Disentangling Causal Ambiguity: Presenting A Formal Model

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"Precisely because organizational issues are intrinsically messy, any model that organizes and simplifies causal ambiguity has the power to deepen our understanding of strategic issues and to strengthen our recommendations for managing causal ambiguity". (King, 2007)

I

INTRODUCTION

The rise and success of RBV has been unparalleled by any other view in recent times, which has made it the dominant logic in strategic making. The rise of RBV marks a definite shift in strategic thinking, or as some might say, a re-focus on strategic resources and later on strategic capabilities. But the tall claims of RBV have been equally refuted by its critics, whose scepticism about RBV is not unfounded. Unlike its previous counter parts, which had a tremendous impact on strategic thinking such as Competitive Forces Approach (CFA) and Strategic Forces Approach (SFA), managers have limited incentive to actually strategize anything in RBV.

In the two previous approaches of strategic making, managers had an incentive to play games (SFA) or make strategic moves (CFA), however in RBV, managers are mere mute spectators of chance and luck. This is not hard to explain, if we consider the main tenant of RBV that are distinct resources (often complimentary or as commonly known as bundle of resources) and capabilities which provide sustainable competitive advantage for a firm. In this definition, 'distinct' or what is technically referred to as heterogeneity of either resource or capability or both, is very necessary to enable a firm to achieve Sustainable Competitive Advantage (SCA). Homogeneity leads to the erosion of rent and, hence, the importance of heterogeneity.

If we have to believe the claims of RBV, then this heterogeneity is achieved by either one or a combination of factors such as Luck, History-Dependent factors, Time-Compression Diseconomies, Ownership of Enforceable Property Rights, Socially Complex Resources, such as reputation and trust and, finally, Causal Ambiguity. However, nothing significant can be done in present times to alter History-Dependent factors, because if competitors have achieved distinct resources due to History-Dependent Factors, then the focal firm can do little or nothing to achieve the same resources due to the reason of Time-Compression Diseconomies. A fertile land will continue to give Richardian rent, while the owner of barren land will continue to envy the success of its neighbours. This unsuccessful owner has little incentive in RBV to make her prosperous, but can do a lot if she embraces the claims of SFA or CFA.

Certain resources are protected by enforceable property rights, but in today's fast paced Schumpeterian revolution, no technology is off-limit to competitors, while Socially Complex Resources are very hard to copy and their effect on SCA are still harder to gauge. Leaving aside luck as a random variable, which cannot be controlled and hence cannot be strategized, we are left with Causal Ambiguity as the only construct which can be strategized to gain heterogeneity and, hence, competitive advantage according to RBV.

This is the reason why Causal Ambiguity has emerged as one of the most powerful constructs in recent times. But the emergence of Causal Ambiguity has been plagued by the ambiguity surrounding it. The traditional thinking is that Causal Ambiguity can not be strategized as no-one in or outside the firm can understand the Causal Ambiguity surrounding a resource or capability or both. This claim about Causal Ambiguity has been left unchallenged till now, but this paper makes use of recent advancements in Capability literature and System Design and the vast and often left unnoticed literature on routines presents a formal framework for strategizing Causal Ambiguity. This paper presents four propositions about capability and the Causal Ambiguity surrounding it.

The remainder of this paper is organized as follows: Section two presents a formal explanation of the importance of Capability; Section three emphasizes the heterogeneity factor of capability; Section four reviews the literature to put forward the factors deemed to be important to achieve and maintain this heterogeneity; Section five looks into the present understanding among scholars about Causal Ambiguity; Section six formally introduces Capability

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as a system, followed by Section seven which marries the vast literature on Complex Adaptive System with Capability literature; while the last section concludes the paper with discussion on the research and wider implications of such a study.

II

WHY CAPABILITY?

"How firms achieve and sustain competitive advantage" is the fundamental question in strategic management (Rumlet et al, 1994). This question is answered by three main paradigms. Though each paradigm has its own merits and demerits, a cursory glance at each of them is enough to understand the importance of capability in today's ever-evolving and turbulent environment.

The three main paradigms are:

I. Competitive Forces Approach (Porter ,1980).
II. Strategic Forces Approach (Shapiro, 1989).
III. Resource Based Approach or View (Dexter and Cool, 1989; Penrose, 1959; Wernfelt, 1984; Barney,1986, 1991, 2001).

