and modelled to forecast future periods (FCF in future periods). Finally, by modelling the stock of fish and competition for fish as well as other relevant dynamics, the probability that the necessary capabilities (knowing how to fish) will retain their ability to access fish can be estimated. In these dynamical systems models, the variance or volatility in outcomes (like the volatility of FCF in future periods) can be estimated. This is the essence of a discounting process. Resources and information about acquiring and processing information are the key elements of the analysis.

Although not quantified, Sietanidid (2008) provides an example of how social value was not created in the sense meant here. She laments the fact that although considerable value (resource benefits in the current period) was created in the specific projects that resulted from a partnership between a British bank and the Prince's Trust (a charitable foundation), little future value was created in the partnership because information from the trust did not flow to the bank to change their procedures more broadly. An opportunity was lost. Unfortunately, with current methods the opportunity cost could not be quantified.

In contrast, Tapsell and Woods (2008) provide an example of how social value can be, and in fact was created among the Maori of New Zealand through both resources and information. In a classic social entrepreneurship venture, young Maori developed a company that compiled and sold maps of traditional cultural sites for the Maori. It was an economic venture and so created economic value that could be measured with traditional

DCF techniques. In addition, however, intangible social value was created. By compiling, documenting and making information about the Maori's culture heritage available not only to tourists, but also to young people who were increasingly alienated from their history, cultural resources were made available. Future access to them, wherever they might be on the island, was enhanced as well. Of course this wasn't measured in the case, but if it had been, both current and future value could have been estimated. In addition, by using dynamical models of demographic changes as well as natural and social systems models, the probability that the maps would provide future value could be calculated. If the probability is high and variance is low, the discount rate would be low. If the variance or volatility is high, the discount rate would be high, meaning there is a higher likelihood that less value might be created in the future by this particular programme. These ideas suggest the following proposition:

Proposition 2 Both access to resources in the present and information about how to acquire resources in the future are important components of social value creation. Both are needed to evaluate current and future benefit versus costs.

With respect to economic value creation analysis, FCF measures both of aspects of Proposition 2. In the current period, explicit calculation of the 'resources acquired through markets versus those consumed' are core to the calculation of current period FCF and is critical for establishing a starting platform from which value is calculated. Based upon this information, forecasts about the future of markets, operations and technology leverage – forecasts which implicitly use the information available in the current period – are used to forecast continued access and use of resources in future periods. A key observation for the present work is that FCF from any period measures the accumulated 'buying power' available for the acquisition of resources in the future. Current period value was accumulated through organising activity and the processing of resources. In this respect, economic currency and the ubiquity of markets provides a ready mechanism to measure of an organisation's success at positioning itself to remain viable within its resources streams into the future.

When an organisation has an operational or dynamic capability (Helfat et al., 2006), it has the capacity to perform some function which adds value to the organisation, like manufacturing or distribution capabilities. The organisation has the resources and the information, knowledge and technology to continue in the future what it has done successfully in the past (assuming the environment and the competition remains relatively stable). In short, the organisation 'knows how to fish' in some sense, and thus, as long there are fish to catch, one has confidence that resources will be available for that firm in the future.

It is the job of the CEO, CFO and management in general to build capabilities and develop business strategies (Teece et al., 1997). They then project out their implications including their prospects for success at driving future FCFs taking into account the changing dynamics in the environment and internal to the system that might impact their probabilities. This is the role of strategy within the firm. It attempts to deal with the realities of the differences between economic value creation and social value creation. These various assumptions and modelling calculations are made explicit when future cash flows are calculated. Thus, the successful use of FCF in financial analysis supports Proposition 2 in regard to economic value creation.

The challenge for the social entrepreneurship community is determining a metric that is analogous to FCF for social enterprises. To the extent that value provided can be reduced to a dollar value, FCF remains relevant.

5.2 Assessing risk in the delivery of future social value

Unfortunately, simply knowing how to fish does not necessarily mean there will be fish to catch. In other words, there is always risk when forecasting future benefit. This relates to the challenge of recognising weak signals that reflect reordering forces in the environment. If these signals are detected, and if a structural reordering is forecasted to be possible, there is a potential in the environment for a change to how resources will be gathered in the future. This is analogous to the risk that future cash flow will be realised.

The uncertainty and risk associated with these possible futures must be included in any assessment of future potential for access to social services resources. At present, aside from an ad hoc process that attempts to reduce some aspects social value to dollars and cents and then using DCF to evaluate risk, there is no method for quantitatively assessing future risk in social enterprises and then comparing outcomes and an associated variance with current value. The method we suggest in Proposition 2 opens the door to assessing risk and implies a third proposition:

Proposition 3 When forecasting 'future access to resources' for constituents, the stochastic nature of fluctuations in the system implies that information may be found within the fluctuations that reflect the reordering forces operating in the environment, forces that might impact the future availability of resources for constituents. Available information includes not only an expected value, but also higher order statistical moments such as variance, skew and kurtosis making it possible to quantify the level of risk regarding the system's potential to acquire resources in future time periods.

