# THE ORGANIZATION MATRIX AND THE EVOLUTION OF STRATEGY[1]:
# A THEORY OF CHANGE[2]

**Robin Matthews**

**Professor of International Business Kingston Business School**

**JM Keynes Professor of Management Moscow School of Economic and Social Sciences**

**Academic Director of the Kingston Russian MBA programme at the Academy of National Economy**

**PRELUDE**

*In Spring 1750, children began to disappear from the streets of Paris: little mites and even big boys of 14 and 15. People blamed the authorities. Street fighting broke out.*

*Bad harvests had caused migration to the cities. An Edict of 1749 ordered a roundup of all homeless in Paris; children included. Constables, paid per arrest, were overzealous in scooping up every child they could find: even in churches.*

*Rumours spread. Louis XV was (wrongly) believed to be a leper. Leprosy was thought to be cured by washing in the blood of children. The king had to flee Paris. There was a real danger revolution. Instead, the riots died down*

*Did the events of 1750 prefigure those of 1789? Louis XVI came to the throne in 1774 on a wave of goodwill: even his Austrian wife Marie Antoinette (Austria was a traditional enemy of France), was at first welcomed to Paris. He called an assembly to discuss raising taxes in 1789. By 1794 King Louis had been executed. French governments were overturned. Many of the nobility fled. Revolution spread. European war followed.*

**INTRODUCTION**

The paper is concerned with the strategic analysis and management change on all scales, in business and in society. Russia in 1905, in 1917, in 1989, or 1998 might have been chosen as a prelude exhibiting both limited and most dramatic change. So might the gradual hardly discernible changes that occur in daily life, occasionally interspersed tragedy. Societies and businesses are always at the edge of change (the *possibility frontier*). The paper has four main objectives:

1. to outline a general theory of organizational change
2. to develop a meta model of strategic analysis based on earlier papers in the journal Economic Strategy
3. to describe the *possibility frontier* as an attractor where evolution is possible and towards which, organizations gravitate
4. to discuss strategic decision making on the *possibility frontier* in terms of the Enneagram.

The paper provides a theoretical background to the conceptual and empirical work carried out by a group of Russian scientists and scholars associated with the journal, Economic Strategy. The paper owes much to on going discussions with Russian colleagues, especially Dr Alexander Ageev. A general aspiration of this work is to develop a specifically Anglo Russian approach to business and to business strategy: a successor to much of the current scholarship in business, that is predominantly North American.

**Some general questions about strategy**

Consider the following questions. *What is the nature of change? Is there explanation that applies to change in business and to change in society? Why are some changes limited, while others result in major revolutions? Does a correspondence exist with changes in physical systems? Does the end of Enron, or WorldWide or Marconi, in any way resemble the end of Tsarism, or Communism or the extinction of Dinasoars? Does, the gradual (Darwinian) evolution of a species, or co-evolution of an ecology of plants and animals, correspond to the gradual (Darwinian) evolution of products, firms, industries, economies, and technologies? Are the processes that bring sudden revolutionary financial, economic and political change (stock market collapses, the end of business or national empires) driven by similar processes to those that bring sudden calamitous changes in the physical world, (punctuated equilibrium; earthquakes, volcanoes, mass extinctions)? Is change the inevitable outcome of events outside the control of organizations (outer dynamics)? Or is a degree of self adaptation or self determination possible? What is the relationship between the ability to self adapt and chaos? Is change on a scale that implies the extinction of mankind a possibility?* These questions relate to strategy. We will speak about business strategy, but they apply to politics economics and society.

Strategy is an evolutionary process, a trajectory through time that, if successful, may result in survival and increased fitness (with respect to the business environment), or, if unsuccessful, may result in the extinction of an organization. Strategy is a search process: a search for alternative solutions to problems resulting from changes in the business environment (changes in the macro-economy, in technology, in government policy, in the strategy of rivals and so on). Clearly strategic problems are complex,

falling into the NP class: that is involving, large numbers of variables (physical assets, human beings and intangible assets such as reputation, knowledge and learning), and such that the size of the problem increases exponentially with the number of activities (N). Generally they have no simple (minimax) solutions. One of the hypotheses upon which the work of Economic Strategy is based is that approaches to such problems from the physical and biological sciences (statistical mechanics and evolutionary programming for example) should be adopted in the design of organizational strategy.

**Strategic decision making is different from management**

Unless organizations are capable of self adaptation (inner dynamics) they are at the mercy of their environment. They are driven by Darwinian processes (external dynamics): they are like paper blown about in the wind, rootless, incapable of inner direction. Thus the existence of strategy depends on the possibility of an inner dynamic, which might be proactive or reactive in the face of events. The dominant form of strategy, I hypothesise is the latter, reactive, in the manner of Kutuzov (as described by Tolstoy), flowing and containing direction or trajectory in response to events or expectations of events: a trajectory which is prescribed by a set of general parameters which determine the *karma* of an individual or organization. The strategic trajectory itself and be described in many ways: one of which is the Enneagram.

Unless societies create a surplus (over cost) they merely provide subsistence and cannot evolve or grow. On the organization matrix, surplus is created by linking activities. The primary roles of decision makers are

1. to identify potential payoffs on the organization *matrix (identification of payoffs)*
2. to form coalitions between activities that have the potential to create payoffs, a surplus over cost (*coalition formation*),
3. to create linkages on the organization matrix between activities so that potential payoffs can be realised *(creating linkages)* and
4. to discover new potential (*creative imagination*): in this way society and business co evolves

Manager and management are terms that describe *status* (authority, position and power to dictate the distribution of the surplus because they have control of assets or resources), rather than *function* in the sense of carrying out the four roles[3]. Strategic decision making takes place at many levels of the organizational hierarchy (see figure 3). Though sometimes *status* and *function* coincide, the terms strategic decision maker or strategic agent (more succinctly, decision maker or agent) is preferred in relation to the four roles.

The roles may be carried out in a *psycho-static* way, entirely programmed by grammar and external dynamics: or in a *psycho-kinetic* (conscious) way. A hypothesis in the paper is that the need for the latter is urgent.

**Interdisciplinary influences**

The paper is indebted to other contributions and to discussions with colleagues. Specifically it draws on recent and older literature in evolutionary theory[4]. In the interaction of inner and outer dynamics (see figure 2), it draws on Prigorgine's ideas of dissipative systems (Prigorgine 1980; Prigorgine and Stengers, 1984). It also parallels the notion of self ordered criticality set out by Bak, Tang and Weisenfeld 1987, 1988; Bak and Chen, 1991; Bak 1997). The organization matrix can be restated in terms of Kauffman's notion of landscapes (Kauffman 1996, 1996, 2001). The theory incorporates Darwinian gradualism and punctuated equilibrium (Gould, 2002). The notions of inner and outer dynamics link thinking about the organization matrix to that the dissipative systems, to evolutionary theory and to ideas of self adaptation (Holland 1998 Kauffman 1993). Literature on dynamic and core capability and resource based theories of the firm (for example, Wernerfelt, 1984, Prahalad, Hamel, 1990, Teece, Pisano, and Shuen, 1997) is essentially concerned with the ability of organizations to self adapt, or to develop the kind of inner dynamics that enable an organization to survive environmental changes. One of the contributions of the paper is to integrate the two streams of thought.

---

[3] Control over the distribution of the surplus is one of the powers conferred by organizational grammar (see below) which defines contracts and property rights (see below). On managers as leaders, Bertold Brecht remarked that it was not Alexander who conquered Persia, but his soldiers. A leader is an archetype. The representations of leaders, actual people are often very different from the archetype they represent, but we imbue them with archetypal charisma when we require it.

The paper also uses mystical ideas and is indebted to a number of mystical teachers. One of the features of the work of scholars associated with the journal Economic Strategy is the attempt to blend ideas from science and mysticism and use them in a business context. Business is at the centre of culture and the language of business is familiar, so translating ideas into the business field for the use of practical people is urgent. An openness exists to new ideas in Russia, that is perhaps unique. Russian history means that Russia[5] is not so captured by the normal science in the business field (in the Kuhnian sense) as the West: or at least Russian normal science is more open.

Mysticism, in modern times has being wrongly considered unscientific. In fact it is concerned with the direct perception of reality, and with techniques for gaining such perception. As with science, mystical ideas should be validated by rigorous testing by individuals: in this respect, nothing should be accepted merely on faith or trust. The notion of creative imagination originated in the work of Ibn Arabi, and was made accessible by Corbin (Corbin, 1960). The Enneagram emerges from ancient sources but credit for bringing it to light owes much to Russian mystical thinkers, G Gurdjieff (1969, 1979) and P. Ouspensky (1969) and to J. Bennett (1966) in the UK. So what emerged from Russia at the beginning of the twentieth century, so to speak, returns to Russia at the beginning of the twenty first century.

