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# Images of Organizational Evolution

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## Abstract

**Purpose:** This paper develops the notion of building a brand-new theory of organisational structure using internal capabilities and emphasizes the process of how those capabilities (synergies) are recognized, built, and prioritized. Exchangeable payoffs generated by synergies or stand-alone values are recapitulated by a firm matrix that applies to firms in both the public and private sectors. Evolving ideas from cooperative games, activity analysis, and conditions for a cost-effective framework are set out. This research adopts a mathematical form that can be transformed into a decision support system vector. **Design/Methodology/Approach:** This study employs an epistemological metrics-driven analysis to investigate the co-evolution between firms and payoffs. Three key dimensions were considered in capturing this dynamic relationship. First, we advocate for a metrics-driven approach to co-evolution, emphasizing its crucial role in anticipating and realizing payoffs. Second, we demonstrate that a single-lens perspective offers only a partial explanation of co-evolutions, particularly regarding synergy and payoff dynamics. Third, we integrate a metrics-driven approach with the moderating effects of game theory practices and activity analysis. This synthesis allows for the application of quantitative research methods to explore, recognize, and classify the nature of co-evolutions. **Findings:** The findings indicate that organizations have unique preferences in terms of amalgamating synergies for re-engineering payoffs. This process is achieved by exploiting organizational strategic-renewal action such as managerial actions/intentionality of the organizations seems to describe unique internal behavioural patterns, the firm's timing, and the frequency of those synergised but renewed critical actions. **Practical Implications:** This research can positively impact an organization's efficiency, innovation, em-

ployee satisfaction, competitive positioning, adaptability, and overall organizational performance. **Research Limitations:** The limitations of this research are: 1) limited perspective as relying solely on internal capabilities, considering external factors can provide a more holistic understanding and prevent potential blind spots, and 2) increased complexity especially as it involves cross-functional teams and matrix arrangements. Complexity can create coordination challenges, communication gaps, and decision-making bottlenecks. **Originality:** This research innovatively introduces a new organizational structure theory focusing on internal capabilities. The integration of cooperative games, activity analysis, and a cost-effective framework offers a unique perspective.

## Keywords

Strategy, Cooperative Games, Organization Matrix, Evolution, Activity Analysis

## 1. Introduction

This research paper examines two related features of the organization matrix. First, it is an archetypal structure (definition of archetypal structure required). It can be defined at many different *levels* of an organization. It applies to many different *types* of organizations. It has *parallels* in many other disciplines. It is capable of many different *representations*. It also exists in several different *ontological* spaces (what is ontological space source to develop knowledge and development). Second, it forms the basis of an evolutionary model. Evolution happens through coalition formation on the organization matrix. Most important the model explains how organizations gravitate to a state of self-ordered criticality in which evolution takes place (Morgan et al., 2023; Kumar & Srivastava, 2023; Wang et al., 2023a; Adamou et al., 2021; Alford, 2017; Hamel & Prahalad, 1990; Newman, 2008; Tlemsani & Matthews, 2010). In this paper, we only consider a cursory discussion of the ontological dimensions, limited to the extent to which it throws some light on the nature of human intervention (creativity and entrepreneurship) in the evolution of organizations. Furthermore, **Figure 1** demonstrates the key insights of this study.

The organization matrix fosters the relationship of independence and interdependence between activities. Alternatively, it can be seen as an info set or as an interrelated set of payouts. Activities can be mapped into payoffs (fitness space), which in turn can be considered as signals or information. As such the organization matrix becomes an information processing system, similar to a large interconnected neural network (Amit et al., 1985). The theory is used to provide a comprehensive model that will be used to examine existing practices in the evolution of organizations through coalition formation.

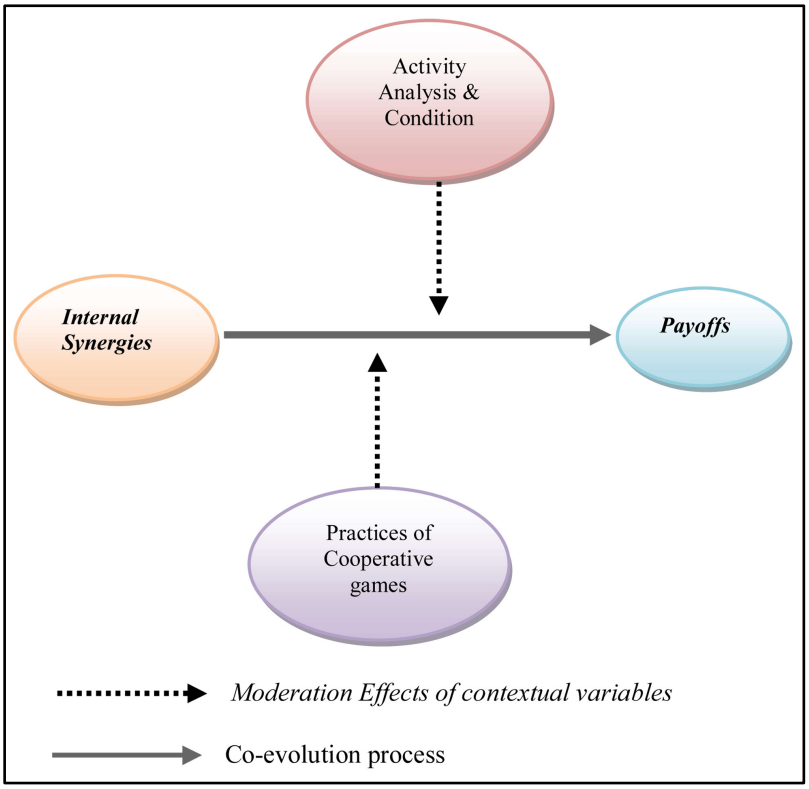


**Figure 1.** Key insights of this paper. Source: Authors.

Formally, the *organization matrix* can be defined as a matrix of potential payoffs (or information) $\boldsymbol{a}$ ($\boldsymbol{a} = [a_{jk}]$) or a matrix of potential activities $\boldsymbol{A}$ ($\boldsymbol{A} = [A_{jk}]$). We may think of activities, $[A_{jk}]$, as existing at the genotype level and payoffs, $[a_{jk}]$, as being phenotypes. Diagonal activities $[A_{jk}]$ (or in the payoff matrix $[a_{jk}]$), in the organization matrix, that is elements where $j = k$, represent stand-alone activities (or payoffs from them), and off-diagonal elements $[A_{jk}]$ or $[a_{jk}]$ where $j \neq k$ represent linked activities (or payoffs from linked activities); that is synergies, complementarities or network effects. In terms of payouts the firm matrix is defined as:

$$\boldsymbol{a} \equiv \left[ a_{jk} \right] \equiv \begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1N} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2N} \\ a_{31} & a_{32} & a_{33} & \cdots & a_{3N} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{N1} & a_{N2} & a_{N3} & \cdots & a_{NN} \end{bmatrix} \tag{1}$$