- **Competitive Forces Approach:** Popularized in standard textbooks of strategic management as Porter's five forces analysis tends to answer the fundamental question of strategic management by taking industry or strategic groups as the unit of analysis. It is the structural impediments of the industry and the way a firm positions itself vis a vis the particular industry which leads to competitive advantage. What is important is that Monopoly rent is generated mostly at the industry level.
  That rent is generated at industry level is a hotly contested claim in the strategic management field (Cool and Schendel, 1988; Lewis and Thomas, 1990; Rumlet, 1991). These large scale empirical studies have recently proven that the source of rent is at firm and SBU levels and, hence, there is a need for a theory to explain this source of competitive advantage.
- **Strategic Forces Approach:** tries to answer the fundamental question of how competitive advantage is achieved by taking the unit of analysis to managerial moves and counter moves. Though this type of analysis formalizes long held intuitive beliefs about competitive maneuvers between equally matched competitors, but most of the predictions of this approach fizzle away, when it comes to analysing competition between competitors who are unevenly matched due to differently sized factor endowments. An organization A , with one tenth the intangible resource, say reputation of organization B, will never be able to send credible threat signals to Organization B, as Organization B, will evaluate those signals as non-credible. What this approach fails to capture is the difference in resource size which gives organizations the position in the market from where they can play strategic games for maintaining or enhancing that position.
- **RBV (Resource Based Approach):** not only builds on the drawback of both Competitive Forces Approach and Strategic Forces Approach but also greatly compliments both these approaches (Teece et al. 1997). It tries to answer the basic question of strategic management by taking the unit of analysis to the firm level (unlike Competitive Forces Approach) and highlighting the need for long term investment in resources to build a sustainable competitive advantage (unlike behavioural moves and counter moves of Strategic Forces Approach).
  RBV sees firms as a bundle of valuable distinct resources which need to be deployed effectively and efficiently through valuable capabilities to gain a sustainable competitive advantage (Dexter and Cool, 1989; Penrose, 1959; Wernfelt, 1984; Barney, 1991, 2001). There exist two different views in RBV as to what capability is; while one view sees capability as a resource itself others sees capability as an process which makes use of resources (Grant, 1991; Amit and Shoemaker, 1993). According to this second view, any distinct resource, no matter how valuable it is, comes to naught if it is not exercised properly by an equally competitive capability.

III

HETEROGENEITY OF CAPABILITY

That capability is needed to roll out tangible and intangible resources from factor market to product market is not the only reason that capability is important and worthy of study. It is the heterogeneity of capability in the population of firms which makes capability an important construct and helps explain how firms achieve SCA

and maintain it. RBV logic has long hypothesised that any resource or capabilities need to be heterogeneous for them to contribute to the SCA of a firm (Lippmann and Rumlet 1982; Reed and DeFilippi 1990; Rumlet 1987; Coyne 1986; Hall 1992; Dierickx and Cool 1989). Capability literature has explored the idea of heterogeneity in the guise of Core-Competence (Parhalad and Hamel, 1990) and Core-Capability (Leonard-Barton, 1995).

Heterogeneity of Capability and Competitive Heterogeneity have been formally explored recently by Hoops and Madsen (2008). These authors use the VPC (Value, Price and Cost) framework to study the effect of heterogeneity and through their extensive literature review hypothesised that variance in VPC of a firm arises with the variance in the framework of certain distinctive capabilities. VPC framework helps us to explain why, when and how variance among the population of a firm's capabilities leads to variance in profitability and, hence, long term SCA of a firm. Any heterogeneous capability, if it either increases the Value or lowers the Cost, helps the firms to garner profit by either large V-P profile or large P-C or both.

This large V-C profile can only be achieved and then maintained if the capabilities or resources involved are heterogeneous, otherwise if they are homogenous, then it will ultimately lead to a uniform V-C profile among the population of a firm and, hence, erode SCA as such. But it is not to suggest that all heterogeneous Capabilities leads to SCA or homogenous Capabilities do not contribute to SCA. Not all heterogeneous capabilities lead to SCA as these heterogeneous capabilities may increase value or lower cost in comparison to competitors, but still the variance in V-C profile may be the same. Similarly, the concept of complimentarity (**Milgrom** and Roberts 1995) explores the idea that certain homogenous capabilities may be needed to ultimately support heterogeneous capabilities and, hence, they might be a valid contributor to SCA in their own right (For more on this idea please see Hoopes and Madsen, 2008).

IV

HOW THIS HETEROGENEITY IN CAPABILITY IS ACHIEVED AND THEN MAINTAINED

In this section we explore how heterogeneity is achieved and maintained. It is particularly germane to this research as to how this heterogeneity is maintained by firms to maintain their SCA. Scholars have long hypothesised that heterogeneity of resource or capability is achieved and maintained by its inimitability. Inimitability is now a major construct in RBV (King and Zeithaml, 2001), which tends to explain inter-firm performance difference.

Scholars have proposed that inimitability can be achieved in a variety of ways. History-Dependent factors, Time-Compression Diseconomies, Ownership of Enforceable Property Rights, Socially Complex Resources, such as reputation and trust, and finally, Causal Ambiguity. Causal Ambiguity is the construct which has received most attention in RBV and is the main focus of this research as well.

Ambiguity as to what factors lead to SCA or ambiguity about cause-effect relationship is termed Causal Ambiguity. If the effect of other factors affecting inimitability is straight forward, then the effect of Causal Ambiguity is quite complex (King and Zeithaml, 2001). In fact, despite receiving much attention in the literature especially RBV, there is still a lot of ambiguity about Causal Ambiguity (King, 2007). There exist two different views about the extent of Causal Ambiguity among scholars. While one section holds the belief that there is an equal amount of inter and intra firm causal ambiguity (Lipmann and Rumlet, 1982; Barney, 1991) and, hence, there is no room for strategizing through causal ambiguity by the focal firm. The other view is that differences exit between inter and intra firm Causal Ambiguity.

