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**ORGANIZATIONAL RESILIENCE IN MARITIME
BUSINESS: COMPLEX ADAPTIVE SYSTEMS
APPROACH**

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APPROVAL PAGE



DECLARATION

I hereby declare that this doctoral thesis titled as “**Organizational Resilience in Maritime Business: Complex Adaptive Systems Approach**” has been written by myself in accordance with the academic rules and ethical conduct. I also declare that all materials benefited in this thesis consist of the mentioned resources in the reference list. I verify all these with my honour.

11/01/2021

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ABSTRACT
Doctoral Thesis
Doctor of Philosophy (Ph.D.)
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Approach
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In the second half of the 20th century, especially after the 1980s, the business world faced important developments like technological advancements, changing customer expectations, removal of trade barriers, and through so many political, social, and economic transformations and interactions between those patterns. Such developments in the global business environment and international trade shape the maritime business. One of the important understandings of dealing with these changes and advancements is to develop organizational resilience and ensuring its continuity. Although different cultural and industrial dynamics are important to identify and develop resilience capabilities; context-dependent approach creates variety in an organizational field which induces a lack of consensus on evaluation and development of organizational resilience factors/enablers/features.

To fill this gap and to understand global developments and sui generis situations of maritime business, this dissertation offers Complex Adaptive Systems (CAS) Approach as a theoretical lens. Traditional ways of managing organizations were not able to answer the requirements of all this cycle of interaction and change since maritime business organizations compete fiercely in dynamic markets in highly volatile business environments. And managing

maritime businesses not only as a system but as a complex adaptive system will allow organizations to easily handle many problems and enables to develop resilient maritime organizations.

This thesis aims to suggest an organizational framework to show how maritime business organizations can develop resilient organizations via Complex Adaptive Systems (CAS) Approach if appropriate design features of Complex Adaptive Systems could be defined and included in organizational properties. The sample of the dissertation has decided as Bulk Shipowner Organizations due to the importance of bulk carriers in global maritime transportation and the Turkish fleet.

To reach the mentioned aim, a systematic literature review conducted to figure out features/enablers/characteristics of Complex Adaptive Systems. After revealing the most used features of Complex Adaptive Systems, Maritime Expert opinions gathered to evaluate which features of CAS could help to develop organizational resilience in maritime business via two-round Delphi research. And as the last step, Interpretive Structural Modelling applied with the help of the same maritime experts' opinions to analyse and evaluate effective features that trigger other features while developing organizational resilience in the maritime business.

The results of the study show that Complex Adaptive Systems is a proper lens to develop organizational resilience in the maritime business. Using proper Complex Adaptive Systems features while designing organizations help to enable resilient maritime business organizations. Among the 15 CAS features determined from the literature, Diversity Feature, Emergence Feature, Co-evolution Feature, Interaction Feature, Non-linearity Feature, Dynamism Feature and Unpredictability Feature are the most effective features that dominate the rest of the features while developing organizational resilience in the maritime business.

Keywords: Organizational Resilience, Complex Adaptive Systems, Maritime Business, Bulk Shipping, Interpretive Structural Modelling

ÖZET

Doktora Tezi

Deniz İşletmeciliğinde Örgütsel Dayanıklılığın Kompleks Adaptif Sistemler Yaklaşımı ile İncelenmesi **Hatice AKPINAR**

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20. yüzyılın ikinci yarısı, özellikle 1980'lerden sonra, iş dünyası teknolojik gelişmeler, değişen müşteri beklentileri, ticaret engellerinin kaldırılması ve bu kalıplar arasındaki pek çok siyasi, sosyal ve ekonomik dönüşüm ve etkileşim gibi önemli gelişmelerle karşı karşıya kalmıştır. Küresel iş ortamında ve uluslararası ticaretteki bu tür gelişmeler denizcilik işletmelerini de şekillendirmektedir. Bu değişim ve gelişmelerle başa çıkmanın önemli anlayışlarından bir tanesi de örgütsel dayanıklılığın sağlanması ve sürdürülmesidir. Dayanıklılık yeteneklerini belirlemek ve geliştirmek için farklı kültürel ve endüstriyel dinamikler önemli olsa da; bağlama bağlı yaklaşım, örgütsel alanda çeşitlilik yaratsa da örgütsel dayanıklılık faktörlerinin / kolaylaştırıcılarının/ özelliklerinin değerlendirilmesi ve geliştirilmesi konusunda fikir birliği eksikliğine neden olur.

Bu boşluğu doldurmak ve küresel gelişmeleri ve denizcilik işletmelerinin kendine özgü durumlarını anlamak için, bu tez, Kompleks Adaptif Sistemler (CAS) Yaklaşımını teorik bir mercek olarak sunmaktadır. Kuruluşları yönetmenin geleneksel yolları, tüm bu etkileşim ve değişim döngüsünün gereksinimlerini karşılayamamaktadır çünkü denizcilik işletmeleri, son derece değişken iş ortamlarında dinamik pazarlarda şiddetli rekabet içinde iş yapmaktadır. Denizcilik işletmelerini sadece bir sistem olarak değil, aynı zamanda karmaşık uyum sistemi olarak yönetmek, kuruluşların birçok sorununu

kolayca ele almasına ve dayanıklı denizcilik örgütlerinin geliştirilmesine olanak tanıyacaktır. Bu tez, Kompleks Adaptif Sistemlerinin (CAS) yeterli tasarım özelliklerini tanımlanıp örgütsel özelliklere dahil edilebilirse, denizcilik işletmeleri kuruluşlarının Kompleks Adaptif Sistemler (CAS) Yaklaşımı aracılığıyla nasıl dayanıklı örgütler geliştirebileceklerini göstermek için bir örgütsel çerçeve önermeyi amaçlamaktadır. Dökme yük gemilerinin küresel deniz taşımacılığında ve Türk filosunda orantılı önemi nedeniyle, tezin kapsamı ve örnekleme Dökme Yük Gemi İşletmeleri olarak seçilmiştir.

Söz konusu amaca ulaşmak için, Kompleks Adaptif Sistemlerinin (CAS) sağlayıcılarını / kolaylaştırıcılarını / özelliklerini belirlemek adına sistematik literatür taraması yapılmıştır. Kompleks Adaptif Sistemlerinin en çok kullanılan özelliklerini ortaya çıkardıktan sonra, bu özelliklerin hangilerinin denizcilik işletmelerinde örgütsel dayanıklılığın geliştirilmesine yardımcı olabileceğini değerlendirmek için Denizcilik Uzmanlarının görüşleri iki aşamalı Delphi araştırmasıyla toplanmıştır. Tezin son aşaması olarak Yorumlayıcı Yapısal Modelleme yöntemi ile denizcilik işletmelerinde örgütsel dayanıklılığı geliştirirken diğer özellikleri tetikleyen en etkili özellikleri analiz etmek ve değerlendirmek için denizcilik uzmanlarının görüşlerine yeniden başvurulmuştur.

Çalışmanın sonuçları, Kompleks Adaptif Sistemlerin (CAS) denizcilik işletmelerinde örgütsel dayanıklılığı geliştirmek için uygun bir mercek olduğunu göstermektedir. Örgütleri tasarlarlarken uygun Kompleks Adaptif Sistemler (CAS) özelliklerini kullanmak, dayanıklı denizcilik işletmelerinin oluşmasını sağlayacaktır. Tespit edilen 15 Kompleks Adaptif Sistemler (CAS) özellikleri arasından örgütsel dayanıklılığı sağlarken diğer özellikleri tetikleyen ve etki eden en etkili özellikler olarak Çeşitlilik Özelliği, Ortaya Çıkış Özelliği, Birlikte Evrilme Özelliği, Karşılıklı Etkileşim Özelliği, Doğrusal Olmama Özelliği, Dinamizm Özelliği ve Tahmin Edilemezlik Özelliği ortaya çıkmıştır.

Anahtar Kelimeler: Örgütsel Dayanıklılık, Kompleks Adaptif Sistemler (CAS), Denizcilik İşletmeleri, Dökme Denizcilik, Yorumlayıcı Yapısal Modelleme

ORGANIZATIONAL RESILIENCE IN MARITIME BUSINESS: COMPLEX ADAPTIVE SYSTEMS APPROACH

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ABBREVIATIONS

AHP	Analytic Hierarchy Process
ANP	Analytic Network Process
CAS	Complex Adaptive Systems
DEMATEL	The Decision Making Trial and Evaluation Laboratory
FCA	Formal Concept Analysis
FSA	Formal Safety Assessment
IACS	International Association of Classification Societies
IMEC	The International Maritime Employers' Council
IMO	International Maritime Organization
ILO	International Labour Organization
IoT	Internet of Things
IRM	Initial Reachability Matrix
ISM	Interpretive Structural Modelling
ISPS	International Ship and Port Facility Security Code
ISSA	International Ship Suppliers and Service Association
KPIs	Key Performance Indicators
MCDM	Multi Criteria Decision Making
MICMAC	Matriced' Impacts Croises Multiplication Appliquee au Classement
OECD	Organisation for Economic Co-operation and Development
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QUORUM	Quality of Reporting of Meta-analysis
RFID	Radio-frequency Identification
SES	Social Ecological Systems
SLR	Systematic Literature Review
SSIM	Structural Self-Interaction Matrix
TSA	Turkish Shipowners Association
UNCTAD	United Nations Conference on Trade and Development

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INTRODUCTION

Throughout the 20th century, especially developments in production technologies challenged the logic of business and organizations while stepping into the 21st century the developments in information technologies shape the logic of the global world (Palmberg, 2009: 483). Those developments bring different applications which require more flexible and adaptive organizational structures due to new understandings in a global business environment where the interconnectedness of organizations increases; pressures for competitiveness and expectations and preferences of customers changing much faster (Palmberg, 2009: 483; Arevalo and Espinosa, 2015: 21). Along with technological transitions, organizations needed to focus not just on their internal issues but also multiple developments and requirements of their worldwide “stakeholders and resource holders” (Hulsmann et al., 2008: 14) where the global business environment witnessed another important shift “from networks to ecosystems” (Aarikka-Stenroosa and Ritala, 2017: 23). So such an interconnected and interdependent business environment, typical relationship and network studies could not enough to understand global business issues.

In this changing world, the maritime industry becomes more complex, dynamic and uncertain (Goulielmos, 2017a: 1214) and the parties/stakeholders of the maritime business system become open to make mistakes in such a volatile business environment if they overlook, undervalue or misread the business trends (Scarsi, 2007: 577). The Maritime business is the main international logistical arm of supply chains (Thanopoulou and Strandenes, 2017: 325) which enables maritime transportation leg of distribution operations. The Maritime business itself has a very unique, non-linear environment which is affected by any change in the world; cyclical, dynamic, unpredictable which all create high uncertainty for the stakeholders of the maritime system. Like other players of transportation, maritime business facing increased pressure to develop efficient and effective organizational systems. As a system, maritime business withstands different kinds of operational and environmental disruptions which could have the potential to harm maritime organizations and institutions (Akpınar and

Ozer-Caylan, 2021). Those disruptions are in a wide range of variety from natural disasters like hurricanes or tornadoes to man-made disasters like accidents or terrorist attacks (Mansouri et al., 2009: 1407).

Problems and disruptions harm the capacity of the maritime transportation system that transfer goods (Berle et al. 2011: 700) which incur the cost and delay the process (Hamel and Valikangas, 2003: 54). Maritime disruptions induce problems through the transportation process which cause delays and financial losses to maritime organizations and shippers (Yang and Hsu, 2018: 221). It is impossible to anticipate all risks and situations of future events (Ruiz-Martin et al., 2018: 12) where traditional statistical methods are insufficient (Aven, 2013: 2082). Organizational resilience helps to explain changing environmental conditions (McAslan, 2010: 7) and offers resilient management abilities to confront those difficulties. With all these global trends and sui generis problems of maritime business, it is important to still be efficient and effective while finding solutions, handling breakdowns and clear up interruptions to offer sea transportation service (Goulielmos et al., 2007: 51). Thinking different than others while they expect a similar future (Scarsi, 2007: 581) put organizations one step ahead.

The resilient management philosophy is the one that could ensure “one step ahead” thinking for the maritime business. Organizational resilience of maritime business refers to the survival ability of the organizations to solve the problem not just in the face of disruption but also noticing difficulties before giving symptoms which also helps to gain a competitive advantage to prosper. However, applying the organizational resilience philosophy and ensuring the continuity of this resilience thinking can be challenging for maritime businesses organizations. Because there is no “magic recipe” that shows how to develop resilient organizations that work in all segments of the maritime industry. In such uncertain and complex business environment, approaching organizational resilience through the lenses of Complex Adaptive Systems (CAS) Approach have potential to enable much more applicable results that work in all segments of the maritime industry. Because Complex Adaptive Systems (CAS) approach offers new understanding to create new lenses while managing organizations (Burnes, 2005: 74). Manage organizations with a CAS approach allows managers to

understand that it is really difficult to control their system in this dynamic environment (Choi et al., 2001: 360). Conceptualizing maritime business not just a system but also as a Complex Adaptive System provides to develop organizational resilience successfully.

This thesis aims to suggest an organizational framework to show how maritime business organizations can develop resilient organizations via the CAS approach if adequate design features of CAS could be defined and included in organizational properties. The main motivation of this study is; it could be possible to manage maritime business organizations to become more resilient to disturbances if adequate design features of Complex Adaptive Systems (CAS) could be defined and included in organizational properties.

The concepts of organizational resilience and the Complex Adaptive Systems (CAS) approach are not analysed in-depth in the context of maritime business which influences the preference of research design. The qualitative scientific research design has been preferred in this study. The study uses the “functionalist” paradigm. Under the classification in their salient study of Burrell and Morgan (1979), this dissertation could be analysed as:

- “*Realist*” according to “*Ontological Assumptions*”
- “*Positivist*” according to “*Epistemological Assumptions*”
- “*Determinist*” according to “*Human Nature Assumptions*”
- “*Nomothetic*” according to “*Methodological Assumptions*”

In the first chapter of this study, the concept of the Complex Adaptive Systems approach was introduced. After a brief introduction to Complex Adaptive Systems (CAS), the chapter has explained complexity theory and other related theories and approaches as the roots of Complex Adaptive Systems. Finally, after a detailed definition of Complex Adaptive Systems as a concept, the features of the concept as the enablers of the system have been disclosed.

In the second chapter, the concept of Resilience has been introduced with different meanings according to different disciplines. The organizational resilience concept explained among other disciplines where the management philosophy of resilience and competitive advantage that it creates has explained.

In the third chapter, after Maritime business defined as a system, the complexity drivers of maritime business categorised. Those drivers are the main reasons why the maritime business should be managed as CAS. With the help of CAS features, the explanations of CAS dimensions according to maritime business have explained.

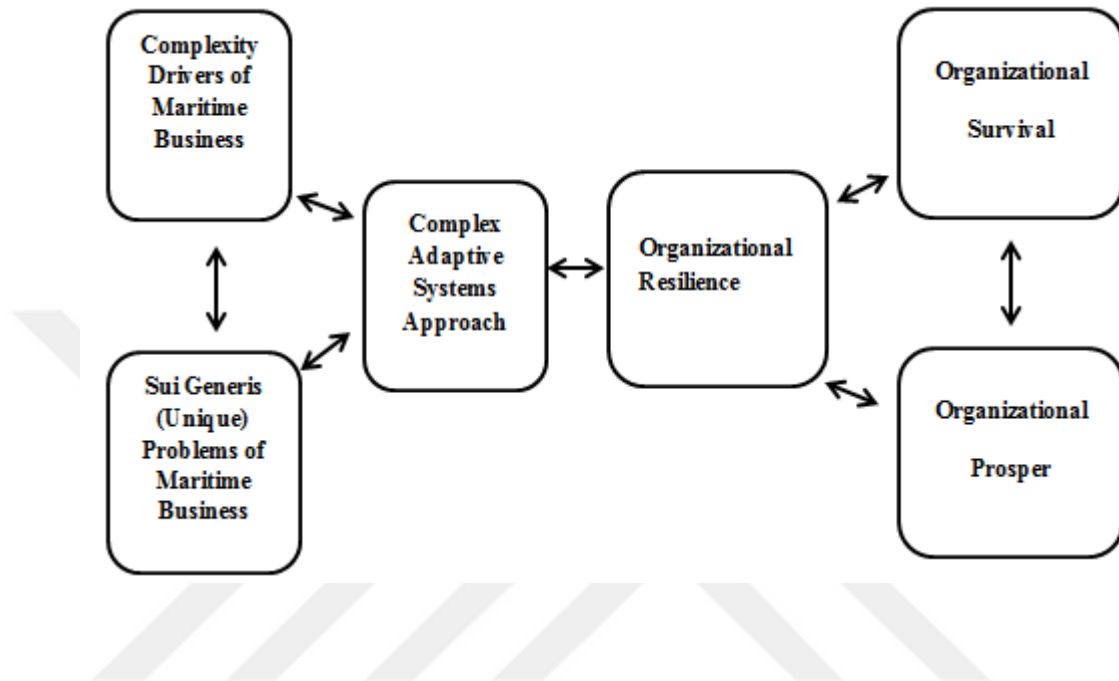
The fourth chapter of the dissertation planned as explaining the requirement of resilience management philosophy for the maritime business industry. After that understanding resilience management from Complex Adaptive Systems lenses will briefly be introduced as the main approach of this dissertation where aligning Organizational Resilience and Complex Adaptive Systems Approach is the last section of this chapter.

The fifth chapter is the application chapter of the dissertation where research methodologies conducted a Systematic Literature Review, Delphi Study and Interpretive Structural Modelling. Bulk Shipowner Organizations determined as the scope of the dissertation. After the 15 CAS features revealed at the end of the systematic literature review, maritime experts evaluated determined features to develop organizational resilience in maritime businesses. Accepted features analysed by maritime experts to figure out binary relations. At the end of the research process, the most effective features revealed while developing organizational resilience in maritime businesses.

The dissertation ends with the general discussion and conclusion of the research, theoretical and practical contribution of the study and limitations and suggestions for further research.

So within mutually supportive relationships of the CAS approach and organizational resilience concept, the model of the study could be figured as below:

Figure 1: Conceptual Model of the Study



CHAPTER ONE

COMPLEX ADAPTIVE SYSTEMS APPROACH

1.1. ROOTS OF COMPLEX ADAPTIVE SYSTEMS APPROACH

Complex Adaptive Systems (CAS) is a system which includes too many and a great variety of components called “agents” which locally interact with each other. Local interaction is the main concept which depends on the behaviour of each agent. The behaviour of the agents depends on the interaction with the other agents that creates the autonomy of the system. Those local interactions create its own reality where without formal control, the system works. Those interactions give self-organization opportunity emerge from the behaviours of each agent that enables co-evolution which shapes the system (Colbert and Kurucz, 2011: 406). Simplicity is the basic focus in Complex Adaptive Systems (CAS) where by following simple interaction rules, agents emerge complex system that adapts according to local interdependent interactions (Thietart and Forgues, 2011: 56).

Complex Adaptive Systems (hereinafter CAS) gets its origin from different disciplines such as biology, cybernetics, ecosystem thinking, complexity and chaos theories. According to Dooley (1997) CAS uses parts from three paradigms as information processing, system approach and population ecology theory. Choi et al. (2001) confirms the roots of CAS as non-linear dynamical systems, artificial intelligence where Merali and Allen (2011) informed Prigogine’s dissipative structures and Maturana and Varela’s autopoiesis are constitute roots of CAS. Those studies enlighten the co-evolutionary dynamic of interdependent emergent behaviours of agents where self-organization occurs. With their own methodologies, those disciplines contribute wide variety of techniques to study CAS such as cellular automata (CA), genetic algorithms or neural networks (Anderson, 1999: 225) where chaos theory and dissipative structures give opportunity to study mathematical models (Burnes, 2005: 79). By using agent based approach to model CAS; simple things could arise from complexity and chaos could arise from simple interactions (Burnes, 2005: 79). Far-from-equilibrium

structure enables paradoxical situation that chaos and order, freedom and control co-exist (Dooley, 1997: 78). With the help of literature Table 1 shows studies and concepts used by CAS approach.

Table 1: Studies and Lenses used by Complex Adaptive Systems

Author/s	Study / Lens
Poincare (1890), E. Lorenz (1963)	“Strange Attractors”
Cannon (1926)	“Homeostasis”
Barnard (1938)	“Cooperative Systems”
Von Bertalanffy, (1950, 1968)	“Systems Approach”
Ashby (1956)	“Law of Requisite Variety”
John von Neumann (1958)	“Cellular Automata & Self-Reproducing Systems”
Mandelbrot (1961,1963)	“Fractals”
Lorenz (1963)	“Sensitive Dependence On Initial Conditions”
Katz and Kahn (1966)	“Open Systems”
Prigogine (1967)	“Dissipative Systems”
Beer (1972)	“Viable Systems Model”
Maturana & Varela (1973)	“Autopoiesis”
Holland (1975)	“Adaptation”
Prigogine (1978) ; Jantsch (1980)	“Self-Organizing”
Prigogine & Stenger (1984)	“Order Out of Chaos & Dissipative Structures”
Quinn (1985)	“Innovation & Controlled Chaos”
Morgan (1986)	“Self-organization & Autopoiesis”
Gleick (1987)	“Deterministic Chaos”
Goldstein (1988)	“Far-From-Equilibrium Approach”
Kauffman (1989)	“Fitness Landscapes”
March (1991)	“Exploration and Exploitation”
R. Lewin (1992)	“Edge of Chaos”

Adapted from: Allen et al. (2011: 4- 9); Maguire (2011: 81); McMillan (2008: 48); Allen and Boult, (2011: 165).

CAS focuses on the interaction between agents and the environment where co-evaluation happens at the same time (Choi et al., 2001: 352). Organizations accepted as complex, dynamical, non-linear agents at far-from-equilibrium where chaos and order co-exist. Within that complexity all agents behave according to same simple rules (Rowe and Hogarth, 2005: 398). CAS is able to define how organizations sustain their organizational life with the help of self-organization and how those interactions emerge new outcomes. CAS able to adapt themselves to changing environment which gives opportunity to co-evolution together with the environment (Surana et al., 2005: 4238) in order to survive. All biological systems could be considered as CAS in which they are sensitive to initial conditions (Burnes, 2005: 79). From thermodynamic viewpoint, total energy of CAS could not be knowable because of dynamic, non-linear dependency but yet something could be anticipated (Surana et al., 2005: 4238). Complex adaptive systems are systems that have the ability to adapt and evolve through the interactions with other agents in its environment (Merali and Allen, 2011: 41).

Using CAS lens helps to understand organizational change through uncertain and unforeseen emergence. By pushing organization to the edge of chaos, the place where organizational creativity and innovation increases, organizational change can be reach through the interdependent adaptation (Rowe and Hogarth, 2005: 399). Since 1980 complexity theory and CAS studies accelerate with the contributions of Santa Fe Institute (Anderson, 1999: 217).

1.1.1. Complexity Theory

Complexity theory is accepted as a new science (Burnes, 2005: 80) which begun to studied at Santa Fe Institute in New Mexico (Chan, 2001: 1) in the mid 1980 (Allen et al., 2011: 4). As a new field of science, complexity theory could not be accepted in the strict sense by the most scientific authorities (Burnes, 2005: 80). As the 1990 approached there were so many definitions and studies appear to explain complexity theory (Burnes, 2005: 77). Science of complexity is the outcome of open systems approach that clarifies adaptation, change and transformation (Merali and Allen, 2011:

43). Complexity is confused with the word “*complicated*”. Briefly complexity theory tries to explain the interaction of the things where complicated means things tangled each other (Perona and Miragliotta, 2004: 104).

The system called complicated when the system is known, such as a computer or a car (Aelker et al., 2013: 80). Complex systems are comprised of single agents that interact each other with non-linear manner often show chaotic, self-emerge behaviours usually far from equilibrium (Allen et al., 2011: 5). So just realising simple rules could not guarantee to solve and understand the system (Perona and Miragliotta, 2004: 104) which means system has its own uncertainty (Aelker et al., 2013: 80).

Feedback is the crucial element in complexity theory that shows strong connection of interdependency between agents. With the help of non-linear feedback, complex systems emerge and self-organize, adapt and learn (Richardson, 2011: 367). Complexity could be assessable as the feature of the system where the systems move from one state to another. These states are called as the order to disorder (Arevalo and Espinosa, 2015: 23). Complexity arise from the “*inter-relationship, inter-action and inter-connectivity*” of agents “*within a system*” and “*between a system*” and “*its environment*” (Chan, 2001: 1). Complexity science enables structure to work on such systems (Chaffee and McNeill, 2007: 233) and helps us to understand chaotic fluctuations and uncertainties that come after changes and transformations (Arevalo and Espinosa, 2015: 23).

Under daily conditions, systems are on “*quasi-equilibrium*” state where agents are on balance condition between order and chaos. This special state called as “*edge of chaos*” (Choi et al., 2001: 356) in which that state could be called as the gift of this new science to organizational studies (Townsend, 2007: 10). Besides creating its own terminology and explanations, this new science, complexity theory ensures many advantages for organizational studies (Goulielmos and Giziakis, 2002: 20) such as; understanding disorder within order state where in an ever-changing environment accepting the uncertainty and non-predictability (Chaffee and McNeill, 2007: 232). The notion of order within chaos effects the way of looking organizational life that shows planning as a difficult process that requires some level of decentralization especially in

decision making (Bovaird, 2008: 320). And what shows researches as stable and orderly states do not always give rise to success where stable conditions could result to a death of an organization (Chaffee and McNeill, 2007: 233).

There is no consensus on definition, conceptualization or measurement of complexity (Maguire, 2011: 83). Should it be a metaphorical light to provide new lens to organizations or should it enable new mathematical measurement tools (Burnes, 2005: 86). Any of these attempts require different “*ontological and epistemological*” questions (Maguire, 2011: 83) but complex systems are more research perspective to study (Morel and Ramanujam, 1999: 279). Burnes (2005) called “*complexity theories*” in order to explain the eclectic manner of the complexity theory derived from scientific disciplines and different theoretical lenses such as thermodynamics, fractal geometry, chaos theory, networks science (Arevalo and Espinosa, 2015: 23) systems approach, organizational cybernetics, Maturana and Varela's work on autopoiesis, change management (Perona and Miragliotta, 2004: 105). According to Burnes (2005) complexity theory uses different disciplines such as, physics, meteorology, mathematics, biology and chemistry in order to understand organizations and organizational change. Complexity theory is the main root of the CAS approach.

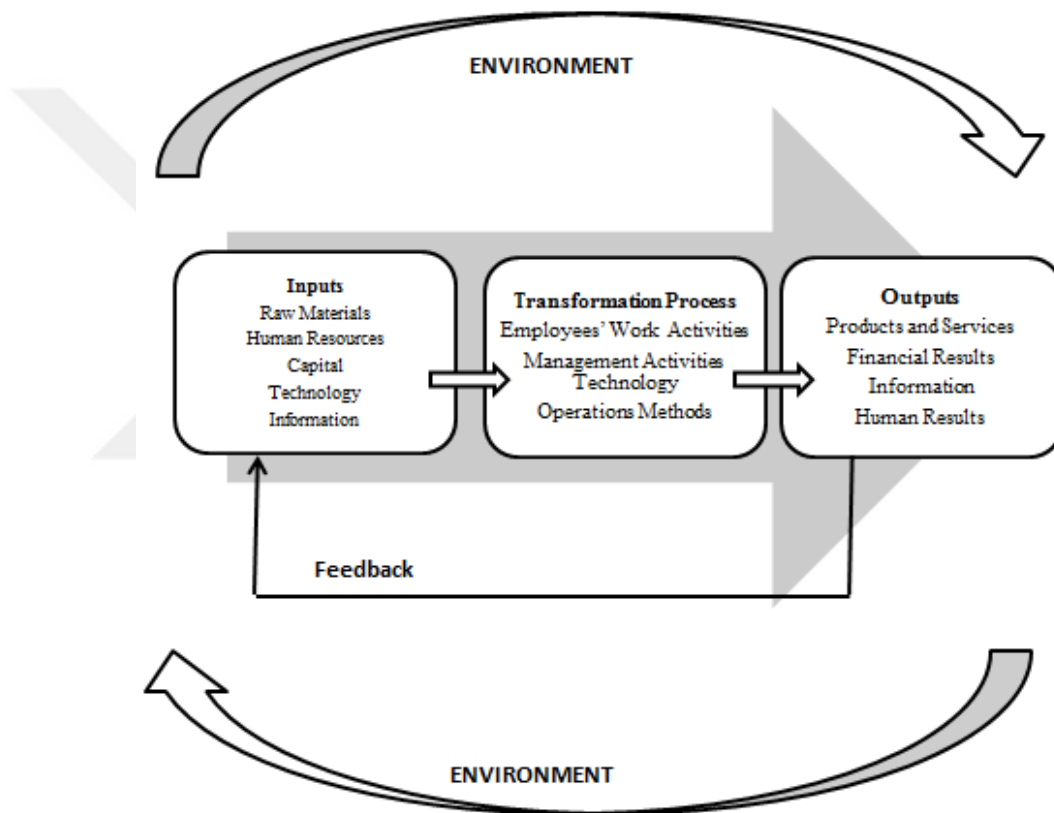
1.1.2. Systems Approach

Systems approach and cybernetics changed the way of thinking from the mid-1940s with the works of valuable researches such as Ashby and von Bertalanffy (Dooley, 1997: 71). External environment defines everything outside the organization that influences the organizational performance (Robbins et al., 2014: 29) The importance of environment to organizations come from the opportunities and challenges that offer as a chance for survival and success (Anderson & Tushman, 2001: 677).

A system is a web of interrelated elements which consists a whole. Systems could be defined as *closed systems* and *open systems* where closed systems have no interaction with their environment and open systems have affected and affect their environments (Robbins and Coulter, 2018: 39). Open systems could enable self-

maintenance based on throughput of resources from the environment. The difference of closed and open systems lies on the concept of entropy which defines the energy that cannot be transformed into work (Scott and Davis, 2016: 98). The illustration of open systems could be seen in Figure 1.

Figure 2: Organizations as Open Systems



Source: Robbins and Coulter (2018: 39).

From 1960s open systems view settled as a key word into organizational studies (Anderson, 1999: 216). Systems approach is one of the necessary lenses to understand CAS approach in organization studies (Allen et al., 2011: 4). Contrary to Cartesian paradigm, systems approach proposes that the whole could not be understood from the properties of its parts (Merali and Allen, 2011: 32). Feedback mechanism shapes the system such as negative feedback awakens the homeostasis mechanism where the

system tries to survive (Boisot and McKelvey, 2011: 280). With the help of systems approach organizations seen as “*organism*” and the environment is the important player (Dooley, 1997: 71) where the systems exchange resources with it (Anderson, 1999: 216). According to Ashby’s Law of Requisite Variety (1956) the systems internal complexity should match its external complexity (Boisot and McKelvey, 2011: 281). With output and feedback loops, open systems enhance boundary filtering where necessary inputs and outputs pass (Justice et al., 2016: 183). Those loops help to maintain equilibrium. Interactions and feedback loops maintains evolution with the environment via matching the internal variety and external variety where the survival chances of organizations increase (Boisot and Child, 1999: 238).

1.1.3. Contingency Theory

Another important theory could be used as CAS root is Contingency Theory (Allen et al., 2011: 4) which aims to describe relation between environmental conditions and organizational practices (Vidal et al., 2014: 1248). Contingency theory claims that there is no one recipe that fits all organizations. Organizations should organize according to nature of environment (Dooley, 1997: 71) as same as the CAS approach insists the importance of agent base interdependency.

Business environment shapes the way of doing businesses. Contingencies are important determiners that should be considered. Micro and macro environmental factors are necessary developments for the organizational life that require high attention (Vidal et al., 2014: 1248). Many studies show the effects of contingencies in the literature that proves organizational life exist within the harmony of environmental balance in which CAS lenses propose the same understanding too (Dooley, 1997: 72).

1.1.4. Chaos Theory

Chaos theory discovered by Edward Lorenz on his weather systems studies. He found that tiny, unimportant error could induce huge and unpredictable consequences which called butterfly effect. He also discovered that chaotic circumstances do not

follow cause and effect law but watch a special pattern that could be perceivable (Burnes, 2005: 77). Chaos theory helps to understand the systems which show non-linear behaviours. They do follow some patterns and *strange attractors* but at any point their future direction could not be predictable from their historical data (Murphy, 1996: 96). Theory deals with the dynamic systems which are changing regularly in an evolutionary manner (Burnes, 2005: 77). In chaotic systems, elements cycle around “*strange attractors*” that put the system in boundaries within a series of movements (Anderson, 1999: 217). Attractors are also used at Newtonian physics where their behaviours explained as “*repetitive, predictable and within same range*”. Around 1960s with new lenses and works, *strange attractor* term coined by Edward Lorenz (so-called Lorenz Attractor) in order to explain area which is “*nonrepeating and unpredictable*” (McMillan, 2008: 103) as illustrated Figure 2:

Figure 3: Illustration of Strange Attractors - “The Lorenz Attractor”



Source: Morgan (2006: 253).

As a term “chaos” popularised in management literature and often indicates “*a new order arises out of disorder and randomness*”. But as behaviour, chaotic systems follow deterministic way where initial conditions play an important part for the rest of the pattern (Merali and Allen, 2011: 42). *Fractal* geometry, coined by a mathematician Benoit Mandelbrot, helps to figure out significant importance of natural forms. With the help of fractal geometry design themes, relationships and patterning make sense

(McMillan, 2008: 117). Chaotic systems share some features with CAS such as strange attractors, self-renew, self-organize, non-linearity (Murphy, 1996: 96; Speakman and Sharpley, 2012: 71) and sensitivity to initial conditions (Merali and Allen, 2011: 42). Chaos theory could not accept Newtonian laws that follow linear causality with mechanistic perspective (Burnes, 2005: 77).

According to Dooley (1997) CAS approach has gained its point of view by using chaotic behaviours of non-linear systems. Systems found on place called “the edge of chaos” which means order and chaos, stability and instability happen at the same time (Speakman and Sharpley, 2012: 74). Chaos theory helps to clarify adversity of forecasting future that affects the strategic outcomes of organizations (McAslan, 2010: 5). With the help of chaos CAS approach explains the dynamic behaviour of non-linear systems that are broken by the touches of change which are sensitive to initial conditions (Morel and Ramanujam, 1999: 280) shows the randomness that highlight the role of chance (Murphy, 1996: 100). Possibility of many outcomes creates uncertainty where predicting future is impossible (Thietart and Forgues, 2011: 55).

1.1.5. Population Ecology Theory

Population Ecology Theory explains that organizational survival depends on environmental selection in a “*Darwinian landscape*” rather than organizational adaptation to conditions (Dooley, 1997: 72). But adaptation and natural selection are not as separate terms as they seem. According to CAS; difficult, new or random conditions create emergent relations that create self-organization and by interdependencies, system co-evolve. Self-organization shows a “*complementary to natural selection*” to systems in order to evaluate (Arevalo and Espinosa, 2015: 22). Because the impact of “*isomorphism*” creates unique understanding between agents of the system which lead to “*imitation*” of other agents in CAS that increase the natural adaptation of the system (Dooley, 1997: 73). The co-evaluation of the system proves not only environment has a power on shaping of organizations but also organizational interactions of agents in CAS could shape the environment. Those interdependencies and interactions create co-

evaluation of the system that clarifies “*adaptation and environmental selection are not wholly opposed forces; rather, they are fundamentally interrelated*” (Li et al., 2010: 312). CAS helps us to understand that agents of the system, which we could call Organizations from managerial point of view, are co-creators of their environments (Cunha et al., 2000: 4).

1.1.6. Change Management

Global world already begun to change the way of doing business (Akpınar & Ozer-Caylan, 2021) due to wild competition, shorten life-cycles of products, changing customer preferences, new technologies and so on (Govindan et al., 2017: 109) which leads to change that affects biodiversity, ecosystems and organizational lives (Polasky et al., 2011: 398). Although there are many models, approaches and schools to categorise organizational change the common understanding stands between two lenses as planned change and emergent change. Between 1950s and 1980s planned approach leads the dominant point of view where from 1980s emergent approach begun to reign. Problems that arose during 1970s and the beginning of 1980s show world that there need to be new lenses as CAS, in order to understand organizational change management (Burnes, 2005: 74).

CAS mentions co-evolution of system and agents together where evolution means change whether it is planned or emergent; continues or sudden. Continues and planned change follows adaptation process where sudden and emergent change require complex adaptation process as which means there were no such pre-introduction chance to this new circumstances such as unpredictable human-made developments (Dervitsiotis, 2004: 812) where system requires urgent harmony (Arevalo and Espinosa, 2015: 23). With the requirements and problems of new world CAS approach serves new perspectives on change such as edge of chaos view and a dissipative structures view (MacLean and MacIntosh, 2011: 237) and punctuated equilibrium model and continuous transformation model (Burnes, 2005: 76). CAS approach helps to identify two kinds of change, one of which aims to understand the survival of agents as they affected from

environmental changes and the other one is to identify organizations as networks which interacts with other networks that creates co-evolution of environment (Arevalo and Espinosa, 2015: 23).

1.1.7. Organizational Cybernetics

During World War II, the cybernetic movement began by the Norbert Weiner who inspired from the Greek word “*kybernetes*” means as the steersman in order to define this new science. Cybernetic means “*control and communication in animal and machine*” (Merali and Allen, 2011: 32). Cybernetic systems could fix themselves via self-maintenance and prone to respond to environmental change with adaptation (Boisot and McKelvey, 2011: 280). An important contribution to cybernetics to organizational studies and CAS approach is the conceptualisation of feedback loops. Managers give attention to the non-linear dynamics of systems that are believed as stable. Feedback loops enables maintenance of systems that creates self-regulation. Two most important studies that affect management field are Stafford Beer’s “*Viable Systems Model*” and Jay Forrester’s “*System Dynamics*” (Merali and Allen, 2011: 32). Viable system model (VSM) helps to identify “*human social organization*” which survives while adapting to environmental changes through the application of cybernetics principles (Arevalo and Espinosa, 2015: 26). System dynamics helps to model the systems to see the interconnections.

1.1.8. Dissipative Systems

Work of Prigogine and Stenger's on dissipative systems (1984) affects many researches in order to understand how “*far-from-equilibrium systems*” could be used to understand organizational change (Dooley, 1997: 78). Dissipative structures are under the semi-stable conditions which are fed with energy from outside the system. After several states of instability they reach bifurcation point where system passes to new state to self-organize which could not be predicted from the historical data of the system

(Burnes, 2005: 77). The systems that are far from equilibrium form new order where at the same time produce entropy (Arevalo and Espinosa, 2015: 25).

In CAS, systems that are on the “*edge of chaos*” are adopting, self-organizing in an ever-changing environment which go under dissipative transformations from one state to other (MacLean and MacIntosh, 2011: 236).

1.1.9. Autopoiesis

Autopoiesis means self-production which coined by the work of Maturana and Varela (1973). Although natural sciences discover dissipative systems as a conceptual framework to identify dynamics of self-organization and transformation, autopoiesis enables novel perspective on life, organizational wholeness and sustainability. Maturana and Varela used cybernetics and cellular automata (CA) to explain the model of self-production. The theory tries to understand the dynamics of non-linear systems that are capable to maintain stability for long periods (Merali and Allen, 2011: 43). In CAS, Autopoiesis lens helps to understand that systems are capable of “*self-producing*” which enables equilibrium of the balance (De Zilwa, 2009: 129).

1.1.10. Ecosystem Approach

Ecosystem concept is one of the most useful concepts used in business network studies and in B2B field works which provide a theoretical lens between two points of view which are also the main concepts in CAS lens too: co-evolutionary logic and boundaries & composition. Co-evolutionary logic enables to define the interactions between the actors where boundaries and composition defines contextual depth between actors, institutions and technologies (Aarikka-Stenroosa and Ritala, 2017: 25). An organization could be a member of an industry where that industry is a part of a business ecosystem. In that business ecosystem, actors of the system co-evolve together through cooperation and competition to serve new products and services upon desires of customers (Moore, 1993: 76). Ecosystems could be characterised as CAS where their patterns arise due to local interactions of actors with the feedback mechanisms that

shape emergent conditions. Those complex (Allen and Holling, 2010: 2) non-linear behaviours compose of local interdependency that is sensitive to initial conditions and could not be predictable with past records of the system (Olsson et al., 2004: 76). All business ecosystems pass through four phases as “*birth, expansion, leadership, and self-renewal or death*” (Moore, 1993: 76).

1.2. COMPLEX ADAPTIVE SYSTEMS (CAS)

Natural systems and artificial/man-made systems could be described as complex manner that consists of “*non-linear spatio-temporal interactions*” between vast numbers of components/stakeholders/subsystems/actors that could be called as agents which have potential to change over time (Holland, 2006: 2). Social-ecological systems such as insect colonies, traffic, weather, bee hives, ecologies, cultures, nervous system, the stock market or business organizations could be given as an example to those kinds of systems (Dooley, 1996: 2; Dooley, 1997: 77; Surana et al., 2005: 4237; Chaffee and McNeill, 2007: 232).

Especially works at Santa Fe Institute improves the studies of CAS approach (Chan, 2001: 1). Chaos theory, complexity theory, systems thinking are used by CAS approach (Palmberg, 2009: 485) where mathematic, psychology, political sciences, sociology, economics, organization studies and so on, use CAS approach in their fields (Pathak et al., 2007: 551) from developments of global markets to household behaviours; from social and technological changes to catastrophic events (Carmichael and Hadzikadic, 2019: 3). With the advancements in technology and fast evolvement of internet accent the importance of CAS nature in Social-ecological systems such as societies and organizations that show intense complexity of information and uncertainty (Merali and Allen, 2011: 40). Social-ecological systems exhibit CAS properties because of non-linear dynamics, initial dependency, limited predictability etc. (Polasky et al., 2011: 400).

A great variety of agent behaves according to local interaction under their principles and adjusts their behaviours according to those interactions if it is necessary.

Those agents have their local memories which are able to learn (Dooley, 1997: 77) from their faults and formulate new solutions according to new problems which prove that the agents have autonomous responses (Richardson, 2011: 369). According to CAS, the system is not controlled by any authority or leader but the agents have autonomous responses that shape the system. Flocking behaviours of birds, ant or termites colonies, fishes, crowds of people (Carmichael and Hadzikadic, 2019: 4) and even organizations shows interaction of agents by following simple rules emerge collective response and evolution that is not controlled by any authority (Janssen and Kuk, 2006: 2).

As a distinguishing word “complicated” could not explain the meaning of complexity in CAS (Chaffee and McNeill, 2007: 232). Complex Adaptive Systems are different from complicated systems. Some non-living systems may carry some features of CAS but should not be defined as CAS such as “non-living complex systems” that shows self-organization feature like weather system, hurricanes, volcanoes or ocean currents where each of them respond to their environments according to changes. What makes them different than “*living-self-organizing systems*” is; they do not carry adaptability and learning capabilities (McMillan, 2008: 67) and do not act according to self-interest and do not co-evolve according to circumstances.

As a metaphor, CAS could be used to describe systems such as organizations that exist in a complex ecosystem where agents are independent as an own establishment, culture, learning capacity and history but through interdependency and interaction with other agents and environment, they emerge a system in that ecosystem (Rowe and Hogarth, 2005: 398) which CAS could be comprehensible in the contextual environment (Palmberg, 2009: 485). As a framework for studying and understanding emergent and global properties of systems (Carmichael and Hadzikadic, 2019: 1) CAS explains systems nested within other broader systems, evolving and interacting with each other (Chaffee and McNeill, 2007: 234). That perspective enlightens many problems and relations from changes in local markets to global trade fluctuations (Holland, 2006: 1) like competition and cooperation behaviours of organizations (Surana et al., 2005: 4238). According to Chan (2001) CAS enables some tools like Aggregation of Model, Test Problem Generation and Agent-based Simulation in order to help to analyse the real

world circumstances. CAS associated with second order thinking where iterative interactions exists between control loops and feedback that leads the achievement of purpose by the use of returned information (Ellis and Herbert, 2011: 34).

1.2.1. Agents as Decision Makers

CAS is comprises of agents. As information operator, agents have the ability to re-arrange themselves according to information they receive from interactions between other agents and the environment. Agents are different from each other which create diversity in the system and no single agent could coordinate and lead the system (McDaniel, 2007: 23). As the smallest part of the system, agents refer elements like organizations in an economy, nerve cells in a brain, birds in an ecosystem or individuals or households in a city which depends on the contextual environment (Chan, 2001: 5) according to studied subject. Being an agent indicates conscious behavioural selection and learning according to local interactions and information received from environment (Choi et al., 2001: 353). Agents are the “*decision makers*” in CAS. They decide to behave according to simple rules of the system, interact within system which enables learning and adaptation (Vassilios and Dimitrios, 2011: 152). Ecosystem evolution occurs with the emerge situation of local interactions of agents which makes system complex. Complexity occurs because agents have many alternative choices as a result of interaction where each way has its own consequences (Justice et al., 2016: 185).

1.2.2. Schemas: The Structures of the Systems

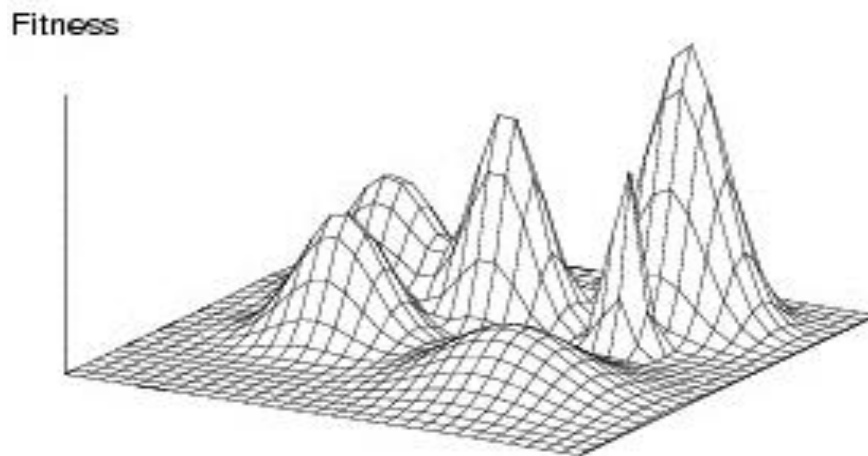
Agents behaviours are arise from the schemas of the contextual environment. Schemas are the structures of the systems which designates the expected action of the agent (Anderson, 1999: 219). Schema explains how an interaction of an agent with the environment and other agents occur according to simple rules. With the help of schemas leaders and managers could create simple patters and common points for the agents to follow like mission, strategy, common language and culture. With these simple tools agents could create their own ways according to interactions. In the long run, schemas

could be changed and revised according the requirements of new situations (Dooley, 1997: 86). The effects of schemas on CAS pursue “*Pareto Principle*” where small number of rules dominates the wide scope of actions. Thus ruling CAS via “few simple rules” arise with the help of schemas even the non-linear interaction of system can change the steering (Choi et al., 2001: 353).