Equally, for activities, we may well write down the right matrix as:

$$\boldsymbol{A} \equiv \left[ A_{jk} \right] \tag{2}$$

The distinction between potential and realised payoffs is important (Vancleef et al., 2021; Wilkinson et al., 2021) noted that potential payoffs are a mapping of activities into payoff space by forming coalitions. Realised payoffs are determined by decisions, first, about which coalitions to form (a mapping from po-

tential payoffs in the organization matrix itself into potential payoffs from coalitions) and second, about cooperative behaviour within coalitions, which transforms potential into realised payoffs. If we limit ourselves to binary decisions in coalitions, cooperate or not, (1, 0 decisions), we have $2^{N(N-1)}$ possibilities in terms of payoffs ($2^N$ coalitions and $N-1$ decisions as to whether to cooperate within them). In this case, potential payoffs are achieved by choices ($\theta_k, \theta_j \in 0,1$) where the connection between payoffs and choices provides an increase to the underlying equation:

$$\left[a_{kj}\right]_{\text{potential}} \sim \left[\theta_k \theta_j\right] \tag{3}$$

The illustration for accomplished payoffs as of the choices is:

$$Z\left(A,\theta,t\right) \equiv \left[a_{kj}\right]_{\text{realised}} = \sum_{k,j \in N} a_{kj}\theta_k\theta_j \quad \left(\theta_k,\theta_j \in 0,1, \quad j,k = 1,2,\cdots,N\right) \tag{4}$$

The organization matrix in (1) is a complex system consisting of large numbers of interacting variables. Together with decisions on the right-hand side of (3) and (4), it becomes a complex adaptive system (Barbrook, 2019; Collander, 2000). Negotiating a coalitional game, where agents form expectations, anticipate and develop models to understand and influence how payoffs can be realised and distributed. The organization matrix can be represented in many different ways, for example, as a landscape, a network, a coalitional game, or a spin glass. It can also be thought of as an information network consisting of neurons interconnected by synaptic junctions of potential strength [aik]. In this case decisions ($\theta_j$, $\theta_k$) can take on two possible states (up↑, down ↓) indicating whether the neuron has fired an electrochemical signal or not. Therefore, coalition formation and search represent the transmission of information through activities or payoffs and organisational learning processes (Mohamed Hashim et al., 2022b, 2024).

As coalitions are built up a landscape of potential payoffs is formed conceptually the landscape is a mapping of all possible ($2^N$) coalitions of activities into fitness or payoff space (Tanushree & Chaubey, 2023). The organization matrix can also be envisaged as a network, with nodes corresponding to diagonal elements and connections to synergies. The principal management task is to convert the potential payoffs into actual payoffs by making connections between nodes (converting off-diagonal potential payoffs into realised payoffs). With a suitable transformation, the organization matrix becomes a game with payoffs corresponding to costs and benefits from cooperation. The distinction between potential and realised payoffs is important: to a great extent, it defines the management role (Liu et al., 2023). A second feature (in addition to its archetypal structure) of the matrix is its evolutionary properties through forming and reforming coalitions (changing coalition structure) on the organization matrix. This research paper aims to examine the following:

1) The evolution of organizations through coalition formation.

2) Changes at the many hierarchical levels of an organization (ranging from

the micro-level, small teams within organizations, to entire organizations and economic systems).

3) Organizational gravitation to an attractor of self-organized criticality, a situation where evolutionary possibilities exist[1].

The organizational environment $E(t)$ acts as an *outer* dynamic, a kind of Darwinian selection process. The organizational or business environment consists of all the factors that influence an organization but which are beyond the organization's control. *Inner* dynamics $A_{jk}(t)$ and $\theta_j\theta_k(t)$ represented in (3) are illustrated on the abscissa of the strategy triangle in Figure 2. New activities are discovered over time, and decisions about coalitions and cooperation are revised to fit the changes in the business environment. Thus, Figure 2 illustrates strategic decisions as a search process resulting in a trajectory of potential (and realised) payoffs over time. Evolution happens through the action of two sets of factors illustrated in Figure 2:

1) Outer dynamics: The environment of organizations $E(t)$ interacting with decisions $\theta_j\theta_k(t)$ and activities $A_{jk}(t)$.

2) Inner dynamics: The fractal structure of the organization matrix is viewed as a hierarchy of activities interacting with decisions.

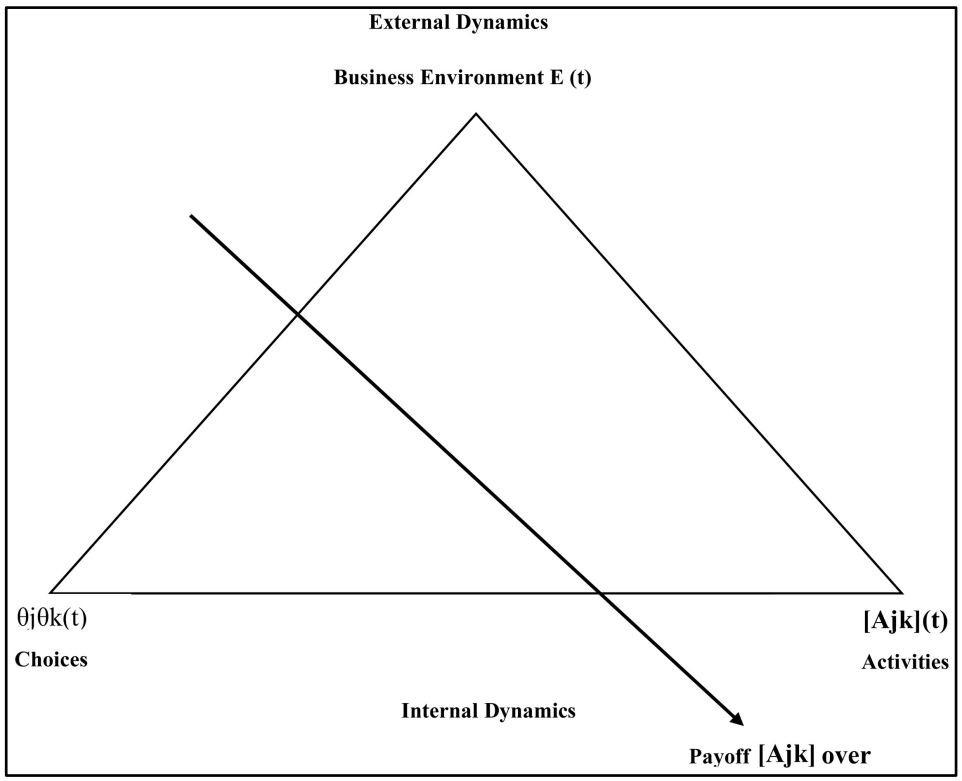


Figure 2. Triangular model of strategic analysis: Source: Authors.

[1]The explanation (3) resembles that of Bak (1997) and Prigorgine (1980). It is related to the idea of managing on the edge of chaos, taken to be a self-adaptive state (Kauffman, 1993). The edge of chaos is often presented as a metaphor in management. The idea of self-adaptation is of course closely related to that of dynamic or core capabilities.

As illustrated in Figure 2, the impact of the business environment on organizations is filtered through organizational grammar. Internally, both the scope of the search for new coalitions and the behaviour (cooperative or not) of agents in coalitions is conditioned by an organizational grammar, a set of rules or control parameters (formal, informal internal and external, operating at the social and personal level) existing at a point in time. Elements of grammar form a complex adaptive system, interacting both among themselves and with the other factors in the model illustrated in Figure 1.