The difference between these two views is quite important as depending on which view is correct, it also explains the crux of Causal Ambiguity. If we have to believe in the first view that Causal Ambiguity is the same among competitors as well as managers in a focal firm, then causal ambiguity comes across as a construct which not only provides SCA to the focal firm by protecting imitation from competitors but it also stunts the growth of focal firm as transferring core-capabilities or resources across functional or geographic boundaries become prohibitive, since managers at the focal firm themselves have no clear idea about the cause-effect relationship of competence which has to be rolled out.

Not only does it hamper growth but it also erodes competitive advantage in the long run because, as hypothesized by Reed and DeFillipi (1990), firms need to continuously re-invest in the barriers to imitation as these barriers are not static but rather they deplete on a regular basis and it is upto the organization to continually re-invest

proper resources to maintain or increase the dynamic barrier. If the managers have no clue as to what factors lead to competitive advantage, they can simply not invest back into the barrier to imitation.

But if we have to believe in the second view which holds that there is a difference between inter as well as intra firm causal ambiguity, it leaves scope for strategizing as managers in a focal firm can not only re-invest in the barrier to imitation, but also re-deploy capabilities effectively. It is the second view which this paper builds on and tries to clarify some ambiguity about causal ambiguity, so that it helps in strategizing for the focal firm.

V

UNDERSTANDING CAUSAL AMBIGUITY

Causal Ambiguity can be divided into two main parts. The first is Linkage Ambiguity which deals with ambiguity among decision makers about the link between competency and competitive advantage (Lipmann and Rumlet, 1982; Barney, 1991) and the other is Characteristics Ambiguity, which is the ambiguity inherent in the competence itself. The main antecedent of Linkage Ambiguity has been hypothesised as Temporal and Spatial distance while the chief characteristics of Characteristics Ambiguity are Tacitness, Complexity and Interconnectedness (King, 2007).

This paper deals mainly with Characteristics Ambiguity while the readers are directed to King (2007) for more on Linkage Ambiguity. As mentioned earlier, Characteristics Ambiguity is of three types and partial explanation of all three is essential for understanding this line of research.

Tacitness is often referred back to the work of Polanyi (1964), which refers to the skill-based competencies and to the fact that an organization or its members know more than they can explain. Tacit based knowledge is usually non-codified and is transferred mainly through apprenticeship and is hardly ever fully transferrable through strategic alliances or imitation (Simonin, 1999).

Interconnectedness or Specificity refers to the fact that resources or capabilities come in bundles (Barney, 1991); take them from the bundle and try to plant them into a new context and they lose their meaning. It also refers to the Williamson (1985) concept of transaction-specific assets and skills and the costs incurred in transferring them into a new domain which makes them prohibitive to transfer. This transaction specific relationship between a firm's internal and external transaction partners can provide a great deal of ambiguity for the competitors.

The third type of Characteristics Causal Ambiguity is Complexity, which is the inherent characteristics of resources or capabilities which may be using large numbers of technologies, organizational routines and individual or team based experience (Reed and DeFillipi, 1990).

VI

CAPABILITY AS A SYSTEM

Of the three characteristics, this paper looks into the complexity of capabilities and the ambiguity arising out of it and tries to explain the underlying factors behind it. This paper posits that to understand ambiguity arising out of the complexity of a capability, capability has to be understood as a complex system in itself. In this section we explore the present understanding among scholars working on system theory in the light of which capability be understood as a system

A system is defined as –"social, biological, technological or otherwise, which is hierarchically nested, meaning that at any unit of analysis, the entity is a system of components and each of these components is, in turn, a system of finer components, until we reach some point at which the components are "elementary particles" or until science constrains our decomposition" (Schilling, 2000: 314).

What is an accepted fact is that a system need not be a living being or even tangible. Technology is not tangible in most cases but it is still accepted as a system. The second proposition is that every system is built up of components and every component can be understood as a system in their own light. To make our definition more intuitive, we can visualize a car as a system which is made up of several different parts such as a door, windows, steering, brakes, engines etc. but if we have to zoom in on one of the constituent components of this system, say the engine, then we can easily define the engine as a system in itself which may be composed of a piston, spark plug, compressor etc. We can keep on decomposing the system like this till we reach to the nuts and bolt level. At this nut and bolt level, science imposes a restriction on us to further decompose the nuts or bolts into constituting components.

In recent years, system theory ideas have been borrowed for product design (Ulrich, 1995), Organization structure (Baldwin and Clark, 1997), Technology (Fleming and Sorenson, 2001) and Marketing (Sanchez, 1995). In all of

these cases, scholars have extended the concept of system to both product and process design. For example, Fleming and Sorenson (2001) have confidentially titled their article "Technology as a complex adaptive system: evidence from patent data". The authors have conceptualized a new technology as a system built up of previous existing technologies. In their view, every new technology can be further decomposed into already existing technologies and so on.

Having defined the system, we need to show how capability is a system and what are it constituting components on which it is built. Some scholars might be tempted to depict Capability as a form of technology and, hence follow the path laid down by Fleming and Sorenson (2001), but not all Capabilities are technology related, rather Capability can have varied forms such as operating capability, marketing capability, human resource capability and dynamic capability to name a few. The problem that lies ahead of us is that we have to encompass a broad design for capability and conceptualize it at a general level, from where it is applicable to any type whether it be technology related or not, unlike Fleming and Sorenson (2001).