1.2.3. Fitness Landscapes

Fitness is the harmony where internal fit and external fit matches. Every organization in business environment needs fitness for survival. Fitness needs organizational process that involves appropriate strategy, proper organizational structure plus organizational culture and so on. Fitness usually quantify by customer satisfaction, profit or loss of organizations. If the organizations meet and supply the customer demand its fitness will increase on the contrary the fitness of the organization will decrease (Li et al., 2010: 312). Although its definition and use is unclear; fitness landscape received its roots from complex systems and evolutionary properties in biological systems (McCarthy, 2004: 129). The Illustration of Fitness Landscape could be seen at Figure 3:

Figure 4: Illustration of Fitness Landscape



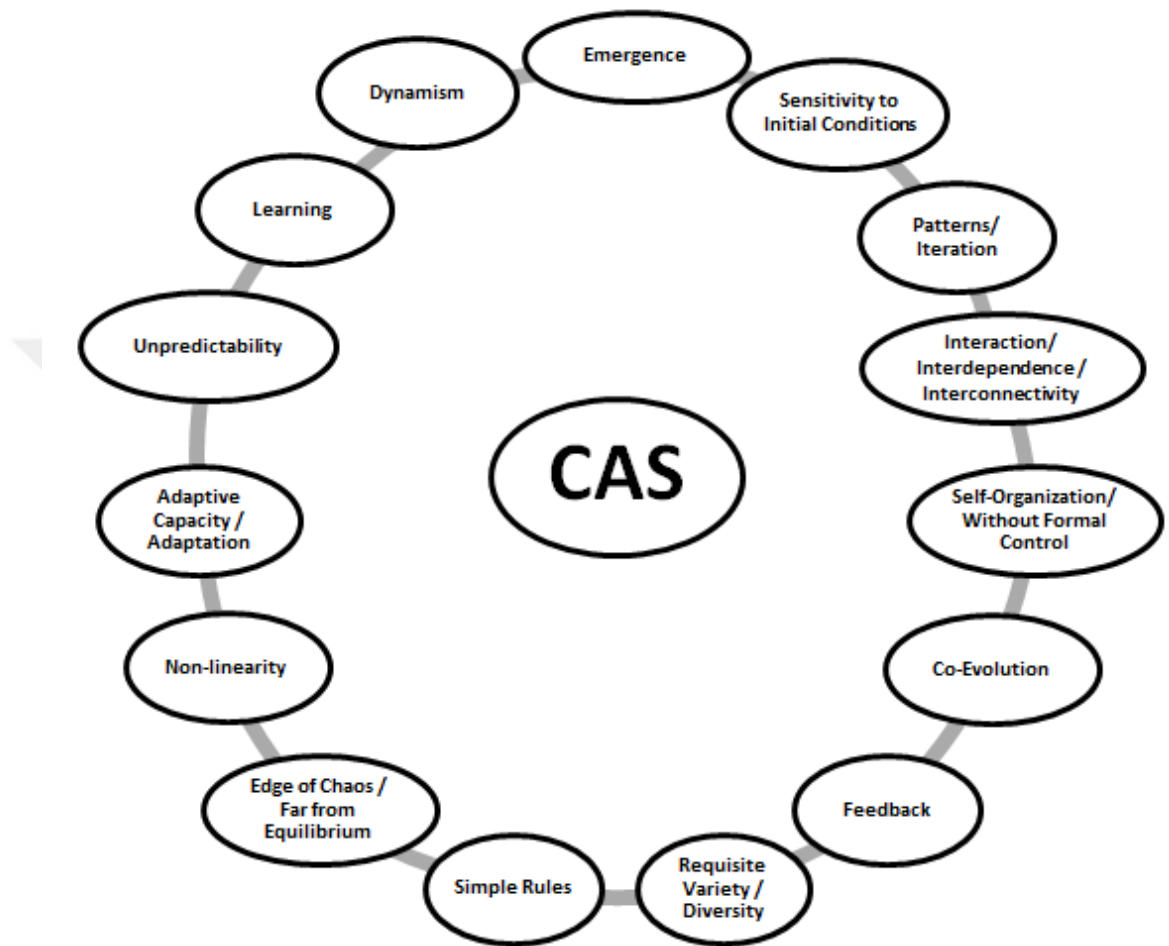
Source: McCarthy (2004: 128).

From the lenses of classical theory of evolution, inhabitants adapt their environment under the force of selection. At the singular level “*biological fitness*” ascertained by “*genetic make-up*” of individuals who has the ability to survive by reproducing. Complex systems literature completed this top down lenses with the Cellular Automata (CA) to explain mechanisms of “*micro level diversity*” and to understand fitness landscapes. The most popular fitness landscape model was developed by Kauffman called as “*NKC Model*” which defines genotypes by a network of N genes with K interdependencies affected by C external interdependencies (Merali and Allen, 2011: 45). In 1992 Kauffman and Johnsen developed new version of that model as “*NKCS Model*” in order to show natural coevolution between interacting species. The NKCS model allows for coupled landscapes through C and multiple species S . (Vidgen and Bull, 2011: 202). From strategic management lenses; fitness related with the balance between external expectations of environment regarding costs, delivery or innovation with internal resources and capabilities of organizations (McCarthy, 2004: 130).

1.2.4. Features of Complex Adaptive Systems

CAS consists of many agents guided by schemas in order to reach fitness to survive. Although different perspectives and definitions exist to define CAS; some common characteristics/features use by literature to explain the whole system. For example Carmichael and Hadzikadic (2019) use concepts of “complexity, agents, adaptation, feedbacks, emergence, non-linear dynamic behaviour, self-organization and historical context”. Ellis and Herbert (2011) use “system adaptation, self-organizing networks, schemata, coevolution and multiple agents” as characteristics of CAS. According to Janssen and Kuk (2006) CAS has use “requisite variety, simple rules, self-organizing, sub optimal, edge of chaos, nested systems, connectivity, iteration, coevolution and emergence”. McDaniel et al. (2009) use “emergence, coevolution, self-organization, nonlinear interdependencies and diverse agents that learn” as key characteristics. With the help of Appendix 1, some common features of CAS could be illustrated at Figure 1 as below.

Figure 5: Features of Complex Adaptive Systems



Source: Derived from Appendix 1

As a whole; the future of CAS could not be predictable. Because of the dynamic and non-linear interrelations, change leads to “*unidirectional evolution*”. The diversity creates innovation. In a chaotic system tiny changes give rise to different solutions which makes prediction impossible (Dooley, 1997: 84). CAS operating chaotically where prediction give place to anticipation. Agents of CAS operate in chaotic environment; interact with other agents under the simple rules direction that induce learning and adaptation which brings self-organizing. With the emergent solutions and circumstances, CAS co-evolves at the edge of chaos. Without any formal control under

the dynamic and unpredictable occasion, agents follow some patterns, interrelated with each other (Pathak et al., 2007: 550-551).

1. Adaptive Capacity / Adaptation

In dynamical volatile environments; organizations, as agents of the ecosystem, could find new ways to keep pace with the changes. Adaptive capacity does not mean focusing environment passively. Instead of this organizations constantly following new developments and try to increase their knowledge in their operating environment which gain them to reconfigure swiftly in their changing environment. In highly turbulent environments this capacity assists better readiness for organizations (Bhamra et al., 2011: 5387). Adaptation infers the routes of living systems that responses environmental change through enabling internal fitness (Eoyang, 2011: 324). A system should be considered adaptive if successfully transform actions as a consequence of a requirement (Moreira, 2013: 5). In literature there are two types of adaptive capacity. As a “*first-order adaptive capacity*” organizations respond to environmental changes with a “*bounce back*” reply. As a “*second-order adaptive capacity*” organizations respond to environmental changes with new capabilities and solutions with new positions and designs (Lee et al., 2013: 30).

2. Learning

Learning comes with a new capacity in CAS where agents “*learn for change*”. organizational learning occurs by the experiences of individual agents of the system under the help of organizational culture (Vidal et al., 2014: 1250) where mistakes opens opportunity for improvement and learning for organizations (Woods, 2003: 1).

In CAS, interrelations of agents under simple rules constitute new ways to learn, evolve and adapt. Learning could be the one of the fast ways to keep pace with the new developments (Carmichael and Hadzikadic, 2019: 10).

3. Emergence

Emergent behaviour in CAS is a qualification of the system. Under micro-level interrelations the emergent behaviour of the whole system co-occurs. Agents which are interdependent each other, interact with simple rules and produce emergent, complex and unpredictable behaviour. Those micro interrelations constitute system level macro behaviours of CAS (Carmichael and Hadzikadic, 2019: 2). Many systems like ecologies, societies, immune system or many artificial systems like artificial neural networks or transportation webs could show emergent properties in a system level base where local interactions shape the whole, under non-linear spatio-temporal interactions (Chan, 2001: 1). Emergence explains the process of CAS (Cunha et al., 2000: 4) where new properties that are not exist before, arise (Arevalo and Espinosa, 2015: 22) during self-organization of the system (McDaniel, 2007: 24). The interacting of agents in non-linear dynamic way creates emergent behaviour of the system which creates observable patterns (Morel and Ramanujam, 1999: 279).

4. Co-evolution

The CAS shows a system that emerges over time which adapts and learns without formal control (Choi et al., 2001: 352). Under those dynamic conditions agents co-evolve together with the environment. System tightly related with all other subsystems which make an ecosystem where the process of whole system called “*co-evolution*” (Chan, 2001: 2). The system is non-linear which evolves and self-organizes through local interdependencies (Surana et al., 2005: 4236) where co-evolution is a response to environmental changes (Li et al., 2010: 310). Interdependencies of agents recreate their relations and environment under co-evolutionary way. CAS approach presumes that systems “*reacts and creates*” its environment (Choi et al., 2001: 356).

Co-evolution proves non-linear dynamics of the system that interact one another and with their environment (Aarikka-Stenroosa and Ritala, 2017: 25) where evolution shows the process of change (Arevalo and Espinosa, 2015: 23). Intelligent systems

evolve via interaction process and adapt; but unintelligent systems evolve but don not adapt where complicated systems interact but do not evolve or adapt (Moreira, 2013: 5).

5. Requisite Variety / Diversity

CAS agents are different and too many in a whole nested system which create diversity. Diversity is essential for self-organising ability to re-organize the system (Folke, 2006: 257). Agents are all different not according to their specifications but regarding their “*attribute values*”. That diversity is the source of emergent behaviour and co-evolution in CAS (Carmichael and Hadzikadic, 2019: 8).

According to Ashby’s “*law of requisite variety*” the survival and adaptation of an organization occurs if the systems internal variety matches with the systems environmental variety (Marchand and Hykes, 2007:159; Dervitsiotis, 2004: 815). Systems survival also depends on system-wide heterogeneity as the outcome of diversity (Levin, 1998: 435).

6. Interdependence /Interconnectivity /Interaction

In order to understand the running of a CAS, relationships are important. Agents are interdependent each other and their interconnectivity constitute the web of relations. The diverse agents are independent but interconnected with other agents and the environment. The reactions of the agents shape the other responds in the CAS by the interactions under the simple rules. Agents have particular roles to play in the system that change according to environmental changes. Interactions creates learning and adaptation which followed by co-evolution. That nested system, evolve with its environment and with other larger systems (Chaffee and McNeill, 2007: 233).

Complexity occurs due to inter-action, inter-connectivity and inter-dependency of agents and environment which proves that any decision or activity in any part of the system will have direct or indirect effect on other related parts of the system (Chan, 2001:4). CAS consists of diverse agents that interacts each other. Those interactions and

interdependencies related with feedback tune of the system where non-linear dynamics shape the relations (Morel and Ramanujam, 1999: 279).

7. Self-organizing / Without Formal Control

In CAS, self-organization refers agents individually arranging their situations according to feedbacks they get from environmental changes and through the interactions with other agents. The agent pursues its own “*local rules*” while getting different signals from their relations and new developments. Self-organization emerges in those interactions which also increase complexity in the system (Carmichael and Hadzikadic, 2019: 13).

CAS is an open system which imports energy/essential resources from environment. According to second law of thermodynamics, system has potential to increase its entropy that causes chaotic disorder where Self-organization in CAS occurs at this point. With increased chaos, system reaches threshold points and self-organization occurs. As a dissipative structure, agents of the system could survive if the members of the system contribute energy (Anderson, 1999: 222). Self-organization also explains collective intelligence of systems and social groups such as termites, bees, and ants where they show collective behaviour without formal control (Arevalo and Espinosa, 2015: 25).

By self-organizing, systems operate under autonomous behaviour (Arevalo and Espinosa, 2015: 21) which means without formal central authority. There is no single agent who controls the behaviours’ and evolution of other agents and the environment. By following local, simple rules the patterns of working conditions occurs. The CAS adapts, learns and creates patterns of action (Chaffee and McNeill, 2007: 233).

8. Edge of Chaos / Far from Equilibrium

The agents of CAS situated between order and disorder (Arevalo and Espinosa, 2015: 21) which is called edge of chaos. This situation is *far from equilibrium* where the

innovation, learning and adaptation increase for organizational survival. Competitive environments create buffering and preserving synthesis when system responds changing circumstances (Cunha and Cunha, 2006: 843). CAS usually stays at the edge of chaos conditions where creativity and innovation of the system is at top level as the point of change which is very sensitive on initial condition as any small affect create much bigger results (Mason, 2007: 13).

This situation is the “*quasi-equilibrium*” balance where chaos and non-chaos and regularity and randomness exist at the same time. This state consists of emergent conditions through self-organization behaviour (Surana et al., 2005: 4237). At the edge of chaos, CAS is constantly transforming itself according to feedback loops and non-linear interdependencies where classical “*cause and effect*” law don not valid (Burnes, 2005: 76).

9. Sensitivity to Initial Conditions

In a CAS one solution does not give rise to a “*single expected result*” as an opposite to mechanical paradigm. Small change could cause a large effect than to be expected called as the “*butterfly effect*” in literature, explains sensitivity to initial conditions which means any change could cause any unexpected results. The consequences are also unpredictable because of non-linear interactions of the agents (Chaffee and McNeill, 2007: 233). The butterfly effect proves that small things make sense in the system (McMillan, 2008: 67).

In a simple system, any small change could result with a small result. But in CAS due to non-linear relationship any small change could result with unpredictable circumstances where initial conditions play significant role (Mason, 2007: 13). In CAS, history matters where initial conditions draw the way of patterns although future of system could not predicted from its past. CAS agents act according to local rules and through their own benefits, history of the agent determines the system-wide evolution. Possible outcomes of the future shaped from the very beginning of the system, by systems initial conditions (Choi et al., 2001: 359).

10. Non-linearity

Interactions between agents are mostly non-linear where small inputs could result large outcomes and large inputs could bring out small outcomes (McDaniel et al., 2009: 193). CAS rejects linear relationship of “*Cartesian paradigm*” which explains “*whole is the equal to the sum of the parts*”. Non-linearity clarifies any problem could have more than “*one possible solution*”. Self-organization occurs due to non-linear interactions between agents in dynamic environment in non-deterministic way which increases complexity of the whole system (Arevalo and Espinosa, 2015: 23).

In CAS, any small change could significantly change the whole system where interactions shaped by feedbacks (Anderson, 1999: 217). The behaviour of CAS originates from dynamic interactions of agents in non-linear ways (Choi et al., 2001: 356) which means the whole success of the systems goes beyond the sum of systems parts (Moreira, 2013: 5).

11. Dynamism

The agents in CAS interact with other agents and the environment which creates dynamic realities. With the help of feedback loops, environment forces the agents in the CAS to change which in turn cause changes in the environment (Choi et al., 2001: 356). That creates cyclical dynamic environment to agents. CAS consists of competing and collaborating agents that interact in non-linear ways which emerge self-organization in a dynamic environment. Those interactions shape the dynamic behaviour of CAS (Boustani et al., 2010: 142). The future of the whole system emerge dynamically in non-linear way as a collective action of all agents (Tukamuhabwa et al., 2015: 5614)

12. Unpredictability

A CAS is an emergent system (McDaniel, 2007: 24) and the future circumstances of the system are unpredictable (Dooley, 1997: 83). Because system self-organize

according to simple rules in an interrelated network spontaneously that create unpredictability of future situations (Mason, 2007: 12). But some order exists within unpredictability and could be realised with the help of patterns which created by simple rules (Burnes, 2005: 76).

Any changes in the system can cause any unexpected results and because of the non-linear interrelationships of agents between each other show that there is no one way to reach a solution in CAS. The situations change according to initial conditions and the collective behaviour of the agents. However there is also an order in this disorder which could show a way to study complex behaviour of non-linear systems (Palmberg, 2009: 485).

13. Feedback

Feedback system is the backbone of the agent, gives signal that enables survival of the organization. Whether positive feedback or negative feedback, the agent understands the process of its operation and take necessary precautions (McDaniel, 2007: 24)

Feedback is the outcome of the system at “ t ” time which affects the input of the system at “ $t+1$ ” time. As a result of non-linear interactions with other agents, the system gets the feedback belongs the environment and the agents of the CAS which effects the future decisions and interactions (Carmichael and Hadzikadic, 2019: 10).

14. Simple Rules

CAS is a complex system with an emerging patterns which covered by simple rules (Janssen and Kuk, 2006: 3). Simple rules determine boundaries of the system behaviours (Cunha and Cunha, 2006: 846) like flocking birds flying behaviours which appear as a self-organized, emergent action (Chan, 2001: 6; Palmberg, 2009: 486).

In CAS, the agents follow simple rules under local knowledge as a part of a large system (Carmichael and Hadzikadic, 2019: 8). Those simple rules could prove that all agents act according to their own decisions without formal, centralized decision maker

(Chan, 2001: 3). Simple rules shape the borders of the agent behaviours and create “*collective behaviour*” of the CAS through the interactions of the agents (Surana et al., 2005: 4237).

15. Patterns / Iteration

Agents of the CAS follow simple rules for their operations. Those rules create basic patterns that could be followed. Through the non-linear interactions same rules create same patterns which then become a collective behaviour of the system (Carmichael and Hadzikadic, 2019: 1).

Patterns of the CAS emerge from dynamic, non-linear interrelation of agents (Dooley, 1997: 76; Chaffee and McNeill, 2007: 232) which create “*irregular but similar*” movements (Burnes, 2005: 79). System-wide patterns arise as an outcome of collective relations (Tukamuhabwa et al., 2015: 5616). As a system, CAS re-organizes itself according to feedbacks and inter-relations where new patterns and possibilities emerge (Mason, 2007: 12).

CHAPTER TWO

ORGANIZATIONAL RESILIENCE MANAGEMENT PHILOSOPHY

2.1. DEFINITION AND CONCEPT OF RESILIENCE

Nowadays Organizations faced different and difficult problems and/or disruptions from inside or outside of the company (Annarelli and Nonino, 2016: 2) which could be categorized as a man-made or natural disasters (Park et al., 2011: 396) such as terrorist attacks, cyber-attacks, equipment failure, hurricanes, economic recession, industrial strikes, earthquakes, tsunamis, civil wars, human errors, financial fraud and so on (McAslan, 2010: 1). The notion of global world lies in the flux of a changing business environment and markets along with increased business risks (Braes and Brooks, 2010: 15) and crisis that create turbulent and volatile environment (Hamel and Valikangas, 2003: 52) to organizations. Also global world offers globalised opportunities along with hyper-competitive (D'Aveni, 1994: xiii) environment, more dependent relations both socially and technologically (Annarelli and Nonino, 2016: 2) with increase managerial risks and organizational vulnerability (McAslan, 2010: 1) which cause organizational failures.

With all above mentioned disruptions, difficulties and risk of organizational failures of 21st century, management literature asks basic questions at Table 2, in order to understand the circumstances, one of which can be summarized the situation as: *“Why some organizations are successful to overcome those disruptions while others fail?”* Concept of resilience helps organizations to find the answer of below mentioned questions:

Table 2: Sample Questions from Management Literature

Vogus and Sutcliffe, 2007 (pp.3418)	<i>“Why are some organizations and institutions capable of maintaining function and structure in the face of environmental jolts and other large disruptions?”</i>
	<i>“Why do some organizations crumble in the face of high levels of on-going strain while others thrive and grow more resourceful and poised to tackle future challenges?”</i>
Burnard and Bhamra, 2011 (pp.5582)	<i>“How do some organizations overcome disruptive events and disasters while others fail?”</i>
	<i>“What enables these organizations to adapt and transcend these events? And what sets these organizations apart?”</i>
Annarelli and Nonino, 2016 (pp.2)	<i>“Why do some organizations successfully overcome these events, whereas others are not able to do so?”</i>
	<i>“What makes it possible for these organizations to withstand and adapt to challenges?”</i>

Source: Compiled by author

The origin of the resilience concept belongs the latin word “resiliens” (Vidal et al., 2014: 1246) or “resilire” (Omer et al., 2012: 686) which means “bounce back”, “get back to a natural state” or the “ability to rebound or jump-back” (Fani et al., 2015: 66). The notion of *Resilience* was first used by Holling in 1973 (Annarelli and Nonino, 2016: 3) in his salient study as “*Resilience and Stability of Ecological Systems*” (Bhamra et al., 2011: 5381). Since then, the concept using by different disciplines like engineering, psychology, supply chain management, disaster management, risk management with different meanings (Akgün and Keskin, 2014: 6919; Vidal et al., 2014: 1246). The definitions of the Resilience used in different disciplines could be seen at Table 3.

Resilience, as one of the systems’ property (Linkov et al., 2014: 407) which could absorb disruptions, re-adjust after a disturbance to continue performance and recover as soon as possible (Omer et al., 2012: 687). Another definition of the concept is; resilience as a capability which is the sum of organizations internal and external ability that could advance organizational performance (Yang and Hsu, 2018: 224).

According to Folke (2006) even literature focuses on the absorption of the shocks while maintaining the organizational performance there is another important property that resilience could enable organizational “*renewal and development*” while Brusset and Teller (2017) add “*rebuilding*” concept from the Sociological and Ecological perspective. From different lenses of disciplines, categorisation of the Resilience concept changes in which Wang et al. (2016) describe five resilience meaning as Human resilience, Ecological and Engineering Resilience, Information and Communication Resilience and Business Resilience. According to Brusset and Teller (2017) managers used different lenses while dealing with the concept such as operational, technological or from marketing views.

While providing wide range of point of view; those definitions create dismantlement and a lack of conceptual consensus (Sullivan-Taylor and Branicki, 2011: 5567) that cause a problem of understanding regarding resilience (Devanandham and Ramirez-Marquez, 2010: 291). Even there is a deprivation of consensus on the description of the Resilience concept, the literature classify the concept according to three main properties as (Ruiz-Martin et al., 2018: 15):

- 1) that organizations *have* as the *feature* of the organization
- 2) that organizations *doing* as the *output* of the process
- 3) that organizations *uses* as the *evaluation* of the performance

Lengnick-Hall & Beck (2005) define three part of resilience as cognitive, behavioural and contextual while Serrat (2013) refer active & passive resilience and operational & strategic resilience also Annarelli and Nonino (2016) classify static resilience and dynamic resilience.

There are also confusing concepts that are used interchangeable with the term resilience in the literature. Those concepts overlap with the term resilience and used alternatively in studies according author’s point of view and from the contextual evaluation. Although those concepts have something common while explaining the concept of resilience; they all have different and distinguishing properties such as

robustness, flexibility, adaptability (Mansouri et al., 2009: 1407), vulnerability, fragility (Nan and Sansavini, 2017: 37), agility, survivability (Hosseini et al., 2016: 47), redundancy, risk and responsiveness (Purvis et al., 2016: 579) and so on. None of them can define resilience itself solely but combination of them makes sense while defining the qualification of resilience (Lengnick-Hall et al., 2011: 244).

There are many examples that could be seen from the literature regarding using those confusing concepts such as Limnios et al. (2014) explain the use of engineering definition of robustness while defining organizational resilience. Lee et al. (2013) questioned whether concept of adaption could be reviewed as resilience or not. Gunasekaran et al. (2015) indicate risk is dissimilar than resilience. The main point in risk management is the ability to quantify all possible disruptions (Rajesh and Ravi, 2015: 126) but in resilience concept also unforeseeable events should be considered even it is difficult to quantify them.

2.1.1. Disruption and Vulnerability Concepts

Due to organizational environment which consists of complex business (Caralli et al., 2011: 2) and complex global supply chains (Barroso et al., 2015: 13) organizations face difficult risks to handle. The literature uses concepts such as vulnerability, disruptive event and risk (Carvalho et al, 2012c: 330) so often in order to define resilience of the organizations (Erol et al., 2010: 304).

Vulnerability is the sensibility of the organization (Sheffi, 2005: 32) which is the property of the system that may fail the process to handle the problem and survive afront a disruption (Berle et al., 2013: 254). According to literature decreasing vulnerability, (Erol et al., 2010: 304) rising the adaptively of the system would enable the resilience (Omer et al., 2012: 687).

Disruption could be explicable as foreseeable or unforeseeable event (Carvalho et al, 2012c: 330) which is a sudden fault of the system (Rajesh and Ravi, 2015: 126) as an undesirable change in the process and operation (Dessavre and Ramirez-Marquez, 2015: 145). In their studies, Sheffi and Rice (2005) figured resilience stages as disruption

stages. Disruptions could be categorised as a high impact/low probability (HILP) or low impact/high probability (LIHP) (Gurning and Cahoon, 2011: 252) events where impact shows the severity and probability of frequency. Casual disruptions could be seen as HILP (Mari et al., 2015: 103) which require readiness rather than planning. Beside LIHP disruptions require order and design (Sheffi, 2005: 33).

From the engineering lens resilience is the skill of the item to turn its normal phase after deterioration (Sheffi, 2005: 8). Resilience could be quantified by the degree of its vulnerability to a disruptive event (Erol et al., 2010: 304) which is the property of the system as a success factor (Rajesh, 2017: 161) to provide critical services to customers (Burnard and Bhamra, 2011: 5582). For organizations, it could be quantify their ability in which they return their routine performance degree whether it is a high impact/low probability (Sheffi, 2005: 8) or low impact/high probability disruption.

2.1.2. Definitions of Resilience in Different Disciplines

Resilience concept has been used by different disciplines from different points of view in a wide range (Ince et al., 2017: 230) focused on the relations between people and nature (Carpenter et al., 2001: 765) such as strategic (Hamel and Valikangas 2003; Teoh and Zadeh, 2013), ecology (Carpenter et al., 2001: 765; Folke et al., 2002), supply chain management (Sheffi and Rice, 2005), organizational (Lengnick-Hall et al., 2011: 243) and economics (Rose, 2004: 308; Briguglio et al, 2009: 232). Those discipliner points of view add variety (Bhamra et al., 2011: 5375) into Resilience concept along with lack of consensus on the description of the term (Elleuch et al., 2016: 1449). The definition of resilience concept according to different disciplines could be seen at Table 3.

Resilience concept comes from the Latin word “resilire” (Omer et al., 2012: 686) originated in the ecology discipline (Carpenter et al., 2001: 765) with the remarkable work of Holling (1973) (Burnard and Bhamra, 2011: 5583). Resilience is a the essential part (Patriarca et al., 2018: 265) and ability of an element or a system (Burnard and Bhamra, 2011: 5583) bounce back to adversity (Fani et al., 2015: 70) return to normality

after confronting threat (McAslan, 2010: 7) and even proceed more powerful (Vidal et al., 2014: 1246). Resilience symbolise degree of endurance (Sawalha, 2015: 348) to oppose systematic faults as a talent to adapt in complex environments (Soni et al., 2014: 11). From socio-ecological view resilience is relevant with a) size of the adversity that the system soaks up; b) the level that the system could self-organize; and 3) the level that the system could create adapt and learn capability (Folke et al., 2002: 438). According to Juarrero (2011) from ecological perspective; resilience concept defines the “ability to adapt and survive” on the other hand Woods (2003) describes the concept from engineering point of view that provides proactive engineering tools to manage problems.

Although resilience is a new field of research (Enjalbert et al., 2011: 335) common aspects of the definitions focuses on a capacity of the system, community or society (Cimellaro et al., 2010: 3639) which enables to confront environmental changes (Yang and Hsu, 2018: 223) in the face of disturbances. Resilience also specified as the junction of adaptation, flexibility and robustness (Soni et al., 2014: 11) which could not be solely provide just a single capability (Nan and Sansavini, 2017: 37). The concept helps to complete the deficiency of traditional risk management solutions that are insufficient to solve problems of global business world which enables adaptive management approach along with anticipation capabilities (Braes and Brooks, 2010: 17).

Table 3: Definitions of Resilience Concept According to Different Sciences

Author/s	Context	Definition
Holling (1973)	“Ecological systems”	<i>“The measure of the persistence of systems and of the ability to absorb change and disturbance and still maintain the same relationships between state variables”</i>
Tilman & Downing (1994)	“Ecological systems”	<i>“The speed at which a system returns to a single equilibrium point following a disruption”</i>
Gunderson (2000)	“Ecological systems”	<i>“The magnitude of disturbance that a system can absorb before its structure is redefined by changing the variables and processes that control behavior”</i>
Paton et al.(2000)	“Disaster management”	<i>“Resilience describes an active process of self-righting, learned resourcefulness and growth. The concept relates to the ability to function at a higher level psychologically given an individual’s capabilities and previous experience”</i>
Carpenter et al.(2001)	“Socio– ecological systems”	<i>“The magnitude of disturbance that a system can tolerate before it transitions into a different state that is controlled by a different set of processes”</i>
Walker et al. (2002)	“Socio– ecological systems”	<i>“The ability to maintain the functionality of a system when it is perturbed or the ability to maintain the elements required to renew or reorganize if a disturbance alters the structure of function of a system”</i>
Bruneau et al. (2003)	“Disaster management”	<i>“The ability of social units to mitigate hazards, contain the effects of disasters when they occur and carry out recovery activities that minimize social disruption and mitigate the effects of future earthquakes”</i>
Rose (2004)	“Economy”	<i>“Ability or capacity of a system to absorb or cushion against damage or loss”</i>
Walker et al. (2004)	“Ecological systems”	<i>“The capacity of a system to absorb a disturbance and reorganize while undergoing change while retaining the same function, structure, identity and feedback”</i>
Bodin & Wiman (2004)	“Physical systems”	<i>“The speed at which a system returns to equilibrium after displacement, irrespective of oscillations indicates the elasticity”</i>
Luthans et al. (2006)	“Psychology”	<i>“The developable capacity to rebound from adversity”</i>
Hollnagel et al. (2006)	“Engineering”	<i>“The ability to sense, recognise, adapt and absorb variations, changes, disturbances, disruptions and surprises”</i>
Briguglio et al. (2009)	“Economy”	<i>“The policy-induced ability of an economy to recover from or adjust to the negative impacts of adverse exogenous shocks and to benefit from positive shocks”</i>
Herrman et al. (2011)	“Psychology”	<i>“Resilience refers to positive adaptation, or the ability to maintain or regain mental health, despite experiencing adversity”</i>
Nan & Sansavini (2017)	“Engineering”	<i>“The ability of the system to withstand a change or a disruptive event by reducing the initial negative impacts (absorptive capability), by adapting itself to them (adaptive capability) and by recovering from them (restorative capability)”</i>
Parnaby & Broll (2020)	“Psychology”	<i>“Resilience, entail sbouncing back from adversity while maintaining a degree of normal physical andpsychological functioning”</i>

Source: Compiled by author

According to Akgün and Keskin (2014) many studies through literature handle the concept of resilience under “*passive*” meaning which indicates resilience as a process of recovery but also resilience thinking intrinsically comprise from the very beginning of disruptions. Even the literature itself indicates deprivation on the definition of resilience (Hosseini et al., 2016: 49) there are some common features which many studies use like ability to adapt, capability of the system where the studies also indicate two important results that the concept of resilience enables a) survival of the organizations and b) dealing with change and disruptions (Ruiz-Martin et al., 2018: 15).

2.2. ORGANIZATIONAL RESILIENCE MANAGEMENT PHILOSOPHY

Organizational resilience management philosophy ensures understanding of how individuals, organizations, industries and even countries capable of standing such a turbulent and volatile environments despite the unstable, complex and difficult events (Vogus and Sutcliffe, 2007: 3418). Resilience provides alternative choice and management strategy (Park et al., 2011: 397). The goal of the resilience perspective procures two outcomes as a) to enable recovery within an acceptable time b) to reduce the impact of the disorder (Azevedo et al., 2011: 8). This perspective enables new point of view to see the business relations and processes than deterministic views of organization theory (Vogus and Sutcliffe, 2007: 3418) which suggests adaptation, flexibility, robustness to respond to unforeseeable risks with the help of innovation (Park et al., 2011: 397) and renewal (Hamel and Valikangas, 2003: 53) to make progress.

Eventually resilience management philosophy insures simple useful perspective for managers (McManus et al., 2008: 86) who tight between empowered decentralized philosophy versus order and control approach (Clegg et al., 2002: 483). Becoming a resilient organization actualise as a process (Tukamuhabwa et al., 2015: 5615) which not only provides “*bouncing back*” to the same position but also to reach another favourable organizational state (Ruiz-Martin et al., 2018: 17).

According to Ruiz-Martin et al. (2018) organizational resilience arise from the combination of different fields such as crisis management, business continuity

management and risk management where also Ribeiro and Barbosa-Povoa (2018) mentioned the resilience concept as a product of business environment which should not be characterized as a separate concept from other fields and approaches. In their study Hosseini et al. (2016) analyse resilience concept according to fields of research in the literature which they found Psychology as the most common field followed by Environmental, Social and Ecology fields of studies.

The philosophy enables organizational sustainability via ensuring to absorb disturbance while at the same time carry out its fundamental functions (Justice et al. 2016: 185) which could be developed as an organizational capability (Carvalho et al., 2012a: 355). This study uses organizational resilience management philosophy as being a resilient organization with the strategic point of view which creates competitive advantage to organizations as seen from the following sections.

2.2.1. Organizational Resilience

In volatile, uncertain and turbulent environments and markets being flexible, agile or dynamic could not be enough to survive and prosper (Lengnick-Hall et al., 2011: 243). Organizational resilience is served as a new management concept that describes the ability of organizations to deal with the difficulties in the face of adversity (McAslan, 2010: 2). Despite resilience concept has been used different disciplines for a while (Limnios et al., 2014: 104) there is little consistency in using organizational Resilience concept (Braes and Brooks, 2010: 15). The literature could not ensure a list of features or characteristics in order to develop resilient organizations (Sawalha, 2015: 349). Organizational resilience depends on different kind of features which belongs to contextual harmony. The definitions of organizational resilience concept from different studies could be seen at Table 4 as below:

Table 4: Definitions of Organizational Resilience Concept

Author/s	Definition
Horne & Orr (1998)	<i>“Resilience is the fundamental quality to respond productively to significant change that disrupts the expected pattern of event without introducing an extended period of regressive behaviour”</i>
Hamel & Valikangas (2003)	<i>“Resilience refers to the capacity for continuous reconstruction”</i>
McDonald (2006)	<i>“Resilience conveys the properties of being able to adapt to the requirements of the environment and being able to manage the environments variability”</i>
Caralli et al. (2011)	<i>“The ability of the organization to achieve its mission even under degraded circumstances”</i>
Lengnick-Hall et al. (2011)	<i>“Firm's ability to effectively absorb, develop situation-specific responses to, and ultimately engage in transformative activities to capitalize on disruptive surprises that potentially threaten organization survival”</i>
Vidal et al. (2014)	<i>“The ability and capacity to withstand systemic discontinuities and adapt to new risk environments”</i>
Fani et al. (2015)	<i>“Organization that can actively adapt to future and before changes occur, react, called resilient”</i>
Patriarca et al. (2017)	<i>“Combination of four cornerstones: monitoring, responding, learning, and anticipating.”</i>
Al Balushi (2020)	<i>“Unlike traditional risk management approaches that were mostly reactive, organizational resilience is proactive. Strategic resilience and operational resilience are the two main elements of resilience, with first dealing with readiness for difficulty and the other with overcoming difficulty.”</i>

Source: Compiled by author

Literature uses different concepts to explain organizational resilience such as “*Business Resilience and Enterprise Resilience*”. IBM used business resilience concept and defines concept as “*the ability of enterprises to adapt to a continuously changing business environment*” (Carlson et al., 2012: 32). Kamalahmadi and Parast (2016, pp. 121) defines Firm/Enterprise Resilience as

“...the dynamic capability of an enterprise, which is highly dependent on its individuals, groups, and subsystems, to face immediate and unexpected

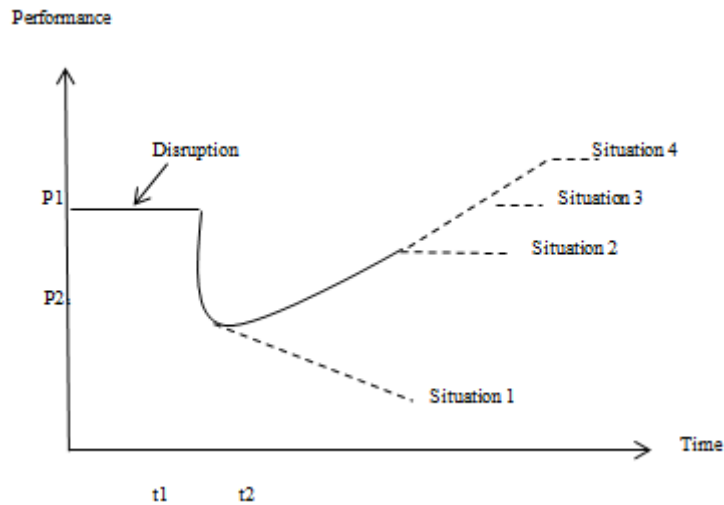
changes in the environment with proactive attitude and thought, and adapt and respond to these changes by developing flexible and innovative solutions...”

But in this study organizational resilience concept preferred to use to explain firm-level resilience (Hall et al., 2018: 81) as the most common and established usage in management literature. According to Lengnick-Hall et al. (2011) literature offers two perspectives for organizational resilience as “*organizational resilience as ability*” and “*organizational resilience as development of new capabilities*”. Ruiz-Martin et al. (2018) propose a four-level Maturity Model for Organizational Resilience (MMOR) that is a process showing four phases of maturity as fragile, robust, resilience and antifragile. According to Vidal et al. (2014) organizational resilience should be considered into two dimensions as “*strategic resilience*” and “*operational resilience*” where the combinations of these two dimensions constitute the organizational resilience.

In the past, organizations run risk management, business continuity, crisis management or emergence management solutions separately in order to solve disruptions of the operational, managerial or strategic problems (Braes and Brooks, 2010: 15). Organizational resilience is the combination of these fields under a holistic point of view plus offers a readiness for all kind opportunities in order to survive and thrive (Limnios et al., 2014: 104). When considering organizational dimension, resilience could include many characteristic while the concept itself and characteristics have remained unspecified and unclear (Burnard and Bhamra, 2011: 5583). Literature uses; sense-making, learning improvisation (McDaniel, 2007: 37) and adaptation (Morais-Storz and Nguyen, 2017: 94) mostly while defining characteristics of the resilience. The most common outcome of the organizational resilience concept is survival of the organization (Braes and Brooks, 2010: 16). Successful organizational resilience management comes from the ability of people and the organizations to show remarkable performance (McDaniel, 2007: 37). Adaptation includes reactive response sometimes which is not enough to success (Morais-Storz and Nguyen, 2017: 94). Organizational resilience process development should include prevention, preparedness, mitigation response and recovery (Braes and Brooks, 2010: 16).

In their study Nan and Sansavini (2017: 36) figure resilience concept by “*Illustration of Essential Resilience Capabilities*” while Sheffi (2005: 80) figures resilience concept as “*Disruption Profile*”. Also Ince et al. (2017: 236) figure resilience as “*Actions and Reflexes of the Resilient Organizations in the Event of Disruption*” and Barroso et al. (2015: 20) show resilience under the name of “*Resilience Triangle*”. Those figures could be seen at Appendix 2. By guidance of above mentioned precious studies of the literature, organizational resilience concept should be figured as below:

Figure 6: Situations of Organizational Resilience



Inspired by: Nan and Sansavini (2017: 36); Sheffi, (2005: 80); Ince et al. (2017: 236); Barroso et al. (2015: 20).

Disruption could be any event from managerial faults to operational failures that affects organization to lose its original performance level. Performance level could be any financial and non-financial measurement that organization confronts a problem. As seen from Figure 1, disruption occurs at (t1). Within time period (t2-t1) organization does necessary precautions or applies solutions such as adaptation to new technology, acquiring new equipment, signing new joint venture or designing new organizational structure in order to confront problems of disruptions. (t2) is the bifurcation point whether the precautions and solutions work or not for the organization. If they work;

organization runs into new positions (situation 2-3-4) but if the solutions are not enough to save organization or if the organization is in inertia the situation ends with the worst scenario as organizational death (situation 1).

After bifurcation point (t_2), if precautions are good enough to recover the problems, then organizational situation may run into other three situations which are Situation 2 as a lower performance level than pre-disruption situation but this is the position where organization grants its survival; Situation 3 where organization catches pre-disruption performance level and Situation 4 as a better position than the pre-disruption phase.

Although organizational resilience shows increased importance between managers, developing a resilient organization has no recipe. Organizations need to form necessary harmony to create organizational resilience in such a volatile and uncertain business environment (Braes and Brooks, 2010: 17). This is where strategic resilience concept arises as a key in organizational resilience management philosophy. Strategic resilience includes not a one-time response to any disruption but it's about being ready and having ability to change before it is necessary (Morais-Storz and Nguyen, 2017: 94). It's about catching opportunities in the middle of the storm as it is explained in the following section.

2.2.2. Strategic Organizational Resilience Management

There are many risks and perils that might affect organizational survival and success from natural calamities to man-made catastrophes (Vidal et al., 2014: 1246). Those disruptions always happen into three version as a) an expected event does not happen, b) an unexpected event does occur, and c) an event which does not known has occur (Weick and Sutcliffe, 2007: 29). In such a global world the disruptions always occur whether or not organizations ready. The critical question is how to become ready and build up such system that should work even in three version of disruption.

Resilience is a key answer to above question as a process which enables a capacity (Akgün and Keskin, 2014: 6919) as an continuing formation to learn, to adapt

and to change (Bristow and Healy, 2014: 95) which creates sustainable performance in the long run (Yılmaz Borekci, İşeri Say and Rofcanin, 2015: 65). This capacity reserves different and multiple solutions urge to organizations become resilient. This diversity creates alternative solutions to global problems of business environments (Lengnick-Hall et al., 2011: 251).

Stable systems do not have capability to “*learn and adapt*” from disruptions and failures (Coetzee et al., 2016: 200). Developing resilient organizations means creating dynamic systems that is not a “*one-time-respond*” but is a wide range period starts from the pre-event anticipating to post-event healing (Erol et al., 2010: 306). From strategic point of view resilience is an evolving organizational improvement that setting itself via anticipating to environmental changes and bounce back from disruptions and thrive (Vidal et al., 2014: 1245). It is proposing that developing resilient organizations enables maintaining roads for evolution in ever-changing business environment where the future is uncertain (Folke, 2006: 253). Strategic organizational resilience is about being aware (Valikangas and Romme, 2013: 48) of faults and errors before anything getting worse and damage the system (Weick and Sutcliffe, 2007: 68). Because of its evolving characteristic and as an on-going process strategic resilience is difficult to achieve and hard to define features to develop a resilient system (Tukamuhabwa et al., 2015: 5615).

Strategic organizational resilience is the talent to convert problems into opportunities (Vidal et al., 2014: 1246) where organization replenish itself before environmental enforcement (Valikangas and Merlyn, 2005: 55). This type of resilience is strategic because it enables organizations learn and adapt before the environment requires emerging transformation (Valikangas and Romme, 2013: 44). Strategic resilience discovers a way out before the disruption (Valikangas and Merlyn, 2005: 55) which permits organizations to utilise from uncertainties (Valikangas and Romme, 2013: 44).

2.3. ORGANIZATIONAL RESILIENCE AND COMPETITIVE ADVANTAGE

Technological transformations, demographic and social trends and different necessities of recent business conditions challenge the organizations existence and force them keep pace with modern requirements of global world to become competitive (Vidal et al., 2014: 1251). Doing their business better than rivals could enable competitive advantage (Hulsmann et al., 2008: 16) in which competition pressures organizations ready to change and become resilient (Vidal et al., 2014: 1251).