Organizational grammar, together with the fractal hierarchical structure and pressures from the environment push organizations towards the state of self-ordered criticality envisaged by (Shaymardanov et al., 2023; Hyunmin, 2023; Arstila, 2018; Mohamed Hashim et al., 2022a; Bak, 1997; Bak, Tang, & Weisenfeld, 1988) in which evolution takes place. Evolution is seen as a continuous process, especially at microscopic levels of the organization matrix. Larger and larger changes become less and less frequent as we ascend the macroscopic scale, from projects to businesses, to organizations and whole social systems: but the relationship between the size of changes and frequency is statistical.

The evolution of organizations through dynamics capability and coalition formation has several potential research contributions. Here are some key research contributions in this area:

1) Understanding organizational change: Contributes to our understanding of how organizations evolve and change over time. By studying how coalitions form, dissolve, and reconfigure within organizations, researchers can gain insights into the dynamics of organizational change. This research helps identify the underlying mechanisms and processes that drive organizational evolution.

2) Informing leadership and strategy: By investigating the factors that influence the formation and dynamics of coalitions, researchers can provide guidance for leaders on how to effectively manage coalitions, build alliances, and navigate complex organizational networks. This research can inform strategic choices, organizational design, and leadership development practices.

These contributions contribute to a more comprehensive understanding of how organizations function and evolve in today's complex and dynamic business environment. The research gaps in this subject matter are:

1) One research gap could be exploring how coalitions evolve and change over time within organizations. This could involve studying the factors that influence coalition formation, how they dissolve or reconfigure, and the consequences of these changes on organizational outcomes.

2) Coalition formation strategies: Research could focus on identifying and examining the strategies employed by organizations to form and manage coalitions effectively. This could include studying the role of leadership, communication, resource allocation, and organizational culture in facilitating successful coalition formation and evolution.

3) Performance and outcomes: Exploring the relationship between coalition formation and organizational performance is another research gap. Investigating the impact of coalitions on various performance indicators, such as innovation, productivity, and financial outcomes, can provide insights into the effectiveness of coalition-based organizational evolution (Tlemsani et al., 2023c).

4) Success and failure of coalitions: A further research gap could be examining the success and failure of coalitions within organizations. This could involve analysing the factors that lead to the successful formation and maintenance of coalitions, as well as the reasons why some coalitions fail. Additionally, the research could investigate the impact of coalition success or failure on the overall evolution of organizations, including their adaptability to changing internal and external conditions.

This research critically examines how the internal capabilities, the synergies and its integrations have a say on payoff. It analyses the empirical association between the firms' competitive capabilities and the payoffs/values. The payoff results are interpreted by firm metrics using the data derived from both the public and private sectors. A metrics-driven epistemological analysis sheds light on the co-evolution and the payoff using three distinct dimensions. This combination allows for the application of quantitative research methods. The findings signal that organizations have unique inclinations in terms of amalgamating synergies for re-engineering payoffs.

This research has significant implications for fostering adequate levels of organization efficiency, innovation, employee satisfaction, competitive positioning, adaptability, and overall organizational performance. Finally, the novelty of this research leads to a new organizational structure theory and an innovative perspective focusing on internal capabilities.

## 2. Activities and Payoffs

The co-evolutionary theory argues that the concurrent operating procedure of the organization and selection (priority) of activities explains the process of renewal of co-evolution (Xiao et al., 2023; Joshua et al., 2023; Tlemsani, 2010, 2019). There is a necessity to treat strategic actions aligned with the organizational competencies within the business environmental boundaries to build advantages. Thus, proposed propositions/strategic renewal definitions metrics, which empirically connect organizational synergies and payoffs amid practices of game theories and activity analysis and conditions.

We can see the organization matrix as a complex adaptive system with many interacting agents and activities (Wang et al., 2023b; Lang et al., 2021; Xiao et al., 2021; Mohamed Hashim et al., 2021; Adamou et al., 2021). Returning to the theatre metaphor, interactions may be local, confined to sub-coalitions (marginal changes to the score, cloakroom arrangements, ticketing), or they may percolate throughout the whole theatre (changes in the cast, the programme, the entire genre, or discourse). They may be confined to the theatre or extend to

the whole environment. Changes may emanate from activities and decisions anywhere within the theatre or stakeholder group (inner dynamics), or they may be triggered from the outside (outer dynamics). Change may be a variation upon earlier productions, or they have emergent properties, novelty, or new creations. Generally, we might expect marginal changes to be frequent, even continuous, and dramatic changes intermittent and infrequent (Tlemsani, 2020). On the organization matrix, activities produced at one level are combined and transformed (consumed) and become inputs at another. They are in turn, combined and transformed at successive levels until they extend in scope to economy-wide institutions and organizations.

Coalitions formed at one level of the organizational hierarchy become diagonal elements in the organization matrix at a higher level. Similarly, stand-alone activities (diagonal elements) at one level of the organization matrix are made up of collections (coalitions) of lower-level activities. Coalitions are in turn formed at this higher level and make up diagonal elements at a still higher level. Denoting $\left[C_{jk}^{i}\right]$ as a coalition structure, we have a (set of) supply chain relationship (Yang et al., 2021; Hota, 2023; Anjali et al., 2023):

$$\left[A^{m}\right]\to\left[C_{jk}^{m-1}\right]_{\text{only } j=k}\to\left[A_{jk}^{m-1}\right]_{\text{all } jk}\to\left[C_{lp}^{m-2}\right]_{\text{only } l=p}\to\left[A^{m-2}{}_{lp}\right]_{\text{all } lp}$$
$$\to\cdots\to\left[C_{rs}^{2}\right]_{\text{only } r=s}\to\left[A_{rs}^{2}\right]_{all\ rs}\to\left[C^{1}\right]_{\text{only } t=v}\to\left[A^{1}\right]_{\text{all } tv} \quad (5)^{2}$$

and generally, $m\geq m-1\geq\cdots\geq 1$

Leaner regression of coalitions formed at the organisational hierarchical level is mentioned above and discusses the coalitions of basic activities $A^m$ are formed at successively higher and higher levels of the organization matrix. This is illustrated in (5). The matrix of fundamental activities $A^i$ is partitioned into coalitions $C_{jk}^{m-1}$. New coalition possibilities may emerge (off-diagonal elements as $A_{jk}^{m-1}$). These may be combined into the coalition $C_{lp}^{m-2}$. If we represent the chain in (5) as payoffs from activities, diagonal elements represent the surplus (or value-added) by lower-level coalitions. Off-diagonal elements represent gains to be had from further coalition building. It is useful to consider payoffs as the *sum* of value added at successive coalition levels.

As noted above, payoffs represent the potential energy of activities, and they remain simply a possibility till they are activated by decisions. Once created, they can be supplied in several methods to stakeholders (decision-making agents). One such solution to the distribution problem is the Shapley value, which is arrived at by attributing to every activity the value it adds (through synergy or complementarity) to its own coalition[3]. They are the surplus of benefits over costs (with respect to the entire stakeholder group) that are created by organizations. They include tangible and intangible benefits (and costs) that can be distributed to stakeholders in any number of ways. The interpretation of the surplus in

[2]Expression (5) components can be seen as alternative definitions of value chain(s).

