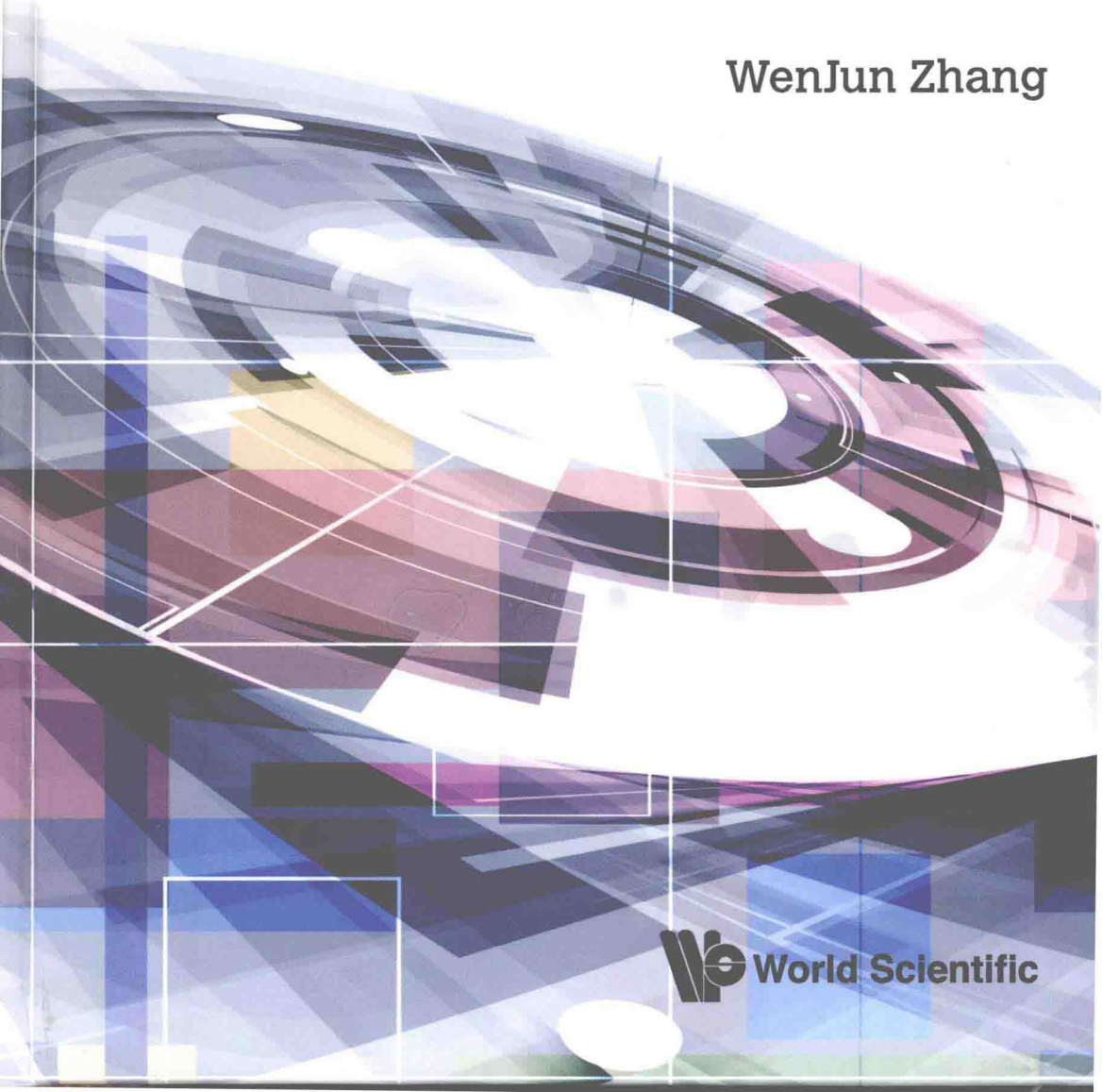
SELFORGANIZOLOGY

The Science of Self-Organization

WenJun Zhang



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World Scientific
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Published by

World Scientific Publishing Co. Pte. Ltd.