Much is written in management theory on the relationship between strategy, chaos and self organization. The paper shows how organizations naturally gravitate through inner dynamics to the *possibility frontier*, illustrated in figure 5. The notion is closely related to Bak's idea of self ordered criticality in physical systems[6]. The following should be understood from reading the paper.

i. The probability frontier states that organizations and societies are in a state of permanent revolution, subject to continuous change on all scales at all times.

---

[4] See Brabazon, Matthews, Piranfar, and Tlemsani (2003) for an extensive set of references.
[5] We usually hear of Russian business in a negative rather than a positive sense. Openness to ideas among many and not only (or always) in the younger generation) is one of the positives.
[6] The mathematics differs. The possibility frontier is based on the binomial and negative binomial theorems.

ii. The *probability frontier* is an attractor: organizations of all types gravitate to such a state.

iii. The possibility frontier is a chaotic attractor: outcomes, the size of the change is sensitively dependent on initial conditions (SDIC).

iv. The *probability frontier* and other concepts in the paper constitute a general theory. They apply to organizations, large or small, privately or publicly owned, for profit or not for profit. This includes governmental institutions and nations which are sets of organizations and institutions.

## THE ORGANIZATION MATRIX

The organization matrix is a central idea in the paper. It is a basis for a meta model of strategy Evolution of organizations (including firms and industries) is a process of forming and reforming coalitions on the organization matrix: a process that takes place at many hierarchical levels, ranging from coalitions of small teams within an organization, to firms as coalitions of business units or divisions, to partnerships between firms or institutions. Organizational evolution results from a combination of selection, driven by the environment (*outer dynamics*) and self adaptation (*inner dynamics*) through internal processes.

The organization matrix can be expressed alternatively as:
 i. an array of activities or
 ii. a set of payoffs associated with activities.

A matrix is an array of elements, like seats in a theatre, identified by a row and column number (row 2, seat 9, A29). In the organization matrix, diagonal elements (row 4 column 4, A44) denote stand-alone activities and off diagonal elements denote joint activities (activity 2 combined with activity 4, **A**24, or payoffs from linking activity 2 with activity 4, a24).

Figure 1(a) is gives a simple illustration of the organization matrix in terms of payoffs and figure 1(b) gives an alternative illustration in as a simple network, whose nodes are diagonal and connections off diagonal elements respectively. Payoffs from activities

independently ($a_{11}$ and $a_{22}$) are each 3. Potential synergies are positive (the matrix in 1(a) is superadditive or positive sum. As independent entities (teams or firms perhaps) they create payoffs that total to 6. When they are combined (as a partnership or merger, for example), potential synergies are created and their combined potential value is 10. Figure (b) gives an alternative network interpretation of the organization matrix, where diagonal elements are nodes and off diagonal elements, (a21) and (a12), are synergies.
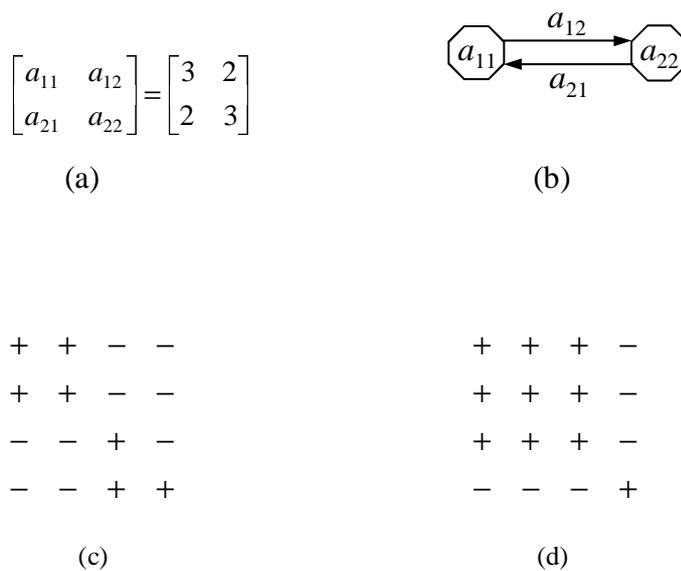
$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} = \begin{bmatrix} 3 & 2 \\ 2 & 3 \end{bmatrix}$$

(a)



(b)

```
+  +  −  −
+  +  −  −
−  −  +  −
−  −  +  +
```

(c)

```
+  +  +  −
+  +  +  −
+  +  +  −
−  −  −  +
```

(d)

Figure 1: illustration of the organization matrix [Ajk] and [ajk]

**Coalitions**

We distinguish between the organization matrix itself and coalitions, which are made up of subsets of interdependent activities. Activities are combined into coalitions as a result of decisions (θ), which can be represented by binary strings (0's and 1's), indicating and co-operation and non co-operation respectively, within coalitions[7].

**In (c) we have a picture of a potential coalition structure. Given appropriate decisions, (1100) and (0011), we have two two member coalitions consisting of, first activities A11, A22, A21, A12, and second activities A33, A34, A43 an**d A44:

---

[7] Representing coalitions as binary strings is a similar device as that used in genetic algorithms (Holland,1992; de Jong, 2002)

for example printing and information technology (industries or firms). In (c), consider the element A34 to be relatively weak as compared to A43 – so that synergies are overall positive in that coalition. Now suppose that new possibilities emerge as in (d). New synergies are discovered, Activities 1 and 2 can be combined in a new technology with activity 3. Printing becomes linked with information technology, leaving a subset of itself (A44), specialist printing as a stand alone activity. Old coalitions disappear. We have a new coalition structure in (d). **There we have a picture of a coalition structure (and payoffs if synergies are realised) of two new coalitions (1110) and (0001), consisting of first, activities A11, A22, A21, A12 A33, A32, A31, A13, A23 and second, a stand alone activity A44, which forms a one member coalition.**

**The analytic model: the strategy triangle**

A summary of the theory is contained in figure 2. At the base of the diagram we have on the right hand side, the organization matrix [Ajk] at a point in time (t). **Activities** give rise to a trajectory (T) of potential payoffs [ajk] over time, which are realised by strategic decisions ($\theta j \theta k$), by decision makers (any two decision makers are arbitrarily named j and k) to form a coalition (which might be a team, a project or a business unit within an organization, or a merger or a partnership between organizations) in order to realise payoffs (synergies, akj, j $\neq$ k) over time (t). See figure 8 for a further description of T.