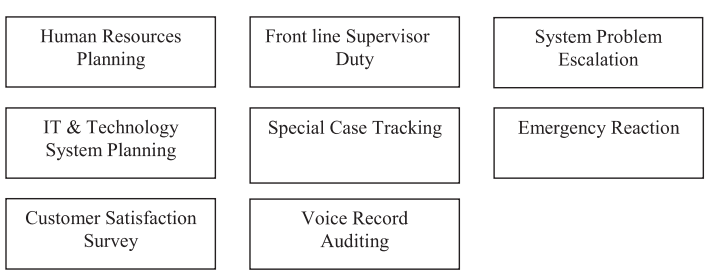
Capability Re-visited: Our quest for understanding capability as a system with an underlying structure, which might be applicable to all types of capabilities, forces us to re-visit the capability literature. Scholars have conceptualized Capability as a bundle of routines which make use of tangible and intangible resources. This definition, though very vague, does give us a hint as to what could be the underlying structure behind capability. That capability is nested on organizational routines has always been an accepted proposition, but only recently scholars from operations management have proven this proposition in an empirical setting (Peng, Schroeder and Shah, 2008). Before we explore the findings of these scholars, it is necessary to understand in detail what we mean by the definition that capabilities are nested on routines.

Scholars have long conceptualized that capabilities make use of resources through recurring patterns which could be either cognitive or activity based. These recurring patterns or processes are known as routines in evolutionary economics (Nelson and Winter, 1982). These routines act as collective reservoir or joints which pools in individual skills for a greater cause. Routines provide organization a tool, for coordinating, controlling, providing truce among conflicting interests, stabilizing, economizing on cognitive resources, uncertainty reduction, last but not the least, holding knowledge by acting as a reservoir. (Becker, 2004)

Without these routines or recurring patterns, organizations would be unable to exercise their ability to roll out products or services in the product market, thus making use of resources in the factor market. These routines convert ability into *capability*. An organization might be able to come up with an effective solution to a recurring problem in the manufacturing line and, hence, be *able* to solve that problem once, but to be *capable* of solving that problem time and again whenever the problem arises, it needs to pool in its resources and individual skills into a collective pattern of activity which can be activated at any time with precision and the same result till the problem itself does not change or advancement in technology force change in the solution or render the solution obsolete.

These collective actions to take care of business day to day needs are known as Operating Routines, while the routines which act to change the existing routines to enable organizations to cope with the destructive nature of the market are termed as Search Routines. The operating routines give rise to static capabilities, while search routines give rise to dynamic capabilities. Pan, Pan, Chen and Hsieh (2007), in their study of a call centre firm, found that most of the firms' higher order functional modules (capabilities) were decomposed into lower level routines. For example, these authors found that the organization has 8 key operating routines.

Figure 1: Key Operating Routines of a Call Centre



Source: Pan, Pan, Chen and Hsieh (2007)

The focal organization, when it has to exercise its key functional activities which is akin to the capability of that organization, would do so by making use of these routines. For example, Front-Line Management capability would be activated by three distinct routines, i.e. Front-line Supervisor Duty, System Problem Escalation and Emergency Reaction. (For more type of capabilities and on the routines on which they rest please refer to the diagram)

Figure 2: Functional Modules of Call Centre

Resource Planning	Customer Satisfaction Survey	Front line Management
Human Resources Planning	Voice Record Auditing	Front line Supervisor Duty
IT & Technology System Planning	Special Case Tracking	System Problem Escalation
	Quality Control	Emergency Reaction

Source: Pan, Pan, Chen and Hsieh (2007)

This study of the authors provides a passing reference to our proposition as they shy away from naming their functional modules as capabilities, but their notion of functional modules is quite similar and probably the same as our notion of capability. Nevertheless, it provides us with an intuitive picture of what could be the underlying structure of capabilities.

If the study by Pan, Pan, Chen and Hsieh (2007) provides a vague description of our proposition, then the second-order confirmatory analysis of Pang, Schroeder and Shah (2008) provides a direct and perhaps the only empirical reference to our proposition. In their study, these authors identify two dynamic capabilities, i.e. improvement capability and innovation capability which they termed as two most important Capabilities for a manufacturing enterprise. Through their extensive literature review, they came up with three underlying routines each for each of the two capabilities. They hypothesized that Improvement Capability rests on three routines:

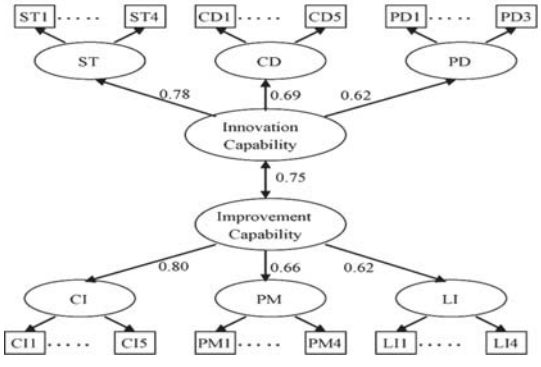
1) Continuous improvement (CI)
2) Process management (PM)
3) Leadership involvement in quality (LI)

While Innovation Capability rest on three routines:

1) Search for new technologies (ST)
2) Process and equipment development (PD)
3) Cross-functional product development (CD)

They specified a second-order factor model where each measurement item (note that each underlying routine where operationalized through specific measurement items, which were mapped into the latent construct according to the given literature) was loaded onto first-order routines, and then each first-order routine was loaded on to the two specific capabilities. These authors find a strong correlation between conceptualized routines and the capabilities arising from their interplay.