5 Toh Tuck Link, Singapore 596224

USA office: 27 Warren Street, Suite 401-402, Hackensack, NJ 07601

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

Library of Congress Cataloging-in-Publication Data

Zhang, Wen-Jun.

Selforganizology : the science of self-organization / WenJun Zhang, Sun Yat-Sen University, China.

pages cm

Includes bibliographical references and index.

ISBN 978-9814699488 (hardcover : alk. paper)

1. System theory. 2. Management. 3. Organizational behavior. I. Title. II. Title: Self organizology.

Q295.Z43 2015

003--dc23

2015026523

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

Typeset by Stallion Press

Email: enquiries@stallionpress.com

Printed in Singapore

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The Science of Self-Organization

In memory of my father, GuoXiang Zhang, and mother,
GuiFang Niu

Preface

This book is the first monograph on selforganizology in the world. It covers contents such as organization and organizational theory, selforganizology: the science of self-organization; agent-based modeling, intelligence principles, catastrophe theory and methods; self-adaptation and control systems, celluar automata and spatial diffusion models, artificial neural networks, ant colony optimization, fish and particle swarm optimization, synergy, coevolution and evolutionary algorithms, correlation analysis, community succession and assembly, and mathematical foundations. From this unique book, researchers, teachers, and students will have an in-depth and complete insight on selforganizology and its applications.

I am so grateful to the teachers and scientists who gave me instructions in the past years, Profs. ShiZe Wang, HonSheng Shang, ZhenQi Li, DeXiang Gu and KG Schoenly. I am also indebted to the people who have contributed valuable suggestions, Profs. Yi Pang, GuangHua Liu, and ZhiGuo Zhang, *et al.* Special thanks are given to the anonymous reviewers for their comments and suggestions on this book. I thank my postgraduates and undergraduates LiQin Jiang, LiMin Luo, Yue Zhao, and other students for their help and cooperation in field investigation, manuscript preparation and paper publication. Also, special thanks are given to my family members, Yanhong Qi and Qi Zhang. I thank Ms Darilyn Yap and Ms Yugarani Thanabalasingam for their patience and suggestions on editing this book. This book is supported in part by International Academy of Ecology and Environmental Sciences (IAEES) and Discovery and Crucial Node Analysis of Important Biological and

Social Networks (2015.6-2020.6), from Yangling Institute of Modern Agricultural Standardization, China.

I hope this book will help readers be aware of theories and methods of selforganizology. To keep track of the new theories and methods in selforganizology, readers can browse articles published in the journal, *Selforganizology*, by the journal page: http://www.iaees.org/publications/journals/selforganizology/online-version.asp.

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Contents

Chapter 1

Organization and Organizational Theory

To better understand self-organization, it is necessary to have a basic knowledge on organization and organizational theory. Some details can be found in Zhao and Zhang (2013).

1.1 Definitions

1.1.1 *Organization*

The definition of organization has been updated and improved over the past hundred years.

Daft and Armstrong (2007) treated organization as a goal-directed social entity that is designed as a deliberately structured and coordinated dynamic system connecting with the external environment. An organization cannot thrive without successful and powerful traits. Faced with threats and chances, it should be sensitive to external changes and keep adapting and learning (Hannah and Lester, 2009). Learning is not limited to the scope of knowledge per se but a "problem-oriented action" or "knowing" (Kuhn and Jackson, 2008). Roberts (2007) discussed contemporary organization by summarizing several influential books and has managed to address relevant problems. Rashman *et al.* (2009) reviewed the literature on organizational learning and knowledge relevant with public organizations particularly, and maintained their uniqueness by using the dynamic model. The external situations in the environment are also vital issues. Analyzing the community context will revitalize the research on organizations (Freeman and Audia, 2006), since organizations function with

other social units interdependently. King *et al.* (2010) noted that we should locate the organization in a wider social landscape and then explore its uniqueness as a social actor.