[3]That many distributions of payoffs are possible is illustrated by the fact that any weighted average $\lambda_i$ (with $\Sigma\lambda_i = 1$) of the Shapley weighting constitutes a feasible distribution.

terms of transferable payoffs extends the generality of the organization matrix: discussion of agency issues includes the entire stakeholder group. Unless organizations create a surplus for stakeholders, they cease to be viable and in an evolutionary system, they will be *selected out* sooner or later.

Transformation of the organization matrix into a coalitional game can result in many different payoff structures. If off-diagonal elements are positive, then the coalitional game will be a positive sum, giving aggregate benefits from cooperation but payoff structures may be such to discourage cooperation thereby inhibiting the realisation of payoffs from coalition formation.

Decisions about coalition formation on the organization matrix are taken by stakeholders who have competing objectives: a desire to increase payoffs in general (growth) and a desire to increase the share, the absolute amount (distribution) of payoffs accruing to themselves. So, the search is subject to mixed motivations (Tlemsani et al., 2023a). Clearly, it may be in the interest of stakeholder groups to pursue strategies that benefit them at the expense of others. Decisions ($\theta_j$, $\theta_k$) can be symbolised by strings of zeros and ones, indicating stakeholders who participate (1's) in particular coalitions and who do not (0's). Corresponding to the tiers of the theatre, there are tiers (or hierarchies) of decisions to be made about participation within coalitions. Agents might, for example, decide to join a coalition but not participate in some of its activities. Agent X may hire Y as part of the orchestra (a joint decision). X's participation as part of the orchestra is partly *hard-wired* (by the score) and partly volitional (rehearsing, practicing, and helping other members). In general cooperation within organizations is conditioned by (internal) grammar. Formal grammar (treaties, contracts, and agreements) are attempts to hardwire certain behaviour into organizations. Often informal aspects are significant.

Typically, partnerships of all kinds, ranging from minor restructuring within an organization to alliances and mergers between them, are arranged by (senior) managers, but success in realising potential is contingent upon decisions within sub-coalitions(transformation/integration coalition). Often strategy is mistakenly distinguished from implementation because only top-level decisions are considered (Tlemsani et al., 2023b). The realisation of potential payoffs is determined by sets of coalitions within coalitions and decisions within decisions. In illustration (5) for example, if we consider the organization matrix (at level $m$-2), $\left[A_{lp}^{m-2}\right]_{\text{all } lp}$, realisation of payoffs depends on what happens in the coalition $\left[C_{lp}^{m-2}\right]_{\text{only } l=p}$ which contains the coalitions it is composed of, summarised by $\left[C_{jk}^{m-1}\right]_{\text{only } j=k}$: in turn, the latter contains, $\left[C_{jk}^{m-1}\right]_{\text{only } j=k}$ and the elementary matrix $[A^m]$. Expression (5) contains the instructions for building the fractal structure of the organization matrix.

Activities and information constitute the underlying genotype, or information storage space and payoffs are the phenotypes the observable behavioural traits. As with genetic variations, the relationship between activities and payoffs is not

static and therefore difficult to predict. One activity (or coalition) may affect several different types of payoff (pleiotropy) and a particular type of payoff may be affected by several activities simultaneously (polygeny) for example, businesses are made up of sets or sub-coalitions of functional activities, which in turn are made up of coalitions of departments, teams and formal and informal groups: each can be represented in matrix form as self-similar motifs of interdependence and independence.

The strategy and structure of businesses are in turn affected by how they perform in terms of payoffs: some sub-coalitions may be expanded, others contracted, and new coalitions formed to adjust organizational targets in terms of markets, products or technologies. Similarly, payoffs interact with one another; for example, feedback occurs between market share, investment and growth and variables such as sales, revenue, and profit).

## 3. Coalitions and Coalition Structures

We should distinguish between the organization matrix in general (non-partitioned) sense itself and coalitions, which are partitions of the matrix, made up of subsets of interdependent activities listed in an array on the organization matrix. Activities are merged into coalitions because of decisions characterized by dual strings (0's and 1's), suggesting both cooperation and non-cooperation within coalitions.

Coalitions are essential to cope with the MACRO environmental changes and their influences on internal capabilities. Coalitions are formed by stakeholders who search the organization matrix to find new groupings of activities to develop new markets, products, new organizational forms, and structures. At the macro level coalitions take obvious forms: mergers, acquisitions, alliances, and partnerships. They extend backward, forward, and laterally in the supply chain. They may result in the formation of entirely new technologies, firms, and industries and the elimination of others. At the micro-level, coalitions develop new products, markets, and processes, resulting from the search of the organization matrix at the appropriate level for combinations of activities that will enable this to happen. Coalitions extend beyond the boundaries of the matrix as new activities are discovered.

### 3.1. A Non-Hierarchical Organization Matrix

Given an organization matrix defined in terms of activities, $\boldsymbol{A}$ ($\boldsymbol{A} = [A_{ik}]$, $i,k = 1,2,\cdots,N$), decisions to form a coalition are expressed by a string (vector) of 1's and 0's. So, in an organization matrix of 10 potential activities, a string with 1 in the first, third, fourth, and tenth places (1:0:1:1:0:0:0:0:0:1) represents a four-member coalition made up of activities 1, 3, 4, and 10.

Coalition structures are groups of coalitions. For example, consider an organization consisting of just four activities. If each activity operates as a set of four independent entities, the coalition structure consists of a string of coalitions

(1000, 0100, 0010, 0001). If it consists of two coalitions each with two members the coalition structure may be (1100, 0011) or (0101, 1010). In the case of a four-member coalition the coalition and the coalition structure are formally identical (1111). The relationship between coalitions and coalition structures is summarized in Table 1 for an organization matrix with four activities. In general, with $N$ activities there are $2^N$ possible coalitions: so when there are 4 activities, 16 possible coalitions exist, as shown in Column 3 of Table 1: associated coalition structures are listed in Column 4 of Table 1.

Table 1. Distribution of coalitions ($N$ = 4). Source: Authors.

| Coalitions of size N-C and C | Number of coalitions | Coalitions | Coalition structures |
|---|---|---|---|
| 4:0 | One 4-member coalition | 1111 | 4:0 |
| 3:1 | Four 3-member coalitions can be combined with the null coalition or with a one-member coalition | 1110<br>1101<br>1011<br>0111 | 3:0<br>3:1 |
| 2:2 | Six 2-member coalitions, that can be combined with a one-member coalition a two-member coalition or two null-member coalitions | 1100<br>1010<br>1001<br>0110<br>0101<br>0011 | 2:0:0:0<br>2:1:1<br>2:2 |
| 1:3 | Four 1-member coalitions can be combined with null coalitions, with three one-member coalitions, two one-member coalitions or one-member coalitions | 1000<br>0100<br>0010<br>0001 | 1:0:0:0<br>1:1:0:0<br>1:1:1:0<br>1:1:1:1 |
| 0:4 | One 0-member coalition | 0000 | 0:0:0:0 |

Coalition is a general term that takes on a meaning corresponding to the level of generality we are focusing on, examples of a coalition are groups that consist of business divisions that make up a firm, unit activities that make up a value/supply chain, firms in an industry, activities that make up a business. At the hierarchical level immediately above, coalitions become the diagonal elements of the (higher level) organization matrix. A project can be seen as a coalition structure of assets, a firm as a coalition structure of projects, an industry as a coalition structure of firms and so on. According to the context, a coalition (or coalition structure) of activities can refer to many different entities ranging from the microscopic level to the global economy (teams, projects, divisions, firms, industries, and sectors).