Figure 3: Second Order Factor Model, depicting the underlying structure of Capabilities.



Source: Pang, Schroeder and Shah (2008)

The findings of these authors validate the proposition that capabilities rest on routines and also show as the way to move forward. Having defined Capability as a system built up of components (routines) which can be further classified into finer components (routines can be classified into sub-routines and so on). We summarize the discussion of this section with the following proposition.

Proposition 1: Capability is a system built up of sub-components or modules, called routines.

Our task in the next section is the most challenging one that is to integrate this knowledge with the literature on complex adaptive system and try to understand how and when complexity arises in a capability system, giving rise to the enduring enigma named Causal Ambiguity.

VII

COMPLEX ADAPTIVE SYSTEM AND CAPABILITY

Before we embark on our final and most important journey in this last section and attempt to understand Causally Ambiguous Capability as a Complex Adaptive system, we have to define what we actually mean by complex. If we have come across different meanings for the same term previously in this paper, then we have come across another such term which provides us with a wide and often diverging view of what is complex.

Though complexity is studied in diverse subjects from physics to organizational behaviour, but we limit our discussion of complexity to knowledge management as this literature corresponds to process complexity, and capability is also understood to be a process in the literature. MacMillan et al. (1985), Winter (1987), Zander and Kogut (1995) and Tyre (1991) have defined complexity of knowledge on different parameters. But the two parameters which come across as fairly consistent in this literature is the sheer number of elements (components or modules) and the degree of interaction among those elements.

But the idea that the number of elements and their interactions makes a system complex is not limited to theoretical insights in knowledge management only; this idea has been analytically explored in evolutionary biology (Kaufmann, 1993)[1]. Kaufmann hypothesized a fitness landscape consisting of homogenous genes (components/ modules) and the organism with heterogeneous characteristics as the different combination of these fairly homogenous genes. The total number of genes can be represented by N, which can be the total number of components or modules in any system whether it is biological or not.

Though in real life every component N can vary on a continuum scale from 0 to 1 infinitely, for simplicity and mathematical easiness, Kaufmann model takes N from a uniform [0, 1] distribution meaning any N can have only two values, either 0 or 1. This implies that either the particular N is present in the organism or it is not. To what extent it is present in the organism is not taken into consideration by Kaufmann. Finally, Kaufmann's model has the second parameter K which defines the interdependence between N genes (components/ modules). K can vary any where between 0 and N-1.

Kaufmann finds that the landscape changes from smooth to rugged as K increases from 0 to N-1. Kaufmann's findings, as discussed earlier, have profound implications for scholars working on system theory in diverse subject areas, as for the first time, it formalizes the proposition that K or the interaction drags a system towards complexity or simplicity. Recently, organization scholars have used the fitness landscape framework to study learning curves, dominant design and imitation (Levinthal, 2007), but as Sorenson (2002) points out, very few scholars have taken endeavour to collaborate NK model findings with real world data.

WHAT NK LANDSCAPE MEANS FOR US

As pointed out at the end of the previous section, our task is to integrate this knowledge of a complex system and the idea that the degree of interaction among constituting components of a system ultimately decides whether a system will end up as complex or simple and, hence, causally ambiguous or not. In our case, we have a system which we call Capability which has N number of components (remember routines) and K is the degree of interaction among these routines. While defining N is quite simple, defining the interaction between routines might be a little tricky.

To understand the interaction among routines, we have to first understand the interaction among components at the general level before applying that knowledge to understand process/ activity/routine interaction. One of the best ways to understand the interaction among components in a system is Design Structure Matrix (DSM) [2],

originally invented to document interaction between elements (components/modules) in complex system architecture (DSM.org).

DSM is a matrix based tool which helps define various types of interactions between constituting elements of a system. For example, consider the following example of an automobile Climate Control System which consists of 16 elements or components, i.e. Radiator, Engine fan, Heater Core, Heater Hoses, Condenser, Compressor, Evaporator Case, Evaporator Core, Accumulator, Refrigeration Controls, Air Controls, Sensors, Command Distribution, Actuators, Blower Controls and Blower Motor.

Now in this Climate Control System, the Radiator needs material exchange with the Engine Fan and vice versa, but apart from Engine fan, the Radiator does not need any material exchange with the other 14 elements of this system. Next, consider the case of the Condenser which needs material exchange with the Engine fan, the Compressor and Evaporator Core but is free from any other interaction with the remaining 12 elements. The DSM matrix mathematically formalizes this interaction through matrix representation of these elements. The DSM of Climate Control System below represents the Radiator –A to Blower Motor- P both vertically and horizontally. The diagonal interaction, represented by letters A to P, is the interaction of the constituting element with itself, while the X mark interaction is the interaction of the respective element with other elements.