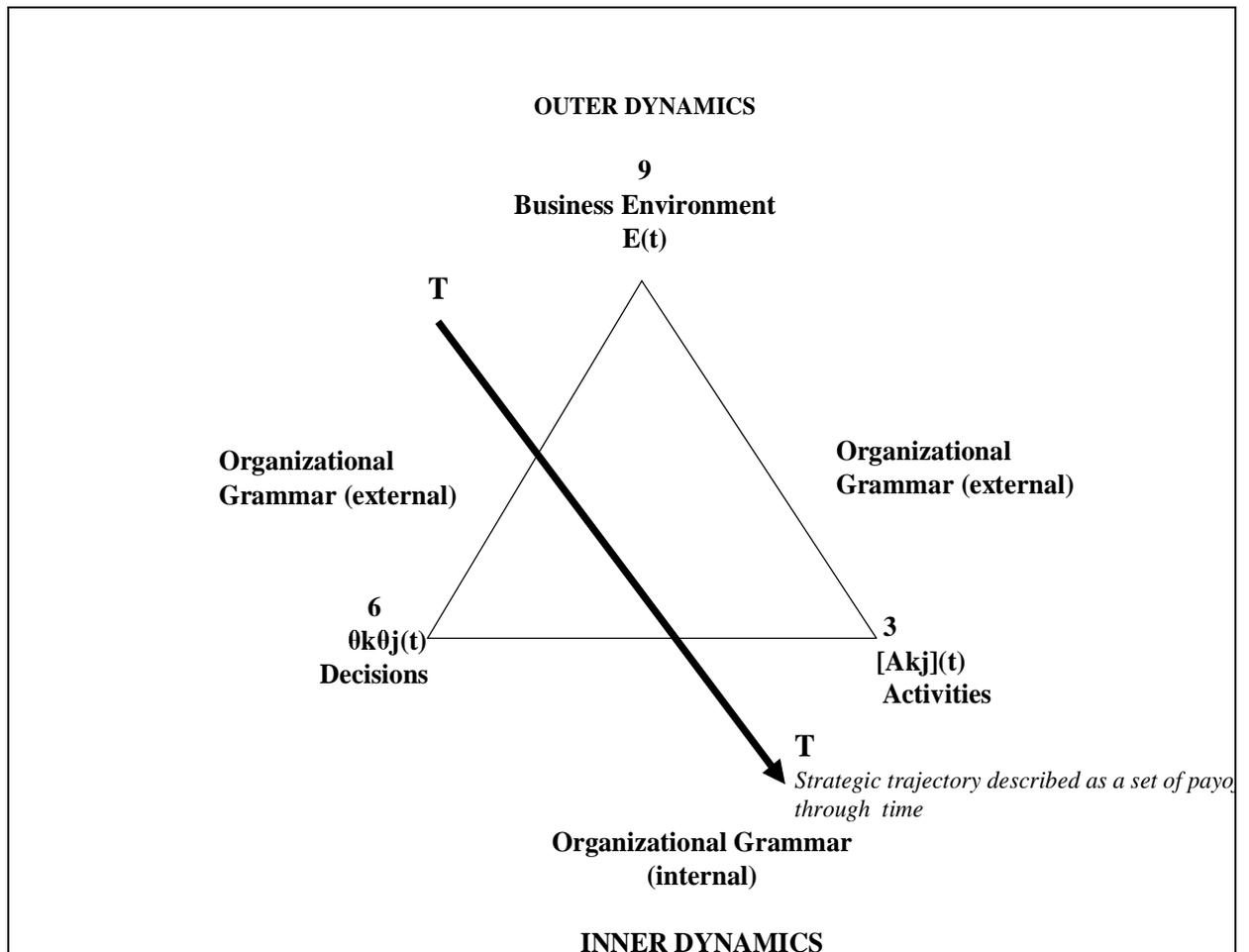**OUTER DYNAMICS**

**9**
**Business Environment**
**E(t)**

**T**

**Organizational**
**Grammar (external)**

**Organizational**
**Grammar (external)**

**6**
θkθj(t)
**Decisions**

**3**
[Akj](t)
**Activities**

**T**
*Strategic trajectory described as a set of payo*
*through  time*

**Organizational Grammar**
**(internal)**

**INNER DYNAMICS**

Figure 2: Strategic analysis

Strategy takes place in reaction to or anticipation of changes in the business environment over time E(t). Responses are conditioned by a set of rules, just as in a game of chess for example. These rules are connected by a kind of grammar. We will speak about grammar later.

Activities on the matrix are defined at many levels: a hierarchy stretching from the macro level, the organization or the set of organizations in an industry or sector, to their constituent businesses, projects, teams, and fundamental activities and processes at the micro level. Activities are the building blocks of organizations. They give rise to potential payoffs ($[akj]_{potential}$, k, j = 1, 2, ….., N), either independently or in association with other activities.

Evolution takes place through forming and reforming coalitions on the organization matrix as

   i.     new payoffs and new activities are discovered,

  ii.     new coalitions are formed and

 iii.     existing coalitions abandoned.

    .

Evolution takes the form of a co-operative (coalitional) game, creating new firms, industries, and products. Evolution refers to the emergence of new structures at many levels of organization.

The organization matrix consists of a pattern of independence and interdependence, encompassing non linearity, in that for some coalitions between activities off diagonal elements are potentially positive (encouraging coalitions between them), whilst for others, diagonal elements are negative (discouraging coalition formation). New discoveries, new technologies and new markets bring about changes in the organization matrix, causing potential payoffs to change and providing the incentive for existing coalitions to break up and new coalitions to form on all scales, large and small, as decisions ($\theta$) flip from 1 to 0 (abandoning coalitions) or alternatively from 0 to 1 (forming new coalitions): that is

   i.     changes within organizations,

  ii.     emergence of new organizations, firms and industries, and

 iii.     disappearance of existing organizations, firms and industries.

In terms of payoffs, the organization matrix is written as

$$\boldsymbol{a} \equiv [ajk] \equiv \begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1N} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2N} \\ a_{31} & a_{32} & a_{33} & \cdots & a_{3N} \\ \vdots & & & & \vdots \\ a_{N1} & a_{N2} & a_{N3} & \cdots & a_{NN} \end{bmatrix} \qquad (1)$$

Similarly for we could write the appropriate activity matrix as

$$A \equiv [Ajk] \tag{2}$$

**The organization matrix is a hierarchy**

**Figure 3 is a** hierarchical representation of the organization matrix. It is useful to think of activities on the organization matrix in terms of theatre. Like an imaginary Bolshoi theatre, the matrix is cylinder shape with many linkages between one tier and another.
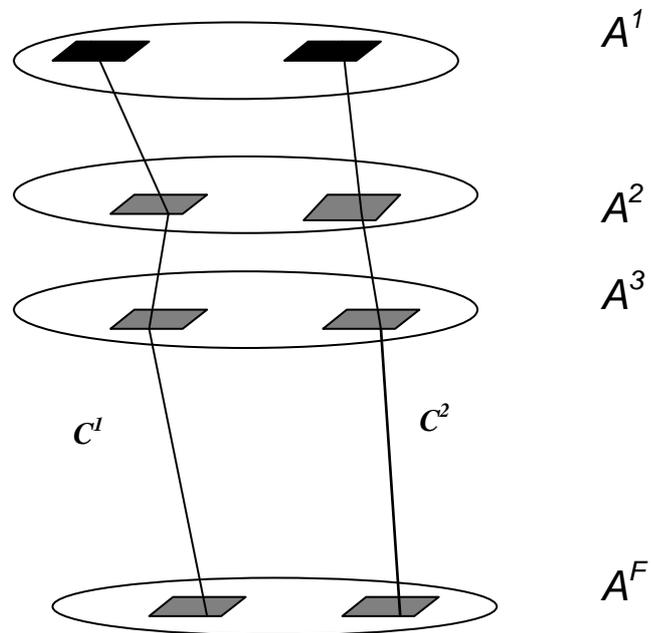


Figure 3: Hierarchies of the organization matrix

The organization matrix consists of more than just tiers of seats to accommodate the audience: production and consumption activities. They include all layers of activities that go on in the theatre: not only the direct activities, choreography, dance, sets, score, costumes, music and so on, but also supporting activities, restaurants, bars, cloakrooms, maintenance, ticketing: everything to do with the production (and consumption) of the activities are decomposed into coalitions or building blocks, and

communication is through physical connections (stairways and corridors) and information architectures and routines (messages and signals); part of the grammar of organizations.

**The organization matrix is a fractal**

The organization matrix is a fractal in that the pattern of independence and interdependence is repeated at every level of organization right down to the level of fundamental activities as illustrated in figure 3.

**Fundamental activities**

The organization matrix consists of M levels ($A^1$, $A^2$, ......,$A^F$) each containing ni activities, N activities in all, with F denoting the fundamental activity level. **The idea of a fundamental activity or coalition is a useful device: fundamental activities are the elements out of which everything is constructed[8]: they are the building blocks of the evolutionary process.** Coalitions are horizontal or vertical relationships between activities (at the same hierarchical level or at different levels) on the organization matrix: usually both. **Thus the idea of a coalition is a more general concept that supplants the notions of supply chain and value chain that appears in the strategy literature.**

A horizontal coalition might for example, consist of a group of firms in an industry, or a group of business divisions that make up a firm or a group of activities that make up a business unit. A vertical coalition might be a group of activities that make up a value chain or supply chain. Coalitions may represent linkages at the fundamental level[9] between teams or even between members of teams (sub teams).

---

[8] The idea of an elementary activity, as defined, is probably imaginary. Since this is so, it makes sense to think of elementary activities and elementary coalitions as equivalent.

[9] The search for elementary systems may be ever receding like the search for the elementary particle. And the elementary coalition is complex. The idea of an elementary coalition is contained in the requirements for the existence of the core (of a coalition). Proofs depend upon balancedeness (a kind of strong superadditivity or supermodularity) in the sense that since every coalition may be split into $\lambda$ different parts ($\lambda \rightarrow 0$ and $\Sigma\lambda = 1$), every such sub (or part time) coalition should add value.

**[[Coalitions as hierarchies**

Suppose, that a coalition is a multi level entity, with M levels, each consisting of ni sub coalitions (n1, n2,…..Nf) and having $\Sigma$ni = N activities in all. Let c1 be the top level of the coalition, c2 the next level and so on, until we reach cf the fundamental level of the coalition[10]. We should note two points to be noted about coalitions viewed as hierarchies of activities.

1. Successively higher levels of a coalition necessarily contain more fundamental activities than lower levels.
2. A coalition at any level is a coalition of sub coalitions from lower levels. So as we ascend the organization matrix we necessarily have fewer and fewer sub coalitions. That is writing ni as the number of sub coalitions at each of the M levels we have n1 $\leq$ n2 $\leq$ …….$\leq$ Nf.

As an illustration, consider an alliance between two firms (taking place at c1). Each firm consists of many business units (at c2) and each business unit consists of many teams or projects (at c3). Thus as collections (sets) of fundamental activities, have a cylindrical shape. But as collections of sub coalitions they have a pyramid shape: wider at the bottom than he top.**]]**

**Realising potential payoffs on the organization matrix**

Potential payoffs on the organization matrix are realised by decisions ($\theta$k, $\theta$j, $\epsilon$ 0,1) and the relationship between payoffs and decisions gives rise to the fundamental equation,

$$[akj]_{potential} \sim [\theta k\ \theta j] \tag{3}.$$

The expression for realised payoffs from the decisions takes the form

---

[10] Defining activities in this way is to treat coalitions of activities as qualitatively different from the fundamental activities of which they are composed. Thus an organization is for example more than just the sum total of its fundamental activities.

$$Z \equiv \text{akj}_{\text{realised}} = \sum_{k,\,j \in N} akj\; \theta k \theta j \qquad\qquad (\theta k, \theta j\; \varepsilon\; 0,1,\, j,\, k = 1,2,\ldots\ldots,N) \qquad\qquad (4).$$

Equations (3) and (4) illustrate the interdisciplinary nature of the work and the generality of application. Strategic problems are (NP) difficult, in that they contain large numbers of variables. Information (Kalmogorov) entropy exists: the value of current information declines the farther we traverse space or time. Thus decisions are taken with Bounded Rationality: Strategic problems are such that no overall minimax solutions exist: but we have much to learn from other disciplines.