From organizational point of view resilience is an important ability to recover from disruptions (Lee et al., 2013: 29) which this recovery could enhance better market position (Tukamuhabwa et al., 2015: 5592) and could be considered as a source of competitive advantage (Chowdhury and Quaddus, 2017: 187). The literature agreed being a resilient organization could ensures sustainable competitive advantage (Sheffi, 2005: 25; Lee et al., 2013: 29; Barroso et al., 2015: 18; Purvis et al., 2016: 580). According to Goulielmos et al. (2007) competence could be measurable via the performance of recovery in the face of disruption where in competitive business environments fast responding organizations could gain increased market shares (Sheffi and Rice, 2005: 44) along with properly overcoming problems (Goulielmos et al., 2007: 51). Challenging business environment creates tough competition between organizations which creates conscious customers who desire more. Business environment consists of many rivals that are ready to take places of fallen ones (Sheffi, 2005: 25). Those competitive environments require resilient organizations that shaped by market stakeholders whom expected products and services be delivered despite a disruption (McAslan, 2010: 8). By shaping strategies and solutions from the resilience management philosophy (Ribeiro and Barbosa-Povoa, 2018: 120) organizations could create competitive advantage (Carvalho et al., 2012a: 356). Organizational resilience management philosophy should be used from daily problems to catastrophic events (Purvis et al., 2016: 580) to understand their business environment along with to adapt rapid changes in front of competitors (Lee et al., 2013: 29). Organizations should invest on their abilities to recover fast from any disruption (Sheffi, 2005: 25) and have to figure

out resilience strengths and weaknesses to apply effective resilience strategies (Lee et al., 2013: 29). With the help of proper resilience management philosophy organizations create their source of competitive advantage that represents capacity to align and enable required functions under tough contextual environment (Purvis et al., 2016: 580).

2.4. ENABLING ORGANIZATIONAL RESILIENCE THROUGH COMPLEX ADAPTIVE SYSTEMS APPROACH

CAS approach enables significant point of view to understand resilience of systems (Carmichael and Hadzikadic, 2019: 2). Through CAS lens, organizations could handle environmental change via positive and negative feedbacks (El-Ghalayini, 2017: 7) as self-organization appears as an outcome of change process (Arevalo and Espinosa, 2015: 27) where system protects itself through proper fitness (Boisot and Child, 1999: 237). Resilience of complex adaptive systems is not just to continue its functions and back to a stable state after a disturbance (Quendler, 2017: 536) but also re-organize while affected from changing environment (Folke, 2006: 259). When organizations function as CAS, variety improves fitness of the system that gives chance of survival (Boisot and Child, 1999: 238) renewal and adaptation (Bristow and Healy, 2014: 95). Complexity drivers of the markets also prove diversification matters to handle uncertainties (Hatun et al., 2010: 259).

CAS are more resilient than simple system due to self-organization that enables emergence (Morel and Ramanujam, 1999: 282) through dynamism which helps to understand how disorder makes system-wide transformation paths (El-Ghalayini, 2017: 8) where non-linearity proves any problem could have more than one solution (Arevalo and Espinosa, 2015: 23) and with the help of adaptation and learning, systems are capable of emergent behaviours (Child and Rodrigues, 2012: 14) that creates quick responses where contextual dependencies and relations are important (El-Ghalayini, 2017: 8). But in practice, there is lack of consensus on how to achieve resilient organizations (Teoh and Zadeh, 2013: 1). Resilience refers the capability of the system to serve in face of disruptions, before and after events (Quendler, 2017: 536) which

could be called as the “*property*” of the CAS. But achieving resilient management requires more investment on systems “*design*” that enables quick response time and lesser recovery cost (Mansouri et al., 2009: 1408). According to Christopher and Peck (2004) resilience should be designed through certain features included into systems. Resilience capacity could be developed (Lengnick-Hall et al., 2011: 253) through the understanding of complex inter-dependencies between agents of the system (Folke et al., 2002: 439). In order to manage uncertainty and unpredictability of future situations, organizations should be resilient (Vasconcelos and Ramirez, 2011: 238) if business dynamically designed (Juarrero, 2011: 163).

According to Saenz and Revilla (2014) systems could be resilient if the design of the system could be balanced between proactive and reactive capabilities. Also Rajesh and Ravi (2015) agreed that designing system could make it more resilient. Organizational design makes sense in confronting adversity which helps to catch competitive advantage (Jones, 2013: 11). Literature groups functions of developing organizational resilience under different headings. According to Erol et al. (2010) functions consists of “*prevent, protect, respond, and recover*”. Ponomarov and Holcomb (2009) and Bhamra et al. (2011) categorise the functions under three headings as “*readiness and preparedness; response and adaption; recovery and adjustment*” which means system should be ready to prevent while at the same time adapt to response and at the end of adversity, protect and re-organize to re-calibrate the fitness. Those main headings are just the categorisation of the system where solutions and applications are context dependent as literature still lacks on consensus according to how to “*measure*” and “*assess*” organizational resilience.

Although application of developing resilient organizations change according to industrial and organizational dependencies; getting into system wide configuration could offer new road map. As the main proposal of this study; building a system from CAS lens develops and improves organizational resilience. CAS approach provides a holistic theoretical lens that could be used to achieve and model organizational resilience which helps to understand why some organizations better than others to cope with problems.

CHAPTER THREE

MARITIME BUSINESS AS COMPLEX ADAPTIVE SYSTEMS

3.1. MARITIME BUSINESS IN GLOBAL SUPPLY CHAIN

Throughout history supply chains exist to serve wide variety of requirements of societies and people that leads commercial and trading activities (MacCarthy et al., 2016: 1697). Supply chain is a system where members provide products and services in return for a payment (Flynn et al., 2016: 5). Sides of supply chain system transfers costs, information and products between manufacturers, suppliers, distributors, retailers and final customer. A supply chain usually consists of two significant processes as material management which consist inbound logistics activities and physical distribution which consist of all outbound logistics activities (Surana et al., 2005: 4239). Also literature calls supply chains as supply networks which forms from set of supply chains, contains suppliers' suppliers (Marchi et al., 2014: 443) along with many interactions among resources, processes or players (Surana et al., 2005: 4235). Supply chains are significant for global economy and commercial life of organizations (MacCarthy et al., 2016: 1696). Especially competitive services/products not only compete on quality and cost base but also on availability which makes supply chain coordination, collaboration and harmony as a matter of organizational survival (Alfaro-Saiz et al., 2020: 490).

Maritime business is the main international logistical arm of supply chains (Thanopoulou and Strandenes, 2017: 325) which enables maritime transportation leg of distribution operations. As a vital player of worldwide multimodal transport which could be seen at Table 5, maritime business connects other transport modes like railway and airborne (Praetorius and Kataria, 2016: 121) and serves as an important player in the supply chains. Maritime business assists global supply chain via transporting approximately four fifths of world merchandise trade by sea (UNCTAD, 2019: 4). Praetorius and Kataria, (2016) considers maritime transportation as an important element of Service Supply Chain Management (SSCM) in their salient

study. The importance of maritime transportation mode at total world trade and global supply chain operations could be seen from Table 5.

Table 5: World Total Trade versus World Seaborne Trade

Years	World Total Trade (all modes) Billion Tonnes	World Seaborne Trade Billion Tonnes
2008	10,86	8,61
2009	9,56	8,29
2010	10,82	9,13
2011	11,56	9,51
2012	11,83	9,93
2013	12,19	10,26
2014	12,57	10,61
2015	12,85	10,82
2016	13,13	11,14
2017	13,75	11,6
2018	14,28	11,9
2019*	14,84	12,26

**Estimated*

Source: Turkish Chamber of Shipping (2019: 33).

Shipping determined by trade (Stopford, 2009: xv) and takes part in a wider international logistics industry which is an integral element of, global supply chains (Cullinane, 2010: 1). Supply Chains are also evolving and changing due to macro and micro environmental factors like technological developments, economic reasons, political and regulative perspectives (MacCarthy et al., 2016: 1696) modification of distribution channels, various customer preferences, shorter life cycle of products/services, changing operational and manufacturing processes that require rapid adaptation (Alfaro-Saiz et al., 2020: 490) and so on, that makes business environments dynamic and complex. Supply chains are not just consists of “*one-on-one business relationships*” but due to rapid global changes and above mentioned

factors, also enclose multiple business networks and relationships (Surana et al., 2005: 4239).

Literature indicates that while managing supply chains, traditional approaches are not enough to handle new requirements of processes and operations. Many different works and researchers offer complex adaptive systems approach as a new way of understanding management necessities of supply networks (Marchi et al., 2014: 443). From supply chain management approach, it is also appropriate to evaluate maritime business as CAS.

3.2. MARITIME BUSINESS AS A SYSTEM

Global business uses different conceptual expression to indicate maritime transport industry such as shipping business, ocean shipping or world seaborne trade. According to Oxford Wordpower Dictionary (1994, pp.385) *marine* has three meanings, one of which means “*connected with ships or sailing*” where at the same page *maritime* has explained as “*connected with the sea or ships*”. At page 573; the same dictionary defines *shipping* as “*i) ships considered as a group or as a traffic; ii) the transport of goods by ship*” which all definitions show why those words used reciprocal in the literature. Moreover Oxford Wordpower Dictionary (1994, pp.82) defines business as “*i) buying and selling as a way of earning money; commerce, ii) the work that you do as your job, iii) the amount of trade done, iiiii) a firm, a shop, a factory etc which produces or sells goods or provides a service*”. In their valuable book, Boone and Kurtz (2015) define business as “*all profit-seeking activities and enterprises that provide goods and services necessary to an economic system*”. According to Duru (2019, pp.5) shipping business belongs to specific branch of transportation economics as an important field of study. In the light of above definitions and statements maritime business consists of “*all profit-seeking activities as a job which provides maritime transportation service*” This study does not see any difference between maritime business, maritime transportation, shipping business or other given examples used in the literature and chooses to use *maritime business* as a general statement. Also industry have two meanings at Oxford

Wordpower Dictionary (1994, pp.327) as i) *the work of making things in factories and ii) all the people, buildings etc. that are involved in producing something, providing a service, etc.* As Stopford (2009, pp. 53) states *merchant shipping industry's product is transport*. The maritime industry consists of every one of stakeholders of the system that deals with the maritime business.

As a derived from the requirements of countries, businesses and consumers maritime transportation strictly related with of global trade (De Monie et al., 2011: 14) where global economy and trade patterns shapes the developments (UNCTAD, 2017: 3). Ships and ports link world-wide supply and demand (Panayides et al., 2012: 149). Maritime business carries raw materials, semi-finished goods along with finished products and constitutes “*international merchandise trade*” (UNCTAD, 2017: xiii) where ships supply by shipowner organizations and serves for the requirements of shippers (Goulielmos and Plomaritou, 2014: 1136) in a wide range of ship size and types whether under pre-determined program or as a spot (Liu et al., 2018: 202).

3.3. COMPLEXITY DRIVERS OF MARITIME BUSINESS ENVIRONMENT

Second half of the 20th century, especially after 1980s, business world faced important developments. Technological advancements, changing customer expectations, removal of trade barriers and through so many political, social and economic transformations and interactions between those patterns (Hulsmann et al., 2008: 16) necessitates promptness in decision making. Such developments at international trade shape the maritime industry (Fremont, 2007: 440). As a system, maritime business withstands different kinds of operational and environmental disruptions which could have potential to harm maritime organizations and institutions. Those disruptions are in a wide range of variety from natural disasters like hurricanes or tornadoes to man-made disasters like accidents or terrorist attacks (Mansouri et al., 2009: 1407). In this changing world, the maritime industry becomes more complex, dynamic and uncertain (Goulielmos, 2017a: 1214) and the parties/stakeholders of the maritime business system are open to make mistakes in

such a volatile business environment if they overlook, undervalue or misread the business trends (Scarsi, 2007: 577).

Contrary to the modernist metaphor which sees world as machine under the assumption that things could be knowable and predictable via research and scientific methodology; complexity science provides new view to changing, unpredictable and uncertain business environment (Plummer and Armitage, 2007: 63). Threats could be determined under four categories as human factors, natural factors, organizational factors and technological factors (Mansouri et al., 2009: 1413). According to Scarsi (2007) the main reasons of faults could be summarized as errors due to companies' structure, imitation and/or emulation, faults regarding decision-making attitude, lack of managerial culture and lack of experience. Sheel (2016) explains drivers of complexity in supply chains as, competitive environment, changing of industry standards customer requirements, new technologies, outsourcing, alliance/mergers/acquisitions and operations to new geographies. Maritime disruptions could be explained as "*several undesirable external and internal incidents*" that cause a problem need to be solved in maritime transportation which could be stoppage, deviation, and loss of service platform or delay (Gurning & Cahoon, 2011: 252). Complexity drivers of maritime business are the main reasons of disruptions that faced by organizations. According to their occurrence, complexity drivers could be categorised as; dynamic behaviour of organizations, physical situation, organizational characteristics, operational characteristics. Or according to their origin, complexity drivers could emerge from external environmental problems (Sheel, 2016: 40) or from internal organizational faults. Gurning and Cahoon (2011) use the term "*stimulator*" as the trigger of maritime disruptions and categorise stimulators from lack of facilities and management at ports, political riots or wars, severe weather conditions to insufficient empty containers, uncertainty of bunkering costs and shortage of ships.

Maritime business itself has a very unique, non-linear environment which is affected by any change in the world; cyclical, dynamic, unpredictable which of all create high complexity for the stakeholders of maritime system. Complexity drivers

of maritime business system are the main reason of why maritime business organizations should be managed as Complex Adaptive Systems (CAS). Those complexity drivers could be categorised under four headings in this dissertation as:

- Uncertainty in Maritime Business Environment
- Crises of Maritime Business Environment
- Difficulty of Forecasting Future of Maritime Business Environment
- Changing Patterns of Maritime Business Environment

Uncertainty in maritime business involves macro and micro environmental factors of global business environment. Globalization creates high interconnectedness between organizations where any change in a one place could make possibly unwanted transformation in any part of the world. Those interconnectivity causes uncertainty under political, economic, social and technological circumstances (Justice et al., 2016: 180).

Crises of maritime business refer to the maritime cycles. Many maritime economics confirm that the maritime industry has cyclical business environment. Those cycles could be categorised according to their duration as short, medium, long and secular (Goulielmos, 2017b: 1462). The fundamental problem about maritime cycles is the general schema could be knowable but there could be no possible way to know the timing and duration of each stage of the cycle (Scarsi, 2007: 580).

Difficulty of forecasting future in maritime business refers challenge of forecasting future demand and supply requirement to maritime transportation. Forecasting always become a problem for business environment (Sheffi, 2005: 111) and especially when it comes to the maritime industry, forecasting shipping demand is difficult (Goulielmos, 2017a: 1213).

Changing Patterns of Business refers the changing patterns of doing business in maritime business. Globalization, digitalization, vertical integration, outsourcing, new alliances/mergers or acquisitions, shorter product life cycles, changing requirements of customers, new technologies and so many developments create new

understanding of doing business. In order to reduce the risks of new world and become an efficient and effective organization, the maritime industry could pace with the new developments and understands the requirements of new world (Rajesh & Ravi, 2015: 126)

3.3.1. Uncertainty in Maritime Business Environment

Uncertainty means even the possible events could be knowable, it is nearly impossible to know relative likelihoods of their consequences (Burnard and Bhamra, 2011: 5584) because what is coming is always uncertain (Polasky et al., 2011: 398). Natural and man-made disasters are potentially unpredictable which cause threat to organizational survival (Bhamra et al., 2011: 5375). Also with latest developments in every part of the life and with the help of globalisation, world goes an important transformation which creates change and uncertainty, especially in macro environment for the long run (Quitau et al., 2018: 7). In their study; Mansouri, Mostashari & Nilchiani, (2009) uses complex systems lenses and categorise the basic reasons of uncertainty into four as “*natural disasters, organizational factors, technological factors and human factors*”. Dervitsiotis (2004) declares the change drivers as the source of uncertainty such as, deregulation of several industries, increased globalization, new technologies where Sanchez-Rodrigues and Naim, (2010) categorise customers, manufacturing and suppliers as the injured parties from uncertainty.

Environmental change affects the “*global economic environment*” (Dervitsiotis, 2004: 809) where the maritime industry stakeholders play significant roles. As a system, the maritime industry has an environment which consists of everything outside the system. Under CAS perspective, environment assumed as a chaotic and system has partly chaotic behaviours because of their relationship with environment (Vrancken and Vree, 2004: 272). World is socially and technologically interconnected ever than before. These dependencies also create uncertainty to maritime organizations where survival of organizations and competitive positions depends on relations (Bhamra et al., 2011: 5375). In order to struggle with the

unknown environmental conditions, organizations should transform themselves (Dervitsiotis, 2004: 809).

Maritime business is a “*regulated profession*” in which stakeholders should obey international law and conventions. There are many standards, strict safety and security enforcements published by International Maritime Organization (IMO), International Labour Organization (ILO), and procedures of flag state authorities, inspections of port state authorities, rules of classification societies and applications of insurance companies (Goulielmos and Plomaritou, 2014: 1136). Those regulations and rules impose high operational and management applications and standards for organizational survival (Scarsi, 2007: 581). With the blow of globalisation, maritime business passed brilliant years especially after 2000s until 2008 where international trade increase and shipping industry benefited from those developments with the involvement of developing and emerging countries as an industrial production locations (Quitau et al., 2018: 8). But by 2009, seaborne trade began to see the effects of economic downturn of the world trade and face weak global demand under high uncertainty (UNCTAD, 2017: 1).

Macro and micro environmental factors shape the supply and demand balance globally. Terrorist attacks, climate change, political instability, strikes, diseases, natural disasters like tsunamis or hurricanes, changing demographic and social needs because of many established industrial nations are get ageing, new developments like “*Economic Partnership Agreement*” (between European Union and Japan); a slowdown in China, Belt and Road Initiative, decision of the United Kingdom to exit from the European Union or increase in tariffs among China and the United States, recessions in several emerging economies (Purvis et al., 2016: 579; UNCTAD, 2017: x; Liu et al., 2018: 202; UNCTAD, 2018a: x; Quitau et al., 2018: 14) and outbreak of Coronavirus disease (COVID-19) have all direct or indirect effects on maritime transportation demand.

Recent international legislations like “*The International Convention for the Control and Management of Ships’ Ballast Water and Sediments*” and “*International Labour Organization Work in Fishing Convention (No. 188)*”, air pollutants and

pollution from oil, CO2 emissions regulations, emergence of shipping routes in the Arctic routes; mergers and mega alliances or bankruptcies of big shipping companies, new telecommunication and information technologies, digitalization, increased e-commerce between countries, (De Monie et al., 2011: 14; Comtois & Lacoste, 2015: 215; UNCTAD, 2017: xii Quitzau et al., 2018: 16) are transforming the maritime transport industry, create uncertainty to industry and prevent correctly forecast the future markets according to different ship types and sizes (Notteboom, Rodrigue & De Monie 2011: 35).

3.3.2. Crises of Maritime Business Environment - Maritime Cycles

Maritime business is dominated by shipping cycles. As a global business; shipping markets are subject to geopolitical changes and economic rises and falls (Scarsi, 2007: 577). There are four phases in an ordinary the maritime industry cycle as market trough, recovery, market peak and a collapse (Chiste and Vuuren, 2014: 5).

Maritime business faced roughly 27 cycles, 10 years on average duration between 1741 and 2015 (Goulielmos, 2017b: 1463). Also according to Chiste and Vuuren (2014); the maritime industry passed 15 cycles from 1869 to 2002 with an average length of 7.1 years. There are two main reasons of maritime business cycles. According to shippers, cargo-owners/sellers/buyers perspective, the most substantial subject of a the maritime industry cycle is the cycles of wider economy. The trade fluctuation, rise and falls affect the demand of maritime transportation demand (Chiste and Vuuren, 2014: 1). On the other side, shipowners and ship management companies as supply side of the the maritime industry feel under stress while adjusting ship supplies according to demand requirements; time lag between ordering a new ship and delivering it causes fluctuations in freight market from 2-4 years (Scarsi, 2007: 578). Timing, duration or consequences of the maritime industry cycles are unpredictable (Speakman and Sharpley, 2012:68). Those cycles effects the pricing and investment strategies of the maritime industry stakeholders (Notteboom et al., 2011: 32) but according to their service requirements not all kinds of goods are

affected as the same proportions (De Monie et al., 2011: 26). The cyclical behaviour of one good could rise opportunity to another ship size and ship type.

According to developments in global financial downturn in 2008, global economic crises resulted with an important recession in all OECD countries (De Monie et al., 2011: 13) which caused sharp decline in the maritime industry demand (Song and Panayides, 2012: 149). That crisis triggered fleet adjustments, required consolidation in the shipping industry, new alliances formed and many stakeholders re-organize their operation process (Quitau et al., 2018: 29).

3.3.3. Difficulty of Forecasting Future of Maritime Business Environment

Maritime business stakeholders have challenges regarding forecasting the future of maritime transportation (Comtois and Lacoste, 2015: 216). Substantially organizations should not rely upon statistical forecasting ever so they use sophisticated algorithms (Sheffi, 2005: 124) because of two reasons as a)poor forecasts and b)measurement errors (Gurning and Cahoon, 2011: 251).

Especially with increasing dependency between stakeholders, uncertainty of macro and micro environmental factors, changing business patterns create difficulty to analyse the market and forecast the future of the industry (Goulielmos and Plomaritou, 2014: 1136). Also methods of forecasting are usually not successful to forecast low-probability but high impact events (LPHI) (Sheffi, 2005: 109). Maritime business is highly volatile, turbulent and open to any global changes because industry itself depends on *exogenous factors* (Notteboom et al., 2011: 34). Whether forecasting supply side of shipping is quite possible from many shipping sources like shipping order books of shipyards, ship sale and purchase market or records of flag states and so on; demand side of forecasting could not be accurate (Scarsi, 2007: 580). Macro and micro environmental changes occur any time at any country which prevents to capture the correct numbers. Deciding the future on the base of time series analysis could not encounter the future expectations as experienced by industry before 2007 where all future expectations showed brilliant hope while 2009 crisis suddenly arose (De Monie et al., 2011: 29). Also risk assessment and scenario

planning could be expensive and time consuming (Speakman and Sharpley, 2012:68). As explained by Goulielmos (2017) any tiny deviation in maritime future forecasting could cause calculation error which means hundreds of ships and thousand tonnes of cargoes. The maritime industry confronted wrong market judgements such as great investments on tanker ships up to 1973 and many orders on dry bulk ships until 2008 (Thanopoulou and Strandenes, 2017: 327).

Maritime business develops some tools to deal with fluctuations of the profession such as Baltic Dry index (De Monie et al., 2011: 22), freight forward agreements, financial tools like hedging, future exchanges such as the New York Mercantile Exchange, the International Maritime Exchange and London Clearing House (Comtois and Lacoste, 2015: 216) and so on. But identification of any crises or when it will happen is nearly difficult (Goulielmos, 2017a: 1211) without understanding the “*complexity of the situation and the dynamic and complex network of relationships*” (Speakman and Sharpley, 2012:68).

3.3.4. Changing Patterns of Maritime Business Environment

There are evidences that world is on the edge of significant transition which looks like it will continue to do so for the following years. Therefore macroeconomic environment intertwined with uncertainty and difficulty of unpredictability for medium and long terms (Quitau et al. 2018: 7).

The changes on macro-economic environment already started to affect maritime business. The UNCTAD, (2018a) has explained most important trends that effect and redesign the future of the maritime industry industry. New technologies have already begun to change the way of doing business. Those changes have two kinds of results one as a)ensuring new opportunities to the organization to grow while on the order hand b)inducing new problems and threatening the organizational survival, as the second (UNCTAD, 2017: xii). As a “*restrictive regulatory environment*” especially after big ship disasters, maritime business enforce and implement new conventions and rules, which all change the industry from management applications to ships designs (Chiste and Vuuren, 2014: 3). By the

launching of first container ship, industry itself and the whole transportation chains changed in a revolutionary way (UNCTAD, 2017: 14). With the growing economic growth of China, dry bulk shipping market have faced new important trends like shipowners order new bigger ships to shipyards in order to reach economies of scale while matching supply and demand (Comtois and Lacoste, 2015: 215). Maritime business is directing by the strategic alliances, mergers & acquisitions where small shipping companies are taken over by strong ones to get more market share which reshapes competitive environment (Notteboom et al., 2011: 34; Quitzau et al., 2018: 10). New developments such as modernization of the Panama Canal or emergence of shipping routes in the Arctic, modernization of ports and terminals (Comtois and Lacoste, 2015: 215), autonomous ships (UNCTAD, 2018a: xi) abolition of liner conferences, joint ventures of terminal operators with shipping lines (Notteboom et al., 2011: 44) and increasing importance of reverse & forward logistics operations, make enormous changes in the maritime industry transportation. New technological developments like three-dimensional printing, Internet of Things, e-commerce, cloud technology and big data are current trends that have vital effect on transport chains globally such as liner shipping companies, air carriers or third party logistics service providers (UNCTAD, 2017: 14; Goulielmos, 2018: 105). Although the effects of 2008/2009 crisis lasted long, the radical structural changes have started to become with the developments in digitalization. A new step of globalisation as the “*era of data flows*” started (Quitzau et al., 2018: 26) to reshape the trade, logistics and as an important player: the maritime industry by “*smart*” intelligent-developments (Akpınar & Ozer-Caylan, 2021). But among those developments, new concerns arise like cyber-security problems or new safety applications (UNCTAD, 2018a: xi) which shape the future negatively and increase uncertainty of the maritime business.

3.4. MARITIME BUSINESS AS A COMPLEX ADAPTIVE SYSTEM

Macro and micro environments in any industry could be categorised as volatile and instable; open to disruptive changes that causes unpredictability and uncertainty. Such events like 9/11, Tsunami disasters, 2008 mortgage crisis (Chia,

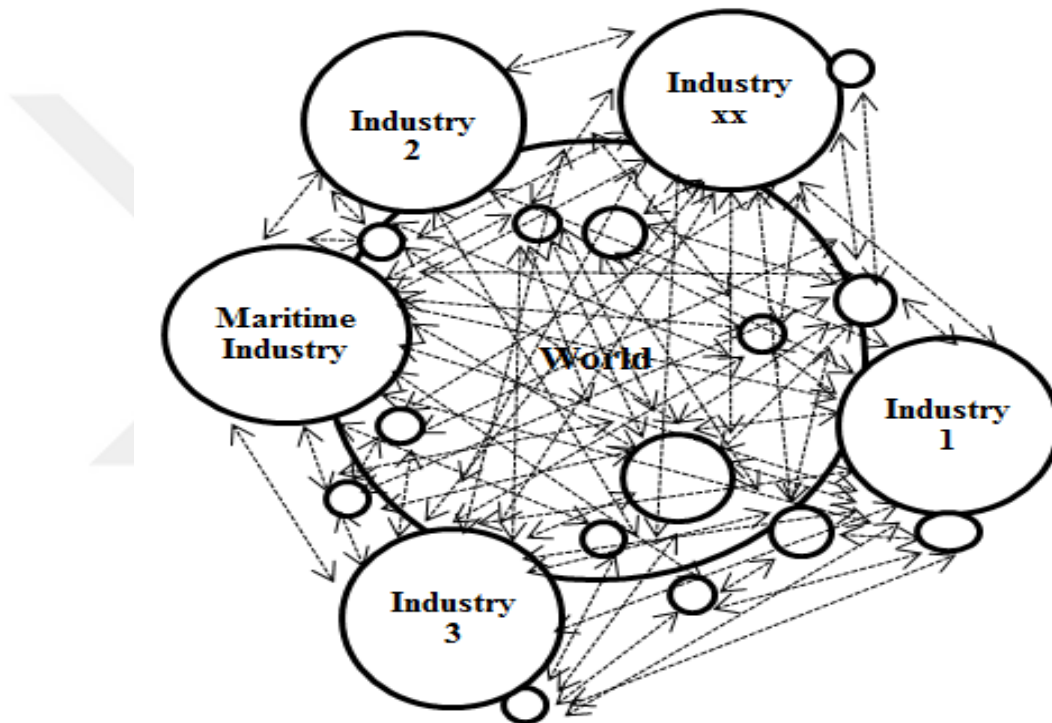
2011: 182) or outbreak of Coronavirus disease (COVID-19); mergers/alliances, outsourcing trends, changing customer requirements, new competitive standards, new technologies (Serdarasan and Tanyas, 2012: 3); empowerment of individuals, increased transparency especially by new corporate governance applications, interconnectedness between world trade stakeholders, decreased cost of information enables and increases the complexity (Palmberg, 2009: 484) which induce significant changes on “*socioeconomic environments*”.

Within such volatile and turbulent environment, managing organizations by traditional management applications could not enough to understand uncertainty and do not led successful management. That turbulence requires new understanding like CAS for better results (Marchi et al., 2014: 443). Those turbulent *sociotechnical systems* could be healthcare industry, air traffic management system, maritime operations or a production plant (Patriarca et al., 2018: 265). According to literature, there are many papers that consider Supply Chain (Li et al., 2010, Tukamuhabwa et al., 2015, Surana et al., 2005: 4235), Shipping Ports (Justice et al., 2016), Nurse profession (Chaffee and McNeill, 2007), fisheries (Mahona et al., 2008), maritime container shipping industry (Caschili and Medda, 2012) and Health care organizations (Boustani et al., 2010) as Complex Adaptive Systems (CAS). According to Goulielmos et al. (2007) maritime business organizations and ports could be classified as CAS.

In their salient paper Justice et al. (2016) considers container ports as CAS and with the help of CAS lens, try to better understand the complexity of change. In their inspiring paper, Caschili and Medda (2012) contribute literature through identifying container shipping industry as CAS. Moreira, (2013) offers to use CAS as a framework that considers maritime business system as a complex adaptive system in which system operates by independent agents which learn and adapt to their environment. Mansouri et al., (2009) uses “Maritime Infrastructure and Transportation Systems” concept in order to explain “*complex, interdependent and co-evolutionary*” characteristic of the maritime industry which are inherent dimensions of CAS. We could consider world as the biggest CAS where all other

industries and businesses are the agents of the giant CAS. Those agents are also behaving like CAS in their industries where they have their own independent agents with their own dynamic and non-linear relations. The illustration of World Industries as Complex Adaptive Systems could be seen at Figure 6.

Figure 7: World Industries as Complex Adaptive Systems



Source: Drawn by Author

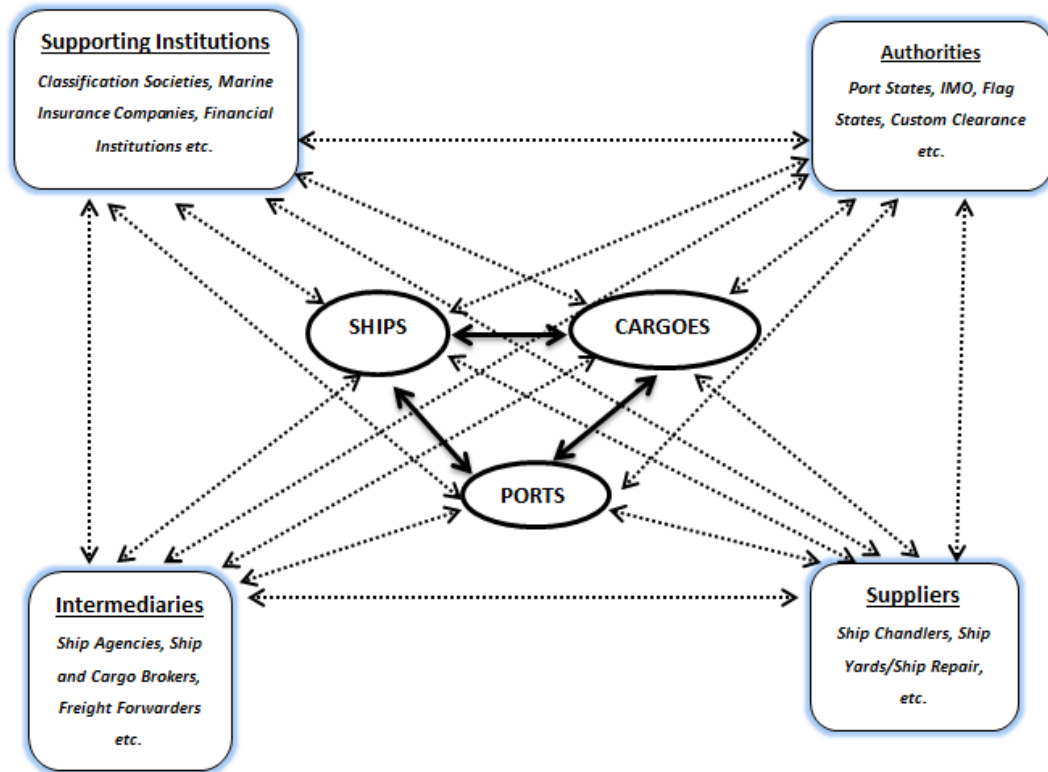
From the Complexity theory perspective Maritime business acts as CAS (Boustani et al., 2010: 141) which adapts its dynamic and unpredictable environment by the help of learning and feedback; that self-organize; interacts and interdepends non-linearly by all agents within the system which creates emergence and system-wide co-evaluation; ruled by simple rules and the patterns could be followed but not forecasted because of sensitive dependence on initial conditions that operate on the edge of chaos. From the transportation ecosystem perspective, maritime business is an important chain in world-wide supply chain operations (Baird, 2012: 189). Many

studies indicated supply chains as CAS (Blackhurst, 2004: 1640) because of interdependent and diverse players that operate in dynamic and uncertain environment. Global developments make the maritime industry even more connected via online data flow (Quitau et al., 2018: 21) that creates many changes which are the main reasons of complexity (Rypkema et al., 2015: 3873) and makes the maritime industry “*in a flux*” (De Monie et al., 2011: 22). With the help of Appendix 1, common features of CAS for the maritime industry could be identified as follows.

3.4.1. Agents of Maritime Business as Decision Makers in Complex Adaptive Systems

Agents of CAS are the main players of the system which are the main decision makers. Stopford, (2009, pp.48) divided maritime business into five groups which are *vessel operations* that involved with ships; *marine resources* that includes offshore oil, gas, renewable energy; *shipbuilding* that includes merchant and naval ship building along with marine equipment; *marine fisheries* that includes marine aquaculture and seafood processing and *other marine related activities* that includes maritime tourism, research and development, Education and training etc. Berle et al. (2011) divide the maritime industry system into five elements involving *ports, terminals, intermodal connections, navigable waterways* and *shipping networks* where Vassilios and Dimitrios (2011) divide the maritime industry into eight sub sector as *shipbuilding, marine equipment, maritime services, shipping, fishing, offshore services* and *yacht building*. Deveci (2013) separates the maritime industry system as the stakeholders of maritime business under six main headings as *maritime supplier organizations* like ship chandlers or maritime education institutions; *government authorities* like coast guards or transportation ministry; *supporting organizations* like marine insurance companies or classification societies; *customers* like shippers or charterers; *intermediaries* like ship agencies or forwarders and shipowners and shipping management companies as a *maritime transport suppliers*.

Figure 8: Maritime Business as a Complex Adaptive System



Inspired by: Vassilios and Dimitrios (2011: 136); Deveci (2013: 24).

Ships are supplied by ship owners or third party ship management companies. Shipowners are the main agents in maritime transportation that operates ships directly under their own account. Third party ship management companies offer variety of different services covering the whole range of ship management services like operations management, technical management, freight management, insurance, crewing, chartering, accounting, ship sale and purchase, bunkering and etc. (Mitroussi, 2004: 325). Cargoes are owned by customers like shippers or charterers who demand maritime transportation (Goulielmos and Plomaritou, 2014: 1134). And ports are the significant provider as one of the agent of the maritime industry that offers significant interface between land and sea (Stopford, 2009: 81). Supporting Institutions are the assisting agents of the system that helps operations like classification societies or marine insurers etc. Authorities are the ruler agents of the system that regulate the way of doing business like IMO, ILO, Port States or Flag

States etc. Intermediaries are the facilitating agents of the system which handle necessary operations like ship agencies, freight forwarders or ship/cargo brokers etc. Suppliers are the service helper agents of the system like ship chandlers or ship yards.

3.4.2. Schemas of Maritime Business as Structures Complex Adaptive Systems

Schemas of the CAS show the structures of the system which are shared between agents like beliefs, norms or values (Choi et al., 2001: 353). Schemas of Maritime Business as CAS consist of the way of doing business like one of the goals of agents in Maritime CAS is to offer low-cost services to their customers (Progoulaki and Theotokas, 2010: 576). Management in maritime business usually done by distance (Goulielmos, 2018: 119) and size, age or type of organization can have a significant effect on Maritime CAS (Mitroussi, 2003: 81). Despite geographically dispersed maritime operations, maritime CAS also operates with wide range of different cultural human resources, both on board and ashore (Progoulaki and Theotokas, 2016: 864). There are main maritime centres that work under same environmental conditions. English using as a main communication language where ships are main mobile assets. International flags permit shipowners to choose flag of registration which determines tax, financial and legal jurisdiction of ships. The classification societies supervise and certificate technical safety of ships where P and I Clubs and marine insurers protect cargo, ship, environment and third parties in any ship peril or accident (Stopford, 2009: 48). As Lorange (2001, pp. 25) states “timing is everything in shipping” due to cyclical course of maritime business (Scarsi, 2007: 582); making decision are all matter of organizational survival such as decisions regarding sale and purchase of a ship, proper planning of ship crew change/repatriation, ordering to build new ship, get involved into a new alliance or partnering with a terminal in order to serve better than rivals etc. As its nature maritime business itself needs a regulative environment for international harmony.

Maritime business agents are all around the world, which requires basic standards for running daily routines (Akpınar and Ozer-Caylan, 2016: 460).

Table 6. Ships Classed by IACS members, 2019

	Total deadweight	Total number of vessels
IACS Fleet	1.83 billion	62.081
World Fleet	1.89 billion	71.856

Source: IACS (2019: 57).

The choice of ships flag has an important effect on commercial and operational management of ships; new convention ratified by ship's flag state or any new application accepted by port state authority of ship's call port (Celik and Topcu, 2014: 112-113); any increase or decrease in new building ships price that have direct effect on second hand sale and purchase prices and demolition market prices are the ways of doing business ships classed by 12 International Association of Classification Societies (IACS) member organisations as seen from Table 6, could be given as the examples of maritime schemas.

Table 7. Country of Demolition by Major Vessel Type, 2018 (Thousand gross tons)

Ship Type	Bangladesh	India	Pakistan	Turkey	China	World total
Oil tankers	5.989	1.946	2.824	66	14	10.884
Bulk carriers	1 115	465	829	18	53	2.495
General cargo ships	127	149	57	65	5	405
Container ships	620	402	38	54	152	1.284
Gas carriers	347	455	48	3	97	951
Chemical tankers	43	167	28	28	2	268
Offshore vessels	181	581	72	143	30	1.156
Ferries & passenger ships	--	171	--	14	--	185
Other	210	353	47	29	5	673
Total	8.632	4.690	3.943	418	359	18.300.9

Source: UNCTAD (2019: 35).

For example demolition yards located mainly in the Far East like India, Pakistan or Bangladesh (Stopford, 2009: 212) as seen from Table 7 or top five shipowner countries own more than half of the world fleet (UNCTAD, 2019: 36) as seen from Table 8 are all can be shown as the examples of maritime schemas.

Table 8. Top Five Ownership of World Fleet, 2019

Country or territory of ownership	Number of vessels
Greece	4.536
Japan	3.822
China	6.125
Singapore	2.727
Hong Kong, China	1.628

Source: UNCTAD (2019: 37).

3.4.3. Fitness Landscapes of Maritime Business as a Complex Adaptive Systems

Fitness landscapes enables visualise and model the dynamics of evolution that shapes the CAS such as if the system better suited to the environment can reach higher elevation in the landscape. Fitness landscapes shows the adaptation of the system to its environment where environment conceptualises like an area that consists of hills, mountains or valleys. Fitness landscapes could also be called adaptive landscape or business landscape (Dervitsiotis, 2004: 811). The hills or top of the mountains in landscape analogy shows the optimal performances of the agents (Pathak et al., 2007: 551).

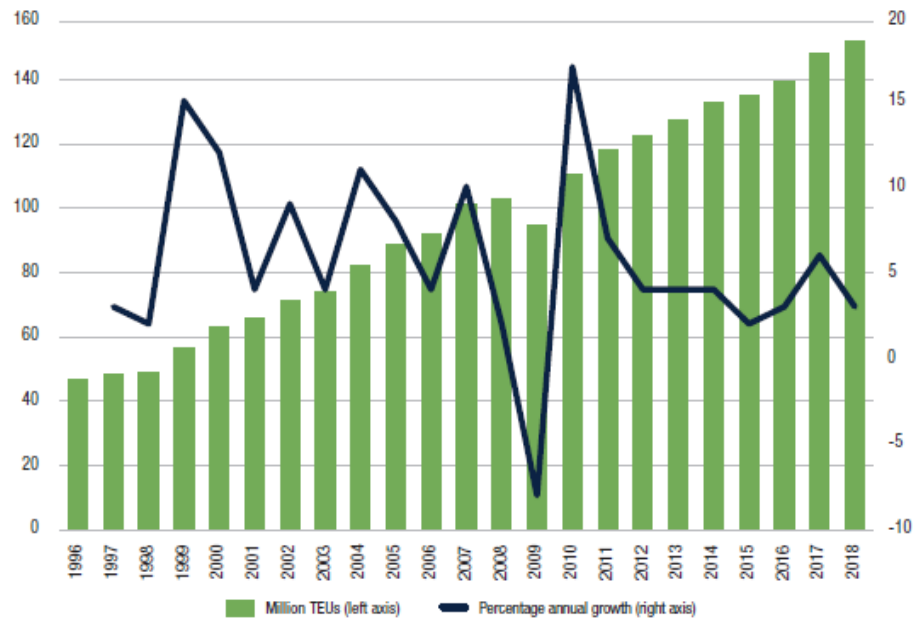
Figure 9. World Real Gross Domestic Product Annual Growth Rate



Source: UNCTAD (2018b: 44).

Maritime business is a unique industry offers magnificent profits along with significant loses. Due to volatility and cyclical nature of business, the ability of ship agents shows the difference of success. In upper trends of industry fitness landscape show upper trends like elevated freight rates, ship prices, and increase share price of listed shipping companies but while industry getting worse the assets and values of all related agents downstream trend (Scarsi, 2007: 580). Maritime agents usually imitate rivals to reach the optimal fitness situation in the landscape to catch the new trends like ordering bigger ships, offering backward/forward logistics operations, start to operate port/terminal services or many shipping firms have expanded into shipbuilding (Goulielmos, 2018: 105) and nowadays start to catch digitalisation race. All those trends and market developments offer new adaptation/fitness opportunities and threats to maritime business agents.

Figure 10. Global Containerized Trade Annual Growth Rate



Source: UNCTAD (2019: 12).

Conceptualising the dynamic environment of maritime CAS as a landscape helps to evolve the optimal states (Choi et al., 2001: 355) like showing the adaptation requirement of the system. Maritime business always shows proper adaptation capability to global transformation of macro and micro environmental changes (Thanopoulou and Strandenes, 2017: 326). While comparing World real gross domestic product annual growth rate (Figure 8) randomly with Global containerized trade annual growth rate (Figure 9) or World Fleet and Seaborne Trade Annual Growth Rate (Figure 10) similar hills, mountains or valleys shows the fitness of maritime business to macro-economic developments as an example.

Figure 11. World Fleet and Seaborne Trade Annual Growth Rate



Source: UNCTAD (2018a: 23).

3.4.4. Examples on Features of Complex Adaptive Systems from Maritime Business Context

From CAS perspective, each feature has its own speciality which requires own interpretation. This section shows the examples of CAS features form Maritime business context according to Appendix 1.

1. Adaptive Capacity / Adaptation from Maritime Business Context

Adaptation feature of CAS explains the adaptation capability of an agent to its environment. Through the instrument of globalisation, maritime business develops and increases the volume of transportation. Through “*trade deregulations*” maritime industry began to serve North–South markets beside the major East–West routes (Fremont, 2007: 431). Maritime business Organizations have enlarged their business areas (Goulielmos, 2018: 105), new ports and new shipping networks have created (Ducruet and Notteboom, 2015: 145) hub and spoke networks have established

(Fremont, 2007: 431), new bigger ships have launched, strategic alliances/partnerships or mergers occurs according to new developments (Caschili and Medda, 2012: 6; Moreira, 2013: 12). Maritime business organizations “*logically adapt*” to new developments (Ducruet and Notteboom, 2015: 145) at system wide. Each player in maritime industry industry act according to their own decisions and upon their benefits. As a regulatory industry, agents accept new rules and even though no single Organization could change or control the transition, sometimes they influence the new trends where co-evaluation occurs at *system-level* (Carmichael and Hadzikadic, 2019: 10). Especially past century showed enormous technological and managerial developments that maritime business has passed and succeed (see McConville, 2000) where all those developments are proof of industry-level-adaptation capacity.

2. Learning from Maritime Business Context

Learning is one of the important features of CAS where agents through their interactions and simple rules of the system generate new understandings and ways to learn (Carmichael and Hadzikadic, 2019: 10) that improves fitness of the system. Maritime industry Organizations try to reach effective and efficient performance while serving sea transportation through adding value to their services (Goulielmos and Plomaritou, 2014: 1139). Through macro and micro environmental developments, each maritime Organization as an agent in CAS, could learn and monitor the environment and other agents through their operations such as shipowner Organizations imitating or emulating other shipowners in the system (Scarsi: 2007, 577) that spreads the system-wide learning, experience or failure. As a volatile industry, maritime industry environment exists between order and chaos where agents self-organise at the edge of chaos as a perfect place to learn and innovate. By following simple rules agents co-evolve over time and progress that means learning happens (Marchi et al., 2014: 445).

3. Emergence from Maritime Business Context

Developments on technology and communication tools, de-regulations on trade restrictions, the recent expansion of Panama Canal (Thanopoulou and Strandenes, 2017: 327), recent economic growth of emerging countries like China and India emerge new states like serving with bigger ship; shipowners, shipping lines and ship management companies collaborating via new alliances and mergers or acquisitions between each other and with terminal operators to handle growing supply; shipping lines to re-arrange their container deployment to extent coverage of their service networks (Mengqiao et al., 2015: 1) and etc. Through logistic operations, maritime industry stakeholders offer combine transportation services as an emerge requirement of changing customer preferences. Technologic developments, robotics, 3D printing, big data, the Internet of Things (IoT), cloud technologies, RFID tags, simulation and virtualization models, additive manufacturing, Cyber-Physical Production Systems (Geissbauer et al., 2016; Kagermann, 2015) and so on, emerge as a new way of doing business to answer today's customer requirements.