Figure 4: Climate Control System Mapped on a DSM

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Radiator	**A**	**A**	**X**														
Engine fan	**B**	**X**	**B**														
Heater core	**C**			**C**													**X**
Heater Hoses	**D**				**D**												
Condenser	**E**		**X**			**E**	**X**		**X**								
Compressor	**F**					**X**	**F**		**X**	**X**							
Evaporator Case	**G**							**G**									**X**
Evaporator Core	**H**					**X**	**X**		**H**	**X**							**X**
Accumulator	**I**						**X**		**X**	**I**							
Refrigeration Controls	**J**										**J**						
Air Controls	**K**											**K**					
Sensors	**L**												**L**				
Command Distribution	**M**													**M**			
Actuators	**N**														**N**		
Blower Controls	**O**															**O**	**X**
Blower Motor	**P**			**X**				**X**	**X**							**X**	**P**

Source: DSM.org

But, as noted earlier, the idea of system design is not limited to product architecture as it has been expanded to activity based architecture also. So in our case, if a capability is built up of say 9 routines (which are activity based), numbering from 1-9, then the DSM of this Capability system could look like following Figure.

Figure 5: Routine Interaction Mapped On a DSM

	1	2	3	4	5	6	7	8	9
1	**1**								
2		**2**							
3		*	**3**						
4	*	*	*	**4**					
5		*		*	**5**				
6		*				**6**	*		
7					*		**7**	*	
8			*				*	**8**	
9						*			**9**

Source: Author

Again the numbers 1-9 represent distinct routines and the * represent the interaction of these routines with other routines. There is a slight complexity here as visualizing the interaction between components of a product system is quite simple, for example, in our previous example of Climate Control System when we say the Radiator interacts with the Fan, we mean that the Fan cools the Radiator and hence, the Radiator is dependent on the Fan for cooling and hence, there is a flow of material energy between these two constituting elements. But what could we mean by the interaction between different routines?

The idea of interaction between different team based routines has been put forward by Henderson and Clark (1990). These authors hypothesized and found that in the Photolithographic industry, most of the incumbents are locked in a series of routines. To make the complexity arising out of these distinct routines simpler and economize on the limited cognition, gatekeepers emerge to communicate between different teams practising different routines. For example, in our case, routine 1 is stand alone– it does not need any communication flow from any other routine constituting the capability, but to execute routine 4, the organization needs the input from routines 1,2 and 3. This idea of routine based interaction has been summarized by Henderson and Clark (1990) as process architecture and these authors further propose that due to the specific lock- in between different routines, many incumbents fail to change when a need for a different set of interactions between routines may arise.

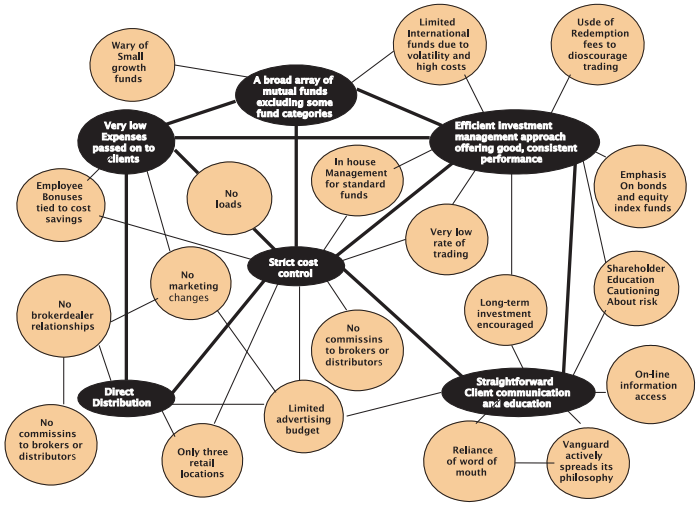
Having defined what we mean by interactions between different element/components/routines of a system and having explored how complexity science proposes that it is the degree of interaction between the constituting elements which drags a system towards the complexity. During the explanation of Causal Ambiguity, we have already stated that how complexity is the chief characteristics of Causal Ambiguity. Now we are in a position to state our second and third propositions.

Proposition 2: A Lower degree of interaction among the constituting routines making use of homogenous resources will result in low Causal Ambiguity of Capability.

Proposition 3: A Higher degree of interaction among the constituting routines making use of homogenous resources will result in high Causal Ambiguity of capability.

The premise of most of the simulations and a few empirical studies has been so far that systems interaction is random, but recent work on systems at the firm level (Siggelkow 2002) and product system (Baldwin and Clark 2000) has given an indication that the real world systems might not be as random as presently thought, but there is an inherent pattern in the interactions among constituting elements of a system. For example, Porter (1996) and Siggelkow (2002) work on the strategic choices of IKEA, Southwest Airlines and Vanguard has shown that the constituting strategic choices of the decision making (any parallel between these strategic choices and routine would be unfounded, but both the concepts constitute an activity based system) do not interact in a random way, but rather they show a remarkable pattern in their interaction. Consider the case of Vanguard, the diagram below shows the interaction between constituting strategic choices of Vanguard managers.

Figure 6: Vanguard Strategic Choices and their Interactions with each other



Source: Porter (1996)

The diagram above presents a crude representation of the hypothetical system constituting the Strategic decision making of Vanguard Managers, which in itself is not self-explanatory but when it is mapped into a DSM matrix (below), it starts showing the pattern in interaction.

