PALGRAVE STUDIES IN
FINANCIAL SERVICES TECHNOLOGY

Beyond Fintech
Bionic Banking

Bernardo Nicoletti

palgrave
macmillan

Palgrave Studies in Financial Services Technology

Series Editor
Bernardo Nicoletti, Rome, Roma, Italy

The Palgrave Studies in Financial Services Technology series features original research from leading and emerging scholars on contemporary issues and developments in financial services technology. Falling into 4 broad categories: channels, payments, credit, and governance; topics covered include payments, mobile payments, trading and foreign transactions, big data, risk, compliance, and business intelligence to support consumer and commercial financial services. Covering all topics within the life cycle of financial services, from channels to risk management, from security to advanced applications, from information systems to automation, the series also covers the full range of sectors: retail banking, private banking, corporate banking, custody and brokerage, wholesale banking, and insurance companies. Titles within the series will be of value to both academics and those working in the management of financial services.

More information about this series at
https://link.springer.com/bookseries/14627

Bernardo Nicoletti

Beyond Fintech

Bionic Banking

palgrave
macmillan

Bernardo Nicoletti
Temple University
Rome, RM, Italy

ISSN 2662-5083 ISSN 2662-5091 (electronic)
Palgrave Studies in Financial Services Technology
ISBN 978-3-030-96216-6 ISBN 978-3-030-96217-3 (eBook)
https://doi.org/10.1007/978-3-030-96217-3

This Palgrave Macmillan imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Foreword

Over the last 30 years, my research interests have been in human factors engineering. My research started from traditional human factors engineering, then human-computer interaction (HCI) and cognitive engineering. Over the last few years, my research interests have been very much in human-centered artificial intelligence (HCAI), human-AI interaction, and impacts and adoption of AI solutions. When Bernardo asked me to write the foreword on his book on bionic banking, I was perplexed. After reading some chapters of his manuscript, I found it extremely interesting and able to generate challenging ideas.

The book marries very well with the lessons to be learned and actions to be taken from my research. The third wave of AI is characterized by technological enhancement and application plus a human-centered approach, which provides an excellent opportunity for the HCI practitioners to provide integrated HCAI solutions to address emergent challenges. This approach requires a systematic consideration of ethically aligned design, AI technology that fully reflects human intelligence, and human factors design. Specifically, HCI professionals should take a leading role in the human factors design in the HCAI framework by providing explainable, comprehensible AI and useful, usable AI. HCI professionals can also contribute to ethical AI design and AI technological enhancement.

The deep involvement of the HCI community in these areas has yet to be fully realized but is necessary and urgent. In order to provide full

disciplinary support for HCAI solutions, the work of the HCI community should include research on human-machine integration/teaming, user interface (UI) modeling and HCI design, transference of psychological theories, enhancement of existing methods, and development of HCI design standards. HCI professionals should proactively participate in AI research and development to increase their influence, enhance their AI knowledge, and integrate methods between the two fields to promote practical cooperation. It is crucial to research the applications of these theories to specific segments, like financial services, as in Bernardo's book.

Human-computer interaction, especially with physical robots, is becoming a trend in the manufacturing industry. However, the development of the services also puts a higher demand for effectiveness and flexibility in the service world. The book by Bernardo moves in this direction by analyzing most of these ideas in the service world of financial institutions rather than in the physical world of manufacturing organizations.

Enterprise management theories about the so-called bionic organization currently face a significant funding gap. Bionic theories have been mainly applied to the enterprise life cycle because of similarities between economic organizations and organisms. The digital transformation has originated relevant advancements in bionics research, which allows discussing bionic organizations for the first time as business realities in which humans and automation, especially robotic process automation systems and artificial intelligence tools, cooperate in executing operations or support decision making.

This book presents the interaction, process, integration, and intelligence (IPII) design implementation for achieving a unified experience in digital solutions that human factors ergonomic professionals deliver. It aims to enhance comprehensively current ergonomics design approaches (i.e., user-centered design (UCD) approach) in delivering digital solutions to financial services organizations. It considers in an integrated way business process design; integration design across data, platform, devices, and applications; and finally, intelligence design that best allocates capabilities between humans and automation.

From the point of view of the financial services digital solutions, the book and the case studies presented on implementing the IPII design approach provide supporting evidence. The book is full of quantitative metrics to demonstrate the return on investment regarding operational and unified experience benefits. Implementation of the IPII

design approach requires a mindset change amongst financial services managers and operators. They need to approach design from an end-to-end experience perspective, considering business processes, integration, and intelligent design in the early stages instead of employing the traditional approach that focuses on the interaction design portion of a solution. Additionally, financial service professionals need to seek more opportunities for collaboration across different disciplines.