4. Co-evolution from Maritime Business Context

CAS consists of many diverse and rational agents whose reciprocal interactions create non-linear dynamics that create system wide co-evolution (Moreira, 2013: 4). Such as, inter-relations of shipping agents, maritime classification societies or regional port states; strategic alliances between shipping lines; co-operations between shipowners and terminal operators create such system-wide evolution (Marchi et al., 2014: 443). CAS could enable to identify some patterns come through such evolution and how maritime industry acts as living system (Aelker et al., 2013: 83). With growing sizes of transportation demand, maritime supply side increases the ship sizes as an answer. Each maritime industry stakeholder/agent obliged to conform to national and international rules and conventions (Caschili and Medda, 2012: 10), developing technologies, canal

expansions or applying new safety and security rules are all the examples of system-wide co-evolution.

5. Requisite Variety / Diversity from Maritime Business Context

Organizations operate in nested, larger systems as a part of a community like other stakeholders such as its customers and its suppliers and government, (Dervitsiotis, 2004: 812). Maritime business consists of many stakeholders as the agents that generate a maritime system which is very significant to national economy (Mansouri et al., 2009: 1406). As mentioned, maritime industry includes different sectors with diverse agents such as port services, maritime supply and spare parts, maritime classification societies, educational institutions and many others who are ruled by national and international regulations (Caschili and Medda, 2012: 9). As the agents of CAS, those stakeholders create the non-linear relations while doing their business. For example transporting one container from one place to another includes *“more than 30 people and more than 200 interactions”* (Quitau et al., 2018: 22). The land side and the maritime transportation side consist of several systems where both side are parts of nested maritime industry system. Any problem belong any side could cause a *“ripple”* effect which could spread to wider economy and induce significant disruptions (Berle et al. 2011: 698).

6. Interdependence /Interconnectivity /Interaction from Maritime Business Context

Maritime business consists of many rational agents such as shipowners, charterers, freight brokers or port authorities who are interconnected, interacting and interdependent (Vassilios and Dimitrios, 2011: 135; Caschili and Medda, 2012: 11).

As a CAS, the agents of the maritime business act according to one another while operating their businesses. Non-linear interdependent relations of the agents shape the CAS where the turbulence in maritime industry is generally the result of interrelated collective actions of agents (Notteboom et al., 2011: 34) which create multiplier effect (Berle et al., 2011: 696).

7. Self-organising / Without Formal Control from Maritime Business Context

Self-Organization of CAS occurs as an outcome of interrelations between agents and the environment. Self-Organization refers to the process where new structures, properties or patterns of the system emerge without any imposition (Pathak et al., 2007: 550). With the help of Self-Organization feature of the CAS, “*holistic patterns of structures*” emerge (Justice et al., 2016: 185). The future decisions and situations of agents and the CAS are not determined and control by any authority. The decisions are made by agents rationally through their own future expectations and their own benefits. The decisions are self-organise by local interactions of each agent non-linearly and situations are emerging at the end of each interaction. Maritime industry self-organises according to inter-firm relations (Marchi et al., 2014: 447) of agents and the structure is not dominated by constant competent (Moreira, 2013: 12). Shipping freight market is a good example to show the self-Organization of cargo freight price which comes into balance and emerge where supply and demand meets without control of any stakeholder (Justice et al., 2016: 185).

8. Edge of Chaos - Far from Equilibrium from Maritime Business Context

In CAS, edge of Chaos indicates the place between order and disorder (Arevalo and Espinosa, 2015: 21) where shows a “*quasi-equilibrium*” situation among chaos and non-chaos (Surana et al., 2005: 4237). Such trends like globalisation, shorter product life cycles and many others increase complexity of global world trade that show some order and disorder situations at the same time (Aelker et al., 2013: 79). As an indigenous characteristics and industry-wide speciality due to turbulent and uncertain business environment, maritime industry mainly operate under the edge of chaos situation like prolong negative effects of last global financial crisis (Caschili and Medda, 2012: 11) or new safety and security applications ruled by international conventions. But as having negative

circumstances, this “*far from equilibrium state*” offers many opportunities and new solutions for the stakeholders of the maritime industry such as due to unstable demand, shipping lines co-operate to handle the situation and rationalise costs through strategic alliances and mergers (Bergantino and Veenstra, 2002: 232; Caschili and Medda, 2012: 11) or in order to supply increased transport demand, shipowners or managers decide to order bigger ships (Ducruet and Notteboom, 2015: 126).

9. Sensitivity to Initial Conditions from Maritime Business Context

Past has an important effect on future situations of maritime business agents where small problem could have potential to designate the consequences (Goulielmos, 2005: 542). According to CAS, the initial conditions matters. Those conditions draw the way of alternative futures among one of which agents choose. Traditional science believes that control and prediction could be possible on systems where CAS insists due to non-linear interactions and the initial conditions, future possibly has many alternatives which is not easy to control and forecast. CAS leaves the understanding of mechanistic “*cause and effect*” relations and concentrates on holistic approach that comprises the whole ecosystem. The whole system has its own dynamics which creates interactions, affect each other and emerge as self-Organization that depends on initial conditions of maritime industry stakeholders (Goulielmos et al., 2007: 53).

10. Non-linearity from Maritime Business Context

Variety feeds the non-linear interactions of maritime business agents such as globalisation ensures distinct probable combinations of resources from varied sources at different stages of operations (Aelker et al., 2013: 82); economic conditions and trade restrictions/deregulations of countries (Mengqiao et al., 2015: 1) or other macro and micro environmental developments have essential effects. Maritime business Organizations are complex adaptive systems that emergence, learning and adaptation occurs. As the part of the system, each maritime business

agent non-linearly relate with each other (Goulielmos, 2018: 113) and with the larger environmental factors. Non-linear networks of the system is cohesive each other (Goulielmos et al., 2007: 55).

11. Dynamism from Maritime Business Context

CAS is a dynamic system where trends, activities, connections and relations are re-shaping over time. As a CAS, maritime business effected and effects from those changes and channels the global transformation. Containerisation is the symbol of global transformation which supported increase connectivity of the world; many important shipping ports began to invest in digitalisation; maritime industry agents already begun to talk “*smart shipping, smart containers, or smart navigation*” (Quitau et al., 2018: 27); vessel sizes increases and new shipping alliances occurs; shipping lines are included in port terminal business (UNCTAD, 2018: xi); recent sustainability requirements, changing customer preferences and many other factors show the dynamic behaviour of maritime industry as CAS.

12. Unpredictability from Maritime Business Context

CAS comprises of interdependent and interrelated diverse agents that effects each other where those relations are partly linear and predictable and partly non-linear and unpredictable (Patriarca et al., 2017: 1). Those situations that create unclear environment lacks the accurate predictability of future where induce lack of control (Sanchez-Rodrigues and Naim, 2010: 46). Due to dynamic and non-linear structure; the future of maritime industry could difficult to predict. As a result of “*exogenous and endogenous factors*” maritime crisis play significant role on unpredictable structure. (Notteboom et al., 2011: 34). Digitalization, IoT, cloud technologies are already affect the maritime industry (Quitau et al., 2018: 19) such as cyber-security problems of Organizations (UNCTAD, 2018: xii), the changing consumption of commodities or changing supply patterns affect demand for maritime transportation (Scarsi, 2007: 577) while at the same time creating uncertain and unpredictable environment.

13. Feedback from Maritime Business Context

Feedback in CAS creates learning and adaptation. Understanding environmental transformations exists with negative and positive feedback characteristics. With increased pressures like globalisation and competitive race among agents; by using new feedback signals, maritime industry agents extend service range and offer logistics services for their customers (Baird, 2012: 171). Such as with vertical integrations maritime industry gear up new speciality and add new services like hinterland transportation, logistics management services, integrates with port/terminal management. With horizontal integration, industry constitute new mergers and acquisitions, strategic alliances, slot charters (Notteboom et al., 2011: 32; Panayides et al., 2012: 150-153). By getting different feedback warnings, maritime industry agents, especially shipowners compose their fleets by comprising ship type and size for different customer segments (Scarsi, 2007: 582).

14. Simple Rules from Maritime Business Context

By founding in the right place with right ship type and size at the right time (Goulielmos and Plomaritou, 2014: 1135) by transferring proper goods (Mansouri et al., 2009: 1406) maritime industry occurs its mission. Fleet composition determines the positions of shipowner Organizations whether they use chartered ships or their own ships (Scarsi, 2007: 582). Shippers and consignees expect, rapid and trustworthy service at a proper cost where shipowners fulfil those requirements by their own resources or through mergers/acquisitions or alliances (Panayides et al., 2012: 149). So, rules of the game obvious, simple rules exist and agents of the CAS decide their own way by themselves. Agents of CAS, interact in dynamic and non-linear relations where the outcomes are difficult to predict but all are ruled by “*simple-order-generating rules*”. Agents should produce their own simple rules that are not so stable or too chaotic to survive at the edge of chaos (Burnes, 2005: 74).

15. Patterns / Iterations from Maritime Business Context

By generating simple rules, agents form traceable patterns which became the collective behaviour of CAS (Carmichael and Hadzikadic, 2019: 1). The characteristics of CAS depend largely on interactions and patterns of the system (Mahona et al., 2008: 105). Maritime industry is a “*capital-intensive industry*” where some assets procured by own financial capabilities or by leasing opportunities or through by co-operative agreements (Notteboom et al., 2011: 33). The agents of the system are all try to offer reliable service while at the same time, try to balance the costs (Purvis et al., 2016: 579). As a “*derived demand*”; requirement on maritime industry shape the patterns of the system. When the demand of maritime transportation increase, the supply try to answer it by increasing the capacity through giving new ship orders while at the same time second hand ship prices increase; classification societies, P&I Clubs or ship chandlers works increase through new supplies and so on. When the demand for maritime transportation decrease, the supply try balance the supply by laid ships up or sell them under market values or sending ships scrapping; the demand for seafarers decrease directly with ship numbers and so on. With all these developments shipowners also decide whether supplying their ships on voyage or time charter where both chartering options have their own advantages and disadvantages (Scarsi, 2007: 577; Quitzau et al. 2018: 16). Shipowners manned ships from emerging countries in order to minimise running cost and with increased technology on ship design and navigational aids decrease safety manning applications on board which increase global unemployment problems for seafarers (Rypkema et al., 2015: 3873). All these decisions crate *collective behaviour*, which could be called as *patterns* of the system.

CHAPTER FOUR

MARITIME BUSINESS RESILIENCE THROUGH COMPLEX ADAPTIVE SYSTEMS APPROACH

4.1. DEFINITIONS OF RESILIENCE IN SUPPLY CHAIN AND TRANSPORTATION LITERATURE

As societies and industries become more interdependent and complex, vulnerabilities of systems increase. Any disruptive event, crises or a disaster, results injury, loss of life, damage to organizational reputation or image which treats organizations and people (McAslan, 2010: 8). Such like ecosystems, Socio-technical systems are also affected external developments (Mahona et al., 2008: 106) for instance natural disasters like earthquakes, tornadoes, tsunamis (Burnard and Bhamra, 2011: 5582) or man-made disasters like terrorism, oil spills, strikes where any organization, industry or country could face catastrophic results. With developments like changing trade patterns or shorter product life cycles; organizations confront new and difficult risks (Rajesh and Ravi, 2015: 126) which bring uncertainty and have potential to deprive million dollars of financial lost (Mansouri et al., 2009: 1407). In such a hyper-turbulence and hyper-competition (Hulsmann et al., 2008: 14) organizations confront high incidence of change (Carvalho et al., 2012b: 50) which nearly make impossible to predict future (Kamo and Phillips, 1997: 325), make systems open to wide range of external and internal environmental uncertainty (Burnard and Bhamra, 2011: 5584).

Supply Chains are exposed above mentioned problems and experience different disruptions to solve which proves resilience is an important subject for chain members. Resilience has been worked from Supply Chain perspective for a while by different researches as shown at Table 9.

Table 9: Supply Chain Resilience Definitions

Author/Year	Definition
Rice and Caniato (2003)	<i>“A supply network that has advanced security processes and procedures in place, while at the same time being resilient enough to respond to unexpected disruptions and restore normal supply network operations”</i>
Christopher and Peck (2004)	<i>“The ability of a system to return to its original state or move to a new, more desirable state after being disturbed”</i>
Carvalho and Cruz-Machado (2007)	<i>“Supply Chain resilience is concerned with the system’s ability to return to its original state or to a new, more desirable, one after experiencing a disturbance, and avoiding the occurrence of failure mode”</i>
Ponomarov and Holcomb (2009)	<i>“The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function.”</i>
Brandon-Jones et al. (2014)	<i>“The ability of a supply chain to return to normal operating performance, within an acceptable period of time, after being disturbed and supply chain robust-ness as the ability of the supply chain to maintain its function despite internal or external disruptions”</i>
Duong and Chong (2020)	<i>“Supply Chain resilience is a network-wide concept, all partners within the supply chains have to adopt the formative resilient elements to respond and recover from disruptions.”</i>

Source: Compiled by author

As shown from Table 9, Supply Chain resilience has taken its place as one of the major research domains in management and supply chain research fields. The increasing interest to resilience concept at the transportation field is also a product of the problems and disruptions arising due to globalization, technological changes, competitive environment and many other contemporary business issues. There are also valuable systematic literature reviews regarding Supply Chain resilience since past decade which give brief information about resilience from supply chain context like Ali and Gölgeci (2019) or Tukamuhabwa et al. (2015).

Table 10: Resilience Definitions in Transportation Literature

Author	Context	Definition
Ta et al. (2009)	Freight Transportation System	<i>“Ability for the freight transportation system to absorb shocks and reduce the consequences of disruptions. Freight transportation system resilience can be deconstructed along its component dimensions: the infrastructure, the managing organization, and the system users”</i>
Miller-Hooks et al. (2012)	Freight Transportation Networks	<i>“Not only the network’s inherent coping capacity, but also the potential impact of immediate recovery action within a limited budget”</i>
Dunn and Wilkinson (2016)	Air Traffic Networks	<i>“The system is designed to minimise the impact to passengers and economic losses to businesses due to disruptive events, such as extreme weather events, strike action or terrorist threats, for example.”</i>
Zhang and Wang (2016)	Road Networks	<i>“The resilience of such a system is reflected in its ability to continue to fulfil this purpose in the event of natural or man-made disasters. “</i>
Corman et al. (2018)	Railway Transportation	<i>“The flexibility of a timetable to reduce secondary delays using rescheduling (retiming, reordering, rerouting, cancel connections, cancel trains, etc.).”</i>
Wan et al. (2018)	Transportation Resilience	<i>“Ability of a transportation system to absorb disturbances, maintain its basic structure and function, and recover to a required level of service within an acceptable time and costs after being affected by disruptions”</i>
Goncalves and Ribeiro (2020)	Urban Transportation Systems	<i>“The ability of a system to resist, reduce and absorb the impacts of a disturbance (shock, interruption, or disaster), maintaining an acceptable level of service (static resilience), and restoring the regular and balanced operation within a reasonable period of time and cost (dynamic resilience)”</i>

Inspired by: Wan et al. (2018); Goncalves and Ribeiro (2020 :2).

Resilience of transportation field is immature (Wan et al., 2018: 492) and lack of consensus regarding definitions weather resilience concept has been studied for a while as seen from Table 10.

4.2 DEFINITIONS OF RESILIENCE IN MARITIME LITERATURE

Even there is a good few studies and researches regarding Supply Chain resilience in literature; resilience concept in maritime transportation has been rarely studied (Lam and Bai, 2016: 18). Sample resilience studies from maritime transportation context and their definitions could be seen from Table 11 as below. According to Thanopoulou (1998, pp.367) the long-term resilience of bulk shipping company subjects to management of fixed costs.

In their valuable study, Mansouri et al. (2009) search resilience in maritime infrastructure and transportation systems from risk management perspective to develop a Risk Management-based Decision Analysis. Omer et al. (2012) offers port to port resiliency metrics which are “*tonnage resiliency, time resiliency and cost resiliency*”; in order to evaluate maritime transportation infrastructure and measure the impact of disruptions. Trepte and Rice (2014) evaluates US-Nation-wide port system consider three level primary capacities in ports as “*navigable waterways, terminal operations and intermodal connections*”. In their salient study, Justice et al. (2016) provide to “*conceptualise container ports as CAS*”, evaluates resilience of a US ports from complexity perspective and offers “*new metaphors and guidance for managing ports.*”

Sadovaya and Thai (2015) offer an “*Effective Maritime Security Management Model*” in order to provide “*security performance, business resilience and other business performance*”. Farhadi et al. (2016) determine the “*resilience of port operations regarding major disasters*”. Turan et al. (2016) study similarities and gaps between aviation and maritime transport sectors “*focus on safety of marine transport regarding human and organizational factors*”. Lam and Bai (2016) use quality function deployment approach to analyse resilience of maritime supply chain from Maritime supply chain risks perspective. They conduct In-depth structured interviews liner shipping companies in Singapore and indicate top three of resilience measures according to their research as “*contingency plan, monitoring and maintenance, and supply chain relationship management, followed by advanced IT system, strategic alliances, and forecast accuracy*”.

Doyle et al (2016) investigate the *“effects of duration at sea on seafarers.”* Gharehgozli et al. (2017) evaluate seaport infrastructure from disruptive adverse weather events in order to categorize *“a framework to develop strategies against those risks to ensure port resiliency.”* Yang and Hsu (2018) evaluate *“relationship orientation, security management practices, resilience capability,”* and *“cargo operational performance for maritime firms”* and apply structural equation modelling to findings gathered from maritime firms in Taiwan. Chen et al. (2018) determine *“investment of players in a port–hinterland container transportation network to enhance network resilience according to man-made disasters”*. McVeigh et al. (2019) evaluate resilience concept from *“psychological perspective to merchant seafarers and superintendents.”*

Xu et al. (2019) *“quantify the resilience of handling chain system (HCS) in container ports”*. Kusuma and Tseng (2019) investigate the impact of the special *“sea toll”* program and on seaport resilience and competitiveness. Yuan et al. (2020) evaluates *“factors affecting operational resilience of container lines and determine their performance through a fuzzy cognitive map.”* Hein and Schubert (2020) explain *“the capacity of port cities to bounce back after disasters”*. Rousset and Ducruet (2020) *“determine local exogenous shocks on seaports and maritime networks.”* Asadabadi and Miller-Hooks (2020) handle subject via *“investment strategy for protecting ports from potential future disaster scenarios”*.

Some studies are excluded from Table 11 such as Hillmer-Pegram and Robards (2015) investigate *“resilience of social–ecological marine system that has vulnerable resources due to increasing maritime traffic”* which do not suit with the purpose of this study and also Zis et al (2019) and Zis & Psaraftis (2019) work on low sulphur limits and just suggest the findings of the study could assist operators to improve resilience of networks, but do not define resilience of the system or how it works.

Table 11: Resilience Definitions in Maritime Literature

Author	Topic	Perspective/Lens of Research	Resilience Definition
Mansouri et al. (2009)	<i>"A Risk Management-Based Decision Analysis Framework for Resilience in Maritime Infrastructure and Transportation Systems"</i>	<i>"Risk Management"</i>	<i>"Function of system's vulnerability against potential disruption, and its adaptive capacity in recovering to an acceptable level of service within a reasonable timeframe after being affected"</i>
Omer et al. (2012)	<i>"A Framework for Assessing Resiliency of Maritime Transportation Systems"</i>	<i>"Disaster Management" (Infrastructure Systems)</i>	<i>"As ability of the system to absorb shock as well as to recover from a disruption so that it can return back to its original service delivery levels or close to it."</i>
Trepte and Rice (2014)	<i>"An Initial Exploration Of Port Capacity Bottlenecks In The USA Port System And The Implications On Resilience"</i>	<i>"Disaster Management" (Port Capacity)</i>	<i>"It is important for seaports to build the capability to handle and withstand disruptions to continue to flow cargo through. This capability has been known as resilience, although to this point in time the concept has been mainly applied to supply chains broadly and not specifically to seaports"</i>
Justice et al. (2016)	<i>"US Container Port Resilience In A Complex And Dynamic World"</i>	<i>"Complex Adaptive Systems" (Conceptual)</i>	<i>"Port resilience involves an organizational capability to adjust to a new state of normality after a disruption, being able to adapt to a changing task environment and being able to grasp new opportunities."</i>
Sadovaya and Thai (2016)	<i>"The Effective Maritime Security Management Model (EMSMM): A perspective from practitioners in Singapore"</i>	<i>"Security Management"</i>	<i>"Resilient system is one which fails smartly and reacts adequately to disruption"</i>
Farhadi et al. (2016)	<i>"Use of Nationwide Automatic Identification System Data to Quantify Resiliency of Marine Transportation Systems"</i>	<i>"Disaster Management" (Infrastructure Networks)</i>	<i>"Concerning resiliency of the maritime transportation systems (MTS) previous studies introduced techniques to reduce vulnerability and increase coping capacity. The vulnerability reduction strategies include the implementation of robustness, redundancy, diversity, modularity, and rapidity into the system network, whereas scenarios to increase the coping capacity of a system cover resourcefulness, collaboration, preparedness, and cognition."</i>

Table 11(Continued): Resilience Definitions in Maritime Literature

Author	Topic	Perspective/Lens of Research	Resilience Definition
Turan et al. (2016)	<i>“Can We Learn From Aviation: Safety Enhancements In Transport By Achieving Human Orientated Resilient Shipping Environment”</i>	<i>“Safety Management”</i>	<i>“Resilience is the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations even after a major mishap”</i>
Lam and Bai (2016)	<i>“A Quality Function Deployment Approach To Improve Maritime Supply Chain Resilience”</i>	<i>“Risk Management”</i>	<i>“Resilience is the ability to tackle unexpected disturbances across the supply chain”</i>
Doyle et al (2016)	<i>“Resilience and Well-being Amongst Seafarers: Cross - Sectional Study Of Crew Across 51 Ships”</i>	<i>“Psychology”</i>	<i>“As the ability to ‘bounce back’ from adversity”</i>
Gharehgozli et al (2017)	<i>“Evaluating A “Wicked Problem”: A Conceptual Framework On Sea Port Resiliency In The Event Of Weather Disruptions”</i>	<i>“Disaster Management” (Infrastructure Systems)</i>	<i>“Port resiliency is the ability to resume normal operations at pre-disruptive performance levels after a disruptive adverse event and maintain normal operations and performance over a long period of disruptive adverse change. Port resiliency includes a port's ability to maintain normal operations and performance over a long period of change such as sea level rise.”</i>
Yang and Hsu (2018)	<i>“Evaluating The Impact Of Security Management Practices On Resilience Capability In Maritime Firms- A Relational Perspective”</i>	<i>“Security Management”</i>	<i>“In a context of maritime firms, when a transport system receives an internal or external impact, resilience capability allows the system to reduce the impact of a disruption by proactively identifying strategies to react while recovering to its original and continuing to provide core functions”</i>
Chen et al. (2018)	<i>“Strategic investment in enhancing port–hinterland container transportation network resilience: A network game theory approach”</i>	<i>“ Risk Management”</i>	<i>“Indicate and use Mansouri et al. 's (2009) definition and add: concept of resilience covers more than the post-disaster phase, which only concerns response and recovery issues and includes the capability of systems to actively prevent potential threats from the pre-disaster phase. Therefore, research should focus on reducing vulnerability or enhancing adaptability to increase system resilience”</i>

Table 11(Continued): Resilience Definitions in Maritime Literature

Author	Topic	Perspective/Lens of Research	Resilience Definition
McVeigh et al. (2019)	<i>“Perceptions of Well-Being, Resilience and Stress Amongst a Sample of Merchant Seafarers and Superintendents”</i>	<i>“Psychology”</i>	<i>“Resilience refers to the positive psychological capacity Psychological resilience training in the shipping sector could support safety and strengthen the well-being of employees”</i>
Kusuma and Tseng (2019)	<i>“Analysis of the Impact of the “Sea Toll” Program for Seaports: Resilience and Competitiveness”</i>	<i>“Network Approach” (Sea-toll program in archipelago ports)</i>	<i>“One measure of resilience in a logistics system is the ability to overcome unexpected disruptions throughout the “sea toll” system. Results of the study showed that the “sea toll” had an impact on seaport resilience and competitiveness.”</i>
Xu et al. (2019)	<i>“Model and Resilience Analysis for Handling Chain Systems in Container Ports”</i>	<i>“Operational” (Container Handling)</i>	<i>“Resilience is the common characteristic of efficient global port and shipping supply chain (PSSC) systems with expected delivery capacity of container ports.”</i>
Yuan et al. (2020)	<i>“Effects of new shipping routes on the operational resilience of container lines: potential impacts of the Arctic Sea Route and the Kra Canal on the Europe-Far East seaborne trades.”</i>	<i>“Disaster Management” (Operational-Shipping Routes)</i>	<i>“Shipping resilience signifies the vulnerability of a system when encountering potential accidents, along with the system’s ability to return to an acceptable level after accidents.”</i>
Hein and Schubert (2020)	<i>“Resilience, Disaster, and Rebuilding in Modern Port Cities”</i>	<i>“Disaster Management” (Urban Structure)</i>	<i>“Resilience has used to describe the capacity of cities to bounce back after disasters. Port city resilience also relies on the capacity of a port and its city to change in scale and location.”</i>
Rousset and Ducruet (2020)	<i>“Disruptions in Spatial Networks: a Comparative Study of Major Shocks Affecting Ports and Shipping Patterns”</i>	<i>“Disaster Management” (Local exogenous shocks)</i>	<i>“The capability to recover from disruptions in a shipping context is the possibility to restore past activity within a certain time lapse, over which the transport system loses its resilience.”</i>
Asadabadi and Miller-Hooks (2020)	<i>“Maritime port network resiliency and reliability through co-opetition”</i>	<i>“Disaster Management” (Port Investment)</i>	<i>“The operation of ports depends on not only supporting infrastructure and human capital, but an ability to continue to perform under disruptions from incidents.”</i>

Source: Compiled by author

4.3. REQUIREMENT OF ORGANIZATIONAL RESILIENCE MANAGEMENT IN MARITIME BUSINESS

Through globalisation (Yang and Hsu, 2018: 220) organizations faced with increased sensitivity on geopolitical and technological shocks (Quitau et al., 2018: 30), changing preferences of customer requirements (Akgün and Keskin, 2014: 6918) or prolong effects of economic downturn (Gunasekaran et al., 2015: 6812) which all create organizational problems and disruptions (McAslan, 2010: 4). Those disruptions form challenges for firms where small problem may bring difficult social ramifications (Folke, 2006: 253). Maritime business is designated by developments and changes in global trade and economy. As an industry, maritime transportation affected negatively from weak global merchandise trade or low commodity price levels (Review of Maritime Transport, 2017: 3). As a vulnerable industry, maritime business needs to handle problems of internal and external disruptive events (Berle et al. 2011: 697) in order to survive.

New trends and changes are both source of opportunities and threats to maritime business. The topic at third chapter: Complexity Drivers of Maritime Business, queue the core reasons of disruptions where stakeholders of maritime business must be aware of such as macro and micro environmental developments that create many problems to maritime business stakeholders that reveal uncertainty (Thanopoulou and Strandenes, 2017: 325). Maritime business market is highly volatile which depends on “*exogenous factors*” that cause difficulties on analysing market trends. General schema of shipping cycles could have known but problem is the timing of cycles which is impossible to predict (Scarsi, 2007: 580). Although prolong effects of 2009 economic downturn continued for a long time (Review of Maritime Transport, 2017: 1) maritime business has begun to talk new effects of technological developments, digitalization, block-chain applications, cyber-security incidents, cloud technology and so on (Review of Maritime Transport, 2018: xi) which have potential to transform the working of the industry (Quitau et al. 2018: 18). With increasing the ship sizes, port and terminal operators reconsider their infrastructure capacities (Justice et al., 2016: 181) or any disruption in

dry bulk shipping especially for major bulk cargoes like grain or coal could have bigger drawbacks for communities (Comtois and Lacoste, 2015: 222).

Along with market analysis and calculations, maritime business stakeholders shape the future through their expectations where more or less, move on the same direction. As a collective behaviour, maritime business expectations are quite the same which make mutual up and downs to the industry. Even though it is possible to catch and adapt new trends and changes eventually, the problem is the supply of ships which takes time and makes a gap between supply and demand (Quitau et al. 2018: 8). Also maritime business industry has “*Sui Generis problems*” that inherent features of industry which comes from the way of doing business like empty container repositioning, volatile ship prices, seafarer shortages, ship collisions, piracy, stowaway problems, port congestions, detentions from port state surveys, dispatch or demurrage calculation problems between parties, technical and managerial applications arise from conventions and regulations, seafarers endorsement requirements arise from ships’ flag authority applications etc.

Like other industries, maritime business also uses reactive management approach to disruptions (Goulielmos, 2017a: 1219). Problems and disruptions harm capacity of maritime transportation system that transfer goods (Berle et al. 2011: 700) which incur cost and delay the process (Hamel and Valikangas, 2003: 54). Maritime disruptions induce problems through transportation process which cause delays and financial losses to maritime organizations and shippers (Yang and Hsu, 2018: 221). Management science offers business continuity, risk and disaster management (Burnard and Bhamra, 2011: 5582) tools and applications where those applications are mainly quantitative risk assessments to describe known and predictable situations (Berle et al. 2011: 699) which means industry needs something to deal with “*unknown unknowns*” (Swanson et al., 2010: 924; Justice et al., 2016: 188). It is almost not possible to anticipate all risks and situations of future events (Ruiz-Martin et al., 2018: 12) where traditional statistical methods are insufficient (Aven, 2013: 2082). Despite maritime business have strong tools, conventions, standards and surveys to discern and prevent some unwanted *sui generis* disruptions, such as “*Formal Safety Assessment*” (FSA), “*International Safety*

Management” (ISM) or “*International Ship and Port Facility Security*” Code (ISPS Code); it is hard to prevent maritime disasters (Goulielmos and Goulielmos, 2005: 480). Maritime business should increase organizational resilience in order to confront such undesirable events (Thanopoulou and Strandenes, 2017: 330) where resilient management philosophy also enable competitive advantage to organizations (Gunasekaran et al., 2015: 6812).

Wide range and difficulties of problems that organizations confront in such a volatile environment needs new set of decision types. Important part consists of how systems confront those challenges rather than what the problem is (Carvalho, 2012a: 357). Building resilience enables exploring protective measures that cause the reducing the possibility of threats (McAslan, 2010: 8). As indicated at chapter two, although there is a lack of consensus on description of resilience (Wan et al., 2018: 490) organizational resilience helps to explain changing environmental conditions (McAslan, 2010: 7). With all these global trends and sui generis problems, it is important to still be efficient and effective while finding solutions, handling breakdowns and clear up interruptions to offer sea transportation service (Goulielmos et al., 2007: 51). Thinking different than others while they expect similar future (Scarsi, 2007: 581) put organizations one step ahead. The resilient management philosophy is the one that could ensure “*one step ahead*” thinking for maritime business industry.

Organizational resilience philosophy offers Maritime business stakeholders to understand dynamism of regional and global movements, help to use organizational resources more efficient and effective ways, manage uncertainty (Lee et al., 2013: 29), help to generate quick responses to disruptions, increased capacity to change which brings readiness to adapt and survive. By understanding environmental uncertainty and complexity better than others, resilient organizations cope with significant difficulties which make them more competitive as a substantial strategic advantage. Resilient management offers break down points at system and shows the ways to restore quickly while transporting goods while traditional risk assessments not enough. Especially 21st century inter-connects organizations each other where organizations impressed environmental changes and uncertainty significantly (Serrat, 2013: 1). Through such

dependence; resilience management philosophy offers to understand one of the main reasons of organizational survival and success (Yilmaz Borekci et al., 2015b: 65).

Organizational resilience offers holistic approach to evaluate problems of the system by submitting multiple ways to handle problems that helps to manage uncertainty and the change (Berkes, 2007: 284). Resilient management philosophy enables maritime business organizations to fight against their vulnerabilities that create risk especially in turbulent business environment. Organizations should be ready to all kind of disruptions and unpredictable changes in order to respond quickly (Carvalho et al., 2012b: 49). As a volatile industry, increasing resilience (Notteboom and Lam, 2014) capability helps organizations to decrease the effects of disruptions while at the same enable to operate the core business functions (Yang and Hsu, 2018: 223) in maritime business. Maritime business needs to solve not only one time problems but also needs to resolve and exploit new opportunities from disruptions (Vogus and Sutcliffe, 2007: 3418) via resilient management philosophy which help organizational adaption in fluctuant periods. In order to prevent such problems and become ready for complex environmental changes (Yılmaz Borekci, İşeri Say and Rofcanin, 2015: 65) resilient management philosophy is vital. Organizational resilience of maritime business refers the survival ability of the organizations to solve the problem not just in the face of a disruption but also noticing difficulties before giving symptoms which also helps to gain competitive advantage to prosper. So with the help of above definitions, organizational resilience in maritime business could be defined in this study as:

Struggling the uncertain and volatile business environment; resisting the difficulty of predicting the future; dealing with maritime crises that strain businesses and understanding and applying the changing ways of doing business in maritime industry; not as a one-time solution but applying it strategically as a management philosophy.

4.4. ACHIEVING ORGANIZATIONAL RESILIENCE IN MARITIME BUSINESS THROUGH COMPLEX ADAPTIVE SYSTEMS APPROACH

Business environments become more complex than ever due to complexity drivers of industries which create unpredictability to organizations (Yılmaz Borekci, İşeri Say and Rofcanin, 2015: 65). Like other industries, maritime business faces different and difficult problems which threat organizational survival (Justice et al., 2016: 179). The ability to cope with those uncertainties, threats and problems shows the resilience ability of organizations that help to survive and prosper (Ince et al., 2017: 230). Organizational resilience concept arises as a requirement to deal with business environments which are swiftly changing (Hosseini et al., 2016: 48). There are three characteristics that resilience thinking enables as: i) the amount of difficulty that system faced while continue to serve the core functions, ii) the capacity of self-organization, iii) the capacity of learning and adaptation (Carpenter et al., 2001: 766; Folke, 2006: 259; Schianetz and Kavanagh, 2008: 610). There are different “theoretical lenses” while handling resilience concept such as: systems approach, resource dependence theory, rational choice theory or complex adaptive systems approach (Tukamuhabwa et al., 2015: 5610). It is suitable to consider organizations as CAS where interdependent and adaptive agents (Morel and Ramanujam, 1999: 281) create new intuition and understanding (Cunha and Cunha, 2006: 840). As an approach, CAS has been used by different disciplines like ecology, biology, management and economics (Roundy et al. 2018: 2) to capture the whole picture (Huang, 2009: 1296).

As explained at chapter 3, maritime business should be considered as CAS where agents interdepends each other (Pathak et al., 2007: 550) and the industry shows turbulent and volatile business environment (Mari et al., 2015: 102). As a CAS, maritime business consist of many agents/players/stakeholders that compose the whole system like ship managers, consignees, national authorities, ship chandlers etc. where each agent acts rationally, inter-acts with each other; adapts and learns (Moreira, 2013: 7). As a model, CAS approach offers that maritime business environment is constantly

changing which make pressure on the agents of the system that leads co-evolution of the whole system (Tukamuhabwa et al., 2015: 5615).

Maritime business has risky and uncertain environment (Yang and Xu, 2015: 139). Risk explains situations and variables that we know and have chance to calculate the dimensions which called “*known unknowns*” (Allen and Boulton, 2011: 173). But in such hyper-competitive (D’Aveni, 1994: xiii) and complex environment it is mostly impossible to know or predict and manage future situations of systems (Mari et al., 2015: 102). Those problems need special kind of decision processes, quantitative and qualitative skills to evaluate and sense the situation (Vasconcelos and Ramirez, 2011: 238).

According to CAS, any tiny or insignificant event could cause a big and unpredictable consequence where each part of the system belongs together (Goulielmos et al., 2002: 21). Any misvaluation regarding market trends or future expectations resulted big organizational failures such as tanker shipping faced at 1973 or dry bulk shipping lived at 2008 (Thanopoulou and Strandenes, 2017: 327). With the help of CAS lens, uncertainty, chaos or difficulty of prediction could make sense (Goulielmos et al., 2002: 2002: 20) along with new management understanding like complex and self-organizing agents who adapts and learns via interdependencies that emerge as a new ways of operating (Bristow and Healy, 2014: 95). Turbulent, volatile and competitive business environments like maritime business requires special abilities that enable “*bounce back from disruptions to survive*” and if possible “*catch the opportunities in volatile environment to prosper*” (Yılmaz Borekci, İşeri Say and Rofcanin, 2015: 64). CAS approach helps to turn potential into real that enables the balance between order and disorder as called “*chaotic order*” (Goulielmos, 2005: 533).

In resilient “*social-ecological systems*” complex adaptive systems approach creates new opportunities (Folke, 2006: 253) assists learning and adaptability (Goulielmos et al., 2002: 2002: 19). Resilience thinking arose in ecology in 1960s in order to determine interacting relations of populations (Folke, 2006: 254). Organizational resilience is “*one step-ahead*” management than classic risk management to determine complexities of interdependent nested systems (Linkov et al., 2014: 407).

In such interdependent relations classic top-down management approaches are not enough to handle difficulties where new thinking requirements arise. CAS approach offers bottom up methods based upon those inter-actions and inter-dependencies between agents of the system (Caschili and Medda, 2012: 11) as one of the enabler of resilient management thinking.

CAS approach helps to analyse and resolve the chaotic order (Serrat, 2013: 2) reject predictability (El-Ghalayini, 2017: 7) and maintains new understanding between agents (Pathak et al., 2007: 548). From CAS lens, resilience is an emergent characteristics of the system which depends non-linear interactions of agents, evolves in a dynamic environment and as an outcome of self-organizing process where deterministic methodologies insufficient to explain resilience in such complex systems (Tukamuhabwa et al., 2015: 5614). CAS approach offers strategic thinking where organizations interpret their environments miscellaneous ways as their internal complexity matches their external complexity which enables multiple points of view. CAS lenses procure new sights as organizations able to adapt and integrate quickly (Neill and Rose, 2006: 8) which open a road for more resilient organizations. Resilience consists of different features one of which comes from engineering point of view as obstructive of the system to problems and bounce-back and the second perspective comes from CAS approach as an “*adapt-ability*” of the agents in a dynamic and volatile environment. Thereby resilience is not about to turn normal conditions. It rather means emerge as a co-evolutionary capacity depends on local interactions of agents under dynamic conditions (Bristow and Healy, 2014: 94). CAS approach enables handling organizational concept more holistically configures beyond single dimensional views (El-Ghalayini, 2017: 6).

Above mentioned examples prove that Complex Adaptive Systems are more resilient (Juarrero, 2011: 163) via adaptation and learning as depends on local interactions that shapes and co-evolves together with their dynamic environment which helps to emerge as a self-organization at unpredictable future (Vasconcelos and Ramirez, 2011: 239). Continuity and consistency of the system depends inter-action of agents where system collects *experience* (Arevalo and Espinosa, 2015: 23).

Complex Adaptive Systems are resilient if they face disruptions (Carmichael and Hadzikadic, 2019: 2). And using CAS lens is suitable in maritime business and management (Goulielmos et al., 2002: 18) where CAS lens clarify balance between control and emergence (Marchi, Erdmann and Rodriguez, 2014: 443). Literature shows studies that use CAS lenses while explaining resilience of systems from different disciplines like, Coetzee et al. (2016) use CAS lenses while interpret disaster resilience; Bristow and Healy (2014) use CAS approach to describe building resilient regions and Folke (2006) mentions CAS while explaining ecosystem resilience.

According to Goulielmos (2017, pp. 1211) dry cargo shipowners used two main moves at last economic depression one of which i) try to survive and the other one is ii) find new opportunities to prosper, as showed in the model. Because organizational resilience could not only cope with problems (Carvalho et al, 2012c: 330) and procure endurance that enables organizational survival (Tukamuhabwa et al., 2015: 5614) but also gives chance to prosper via new opportunities and continues development (Folke, 2006: 259). Developing system-wide resilience philosophy requires complex adaptive systems design (Park et al., 2011: 398) that necessities adding CAS features and understanding into organizational processes (Lengnick-Hall et al., 2011: 251).

Maritime disruptions mentioned as undesirable “internal or external” (Gurning and Cahoon, 2011: 252) cases that both “within and outside” (Berle et al., 2013: 254) the system which create uncertainty as a result of negativity in maritime leg of the transportation. According to Gurning and Cahoon (2011) maritime disruptions could be classified into four groups as delay, deviation, stoppage and loss of service. An important point that makes sense after the disruption lay at the time of recovery time. The time to recovery could be the activity of organizational resilience (Sheffi, 2005: 84) which allows the system a proper readiness and responsive capacity to major jolts (Omer et al., 2012: 687). Resilience of a system could be increased according to organizational capabilities which enable decreasing of organizational vulnerabilities (Yılmaz Borekci, İşeri Say and Rofcanin, 2015: 65).

CAS lens and resilience of the organizations are two contexts that are intertwine each other. CAS lens could be used as a contemporary design idea (Daft, 2010: 30).

Complex Adaptive Systems Approach enables the learning and adaptation requirement of organizational resilience concept (Folke et al., 2002: 438) which helps to create dynamic capabilities to handle turbulent changes (Chowdhury and Quaddus, 2017: 186) and gain long-lasting competitiveness (Liu et al., 2018: 202). Designing maritime business agents from CAS view point helps to understand and be ready to new trends, such as digitalisation or automation in shipping. Although these new trends consist many opportunities for each market of maritime business; the obscurity on application and shaping the future of maritime industry is much bigger. Evaluating organizations from CAS lens, as living systems that co-evolve with their environments (Surana et al., 2005: 4236) reveals different ways to achieve organizational resilience management philosophy. Designing organizations as CAS, promotes organizational adaptation (Baumann, 1999: 170) and learning which improves Organizational decision making that increase organizational resilience in maritime business (Mansouri et al., 2009: 1407).

4.5. ALIGNING COMPLEX ADAPTIVE SYSTEM APPROACH WITH ORGANIZATIONAL RESILIENCE FROM MARITIME BUSINESS CONTEXT

Under volatile and turbulent environments risk management applications are inadequate. Instead, designing systems which enables understanding of those systems could better work. Designing the system is one of the aspects of achieving organizational resilience . Designing system from CAS lens could help to understand the whole picture where relational dependencies make sense. With the help of CAS features, the system will become ready to face many disruptions as each one of feature contributes to improve organizational resilience.

By including certain features of CAS, organizational resilience could be reach. In order to reach and improve organizational resilience, this section attempts to figure out contribution of each CAS features from maritime business context. The features of CAS approach are determined according to Appendix 1.

1- Adaptive Capacity / Adaptation feature of CAS from Maritime Business Resilience Concept

Adaptation in CAS explains the evolution of system through continuous and sudden changes where with the help of self-organization and learning, system could able to deal with environmental changes (Folke, 2006: 259). In continuously changing environments, agents of the system adapts as “*natural selection*” explains but in sudden/abrupt changes “*complex adaptation*” process occurs which means adaptation of systems without experiencing pre-adaptation process (Arevalo and Espinosa, 2015: 24). Organizations that are open minded to learning easily increase organizational survival via adaptation feature (Amann, 2007: 236) where adaptation is one of the central focuses of Organizational resilience concept (Plummer and Armitage, 2007: 66).

Adaptation feature of CAS, contributes organizational resilience as offering capacity to agents to co-evolve with the environment where the system face any social, political or economic problems or disruptions (Folke, 2006: 262). Also improvisation is another dimension of CAS adaptability that contributes on organizational resilience. Improvisation helps to interpret new opportunities while re-calibrating organizational fitness which involves “*bricolage*” understanding that solves problems with whatever resources are available (Cunha and Cunha, 2006: 844; Serrat, 2013: 2). Such as integration and co-operation of liner shipping companies (Panayides et al., 2012: 164) forming alliances and partnerships to create market value in order to satisfy their customers’ maritime transportation requirements (Baird, 2012: 173) under proper cost.

2- Learning feature of CAS from Maritime Business Resilience Concept

In CAS, learning is the one of the main features of the system that creates system-wide development. Learning feature of CAS, contributes Organizational resilience as one of the ways of learning occurs through interactions of agents in the system. The CAS feature of learning creates the understanding of living with unpredictability which requires past as a memory of the system (Berkes, 2007: 288).

Organizational resilience philosophy comprises learning (Serrat, 2013: 2) which is one of the main abilities of resilience (Weick and Sutcliffe, 2007: 71). Building learning feature of CAS (Mahona et al., 2008: 105) enables learning from past mistakes (Bristow and Healy, 2014: 94) which gives ability to grow. Systems through adaptation and learning build and sustain resilience (Folke et al., 2002: 439).

Maritime business agents could learn via feedbacks (Berkes, 2007: 284), interacting, monitoring or even by imitating each other (Scarsi: 2007, 577) that enables collecting precious information about other stakeholders of the system like customers, suppliers or authorities like IMO or port states to understand “*ever-changing market situations*” (Baird, 2012: 173). Such as, investing on new technologies due to other stakeholders do so; or because to satisfy customer demand like new container tracking system (Mansouri et al., 2009: 1415) could be examples of the system-wide learning contribution of CAS on resilience concept.

3- Emergence feature of CAS from Maritime Business Resilience Concept

Emergence in CAS, arise from local interactions of agents via simple rules that generates new states (Arevalo and Espinosa, 2015: 22). Those local interactions arise as an emergent behaviour of the system (Burnard and Bhamra, 2011: 5584). In CAS, schemas of the system draw the boundaries of decisions where at the end of those decisions; self-Organization and emergence occurs (Pathak et al., 2007: 551).

The emergence feature of CAS helps to understand that emergence is the output of the system; arises from local interaction of agents as a contribution to resilience philosophy where resilience seems as an emergent feature of the system (Allen and Holling, 2010: 2). Emergence feature cannot be prepared previously but evolve as collective consecutiveness of decisions (Erol et al., 2010: 305). Adding the characteristics of emergent feature of CAS helps to develop organizational resilience (Burnard and Bhamra, 2011: 5584). Such as maritime business stakeholders try to integrate emerging technologies (Review of Maritime Transport, 2017: xii) on their systems as new requirement of doing business like applications of big data, bitcoin, the

Internet of Things (IoT), cloud technologies, RFID tags (Geissbauer et al., 2016; Kagermann, 2015).