Figure 7: Vanguard Strategic Choices Mapped on a DSM

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	*	*	*	*							*				*										
2	*	*																							
3	*		*	*																					
4			*	*	*	*	*	*	*	*	*				*										*
5				*	*																				
6				*		*																			
7				*			*				*														
8				*		*		*			*														
9				*					*																*
10				*						*															*
11	*			*				*			*	*	*	*	*	*				*	*				*
12											*	*			*										
13											*		*												
14														*				*			*				*
15	*			*							*	*			*			*			*				
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22																		*				*			*
23																							*	*	*
24																							*		*
25								*	*	*	*											*	*	*	*

Source: Author

Note that due to inadequate space, the name of strategic choices could not be fitted into the above diagram but the number 1 to 25 represent strategic choices in the following sequential order

Figure 8: Sequence of Strategic Choices of Vanguard.

1)	A broad array of mutual funds
2)	Wary of small growth funds
3)	Limited international funds
4)	Efficient investment management approach
5)	Use of redemption fees
6)	Emphasis on bonds
7)	In house management
8)	Very low rate of trading
9)	Long term investment encouraged
10)	Shareholder education cautioning about risk
11)	Strict cost control
12)	No loads
13)	No first class travel for executives
14)	Limited advertising budget
15)	Very low expenses passed on to budget
16)	Employees bonus tied to cost saving
17)	No broker dealer
18)	No marketing changes
19)	No commission to brokers
20)	Only three locations
21)	Direct distributions
22)	On-line information access
23)	Vanguard activity spread
24)	Reliance on word of mouth
25)	Straightforward client communication

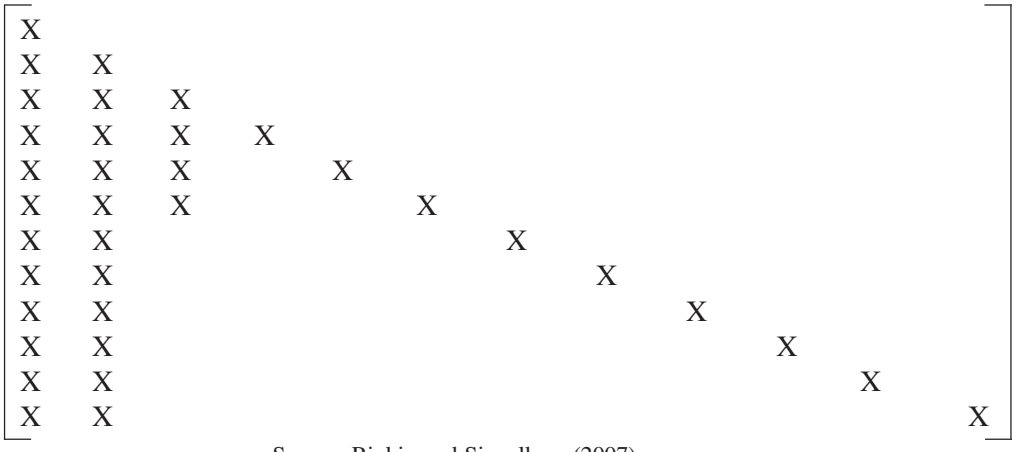
Source: Author

H. Hierarchical

What does this pattern of interaction mean in a strategic sense? Every organization follows a structure, for example, some organizations are hierarchical, where the Top Management Team (TMT) makes most of the decisions which are followed mutely by those who are lower in the hierarchy; this approach is also popularly known as top-bottom approach. In such an organization, the decision making once mapped onto a DSM matrix will show this type of pattern:

Figure 9: A Hierarchical DSM

H. Hierarchical



Source: Rivkin and Siggelkow (2007)

As seen in the diagram above, the first few decisions taken by TMT are affecting every bottom decision, while bottom decisions are not able to affect top decisions. Working on this hypothesis that every organization displays a distinct style of functioning and structure, Rivkin and Siggelkow (2007) have proposed 10 types of structures as seen in the real world systems. They are Random, Local, Small-world, Block-Diagonal, Preferential attachment, Scale-free, Centralized, Hierarchal, Diagonal and Dependent. Further more, these authors have used these patterned DSM matrixes in their simulation study to gauge the effect of these patterns on the complexity of the system.

The finding of this study is consistent with the authors hypothesis that more than the degree of interaction, it is the pattern of interaction which effects the complexity of a system. For example, by keeping the degree of interaction constant but by varying the pattern of interaction, the authors find that with the same degree of interaction, patterns of interaction like Block-Diagonal, Diagonal and Dependent show more complexity in the system than say Centralized or Hierarchal system. These findings lead us to our fourth and last proposition, which works on the idea that a certain pattern of interaction leads to complexity of a system, while certain other might drag the system towards simplicity.

Proposition 4: A Certain pattern of routine interaction in a Capability system will lead to heightened Causal Ambiguity about that particular Capability.

Proposition 5: A Certain pattern of routine interaction in a Capability system will lead to lessened Causal Ambiguity about that particular Capability.

VIII

DISCUSSIONS

Aldrich is quoted in Murmann et al. (2003), "if we truly focused on routines, competencies, practices, and so on, we would NOT follow people anymore in our research. Instead we should follow how competencies spread, replicate, and insinuate themselves into organizations. People would disappear from the equation" (2003: 27). This claim has been equally and critically refuted by King (2007) who states that "if people disappear, so does causal ambiguity, because causal ambiguity about competencies is inextricably bound to organizational decision makers" (2007: 173). This paper presents a model which makes use of the evolutionary concept of routines as replicators and firms as interactors.[3]

This model posits that what is causally ambiguous has to be separated from "to whom it is Causally Ambiguous".