Considering evolution as coalition formation on the organization matrix, there are $2^N$ possible coalitions. When potential coalitions are separated from decisions about co-operation, assumed to be a binary choice, co-operate or not, we have a configuration of $2^N$ possibilities (set out in 4).

**Alternative statement of the strategy triangle: the meta model**

We may summarize the discussion of strategic analysis with a general expression, a meta model. Organizations are coalitions of activities. Realised payoffs from organizations (or coalitions) are denoted Z. We state the identity in table 1.

| Realised payoffs **of** a coalition or from the set of coalitions on the organization matrix Z | **Are (less than or equal to)** the sum of potential payoffs (akj) from a coalition that are activated (realised) by strategic decisions ($\theta k \theta j$). Strategic decisions can take on one of two values activate (1) don't activate (0). |
|---|---|

Table 1: realised and potential payoffs

Generally,

$$Z \leq G(\text{E}(t),\, \text{A}(t),\, \theta(t);\, (\Omega)\,) \qquad\qquad (5)$$

This is the fundamental meta model of organizational strategy. It summarises figure 2 and is explained in table 2.

| | |
|---|---|
| The sum of (realised) payoffs from activities (in the organization or coalition) <br><br><br> Z <br><br> (in the case of the strict inequality (< ) holding (instead of the equality ) then potential payoffs are unrealised by decisions. | depend upon the <br><br> 1. **business environment E(t),** <br><br> 2. **activities A(t)** <br><br> 3. **decisions θ(t).** <br><br> 4. **an ontological dimension (Ω) that emerges from creative imagination (from the imaginal gallery: see below).** <br><br> 5. **the functional dependence is summarized by G (organizational grammar)** |

Table 2: the meta model of strategy

**Organizational Grammar**

Strategy is a search process, a trajectory of moves from one coalition structure (system state) to another. **As in a chess game, for example, it is determined by the existing system state, the configuration of pieces (coalition structure) on the board: in other words strategic alternatives are path dependent. Strategy consists of (a trajectory of) moves over time (taking an organization from one system state to another):** moves that are restricted by two factors.

1. Strategic moves can only take place in the context of the current system state. Decision makers can only move from where they are now and where they are now is the result of previous moves: system states are path dependent.

2. Decisions take place within the context of organizational grammar (summarized by the term *G* in table 2 **and inequality (5)** above)

In organizations, the determinants of moves are closer to a set of interacting algorithms than to a fixed set of rules. The rules contained in organizational grammar are evolving, ambiguous and in a sense competing with one another.

We can think of organizational grammar as having three dimensions: *formal informal, external internal* and *social individual. Formal mechanisms* include rules, laws, regulations, treaties, hierarchies, agreements, contracts; *informal mechanisms* include customs, cultures, habits, norms, values, a sense of mission, or a vision of the future. *Formal* and *informal* mechanisms are constructed both *internally* and *externally*: firms have their own rules, cultures and so on. In addition there are *individual* and *social* values, norms and perhaps most important, habits of behavior and thought that govern individual and social behavior.
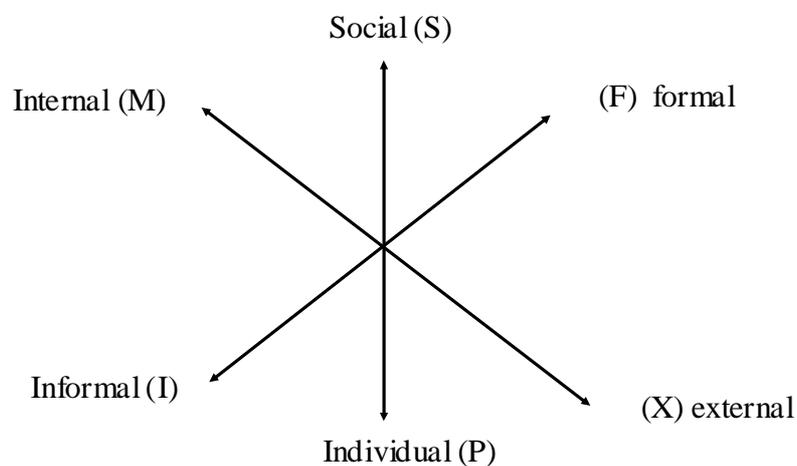
Figure 4: Dimensions of organizational grammar

Two functions of organizational grammar are noted here

(a) Grammar limits search

(b) Grammar programmes search

The programming function of grammar is discussed later.

Consider grammar as limiting search. As in a game of chess, strategic search is not ergodic: not every alternative is feasible because of the restrictions placed on search by grammar. Even so, the search problem on the organizational matrix falls into the

NP class[11]: the size of the problem and thus the length of time required to compute a suitable algorithm, increases exponentially with the number of activities. In addition to the N variables on the organization matrix, grammar itself represents the interaction of large numbers of rules. Many organizational tasks are concerned with combinatorial search problems of this type, subject to the kind of difficulties we have outlined.

See table 3 and figure 4 for a sketch of organizational grammar. More detailed treatment is the subject matter for another paper.

---

[11] Algorithms used to describe computable problems are of two classes, based on the length of time it takes to find a solution to a problem as a function of some number N that measured its size. Polynomial problems (algebraic power of N, $N^2$, or $N^3$ and so on) that are said to be tractable are such that the length of time required to crack them does not become unbounded as the size increases: class P. NP problems are such that the length of time increases in an exponential fashion (to the power N) are intractable because the length of time required to solve them spirals out of control (Coveney and Highfield, 1995).

| | | |
|---|---|---|
| F S X | FORMAL SOCIAL EXTERNAL | Extra organizational, societal, codified, written: laws, regulations, treaties, contracts, rituals, traditions, constitutions. |
| F S M | FORMAL SOCIAL INTERNAL | Intra organizational, group, codified, written: formal organizational routines, architectures, structures, systems, hierarchies, contracts |
| F P X | FORMAL PERSONAL EXTERNAL | Extra organizational, individual, codified, certified: formal general education, shared paradigms, personal qualifications. |
| F P M | FORMAL PERSONAL INTERNAL | Intra organizational, individual, certified, codified, corporate: specific education, skills, knowledge, on the job training. |
| I S X | INFORMAL SOCIAL EXTERNAL | Extra organizational, societal, group, uncodified, informal: customs, conventions, mores, morals, cultures, codes |
| I S M | INFORMAL SOCIAL INTERNAL | Intra organizational, societal, group, uncodified: corporate customs, culture, mores, codes |
| I P X | INFORMAL PERSONAL EXTERNAL | Extra organizational, individual, uncodified: personal history and values, behaviour, learned paradigms that influence thinking, mental maps, conditioning, habits of thought and behaviour. |
| I P M | INFORMAL PERSONAL INTERNAL | Intra organizational, situated in the individual, personal paradigms and schema for assessing the world, mainly unconscious the result of experience (learned within the organization). |

Table 3: Elements of organizational grammar

## THE POSSIBILITY FRONTIER

We are now in a position to understand how organizations evolve (large and small, public and private, profit and not for profit): that is, to develop a general theory of organizational change ranging from the micro to the macro level.

We explain

    a.   how organizations how organizations gravitate to a probability edge

    b.   why the probability edge is a (chaotic) attractor and

    c.   why evolution takes place at the probability edge.