4- Co-evolution feature of CAS from Maritime Business Resilience Concept

Co-evolution in CAS occurs through interactions of agents that adapts and self-organises (Dobrescu et al. 2009: 69). CAS approach shows the importance of relationships between agents which are shaped by agents own interest and decisions. Those decisions and interactions affected by environment while at the same time shapes the environment as a spontaneous way (Mason, 2007: 10). The contribution of co-evolution feature of CAS to resilient philosophy comes from the understanding that evolution is the outcome of change that emerges from local interactions. While agents make new decisions through their benefits they also “*co-create*” their environment (Arevalo and Espinosa, 2015: 22).

In maritime business co-evolutionary change occurs through the decisions of maritime business stakeholders as the agents of the system. The increasing sizes of ships (Caschili and Medda, 2012: 10), supplying reverse & forward logistics services of liner shipping companies or serving as a terminal operator under some agreements (Fremont, 2007: 431) could be all the examples of co-evolutionary resilience.

5- Requisite Variety / Diversity feature of CAS from Maritime Business Resilience Concept

Diversity is the centre of CAS approach where different agents come together and generate the system. Agents make their own decisions according to their benefits as a response to environment (Pathak et al., 2007: 551). It enables new opportunities to develop Organizational resilience which is the main contribution of diversity feature. As a universal strategy, diversification creates new options to handle problems easily (Berkes, 2007: 289) which increase resilience capacity of the system. Diversity feature increases the adaptation and learning capability of the system (Folke et al., 2002: 438) especially in complex and turbulent environments (Marchand and Hykes, 2007: 159) as

a key to Organizational resilience (Levin, 1998: 435). Diversity could be considered as the compass of the system that increases the fitness (Juarrero, 2011: 163).

As a CAS, maritime business composed of various sectors and agents (Moreira, 2013: 3) as explained at Chapter 3 which creates great variety to the system. Also agents themselves use diversity approach strategically on their own operations (Notteboom et al., 2011: 40) to increase Organizational resilience.

6- Interdependence /Interconnectivity /Interaction feature of CAS from Maritime Business Resilience Concept

CAS consists of agents that interdepends each other. That interaction of agents forms the web of relations in the system (Chaffee and McNeill, 2007: 233).

CAS offers opportunity to realise this interdependencies between agents as a main contribution on developing Organizational resilience where system resilience is the outcome of non-linear interdependencies of agents (Erol et al., 2010: 305). As agents do their works in a web of relations that induce resilience of one agent could affect the resilience of overall system. Each agent has its own significant existence on determining systems resilience (Yilmaz Borekci et al., 2015a: 6839). The resilience of each agent comes from the inter-relational dependencies that have potential to raise or reduce the survival of other agents. The resilience of the system comes from interdependencies of agents that evolve by adaptation and learning capacities while facing disruptions. Recognising those interdependencies give chance to manage the affection from others which increase the resilience capability (Nan and Sansavini, 2017: 35).

Maritime business comprise of diverse agents that interrelate in global business environment. To ensure long term survival, agents have to consider different factors while making decisions to manage these interdependencies (Pathak et al., 2007: 548). As an important resilience contributor, agents of the maritime business must be aware of those dependencies and relationships to increase survival chance and prosper (Yang and Hsu, 2018: 221). Maritime business agents use mergers / mega alliances / partnerships / vessel sharing agreements etc. where each of these relationships can increase

organizational resilience but also should be managed in order not harm organizational survival.

7- Self-organising / Without Formal Control feature of CAS from Maritime Business Resilience Concept

According to CAS, self-organization of the system proves that diverse agents of the system response to environmental changes (El-Ghalayini, 2017: 8) via non-linear relationships at the edge of chaos (Arevalo and Espinosa, 2015: 22). With the help of self-organising feature of CAS, resilience of the system possibly increase where resilient capacity is tightly related with systems self-organization (Berkes, 2007: 290).

System which is capable of self-organising at the face of disruption has potential to generate a capacity to learn and adapt (Mahona et al., 2008: 105). As complex adaptive systems easily self-organise; designing organizations according to features of CAS can help to increase resilience capabilities of organizations. Self-organising ability of maritime business agents/stakeholders belong the relations of “*biotic and abiotic*” elements of the system (Allen and Holling, 2010: 15). Maritime business agents could use shared principles and values in order to direct self-organization feature (Mahona et al., 2008: 107) like circulars, directions or policies. And also agents can apply new marketing tactics, new strategic alliances or develop new strategies to self-organise (Mason, 2007: 12) which increase Organizational resilience.

8- Edge of Chaos / Far from Equilibrium feature of CAS from Maritime Business Resilience Concept

From CAS perspective, agents should be kept at the “*edge of chaos*” condition in order to generate creative and innovative solutions (Cunha and Cunha, 2006: 846). This condition states “*quasi-equilibrium balance*” of the system as “*flexible but disciplined*” (Mason, 2007: 13) where at the same time order and disorder exist (Surana et al., 2005: 4237). CAS helps agents to understand that system does not need to be at stable

condition in order to be resilient (Coetzee et al., 2016: 197) but should be balance at the edge of chaos (Mason, 2007: 15).

CAS approach proves that keeping system at the edge of chaos increase resilience capability. With the help of “*strange attractors*” (McMillan, 2008: 83), CAS can easily limit the boundary of system even unpredictability of future still exist. Culture could be used as a strange attractor (Murphy, 1996: 98) as creating common values. Improvisation is also a good application for managers at the edge of chaos state which enables a balance between order and chaos (Mason, 2007: 15).

9- Sensitivity to Initial Conditions feature of CAS from Maritime Business Resilience Concept

In CAS, sensitive dependence on initial conditions feature explains the butterfly effect which means, any tiny local change or discrepancy can potentially give rise something unpredictable (McMillan, 2008: 97).

CAS is strict to its initial condition which is the history of system (Chaffee and McNeill, 2007: 235). Even two agents have similar initial conditions the tiny difference at the beginning drive totally different paths then each other (Anderson, 1999: 217). Significant sensitivity on its own past is one of the features of CAS that leads system into chaos where also one makes some patterns obvious to deduce, anticipate (Murphy, 1996: 100) and increase the organizational resilience.

The contribution of sensitivity on initial conditions feature of CAS to Organizational resilience philosophy is ratifying there is no “*one-size-fits-all*” recipe. Each agent is unique from the very beginning of the system that steers its own future way. From each worker to each department; each unit give different responses to environment on their own way which gets its roots from their cultures and past (McMillan, 2008: 117).

10-Non-linearity feature of CAS from Maritime Business Resilience Concept

Core of CAS is come out from the feature of non-linearity. Understanding and evaluating CAS lies behind the non-linear interactions of system's agents. Agents' non-linear dependencies, with the help of negative and positive feedback mechanisms, create system-wide patterns (McDaniel, 2007: 23). From CAS lens, resilience of maritime business agent emerges from non-linear and dynamic interactions with other agents as a collective behaviour (Tukamuhabwa et al., 2015: 5614). By guiding CAS from few simple non-linear rules, the complex behaviour of CAS arise (Choi et al, 2001: 353).

The contribution of CAS lens on organizational resilience is helping managers to understand complexity type of management (Mason, 2007: 12) in such an uncertain environment where resilience management philosophy requires “non-linear, dynamic and ready to respond” kind of management applications (Folke, 2006: 253). By following non-linear relationships, maritime business agents can easily understand that “*as long as energy injected into system*” all ways come into bifurcation point which is the time of transformation. Although it is impossible to know when and how transformation will happen, CAS lens offers “*strange attractors*” understanding as the only thing that suits in anticipating the system. Those attractors shape the boundaries of the change and keep it in a “*basin*” which helps maritime business agents to increase their organizational resilience (Bovaird, 2008: 322). Such as by following new trends and market analysis, agents could easily figure out strange attractors of the system such as new cyber risks through increase digitalisation requirement of new world or using autonomous technology in shipping that leads to new emerging management applications (Marsh & McLennan, 2017: 9; Review of Maritime Transport, 2018: 15) or new applications of flag states which all help to shape and be ready to “fracture points” of future states.

11- Dynamism feature of CAS from Maritime Business Resilience Concept

Dynamism in CAS refers the action, motion and kinesis side of the system. As Cunha and Cunha (2006, pp 842) indicated that “*markets should be considered as processes in a state of perpetual flux; as Schumpeterian type*”. Since many industrial environments could be considered as dynamic and volatile, it is much better to evaluate situations and market dynamics to find alternative ways to cope with uncertainties (Mason, 2007: 11).

Maritime business has a dynamic environment as explained at Chapter 3. Understanding evolving dynamics of industry (Erol et al., 2010: 305) helps to increase organizational resilience. Maritime business stakeholders as the agents of the system are interacting each other and with their environments. System-wide resilience emerges through these interactions and can only be evaluated through determining dynamic relations (Coetzee et al., 2016: 202). Technological transformation from “*embedded systems to cyber-physical systems*” (Xu et al., 2018: 2941), new requirements of changing business environment that is triggered by changing customer demands (Jager et al., 2016: 119) and also sui-generis problems of industry such as talented seafarer shortages and gender diversity requirement of industry all proves dynamic structure of new business order. Playing its part as the enabler of sea-leg transporter, maritime business agents should aware of potential opportunities along with new and unforeseeable risks to increase their survival chance and to catch organizational prosper.

12- Unpredictability feature of CAS from Maritime Business Resilience Concept

Agents of the CAS interacts each other where any action of an agent could affect directly or indirectly to others whether negatively or positively (Dobrescu et al. 2009: 69). Also non-linear interactions could alternate ways and future situations in unexpected way. Sensitive dependence of agents to their history and emergence of different situations according to dynamic structures of diverse agents proves that future situations are unpredictable (Dooley, 1997: 83). Such interdependency and

unpredictability in CAS increase vulnerability of agents which need organizational resilience management applications (Tukamuhabwa et al., 2015: 5592).

The unpredictability feature of CAS helps to increase organizational resilience by raising awareness of managers to figure out *unpredictable* future. Through offering some tools, CAS offers to increase organizational resilience; such as patterns or strange attractors (McMillan, 2008: 111). Strange attractors are the boundary painters of systems which permits “*change and order*” at the same time; such as vision and values, customer relationship management activities or new market entry applications. Maritime business agents should empower their human resource capital through giving them clear and simple vision, tighten their customer relations via “voice of customer” applications or determine simple goals to serve new market (Mason, 2007: 13).

13- Feedback feature of CAS from Maritime Business Resilience Concept

In CAS, negative and positive feedbacks help shaping the system. Through negative feedback; system stands still and back to original condition. By getting positive feedback, system starts to produce chaos move from equilibrium situation to generate and apply change (Mason, 2007: 13). In CAS, feedbacks are the narrators that explain interactions between agents and the environment (Dobrescu et al. 2009: 69).

CAS lens provides to increase organizational resilience via developing a new understanding rather than traditional linear management applications. This complex and uncertain environment requires new principles working around non-linear interactions shaping by feedback loops emerge as learning and adaptation. By applying this new principles, maritime business agents can create more resilient organizations that are ready to change before it is necessary (Bristow and Healy, 2014: 101). By developing IT systems and strong communication applications such as latest social media management applications of liner shipping companies; or via strengthen relations with the system itself, such as getting new membership according to organizational goals and benefits from any maritime association like Maritime Employers' Council (IMEC) or International Ship Suppliers and Service Association (ISSA); maritime business agents effectively develops feedback loops to increase Organizational resilience.

14- Simple Rules feature of CAS from Maritime Business Resilience Concept

Simplicity is the main designer of system from CAS lens. By composing system around few simple rules, agents form minimal structures. Those structures give simple management mechanisms to reach organizational targets without generating “*Organizational inertia*” (Cunha and Cunha, 2006: 842). Agents can easily form control through local, non-linear and simple behavioural rules (Surana et al., 2005: 4239)

Simple rules feature of CAS contributes development of organizational resilience by providing “minimal structures” viewpoint. Minimal structures enable few simple rules to coordinate system, empowers agents to give their own decisions, provide space for innovation and improvisation (Cunha and Cunha, 2006: 843). Simple rules easily learned and shared by agents which create adaptation of the system (Marchi et al., 2014: 451).

Minimal structures enable rapid response (Cunha and Cunha, 2006: 843) which can be used as a tool that increases organizational resilience of agents. The centre of CAS analysis belong simple-local-interactions of agents that create non-linear complex behaviour (Coetzee et al., 2016: 203). By balancing simple rules of the system, the agents can equalise order and chaos (Mason, 2007: 12). Minimal structures ease local rules of interaction that provides system-wide evolution (Bristow and Healy, 2014: 94). Maritime business agents can use minimal structure vision and create few simple rules by using culture, maritime traditions or organizational values (Mason, 2007: 15). Managers can create clear organizational identity and give simple goals to empower ship crew and ashore personnel, coordinate operations or create innovative organizations which all these applications help to increase organizational resilience.

15- Patterns / Iterations feature of CAS from Maritime Business Resilience Concept

The unpredictability of future state of CAS does not mean that agents lost all control and live by chance. Patterns and iterations feature of CAS helps that although future is not certain; behaviours of the system show some similarities which can be

observable (Choi et al., 2001: 357). With the help of patterns, CAS can able to anticipate and speculate alternative futures. Agents of the system can learn to follow and sense patterns (McMillan, 2008: 78) which make contribution on developing more resilient Organizations. Anticipating and recognising patterns could increase abilities of agents for increasing their Organizational resilience capacities (Lengnick-Hall et al., 2011: 253).

The concept of CAS helps to understand that maritime business industry is a living system which co-evolves. The co-evolution feature let system to determine patterns that arise in paths of evolutions (Choi et al, 2001: 364). The holistic-collective behaviours of agents induce patterns (Tukamuhabwa et al., 2015: 5616) and by figuring patterns of the industry, maritime business agents can able to sense and anticipate future of the whole system which increases organizational resilience. Such as, maritime crises are unpredictable but collective decisions of the system can be anticipated from order books of shipyards or current ship fleets of owners as the clues of maritime business patterns of industry.

The features of CAS and their contributions to organizational resilience philosophy from maritime business context could be seen from Table 12 as below:

Table 12: Alignment of Complex Adaptive System features with Organizational Resilience from Maritime Business Context

CAS Features (See Appendix 1)	CAS Feature's Contribution to Organizational Resilience Concept	Maritime Business Applications
Adaptive Capacity / Adaptation	Adaptation feature of CAS, gives capacity to agents of the system to re-calibrate fitness to co-evolve and handle environmental change and even improvise for new opportunities (Folke, 2006: 262;; Cunha and Cunha, 2006: 844; Amann, 2007: 236; Plummer & Armitage, 2007: 66; Arevalo & Espinosa, 2015: 24; Serrat, 2013: 2). It's about being ready without experiencing pre-adaptation process (Arevalo and Espinosa, 2015: 24). Also improvisation is another dimension of CAS adaptability that contributes on organizational resilience. Improvisation helps to interpret new opportunities while re-calibrating organizational fitness which involves "bricolage" understanding that solves problems with whatever resources are available (Cunha and Cunha, 2006: 844; Serrat, 2013: 2).	Such as through "trade deregulations" maritime business began to serve North-South markets beside the major East-West routes (Fremont, 2007: 431). Maritime business organizations have enlarged their business areas (Goulielmos, 2018: 105), new ports and new shipping networks have created (Ducruet and Notteboom, 2015: 145) hub and spoke networks were established (Fremont, 2007: 431), new bigger ships launched, integration of Organizations via strategic alliances/partnerships/mergers occur according to new developments (Caschili and Medda, 2012: 6; Panayides et al., 2012: 164; Moreira, 2013: 12).
Learning	Learning feature of CAS, contributes organizational resilience as one of the ways of learning occurs through interactions of agents in the system. The CAS feature of learning creates the understanding of living with unpredictability which requires past as a memory of the system (Berkes, 2007: 288). Building learning capacity (Mahona et al., 2008: 105) as in the CAS enables learning from past mistakes (Bristow and Healy, 2014: 94) which gives ability to grow. Systems through adaptation and learning build and sustain resilience (Folke et al., 2002: 439).	Maritime business agents could learn via feedbacks (Berkes, 2007: 284), interacting, monitoring or even by imitating each other (Scarsi: 2007, 577) that enables collecting precious information about other stakeholders of the system like customers, suppliers or authorities like IMO or port states to understand "ever-changing market situations" (Baird, 2012: 173). Such as, investing on new technologies due to other stakeholders do so; or because of to satisfy customer demand like new container tracking system (Mansouri et al., 2009: 1415) could be examples of the system-wide learning contribution of CAS.
Emergence	The emergence feature of CAS helps to understand that emergence is the output of the system; arises from local interaction of agents as a contribution to resilience philosophy where resilience seems as an emergent feature of the system (Allen and Holling, 2010: 2). Emergence feature cannot be prepared previously but evolve as collective consecutiveness of decisions (Erol et al., 2010: 305). Adding the characteristics of emergent feature of CAS helps to develop Organizational resilience (Burnard and Bhamra, 2011: 5584).	Such as maritime business stakeholders try to integrate emerging technologies (Review of Maritime Transport, 2017: xii) on their systems as new requirement of doing business like applications of big data, bitcoin, the Internet of Things (IoT), cloud technologies, RFID tags (Geissbauer et al., 2016; Kagermann, 2015)

Table 12 (Continued): Alignment of Complex Adaptive System features with Organizational Resilience from Maritime Business Context

CAS Features (See Appendix 1)	CAS Feature's Contribution to Organizational Resilience Concept	Maritime Business Applications
Co-evolution	The contribution of co-evolution feature of CAS to resilient philosophy comes from the understanding that evolution is the outcome of change that emerges from local interactions. While agents make new decisions through their benefits they also “co-create” their environment (Arevalo and Espinosa, 2015: 22).	In maritime business co-evolutionary change occurs through the decisions of maritime business stakeholders as the agents of the system. The increasing sizes of ships (Caschili and Medda, 2012: 10), supplying forward and backward logistics services of liner shipping companies or serving as a terminal operator under some agreements (Fremont, 2007: 431) could be all the examples of co-evolutionary resilience.
Requisite Variety / Diversity	It enables new opportunities to develop organizational resilience which is the main contribution of diversity feature. As a universal strategy, diversification creates new options to handle problems easily (Berkes, 2007: 289) which increase resilience capacity of the system. Diversity feature increases the adaptation and learning capability of the system (Folke et al., 2002: 438) especially in complex and turbulent environments (Marchand and Hykes, 2007: 159) as a key to Organizational resilience (Levin, 1998: 435). Diversity could be considered as the compass of the system that increases the fitness (Juarrero, 2011: 163).	Maritime business is consists of many stakeholders that generate a maritime system which is very significant to national economy (Mansouri et al., 2009: 1406). Maritime business includes different sectors with diverse agents such as port services, maritime supply and spare parts, maritime classification societies, educational institutions and many others who are ruled by national and international regulations (Caschili and Medda, 2012: 9). As the agents of CAS, those stakeholders create the non-linear relations while doing their business. Any problem belong any agent could cause a “ripple” effect which could spread to wider economy and induce significant disruptions (Berle et al. 2011: 698).
Interdependence/ Interconnectivity/ Interaction	As agents operate in the networks of relations that induce the resilience of one agent could affect the resilience of overall system. Each agent has its own significant existence on determining systems resilience (Yilmaz Borekci et al., 2015a: 6839). The resilience of each agent comes from the inter-relational dependencies that have potential to increase or decrease the survival of other agents. The resilience of the system comes from interdependencies of agents that evolve by adaptation and learning capacities while facing disruptions. Recognising those interdependencies give chance to manage the affection from others which increase the resilience capability (Nan and Sansavini, 2017: 35).	Maritime business comprise of diverse agents that interrelate in global business environment. To ensure long term survival, agents have to consider different factors while making decisions to manage these interdependencies (Pathak et al., 2007: 548). As an important resilience contributor, agents of the maritime business must be aware of those dependencies and relationships to increase survival chance and prosper (Yang and Hsu, 2018: 221). Maritime business agents use mergers / mega alliances / partnerships / vessel sharing agreements etc. where each of these relationships can increase organizational resilience but also should be managed in order not harm organizational survival.
Edge of Chaos/ Far from Equilibrium	CAS helps organizational resilience that system does not need to be at stable condition in order to be resilient (Coetzee et al., 2016: 197) but should be balance at the edge of chaos (Mason, 2007: 15). CAS approach proves that keeping system at the edge of chaos increase resilience capability. With the help of “strange attractors” (McMillan, 2008: 83) CAS can easily limit the boundary of system even unpredictability of system behaviour still exist.	CAS approach proves that keeping system at the edge of chaos increase resilience capability. With the help of “strange attractors” (McMillan, 2008: 83), CAS can easily limit the boundary of system even unpredictability of future still exist. Culture could be used as a strange attractor (Murphy, 1996: 98) as creating common values. Improvisation is also a good application for managers at the edge of chaos state which enables a balance between order and chaos (Mason, 2007: 15).

Table 12 (Continued): Alignment of Complex Adaptive System features with Organizational Resilience from Maritime Business Context

CAS Features (See Appendix 1)	CAS Feature's Contribution to Organizational Resilience Concept	Maritime Business Applications
Sensitivity to Initial Conditions	In CAS, sensitive dependence on initial conditions feature explains the butterfly effect which means any tiny local change or discrepancy can potentially give rise something unpredictable (McMillan, 2008: 97). CAS is strict to its initial condition which is the history of system (Chaffee and McNeill, 2007: 235). Even two agents have similar initial conditions the tiny difference from the beginning drive totally different paths then each other (Anderson, 1999: 217). That significant sensitivity on its own past is one of the features of CAS that leads system into chaos where also one makes some patterns obvious to deduce and anticipate (Murphy, 1996: 100) and increase the organizational resilience.	There is no “one-size-fits-all” recipe. Each agent is unique from the very beginning of the system that steers the future way. From each worker to each department; each unit give different responses to environment on their own way which gets its roots from their cultures and past (McMillan, 2008: 117).
Non-linearity	By following non-linear relationships, maritime business agents can easily understand that “as long as energy injected into system” all ways come into bifurcation point which is the time of transformation. Although it is impossible to know when and how transformation will happen, CAS lens offers “strange attractors” understanding as the only thing that suits in anticipating the system. Those attractors shape the boundaries of the change and keep it in a “basin” which helps maritime business agents to increase their organizational resilience (Bovaird, 2008: 322).	Such as by following new trends and market analysis, agents could easily figure out strange attractors of the system such as new cyber risks through increase digitalisation requirement of new world or using autonomous technology in shipping that leads to new emerging management applications (Marsh & McLennan, 2017: 9; Review of Maritime Transport, 2018: 15) or new applications of flag states which all help to shape and be ready to “fracture points” of future states.
Self-organising / Without Formal Control	Self-organization of the system proves that diverse agents of the system response to environmental changes (El-Ghalayini, 2017: 8) via non-linear relationships at the edge of chaos (Arevalo and Espinosa, 2015: 22). With the help of self-organising feature of CAS, resilience of the system possibly increased where resilient capacity is tightly related with systems self-organization (Berkes, 2007: 290). System which is capable of self-organising at the face of disruption and can build capacity for learning and adaptation can success (Mahona et al., 2008: 105).	Self-organising ability of maritime business agents/stakeholders belong the relations of “biotic and abiotic” elements of the system (Allen and Holling, 2010: 15). Maritime business agents could use shared principles and values in order to direct self-organization feature (Mahona et al., 2008: 107) like circulars, directions or policies. And also can apply new marketing tactics, new strategic alliances or develop new strategies to self-organise (Mason, 2007: 12) which increase organizational resilience.
Unpredictability	The unpredictability feature of CAS helps to increase organizational resilience by raising awareness of managers to figure out unpredictable future. Through offering some tools, CAS offers to increase organizational resilience; such as patterns or strange attractors (McMillan, 2008: 111).	Strange attractors are the boundary painters of systems which permits “change and order” at the same time; such as vision and values, customer relationship management activities or new market entry applications. Maritime business agents should empower their human resource capital through giving them clear and simple vision, tighten their customer relations via “voice of customer” applications or determine simple goals to serve new market (Mason, 2007: 13).

Table 12 (Continued): Alignment of Complex Adaptive System features with Organizational Resilience from Maritime Business Context

CAS Features (See Appendix 1)	CAS Feature's Contribution to Organizational Resilience Concept	Maritime Business Applications
Dynamism	CAS lens proves that industries show perpetual flux structures (Cunha and Cunha, 2006: 842). It is much better to evaluate situations and market dynamics to find alternative ways to cope with uncertainties (Mason, 2007: 11). Understanding evolving dynamics of industry (Erol et al., 2010: 305) helps to increase organizational resilience. Maritime business stakeholders as the agents of the system are interacting each other and with their environments. System-wide resilience emerges through these interactions and can only be evaluated through determining dynamic relations (Coetzee et al., 2016: 202).	Technological transformation from “embedded systems to cyber-physical systems” (Xu et al., 2018: 2941), new requirements of changing business environment that is triggered by changing customer demands (Jager et al., 2016: 119) and also sui-generis problems of industry such as talented seafarer shortages and gender diversity requirement of industry all proves dynamic structure of new business order. Playing its part as the enabler of sea-leg transporter, maritime business agents should aware of potential opportunities along with new and unforeseeable risks to increase their survival chance and to catch organizational prosper.
Feedback	CAS lens provides to increase organizational resilience via developing a new understanding rather than traditional linear management applications. This complex and uncertain environment requires new principles working around non-linear interactions shaping by feedback loops emerge as learning and adaptation. By applying this new principles, maritime business agents can create more resilient Organizations that are ready to change before it is necessary (Bristow and Healy, 2014: 101).	By developing IT systems and strong communication applications such as latest social media management applications of liner shipping companies; or via strengthen relations with the system itself, such as getting new membership according to organizational goals and benefits from any maritime association like Maritime Employers' Council (IMEC) or International Ship Suppliers and Service Association (ISSA); maritime business agents effectively develops feedback loops to increase Organizational resilience.
Simple Rules	Simple rules feature of CAS contributes development of organizational resilience by providing “minimal structures” viewpoint. Minimal structures enable few simple rules to coordinate system, empowers agents to give their own decisions, provide space for innovation and improvisation (Cunha and Cunha, 2006: 843). Simple rules easily learned and shared by agents which create adaptation of the system (Marchi et al., 2014: 451). Minimal structures enable rapid response (Cunha and Cunha, 2006: 843) which can be used as a tool that increases Organizational resilience of agents.	Minimal structures ease local rules of interaction that provides system-wide evolution (Bristow and Healy, 2014: 94). Maritime business agents can use minimal structure vision and create few simple rules by using culture, maritime traditions or organizational values (Mason, 2007: 15). Managers can create clear organizational identity and give simple goals to empower ship crew and ashore personnel, coordinate operations or create innovative organizations which all these applications help to increase organizational resilience.
Patterns / Iterations	With the help of patterns, CAS can able to anticipate and speculate alternative futures. Agents of the system can learn to follow and sense patterns (McMillan, 2008: 78) which make contribution on developing more resilient organizations. Anticipating and recognising patterns could increase abilities of agents for increasing their organizational resilience capacities (Lengnick-Hall et al., 2011: 253).	The holistic-collective behaviours of agents induce patterns (Tukamuhabwa et al., 2015: 5616) and by figuring patterns of the industry, maritime business agents can able to sense and anticipate future of the whole system which increases organizational resilience. Such as, maritime crises are unpredictable but collective decisions of the system can be anticipated from order books of shipyards or current ship fleets of owners as the clues of maritime business patterns of industry.

Inspired by: Choi et al. (2001: 358); Caschili and Medda (2012: 9); Aelker et al. (2013: 83); Tukamuhabwa et al. (2015: 22).

CHAPTER FIVE

ORGANIZATIONAL RESILIENCE IN MARITIME BUSINESS: A RESEARCH ON COMPLEX ADAPTIVE SYSTEMS APPROACH

5.1. PROBLEM AREA AND RESEARCH GAP

Business environments affected from disasters, globalization, short life of products, different technological developments or changeable customer preferences that induce complexity and uncertainty to organizational survival (Kamalahmadi and Parast, 2016: 116). 21st century requires connectedness between organizations and industries to gain organizational success where at the same time that connections is web of systems which causes a more fragile and sensitive global structures. These fragile bonds induce sensitive balance where any disruption can potentially turn on a system-wide calamity and becomes very difficult to anticipate the future (Morais-Storz and Nguyen, 2017: 99). The success of organizations to handle those problems and make necessary proper reactions is a “*strategic requirement to organizational survival*” (Carvalho, 2012a: 355).

Besides other managerial trends like risk management, business continuity management or probabilistic calculation methods; organizational literature borrows the concept of “*resilience*” which has been used by other disciplines (especially engineering, psychology and ecology sciences) for some time, to enable proper interpretation and anticipation of problems as a requirement of the dynamic organizational environment (Tamvakis and Xenidis, 2013: 340). Resilience thinking for management has arisen as an emerging framework which provides brief understanding for interactions and dynamic behaviour of systems (Plummer and Armitage, 2007: 64). Despite it is almost not possible to avoid all risks, resilience management enables talent to be ready for unforeseen outages and respond to them faster and more efficient way then the rivals do (Hohenstein et al., 2015: 91) and contributes to long-term organizational performance (Lam and Bai, 2016: 18). In highly volatile and uncertain business environment, maritime business organizations require new managerial ways since traditional ones

does not cover the solutions needed by today's developments. Developing resilient management thinking provides maritime organizations (Erol et al., 2010: 307):

- able to sense and prevent devastating event
- able to manage the consequences of devastating event
- able to recover from devastating event

As seen from the above, resilience concept provides the opportunity to resist and survive in the face of devastating events and offers proper solutions for maritime business organizations. But there are some gaps throughout the literature such as:

- Gap1- Organizational resilience studies are in their infant stage where maritime business context studies are relatively less and peculiarly well based maritime business resilience definition from organizational point of view is lacking.
- Gap2- Complex adaptive systems are partly worked from maritime business context where sector base analogy and its features have not been fully studied.
- Gap3- Researchers study and investigate resilience concept and apply to organizational studies and propose some features that help to increase/promote and develop resilience of systems. Although different cultural and industrial dynamics are important to identify and develop resilience capabilities; context dependent approach creates variety in organizational field but induce lack of consensus on evaluation and development of organizational resilience factors/enablers/features.

5.2. RESEARCH MOTIVATION AND AIM OF THE STUDY

With economic and social developments, globalized business environment along with introduction of new technologies; change becomes inevitable in customer preferences or the way of doing and operating maritime businesses (Dervitsiotis, 2004: 811). As the sea leg of global supply chains, maritime business involves many stakeholders where those players constitute a dynamic web of organizational and operational relations. In such cyclical and volatile business environment, maritime

industry could be identified as Complex Adaptive System (CAS) due to dynamic, emergent web of interdependent relations which show non-linear patterns. Especially after 1990 with growing appliance of merger and acquisitions (Fremont, 2007: 431) in maritime industry; CAS approach suits fit with the volatile and dynamic environment of the maritime industry because of explaining not just causal interactions of business relations but focus on dynamic co-evolution to understand and identify their development (El-Ghalayini, 2017: 7).

This study proposes that identifying maritime business as CAS offers new managerial understandings to realize current organizational situations like managers of maritime business organizations able to learn how to overcome with the uncertainty and changing conditions to evolve instantly and effectively; allows managers to understand that it is really difficult to control their system in this dynamic environment where special management practices required especially in volatile times rather than ordinary times. Also organizations could not compete as a sole organization but as a web/system of organizations.

According to Mahona et al. (2008, pp.104) “*an alternative way to dealing with complexity in systems rather than constructing tight control mechanisms is concentrating on resilience of systems.*” Organizations should focus on adaptation to changing conditions and difficult environmental situations in order to survive (Hulsmann et al., 2008: 14). Complex Adaptive Systems are more resilient than other systems because resilience is the emergent occurrence of the system formed from non-linear, dynamic interactions with self-organized agents (Tukamuhabwa et al., 2015: 5614). So main motivation of the study is:

- Managing and designing maritime organizations from CAS approach could enable more resilient organizational systems.

This thesis aims to suggest an organizational framework to show how maritime business organizations can develop resilient organizations via CAS approach if adequate design features of CAS could be defined and included into organizational properties. Because one of the alternative remedies to deal with risks and problems is to have settled

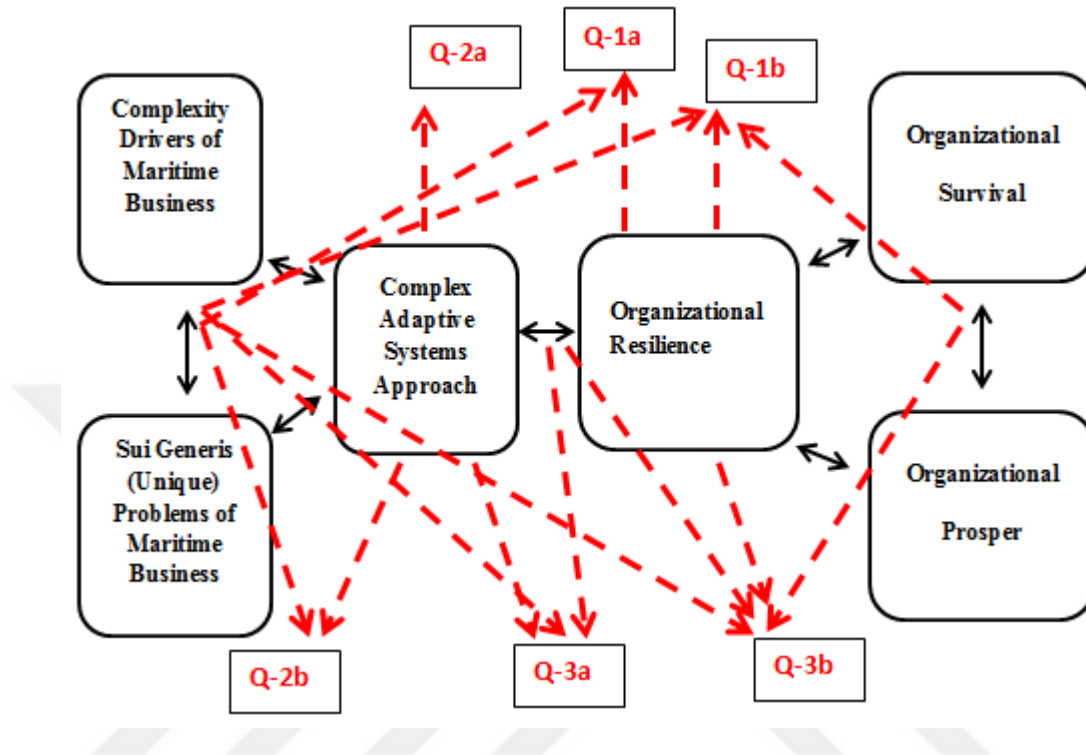
resiliency in the organizational design by adding some features into system where complex adaptive systems approach arise. Because maritime business is not just simply a system but should be consider as a complex adaptive system. To develop organizational resilience, this study proposes that maritime organizations need to take CAS approach. The goals of this study are:

1. To define organizational resilience for maritime business and to present the requirement of organizational resilience philosophy to address the Gap 1.
2. To figure out maritime business is a CAS to address the Gap 2.
3. To evaluate how complex adaptive systems approach can be applied to the maritime businesses to develop organizational resilience via adding proper CAS features into organizational properties in order to address the Gap 3.

5.3. CONCEPTUAL FRAMEWORK AND RESEARCH QUESTIONS

The main question of this study has already been asked at chapter two as: *“in such a volatile and competitive business environment how do some organizations succeed to overcome disruptions and problems while others fail?”* Organizational resilience could be one of the answers to that question. Disruptions and problems are burst in number and impact in the global business environment, affecting maritime business organizations’ daily operations and organizational survival. Therefore maritime business organizations’ should be resilient to confront their vulnerabilities, answer correctly in a timely manner to the adverse effects of disruptions. In order to develop organizational resilience of the system, alternative way to manage problems and risks is to have settled resiliency in the organizational design through adding some features into a system where complex adaptive systems approach arise. Thus maritime business is not just a system but should be considered as a complex adaptive system. If Figure 1 Model of Organizational Resilience through Complex Adaptive Systems Approach is tilted sideways and examined, Figure 12 arises as the conceptual framework and questions of thesis.

Figure 12: Conceptual Framework of Dissertation



Question 1a - What is maritime organizational resilience?

Question 1b - Why maritime organizations should be resilient?

Question 2a - What is complex adaptive systems approach?

Question 2b - How maritime business could define as CAS?

Question 3a - Does CAS approach helps to develop organizational resilience in maritime business? What are the main features of CAS approach that contributes to develop organizational resilience?

Question 3b - Which features of CAS as determined from literature could help to develop organizational resilience in maritime business? Which of these CAS features are the most effective that leads to other features while developing organizational resilience in maritime business?

5.4. ORIGINALITY OF THE STUDY

As seen from literature, abundance of methods and practices regarding enhancing and developing resilient organizations create diversity as well as complexity. The context dependent issues and solution proposals make it almost impossible to carry out repeatable or generalizable studies. Besides its suitability already, CAS approach offers new understanding for maritime businesses to figure out solutions that are compatible with the new requirements of the global and changing business environment. Although there are some studies used or recommend to use CAS approach as one of the applicable lenses for resilience studies like Tukamuhabwa et al., 2015, to the best of author's knowledge, no study has so far identified the features of CAS and use that features to develop organizational resilience. Also as seen from literature organizational resilience studies are rarely worked from maritime business context. This dissertation is one of the very first studies to define resilience in maritime business context from an organizational perspective with CAS lenses.

So the originality of the dissertation lies in three folds:

- First of all, organizational resilience definition revealed for maritime business.
- Secondly, the key and most used features of Complex Adaptive Systems are revealed from the literature in order to figure out if that features can be used in developing resilient maritime organizations.
- And finally determining which of these CAS features are the most effective to trigger other features in developing organizational resilience in maritime business.

5.5. SCOPE AND SAMPLE OF THE RESEARCH: BULK SHIPPING

Maritime transportation is one of the main vehicles of the global merchandise trade (imports and exports) as shown at Table 13 and carried millions tons of cargoes each year.

Table 13: “Global Merchandise Maritime Trade in Selected Years (Million tons)”

	Tanker Trade*	Main Bulks**	Other Dry Cargo***	Total (all cargoes)
2010	2752	2232	3423	8408
2011	2785	2364	3626	8775
2012	2840	2564	3791	9195
2013	2828	2734	3951	9513
2014	2825	2964	4054	9842
2015	2932	2930	4161	10.023
2016	3058	3009	4228	10.295
2017	3146	3151	4419	10.716
2018	3194	3210	4601	11.005

* Crude oil, refined petroleum products, gas and chemicals

** Phosphate, bauxite/alumina, iron ore, grain and coal

*** Minor bulks, containerized trade and residual general cargo

Source : UNCTAD (2019: 5).

As the main cargoes of carriage, tanker ships (crude oil/ refined petroleum products/ gas and chemicals), bulk carries (major bulk cargoes/ minor bulk cargoes) and container ships are the basic ship types.

Table 14: World Fleet by Ship Types (Thousand dead-weight tons)

Ship types	2018	2019
General cargo ships	73.951	74.000
Bulk carriers	818.921	842.438
Gas carriers	64.407	69.078
Container ships	253.275	265.668
Offshore vessels	78.269	80.453
Ferries & passenger ships	6.922	7.097
Oil tankers	562.035	567.533
Chemical tankers	44.457	46.297
Other/ not available	241.948	250.783
World total	1.926.183	1.976.491

(Oceangoing commercial ships of 100 tons and above)

Source: UNCTAD (2019: 29).

The scope of dissertation is determined as the “bulk shipping”. The reasons for this choice are several. Such as; if world fleet by ship types checked, according to dead weight tons at Table 14, it will be seen that bulk carriers have the highest rate.

According to Turkish Chamber of Shipping statistics at Table 15, it will be seen that bulk carriers have also the highest rate in total fleet regarding dead weight tons.

Table 15: Turkish Fleet by Ship Type (1000 GT and Over)

<i>Ship types</i>	<i>Number</i>	<i>Dead-weight tons</i>
Dry Cargo	141	739.404
Bulk Carrier	56	2.471.477
Container	49	1.041.029
Dry Cargo/Container	10	62.835
Chemical Tankers	54	531.182
Lpg Tankers	5	27.804
Asphalt Tankers	4	57.620
Ro-Ro Ships	18	195.680
Ro-Ro-Ferry/Passenger	17	27.790
Ferry Boats	29	22.186
Train Ferries	6	2.960
Passenger & Cargo Ships	9	7.227
Fishing Boats	2	569
Scientific Research Vessel	6	7.780
Harbour Ferries	1	0
Harbour Car Ferries	6	1.974
Tugs	1	0
Service Ships	44	86.454
Oil Tankers	22	1.423.480
Train Ferries/Ro-Ro	1	6.266
Dry Cargo/Ro-Ro	6	87.637
Marine Vehicles	29	13.686
TOTAL	516	6.815.040

Source: Turkish Chamber of Shipping (2020: 5).

Also according to Turkish Shipowner Association (TSA 2019), bulk ships have the highest percentage according to dead weight tons as seen at Table 16.

Table 16: Turkish Fleet Percentage by Ship Type (300 GT and Over)

<i>Ship types</i>	<i>DWT</i>	<i>Number</i>
Bulk carriers	% 49	% 15.6
Oil tankers	% 17	% 6.3
General cargo ships	% 12	% 33.8
Chemical tankers	% 8	% 12.3
Container ships	% 8	% 4.7
LNG Carriers	% 1	% 0.7
Ro-Ro	% 1	% 1.8

Source: Turkish Shipowner Association (2019:7).

Also as shown at chapter 3, with all markets and stakeholders, maritime industry has the characteristics of Complex Adaptive System rather than a system. Especially bulk shipping has distinctive features where its own characteristics show CAS properties very clearly, such as:

- Bulk shipping is the one of the real-world examples of perfect competition where freight rates are “*emerged*” and determined by market itself and accepted by the parties (Goulielmos, 2017: 1214).
- In addition, shipowner organizations are often run by families who are influenced by their relatives/competitors and exhibit imitative behaviours, just like the massive investments made to order the largest ship (Scarsi, 2007: 581), which shows “*self-organization*” of agents according to other agents and market, where also system-wide “*co-evolution*” occur.
- Developing and enabling resilient bulk shipowner organizations are important due to any disruption regarding main bulk goods affect societies and many other industries since the area of the negative impact will be global (Comtois and Lacoste, 2012: 222).

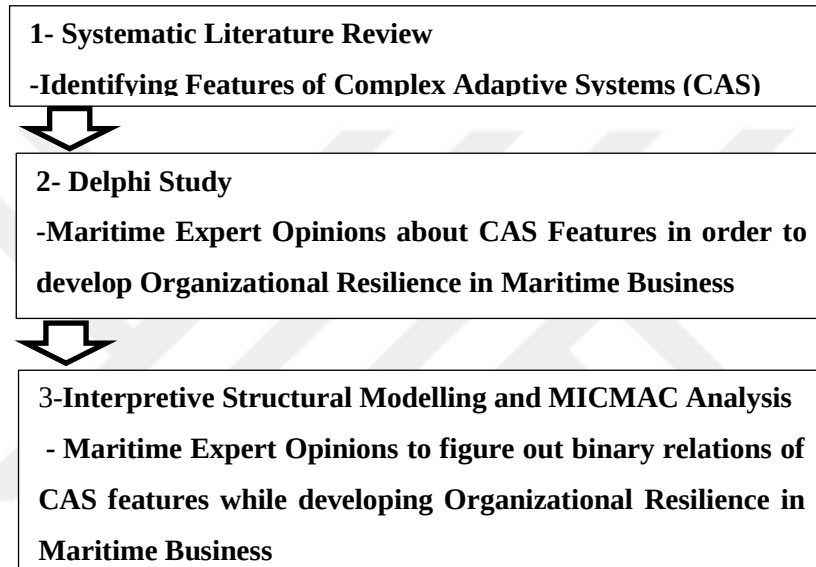
Due to their deciding authorities in the operation and administration of ships, shipowner organizations have important managerial effects on global trade. So considering its proportional significance of bulk carriers in global maritime transportation and in Turkish fleet, the scope of dissertation has been decided as Bulk Shipowner Organizations.

5.6. METHODOLOGY OF THE STUDY

After determining the enablers/elements/features of CAS from literature; this study searches the applicability of mentioned features to develop organizational resilience from maritime business context in the light of research questions. To figure out and address the questions; study applies hybrid group decision-making approach, followed the guidance of Agarwal et al. (2020), which consists of Delphi Technique and Interpretive Structural Modelling. As an integrative approach, mentioned methods

provide aspects from all angles of a research problem rather than using stand-alone approaches (Creswell, 2013: 42) which creates generalizability, diversity and better understanding (Molina-Azorin, 2018: 182). The process of research could be seen from Figure 13 as below.

Figure 13: Research Process of Dissertation



5.6.1. Research Paradigm, Methods and Rigor of Study

The concept of “paradigm” goes back from the late 18th century, Georg Christoph Lichtenberg to early 20th century Ludwig Wittgenstein. But concept gets its popularity with the “The Structure of Scientific Revolutions” book of Kuhn where he used paradigm as “*a model of scientific practice*” (Wendel, 2008: 133). In their four paradigms for the analysis of Social theory, Burrell and Morgan (1979) comprise two dimensions which are “*the sociology of regulation*” and “*the sociology of radical change*” and “*objective and subjective*” approaches. According to their classification, this study follows “*functionalist*” paradigm. As “*functionalist paradigm*” sees the world at the balance between order and disorder where identify society as stable. Even though CAS approach is on the opposite side of Newtonian mechanism; approach defends agents stand at far-from-equilibrium state where chaos and order co-exist, as explained

at Chapter 1. CAS proposes stability and instability, order and chaos happen at the same time. Also according to Leblebici (2008) roots of CAS such as systems approach, cybernetics, population ecology, organizational flux and transformation also state under the functionalist paradigm. As seen from process of dissertation at Figure 13, qualitative scientific research design has preferred in this study. The fact that concept of organizational resilience and the complex adaptive systems approach, as the focus of the research, are not analysed in depth in the context of maritime business has influence the preference of such a research design. As the intent of qualitative research is to understand a particular situation; study can be describe as descriptive portrait which uses metaphors and analogies (Creswell, 2013: 330).