Such a separation can only be made if we embrace evolutionary concepts and ideas and marry them with extant literature on Causal Ambiguity. What is Causally Ambiguous is the replicator, which has to be replicated intra-firm or imitated inter-firm, and to whom it is Causally Ambiguous is the firm, which acts as an interactor for these replicators. This differentiation makes its clear that the true source of Causal Ambiguity does not lie solely in the minds of Top Management Teams or Middle Managers, as proposed by King and Zeithmal (2001) and King (2007), but rather it is a function of replicators themselves and the relationship these replicators come to enjoy with their interactors.

This model does not undermine but compliments the model of King (2007) and it does not make people disappear, as cautioned by King (2007), but rather its exemplifies one of the chief characteristics of Causal Ambiguity, i.e. complexity, which can only be understood by disentangling the Capability involved, which is but a certain combination of replicators. People or groups of people in the form of firms though not the central focus of this model are still very important because, as hypothesized in the evolutionary perspective, the interactors ultimately change the code of replicators or at least modify the non-tacit part of replicators. (Knudsen, 2002).

How does the interactor (firm) change the replicator (capability)? This is where the importance of this model comes into play. In particular, the proposition of this paper is that certain modes of administration like Centralized, Hierarchical etc. might lead to too simplistic capabilities as most of the capabilities of this type of organization might be less Causally Ambiguous than the capabilities of a Dependent or diagonally structured organization or SBU. In such a scenario, Top Management Team (TMT) has the incentives to change the structure strategically to increase the Causal Ambiguity for its competitors.

Next, we can consider the extreme case of Intra-Firm Causal Ambiguity, which might be hampering the growth of focal firms as it might be unable to roll out the benchmark capabilities to new geographic or product locations. In this case, TMT can sit back and analyse the specific capabilities which it wants to replicate internally in the way proposed in this paper, and use insights from the vast literature of DSM, and re-partition its routines in a way that some of the Causal-Ambiguity is reduced but still it cannot be imitated by competitors.

These are but a few examples of what could be the implications of such research as this paper, which for the first time, links Causal Ambiguity to the structure of the organization and gives incentive to managers to change the structure and mode of functioning to manipulate Causal Ambiguity for maintaining Heterogeneity of core-capabilities and, hence, providing SCA to the focal firm.

Testing of this model will require the use of the grammatical model[4] to analyse the activity based routines and appropriate scales to measure both the degree as well as the patterns of interactions between these routines. Above all, the use of second-order factor analysis might be required to link the routines to the focal capability. Such a study will require both qualitative (in the initial stage) as well as quantitative analysis of data to reach any definite conclusions. Appropriate industry selection should be of paramount importance for such a study as the assumptions imposed by Kaufmann's (1993) model of heterogeneous interactors in a population of interactors composed of homogenous replicators will be a challenge for any social-science setting, but this should not deter scholars as such a scenario is not extremely hard to find. Many industries such as the call-centre industry make use of highly homogenous operating procedures or routines which give rise to heterogeneous capabilities.

Most importantly, this model is limited to only complexity; further studies making use of the evolutionary concept can disentangle other chief characteristics of Causal Ambiguity i.e. Tacitness and Interconnectedness. For example, as hypothesized by this model that capability is nested on routines, gives us a hint about the Interconnectedness factor of Causal Ambiguity. Consider a Capability made up of 6 routines, out of which routine 4 and 5 are mutually non-detachable from the each other, as they are using information flows from each other to activate themselves. In such a scenario, any attempt to replicate these same sets of routines minus routines 4 or 5 will be an exercise in futility because, as hinted in Interconnectedness literature, some competencies are tied to a context. Similarly, there is a solid literature on tacit knowledge in evolutionary economics, which can be amply used by scholars to understand this concept in terms of Causal Ambiguity.

NOTES

1) This paper does not intend to confuse its reader with technical jargon or mathematical details surrounding

fitness landscape. A good technical exposition of fitness landscape can be found in Kaufmann (1993) and in Fleming and Sorenson (2001), Rivkin and Siggelkow (2007) .The emphasis in this paper is to use the end-result of fitness landscape to help solidify our propositions rather then *exemplify* the findings or technical details of fitness landscape.

2) Data Structure Matrix is a well established technique for analysing a product or process system, usually used to partition the system to make it more economical and less time consuming by eradicating repeated components or re-assigning different functions to a single component or both. A full exposition of this technique is inexhaustible and could not be documented in one single article. Keen readers are directed to the website DSM.org which maintains exhaustive materials on DSM.

3) The idea of replicator and interactor has been put forward recently to partially solve philosophical and ontological issues in borrowing evolutionary concepts from biology to social science, particularly evolutionary economics. A full explanation of these concepts is impossible in few paragraphs but this idea has been beautifully introduced and explored in Hodgson and Knudsen (2004).

4) The Grammatical Model is used to study any sequential activity, where these activities are woven together through artificial grammar. A detailed explanation of the Grammatical Model and how it works is beyond the scope of this paper, but interested readers can find out more from Pentland and Rueter (1994).

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