Anticipating the argument in this section, the possibility frontier is summarized in figure 5. The model states that organizations (of all kinds) gravitate to the frontier set out in figure 5, which states that change is continuous, it takes place on all scales, but that small scale changes have a higher probability than large scale changes. In other words we live in a state of permanent revolution.
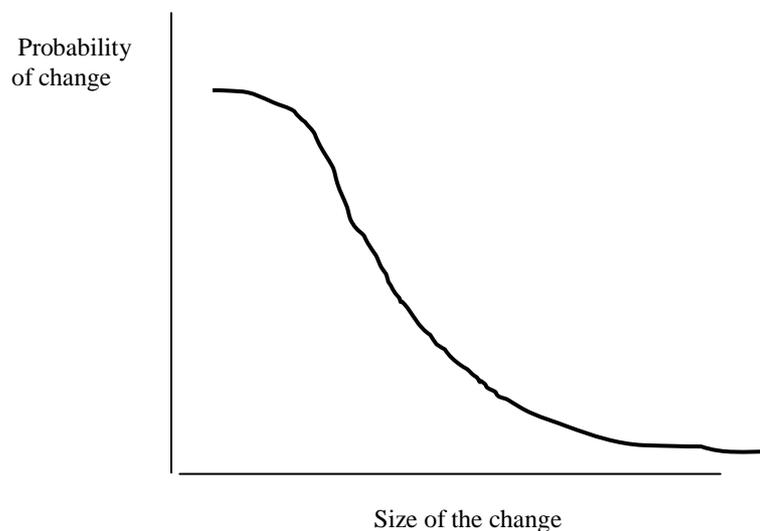
Figure 5: The possibility frontier

Having stated in the last section that grammar prevents decisions from roaming (randomly) over the entire decision space we will for the moment assume that decisions are randomly distributed, later in the section reintroducing the role of grammar

1.  We will consider the formation of coalitions on the organization matrix. Since decisions are binary (confined to the set 1, 0, join a coalition or not), coalition formation involves the binomial distribution.

2.  Then we consider the break-up (reformation) of coalitions. Again this is a binary decision: here involving the negative binomial distribution.

Thus we will complete the analysis of evolution as a process of coalition formation and reformation.

**A probabilistic model of inner dynamics (self adaptation)**

*1. Coalition formation*

To achieve our aims, we suppose that every elementary coalition is equally likely to occur. Then the probability of any coalition (at whatever hierarchical level) is the product of the probabilities of the elementary coalitions it contains. Since higher level coalitions contain more elementary coalitions than lower level coalitions, they are less likely to occur. So in general terms, there is an inverse relationship between the size of a coalition and the probability of its occurrence.

This is a very important result indeed. It means that organizations gravitate, or self adapt, to a possibility frontier (an attractor), in which small coalitions are highly likely and larger changes are progressively less likely, as we ascend the hierarchy of the organization matrix.

We can express the matter more formally. Any coalition can be thought of as a collection (union) of sub coalitions or equivalently, as a collection (a union) of $f$ fundamental (or elementary) activities ($\bigcup_f cf$): for example a business unit is an ensemble of primary and secondary activities, which are coalitions within functional areas of teams of people and so on[12].

---

[12] At the fundamental or elementary level the distinction between a coalition and the activity itself can be dropped: the activity may be a coalition but it cannot be disaggregated any further.

Let us call the probability of a coalition at any level i (i ε M) $c^i$ (containing $f$ fundamental activities) occurring $P\{\bigcup_f cf\}$ ($f \leq$ Nf, where N is the total number of activities on the organization matrix).

| | |
|---|---|
| The probability of a coalition of size f forming $$P\{\bigcup_f cf\} \ (f \leq \text{Nf}) = P\{cf\}$$ | is the product of the probabilities of each of the $f$ elementary activities forming a coalition. This product is given by the binomial distribution $$\frac{Nf!}{f!(Nf-f)!}(q)^f(1\text{-}q)^{Nf\text{-}f}$$ where $q$ is the probability of a fundamental activity $cf$ forming part of a coalition ($\theta = 1$) and 1-q is the probability of it not forming part of a coalition. ($f \leq$ Nf: f cannot be greater than the total number of fundamental activities on the organization matrix. |

Table 4: the possibility frontier and coalition size

Thus we have a binomial distribution, of N activities, a binary choice for each activity and decision maker ($\theta j\theta k$) to form part of a coalition (q) or not to do so (1-q), with of course q = ½. if every elementary activity (or elementary coalition) is equally likely. There are Nf elementary activities on the organization matrix (at M levels), the probability of a coalition $c^f$ forming and consisting of exactly $f$ fundamental activities is

$$\mathbf{P\{}c^f\mathbf{\}} \equiv \mathbf{P\{}\bigcup_f cf\ \mathbf{\}} = \frac{Nf!}{f!(Nf-f)!}\ \mathbf{(1/2)}^{Nf} \qquad\qquad \mathbf{(7).}$$

Clearly the probability of the occurrence of a coalition of size *f*, decreases as *f*, the coalition size increases. **Alternatively (7) can be written**
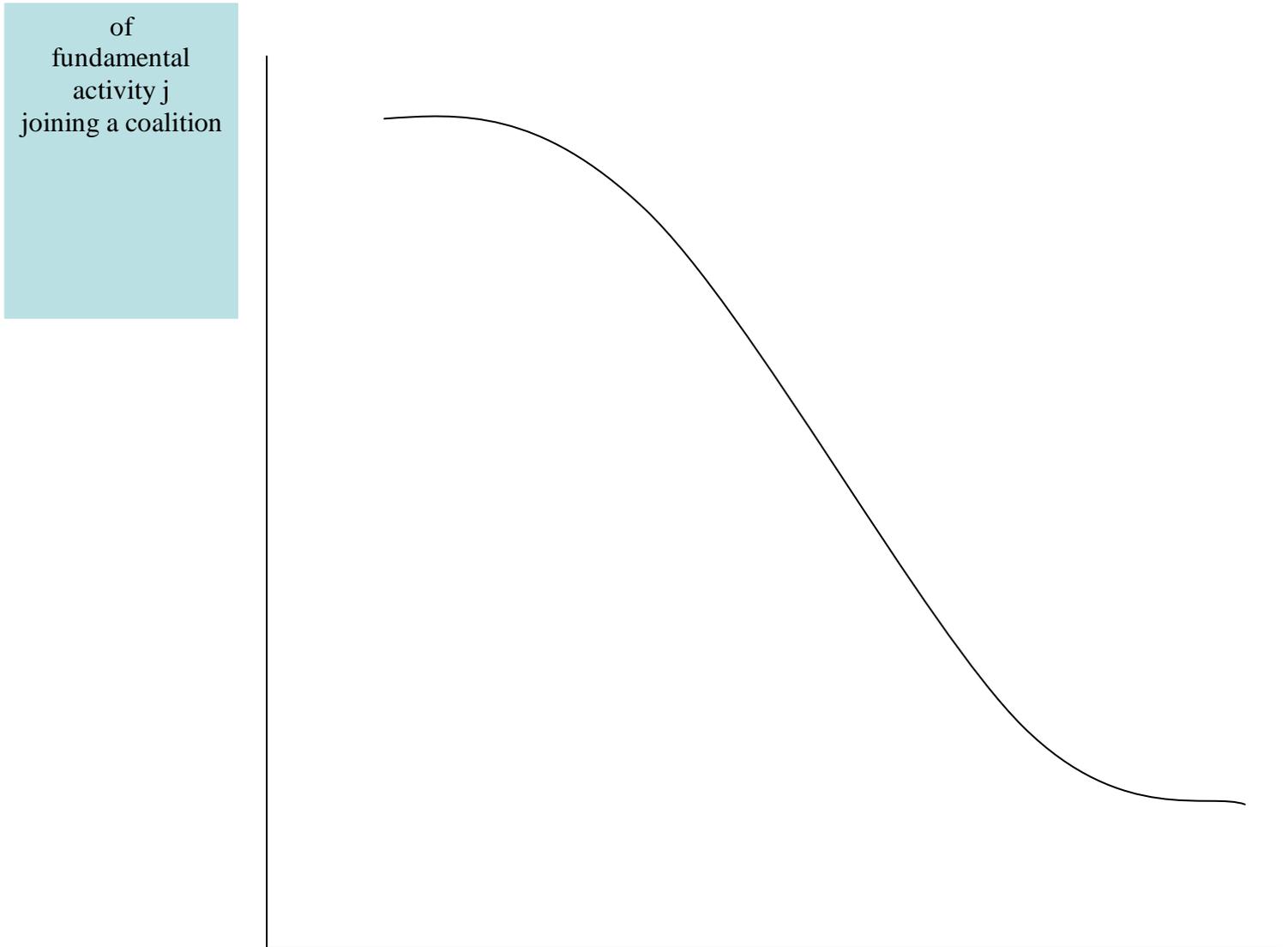
$$P\{c^f\} = \frac{Nf!}{f!(Nf-f)!}\ (q)^f(1\text{-}q)^{Nf\text{-}f} \qquad\qquad (8).$$

of
fundamental
activity j
joining a coalition

Figure 6: The possibility frontier

Size of coalition

## 2. Forming and reforming coalitions

Figure 6 and equation (8) express the probability of an elementary coalition forming part of a coalition. The equation is an example of the binomial distribution, associated

with the binary choice (1, 0), to form part of a coalition or not. state the problem in terms of a binomial distribution. Alternatively, we can think of the probability of (an elementary) **activity** quitting a coalition, once it is formed. The probability frontier expressed as the probability of quitting a coalition once it is formed is a negative binomial distribution.