As is the earlier case, the DCF process fits this model as well. When forecasters determine the discount rate to be used in the DCF calculation, they incorporate observed variance in the value equations of their analysis. It is assumed that greater uncertainty implies greater variance in future expected outcomes, and these together imply a higher discount rate. Thus, the DCF model is consistent with the framing described in Proposition 3.

5.3 Innovation for social value

Experimentation can lead to innovation, but not necessarily. As we described earlier, innovation occurs only when certain specific conditions come together in an ecology that nurtures it with dynamics of requisite complexity. These conditions require the creation and sharing of information through experimentation in a context where opportunity potential exists within the larger-scale and predictable dynamical systems at work in the wider society. These dynamical systems may be economic, but they may also be social, political or cultural.

In the case of the social entrepreneur and of social enterprises, the presence of experiments and fluctuations within an organisation is a critical prerequisite for successful innovation. There is no other way to gather information and knowledge about the possibilities. Unlike, economic enterprises, however, where capital seeks returns that might devolve from innovation, it may be more difficult for social enterprises to overcome resource constraints that would allow the enterprise to cross the bifurcation threshold into the dynamics of requisite complexity wherein innovation becomes a possibility. As a result, it is difficult for social entrepreneurship projects to be truly innovative and to create and accumulate social value.

Experimentation and fluctuation generate information (Haken, 2006). Without experimentation or fluctuation, little information is available that might enable those involved to recognise weak signals and thus to formulate inferences about patterns that are forming. This is the starting point of innovation in social systems. If the weak signals are recognised and if they are found to reflect the influence of an opportunity potential function within a larger scale dynamical system, that new system can be modelled and a new path that exploits new opportunities may become apparent. If constraints can be relaxed in social enterprises so that the process of bifurcation can be enabled, then new paths to social value can come from true 'innovation' in the social sector. This leads to the proposition:

Proposition 4 Innovation for social value occurs when previously unnoticed ordering forces in the environment are recognised or enacted. This occurs when resource constraints are relaxed beyond the bifurcation point so that enough fluctuations generate adequate information so that social entrepreneurs can recognise the patterns that reflect the ordering forces.

This is a tightrope walk, however, because if constraints are too relaxed, no convergence occurs at all. If the benefits of social innovation are to be cumulative consistent metrics of social value creation are needed so that attractors can be recognised and convergence can begin.

5.4 Implications for social entrepreneurship

A dynamical systems perspective describing innovation and social value creation has implications for the burgeoning field of social entrepreneurship. The dynamical systems perspective described here hints that contrary to what some experts have argued (Trexler, 2008), the social entrepreneurship approach may be qualitatively different from previous approaches to doing social good. This implies the following proposition.

Proposition 5 Effective social entrepreneurship relates to:

1. marshalling resources to a venture to relax constraints and thus enable innovation
2. encouraging experimentation to gather information about value creating opportunity potential in the environment
3. recognising patterns that have the potential to create social value by evaluating options using consistent metrics
4. reinforcing value creating activities within the system.

6 Concluding remarks

We use a complexity framing of social entrepreneurship to suggest where the field needs to go. In our view, an effort like social enterprise development cannot progress beyond its being an interesting diversion unless significant effort in made to clarify what is meant by social value and how such value might be created.

Efforts should be made to identify the dynamical systems that are of interest to human social and economic development. We can learn from economics, but economics is not enough. In this paper, we argue that dynamical system and complexity science offer conceptual possibilities that when combined with markets may offer a way forward. Our opinion is that the direction we have laid out here is an essential step in developing a robust theory. The success of this effort will determine whether social entrepreneurship develops into a well-understood mechanism of social value creation or just another fad.

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Notes

1 For example, the dynamical system might describe the attributes of a business, its markets, its financial situation, its knowledge management systems, its climate and its culture. These variables might be $q_1, q_2, q_3, \ldots, q_n$ which we collectively designate as q, a vector whose value represents a particular location in state space S of dimension n. The organisation as it exists at a point in time would occupy a position q in state space depending upon the specific values taken by the various components, q_i. A financial manager might only be interested in profitability and therefore might only be concerned with – and recognise the importance of – q_3 for example, if q_3 measures profits. This does not mean that there are no other relevant state variables, i.e., $q_1, q_2, q_4, q_5, \ldots, q_n$, for the system, only that this particular manager does not recognise nor use them.