According to Burrell and Morgan (1979), scientific nature of the research consists of *Ontological*, *Epistemological*, *Methodological* and *Human Nature*. In the guidance of schema to analyse the nature of research, the assumption of this study are as below:

“*Ontological Assumptions*” of the dissertation states under the “*Realism*” lens. According to this study there is existing problems faced by organizations out there where the reality could be investigated. Also CAS approach suits well with the existing reality out maritime organizations.

“*Epistemological Assumptions*” of the dissertation states under the “*Positivism*” lens. Although CAS assumes that predicting the future is difficult, also admits that it is not impossible to anticipate it by proper ways. CAS offers with the right managerial applications such as by observing schemas and patterns of the system, future could still be managed.

“*Human Nature Assumptions*” of the dissertation states under the “*Determinism*” lens. Despite CAS assumes non-linear relations do not follow cause and effect law, systems follow deterministic way where initial conditions play an important part for the rest of the system.

“*Methodological Assumptions*” of the dissertation states under the “*Nomothetic*” lens. Methodology of the research contains methods and philosophy of the research. As the Nomothetic approach intends general laws and methodology; this study follows

systematic protocols as seen at Figure 13. Whether qualitative or quantitative research design used, following structural research steps are important in nomothetic methodology (Burrell and Morgan, 1979: 8).

According to Creswell (2013), validity of the qualitative studies could be named as “*trustworthiness, authenticity and credibility*” where reliability named as “*consistent and stable*.”

The reliability of SLR belong the consistency of the research where inclusion and exclusion criteria enable the stability of the research findings (Creswell, 2013: 326). The validity of the Systematic Literature Review belongs to the ability of the research to explore all relevant studies. With the help of inclusion and exclusion criteria this dissertation provides the validity of SLR method. As an internal validity PRISMA flowchart is free from methodological biases and as an external validity (Bettany-Saltikov, 2012:65) findings of the PRISMA flowchart are generalizable.

The reliability of *Delphi technique* enhance through interactive nature of the approach with avoidance of group bias. As divided into external and internal validity, Delphi technique has accepted as a valid method among researchers due to generalizability of the findings and confidence placed in the cause and effect relationship (Hasson Keeney, 2011: 1695). The validity of the judgments of the expert opinions belong "degree of consensus" among participants (Mitroff and Turoff, 2002: 22). Also heterogeneity of the participants enables the validity of the results (Linstone and Turoff, 2002: 4). The validity of Delphi research provide by consulting on opinions of Bulk Shipowner Organizations as the maritime experts. Also heterogeneity of the experts according to different organizational departments as Technical, Operation and Crew provides the validity of the Delphi results.

The validity and reliability of Interpretive Structural Modelling (ISM) are also two important subjects that determine the rigor and effectiveness of the study. Reliability of ISM can be provided by reaching through systematic steps of the method which enables study's operations can be repeated (Thakkar et al., 2008: 117). Also avoiding bias decision of the participants helps to increase reliability of the developed model (Agarwal et al., 2020: 3). This study uses systematic steps to provide reliability of ISM

method. Also validity of ISM method used by this study is enhanced by reviewing CAS literature and organizational resilience literature properly. Also applying judgments of maritime experts in a most systematically helps to increase validity of the ISM method in this dissertation.

5.6.2. Systematic Literature Review (SLR)

A literature review is a structured way of searching a chosen topic by applying critical thinking (Machi and McEvoy, 2016: 29). Literature reviews enables researchers to educate themselves regarding searching subject (Denney and Tewksbury, 2013: 219). There are types of literature review like narrative, systematic, descriptive and integrative (Pautasso, 2013: 2) where this study uses systematic literature review to search and understand the subject as it is the approach that best fits the needs of the dissertation. Systematic literature review (SLR) emerges in medical science (Snyder, 2019: 334) and transform from QUORUM as “*Quality of Reporting of Meta-analysis*” to PRISMA model (Kraus et al., 2020: 1024). “*PRISMA*” model as “*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*” is developed by an international network of healthcare-based collaborators in order to strength rigor and quality of the systematic literature reviews (Pati and Lorusso, 2018: 17). SLR is the summary of literature according to one research question. The aim of the systematic literature review is to “*identify, select, appraise and synthesize*” all proper quality papers within literature so as to respond research question of the study that is based on a peer review protocol (Bettany-Saltikov, 2012:5). There are many advantages of SLR studies like enabling structural searching steps, limit individual studies’ biases and their ability to combine outcomes from other studies. Systematic literature reviews help to understand research subject transparently (Tian et al., 2018: 1090) rather than traditional searching and provides wide and accurate search opportunity (Pati and Lorusso, 2018: 16). SLR offers more structured search opportunities for reviewers, enables searching steps to follow in order to receive trustable findings (Wright et al., 2007: 24). According to Moher et al (2010) Systematic reviews and meta-analyses could follow a statement that consists of 27-item checklist and a four-round flow diagram (Table 17) to enhance the conducting

of systematic reviews and meta-analyses. Research protocol and Analysis of Research Findings created according to recommendation of the mentioned 27-item checklist as follows.

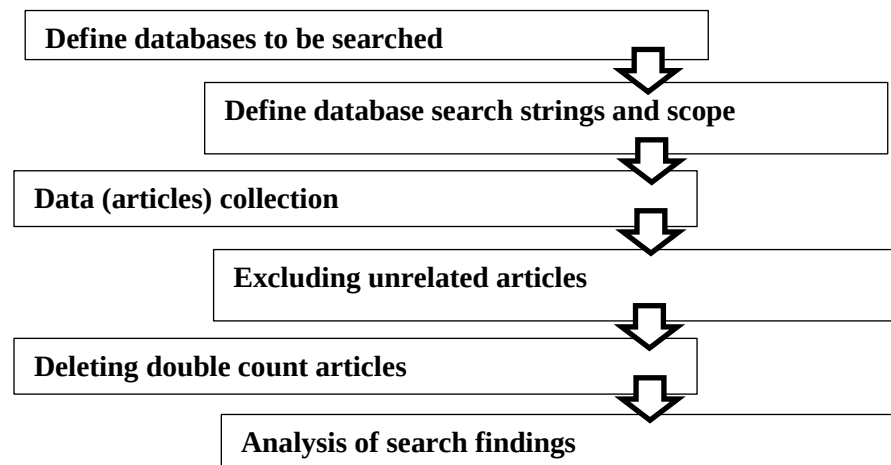
5.6.2.1. Research Protocol of Systematic Literature Review

Question 3a of the dissertation consists of two parts and the SLR research conducted to figure out the second part of the question as:

Question 3a – What are the main features of CAS approach that contributes to develop organizational resilience?

To search the answer, this study applies SLR research to follow the literature and figure out the relationship between organizational resilience studies and CAS approach. Research articles are searched by using Web of Science (WOS) and Scopus, as the most relevant abstract and citation databases that provide peer-reviewed literature data for many different academic disciplines (Tian et al., 2018: 1093) at 21.09.2020. The SLR steps followed by this study are figured as below:

Figure 14: Steps of Systematic Literature Review (SLR)



Source: Taklo et al (2020:9).

Eligible Studies: Inclusion and Exclusion Criteria

After formulating a list of objectives of the study, deciding unbiased inclusion and exclusion criteria has shown among the most important steps of SLR. Inclusion and Exclusion Criteria provide the eligibility of the study which enhance the quality of the

research and clearly define the certain boundaries of the review (Siddaway, 2014: 2). To define the boundaries of SLR, Inclusion Criteria and Exclusion Criteria are set as follows:

Inclusion Criteria

- As explained at chapter 2, organizational resilience concept is the common term used by most of the studies but literature also uses “business resilience” and “enterprise resilience” too. For the sake of research propose, the mentioned keywords are included into search string and used as ("organiza* resilience") OR ("business resilience") OR ("enterprise resilience").
- Also “*” sign used in order to include potential variations of organization such as organizational or organizing.
- Research process consists of analysing the title, research issues, abstract and keywords in peer-reviewed articles in English without time limitation.
- Selected papers are opened via “Kopernio Locker” of Web of Science which enables the best version of papers.

Exclusion Criteria

- Research topic and scope not directly related to the research question.
- Concepts and terms are not directly related to the research questions.
- Book chapters, book reviews, editorials and conference papers

The flowchart of the PRISMA model used by study could be seen at Table 17 as below:

Table 17: PRISMA flowchart of Dissertation

	SEARCH STRING	Timespan (1945- 21.09.2020)	WOS (number of articles)	SCOPUS (number of articles)
Identification	resilience (TITLE-ABS-KEY)	All years	96.004	102.261
	(Search within results) "organiza* resilience" OR "business resilience" OR "enterprise resilience"	All years	103	451
Screening				
Eligibility	(Search within results) "complex adaptive systems" OR CAS	All years	2	31
Included	included peer-review articles and review papers in English Excluded conference papers and book chapters	All years	1	21
	After abstract checking	All years	1	5
	After Removing Duplicates	<u>Total Papers: # 5</u>		

5.6.2.2. Analysis of Research Findings of Systematic Literature Review

Systematic literature review conducted to explore most common features/elements/characteristics of Complex Adaptive Systems to develop organizational resilience. Total five papers determined by Systematic literature review process as below:

Table 18: Articles of SLR Research

	Authors	Publication Name	Journal
1	Winnard et al. (2013)	Surviving or flourishing? Integrating business resilience and sustainability	Journal of Strategy and Management
2	Tukamuhabwa et al. (2015)	Supply chain resilience: definition, review and theoretical foundations for further study	International Journal of Production Research
3	Zio (2016)	Challenges in the vulnerability and risk analysis of critical infrastructures	Reliability Engineering and System Safety
4	Fraccascia et al. (2018)	Resilience of Complex Systems: State of the Art and Directions for Future Research	Hindawi Complexity
5	Van der Merwe et al. (2018)	A framework for conceptualizing and assessing the resilience of essential services produced by socio-technical systems	Ecology and Society

Source: Compiled by Author

From above mentioned review process, one duplicate paper in both research bases is the study of Winnard, Adcroft, Lee and Skipp (2013). In their valuable study, they integrate sustainability and resilience concepts from multidisciplinary approach and treat businesses as complex adaptive systems. Tukamuhabwa, Stevenson, Busby and Zorzini (2015) conduct systematic research on supply chain resilience and propose CAS as a proper lens to study supply chain resilience. Zio (2016) identifies critical infrastructure as complex systems and tries to analyse vulnerabilities to assess resilience. Zio identifies features of those systems from complex adaptive systems perspective even not uses the concept solely. Van der Merwe, Biggs, and Preiser (2018) offer a framework in order to asses and conceptualize resilience of socio-technical systems which produce essential services. According to their study, they conceptualize socio-technical systems as complex adaptive systems and propose that resilience is the innate ability of them. Fraccascia, Giannoccaro, and Albino (2018) conduct a comprehensive systematic literature review regarding the resilience of complex systems and analyse 154

papers. Even though the study uses complex systems concept, they refer complex adaptive systems specialities. They identify dimensions of resilience according to scientific disciplines in which features under *Management* topic has used in this study.

As the number of identified papers are relatively exiguous to evaluate and decide the common features of CAS, Tsiulin et al. (2020) advices “*snowball search*” method which guides additional search process through the references of chosen articles. So by checking the references of above mentioned papers, additional articles are examined. By courtesy of systematic literature review and the references of those studies, Appendix 1 has revealed as the most common features of CAS.

5.6.3. Delphi Research

As the second qualitative method of study, Delphi research has conducted. The Delphi method, usually called as *technique*, was named a future predictor Ancient Greek oracle and used by many different scientific disciplines like biological science, engineering, business and economics and health care (Thangaratinam and Redman, 2005: 120). As a structured approach Delphi technique collects knowledge of the participants under a democratic and anonymous manner and enables objectivity and independent attendance by averting bias in group-think (Foster et al., 2020: 3). Under iterative process, the participants share their knowledge and judgments anonymously by getting feedbacks. As a well suited research instrument, Delphi method is appropriate where there is incomplete knowledge about a subject where the aim of the research is to ensure the conception of subject issue or to gather forecast of participants (Skulmoski et al., 2007: 2).

In addition to the classic-type Delphi, different varieties emerged over time like the Ranking-type Delphi, Decision Delphi and Policy Delphi. Although they have common points in practice like iterative process or feedback, they differentiate in their goals and application lenses. Such as: the goal of Policy Delphi is to define and differentiate views regarding the subject issue while the aim of Decision type Delphi is to prepare and support decisions. The aim of Ranking-type Delphi is to identify and rank key issues about research subject while so the classical one tries to reach consensus on

the issue (Parea et al., 2013: 208). In the light of research aim and goals, this study chooses to use Classical type Delphi technique.

The Classical Delphi Technique

The classical Delphi method arose during the U.S. sponsored military project by “Norman Dalkey of the RAND Corporation” around 1950s. Other than workshops or focus groups, Delphi Technique is used to gather expert opinions from iterative process via anonymous manner to reach a consensus on the subject under investigation where the personal judgment of participants can enable as a common solution to solve research question (Foster et al., 2020: 3). The purpose of Delphi Technique is reaching consensus rather than reaching agreement (Heuzenroeder et al., 2020:3). Besides the suitability to research question, Delphi Method offer many advantages for this study like ensuring judgmental inputs for the uncertainties, providing time and cost opportunities throughout the process and procuring comfort to evaluate to respondents (Avella, 2016: 315).

The classical type of Delphi Technique has chosen to gather Maritime Expert Opinions about CAS Features in order to develop Organizational Resilience in Maritime Business. Delphi method seems the most proper way to collect consensus on proper CAS features from maritime business context. As the important steps of the process, population and the sampling of maritime experts, data collection and analysis of the Delphi methods are as follows.

5.6.3.1. Population and the Sampling of Delphi Research

As the scope of dissertation comprises the bulk shipowners in Turkey, the population of Delphi method consists of managers of Turkish bulk shipowner organizations as the participants, in order to gather expert opinion to reach consensus on proper CAS features from maritime business context. Applying Delphi technique to participants has no strict rules where participant numbers varied from 10 to 18 experts (Goluchowicz and Blind, 2011: 1530), 8 to 16 (Hallowell and Gambatese, 2010: 103) 10 to 100 (Avella, 2016: 308) or 7 to 1000 (Iqbal and Pison-Young, 2009: 599) where

Hallowell and Gambatese (2010, pp. 103) indicate that there is no correlation between effectiveness of Delphi study and the number of panel experts.

In this study, the purposive sampling method used to determine participants for the Delphi study. Since the aim of the research is to suggest an organizational framework to show how maritime business organizations can develop resilient organizations via CAS approach; participants are determined from resilient Turkish bulk shipowner organizations managers intentionally. Although the proposal of the study is to show CAS approach as the most suitable way to develop organizational resilience, the process works backwards via to ask resilient organizations in order to evaluate each CAS feature whether appropriate to develop organizational resilience.

Despite organizational resilience is hard to measure or evaluate; “*organizational survival may be the proof*” (Winnard et al., 2013: 305) to determine most resilient Turkish Bulk Shipowners. As a cyclical business environment, maritime business cycles offer good way to determine resilient maritime organizations. As the 2008 financial crisis causes serious consequences to bulk shipping market (Yin et al., 2019: 330) sample of the study has chosen within organizations survive from 2008 maritime crisis as the inclusion criteria of Delphi population and sampling.

The population of the study determined from the member list of Turkish Shipowners Association that is accessed at 17.10.2020 which could be seen at Appendix 3. Membership list contains 123 members such as brokers, shipowners (container/ chemical/ oil/ general cargo/multi-purpose/ bulk), ship suppliers, forwarders and port authorities. As seen from the member list, some organizations are on the list with their subsidiaries and divisions which causes them to take multiple places. To avoid this confusion their affiliates are excluded from the population of the Delphi study and total 25 bulk shipowner organizations are reached. 6 bulk shipowner organizations that operate with coaster ships and 6 bulk shipowner organizations that established in 2008 and after are also excluded from the population of the Delphi study according to purposive sampling and inclusion criteria.

In the light of the aim of the study, bulk shipowner organizations that established before 2008 are included into the population of the study as seen below.

Table 19: Population of Delphi Research

	Bulk Shipowner Organizations	Established
1	Shipowner A	1954
2	Shipowner B	1955
3	Shipowner C	1959
4	Shipowner D	1967
5	Shipowner E	1968
6	Shipowner F	1975
7	Shipowner G	1978
8	Shipowner H	1980
9	Shipowner I	1990
10	Shipowner J	1993
11	Shipowner K	1995
12	Shipowner L	1999
13	Shipowner M	2000

5.6.3.2. Data Collection Process for Delphi Research

After deciding the sampling of Delphi research according to the goals of dissertation; the next step is to determine the structure of the study which includes rounds and time frame. Classical Delphi rounds are organized according to reaching a consensus on research subject between 2 rounds to 4 rounds. The first round of Classical Delphi consists of unstructured-open ended questions to gather the ideas of panellists about the subject where second & third rounds follow structured questionnaires. In Modified Delphi design, the process starts with round two where *“researchers not carry out the expert panel to generate answers to the round 1 question(s)”* (Avella, 2016: 312). According to Iqbal and Pipon-Young (2009) two-round Delphi is *appropriate when there is a “clear literature base”*. Modified Delphi design can be applied *“when a study has an advanced starting point”* (Heuzenroeder et al., 2020:3). For example, Boendermaker et al. (2003) apply a modified Delphi research where 43 characteristics of a competent GP-trainer were identified from earlier conducted focus group study and perform two rounds of the Delphi procedure.

Petry et al. (2007) design two round Delphi regarding people with multiple disabilities and prepare first round questionnaire from the literature variables. Kermanshachi et al. (2016) apply two rounds Delphi and ask participants about pre-

determined 38 complexity indicators regarding construction complexity issues. Peixoto et al. (2017) search on adoption of discount and outlet e-commerce platforms on two round Delphi study where variables collected from literature and presenting to the experts via structured questionnaire. Fink-Hafner et al. (2019) apply two round Delphi research on globalisation, internationalisation and Europeanization where preparatory round begins with literature review variables. With the help of SLR, this study has clear literature base and two-round Classical Delphi design conducted to reach a consensus regarding features of CAS to develop resilient organizations.

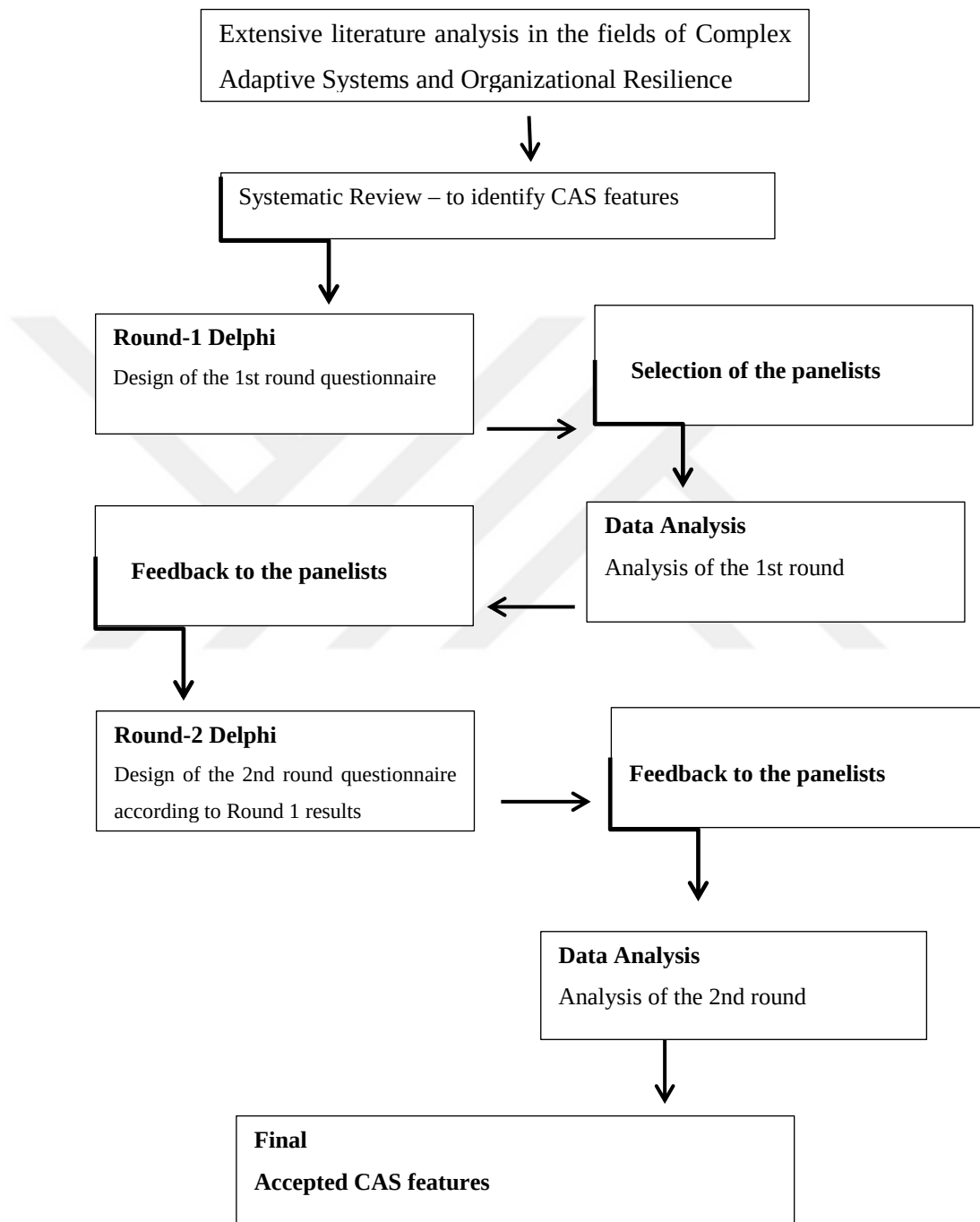
5.6.3.2.1. Consensus Criterion

The consensus criterion determination is necessary step in a Delphi design process. Despite universally agreed consensus rate does not exist for the Delphi design (Hasson et al., 2000: 1011), there are some rates used by researchers. According to Avella (2016) consensus range varies 55 % to 100 % which 70 % is the standard rate to apply. In their study Peixoto et al. (2017) use 80% as the barrier limit for consensus, Boendermaker et al. (2003) apply 80% as criterion for majority agreement, Petry et al. (2007) determine the cut-off point for consensus as 80%, Wilson et al. (2012) consider 75% as criterion rate, (Heuzenroeder et al. (2020) define 70% as consensus agreement rate. According to Gracht (2012) “Average Percentage of Majority Opinions (APMO) Cut off Rate” is a consensus tool used for the consensus measurement in Delphi research which is calculated via

$$“APMO” = \frac{“Majority of agreements + Majority of disagreements”}{“Total opinions expressed”} \times 100\%$$

So this study chooses to apply APMO cut off rate in order to determine consensus rate. The Delphi process figured as below:

Figure 15: Delphi Design Process



5.6.3.2.2. Delphi Questionnaire Development

The Delphi Questionnaire development process started with the features of CAS as revealed at Appendix 1. The questions set according to figure out if mentioned features could be proper to explain and examine situations in maritime business. After the questionnaire prepared, four pilot tests were conducted between 23.10.2020 - 04.11.2020 as three of them with academicians and one of them with Crew Manager who works at one of the Bulk Shipowner Organizations determined among sample businesses. After pilot tests, all amendments done and the final version of the questionnaire revealed which can be seen at Appendix 4.

5.6.3.3. Data Analysis of Delphi Research

In this study two-round Delphi research applied. Analysis of the Delphi research could be seen as follows.

5.6.3.3.1. Profile of the Respondents

As stated, 13 Bulk Shipowner organizations, established before 2008, determined from the membership list of Turkish Shipowners Association. Organizations are shown with letters in the alphabet as organizations request their identity to remain anonymous. 6 of the determined businesses could not be reached which are Shipowner B, Shipowner E, Shipowner J, Shipowner G, Shipowner L, and Shipowner M. The rest of the 7 determined businesses accepted to participate into Delphi research of this study. With the recommendations of the organizations participating in the research; 4 different and new Bulk Shipowner Organizations that established before 2008 were included in the study. The newly included entities received the letters N, X, Y and Z.

This study has been applied to the maritime experts to benefit from their experience. Shipowner Organization Y joined with three different department managers. Thus, the total 11 different Bulk Shipowner Organizations with 13 maritime experts participate the study. The profiles of the experts are seen at Table 20.

Table 20: Profiles of the Respondents

	Respondent	Department	Experience in Maritime Business	Bulk Shipowner Organization - Established
1	Maritime Expert A	Operation Manager	4 years	Shipowner A-1954
2	Maritime Expert C	Crew Manager	34 years	Shipowner C-1959
3	Maritime Expert D	Crew Dept.Officer	11 years	Shipowner D-1967
4	Maritime Expert F	Technical Dept./ Superintendent	13 years	Shipowner F-1975
5	Maritime Expert H	Crew Manager	9 years	Shipowner H-1980
6	Maritime Expert I	Crew Manager	32 years	Shipowner I-1990
7	Maritime Expert K	Technical Dept./ Superintendent	17 years	Shipowner K-1995
8	Maritime Expert N	Crew Manager	20 years	Shipowner N-1980
9	Maritime Expert X	Crew Manager	22 years	Shipowner X-1976
10	Maritime Expert Y1	Technical Manager	22 years	Shipowner Y-1984
11	Maritime Expert Y2	Operation Manager	23 years	Shipowner Y-1984
12	Maritime Expert Y3	Crew Manager	24 years	Shipowner Y-1984
13	Maritime Expert Z	Crew Manager	22 years	Shipowner Z-2005

Delphi questionnaire has been sent via e-mail to each manager's mail address and answers gathered between 05.11.2020 - 18.11.2020.

5.6.3.3.2. Analysis of the First Round Delphi Research

As stated before started, a telephone interview has carried with Manager Z approximately 50 minutes in order to make necessary amendments in the questionnaire form to revise all incomprehensible items as a part of pilot study. So 13 experts' answers included and evaluated into first round of Delphi Research. After receiving answers from participants of the Bulk Shipowner Organizations, each answer entered into an excel sheet to analyse. The cut off rate of the Delphi Research has been calculated according to APMO.

The APMO cut off rate calculated and examined for each statement, where the answers are marked as agree, disagree and without comment.

Table 21: First Round Delphi Results

	First Round Delphi Questions	A*	D**	N***	Consensus Rate
1	The presence of adaptability feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity
2	The presence of learning feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity
3	The presence of emergence feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity
4	The presence of co-evolution feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity
5	The presence of diversity feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	9	3	1	69% Rejection
6	The presence of interaction feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity
7	The presence of self-organizing feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	10	3	-	77% Rejection
8	The presence of far from equilibrium feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	10	1	2	77% Rejection
9	The presence of sensitivity to initial conditions feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity
10	The presence of non-linearity feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	9	3	1	69% Rejection
11	The presence of dynamism feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity
12	The presence of unpredictability feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity
13	The presence of feedback feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity
14	The presence of simple rules feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity
15	The presence of patterns feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity

A*= Agreed; D**=Disagreed; N***=Unable to Comment

The opinions stating that they agree and the ideas that they disagree are collected. Then this sum of agreed and disagreed opinions were then divided by the sum of all the opinions expressed by the panel members, including the non-commentaries and the percentage were calculated to arrive at the overall rate of consensus. The total of all the opinions expressed by the panel members to the 15 statements created in the first round of the Delphi were 195. The total opinions stating that they agree with study were 181, the total of the opinions stating that they disagree were 10 and the total of the opinions stating that they were unable to comment were 4. As a result, first round APMO cut off rate stated as 97% and according to analyse results, seen at Table 20 and 11 CAS features accepted at the end of the first round.

$$\text{APMO} = \frac{181 + 10}{195} \times 100\% = 97\%$$

The Views and Comments about four features that could not reach a Consensus by Maritime Experts at first round of the Delphi Research are as below:

Diversity feature reached 69% consensus rate; not accepted at first round of the Delphi study. One expert had no comment where three experts indicated the disagreement. For example:

Maritime Expert H stated as: *“I prefer controlled continuity rather than diversity.”*

Maritime Expert I stated as: *“It could be better option with the personnel who had a marine origin.”*

Self-organizing feature reached 77% consensus rate and not accepted at first round of the Delphi study. Three experts indicated the disagreement. For example:

Maritime Expert X stated as: *“not only the organization but also suppliers of the company could have mentioned characteristics where organizations should benefit from the experiences in the sector.”*

Far from equilibrium feature reached 77% consensus rate and not accepted at first round of the Delphi study. Two experts had no comment where one expert indicated the disagreement. For example:

Maritime Expert C stated as: *“That feature could prevent organization from having a unique attitude.”*

Non-linearity feature reached 69% consensus rate and not accepted at first round of the Delphi study. One expert had no comment where three experts indicated the disagreement. For example:

Maritime Expert Z stated as: *“Organizations should have a clear stance in his approach to events in order not to be affected.”*

Those 4 statements were re-examined at round two as follows.

5.6.3.3.3. Analysis of the Second Round Delphi Research

The same 13 manager from whom we received expert opinions at 1st round were participated in the 2nd round of Delphi study to re-examine four unaccepted CAS features. Second Round Questionnaire could be seen at Appendix 5. Second Round Delphi questionnaire has been sent via e-mail to each manager’s mail address and answers gathered between 24.11.2020 - 05.12.2020.

In order to make a clear understanding, statements have reconstructed and examples given have expanded. The total of all the opinions expressed by the panel members to the 4 statements created at second round were 52. The total opinions stating that they agree with study were 52, the total of the opinions stating that they disagree were 0 and the total of the opinions stating that they were unable to comment were 0. Analyse results of second round could be seen at Table 22 as below.

Table 22: Second Round Delphi Results

	2.Round Delphi Questions	A*	D**	N***	Consensus Rate
1	The survival and adaptation of an organization happens when the internal diversity of the system matches the environmental diversity of the system. The diversity feature creates new and different options for maritime businesses to solve problems and disruptions. The presence of Diversity feature within Maritime Businesses features ensures the development of organizational resilience and its continuity.	13	-	-	100% Unanimity
2	The self-organizing feature allows maritime businesses to determine their status based on feedback from environmental changes and interactions with other stakeholders. Businesses that regulate themselves individually with these notifications can self-organize themselves. The presence of self-organizing feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity
3	Being far from equilibrium in the global world means being between order and disorder. This feature creates a state of balanced imbalance in maritime businesses in which innovation, learning and adaptation to survive organizationally. The presence of far from equilibrium feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity
4	In the global world, non-linearity means that small inputs cause big results and big inputs cause small results in maritime businesses. In an environment where interactions are shaped by feedback, a small change can significantly change the entire system. The presence of non-linearity feature within Maritime Businesses features ensures the development of organizational resilience and its continuity	13	-	-	100% Unanimity

A= Agreed; D**=Disagreed; N***=Unable to Comment*

To sum up; throughout the Delphi study that was conducted as two rounds, 13 maritime experts, who work for a bulk ship owner organization, evaluated and accepted 11 CAS features within 15 CAS features to ensure the development of organizational resilience and its continuity at the end of the first round. The 4 CAS features, which

were not accepted at the end of the first round, were re-stated at the second round in order to remove the incomprehensible sides to enable clear understanding.

Question 3b of the dissertation consists of two parts and The Delphi research conducted to figure out the first part of the question as:

Question 3b - Which features of CAS as determined from literature could help to develop organizational resilience in maritime business?

To search the answer, this study applies Delphi Research which proves that 15 CAS features can be useful as the enablers of organizational resilience in maritime business according to maritime expert opinions. Thus, 15 features have taken to the next stage to apply “*Interpretive Structural Modelling and MICMAC Analysis.*”

5.6.4. Interpretive Structural Modelling and MICMAC Analysis

“*Interpretive Structural Modelling (ISM)*” formulated by “*J. N. Warfield*” in 1974 which is an interactive process leads to learning and decision making that shows relationships between various elements (Sindhu, 2020: 4) that are directly or indirectly related and indicated into a structural systematic model (Warfield, 1974: 52; Faisal et al., 2006: 541). As an interpretive method, ISM model based on matrix theory and graph theory (Bashir and Ojiako, 2020: 466) and enhances group decision regarding elements of a research subject which is generally complex and uncertain. By involving experts, ISM provides identifying and relating the elements of the issue. Such identification and association provides information to managers and decision-makers in order to understand and focus on the core elements and control other elements that have potential effect on the core ones (Sindhu, 2020: 4). As a group learning process, ISM provides judgement of experts regarding to decide how variables related. In the direction of expert opinions structural modelling has constituted and portrayed in a ISM model (Agarwal et al., 2007: 448).

As providing to gather expert opinions like other methods such as “*brain storming, nominal group technique and Delphi*” (Babu et al., 2020: 8), ISM method offers analytic judgement for the problem discussed. (Govindan et al., 2012: 210).

Researchers use to apply ISM technique in order to evaluate direct and indirect contextual relationships among key factors/variables (Waqas et al., 2020: 8).

ISM applied for modelling and “*multi criteria decision making (MCDM)*” like “*AHP and ANP*”. The advantage of ISM approach over other MCDM tools is; it does not require the intensity of correlation between the features except level of dominance which avoids bias decision of the participants and enhances consistency of the offered model (Agarwal et al., 2020: 3).

Table 23: Comparison of ISM method with AHP and ANP

“Analytic Hierarchy Process (AHP)”	“Analytic Network Process(ANP)”	“Interpretive Structural Modelling Technique(ISM)”
“Discipline of hierarchy has to be strictly followed”	“Deals with loose networks”	“Includes a set of interconnected criteria”
“Fails in complex real life problems”	“Useful in real life non-linear problems”	“Captures the complexities of real life problems”
“Assumes functional independence of an upper part of hierarchy from its lower one”	“Takes into account the Interdependencies and non-linearity”	“Enhances the “leads to” relationships among the criteria”
“Moderate ability for capturing dynamic complexity”	“Lower ability for capturing Complexity”	“Higher ability for capturing dynamic complexity”

Source: Jayant et al. (2015: 15).

ISM technique has been used in several studies in Supply Chain field to understand concepts like “*supply chain risk mitigation*” (Faisal et al., 2006), “*supply chain agility*” (Agarwal et al., 2007), “*supply chain risk variables*” (Babu et al., 2020), “*success factors in supply chain*” (Chowdhury et al., 2020). Although it has some drawbacks; ISM method offers some benefits like:

- Enables to evaluate contextual relationship between variables
- Helps to show contextual relations in a simple and easy to understand diagraphs
- Helps to figure out structural models
- Helps to gather the a professional opinion about complex issues
- Provides to model the relations between variables

Also ISM used in maritime studies like:

- analysing governance policies regarding green and smart port construction (Chen et al., 2019),
- analysing Hanjin shipping case in order to evaluate root causes of failure (Song et al., 2019),
- identifying to allocate risks in Arctic shipping strategic alliances (Jiang et al., 2018),
- enhancing safety management system in Syrian shipping companies (Lebbadi and Adams, 2013).

ISM method follows some steps. After deciding on variables from literature and by using other methods like Delphi or focus group, a Structural Self-Interaction Matrix (SSIM) has constituted in order to figure out mutual comparison of features. SSIM is formulated into a reachability matrix and its transitivity is controlled as a next step. After that, the partitioning of the variables constituted the structural model as a digraph. By courtesy of ISM and MICMAC (Matriced' Impacts Croises Multiplication Appliquee aunClassement) analysis, variables can be classified (Babu et al., 2020: 6). Steps of the ISM process could be defined as:

Step 1- Identify variables/ key factors/ features from literature regarding research problem/issue.

Step 2- The contextual relationship between features from the judgements of experts by designing structural self-interaction matrix (SSIM). where i represents the rows and j represents the columns. Matrix can develop by using symbols as:

V: If feature i leads to feature j,

A: If feature j leads to feature i,

X: If feature i and feature j affect each other,

O: If feature i and feature j are unrelated.

Table 24: Illustration of Structural self-interaction matrix (SSIM)

Featu res i; j ↓	F15	F14	F13	F12	F11	F10	F9	F8	F7	F6	F5	F4	F3	F2
F1	A	A	O	V	X	O	O	V	A	X	X	A	V	V
F2	X	V	X	V	V	X	A	O	X	A	V	O	X	-
F3	A	O	A	X	O	A	V	V	O	V	V	A	-	
F4	V	A	V	A	X	O	X	X	A	X	A	-		
F5	V	X	A	O	A	V	A	A	V	O	-			
F6	A	O	X	X	A	V	O	V	O	-				
F7	X	O	A	V	X	X	A	X	-					
F8	O	A	X	O	O	X	X	-						
F9	A	X	V	O	V	A	-							
F10	V	V	X	X	O	-								
F11	A	O	V	A	-									
F12	X	O	A	-										
F13	A	V	-											
F14	X	-												
F15	-													

Step 3- After determining the SSIM, it is replaced to other matrix by transforming V, A, X, and O relations into 0 and 1; which is called the initial reachability matrix. The constitution process should be as:

- If so the (i, j) record in the self-interaction matrix is V, in that case the (i, j) record in the reachability matrix should be 1, and the (j, i) should be 0.
- If so the (i, j) record in the self-interaction matrix is A, in that case the (i, j) record in the reachability matrix becomes 0, and the (j, i) entry becomes 1.
- If so the (i, j) record in the self-interaction matrix is X, in that case both the (i, j) and (j, i) records in the reachability matrix should be 1.
- If so the (i, j) record in the self-interaction matrix is O, in that case both the (i, j) and (j, i) records in the reachability matrix should be 0.

Table 25: Illustration of Initial Reachability Matrix

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	1	0	1	1	0	1	0	0	1	1	0	0	0
F2	0	1	1	0	1	0	1	0	0	1	1	1	1	1	1
F3	0	1	1	0	1	1	0	1	1	0	1	1	0	0	0
F4	1	0	1	1	0	1	0	1	1	0	1	0	1	0	1
F5	1	0	0	1	1	0	1	0	0	1	0	0	0	1	1
F6	1	1	0	1	0	1	0	1	0	1	0	1	1	0	0
F7	1	1	0	1	0	0	1	1	0	1	1	1	0	0	1
F8	0	0	0	1	1	0	1	1	1	1	0	0	1	0	0
F9	0	1	0	1	1	0	1	1	1	0	1	0	1	1	0
F10	0	1	1	0	0	0	1	1	1	1	0	1	1	1	1
F11	1	0	1	1	1	1	1	0	0	0	1	0	1	0	0
F12	0	0	1	1	0	1	0	0	0	1	1	1	0	0	1
F13	0	1	1	0	1	1	1	1	0	1	0	1	1	1	0
F14	1	0	0	1	1	0	0	1	1	0	0	0	0	1	1
F15	1	1	1	0	0	1	1	0	1	0	1	1	1	1	1

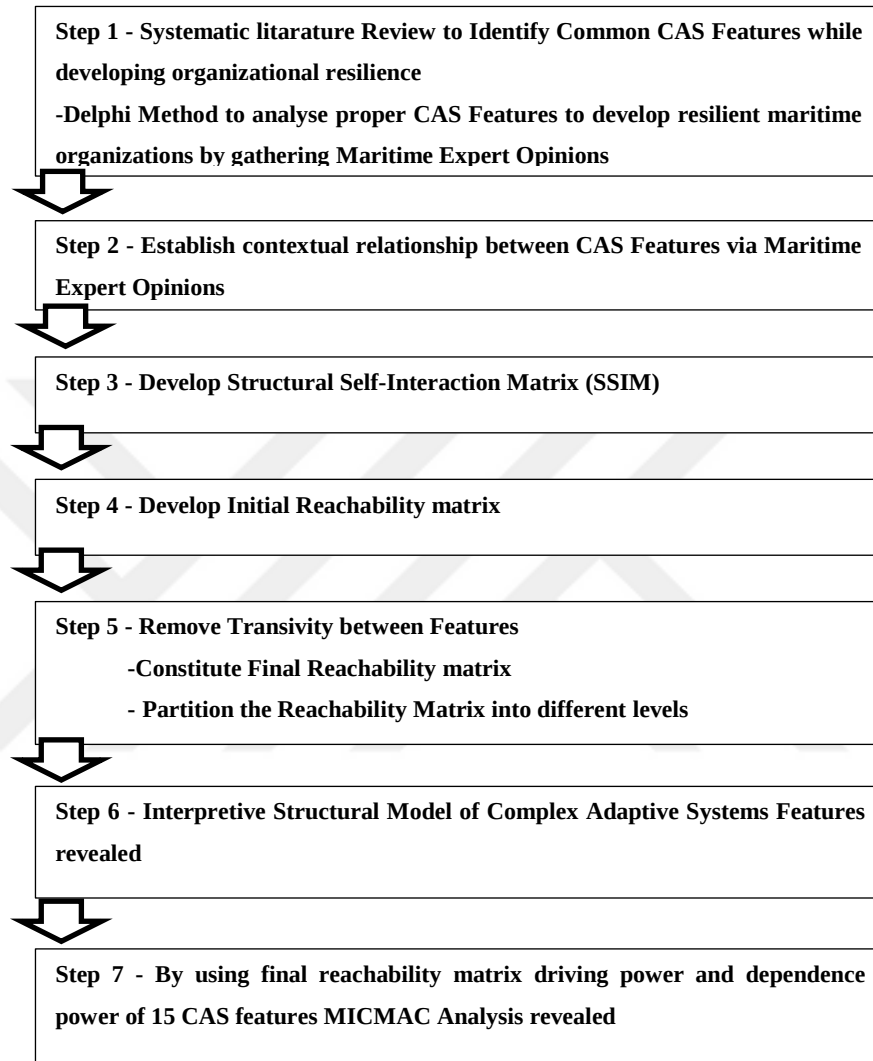
Step 4- After reachability matrix is constituted from the SSIM and the matrix should control for transitivity. The transitivity rule is: if the feature ‘A’ has relation with ‘B’ and ‘B’ has relation with ‘C’, then ‘A’ should has relation with ‘C’.

Step 5- After checking the transitivity, the Final Reachability matrix constituted where reachability set, an antecedent set, and an intersection set is derived for each feature and the matrix is partitioned into different levels.

Step 6- By determining the levels from the rows and columns of the final reachability matrix a conical matrix revealed to develop ISM model

Step 7- By using final reachability matrix driving power and dependence power of each feature determined where those powers are used at MICMAC analysis. The process of the ISM method could be figured as below:

Figure 16: Interpretive Structural Modelling (ISM) Process



Source: Adapted from Sarabi et al. (2020:5).

5.6.4.1. Analysis of Complex Adaptive Systems Features for Developing Resilient Maritime Business Organizations

Interpretive structural modelling (ISM) enables to figure out *inter-relationships* between features of CAS via modelling the influence of one feature on other features. ISM method provides structural framework to understand CAS features relational bonds while developing resilient maritime business organizations. Question 3b of the

dissertation consists of two parts and the ISM research conducted to figure out the second part of the question as:

Question 3b - Which of these CAS features are the most effective that leads to other features while developing organizational resilience in maritime business?

To search the answer, this study applies ISM research via gathering maritime experts' opinions regarding binary relations of 15 CAS feature while developing organizational resilience.

5.6.4.1.1. Data Collection

The Data collected by the group of experts participating in the Delphi stage of this dissertation also took part in the final stage “ISM” because all the participants were familiar with the features. The linguistic forms of questions were prepared which could be seen at Appendix 6, and asked the experts to express their evaluations via phone call which took an average of 47 minutes to 63 minutes long. The binary comparisons of CAS features made with the responses of the maritime experts were recorded with the confirmation e-mail sent by the participants between 07.12.2020-19.12.2020.

5.6.4.1.2. Structural Self-Interaction Matrix (SSIM)

Features of CAS are already discussed at the previous section as Delphi Research and 15 enablers accepted as the enablers of resilient maritime organizations. The experts asked to relate each feature under “*leads to*” expression and form the SSIM matrix. The letters O, V, X and A used in line with the way the method is implemented as explained previous section.

According to Bolanos et al. (2005), Attri et al. (2013), Govindan et al. (2015), Çakırlı et al. (2020), Çalışkan (2020), the frequencies should have taken into account in expressing a large number of expert opinions. In the light of this, the opinions of experts could be seen at SSIM matrix as Table 26.

Table 26: Structural Self-interaction Matrix of CAS Features

Features $i; j \rightarrow$ $\downarrow$															
	F15- Patterns	F14- Simple Rules	F13- Feedback	F12- Unpredictability	F11- Dynamism	F10- Non-linearity	F9- Sensitivity to Initial Conditions	F8- Far from Equilibrium	F7- Self-organization	F6- Interaction	F5- Diversity	F4- Co-evolution	F3- Emergence	F2- Learning	F1- Adaptation
F1- Adaptation	A	A	A	A	A	A	O	A	X	A	O	A	A	X	-
F2- Learning	O	O	A	O	A	O	O	V	V	A	A	A	A	-	-
F3- Emergence	O	O	V	A	A	X	O	O	V	O	O	V	-	-	-
F4- Co-evolution	V	O	V	O	A	A	O	O	V	A	A	-	-	-	-
F5- Diversity	O	O	V	A	A	O	O	V	V	V	-	-	-	-	-
F6- Interaction	V	O	V	O	O	O	O	O	V	-	-	-	-	-	-
F7-Self-organization	O	A	A	A	A	A	O	A	-	-	-	-	-	-	-
F8- Far from Equilibrium	O	A	O	A	A	A	O	-	-	-	-	-	-	-	-
F9- Sensitivity to Initial Conditions	O	O	O	O	O	O	-	-	-	-	-	-	-	-	-
F10-Non-linearity	O	O	O	X	X	-	-	-	-	-	-	-	-	-	-
F11- Dynamism	O	O	V	A	-	-	-	-	-	-	-	-	-	-	-
F12-Unpredictability	O	O	V	-	-	-	-	-	-	-	-	-	-	-	-
F13- Feedback	O	O	-	-	-	-	-	-	-	-	-	-	-	-	-
F14- Simple Rules	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F15- Patterns	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

According to SSIM, the written entries in the table should be interpreted such as;

F1- Adaptation and F2- Learning affect each other as indicated X

F14-Simple Rules, leads to F7-Self-organization as indicated A

F12-Unpredictability leads to F13- Feedback as indicated V

5.6.4.1.3. Initial Reachability Matrix (IRM)

The reachability matrix is a binary matrix where expert opinions turned into numbers from letters. The SSIM matrix is transformed into a reachability matrix form by transforming the opinions of experts into 1s and 0s in the reachability matrix. Following the rules explained at previous section, letters A, V, O and X become 0 and 1 according to columns and lines as seen at Table 27.