If we denote the probability of a coalition ($C^K$) of size K (containing, K elementary **activities**) entirely breaking up P{~$C^K$} we have an expression given by the negative binomial distribution

$$P\{\sim C^K) = (1 + m/K)^{-K} \qquad\qquad (9)^{[13]}$$

| The probability of a coalition ($C^K$) of size K (containing, K elementary coalitions) entirely breaking up is denoted<br><br>P{~$C^K$)<br><br>. | Is given by the negative binomial expression<br><br>$(1 + m/K)^{-K}$<br><br>where m equals average coalition size and K equals the number of elementary coalitions quitting the coalition.<br><br>It is clear from the expression that<br><br>P{~$C^K$) is a declining function of m and K. |
| --- | --- |

Table 6: the possibility frontier and the size of coalition change.

---

[13] I am grateful to Professor Megnad Desai of the London School of Economics for pointing out an error in my original formulation of this.

Probability
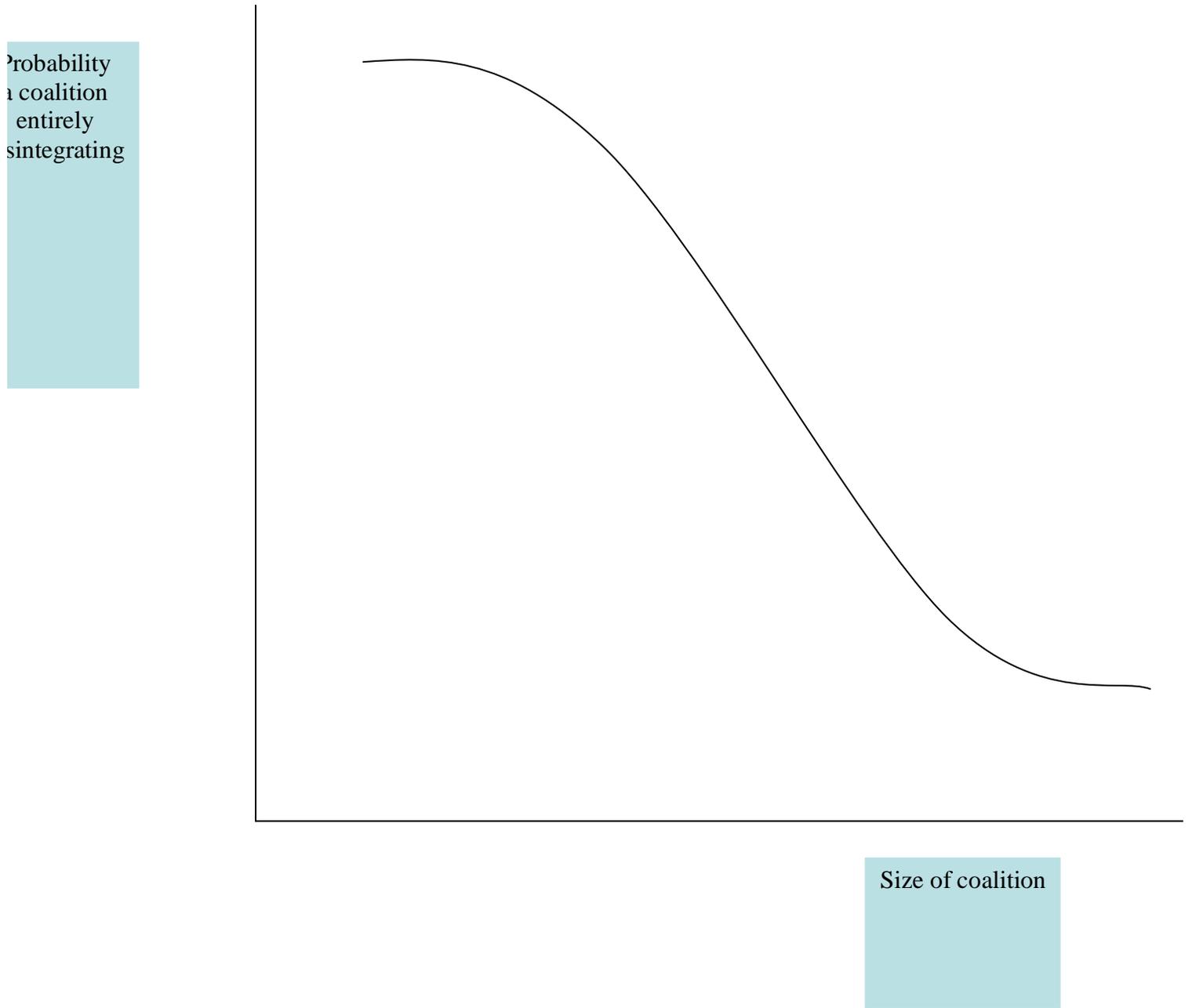a coalition
entirely
sintegrating

Size of coalition

Figure 7: Changes in coalitions

Figure 7 states that when a coalition of size f is formed, small changes are more likely than larger changes. Small changes in coalitions on the organization matrix are likely: larger changes are improbable. In other words the disintegration of an entire organization is less likely than the disintegration of part of it.

Equations (8) and (9) and in figure 6 and figure 7 underlie the evolution of organizations on the organization matrix. They express an inverse relationship between the size of coalition change (in terms of either a coalition of size m forming, or a coalition of a given size m breaking up entirely) and the probability of change happening.

**Disasters are possible**

The possibility frontier is fundamental to understanding organizational evolution at all levels of the organization matrix. We should emphasise the argument: evolution of organizations (of all types) occurs through the process of forming and reforming coalitions. The size of evolutionary change is defined by the size of the coalitions involved in the change. It might occur at such a microscopic level that it goes unnoticed by all but the few it affects. Alternatively, it might affect coalition structure at such a high level of organization matrix, that the impact is cataclysmic.

**The possibility frontier is a chaotic attractor**

The fundamental equations (8) and (9) express the idea that coalitions on the organizations gravitate to a self organized state: *a probability frontier*, which acts as an attractor. It is a chaotic attractor in that it is sensitive to initial conditions (SDIC).

The trajectory of change is sensitively dependent on small details of the initial disturbance. Some disturbances are limited. Others spread throughout the matrix. In 1749 we change was violent but limited. In 1789 change was violent but extensive. Some disturbances result in major revolutions, the overthrow of whole systems, some are serious but they do not spread. Major cataclysms resulting in apocalypses are unlikely but have a non zero probability.

The fundamental equations thus allow for many patterns of change: change limited to elementary levels, through to change that communicates itself throughout the entire organization matrix, the highest organizational level, or even the entire economy or global system. They allow for punctuated equilibrium, long periods of apparent stability followed by sudden transformation. They allow for qualitative evolutionary

change, the emergence of novelty. The constraint imposed on the pattern of change is the (long run) probabilistic relationship between the size of the change and the frequency of change. Equations (8) and (9) are the counterpart of the expressions for self ordered criticality in physical systems (Bak, Tang and Wiesenfeld, 1987, 1988). They underlie an hypothesis about many real world dynamical interacting systems. such systems often exhibit patterns of behaviour: under many general conditions they organize themselves into a state with a complex but rather general structure, given in this case by the fundamental equations.

## IDENTIFYING AND REALISING POTENTIAL

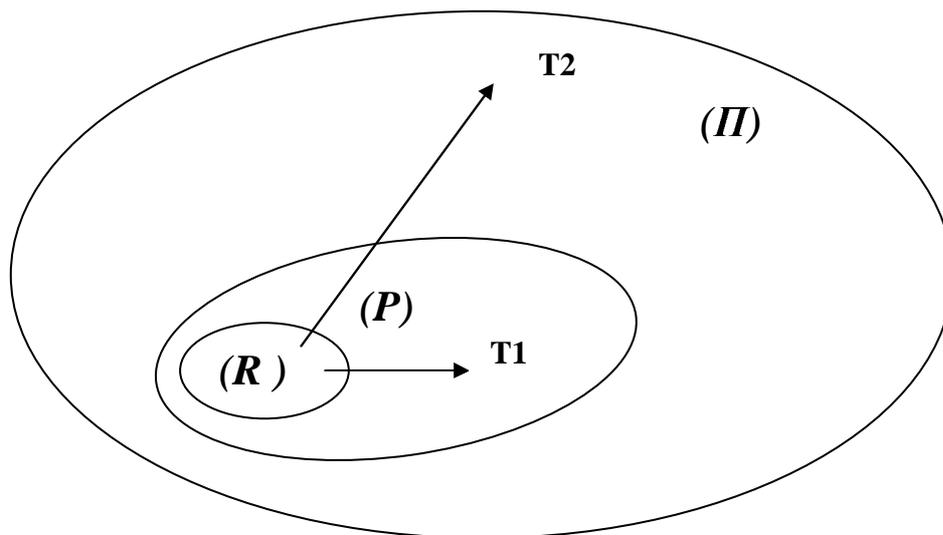### Understanding $\Omega$ in the meta model



Figure 8: $\Omega$ and the relationship between *(R), (P)* and *(Π)*

Equations (3) and (4) link two distinct domains, realised *(R)* space and potential *(P)* space. They represent two dimensions of being. There are very many levels of being: the ontology of this paper focuses on just three. Realised payoffs or are experienced in the sensory world *(R )*. They correspond to the world of sensing or ordinary levels of being: Heidegger's *Dasein*. Potential *(P)* represents the set of possibilities (what *might*

*be* given existing knowledge). Potential payoffs that exist at a point in time, are there to be realised.