Coalitions are formed as a result of decisions that activate payoffs. Decisions may be cooperative (represented by 1's in a string) or non-co-operative (0's in

the string). The representation of coalitions and coalition structures as a string is similar to the formulation of genetic algorithms (Holland et al., 1986). The two processes associated with genetic algorithms, mutation and recombination are inherent in the formation of coalitions. Mutation consists of changing a single element in the coalition string. Recombination consists of combining coalitions. The coalition structure of four independent coalitions (1000, 0100, 0010, 0001) may undergo mutation by dropping activity 2 (0100) entirely giving the structure (1000, 0000, 0010, 0001). Likewise, the coalitions in coalition structure (1010, 0101) may be recombined to form the grand coalition (1111).

### 3.2. A Hierarchical Organization Matrix

As shown in **Figure 3**, a coalition is a multi-level grouping of activities, its structure is defined at a particular level of the hierarchy of the organization matrix. A coalition is defined by a decision string (a bit string of 0's and 1's) denoting which of the $C_i$ activities in the multi-level matrix are included in the coalition. If there are $M$ possible hierarchical levels, then the total number of activities included in a coalition is $C_i$ and

$$C_i = n_1 + n_2 + \cdots + n_m \quad (n_i \geq 0 \quad \text{all} \quad i = 1, 2, \cdots, m) \tag{6}$$

In (5), coalitions of activities formed at one level of the coalition (diagonal elements at the next level of the hierarchy) are counted as separate activities. As noted below generally:

$$n_1 \geq n_2 \geq \cdots \geq n_m \text{ [4]}.$$

If we think of the organization matrix as a multi-level entity with $M$ levels each one containing $N_i$ activities, we can illustrate it in the following way. There are $\sum N_i$ activities in all. Label each of the levels in ascending order as $L^i$ ($i = 1, 2, \cdots, m$). The various levels of the organization matrix are related. Diagonal elements of the organization matrix at one level (level $i$) are coalitions of a lower level ($i = 1, 2, \cdots, i-1$). Off diagonal elements of the organization matrix at the $i$-1 level are candidate activities for the formation of higher level ($K$ level) coalitions. Diagonal activities at any one of the $m$ levels represent coalitions of lower-level activities. Similarly, off-diagonal activities appearing at the m level offer further potential synergies: and so on. Thus, organizations are coalitions of businesses, business units are coalitions of projects, projects are coalitions of value chains, and value chains are coalitions of teams.

The explicit introduction of coalitions into the model implies a modification of the formal definition of the organization matrix itself. Diagonal elements represent coalitions formed at lower levels of the matrix. So, we have, for any of the $M$ levels of the organization matrix, a relationship between diagonal elements at level $i$ ($A^i_{qr}$) and lower-level coalitions $C^{i-1}_{pp}$.

[4]And since higher-level coalitions (activities) effectively contain lower-level activities (coalitions) we have $n_m \supseteq n_{m-1} \supseteq n_{m-2} \supseteq \cdots \supseteq n_1$.

$$A_{qr}^{i} = C_{pp}^{i-1} \tag{7}$$

Coalitions at level $i$ can be formed by linking activities for which $q \neq r$. We can rewrite (7) in terms of the payoffs to a coalition:

$$Z(C,\theta,t) = \sum_{j,k \in C} a_{jk}\theta_j\theta_k(t) \tag{7a}$$

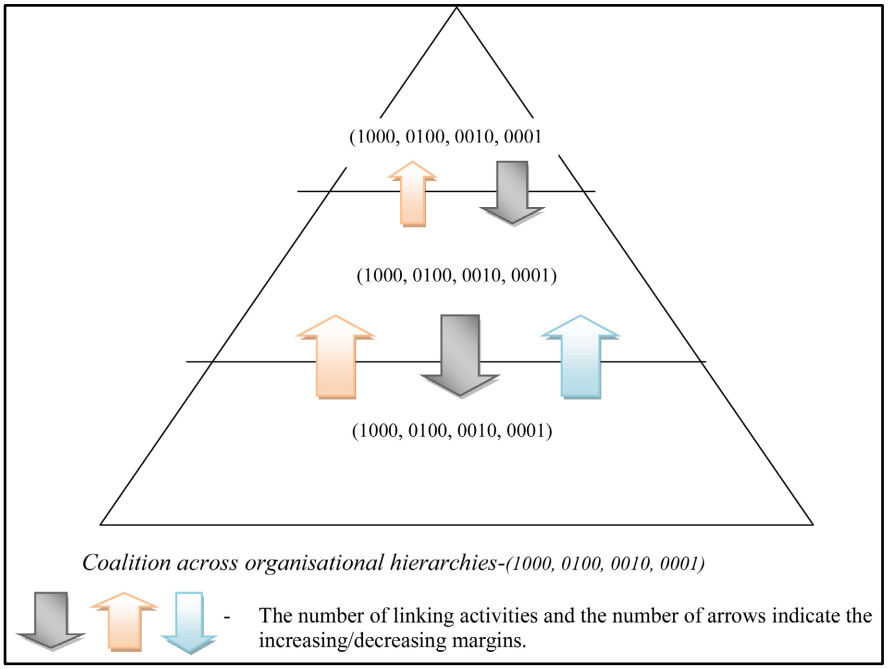


**Figure 3.** A hierarchical organization matrix. Source: Authors.

## 4. Methodology

The overall methodology deployed in this research is epistemological metrics-driven analysis. Exploring existing theories: such as the classical, neoclassical, contingency, systems, and resource-based theories. Understand their principles, strengths, and weaknesses. This will help to identify gaps and opportunities for a new theory. Then, evaluating the internal capabilities of organizations across different dimensions, such as human resources, technology, knowledge management, decision-making processes, and communication channels. Understand how these capabilities contribute to organizational effectiveness and performance. In addition, identifying common patterns between internal capabilities and organizational outcomes. Considering how different combinations of capabilities may lead to different structures, efficiencies, and competitive advantages. Identifying key factors that influence organizational structure and effectiveness. Finally, we developed a conceptual framework that outlines the relationship between internal capabilities and organizational structure. Clearly articulating the underlying assumptions and mechanisms through which capabilities influence organisation structure.

Organizational payoffs are assessed using nine quantitative metrics, which span

across sections consecutively, 3, 4, 5, and numerically capture the association of firms (see Table 2).