In contrast to individual managers, complexity researchers are interested in the function $f(t)$: S $\rightarrow S$ that describes how all of the components of q change over time. The changes are designated dq/dt for the particular initial conditions q_0. The individual path that a system traces out in state space over time is called its *orbit*. If such a system could be defined – and of course, doing so is not always easy – the dynamical system would describe how the states of these variables and thus the component variables of interest change over time. Once defined, mathematical results can be used to infer important characteristics of the dynamical system and thus, presumably, the organisation being studied.

2 The state space for Mars' orbit includes the three physical dimensions – left-right, forward-backward and up-down – and three companion dimensions of momentum (momentum = mass X velocity), one in each direction. A dynamical system representing this planetary system would be one that describes how these six values change over time.

3 Dynamical systems models are generally less accurate in the social sciences (Forrester, 1968; Sterman, 2000). This is because they ignore the microdynamics that occur at the individual interaction level and instead seek to describe the relationships among variables that describe mesoscopic quantities – like changing populations, profitability, sales growth or even cash flows – to identify emergent patterns and structures that are of interest at the macro level. This approach can be frustrating to managers who operate at the micro level yet seek to impact macro patterns.

Over the last half century, however, dynamical system models have increasingly integrated microdynamics with macrodynamics. Separately, both Nobel Laureate Prigogine (1997) and Haken (2006) have described how global order can arise from local instabilities under 'conditions of requisite complexity' (Goldstein et al., 2008). As local instability increases inside the system, fluctuations are likely and tend not to be extinguished. At times, these fluctuations reflect the influence of forces acting from beyond the system's borders. When this occurs, it becomes possible for a dynamic pattern of stability to be recognised – a constant production level or growth rate, or even predictable oscillations like seasonal production patterns and monthly book closing routines. Under these conditions and with the proper metrics and observation instruments, macro structure can be inferred. According to Haken (2006), when such a structure emerges within the system due only to internal affects – in other words, outside forces do not explicitly impose the structure in the way that a star-shaped cookie-cutter forces cookie dough into the shape of a 'star' – the structure is said to result from *self-organising*. Self-organising has been observed in physical systems such as lasers (Haken, 2006), chemical systems (Prigogine, 1997) and biological system such as ecoli bacteria (Nicolis, 1989). Our analysis extends these ideas to social systems.

4 Thus, a more general expression of the relationship for change to q over time is one that includes surprises – that is, it includes a stochastic term. An equation that is often used to represent this situation s called the Langevin equation:

$$dq/dt = K(q) + F(t) \quad (1)$$

Here, the change in the state of the system depends upon a deterministic part, K and F which describes the random fluctuation – the surprises – inherent in the system.

In terms of equation (1) above, a non-zero value for $F(t)$ implied that the state of the system q at time $t + 1$ changed in stochastic ways. Less destabilising fluctuations – where there is no divergence introduced into the system – are also possible and happen all of the time. For example, individuals call out sick or accidents occur in the work place. Many times, these 'fluctuations' are quickly absorbed and dampened within the operating dynamics at work with little lasting impact.

5 Components diverge when they have a positive exponent (that is, the Lyapunov exponent) and have positive amplitudes in their moments.

6 There is a case to be made that the USA and other established democracies exist within a political dynamical system that is quasi-permanently bistable. In other words, the system is maintained at a bifurcation point and is thus continuously unstable. This enables local fluctuations from the norm to occur regularly and for them be retained in the system as microdiversity for a time. Information about all of these variations can then be utilised to see patterns that reflect outside forces such as global trends like climate change or ethnic conflicts. Every four years or so the system 'chooses' to approach one branch or the other, to be structurally conservative or liberal, but before the system locks into one path or another, another choice opportunity occurs. Because there is so much information in the system from its various internal experiments (and there tends to be more information about the opposite branch that the one that is being approached because divergence is dampened more quickly as a stable state is being approached), the system tends to fluctuate back and forth in an aperiodic oscillation.

7 Broadly speaking, there are two types of claims on the firm's FCFs: fixed claim and residual claim. Fixed claimants, debt holders, are those who lent money to the organisation by issuing to it loans and purchasing its bonds. Their claim on the FCFs is fixed by the nature of agreement they signed with the firm. This claim consists of two portions, i.e., principal and interest and it is fixed because debt holders cannot receive more than what the agreement stipulates. Residual claimants, equity holders, are those who have an ownership stake in the firm, which they obtained by purchasing the firm's equity shares. Their claim on the FCFs is residual because they receive what is left after debt holders' claim was satisfied. Debt holders' claim is always satisfied first and this is the most important component of how the overall complex equity markets system is set up. One of the main reasons why the system is often unstable is because the two claimants are fundamentally different from each other, which leads to a conflict.