The strategy trajectories T1 and T2.T1 and T2 might correspond to exploitation and exploration respectively (March 1991. In a previous paper, I termed them T and K trajectories respectively (Matthews (2001b)

New possibilities emerge from a third domain, which we will call the imaginal domain *(Π):* the domain of creative imagination. Search in space *(P)* is akin to exploitation of existing potential, in the sense of what is already thought to be possible: search of the imaginal domain *(Π)* is akin to exploration. Figure 8 illustrates the three domains but it should be emphasised that *(Π)* is unbounded.

**Psycho-static strategy and competitive advantage**

When we are about to enter a room, we don't think, " *Now I must turn the handle, push the door step into the room....*" Unless the door sticks, we just do it without thinking. Much strategy, I suggest, is made in exactly this way. Grammar acts like programming on decision-making agents. Even when something goes wrong (the door sticks) pretty soon the grammar *kicks in* and pre-programming takes over. Grammar is rich enough to take care of contingency. Pre-established norms and modes of interpretation are rarely called into question. The grammar evolves but major paradigm shifts are rare.

Psycho- static strategy follows an evolutionary path but is programmed by grammar and outer dynamics. Table 7 illustrates the process of seeking competitive advantage as a programmed Darwinian process. If we see this as part of a general discourse in which responsibility to stockholders is the only responsibility of organizations, it captures the essence of current corporate strategy. Note that the term exploitation above is part of the same discourse.

| | |
|---|---|
| Reproduction | • Accomplished through reproduction of existing activities in *(R)*: replication and expansion of the underlying genetic **programme (capabilities). Results in payoffs to an organization over time.**<br><br>• The population of activities and coalitions in *(R)* expands at an exponential rate if all reproduce successfully. |
| Inheritance and mutation | • The genetic **programme (capabilities)** is transmitted through time (inherited from generation to generation).<br><br>• In an entropic system mutations or replication *errors* in activities and information will occur in *(R)* and *(P).* |
| Competition | • Competition is the consequence of reproduction of population of activities in finite space *(R).* It limits the capacity to reproduce.<br><br>• Organizations respond in a feedback process between technological change and competition<br>  (i) *(P)* is extended into *(Π)* and<br>  (ii) *(R)* is extended into *(P)*. |
| Selection | • Evolution takes the form of changing coalitions and coalition structures on the organization matrix.<br><br>• Evolution is driven by external dynamics.<br><br>• This is driven by a combination of physical and statistical processes in *(R)* and *(P)*.<br><br>• Some organizations survive, others fail. |

Table 6: Darwinian evolution driven by *psycho-static* processes

**The imaginal gallery and $\Omega$**

We should distinguish explicitly between the (strategic) decision roles set out earlier. *Identification of payoffs, coalition formation and creating linkages* are concerned with realising potential. The issue arises as to the origin of potential, the fourth role, discovery of new potential (*imagination*).

Activities and payoffs exist at different levels of being. The situation with respect to $\Omega$ can be envisaged as an imaginary gallery. Everything that can exist in the gallery is there already: call this domain *($\Pi$)*. But the hidden treasures in the gallery in *($\Pi$)* only emerge to consciousness as visitors move singly or in groups (coalitions) from room to room. To distinguish *($\Pi$)*, we name the realised set *(R)*, contents that are to hand, that are observed as objects or remembered from the past. Visitors to the gallery also have knowledge from guidebooks, mental pictures and learning from previous experience of what exists in neighbouring rooms. We name this potential domain *(P)*: it is not yet realised, but visitors are conscious of it. It is feasible in the sense that it may be capable of being realised.

The three (ontological) spaces or levels of being contained in $\Omega$ have very different properties. They constitute an enormous subject matter in themselves. For example *(R)* is subject to the rules of space and time: no two objects can occupy the same space at the same time, processes take place through time and so on. *(P)* is very different: may alternatives exist at the same time for example. Since (P) is unrealised as yet it is probabilistic or expectational in nature. *($\Pi$)* represents a mystical domain (see for example Izutsu (1983) and (1963)).

**The Enneagram**

Strategic decision making consists of a series of steps; (a) forming a vision, (b) recognising alternatives and (c) considering their fitness with respect to rivals and to the business environment, (d) making choices, (e) implementing strategy and (f) continuously monitoring strategy with respect to vision and alternatives. The strategic process is set out in figure 8 as an Enneagram.
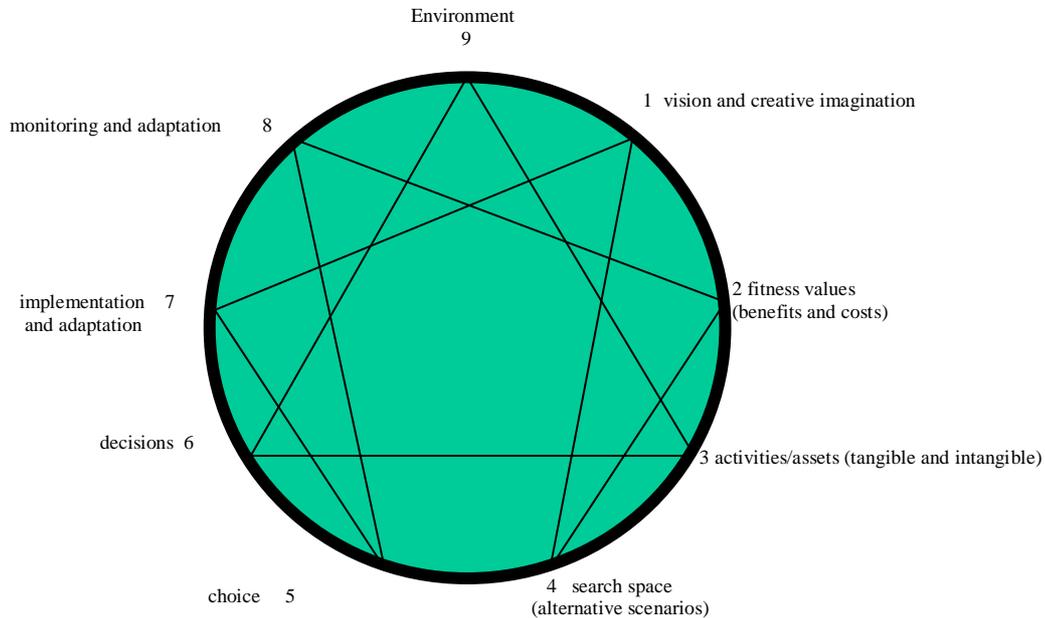
Figure 8: the Enneagram of strategy

The Enneagram of strategy has been discussed in earlier papers in Economic Strategy. It can be further elucidated. The Enneagram is a kind of mandala, based on the number systems based on three irrational numbers, 3, 7 and the golden mean (or golden section) $\psi$. The Enneagram cannot be understood in purely rational terms, however it is capable (to a limited extent) of expression in rational terms. It should be seen as containing a methodology for entering the imaginal gallery. A constant task for human beings is the translation of *(Π)* into *(R )*. A brief interpretation, according to my teachers is as follows.

If we express the first two (3 and 7) in terms of unity (or wholeness, 1) we have

(i)     $1/3 = 0.333\ldots$ and multiples of 1/3, $1/6 = 0.6666\ldots$ and $1/9 = 0.9999\ldots$ which give rise to the strategy (closed) triangle.

(ii)     $1/7$ is given by the series $0.14285714285\ldots$ , $2/7$ by the series $0.2857142857\ldots$, and so on up to $6/7 = 0.8571428571\ldots$ ..

The first two numbers are traced out precisely by the Enneagram which divides the circle into exactly nine parts. The numbers 3 and 7 are combined, linking analysis and process.

(iii)     Ψ = 1.6180339….. (or (√5 +1)/2 )occupies a unique position. Lines 8, 2 and 7, 1 bisect each other in exactly the proportion of the golden mean (or its reciprocal). This bisection forms the apex of an inner 7 sided figure.

The strategy process described by the Enneagram takes place at all levels of being, including *(R )*, *(P)* and *(Π).* The right side of the Enneagram, the open triangle composed f the series 1, 4, 2, may correspond to potential *(P)* and the left hand side open triangle, the series 8, 5, 7, corresponds to realisation *(R)* of potential. Alternatively, the process may describe a mapping from *(Π)* into *(P).*

**The Enneagram describes psycho-kinetic processes**

The two incomplete triangles, 4, 2, 8, 5, and 5, 7, 1, 4, may be rooted in search space *(Π)* (the imaginal gallery) and choice (or will). The first (4, 2, 8, 5) is the process of self adaptation in which fitness is evaluated against possibilities in search space. The second open triangle (5, 7, 1, 4), relates to the realisation of vision. The processes described by the two open triangles, which make up inner dynamics are linked by Ψ the golden mean. Here we have not only an evolutionary process but a psych-kinetic process, or what might be termed conscious strategy. Alternatively the triangles may be rooted in *(R )* and *(P)* in which case we have psycho-static decisions, programmed entirely by grammar.