Table 27: Initial Reachability Matrix of CAS Features

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F 10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	0	0	1	0	0	1	0	0	1	0	0
F4	1	1	0	1	0	0	1	0	0	0	1	0	1	0	1
F5	0	1	0	1	1	1	1	1	0	0	0	0	1	0	0
F6	1	1	0	1	0	1	1	0	0	0	0	0	1	0	1
F7	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
F8	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	0	1	1	0	0	1	1	0	1	1	1	0	0	0
F11	1	1	1	0	1	0	1	1	0	1	1	0	1	0	0
F12	1	0	1	0	1	0	1	1	0	1	1	1	1	0	0
F13	1	1	0	0	0	0	1	0	0	0	0	0	1	0	0
F14	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1

The half of the matrix at SSIM did not filled in order to avoid repetition, but these cells in the initial reachability matrix are filled according to (i,j) and (j,i) relations.

5.6.4.1.4. Final Reachability Matrix

After Initial Reachability Matrix, the Final Reachability Matrix is arrived at by incorporating transitivity. Transitivity refers to the relationship between any three features. The Final Reachability Matrix for the attributes is gathered according to the transitivity. It is main argument states that;

*“If F1 related to F2 and
F2 related to F8
then F1 is necessarily related to F8”*

So according to rule transitivity, the Final Reachability calculated according to Warshall’s Algorithm to find Transitive Closure of graph theory. The steps of transitivity could be seen at Appendix 7 and Final Reachability Matrix could be as seen at Table 28.

Table 28: Final Reachability Matrix of CAS Features

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	Driver Power
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0	4
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	4
F3	1	1	1	1	1*	1*	1	1*	0	1	1*	1*	1	1*	1*	14
F4	1	1	1*	1	1*	1*	1	1*	0	1*	1	1*	1	1*	1	14
F5	1*	1	1*	1	1	1	1	1	0	1*	1*	1*	1	1*	1*	14
F6	1	1	1*	1	1*	1	1	1*	0	1*	1*	1*	1	0	1	13
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0	4
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0	4
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
F10	1	1*	1	1	1*	1*	1	1	0	1	1	1	1*	1*	1*	14
F11	1	1	1	1*	1	1*	1	1	0	1	1	1*	1	1*	1*	14
F12	1	1*	1	1*	1	1*	1	1	0	1	1	1	1	1*	1*	14
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0	5
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0	5
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1	6
Dependence Power	14	14	7	7	7	7	14	14	1	7	7	7	8	8	8	

* Values after incorporating the transitivity

After Final Reachability, the level partitions calculated according to Driver and Dependence Powers of Features.

5.6.4.1.5. Level Partitions

Level Partitions of Features calculated according to antecedent sets and reachability sets. The Antecedent set consists of the feature itself and the other features that help in achieving them. The Reachability set consists of the feature itself and the other features that mentioned feature may help achieve. The intersection of those sets determines ISM hierarchy. According to Driver Power and the Dependence Power MICMAC Analysis can be done. Driver and Dependence Powers provide comprehensions about the “*relative importance*” and “*interdependencies*” (Ravi and Shankar, 2005: 1026) among the CAS features. The Iterations of level partitions can be seen as below.

Table 29: Level Partitions of CAS Features - Iteration 1

Features	Reachability Set	Antecedent Set	Intersection Set	Level
F1-Adaptation	F1, F2, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8, F10, F11, F12, F13, F14, F15	F1, F2, F7, F8	I
F2-Learning	F1, F2, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8, F10, F11, F12, F13, F14, F15	F1, F2, F7, F8	I
F3-Emergence	F1, F2, F3, F4, F5, F6, F7, F8, F10, F11, F12, F13, F14, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F4-Co-evolution	F1, F2, F3, F4, F5, F6, F7, F8, F10, F11, F12, F13, F14, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F5- Diversity	F1, F2, F3, F4, F5, F6, F7, F8, F10, F11, F12, F13, F14, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F6-Interaction	F1, F2, F3, F4, F5, F6, F7, F8, F10, F11, F12, F13, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F7-Selforganization	F1, F2, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8, F10, F11, F12, F13, F14, F15	F1, F2, F7, F8	I
F8-Far from Equilibrium	F1, F2, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8, F10, F11, F12, F13, F14, F15	F1, F2, F7, F8	I
F9-Sensitivity to Initial Conditions	F9	F9	F9	I
F10-Nonlinearity	F1, F2, F3, F4, F5, F6, F7, F8, F10, F11, F12, F13, F14, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F11-Dynamism	F1, F2, F3, F4, F5, F6, F7, F8, F10, F11, F12, F13, F14, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F12-Unpredictability	F1, F2, F3, F4, F5, F6, F7, F8, F10, F11, F12, F13, F14, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F13- Feedback	F1, F2, F7, F8, F13	F3, F4, F5, F6, F10, F11, F12, F13	F13	
F14- Simple Rules	F1, F2, F7, F8, F14	F3, F4, F5, F10, F11, F12, F14, F15	F14	
F15- Patterns	F1, F2, F7, F8, F14, F15	F3, F4, F5, F6, F10, F11, F12, F15	F15	

According to Iteration 1, F1-Adaptation, F2-Learning, F7-Self-Organization, F8-Far from Equilibrium and F9- Sensitivity to Initial Conditions Features of CAS constitute Level I at the ISM hierarchy. The process continues at Iteration 2 at Table 30 as below:

Table 30: Level Partitions of CAS Features - Iteration 2

Features	Reachability Set	Antecedent Set	Intersection Set	Level
F3-Emergence	F3, F4, F5, F6, F10, F11, F12, F13, F14, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F4-Co-evolution	F3, F4, F5, F6, F10, F11, F12, F13, F14, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F5-Diversity	F3, F4, F5, F6, F10, F11, F12, F13, F14, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F6-Interaction	F3, F4, F5, F6, F10, F11, F12, F13, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F10-Nonlinearity	F3, F4, F5, F6, F10, F11, F12, F13, F14, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F11-Dynamism	F3, F4, F5, F6, F10, F11, F12, F13, F14, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F12-Unpredictability	F3, F4, F5, F6, F10, F11, F12, F13, F14, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F13-Feedback	F13	F3, F4, F5, F6, F10, F11, F12, F13	F13	II
F14-Simple Rules	F14	F3, F4, F5, F10, F11, F12, F14, F15	F14	II
F15-Patterns	F14, F15	F3, F4, F5, F6, F10, F11, F12, F15	F15	

According to Iteration 2, F13-Feedback and F14- Simple Rules Features constitute Level I at the ISM hierarchy. The process continues at Iteration 3 as below:

Table 31: Level Partitions of CAS Features - Iteration 3

Features	Reachability Set	Antecedent Set	Intersection Set	Level
F3-Emergence	F3, F4, F5, F6, F10, F11, F12, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F4-Co-evolution	F3, F4, F5, F6, F10, F11, F12, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F5-Diversity	F3, F4, F5, F6, F10, F11, F12, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F6-Interaction	F3, F4, F5, F6, F10, F11, F12, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F10-Nonlinearity	F3, F4, F5, F6, F10, F11, F12, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F11-Dynamism	F3, F4, F5, F6, F10, F11, F12, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F12-Unpredictability	F3, F4, F5, F6, F10, F11, F12, F15	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	
F15-Patterns	F15	F3, F4, F5, F6, F10, F11, F12, F15	F15	III

According to Iteration 3, F15-Patterns Feature constitutes Level III at the ISM hierarchy. The process continues at Iteration 4 at Table 32 as below:

Table 32: Level Partitions of CAS Features - Iteration 4

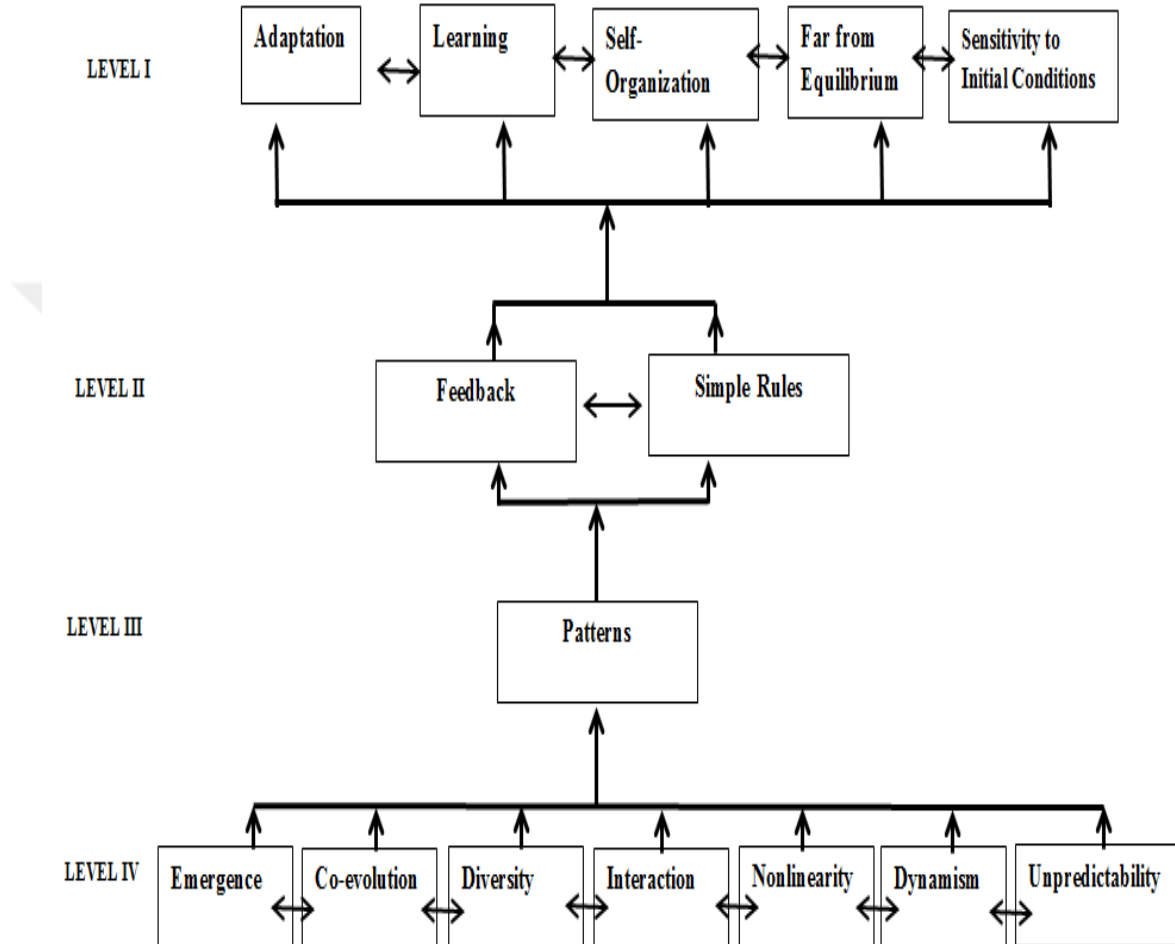
Features	Reachability Set	Antecedent Set	Intersection Set	Level
F3-Emergence	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	IV
F4-Co-evolution	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	IV
F5-Diversity	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	IV
F6-Interaction	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	IV
F10-Nonlinearity	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	IV
F11-Dynamism	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	IV
F12-Unpredictability	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	F3, F4, F5, F6, F10, F11, F12	IV

According to Iteration 4, F3-Emergence, F4-Co-evolution, F5- Diversity, F6-Interaction, F10-Nonlinearity, F11-Dynamism, F12-Unpredictability Features constitute Level IV at the ISM hierarchy.

5.6.4.1.6. Construction of Interpretive Structural Model of Complex Adaptive Systems Features

With the help of Level partitions, ISM based model of developing organizational resilience through CAS Features has emerged at Figure 17. The model shows the relationship between features while developing resilient maritime organizations. The level IV features, Emergence, Co-evolution, Requisite Variety/Diversity, Interaction/Interdependency, Non-linearity, Dynamism and Unpredictability, are at the bottom of the order that impose higher driving power. The level IV features lead to level III Patterns feature where it leads to Level II features of Feedback and Simple Rules.

Figure 17: Organizational Framework to Develop Resilient Maritime Organizations via CAS Features



Level I features are Adaptation/ Adaptive Capability, Learning, Self-Organizing/Without Formal Control, Far From Equilibrium/ Edge of Chaos and Sensitivity to Initial Conditions which can be called as the top level features.

5.6.4.2. Classification of Complex Adaptive Systems Features according to MICMAC Analysis

MICMAC Analysis helps to cluster the features of CAS according to their Dependence Power and Driver Power. There are four types of cluster which are categorized as follows:

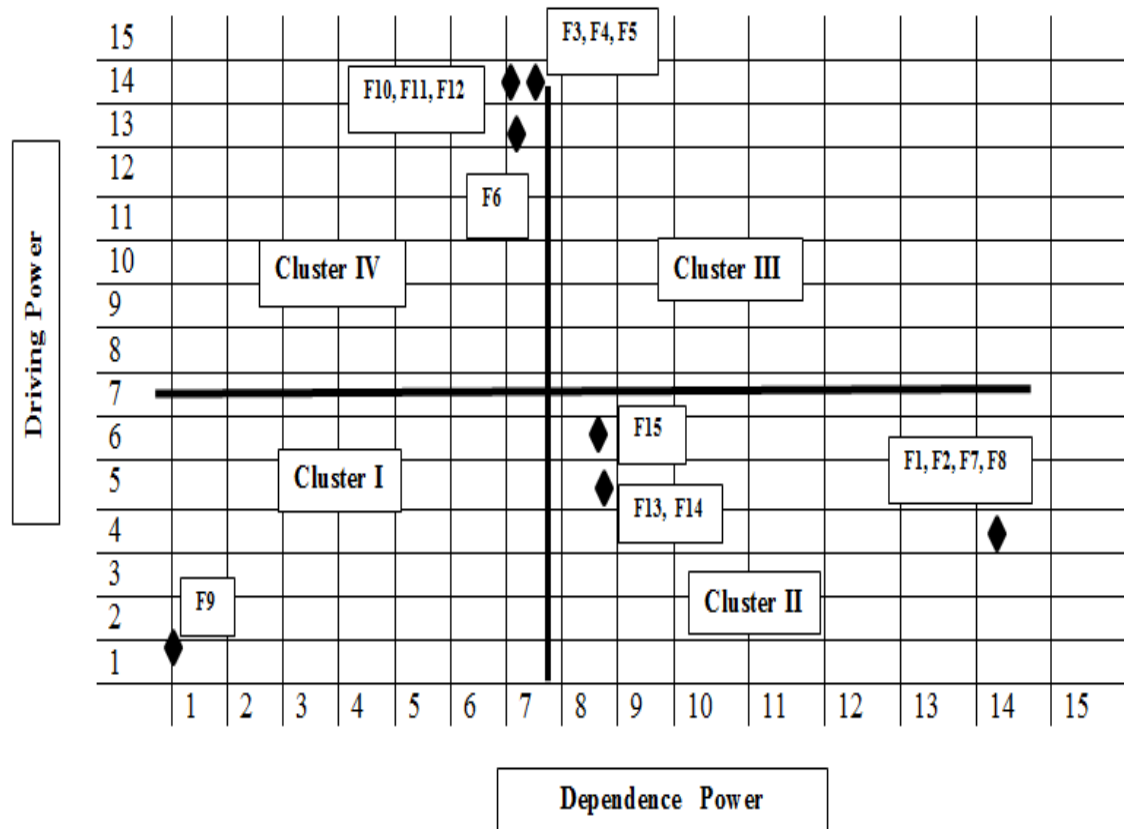
Cluster I- **Autonomous Features** which consists features that have a weak driving and dependence on other features.

Cluster II- **Dependent Features** which consists of weak driving power but strong dependence power.

Cluster III- **Linkage Features** which consists of strong driving and dependence powers.

Cluster IV- **Independent Features** which consists of strong driving power but weak dependence on other features.

Figure 18: MICMAC diagram of CAS Features



F9- Sensitivity to Initial Conditions feature is categorized at **Cluster I** as an Autonomous feature. Although that feature has several links with the system, it is relatively disconnected from the system.

F1-Adaptation, F2-Learning, F7-Self-organization, F8-Far from equilibrium, F13- Feedback, F14- Simple Rules, F15- Patterns features are categorized at **Cluster II** as Dependent Features which have high dependency and low dominance on other features. The study does not constitute **Cluster III**- Linkage Features where non-of the features of CAS has appeared as linkage-middle enabler.

F3-Emergence, F4-Co-evolution, F5- Diversity, F6- Interaction, F10-Non-linearity, F11-Dynamism, F12-Unpredictability features are categorized at **Cluster IV** as Independent Features where providing these features prepares the ground for the realization of other features.

5.7. GENERAL DISCUSSION OF THE STUDY AND CONCLUSION

World trade and transportation systems are getting more uncertain and lean on complex relations where maritime transportation is a “vital backbone” of such operations. But becoming more complex structures leads to vulnerable systems and organizations. Most risk management applications are based on predicting the known the risks where many of them are not enough to fight with unknowns. Coping with today's problems are difficult to organizations in any industry. But for maritime business stakeholders whom they work in such a global web of relations, it is much more challenging. Such a difficult and competitive business environment requires more resilient maritime organizations to survive and prosper. Researchers and academicians are studying and working on some models and frameworks to develop resilience in organizations. But due cultural and industrial differences, proposed models and scales make it impossible to design “*one size fits all*” recipe (Coetzee et al., 2016: 200).

This study aims to provide an organizational framework to develop resilient maritime organizations. To reach that goal this study propose CAS approach because managing and designing maritime organizations from this lens could enable more resilient organizational systems. This study chose to use the Complex Adaptive Systems (CAS) Approach as a theoretical lens of the study according to two different grounds and reasons:

- Maritime business organizations are interrelated with each other on a non-linear, dynamic and emergent behaviour where especially shipowner organizations run by families and each player has the potential to affect and imitate one and another. So such high complex relational bonds could be better define as a Complex Adaptive System rather than such a system.
- The Complex Adaptive Systems Approach has the potential to offer a common application philosophy without context-dependent issues/subject dependent evaluations along with generalizable results for each stakeholder/nation of the maritime industry.

The first goal of the study provides to reach and define organizational resilience for maritime business and show the requirement of organizational resilience philosophy to address Gap 1. To reach the mentioned goal, this study defines the resilience concept from different scientific disciplines, examines vulnerability and risk concepts, clarifies the resilience concept especially from the organizational point of view where maritime business context studies are almost non-existing.

The second goal of the study is to show and evaluate the maritime business as not just a system but as a complex adaptive system where all players interrelated each other to address Gap 2. To reach that goal, the study examines root approaches and theories to explain CAS approach to explain & examine maritime business agents and fitness landscapes. Features/enablers/characteristics of CAS identified throughout the literature. CAS Features offered by Tukamuhabwa et al. (2015) are compatible with the findings of this study like interaction, dynamism, learning, adaptation, coevolution, nonlinearity, self-organization and emergence. The features used by Goulielmos et al., (2007) also compatible with the features of this study like learning, feedback, non-linearity, interchange, self-organization, emergence and adaptation. The features of CAS used by the study of Caschili and Medda (2012) also use learning, interaction and non-linearity, dynamism and emergence like the features of this study. In their study, Serdarasan and

Tanyas (2012) use dynamism, non-linearity, and diversity while describing complexity in supply chains.

This study offers maritime business organizations to use CAS features to understand and develop organizational resilience management philosophy as the third goal to address Gap 3. The study examines to develop organizational resilience via getting evaluations of maritime experts from Bulk Shipowner Organizations to empirically determine the applicability of CAS features to develop organizational resilience at maritime business. To show the applicability of the philosophy, the study determined Turkish bulk shipowners as a sample established before 2008. With the help of maritime expert opinions, this thesis suggests an organizational framework to show how maritime business organizations can develop resilient organizations via CAS approach if adequate design features of CAS could be defined and included in organizational properties.

CAS approach constitutes of many features that help to catch and improve organizational resilience. Most of the features used in resilience studies are compatible with the features used to develop resilient maritime organizations like Carvalho et al. (2012a) uses diversity and adaptability as the features of resilient supply chains. Coetzee et al. (2016) offer some key CAS features to describe disaster resilience as feedback, adaptation, non-linearity and emergence. Jain et al. (2017) offered a model in order to measure supply chain resilience and proposed adaptive capability same as this study.

But none of the studies used 15 CAS enablers at the same time as the enablers of resilient organizations. Also as seen from the literature those valuable studies use different enablers/features/properties to analyse the resilience of organizations according to context base studies. Along with offering methodological diversity, all these different features create methodological complexity and lack of reapplication. To evaluate and analyse resilient maritime organizations, this study proposes a CAS framework that has application potential for each stakeholder/nation of the maritime industry which provides a structural framework to repeatability and generalizability. To reach that goal, this study figures out the most useful CAS features which promote organizational resilience in the maritime business. First of all, a systematic literature review conducted

in order to find most used CAS features throughout the literature where 15 enablers/ characteristics/ features revealed. To figure out the applicability of revealed features, a Delphi study conducted in order to gather expert opinions at two rounds. To achieve the results, Bulk Shipowner Organizations are chosen to run the empirical side of the dissertation. 13 department managers from 11 Bulk Shipowner Organizations accepted to evaluate CAS features. At the end of the second round of the Delphi study, maritime business experts accepted 15 CAS features as the enablers to develop organizational resilience in maritime business organizations. As the last method of the dissertation, ISM helped to determine relations between features of the CAS. From the evaluations of maritime business experts, the binary relations of features revealed, MICMAC analysis conducted and a structural model proposed.

According to the ISM model, the most significant features as the developer of the resilient maritime business organizations are Level IV features; F3-Emergence, F4-Co-evolution, F5- Diversity, F6- Interaction, F10-Non-linearity, F11- Dynamism, F12-Unpredictability. According to maritime business experts' opinions, especially at bulk shipping Interaction feature appears as Level IV at the model due to bulk shipping organizations generally run by families where family give the last decisions regarding management and operations of ships. Family connections shape the way of doing business but also those links affects the decisions of family members. The decision whether to sell or buy a ship or operate under their fleet is all connected with the market signals and rivals' moves. Also although bulk ships serve for different cargoes of different sizes; those cargoes and ship size interact due to substitutability options where circumstances and freights make the system interacts/interconnects. Those interactions appear in a Non-linear way and help Bulk Shipowners to figure out fracture points of the organizations. Non-linear networks of the system affect the operational and managerial decisions of organizations. And deciding at the right time in the maritime industry means survival of the organizations. Emergence feature appears as the sensitivity of Bulk shipowners regarding macro and micro environmental developments where family members make their decisions and produce emergent behaviours because Unpredictability and Dynamism features shapes the market signals in global maritime

industry. As the global trade moves upwards or downwards, bulk shipping trade gets affected along with freight rates which affect the choices of shipowners regarding their fleet composition whether to sell their ships or order new ones; or whether to operate their ships under voyage charter or time charter opinions. Co-evolution feature appears as Level IV at the model due to bulk shipping as a CAS co-evolves according to international legislation and competition between rivals. Shipowners imitate each other at some managerial and operational points, should apply same safety and security standards. But becoming a sub-standard or first-class shipowner depends on commercial trust and reputation that differentiates Bulk Shipowner organizations. Diversification features appear as the Level IV at the model along with the above features to balance the unpredictability and dynamism. Because strategic decisions of shipowners especially diversify with the market expectations and positions of rivals. With the help of the Diversification feature, Bulk Shipowner organizations make their decisions in a wide range of options such as diversifying their fleet between voyage and time charter options; having a diverse employee profile in land personnel and sea crew or get in touch with the rivals to co-operate under different circumstances.

Level IV features have the categorized at **Cluster IV as Independent Features** according to MICMAC analysis and arise as the enablers of the organizational resilience which affect the rest of the features. Thus managers of maritime business organizations pay attention to those features in order to develop strong resilient organizations. Level IV features have the capacity to dominate the whole features as the independent drivers of the system. Thus top management should give serious importance to these features while developing and enhancing organizational resilience.

F15-Patterns feature appears as Level III feature according to decisions of maritime experts. Especially the ability of Bulk Shipowner organizations to manage shipping cycles and market trends leads to developing resilient maritime organizations and providing the flow. Because Bulk shipping is sensitive to global shocks and especially supplying main bulk cargoes like iron ore, grain or coal effect the societies and global production of countries. Despite Bulk Shipping is a capital intensive market

like other segments of maritime industry, following patterns of the industry installs the roof of resilient organization.

Level II features are F13-**Feedback** and F14-**Simple Rules**. According to supply and demand, Bulk Shipping comes into equilibrium state, serving for global trade. By managing the system through simple rules Bulk Shipowner organizations shape the way of handling problems like crew shortages, long port waiting times especially at big grain and coal port loading/discharging operations etc. Simple rules feature could be seen in the culture of the organizations, company policies and circulars. Shipowners use circulars to update ships and balance the communication between ship and shore. Feedback feeds the systems of Bulk Shipowner operations to take the right steps. Bulk Shipowner organizations make necessary adjustments regarding allocation of fleet upon commercial status of the organization and decide whether to buy new ships or sell the existing ones, allocate the fleet between required ship sizes or whether to operate in different segments of the maritime industry.

Level III and II features have the categorized at **Cluster II as Dependent Features** according to MICMAC analysis. Thus managers should be aware of the importance of these features as they are the enablers of Level I features in the model and they are strongly dependent on Level IV features. So while developing organizational resilience in maritime business organizations, dependent features need the existence of independent features to work completely in the system.

And as the top-level outcome of the ISM model, Level I features F1-Adaptation/ Adaptive Capability, F2-Learning, F7-Self-Organizing/Without Formal Control, F8-Far From Equilibrium/ Edge of Chaos and F9- Sensitivity to Initial Conditions need other predecessor features to ensure organizational resilience.

Far From Equilibrium/ Edge of Chaos features shows the innovative place of the Bulk Shipowner organization, where the creativity of ship's crew and shore personnel at the highest level. The challenge of macro and micro environmental developments like any increase at bunker prices, the congestion or strike at next port of call, closing the channel on the course of the ship etc. require sudden and new decisions with minimum financial loss. Giving those difficult decisions brings **Learning** feature

and **Adaptation feature** where **Self-Organization** occurs. Bulk shipowners make their investment or operational decisions according to developments, feedback and the lessons they learnt, adapt to new conditions between ordering new ships or send them to scrap and self-organize according to freight rates where supply and demand meets. **Sensitivity to Initial Conditions feature** means the memory of Shipowner organizations. The history matters and evaluating the signals of developments along with global change enables organizational survival and prosperity. If market trends follow an increase on the supply side, Shipowners tend to buy new ships which increase second-hand ship prices and new orders. Shipowners run their fleet at the highest speed regardless of the bunker prices. But sooner or later each market increase is followed by a decrease. If shipowners could not make the right decisions at the right times mistakes are inevitable.

Level I features' except Sensitivity to Initial Conditions feature, categorized at **Cluster II as Dependent Features** according to MICMAC analysis. Managers should be aware that these variables are proper to control by other features of the system. Thus, it can be concluded that these strong drivers may be categorized as the root enablers of organizational resilience in maritime business organizations. The managers should aim to design their organizational characteristics. **Sensitivity to Initial Conditions** feature categorized at **Cluster I as Autonomous Features** according to MICMAC analysis which means that feature neither depends nor drives other features while developing organizational resilience according to maritime experts' opinions at this study. So Sensitivity to Initial Conditions feature relatively seems separate from other features while developing resilient maritime organizations.

None of the feature categorized under the Cluster III- **Linkage Features** which means none of the 15 CAS features is unstable. Because Linkage cluster has strong dependence and strong driving power where any change on linkage barriers has potential to change balance on other features and on themselves.

With the help of Bulk Shipowner expert opinions and the results of the research process, it is concluded that the designing organizations according to CAS features helps to develop organizational resilience and ensuring its continuity in maritime businesses.

5.7.1. Theoretical Contribution of the Study

Organizational resilience appears as a common solution to fight against unknown problems of organizations and systems but developing and measuring resilience depends on context based premises and conclusions which leads to non-consensus on applications. In order to offer a common applicable and practical way, this dissertation aims Complex Adaptive Systems (CAS) Approach to develop resilience in maritime business organizations. To reach that goal, study offers 15 features as the enablers of developing organizational resilience as a theoretical contribution. As indicated by Gap 1, this dissertation tries to fill the gap where the organizational resilience is relatively less studied from maritime business context. Also as determined by Gap 2, this dissertation contributes to theory by offering system wide CAS Approach analogy to maritime business. Resilience studies in management field are limited and well based maritime business resilience definition from organizational point of view is lacking. One of the goals of this study is to figure out how complex adaptive systems approach can be applied to the maritime businesses to develop organizational resilience via adding proper CAS features into organisational properties. This study offers that, by managing organizational resilience strategically which enables pro-active and re-active management applications at the same time, maritime business organizations could enable organizational survival and prosper along with competitive advantage. The theoretical contributions of the study can be summarized as:

- This study theoretically contributes to develop organizational resilience by offering organizational framework by using Complex Adaptive Systems (CAS) Approach with sample of Bulk Shipowner organizations to maritime businesses.
- This study contributes organizational resilience definition from maritime business context.
- With the help of Interpretive Structural Modelling (ISM) method, this dissertation contributes an organizational framework via CAS features while developing organizational resilience in maritime business organizations.

- By using ISM method and MICMAC Analysis this study contributes to figure out relational linkages of features which help to understand key features as the pre-requisite while developing organizational resilience in maritime organizations

5.7.2. Practical Contribution of the Study

Developing resilient maritime business organizations with the help of CAS features help managers to turn the intangible concept into the applicable and systemic model which offers control and flexibility at the same time.

Also, this study uses multiple methods to avoid any deficiencies/missing data to gather maritime business managers as expert opinions where they evaluate 15 CAS features to develop resilient maritime business organizations. Through Delphi rounds and the ISM method, their evaluations come up with a hierarchical model which shows relations of enablers while developing resilient organizations. So stakeholders of the system like forwarders, ports or ship chandlers easily apply those features to develop resilient organizations too. Legal authorities of the system and rule-makers like local Chambers of Shipping, IMO or Classification societies benefit from this framework and provide supportive settings to develop system-wide resilient organizations.

As indicated Gap 3, literature offers context-dependent solutions and applications which create a lack of consensus to develop resilient organizations. This study offers CAS approach to develop organizational resilience which has the potential to offer more generalizable results for the whole maritime industry. Also, CAS offers a good model and framework to study organizational resilience from a maritime business context which thus brings competitive advantage to maritime business organizations. By using mentioned CAS features managers could develop resilient maritime business organizations and re-arrange organizational strategies. Because organizational resilience is able to give a readiness lens to organizations that provide organizational survival.

Also with the help of the ISM based model, managers of the maritime business organizations should easily aware the relational dependencies of features. Those dependencies show the root enablers that triggers the other factors. So managers could

easily decide to develop resilience strategies on dependence and driving powers of features which leads failure free systems.

5.8. LIMITATIONS OF THE STUDY AND FURTHER RESEARCH

The research has some limitations and further research into this area should be extended. This study is designed on a qualitative research design since makes the subject easier to understand and conceptualize due to the lack of such studies in the literature. Qualitative research design helps to provide a solid base understanding to the maritime business field and examines the main findings and shows the necessity of organizational resilience management philosophy in maritime business management. Further studies could use quantitative design and methods like Formal Concept Analysis (FCA) or DEMATEL (The Decision Making Trial and Evaluation Laboratory) can be used in order to determine the relational weighs of CAS features while developing resilient organizations.

Resilience concept in organizational studies is limited and still in the developmental stage. Further studies should focus on the resilience concept especially from the organizational context. Also, this study uses CAS approach to develop organizational resilience. Further studies could use different lenses and contemporary subjects at management should also be useful to figure out effects of innovation management or entrepreneurship while developing resilience in organizations.

According to the systematic literature review, this study focuses on 15 features of CAS where future studies should extend or limit the number according to their subjects. Also, this study uses Delphi and ISM methods that count as a constraint and future studies should use other decision making methods like AHP or ANP to evaluate CAS features too.

This study chose to work on the Turkish Bulk shipping context where future studies could be extended on other stakeholders like shipping agencies or ship brokers; or on other segments of shipping like tanker shipping, container shipping or chemical shipping markets. Also, different country-based studies can be beneficial to make comparisons and test the applicability of the offered framework.

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APPENDICES

Appendix 1- Common Features Used by Explaining Complex Adaptive Systems Approach

CAS Features Authors	Emergence	Co-evolution	Feedback	Requisite Variety / Diversity	Inter-dependent / Inter-connectivity / Interaction	Simple Rules	Iteration-Patterns	Self-organization / Without Formal Control	Edge of Chaos / Far from equilibrium	Non-linearity	Adaptive Capacity / Adaptation	Unpredictability	Learning	Dynamism	Sensitive Dependence to Initial Conditions
Janssen & Kuk (2006)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
Chaffee & McNeill (2007)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Boustani et al. (2010)	✓	✓		✓	✓		✓	✓		✓	✓		✓	✓	✓
McDaniel et al. (2009)	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
Palmberg (2009)	✓	✓			✓			✓		✓	✓	✓			
Choi et al. (2001)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Chan (2001)	✓	✓			✓			✓	✓	✓		✓		✓	✓
Kamo & Phillips (1997)	✓	✓		✓	✓		✓	✓	✓	✓	✓			✓	
Bovaird (2008)	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Arevalo & Espinosa(2015)	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
Justice et al. (2016)	✓	✓	✓	✓	✓			✓		✓	✓	✓	✓	✓	
McDaniel (2007)	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓		✓
Moreira(2013)	✓	✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	
Surana et al. (2005)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Colbert Kurucz (2011)	✓	✓			✓		✓	✓	✓	✓		✓	✓	✓	
Anderson (1999)	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Rowe & Hogarth (2005)	✓	✓			✓	✓	✓	✓	✓	✓	✓				
Cunha & Cunha (2006)	✓	✓		✓	✓	✓		✓	✓	✓	✓			✓	✓
Pathak et al. (2007)	✓	✓			✓	✓	✓	✓	✓	✓	✓		✓		

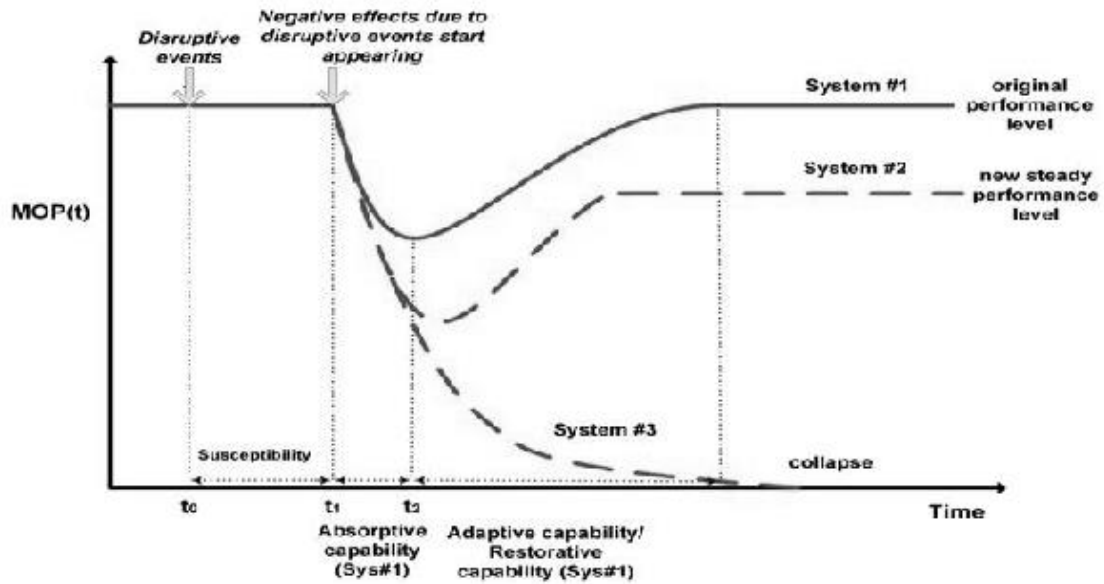
Appendix 1 (Continued) - Common Features Used by Explaining Complex Adaptive Systems Approach

CAS Features Authors	Emergence	Co-evolution	Feedback	Requisite Variety-Diversity	Inter-dependent /Inter-connectivity /Interaction	Simple Rules	Iteration-Patterns	Self-organizing : Without Formal Control	Edge of Chaos - far from equilibrium	Non-linearity	Adaptive Capacity / Adaptation	Unpredictability	Learning	Dynamism	Sensitive Dependence to Initial Conditions
Bristow & Healy (2014)	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓		✓
Coetzee et al. (2016)	✓			✓	✓	✓		✓		✓	✓		✓	✓	
Olsson et al. (2004)	✓	✓	✓		✓		✓	✓	✓	✓		✓	✓		✓
Levin (1998)	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Bettis & Prahalad(1995)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Zhao et al. (2019)	✓	✓		✓	✓			✓			✓			✓	
Nair & Reed-Tsochas (2019)	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Stacey (1995)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Winnard et al (2013)	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓	
Van der Merwe et al (2018)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Fraccascia et al (2018)	✓		✓	✓	✓			✓			✓		✓	✓	
Zio (2016)	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
Tukamuhabwa et al (2015)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Karolidis et al (2020)	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Angeli & Montefusco (2020)	✓	✓	✓		✓		✓			✓	✓		✓	✓	✓

Source: Compiled by Author

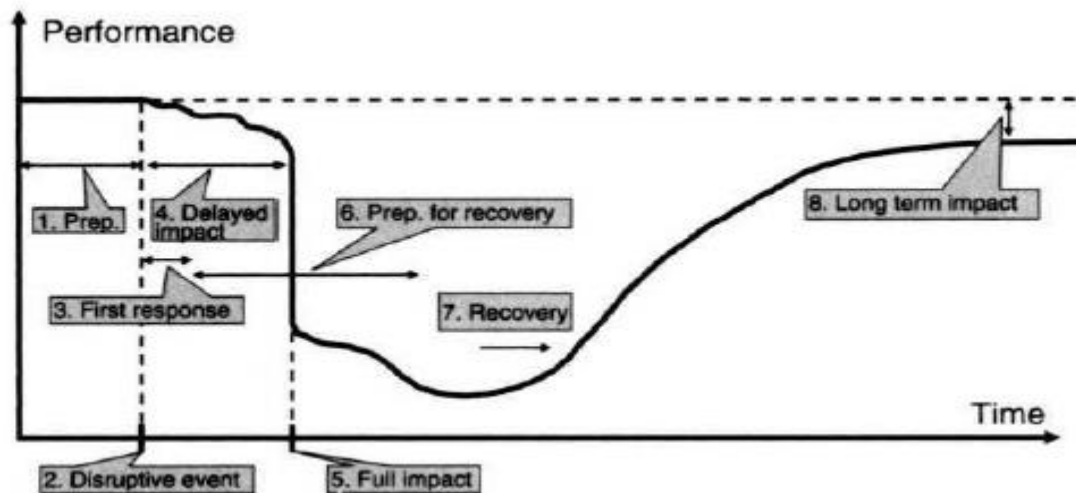
Appendix 2 - Example Figures of Resilience From Literature

Example 1 - Illustration of Essential Resilience Capabilities



Source: Nan and Sansavini (2017: 36).

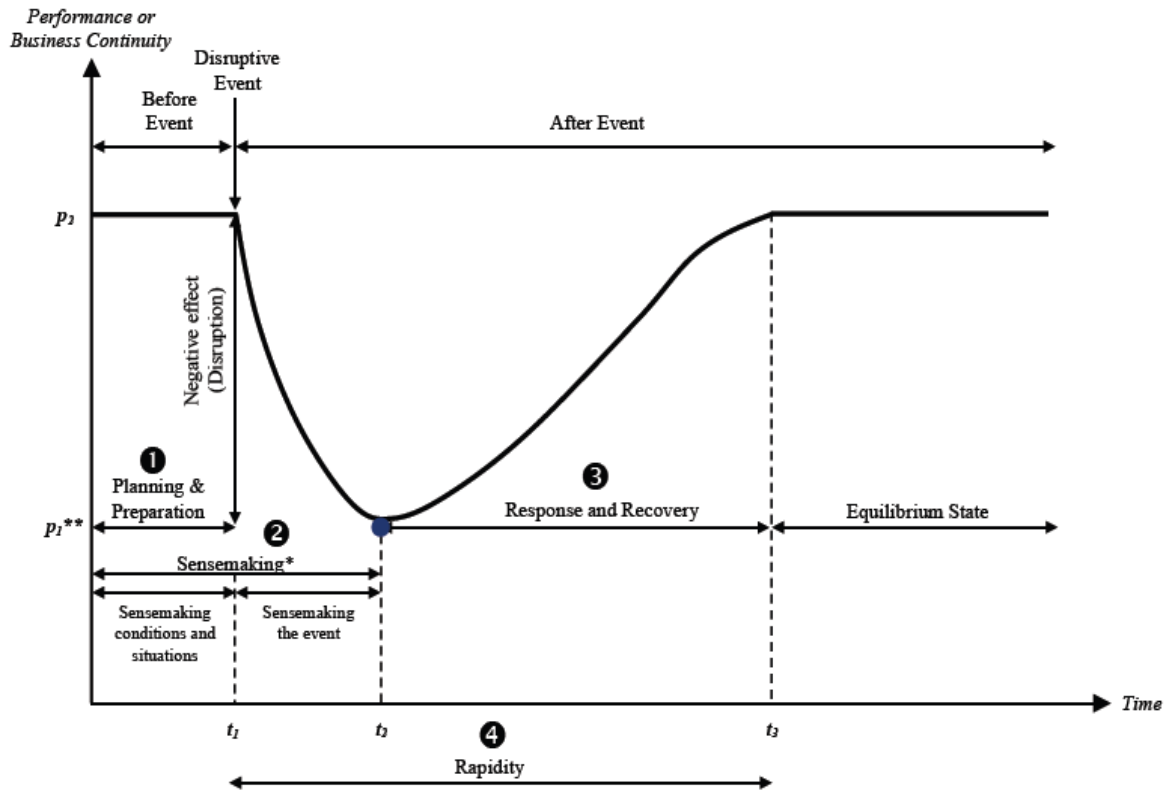
Example 2 - Disruption Profile



Source: Sheffi (2005: 80).

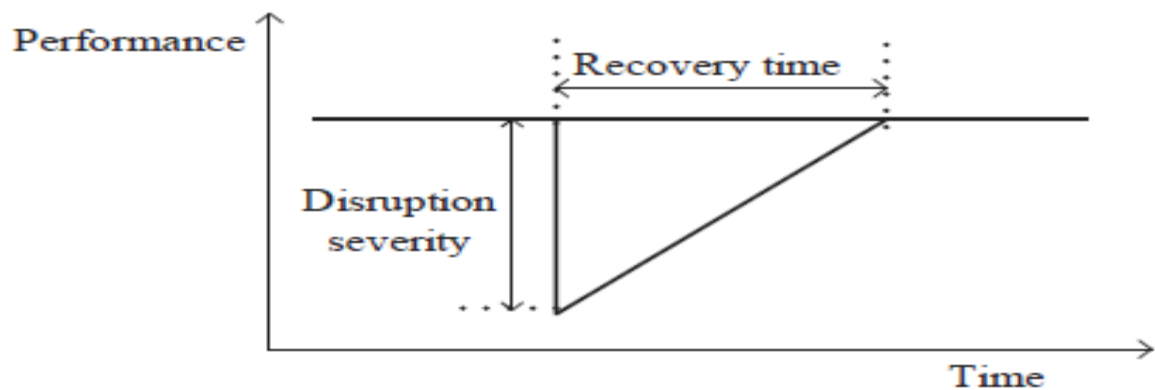
Appendix 2 (Continued) - Example Figures of Resilience From Literature

Example 3 – Actions and Reflexes of the Resilient Organizations in the Event of Disruption



Source: Ince et al. (2017: 236).

Example 4 – Resilience Triangle



Source: Barroso et al. (2015: 20).