Table 2. Summary of organizational payoff metrics: Source: Authors.

| Metrics # | Type of metrics | Description | Outcomes |
|---|---|---|---|
| 1 | Payoff | Potential payoff | Pay-outs |
| 2 | Realised payoffs | Realised payoffs determined by organizational decision | Mapping of activities into payoff space by forming coalitions |
| 3 | Possibilities in payoffs | | Potential payoffs are achieved by choices ( $\theta_k, \theta_j \in 0,1$ ) where the connection between payoffs and choices provides an increase to the underlying equation |
| 4 | The illustration for accomplished payoffs | | Negotiating a coalitional game, where agents form expectations, anticipate and develop models to understand and influence how payoffs can be realised and distributed. |
| 5 | Coalition structure | Coalition structure analysis | Leaner regression of coalitions |
| 6 | A coalition is a multi-level grouping of activities. | | |
| 7 | Critical states in organizations | Probability of the probability of an I-level coalition | |
| 8 | Equivalently the probability of a coalition structure | | |
| 9 | Expressing the number of activities involved in a change in the organization matrix | | |

## 5. Strategy as Search

Strategic decision-making uses the method of continuous evolutionary search for payoffs on the organization matrix: the outcomes of the search are reflected in changing coalition structures (Hannah et al., 2021). Many search algorithms can be conveyed in terms of the organization matrix. Table 3 illustrates a rough

taxonomy of search procedures. Ergodic searches wander through throughout phase space. The focus may be on the matrix itself or on decisions. Ergodic search is such that each one of the $2^N$ possible coalitions is equally likely: or we might think of ergodic search as making every decision associated with a coalition equally likely, giving $2^{N(N-1)}$ configuration. Alternatively, we may think in terms of restricted search. This is in fact the case with economic models and with models used in strategic analysis. A restricted search may take the form of placing restrictions on the form of the organization matrix (decomposition) by introducing organizational grammar.

**Table 3.** Varieties of search. Source: Authors.

| | Ergodic search | Non-ergodic search |
|---|---|---|
| Matrix $[A_{ik}]$ | Statistical mechanics **1** | Decomposition **2** |
| Decisions $(\theta_i\theta_k)$ | Spin glass **3** | Grammar **4** |

## 5.1. Alternative Search Procedures

Table 3 sets out a taxonomy of 4 search procedures and these are discussed as follows:

- Ergodic[5] searches in the statistical mechanics' formulation focus on the organization matrix itself and will spend the most time in classes of coalition structure with the highest probability. Thus, if the situation is as represented in Table 1, with each of the 16 possible coalitions, a coalition structure of two-member coalitions is most likely to occur. In the absence of another dynamic, the coalition structure is likely to gravitate to the most probable one: overwhelmingly the most likely are coalition structures made up of coalitions (of more or less) equal size.
- Kauffman's $N$ and $K$ models can be represented in terms of the organization matrix. *Tuning parameters* (notably $K$, the number of connections) adjust the number of connections and the size of coalitions. In the landscape generated by the Kauffman model, K increases ruggedness which is identified with the connectedness of his landscape. The more rugged, the more difficult the search. In terms of the organization matrix, this is so because high connectivity means that a single move of an activity from one coalition will disturb many coalitions because the activity is interconnected with many others. Increasing ruggedness or interconnectivity means increasing the *unreliability of information* and increasing risk[6].
- Spin glasses are a recent application of statistical mechanics. If decisions $(\theta_i\theta_k)$ are treated as random magnetic spins, as different coalitions are formed

[5]According to the ergodic hypothesis, the search will traverse all possible coalitions and the equilibrium structure is given as $N!$ ($N2!$ $N/2!)^{-1}$: Georgescu-Roegen (1970) critiques the ergodic hypothesis.

[6]In Kauffman's systems, evolution takes place at the edge of chaos, the cusp between order and chaos at $K = 3$. His explanation of the system's gravitation to the cusp is unrealistic—especially in

payoffs change abruptly (phase transitions). A spin glass system evolves by *flipping* from one coalition structure to another. Two essential ingredients are frustration and randomness, leading to many possible structures. Coalitions may become trapped in a basin of attraction: either c*haotically* moving from one coalition state to another or *frozen* into any one of many states. In either case, realised payoffs (and coalitions) will be randomly determined.

- Other sets of search algorithms focus on decisions and directed search. In simulations of directed search, restrictions (move operators) are placed upon transitions (via recombination and mutation in genetic algorithms for example) or on memory devices (in neural networks).

### 5.2. Evolution on the Organization Matrix

In general, evolution of organizations is through the formation of coalitions on the matrix. Searching the organization matrix can be powered by the external environment (*outer dynamics*) and by self-adaptation, the capacity of an organization to evolve partly through processes internal to itself (*inner dynamics*). The two dynamics are illustrated in **Figure 2**. Grammar operates on the transmission of $E(t)$ on $[A_{ik}]$ and $[\theta_i\theta_k]$ (external to a coalition) and on the transmission between on $[A_{ik}]$ and $[\theta_i\theta_k]$ (internal to the coalition).

The fractal structure of the organization matrix permits high connectivity and separation of time scales, which allows for the transformation of a coalition structure on all possible hierarchical dimensions or on just a few of them. The coalition structure of the organization matrix forms an interconnected set through which change emanating from external dynamics can provoke coalition restructuring of varying lengths and time scales. Some changes transform the entire structure: major revolutions that completely repartition the organization matrix on many scales: some are limited to segments of the hierarchy (either high or low levels): and others are confined to tiny niches. *Major floods emerge from tiny streams* (which is why the Chinese authorities fear Felong Gong). Some events have spectacular potential, the life of *some mute inglorious Milton*, but are confined to an almost imperceptible niche, *the short and simple annals of the poor*. Spectacular changes, more often than not, leave parts of the matrix untouched, as Yeats put it *Ireland may be free, and you still break stones*. But apocalypses do occur.

Environmental factors at successive levels of the organization matrix exert pressure (outer dynamics). Consider an arbitrary level of the organization matrix, the business unit level for example. Inner dynamics take the form of relaxation procedures. Organizational grammar ensures that inner relaxation processes are slower than the outer pressure. We have a split of time range between the inner and the outer: otherwise, organizations would be dust in the wind. Grammar provides inertia, and forms building blocks, those bin coalitions, often temporarily, insecurely, so that the fractal structure of the organization matrix is incompletely permeable, a set that is connected only infrequently. It becomes a

connected set when pressure is allowed to build up on every level of the matrix. In that case, change will permeate the business and the organization of society (Flier, Bosch, & Volberda, 2003).

When pressure builds up at all heights of the hierarchy of the organization matrix, all coalitions in the structure approach a state of self-organized criticality. Self-organization occurs in the sense that, as disequilibrium systems, organizations have the capacity to create structures and forms in the lack of influence or exploitation by an outside agent (Tlemsani, 2022). Criticality occurs in that the coalition structure enters a transition state, such that disturbances will propagate through the entire system (rather than, as in non-critical states, being confined to a niche or a segment).

Change at lower levels takes place more or less continuously, perhaps imperceptibly except to those directly affected (minor changes in work patterns, in everyday life, in arrangements for example). Small-scale evolutions take place all the time. Larger and larger scale evolutions take place when higher levels of the organization matrix, together with successively lower levels are all pushed to a critical state. Large macro evolutions result in the collapse of entire political and economic systems (Tlemsani & Al Suwaidi, 2016). Comparatively smaller changes result in the disappearance of industries and firms and the emergence of new ones. We cannot provide a precise mathematical description of the scale of evolution on the organization matrix that permits us to predict the size and timing of changes. But we can attach probabilities and explain the triggering process.