In addition to external conditions, internal components are important. An organization cannot survive or exist without rational structure and design of the system. Rank (2008) argued that although considerable researches aim at unveiling the complicated function of organizational systems, little attention has been given to the "structural interdependencies between formal organizations and informal networks."

Santos and Eisenhardt (2005) stressed organizational boundaries, which may facilitate the understanding of organizations. Kulic and Baker (2008) also held that it was difficult to draw boundaries clearly under real-world situations. As a response, they proposed another method to cover various views of organizations in a simulative environment using computational organizational theory.

Organization can be classified into two basic categories, i.e., self-organization and external-organization (Zhang, 2013). Major difference between the two categories of organizations is whether the organizational instructions/forces come from outside the system or from inside the system. The organization with organizational instructions/forces from inside the system is called self-organization.

1.1.2 *Organizational theory*

Organizational theory is the sociological study of formal social organizations, such as businesses and bureaucracies, and their interrelationship with the environment in which they operate (Wikepedia: http://en.wikipedia.org/wiki/Organizational_theory). Tompkins (2005) argued that organizational theory was the study of how and why complicated organizations behave the way they are. A complex organization is always too enormous and structurally differentiated to be effectively represented by a single individual. Organizational theory is neither a single of theory nor an integrated body of information but a field of studies which cover various scientific fields.

Donaldson (2003) viewed organizational theory as a positive science. Driven by the environment, scientific methods validate and

testify these positive but normative theories. So far, organizational science has made a huge progress by using the positivist approach. Organizational theory has proved to have strong potentiality in the future with regards to the positivist approach.

Hatch and Yanow (2003) called organizational theory an interpretive science. Many interpretive researchers held that social world and natural world ought to be ascertained in different ways.

Willmott (2003) viewed organizational theory as a critical science. While Chia (2003) thought organizational theory as a postmodern science and drew our attention to the requirement for managers and policymakers. Obviously they were more aware of the basic information and situation of our society and industries.

Ocassionally, some peculiar things could boost our understanding on organizational theory. Jones and Munro (2005) examined the works of eighteen researchers on modern organizational theory in the last twenty years. Many topics and debates were discussed including some basic concepts and postmodernism. Warner (2007) mentioned modern literary Guru Franz Kafka. His works shed light on the deep examination of organizations, and were further compared with Max Weber. In addition, some researchers explored the organizational theory in terms of its logics with novel insights and methods (Hannan, 2007; Kamps, 2009; Durand, 2008), which was mainly shaped in the book, *Logics of Organizational Theory: Audiences, Codes, and Ecologies* (Hannan, 2007). However, this approach focuses on the entire process of theory-shaping, which deviates from the traditional way of organizational ecology (Kamps, 2009). Audia *et al.* (2006) connected the theories of organizational ecology and social network and dug into the variations "in rates of foundings over geographic locales" affected by the structure of relations in various populations.

Organizational design is a major field in organizational theory. It is becoming more important due to a series of development trends, such as advances in information technology, attempts by large global economies to rapidly transform the organizational infrastructure of their administration, the professionalization of the non-governmental organization (NGO) and charity sectors, and increasing attempts of

multinational corporations to exploit globally distributed intellectual resources, etc. (Puranam, 2012).

1.2 History of Organizational Theory

Organizational theory has appeared for a very long time in history, which aims to pursue scientism, managerialism, and enhanced efficiency and effectiveness (Üsdiken and Leblebici, 2001). It is an ancient but also modern science. Organization research has occupied its status in science since Aristotle's era (Rosvall and Bergstrom, 2011). The research of organizations began its journey along with the human civilization. However, organizational theory was not recognized as a science until the 1960s (Cunliffe, 2008). Since the 19th century, in particular the era of industrial revolution, organization studies have quickly developed, especially in such areas as sociopolitical questions (Wolin, 1961).