Appendix 3 - Members of Turkish Shipowners Association

	Organizations		Organizations
1	Adakent Gemi İşletmeciliği Ve Tic. Ltd. Şti.	31	Bayraktar Denizcilik Ve Ticaret A.Ş.
2	Akarlar Denizcilik İşletmesi San. Ve Tic. A.Ş.	32	Bayramoğlu Denizcilik Tic. Ltd. Şti.
3	Akbaşoğlu Diş Tic. Ve Gemi İşl. Ltd. Şti.	33	Beykim Petrolcülük Gemi İşletmeciliği San. Ve Tic. A.Ş.
4	Akça Deniz Nakliyat Ve Ticaret A.Ş.	34	C-M Denizcilik Sanayi Ve Ticaret A.Ş.
5	Akmar Deniz Taşımacılığı Ve Ticaret A.Ş.	35	Canbaz Denizcilik Ve Nak.Tic.San.Ltd.Şti.
6	Beşiktaş Shipping Group	36	Çebi Kaptan Denizcilik Ve Ticaret Anonim Şirketi
7	Kıran Holding	37	Cerrahgil Denizcilik Nakliyat Ve Ticaret A.Ş.
8	Marinsa Denizcilik A.Ş.	38	Cevahir Denizcilik Ve Ticaret A.Ş.
9	Beks Gemi İşletmeciliği Ve Ticaret A.Ş.	39	Cvs Denizcilik Sanayi Ve Ticaret Ltd. Şti.
10	Ciner Gemi Acente İşletmeleri San. Ve Tic. A.Ş.	40	Dadaylılar Denizcilik Grubu
11	Densay Denizcilik	41	Denizcilik Anonim Şirketi
12	Er Denizcilik Sanayi Nakliyat Ve Tic. A.Ş.	42	Devbulk Gemi İşletmeciliği A.Ş.
13	Ince Denizcilik Ve Ticaret A.Ş.	43	Devmarin Denizcilik A.Ş.
14	Ya-Sa Denizcilik Sanayi Ve Ticaret A.Ş.	44	Dfds Denizcilik Ve Taşımacılık A.Ş.
15	Alternative Taşımacılık A.Ş.	45	Diler Denizcilik Ve Ticaret A.Ş.
16	Altiner İnşaat Sanayi Ve Ticaret Ltd.Şti.	46	Doğanbey Deniz İşletmeleri San. Ve Tic. Ltd. Şti.
17	Alyans Gemi Kiralama Ve Denizcilik A.Ş.	47	Düzgit Gemi İnşa Sanayi Anonim Şirketi
18	Anadolu Tersanesi	48	Er Gemicilik Nakliyat Ve Diş Ticaret Sanayi Ltd. Şti.
19	Arazlar Kum Çakıl Ticareti Ve Deniz Nakliyatı Ltd.Şti.	49	Er Madencilik Nakliyat Ve Tic. A.Ş
20	Arif Kalkavan Oğulları Gemicilik A.Ş.	50	Erkahraman Denizcilik San. Ve Tic. Ltd. Şti.
21	Arkas Konteyner Taşımacılık A.Ş	51	Ertuğ Nak. Taah. San. Tic. Ltd. Şti.
22	Armador Gemi İşletmeciliği Ltd. Şti	52	Fatoğlu Nakliyat
23	Armeda Ltd.Şti.	53	Füden Denizcilik Ticaret Ve Sanayi A.Ş.
24	Aslan Denizcilik A.Ş.	54	Fupet Petrol Ürünleri Pazarlama Ticaret Sanayi
25	Atasoy Denizcilik Turizm İnşaat San.Tic.Ltd.Şti.	55	Genmak Denizcilik
26	Atasoy Kardeşler Uluslararası Kara Ve Deniz Nakliyatı A.Ş.	56	Genta Denizcilik Ve Ticaret A.Ş.
27	Atomar Denizcilik Ve Taşımacılık A.Ş.	57	Gökalp Denizcilik Sanayi Ve Ticaret Ltd. Şt
28	Avrasya Ekspres Denizcilik Ve Ticaret Ltd. Şti.	58	Hnt Denizcilik Ve Ticaret Ltd. Şti.
29	Aykumport Taşımacılık Liman İşletmesi Ve Lojistik Hizmetler Sanayi Tic. A.Ş.	59	Holitur Turizm İşletmeleri A.Ş.
30	Azim Denizcilik A.Ş.	60	Hürişik Denizcilik Sanayi Ve Ticaret Ltd. Şti.

Appendix 3 (Continued) - Members of Turkish Shipowners Association

	Organizations		Organizations
61	Iasos Denizcilik Nakliyat Tic. A.Ş.	97	Şahin Deniz Kara Nakliye İnşaat Sanayi Ve Ticaret Ltd. Şti.
62	İçdaş Çelik Enerji Tersane Ve Ulaşım Sanayi A.Ş.	98	Sal Transport
63	İlkfer Denizcilik Sanayi Ve Ticaret Ltd. Şti.	99	Şekerciler Denizcilik San. Ve Tic. Ltd. Şti.
64	İmamoğulları Kum Çakıl Deniz Nakliyat Ltd. Şti.	100	Şenkal Kargo Turizm Ve Taşımacılık Tic. Ltd. Şti.
65	İnebolu Tersanecilik San. Ve Tic. A.Ş.	101	Simge Denizcilik Ve Ticaret A.Ş.
66	Kafkametler Denizcilik Ve Ticaret A.Ş.	102	Sonay Denizcilik Ltd. Şti.
67	Kalkavan Transport Denizcilik A.Ş.	103	Sotramp Denizcilik Sanayi Ve Ticaret A.Ş.
68	Kalkavanlar Deniz Nakliyat A.Ş.	104	Sümer Shipping
69	Kaptanoğlu Holding	105	Taşkent Turizm Ve Deniz Hizmetleri Ticaret Ltd. Şti.
70	Kar A.Ş.	106	Tayf Denizcilik Ve Nakliyat Sanayi Ticaret Ltd. Şti.
71	Kutup Yıldızı Denizcilik Ve Ticaret Ltd. Şti.	107	Torlak Denizcilik Sanayi Ve Ticaret A.Ş.
72	Levent Denizcilik	108	Tortaş Deniz Ticaret Ve San. A.Ş.
73	Lider Denizcilik	109	Transoba Denizcilik A.Ş.
74	Manta Denizcilik Nakliyat Tic. Ltd. Şti.	110	Trio Denizcilik İç Ve Dış Tic. Ltd. Şti.
75	Marti Denizcilik Ve Gemi İşletmeciliği A.Ş.	111	Tunçmete Denizcilik San. Tic. A.Ş.
76	Marvel Danışmanlık & Denizcilik A.Ş.	112	Turkon Holding
77	Mecit Çetinkaya Denizcilik Taşımacılık Pazarlama San. Tic. Ltd. Şti	113	Türkter Tersane Ve Deniz İşletmeciliği A.Ş.
78	Med Marine Kilavuzluk Ve Römorkaj Hizm.İnş.San.Ve Tic.A.Ş.	114	Turna Gemicilik Denizcilik Ve Ticaret A.Ş.
79	Medlog Gemicilik Ve Ticaret A.Ş.	115	Unimarin Denizcilik San. Ve Tic. Ltd. Şti.
80	Megatrans Uluslararası Deniz Nakliyat San. Tic. A.Ş.	116	Uygenç Denizcilik Sanayi Ve Ticaret Ltd. Şti.
81	Mete Kardeşler Deniz Taşımacılığı A.Ş.	117	Weships Denizcilik Ve Ticaret A.Ş.
82	Muratgüçlü Denizcilik Ve Ticaret Ltd. Şti.	118	Yağcı Denizcilik Ve Ticaret Ltd. Şti.
83	Naci Selimoğlu Deniz İşletmeciliği	119	Yıl-Tur Denizcilik Ve Yatçılık Turizm Ltd. Şti.
84	Ok Denizcilik Ltd. Şti.	120	Yılmaz Ulusoy Holding
85	Okan Denizcilik Ve Ticaret A.Ş.	121	Zeynaz Denizcilik Ve Ticaret Ltd. Şti.
86	Ömer Çetinkaya Denizcilik	122	Zeyport Zeytinburnu Liman İşl. San. Ve Tic. A.Ş.
87	Omsan Denizcilik Anonim Şirketi	123	Zihni Vapur Acenteliği Ve Tic. A.Ş.
88	Önal Gemicilik Sanayi Ve Ticaret Ltd. Şti.		
89	Orebulk Denizcilik Ve Gemi İşletmeciliği Tic. Ltd. Şti.		
90	Osman Ve Yaşar Ekşioğlu Kum Çakıl İnşaat Ve Ulaştırma A.Ş.		
91	Pasifik Lojistik Grubu Ve Denizcilik A.Ş.		
92	Polarmarine Gemi İşletmeciliği San. Tic. Ltd. Şti		
93	Poyraz Uluslararası Kara Ve Deniz Taşımacılığı Ltd. Şti.		
94	Pruva Denizcilik Kara Nakliyat Ve Turizm Tic. Ltd. Şti.		
95	Ranmarine Denizcilik Tic. Ltd. Şti.		
96	Rayben Denizcilik Tic.Ltd.Şti.		

Source: (<https://armatorlerbirligi.org.tr/uyelerimiz> - accessed 17.10.2020)

Appendix 4 - Turkish Delphi Survey- Round 1

Denizcilik Sektörünün Sayın Mensubu,

Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü Denizcilik İşletmeleri Yönetimi Anabilim Dalı bünyesinde, Doç. Dr. Didem Özer Çaylan'ın danışmanlığında “*Denizcilik İşletmelerinde Örgütsel Dayanıklılık: Kompleks Adaptif Sistemler Yaklaşımı*” isimli bir doktora çalışması yürütmekteyim. Bu çerçevede araştırma yaptığım konu ve ilgili alanda sektörümüzün değerli uzmanlarının görüşlerinin değerlendirilmesine yönelik Delphi Tekniği ile hazırlanmış bir görüşme formu hazırlamış bulunmaktayım. Bu doğrultuda siz değerli uzmanların yorum ve yönlendirmeleri doktora tez çalışmamın kalitesi ve bilime katkısı için büyük önem arz etmektedir.

Denizcilik işletmelerinde **örgütsel dayanıklılık**, var olan belirsiz iş çevresiyle mücadele etme; geleceğin tahminlenmesinin zorluğuna direnme; işletmeleri zorlayan denizcilik krizleriyle başa çıkma ve denizcilik işletmelerinin değişen iş yapış şekillerini sadece karşılaşılan tek bir sorunun çözümü için değil, stratejik bir yönetim felsefesi olarak devamlı uygulanması anlamına gelmektedir. Bu tanımdan hareketle görüşme formumun **ilk aşamasında** belirlenen 15 adet kompleks adaptif sistem özelliği yorumunuza sunulmuştur.

İkinci aşama için ise ilk aşamada elde edilen görüş ve yorumlarınızın değerlendirilmesi sonucu oluşturulacak ifadeler tekrar sizlerin yorumuna sunulacaktır.

Araştırmanın bulguları siz değerli katılımcılar ile paylaşılacak olup, görüş ve yorumlarınızın sadece doktora tezim kapsamında analizi gerçekleştirilecek olup kimlik bilgileriniz ise kesinlikle açıklanmayacak/paylaşılmayacaktır.

Katkınız, ilginiz ve değerli görüşleriniz için şimdiden teşekkür eder, iyi çalışmalar dilerim.

Saygılarımla,
Arş. Gör. Hatice AKPINAR

Denizcilik İşletmelerinde Örgütsel Dayanıklılığın Sağlanması Birinci Aşama Delphi Soru Anketi

Aşağıda yer alan ifadeleri okuduktan sonra, “Katılıyorum, Katılmıyorum, Yorumsuz” seçeneklerinden sizin için en uygun olanını (X) ile işaretleyiniz. “Katılıyorum” ya da “Katılmıyorum” seçeneklerinden herhangi birini işaretlemeniz durumunda neden katıldığınızı/katılmadığınızı boş bırakılan bölümde açıklamanızı rica ederiz.

- 1- Denizcilik İşletmelerinin özellikleri içerisinde **adapte olabilme özelliğinin – Adaptation feature-** (gemi boyutlarının büyümesine, yeni rotalar belirlemesine, evrak ve takip işlerinin elektronik ortama aktarılmasına adapte olabilme gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☒ **Katılıyorum** ☐ **Katılmıyorum** ☐ **Yorumsuz**
Yorumunuz:.....

- 2- Denizcilik İşletmelerinin özellikleri içerisinde **öğrenme özelliğinin - Learning feature-** (diğer işletmelerin hatalarından ders çıkarma, kendi iç bünyesindeki personelinin kurum içi öğrenmesinin sağlanması, iş ortağınız/acentanız vasıtasıyla yeni bir sistem/uygulama edinme gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☒ **Katılıyorum** ☐ **Katılmıyorum** ☐ **Yorumsuz**
Yorumunuz:.....

- 3- Denizcilik İşletmelerinin özellikleri içerisinde **ortaya çıkma/meydana gelme özelliğinin - Emergence feature-** (bulut teknolojisi uygulamaları, simulasyon uygulamaları ya da siber sistem uygulamaları gibi ortaya çıkan yeni iş yapış gereksinmelerini işletme işleyişine dahil etmek gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum ☐ Katılmıyorum ☐ Yorumsuz

Yorumunuz:.....

- 4- Denizcilik İşletmelerinin özellikleri içerisinde **birlikte evrilme özelliği - Co-evolution feature-** (emniyet ve güvenlik uygulamalarındaki gerekliliklere tüm işletmelerin uyması, Panama kanalı genişlemesine bağlı olarak oradan geçen gemilerin yeni bir sınıf gemi tipi oluşturmaları gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum ☐ Katılmıyorum ☐ Yorumsuz

Yorumunuz:

- 5- Denizcilik İşletmelerinin özellikleri içerisinde **çeşitlilik özelliği - Diversity feature-** (her yetkinlik ve sınıftan kara ve deniz personeli ile çalışma, farklı ve çeşitli acenta/ tedarikçi/ broker ile çalışma gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum ☐ Katılmıyorum ☐ Yorumsuz

Yorumunuz:

- 6- Denizcilik İşletmelerinin özellikleri içerisinde **birbirini etkileme / etkilenme özelliğinin – Interaction feature-** (bir işletmenin uyguladığı ve başarılı olduğu bir yöntemin ya da hizmetin diğer işletmelerce uygulanması; bir işletmenin girdiği farklı bir pazara girme gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum ☐ Katılmıyorum ☐ Yorumsuz

Yorumunuz:

- 7- Denizcilik İşletmelerinin özellikleri içerisinde **kendi kendini organize etme özelliğinin – Self-organizing feature-** (bir işletmenin farklı bir durumla karşılaşması neticesinde sorunu kendi yöntem ve yetkinlikleri ile çözebilecek uygulamaları hayata geçirmesi gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum ☐ Katılmıyorum ☐ Yorumsuz

Yorumunuz:

- 8- Denizcilik İşletmelerinin özellikleri içerisinde **denge durumundan uzakta olma özelliğinin – Far from Equilibrium feature-** (bir işletmenin sürekli değişim ve yeni uygulamalar karşısında, mevcut durumdan/denge halinden - alıştığı uygulamalardan farklı bir şekilde yeni ve yaratıcı çözümler bulunması gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum ☐ Katılmıyorum ☐ Yorumsuz

Yorumunuz:

- 9- Denizcilik İşletmelerinin özellikleri içerisinde **ilk duruma bağlı olma özelliğinin – Sensitivity to Initial Conditions feature-** (bir işletmenin başına gelen gelişmelerin sonucunun, olayın ilk başlangıcındaki haline sıkı sıkıya bağlı olarak şekillenmesi gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum ☐ Katılmıyorum ☐ Yorumsuz

Yorumunuz:.....

- 10- Denizcilik İşletmelerinin özellikleri içerisinde **doğrusal olmama özelliğinin – Non-linearity feature-** (bir işletmenin başına gelen olay ve gelişmelerin en basit ve ilgisizmiş gibi görünen olaydan bile etkilenecek şekilde şekillenmesi gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum

☐ Katılmıyorum

☐ Yorumsuz

Yorumunuz:

- 11- Denizcilik İşletmelerinin özellikleri içerisinde **dinamik olma özelliğinin – Dynamism feature-** (bir işletmenin yeni trendler ve değişimler karşısında dinamik olması gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum

☐ Katılmıyorum

☐ Yorumsuz

Yorumunuz:

- 12- Denizcilik İşletmelerinin özellikleri içerisinde **tahmin edilemezlik özelliğinin -Unpredictability feature -** (sektörün doğası gereği geleceğin tahminlenmesindeki güçlüğü kabulü ve bunun çözümü için yeni yönetim uygulamalarının edinilmesi gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum

☐ Katılmıyorum

☐ Yorumsuz

Yorumunuz:

- 13- Denizcilik İşletmelerinin özellikleri içerisinde **geri bildirim özelliğinin -Feedback feature -** (bir işletmenin her konu ve uygulamada geri bildirim özelliği ile sistemini sürekli güncel tutulması ve hatadan arındırılması gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum

☐ Katılmıyorum

☐ Yorumsuz

Yorumunuz:

- 14- Denizcilik İşletmelerinin özellikleri içerisinde **basit kurallar özelliğinin - Simple Rules feature -** (bir işletmenin her konu ve uygulamada basit kurallar ve takip edilmesi kolay prosedürler ile en karmaşık işlerin uygulanmasını kolaylaştırması ya da ilk kez karşılaşılan olayların daha hızlı ve etkili çözülmesini sağlaması gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum

☐ Katılmıyorum

☐ Yorumsuz

Yorumunuz:

- 15- Denizcilik İşletmelerinin özellikleri içerisinde **tekrar eden kalıplar özelliğinin - Patterns / Iterations feature -** (bir işletmenin işletme iç çevresinde ve dış çevresinde tekrar eden olaylar/kalıplar yardımı ile başına gelebilecek bir olaya karşı tedbir alması ya da olayı engelleyebilmesi gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum

☐ Katılmıyorum

☐ Yorumsuz

Yorumunuz:

PROFİL

(Aşağıdaki sorular istatistiksel amaçlı kullanılacak ve kesinlikle gizli tutulacaktır.)

Anketi Cevaplandıran Kişinin ;

Şirketin ;

Adı Soyadı:.....

Adı:.....

Görevi:.....

Kuruluş yılı:.....

Eğitimi:

Yaklaşık Personel Sayısı:.....

Şirket içinde çalışma süresi:.....

Gemi Adedi:.....

Sektördeki çalışma süresi:.....

Appendix 5 - Turkish Delphi Survey-Round 2

Denizcilik Sektörünün Sayın Mensubu,

Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü Denizcilik İşletmeleri Yönetimi Anabilim Dalı bünyesinde, Doç. Dr. Didem Özer Çaylan'ın danışmanlığında “*Denizcilik İşletmelerinde Örgütsel Dayanıklılık: Kompleks Adaptif Sistemler Yaklaşımı*” isimli doktora çalışmamın ilk aşaması siz değerli katılımcıların yorumları ile tamamlanmıştır.

İlk aşamada yer alan 15 özelliği açıklayan ifadelerin 11 tanesinde görüş birliğine varılmıştır. 13 ayrı uzmanımızın uzlaşma derecesi %97 olarak ortaya çıkmıştır. Uzlaşma sağlanamayan 4 ifade tekrar yorumlarınıza sunulmuştur. Araştırmanın bulguları siz değerli katılımcılar ile paylaşılacak olup, görüş ve yorumlarınızın sadece doktora tezim kapsamında analizi gerçekleştirilecek olup kimlik bilgileriniz ise kesinlikle açıklanmayacak/paylaşılmayacaktır.

Katkınız, ilginiz ve değerli görüşleriniz için şimdiden teşekkür eder, iyi çalışmalar dilerim.

Saygılarımla,
Arş. Gör. Hatice AKPINAR

Denizcilik İşletmelerinde Örgütsel Dayanıklılığın Sağlanması İkinci Aşama Delphi Soru Anketi

Aşağıda yer alan ifadeleri okuduktan sonra, “Katılıyorum, Katılmıyorum, Yorumsuz” seçeneklerinden sizin için en uygun olanını (X) ile işaretleyiniz

“Katılmıyorum” seçeneğini işaretlemeniz durumunda neden katılmadığınızı boş bırakılan bölümde açıklamanızı rica ederiz.

1-Bir organizasyonun hayatta kalması ve adaptasyonu, sistemin iç çeşitliliği, sistemin çevresel çeşitliliği ile eşleşirse gerçekleşir. Çeşitlilik özelliği denizcilik işletmelerine sorunları ve aksaklıkları çözmek için yeni ve farklı seçenekler yaratır.

Denizcilik İşletmelerinin özellikleri içerisinde **çeşitlilik özelliği - Diversity feature**- bulunması (devamlı çalıştığınız tedarikçiniz ikmal yapmada problem yaşıyınca önceden bildiğiniz yeni bir tedarikçi ile anlaşmanız gibi) işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

() Katılıyorum

() Katılmıyorum

() Yorumsuz

Yorumunuz:

2- Kendi kendini organize etme özelliği denizcilik işletmelerine çevresel değişikliklerden ve diğer paydaşlarla etkileşimlerden aldıkları geri bildirimlere göre durumlarını belirlemelerini sağlar. Bu bildirimlerle bireysel olarak kendilerini düzenleyen işletmeler, kendi kendilerini organize edebilir.

Denizcilik İşletmelerinin özellikleri içerisinde **kendi kendini organize etme özelliğinin – Self-organizing feature-** bulunması (acentanız ya da iş ortağınızın uyarıları ile son anda öğrendiğiniz bir sonraki uğrak limanınızda uygulamaya konulan yeni bir kuralın gerekliliğinin geminin bir önceki uğrak limanında hazırlıklarının başlatılması gibi) işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum

☐ Katılmıyorum

☐ Yorumsuz

Yorumunuz:

3- Küresel dünyada denge durumundan uzakta bulunmak, düzen ve düzensizlik arasında yer almak anlamına gelmektedir. Bu özellik denizcilik işletmelerinde örgütsel olarak hayatta kalmak için yenilik, öğrenme ve adaptasyonun arttığı bir dengeli dengesizlik durumu yaratır.

Denizcilik İşletmelerinin özellikleri içerisinde **denge durumundan uzakta olma özelliğinin – Far from Equilibrium feature-** (bir sonraki uğrak limanına uzak olan gemideki bir problemi mevcut personel ve ekipmanla çözmesi çok zor iken, kara personelinin gemideki ekipmanlarla geçici ama işe yarar bir çözümle gemiye yardım etmesi gibi) bulunması işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum

☐ Katılmıyorum

☐ Yorumsuz

Yorumunuz:

4- Küresel dünyada doğrusal olmama özelliği denizcilik işletmelerinde küçük girdilerin büyük sonuçlara ve büyük girdilerin küçük sonuçlar neden olması anlamındadır. Etkileşimlerin geri bildirimlerle şekillendiği bir ortamda küçük bir değişiklik tüm sistemi önemli ölçüde değiştirebilir.

Denizcilik İşletmelerinin özellikleri içerisinde **doğrusal olmama özelliğinin – Non-linearity feature-** bulunması (bir limanda meydana gelen grevin başka bir gemi ve yük grubunu etkilemesi gibi) işletmenin örgütsel dayanıklılığının geliştirilmesini ve bu dayanıklılığın devamlılığını sağlar.

☐ Katılıyorum

☐ Katılmıyorum

☐ Yorumsuz

Yorumunuz:

Anketi Cevaplandıran Kişinin Adı Soyadı:

Appendix 6 - Linguistic Forms of Interpretive Structural Modelling Questions

1.	Adaptive Capacity feature leads to Learning feature while developing organizational resilience in maritime business organizations.
2.	Adaptive Capacity feature leads to Emergence feature while developing organizational resilience in maritime business organizations.
3.	Adaptive Capacity feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations .
4.	Adaptive Capacity feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
5.	Adaptive Capacity feature leads to Interdependence /Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
6.	Adaptive Capacity feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
7.	Adaptive Capacity feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
8.	Adaptive Capacity feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
9.	Adaptive Capacity feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.
10.	Adaptive Capacity feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
11.	Adaptive Capacity feature leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
12.	Adaptive Capacity feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
13.	Adaptive Capacity feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
14.	Adaptive Capacity feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations.
15.	Learning feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
16.	Learning feature leads to Emergence feature while developing organizational resilience in maritime business organizations.
17.	Learning feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations .
18.	Learning feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
19.	Learning feature leads to Interdependence /Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
20.	Learning feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
21.	Learning feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
22.	Learning feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
23.	Learning feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations
24.	Learning feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.

Appendix 6 (Continued) - Linguistic Forms of Interpretive Structural Modelling Questions

25.	Learning feature leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
26.	Learning feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
27.	Learning feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
28.	Learning feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations.
29.	Emergence feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
30.	Emergence feature leads to Learning feature while developing organizational resilience in maritime business organizations.
31.	Emergence feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations .
32.	Emergence feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
33.	Emergence feature leads to Interdependence /Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
34.	Emergence feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
35.	Emergence feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
36.	Emergence feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
37.	Emergence feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.
38.	Emergence feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
39.	Emergence feature leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
40.	Emergence feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
41.	Emergence feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
42.	Emergence feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations.
43.	Co-evolution feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
44.	Co-evolution feature leads to Learning feature while developing organizational resilience in maritime business organizations.
45.	Co-evolution feature leads to Emergence feature while developing organizational resilience in maritime business organizations .
46.	Co-evolution feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
47.	Co-evolution feature leads to Interdependence /Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
48.	Co-evolution feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.

Appendix 6 (Continued) - Linguistic Forms of Interpretive Structural Modelling Questions

49.	Co-evolution feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
50.	Co-evolution feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
51.	Co-evolution feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.
52.	Co-evolution feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
53.	Co-evolution feature leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
54.	Co-evolution feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
55.	Co-evolution feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
56.	Co-evolution feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations.
57.	Requisite Variety / Diversity feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
58.	Requisite Variety / Diversity feature leads to Learning feature while developing organizational resilience in maritime business organizations.
59.	Requisite Variety / Diversity feature leads to Emergence feature while developing organizational resilience in maritime business organizations .
60.	Requisite Variety / Diversity feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations.
61.	Requisite Variety / Diversity feature leads to Interdependence /Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
62.	Requisite Variety / Diversity feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
63.	Requisite Variety / Diversity feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
64.	Requisite Variety / Diversity feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
65.	Requisite Variety / Diversity feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.
66.	Requisite Variety / Diversity feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
67.	Requisite Variety / Diversity feature leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
68.	Requisite Variety / Diversity feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
69.	Requisite Variety / Diversity feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
70.	Requisite Variety / Diversity feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations.
71.	Interdependence /Interconnectivity /Interaction feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
72.	Interdependence /Interconnectivity /Interaction feature leads to Learning feature while developing organizational resilience in maritime business organizations.

Appendix 6 (Continued) - Linguistic Forms of Interpretive Structural Modelling Questions

73.	Interdependence /Interconnectivity /Interaction feature leads to Emergence feature while developing organizational resilience in maritime business organizations .
74.	Interdependence /Interconnectivity /Interaction feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations.
75.	Interdependence /Interconnectivity /Interaction feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
76.	Interdependence /Interconnectivity /Interaction feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
77.	Interdependence /Interconnectivity /Interaction feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
78.	Interdependence /Interconnectivity /Interaction feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
79.	Interdependence /Interconnectivity /Interaction feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.
80.	Interdependence /Interconnectivity /Interaction feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
81.	Interdependence /Interconnectivity /Interaction feature leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
82.	Interdependence /Interconnectivity /Interaction feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
83.	Interdependence /Interconnectivity /Interaction feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
84.	Interdependence /Interconnectivity /Interaction feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations.
85.	Self-organizing / Without Formal Control feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
86.	Self-organizing / Without Formal Control feature leads to Learning feature while developing organizational resilience in maritime business organizations.
87.	Self-organizing / Without Formal Control feature leads to Emergence feature while developing organizational resilience in maritime business organizations .
88.	Self-organizing / Without Formal Control feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations.
89.	Self-organizing / Without Formal Control feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
90.	Self-organizing / Without Formal Control feature leads to Interdependence/Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
91.	Self-organizing / Without Formal Control feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
92.	Self-organizing / Without Formal Control feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
93.	Self-organizing / Without Formal Control feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.
94.	Self-organizing / Without Formal Control feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
95.	Self-organizing / Without Formal Control feature leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
96.	Self-organizing / Without Formal Control feature leads to Feedback feature while developing organizational resilience in maritime business organizations.

Appendix 6 (Continued) - Linguistic Forms of Interpretive Structural Modelling Questions

97.	Self-organizing / Without Formal Control feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
98.	Self-organizing / Without Formal Control feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations
99.	Edge of Chaos / Far from Equilibrium feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
100.	Edge of Chaos / Far from Equilibrium leads to Learning feature while developing organizational resilience in maritime business organizations.
101.	Edge of Chaos / Far from Equilibrium feature leads to Emergence feature while developing organizational resilience in maritime business organizations .
102.	Edge of Chaos / Far from Equilibrium feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations.
103.	Edge of Chaos / Far from Equilibrium feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
104.	Edge of Chaos / Far from Equilibrium feature leads to Interdependence/Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
105.	Edge of Chaos / Far from Equilibrium feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
106.	Edge of Chaos / Far from Equilibrium feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
107.	Edge of Chaos / Far from Equilibrium feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.
108.	Edge of Chaos / Far from Equilibrium feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
109.	Edge of Chaos / Far from Equilibrium feature leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
110.	Edge of Chaos / Far from Equilibrium feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
111.	Edge of Chaos / Far from Equilibrium feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
112.	Edge of Chaos / Far from Equilibrium feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations.
113.	Sensitivity to Initial Conditions feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
114.	Sensitivity to Initial Conditions feature leads to Learning feature while developing organizational resilience in maritime business organizations.
115.	Sensitivity to Initial Conditions feature leads to Emergence feature while developing organizational resilience in maritime business organizations .
116.	Sensitivity to Initial Conditions feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations.
117.	Sensitivity to Initial Conditions feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
118.	Sensitivity to Initial Conditions feature leads to Interdependence/Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
119.	Sensitivity to Initial Conditions feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
120.	Sensitivity to Initial Conditions feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.

Appendix 6 (Continued) - Linguistic Forms of Interpretive Structural Modelling Questions

121.	Sensitivity to Initial Conditions feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.
122.	Sensitivity to Initial Conditions feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
123.	Sensitivity to Initial Conditions feature leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
124.	Sensitivity to Initial Conditions feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
125.	Sensitivity to Initial Conditions feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
126.	Sensitivity to Initial Conditions feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations.
127.	Non-linearity feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
128.	Non-linearity feature leads to Learning feature while developing organizational resilience in maritime business organizations.
129.	Non-linearity feature leads to Emergence feature while developing organizational resilience in maritime business organizations .
130.	Non-linearity feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations.
131.	Non-linearity feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
132.	Non-linearity feature leads to Interdependence/Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
133.	Non-linearity feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
134.	Non-linearity feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
135.	Non-linearity feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
136.	Non-linearity feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
137.	Non-linearity feature leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
138.	Non-linearity feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
139.	Non-linearity feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
140.	Non-linearity feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations
141.	Dynamism feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
142.	Dynamism feature leads to Learning feature while developing organizational resilience in maritime business organizations.
143.	Dynamism feature leads to Emergence feature while developing organizational resilience in maritime business organizations .
144.	Dynamism feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations.

Appendix 6 (Continued) - Linguistic Forms of Interpretive Structural Modelling Questions

145.	Dynamism feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
146.	Dynamism feature leads to Interdependence/Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
147.	Dynamism feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
148.	Dynamism feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
149.	Dynamism feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
150.	Dynamism feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.
151.	Dynamism feature leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
152.	Dynamism feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
153.	Dynamism feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
154.	Dynamism feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations.
156.	Unpredictability feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
157.	Unpredictability feature leads to Learning feature while developing organizational resilience in maritime business organizations.
158.	Unpredictability feature leads to Emergence feature while developing organizational resilience in maritime business organizations .
159.	Unpredictability feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations.
160.	Unpredictability feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
161.	Unpredictability feature leads to Interdependence/Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
162.	Unpredictability feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
163.	Unpredictability feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
164.	Unpredictability feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
165.	Unpredictability feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.
166.	Unpredictability feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
167.	Unpredictability feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
168.	Unpredictability feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
169.	Unpredictability feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations.

Appendix 6 (Continued) - Linguistic Forms of Interpretive Structural Modelling Questions

170.	Feedback feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
171.	Feedback feature leads to Learning feature while developing organizational resilience in maritime business organizations.
172.	Feedback feature leads to Emergence feature while developing organizational resilience in maritime business organizations .
173.	Feedback feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations.
174.	Feedback feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
175.	Feedback feature leads to Interdependence/Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
176.	Feedback feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
177.	Feedback feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
178.	Feedback feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
179.	Feedback feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.
180.	Feedback feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
181.	Feedback leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
182.	Feedback feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.
183.	Feedback feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations.
184.	Simple Rules feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
185.	Simple Rules feature leads to Learning feature while developing organizational resilience in maritime business organizations.
186.	Simple Rules feature leads to Emergence feature while developing organizational resilience in maritime business organizations .
187.	Simple Rules feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations.
188.	Simple Rules feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
189.	Simple Rules feature leads to Interdependence/Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
190.	Simple Rules feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
191.	Simple Rules feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
192.	Simple Rules feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
193.	Simple Rules feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.

Appendix 6 (Continued) - Linguistic Forms of Interpretive Structural Modelling Questions

194.	Simple Rules feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
195.	Simple Rules leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
196.	Simple Rules feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
197.	Simple Rules feature leads to Patterns / Iterations feature while developing organizational resilience in maritime business organizations.
198.	Patterns / Iterations feature leads to Adaptive Capacity feature while developing organizational resilience in maritime business organizations.
199.	Patterns / Iterations feature leads to Learning feature while developing organizational resilience in maritime business organizations.
200.	Patterns / Iterations feature leads to Emergence feature while developing organizational resilience in maritime business organizations
201.	Patterns / Iterations feature leads to Co-evolution feature while developing organizational resilience in maritime business organizations.
202.	Patterns / Iterations feature leads to Requisite Variety / Diversity feature while developing organizational resilience in maritime business organizations.
203.	Patterns / Iterations feature leads to Interdependence/Interconnectivity /Interaction feature while developing organizational resilience in maritime business organizations.
204.	Patterns / Iterations feature leads to Self-organizing / Without Formal Control feature while developing organizational resilience in maritime business organizations.
205.	Patterns / Iterations feature leads to Edge of Chaos / Far from Equilibrium feature while developing organizational resilience in maritime business organizations.
206.	Patterns / Iterations feature leads to Sensitivity to Initial Conditions feature while developing organizational resilience in maritime business organizations.
207.	Patterns / Iterations feature leads to Non-linearity feature while developing organizational resilience in maritime business organizations.
208.	Patterns / Iterations feature leads to Dynamism feature while developing organizational resilience in maritime business organizations.
209.	Patterns / Iterations leads to Unpredictability feature while developing organizational resilience in maritime business organizations.
210.	Patterns / Iterations feature leads to Feedback feature while developing organizational resilience in maritime business organizations.
211.	Patterns / Iterations feature leads to Simple Rules feature while developing organizational resilience in maritime business organizations.

Appendix 7 - Warshall's Algorithm to find Transitive Closure

Initial Reachability Matrix (IRM) – Starting Matrix

Features	F15- Patterns	F14- Simple Rules	F13- Feedback	F12- Unpredictability	F11- Dynamism	F10- Non-linearity	F9- Sensitivity to Initial Conditions	F8- Far from Equilibrium	F7- Self-organization	F6- Interaction	F5- Diversity	F4- Co-evolution	F3- Emergence	F2- Learning	F1- Adaptation
F1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	0	0	1	0	0	1	0	0	1	0	0
F4	1	1	0	1	0	0	1	0	0	0	1	0	1	0	1
F5	0	1	0	1	1	1	1	1	0	0	0	0	1	0	0
F6	1	1	0	1	0	1	1	0	0	0	0	0	1	0	1
F7	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
F8	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	0	1	1	0	0	1	1	0	1	1	1	0	0	0
F11	1	1	1	0	1	0	1	1	0	1	1	0	1	0	0
F12	1	0	1	0	1	0	1	1	0	1	1	1	1	0	0
F13	1	1	0	0	0	0	1	0	0	0	0	0	1	0	0
F14	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Initial Reachability Matrix-Transitive Closure Step 1

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	0	0	1	0	0	1	0	0	1	0	0
F4	1	1	0	1	0	0	1	0	0	0	1	0	1	0	1
F5	0	1	0	1	1	1	1	1	0	0	0	0	1	0	0
F6	1	1	0	1	0	1	1	0	0	0	0	0	1	0	1
F7	1	1*	0	0	0	0	1	0	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	0	0	1	1	0	1	1	1	0	0	0
F11	1	1	1	0	1	0	1	1	0	1	1	0	1	0	0
F12	1	0	1	0	1	0	1	1	0	1	1	1	1	0	0
F13	1	1	0	0	0	0	1	0	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	0	0	0	0	0	0	1	1

Appendix 7 (Continued) - Warshall's Algorithm to find Transitive Closure

Initial Reachability Matrix-Transitive Closure Step 2

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	0	0	1	1*	0	1	0	0	1	0	0
F4	1	1	0	1	0	0	1	1*	0	0	1	0	1	0	1
F5	1*	1	0	1	1	1	1	1	0	0	0	0	1	0	0
F6	1	1	0	1	0	1	1	1*	0	0	0	0	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	0	0	1	1	0	1	1	1	0	0	0
F11	1	1	1	0	1	0	1	1	0	1	1	0	1	0	0
F12	1	0	1	0	1	0	1	1	0	1	1	1	1	0	0
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Initial Reachability Matrix-Transitive Closure Step 3

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	0	0	1	1*	0	1	0	0	1	0	0
F4	1	1	0	1	0	0	1	1*	0	0	1	0	1	0	1
F5	1*	1	0	1	1	1	1	1	0	0	0	0	1	0	0
F6	1	1	0	1	0	1	1	1*	0	0	0	0	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	0	0	1	1	0	1	1	1	1*	0	0
F11	1	1	1	1*	1	0	1	1	0	1	1	0	1	0	0
F12	1	1*	1	1*	1	0	1	1	0	1	1	1	1	0	0
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Appendix 7 (Continued) - Warshall's Algorithm to find Transitive Closure

Initial Reachability Matrix-Transitive Closure Step 4

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	0	0	1	1*	0	1	1*	0	1	0	1*
F4	1	1	0	1	0	0	1	1*	0	0	1	0	1	0	1
F5	1*	1	0	1	1	1	1	1	0	0	1*	0	1	0	1*
F6	1	1	0	1	0	1	1	1*	0	0	1*	0	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	0	0	1	1	0	1	1	1	1*	0	1*
F11	1	1	1	1*	1	0	1	1	0	1	1	0	1	0	1*
F12	1	1*	1	1*	1	0	1	1	0	1	1	1	1	0	1*
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Initial Reachability Matrix-Transitive Closure Step 5

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	0	0	1	1*	0	1	1*	0	1	0	1*
F4	1	1	0	1	0	0	1	1*	0	0	1	0	1	0	1
F5	1*	1	0	1	1	1	1	1	0	0	1*	0	1	0	1*
F6	1	1	0	1	0	1	1	1*	0	0	1*	0	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	0	0	1	1	0	1	1	1	1*	0	1*
F11	1	1	1	1*	1	1*	1	1	0	1	1	0	1	0	1*
F12	1	1*	1	1*	1	1*	1	1	0	1	1	1	1	0	1*
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Appendix 7 (Continued) - Warshall's Algorithm to find Transitive Closure

Initial Reachability Matrix-Transitive Closure Step 6

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	0	0	1	1*	0	1	1*	0	1	0	1*
F4	1	1	0	1	0	0	1	1*	0	0	1	0	1	0	1
F5	1*	1	0	1	1	1	1	1	0	0	1*	0	1	0	1*
F6	1	1	0	1	0	1	1	1*	0	0	1*	0	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	0	0	1	1	0	1	1	1	1*	0	1*
F11	1	1	1	1*	1	1*	1	1	0	1	1	0	1	0	1*
F12	1	1*	1	1*	1	1*	1	1	0	1	1	1	1	0	1*
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Initial Reachability Matrix-Transitive Closure Step 7

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	0	0	1	1*	0	1	1*	0	1	0	1*
F4	1	1	0	1	0	0	1	1*	0	0	1	0	1	0	1
F5	1*	1	0	1	1	1	1	1	0	0	1*	0	1	0	1*
F6	1	1	0	1	0	1	1	1*	0	0	1*	0	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	0	0	1	1	0	1	1	1	1*	0	1*
F11	1	1	1	1*	1	1*	1	1	0	1	1	0	1	0	1*
F12	1	1*	1	1*	1	1*	1	1	0	1	1	1	1	0	1*
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Appendix 7 (Continued) - Warshall's Algorithm to find Transitive Closure

Initial Reachability Matrix-Transitive Closure Step 8

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	0	0	1	1*	0	1	1*	0	1	0	1*
F4	1	1	0	1	0	0	1	1*	0	0	1	0	1	0	1
F5	1*	1	0	1	1	1	1	1	0	0	1*	0	1	0	1*
F6	1	1	0	1	0	1	1	1*	0	0	1*	0	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	0	0	1	1	0	1	1	1	1*	0	1*
F11	1	1	1	1*	1	1*	1	1	0	1	1	0	1	0	1*
F12	1	1*	1	1*	1	1*	1	1	0	1	1	1	1	0	1*
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Initial Reachability Matrix-Transitive Closure Step 9

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	0	0	1	1*	0	1	1*	0	1	0	1*
F4	1	1	0	1	0	0	1	1*	0	0	1	0	1	0	1
F5	1*	1	0	1	1	1	1	1	0	0	1*	0	1	0	1*
F6	1	1	0	1	0	1	1	1*	0	0	1*	0	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	0	0	1	1	0	1	1	1	1*	0	1*
F11	1	1	1	1*	1	1*	1	1	0	1	1	0	1	0	1*
F12	1	1*	1	1*	1	1*	1	1	0	1	1	1	1	0	1*
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Appendix 7 (Continued) - Warshall's Algorithm to find Transitive Closure

Initial Reachability Matrix-Transitive Closure Step 10

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	0	0	1	1*	0	1	1*	1*	1	0	1*
F4	1	1	0	1	0	0	1	1*	0	0	1	0	1	0	1
F5	1*	1	0	1	1	1	1	1	0	0	1*	0	1	0	1*
F6	1	1	0	1	0	1	1	1*	0	0	1*	0	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	0	0	1	1	0	1	1	1	1*	0	1*
F11	1	1	1	1*	1	1*	1	1	0	1	1	1*	1	0	1*
F12	1	1*	1	1*	1	1*	1	1	0	1	1	1	1	0	1*
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Initial Reachability Matrix-Transitive Closure Step 11

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	1*	1*	1	1*	0	1	1*	1*	1	0	1*
F4	1	1	1*	1	1*	1*	1	1*	0	1*	1	1*	1	0	1
F5	1*	1	1*	1	1	1	1	1	0	1*	1*	1*	1	0	1*
F6	1	1	1*	1	1*	1	1	1*	0	1*	1*	1*	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	1*	1*	1	1	0	1	1	1	1*	0	1*
F11	1	1	1	1*	1	1*	1	1	0	1	1	1*	1	0	1*
F12	1	1*	1	1*	1	1*	1	1	0	1	1	1	1	0	1*
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Appendix 7 (Continued) - Warshall's Algorithm to find Transitive Closure

Initial Reachability Matrix-Transitive Closure Step 12

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	1*	1*	1	1*	0	1	1*	1*	1	0	1*
F4	1	1	1*	1	1*	1*	1	1*	0	1*	1	1*	1	0	1
F5	1*	1	1*	1	1	1	1	1	0	1*	1*	1*	1	0	1*
F6	1	1	1*	1	1*	1	1	1*	0	1*	1*	1*	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	1*	1*	1	1	0	1	1	1	1*	0	1*
F11	1	1	1	1*	1	1*	1	1	0	1	1	1*	1	0	1*
F12	1	1*	1	1*	1	1*	1	1	0	1	1	1	1	0	1*
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Initial Reachability Matrix-Transitive Closure Step 13

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	1*	1*	1	1*	0	1	1*	1*	1	0	1*
F4	1	1	1*	1	1*	1*	1	1*	0	1*	1	1*	1	0	1
F5	1*	1	1*	1	1	1	1	1	0	1*	1*	1*	1	0	1*
F6	1	1	1*	1	1*	1	1	1*	0	1*	1*	1*	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	1*	1*	1	1	0	1	1	1	1*	0	1*
F11	1	1	1	1*	1	1*	1	1	0	1	1	1*	1	0	1*
F12	1	1*	1	1*	1	1*	1	1	0	1	1	1	1	0	1*
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Appendix 7 (Continued) - Warshall's Algorithm to find Transitive Closure

Initial Reachability Matrix-Transitive Closure Step 14

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	1*	1*	1	1*	0	1	1*	1*	1	0	1*
F4	1	1	1*	1	1*	1*	1	1*	0	1*	1	1*	1	0	1
F5	1*	1	1*	1	1	1	1	1	0	1*	1*	1*	1	0	1*
F6	1	1	1*	1	1*	1	1	1*	0	1*	1*	1*	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	1*	1*	1	1	0	1	1	1	1*	0	1*
F11	1	1	1	1*	1	1*	1	1	0	1	1	1*	1	0	1*
F12	1	1*	1	1*	1	1*	1	1	0	1	1	1	1	0	1*
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1

Initial Reachability Matrix-Transitive Closure Step 15 → Final Reachability Matrix

Features	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	1	0	0	0	0	1	1*	0	0	0	0	0	0	0
F2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
F3	1	1	1	1	1*	1*	1	1*	0	1	1*	1*	1	1*	1*
F4	1	1	1*	1	1*	1*	1	1*	0	1*	1	1*	1	1*	1
F5	1*	1	1*	1	1	1	1	1	0	1*	1*	1*	1	1*	1*
F6	1	1	1*	1	1*	1	1	1*	0	1*	1*	1*	1	0	1
F7	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F8	1	1*	0	0	0	0	1	1*	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	1	1*	1	1	1*	1*	1	1	0	1	1	1	1*	1*	1*
F11	1	1	1	1*	1	1*	1	1	0	1	1	1*	1	1*	1*
F12	1	1*	1	1*	1	1*	1	1	0	1	1	1	1	1*	1*
F13	1	1	0	0	0	0	1	1*	0	0	0	0	1	0	0
F14	1	1*	0	0	0	0	1	1	0	0	0	0	0	1	0
F15	1	1*	0	0	0	0	1*	1*	0	0	0	0	0	1	1