### 5.3. Changes in Coalition Structure

To understand the process of change in coalition structure, it is necessary to transform the organization matrix into game theoretic terms: into the format of a coalitional game. Coalition formation is defined as a set of binary decisions on $\boldsymbol{A}$ ($\boldsymbol{A} = [A_{ik}]$). It is convenient to combine off-diagonal (synergy) elements, writing $a^*_{jk} = a_{jk} + a_{kj}$ for (all $j$, $k$ for $I \neq k$ in an augmented organization matrix $\left[a^*_{jk}\right]$ (and $a_{jk} = a^*_{jk}$ where $j = k$).

$$\boldsymbol{a}^* \equiv \left[a^*_{jk}\right] \equiv \begin{bmatrix} a_{11} & a^*_{12} & a^*_{13} & \cdots & a^*_{1N} \\ 0 & a_{22} & a^*_{23} & \cdots & a^*_{2N} \\ 0 & 0 & a_{33} & \cdots & a^*_{3N} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & a_{NN} \end{bmatrix} \tag{8}$$

Now, define (net) payoffs in (1a) as the differences between benefits and costs: that is potential payoffs ( $a^*_{jk}$ ) may exist as a result of synergies or complementarities from coalition formation, but realising them involves costs ($c_{jk}$), as well as benefits ($r_{jk}$), to agents $j$ and $k$. If positive (net) payoffs $a^*_{jk}$ potentially exist from information sharing, for example, realised (net) payoffs are the sum of the costs and benefits of sharing the information: costs and benefits which must be distri-

buted between $j$ and $k$. Thus, (7a) can be rewritten as:

$$Z\left(C,\theta,t\right)=\Sigma_{ik}\left(r_{jk}-c_{jk}\right)\theta_j\theta_k\left(t\right),\quad \theta_j\theta_k\in 0,1 \tag{9}$$

If positive net payoffs exist, this is a reason for joining or for maintaining the coalition: if payoffs are negative, then it is grounds for quitting. Equation (7b) maps out a set of coalitional games. The formation of a particular coalition structure is the result of perceptions about net payoffs ($a^*$). Changes in coalition structure emanate from *outer* dynamics: changes in perceptions of payoffs (costs and benefits) associated with a coalition are triggered by changes in the business environment $E(t)$. Inner dynamics together with organizational grammar is a source of inertia in an organization (Tlemsani & Matthews, 2021). Not every change in the cost-benefit structure of payoffs will trigger a change in coalitions or coalition structures. The weaker the inertia, the more likely and the more continuous the change.

### 5.4. Evolution at Many Hierarchical Levels

The explanation in the previous section is general. It holds for any level of the organizational hierarchy: ranging from the smallest team to the largest organization or institution and to the evolution of the system itself.

An analogy exists with Bak's sandpile experiment when we consider successive levels of a coalition structure as successively higher and higher levels of the sandpile. At a critical state of the sandpile slides or avalanches begin. The avalanches are caused by communication between the grains of sand: additional grains communicate their momentum (roll) to other grains, which also start to roll. Most of the time the moving sand causes only local disturbances, and nothing very dramatic happens to the pile. There is no global communication. Sometimes bigger avalanches occur, and there is greater communication of the disturbances. Sometimes, but only rarely the moving sand causes huge avalanches: there is a communication of the disturbance throughout the whole pile.

We experience day-to-day change, of some kind or other, at the micro level continuously. Wide-ranging changes are more rarely experienced. One explanation for this is probabilistic. At lower levels of the hierarchy, there are more coalitions than at higher levels. As we ascend the hierarchy of activities, the number of coalitions shrinks in the sense that successively higher-level coalitions are coalitions of coalitions so there are fewer of them. This intuition needs to be formalised.

### 5.5. Critical States in Organizations

Suppose that the organization matrix is a multi-level entity with $M$ levels, each one containing of $N_i$ activities ( $n_1, n_2, \cdots, n_m$ ) and having $\Sigma N_i = N$ activities in all. Label activity $A^1$ ($i = 1$) as the top level of the organization matrix (with an associated coalition structure or coalition $C^1$) and $A^m$ as the lowest level activity (or coalition structure $C^m$). Suppose the probability of a coalition at any level is $P^i(C^i)$.

Thus, the probability of an $i$-level coalition is $P^i(C^i) = n_i/N$. So, we have:

$$P^1\left(C^1\right)=n_1/N, P^2\left(C^2\right)=n_2/N, \cdots, P^{m-1}\left(C^{m-1}\right)=n_{m-1}/N, P^m\left(C^m\right)=n_m/N \quad (10)$$

It is also true by definition that:

$$n_m \geq n_{m-1} \geq n_{m-2} \geq \cdots \geq n_2 \geq n_1. \quad P^m\left(C^m\right) \geq P^{m-1}\left(C^{m-1}\right) \geq \cdots \geq P^2\left(C^2\right) \geq P^1\left(C^1\right)$$

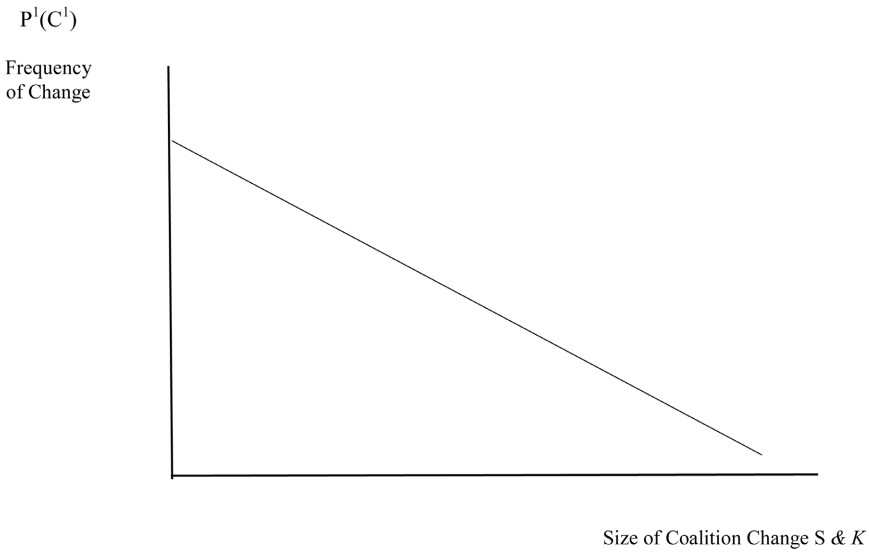


**Figure 4.** The relationship between size and the frequency of change in coalition structure. Source: Authors.

and generally:

$$P^{i+1}\left(C^{i+1}\right) \geq P^i\left(C^i\right) \quad (11)$$

Equivalently, the probability of a coalition structure occurring at a particular level is the cumulative probability of coalitions occurring at lower levels. Then:

$$P^i\left(C^i\right)=\Pi_{i+1}\left(n_{i+1}\right)/N \quad (12)$$

where $P^i(C^i)$ in (11) and (12) is the relative frequency of changes in coalition structure.

Expressing the number of activities involved in a change on the organization matrix when a change in coalition structure takes place as $S$ and $k$ ($k=1,2,\cdots,N$), we now have an opposite logarithmic connection between the size of a change $S$ and $k$ and the frequency of the change $P^i(C^i)$. This has been illustrated in **Figure 4** demonstrating the relationship between the frequency change and the size of coalition change.

Broadly speaking, Equation (11) states that the probability of a change in coalition structure is greater for lower tiers of the organization matrix than for higher tiers. Equation (12) expresses the probability of a change in coalition structure at a particular level of the matrix as the product of probabilities of change at lower levels. Since lower levels of the organization matrix contain: 1) more potential

coalitions and 2) coalitions with ever smaller numbers of activities, then Equation (11) and more general Equation (12) are expressions for self-ordered criticality in organizations. Using the probability of coalitions of different sizes in a coalition structure, they explain:

1) The nature of self-ordered criticality in organizations.