Readers may note that the version of the Enneagram, interpreted by Russian scholars at Economic Strategy, 8 and 1 are connected. This differs from earlier versions. I originally considered this innovation to be an error, but my teachers inform me that it is correct, for current times: adaptation must be linked to vision and creative imagination.

## CONCLUDING REMARKS

### Grammar and the possibility *frontier*

Summarizing the position so far, the *probability frontier* is defined as a self ordered state to which all coalitions gravitate. The state is such that there is an inverse relationship between the size of coalition changes and the probability of their occurrence.

Equations (8) and (9) state that organizations are in a state of permanent revolution. Change takes place continuously. But the continuity of change refers to the permanence of change in itself (coalitions being reformed, regrouped) and not to the size of the change. Change takes the form of coevolution, involving both increasing fitness, the ability of some activities to survive and reproduce by recombination with others, and the elimination of other activities.

In further papers I will explain more fully, how organizational grammar, interacting with the fractal structure of the organization matrix together produce, out of the self ordered state, a critical state, that is a state at which disturbances will propagate throughout the system. In anticipation, a few comments are appropriate now.

We live in a state of permanent revolution, never knowing what the size of the revolution will be. Society is in a constant state of deconstruction, held together by the veneer of grammar. To understand how a critical state is possible, how changes may be communicated throughout the organization matrix, we need to understand how organizational grammar, interacting with the fractal structure of the organization matrix give inner dynamics a different time frame from outer dynamics: pressures coming from the outside of the coalition (*outer dynamics*) operate on a shorter time scale than responses on the inside (*inner dynamics*).

Grammar determines coalition choice, decisions to switch coalitions, and the transmission of changes through the coalition structure: that is, the extent of

communication and dispersion of change. It introduces stability into coalitions and coalition structures[14], so it acts as an inertial force. Furthermore, a pattern of independence and interdependence is repeated at successive levels of the organization matrix, giving the organization matrix (viewed as a hierarchy) the appearance of a self-similar motif within a motif, a fractal structure. The fractal structure of the organization matrix, together with the organizational grammar, my slow down internal responses to changes from the outside, allowing pressures to so build up that the resultant change in the coalition is dramatic. Change is transmitted throughout the entire coalition. If we consider the system of coalitions in society, change on the scale of the collapse of a major firm, industry, nation or entire system may occur.

One hypothesis, implicit in the paper, is that the study and practice of business and business education will become increasingly interdisciplinary, utilising optimisation techniques and search algorithms borrowed from other sciences. Interesting philosophical questions follow this hypothesis. *If much of management is concerned with search algorithms that are (at least in principle) programmable, to what extent can decision making be considered a conscious activity? And what characteristics define the set of problems that are not computational and programmable?*

The idea of business decisions as merely being programmed responses to external influences coincides with postmodern thought (Cooper and Burrell, 1988). The capitalist business cycle originating in phases of *over and under exuberance*, irrational over and undervaluation of assets is, by common assent, seen both as programmed into decision making and largely inevitable.

The notion of programming links neatly with the central argument of functionalism, the dominant school of cognitive science. According to this school, there is only one centre of consciousness, the brain. The brain resembles the computational state of a computer. What matters is the pattern of causal relations between its contents, neurons firing, and voltage levels. A computer programme provides a perfect model of the functional organization of the brain. According to the extreme form of functionalism,

---

[14] Coalition structures or collections of coalitions on the organization matrix are discussed in chapter 2.

Strong AI, the mind is a computer programme implanted in the brain. What people call consciousness is simply a programme state of the brain.

Whilst agreeing that consciousness is based on the material of the brain, what distinguishes the philosophical opposition to the extreme functionalist view is denial of Strong AI and emphasis on intention and awareness of what is being experienced (Searle, 1997). This resembles the mystical approach to a limited extent, but the current philosophic view of awareness is restricted to the *felt* properties of mental states (qualia); pain of a headache, pleasure at winning a prize.

Mysticism has important further caveats:
a) centres of consciousness are not limited to the brain,
b) there are many levels of being,
c) levels of being are interrelated to one another,
d) evolution of consciousness in the form of a journey to different levels of being is possible.

One of the implications of these caveats is the need for consciousness: strategic decisions, in organizations, nations and institutions have ramifications for others in a world that is becoming increasingly connected. The (ecological) environment is a part of a hierarchy of being in itself, not an inert thing, there to be exploited.

We can reasonably argue that many of the excesses of modern business, and perhaps the strategy of nations, rise from unconsciousness rather than malevolence. Capitalism possesses an enormous capability for growth and technological progress. The problem is to create sufficient demand to match this. It is achieved enormous expenditures on marketing and advertising designed to manufacture needs at the same pace as products: producing needs through messages that mix anxiety and libido. A new understanding is needed. Perhaps this paper representing the work of scholars associated with Economic Strategy is a contribution in this respect, to a need for psycho-kinetic decisions.

## REFERENCES

Bak, P. and K. Chen, (1991), Self Organized Criticality, Scientific American, January, 26-33.

Bak, P.,Tang, C., Weisenfeld, K.,(1987), *Phys.Rev.Lett*.59:381.

Bak, Per, (1997), *How Nature Works: The Science of Self Organized Criticality*, Oxford University Press, Oxford.

Bak, P, Tang, C., and Wiesenfeld, K. Self-organised criticality. Physical Review A 1988, 38(1), 364-374.

Bennett, J.G. (1966), The Dramatic Universe, Coombe Springs Press Glos, UK.

Cooper, Robert and G. Burrell, (1988), Modernism, Postmodernism and Organizational Analysis: an Introduction. Organization Studies, 9/1. 91-112. (1988).

Corbin, Henry. (1969), Creative Imagination in the Sufism of Ibn 'Arabi. Princeton University Press..

Cilliers, Paul, (1998), *Complexity and Postmodernism,* Routledge, London and New York.

Corbin Henry (1969) Creative imagination in the Sufism of Ibn 'Arabi, Translated by Ralph Manheim,  Princeton N.J., Princeton University Press.

Coveney, P and Highfield, R. (1995), *Frontiers of Complexity*, Faber and Faber, London.

Georgescu-Roegen, N. (1970), *The Entropy Law and the Economic Process*, Harvard University Press.

Gould, Stephen Jay, (1994), Lucy on the Earth as Stasis, Natural History, No.9.

Gurdjieff, G.I. (1969), Meetings with Remarkable Men, Routledge, Kegan Paul,Ltd., London, UK

Gurdjieff, G.I., (1979), All and Everything, Routledge, Kegan Paul,Ltd., London, UK

Hamel, Gary, and Prahalad, C.K. (1990), "*The Core Competence of the Corporation*". Harvard Business School Press, (May): 79-91.

Ibn 'Arabi, Muhyiddin. Kernel of the Kernel: Ismail Hakki. Bursevi's translation, Beshara Publications Sherborne Glos, UK, (2000).

Izutsu, Toshihiko (1983) Sufism and Taoism, University of California Press

Jenson, H.J. (1998), *Self Organized Criticality: Emergent Complex Behaviour in Physical and Biological Systems,* Cambridge University Press, Cambridge.

Kauffman, S. A. The origins of order Self-organisation and selection in evolution.

New York: Oxford University Press 1993.

Kauffman, S. A. At home in the universe: The search for the laws of self-organisation and complexity. New York: Oxford University Press, 1995.


Marion, Russ, (1999) The Edge of Organization: Chaos and Complexity in Formal Social Systems, Sage Publications, London.

Matthews, Robin, (2000a) A New Model of Strategy Applied to the Russian Situation, *Economic Strategy* Vol.1. 2000 (Moscow). Published in Russian.

Matthews, Robin, (2000b), Information Strategy and Semiotics, *Economic Strategy* Vol.1. 2000 (Moscow). September.

Matthews, Robin. Competition Archetypes and Creative Imagination, Journal of Change Management UK. September, (2002).

Ouspensky, P. D. (1969), In Search of the Miraculous, Routledge, Kegan Paul,Ltd., London, UK.

Porter, M.E. (1990). The Competitive Advantage of Nations, Macmillan, London.

Prigogine.Ilya,. and Stengers, I. (1984), '' *Order out of Chaos*''. Bantam, new York.

Prigorgine, I. (1980) *From Being to Becoming*, New York Freeman.

Searle, J. The Mystery of Consciousness, London, Granta Publications (1997

Teece, D. J. & Pisano, G. and Shuen, A., (1997). "*Dynamic capabilities and strategic management*". Strategic Management Journal, 18: 509-533.

Wernerfelt, B. (1984). "*A Resource Based Theory of the Firm*". Strategic Management Journal, 5:171-180.