According to Cunliffe (2008), the development of organizational theory can be divided into four stages: (1) classical and scientific management/modernism; (2) systems and contingency theories [contingency theory is a class of behavioral theory that claims that there is no best way to organize a corporation, to lead a company, or to make decisions. Instead, the optimal course of action is contingent (dependent) upon the internal and external situation. See Wikipedia: http://en.wikipedia.org/wiki/Contingency_theory]; (3) social constructionism (social constructionism, or the social construction of reality, is a theory of knowledge in sociology and communication theory that examines the development of jointly constructed understandings of the world. See Wikipedia: http://en.wikipedia.org/wiki/Social_constructionism); and (4) postmodernism (postmodernism is a late 20th century movement in the arts, architecture, and criticism that was a departure from modernism. Postmodernism includes skeptical interpretations of culture, literature, art, philosophy, history, economics, architecture, fiction, and literary criticism. See Wikipedia: http://en.wikipedia.org/wiki/Postmodernism). The first stage is classical and scientific management stage, and Adam Smith, Carl Marx, Taylor, Weber, *et al.*, were representative researchers during this period. These researchers have drawn and

distilled various theories from routine and social activities, and built fundamental concepts of organizations. The second stage, system and contingency theories — i.e. modernism — was led by such researchers as Parsons, Woodward, etc. They emphasized the optimization of production efficiency and stressed the need of treating organization as a sophisticated system (Barzilai, 2010). The third stage, social constructionism, was mainly contributed by Berger, Goffman, Weick, etc. They held the shared belief that organizations were important because they were actually communities interacting with each other. In the last stage — postmodernism, more researchers appeared, such as Harvey, Cooper, and Burrell. During this period, various thoughts on organizations formed and evolved.

A little different from the classification described above, Docherty (2001) classified the development of organizational theory into three big stages: (1) classical theory; (2) neoclassical theory; and (3) contemporary theory. In the first stage, the mass production facilitated the overall formation of organizations and relative theories. Focuses in this stage were the studies of some contents about laborers, labor division, and scientific management — such as hierarchy, span of control, the degree of centralization and the specialization of work. Unlike the first one, in the second stage — neoclassical theory, organizational theory puts its main focus on the individuals and their mutual relationship (or interactions). In the last stage, contemporary theory, various theories appeared and organizational theory stepped into a new era.

1.3 Major Theories

Organizational theory is made up of different theories. These theories are summarized as follows (Zhao and Zhang, 2013).

1.3.1 *Classical organizational theory*

Overall, it consists of three sub-theories — scientific management, Weber's bureaucratic theory, and administrative theory.

(a) Scientific management. Frederick W. Taylor is recognized as the pioneer of scientific management. It is thus called Taylorism. He

proposed the theory with the observation, analysis, and synthesis of workflows. The focus is how to minimize cost, maximize economic efficiency, and achieve specialization and standardization. However, this theory is criticized for the reason that this system overlooks the human's perception and senses.

(b) Weber's theory of bureaucracy. Max Weber's theory considered that an organization is governed by top-down rules and regulations. Employees work on strictly defined responsibility and own limited power: Bureaucratic officials need expert training; Rules are implemented by neutral officials; Career advancement depends on technical qualifications judged by the organization, not individuals (See Wikipedia: http://en.wikipedia.org/wiki/Bureaucracy#Max_ Weber).

(c) Administrative theory. Administrative theory was pioneered mainly by Henri Fayol. It takes the form of hierarchical pyramid as its structure. It was concerned principally with achieving the "most rational" organization for coordinating the various tasks specified within a complex division of labour (See: http://www.encyclopedia.com/doc/1O88-administrativetheory.html). Fayol put forward 14 principles to advise managers on how to mandate and fulfill their responsibility. In addition, he outlined five basic elements of management: planning, organizing, command, coordination, and control.

1.3.2 *Neoclassical organizational theory*

The Neoclassical theory began with the Hawthorne studies in the 1920s. Significantly different from the early thoughts and approaches, this theory particularly emphasized "affective and sociopsychological aspects of human behaviours in organizations." (See Wikipedia: http://en.wikipedia.org/wiki/Organizational_theory#Neoclassical_perspective). Personnel relationships among workers, employees, and managers were stressed, reflecting the growing need of humane and emotional care of workers. Laborers with high concentration and volition contribute positively and meticulously, so the company and factory would benefit more and function better. A lot of