2) The reason why self-ordered criticality is an attractor.

The relationship in **Figure 4** is statistical: low-level changes are more frequent, and high-level changes are less frequent in much the same way as small earthquakes are more frequent than larger ones. The frequency relationship operates over the long run, but we are unable to predict whether in the near future, we will experience small changes with customary frequency or whether we will perceive a large *quake*: a revolution, a 9/11, a change in an entire system, punctuating the apparent equilibrium.

## 6. Findings and Further Discussion

The surplus necessary for organizations (or societies) to survive and grow is formed by connecting activities. The main responsibility of decision makers is: 1) to create coalitions among activities that have the possibility to generate a surplus over cost (payoffs), 2) to identify potential payoffs on the organization matrix, 3) to produce connections on the organization matrix between activities so that possible payoffs can be realised and 4) to discover new possibilities. We have come to identify these roles with the terms' manager and management which really describe *status* (position, authority, and power to control the distribution of the surplus), rather than *function* in relation to these roles. Although occasionally status and function coincide, the term strategic decision-maker is preferred.

The four roles form part of strategic decision-making. We have focussed so far on the first three: evolution and emergence by forming and reforming coalitions, diffusion of evolutionary processes through the entire hierarchy so organizations reach a state of self-ordered criticality where evolution is possible and can be described probabilistically by (11) and (12).

The discussion has so far assumed the existence of potential payoffs there to be realised. How can we explain the existence of potential payoffs? In addition to the hierarchic levels of the matrix, we can think of the organization matrix ontologically: activities and payoffs occur at distinct levels of being. Two levels have been discussed so far: those that exist in realised space ($R$), and those that are known to exist in potential ($P$) but not yet realised. Potential activities or payoffs appear on the left-hand side (1) and (2). The expression for realised payoffs is (3). Potential payoffs emerge from the space ($\Pi$). On this basis, this paper attempts to provide an empirical notion to estimate the potential payoff. However, developing more accurate and realistic measures requires further empirical analysis.

There is a need for the organisation to bridge the gap between the estimated payoff position (potential payoff) and the realised payoff position (its ontological

position). That is a growing organisational challenge. On this notion, the ontological position can be seen as a fictional gallery. All that can be present in the gallery is already in it: call in (Π) as the territory However, the secret assets in the gallery in (Π) just come out to awareness as guests turning groups or singly (coalitions) between rooms in the gallery. To differentiate (Π), we label the completed set (*R*), contents that are to hand and seen as items or recalled from the past. Guests to the gallery also have information from booklets, learning from prior experience of what is in nearby spaces and psychological images. We call (*P*) the potential domain: it is not yet completed, but guests are aware of it. It is possible in the idea that it could be accomplished. We might describe the mapping:

$$(P)\to(R) \tag{13}$$

in March's terms as exploitation. This expression is the counterpart of (7) new discoveries expressed by the mapping:

$$(\Pi)\to(P) \tag{14}$$

The domain (Π) is an important part of outer dynamics with respect to the entire organization matrix. The discovery process, imagination, creativity and entrepreneurship, realised as restless technological change is an important dynamic of capitalism in the Schumpeterian system.

The fictional gallery resembles Plato's concept of forms and the Jungian theory of archetypes. The organization matrix itself has an archetype: a fractal structure of independence and interdependence. The ontological dimension of the organization matrix, in particular (Π) throws some light on the nature of human intervention (imagination, creativity and entrepreneurship) in the evolution of organizations.

The second concern of this research is the extent that strategic decision-making can be considered conscious. Decision making to a great extent is about searching for solutions in a complex environment, designing search algorithms in situations where no overall minimax solution exists or can exist, concerned with hard combinatorial problems. One argument implicit in this paper is that organizations will draw to a greater and greater extent upon advances in the major sciences concerned with developing search algorithms. Although there is a vast array of alternatives or scenarios, simulations of search problems often reveal that they fall into many fewer distinct patterns. To the extent that many management problems consist of sifting through alternative coalition structures, they are in principle programmable (Nooteboom, 2014).

The empirical disposition of the organisational matrix/vectors should be selectively utilized as a part of the organisational decision support system while estimating/designing the organisational structure. As stated in the diagram (arrow diagram across organisational hierarchies), the underlying composition of estimating organisational structure must be developed as a combination of the coalition, payoffs, and active association. As stated, the idea of estimating organisa-

tional structure using payoff is derived from using a phenomenological view. We anticipate this ideology can be further extended using artificial intelligent technological capabilities (complex algorithms based on regressions/vector formulas) to estimate the organisational structure with accuracy and accuracy.

The definition of what constitutes the mind and consciousness in this paper is consistent with Chalmers' (1996) viewpoints. The materialist or functionalist position is accepted up to a point. Strategic decision-making and search can be simulated by strong AI (Searle, 1997) up to a point. A form of dualism is accepted in this paper: between decisions based on creative imagination and decisions that can conceivably be programmed or simulated by strong AI. The qualification that *may* be attached to emergence is important. The view we take is not that consciousness exists but there is a possibility of consciousness. It emerges only with certain conditions are met.

## 7. Conclusion

This research indicates that the co-evolution approach is productive in overcoming incomplete explanations of the single-lens dimension. However, our study captured at least three key dimensions while investigating the co-evolution between the firms and payoffs. First, we proposed the approach of metrics-driven approach to co-evolution. Such a metrics-driven initiative is crucial for anticipated/realised payoff. Second, we have proved that the single-lens perspective/dimension only provides a partial explanation of the co-evolutions (synergy/payoff). Third, a metrics-driven approach/interpretation can be integrated with the moderation effects of game-theory practices/activity analysis. Thus, these metrics can be applied in quantitative research to explore, recognize and determine the nature of co-evolutions and their classification.

Choices around corporate structure have been treated in the context of a co-operative game ($N\&Z$) with movable payoffs in the form of economic rents. Efficiency conditions have been exposed to vary in an integrated structure, in which the coalition of all activities is convex, and a subdivided organization, in which the core is vacant. The pathway of an organization matrix oscillates among a formation of positive elements signalling rent or competitive advantage, the effects of competition and variations in the external and internal setting erode a zero value as the position. The role of the centre, by adaptation and learning, is frequently to reconstruct competitive advantage: restructuring the coalitional structure is a significant strategic variable for so doing.

Some restructuring in organizations is provoked by competitive pressures, generating zeros in the organization matrix, but the degree to which it is accepted by high-rent firms in the public, and even the charitable sector, indicates a progressively ruthless economy. Present concerns, like concentrating on core businesses, reengineering and inner markets, confirm the authority of top management to dispose of assets, including human resources, a metonymy for human beings, at will, and these strategies expand the authority of top managers to re-

allocate the surplus produced by organizations to their stockholders, themselves and financial arbitrageurs.

Research limitations are that the strategic payoff is calculated using the numbers/metric approach but not in terms of their magnitude. Thus, the marginal improvements of those activities over time are not captured or not reported. Thus, future researchers may focus on further exploring to what extent the generated metrics can be applied to specific industries or introducing ratio approaches. Further, how an existing co-evolution state/phenomenon can be disrupted by a new entrance either from the same or closely related industry may reveal very interesting insights.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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