This book aims to determine how a bionic organization can be defined and its fundamental elements in the case of financial services. Specifically, it investigates the two pillars of bionic enterprises: automation and humans, and the core objectives and outcomes. To provide an exhaustive overview, the book proposes a new conceptualization of the business model of a bionic organization based on the Business Model Canvas framework. Ultimately, the study of bionic organizations aims to discover how they evolved in the post-pandemic phase due to the disruptive events generated by the spread of the pandemic.

My suggestion is to read this book from start to end or go through some chapters, learn the proposed approach, and research or apply it concepts and tools. This reading will help you in your professional and personal life.

November 2021

Wei Xu, Ph.D.
Professor of Human Factors
Engineering/Psychology
Zhejiang University
Hangzhou, China

Contents

Acronyms

AI	Artificial Intelligence or Augmented Intelligence in this book
AMS	Adverse Media Screening
ANN	Artificial Neural Network
API	Application Programming Interface
B2B	Business-to-Business
B2C	Business-to-Customer
BATX's	Baidu, Alibaba, Tencent, and Xiaomi
BBS	Bionic Banking System
BCG	Boston Consulting Group
BI	Business Intelligence
BLCP	Benefits, Limitations, Challenges, and best Practice
BMC	Business model Canvas
BT	Bionic Transformation
CLV	Customer Lifetime Value
COE	Center of Excellence
CRM	Customer Relationship Management
CRPA	Cognitive Robotic Process Automation
CtQ	Critical to Quality
CX	Customer Experience
DB	Digital Banking
DT	Design Thinking
E2E experience	End-to-End Experience
EBITDA	Earnings Before Interests Taxes Depreciation and Amortization
ERP	Enterprise Resource Planning
ES	Expert System

EU	European Union
GDP	Gross Domestic Product
HAC	Human-Automation Collaboration
HAI	Human-Automation Interaction
HATI	Human-Automation Team Interaction
HCAI	Human-Centered AI
HCD	Human-Centered Design
HCM	Human Capability Management
HD	High Definition
HFE	Human Factors/Ergonomics
HR	Human Resources
HRI	Human Robot Interaction
IaaS	Infrastructure-as-a-Service
ICT	Information and Communication Technologies
IEA	International Ergonomics Association
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IPA	Intelligent Process Automation
IPDP	Innovative Product Development Process
IPII	Interaction, Process, Integration, and Intelligence
IPO	Initial Public Offers
IS	Information System
ISO	International Organization for Standardization
IVP	Innovative Value Propositions
JPEG	Joint Photographic Experts Group
KBI	Key Behavioral Indicator
KPI	Key Performance Indicator
LPD	Lean Product Development
MiFID	Markets in Financial Instruments Directive
MIT	Massachusetts Institute of Technology
ML	Machine Learning
MRP	Material Requirements Planning
NLP	Natural Language Processing
OCR	Optical Character Recognition
OTP	One Time Password
PaaS	Platform-as-a-Service
PFO	Product Feedback-Oriented
PML	Project Management Lifecycle
PoC	Proof of Concept
PPE	Personal Protection Equipment
PPI	Processes, Protocols, and Infrastructures
PSO	Product Sharing-Oriented
PSS	Product Service System

PUO	Product Use-Optimization
QFD	Quality Function Deployment
R&D	Research and Development
RPA	Robotic Process Automation
RRSP	Registered Retirement Savings Plan
SaaS	Software-as-a-Service
SMACIT	Social, Mobile, Analytics, Cloud and to the Internet of Things (IoT) Technologies
SME	Small Medium-sized Enterprises or Subject Matter Experts
SMS	Short Message Service
STP	Straight Through Processing
TCM	Transition Change Management
TRIZ	Theory of Inventive Problem Solving
UAO	User Activity-Oriented
UC	University of California
UCD	User-Centered Design
UI	User Interface
UX	User Experience
UXD	User Experience Design
VPN	Virtual Private Network
VR	Virtual Reality
WOZ	Wizard of Oz

List of Figures

List of Tables

CHAPTER 1

Bionic Banking Introduction

Research Background

This book provides an exhaustive explanation of the theory of bionic enterprise. The context of the research is mainly related to the organization and management of bionic banking. This research field is vast and comprises various interrelated academic disciplines such as economics, organizational studies, automation, and business strategy. Because of this, the research has many application areas. In particular, it refers to the management and administration of an innovative form of organization. The multidisciplinary nature is also due to the continuous reference to emerging solutions, jobs, and automation management.

It is not possible to identify a specific targeted financial sector for the practical application of this book since the interdisciplinary character of the research allows to extend the main findings, resulting from the analysis, to every industry and market. The book directly refers to the banking and insurance industry because of the characteristics of the financial sector, which suit particularly to a bionic transformation. The demonstration of this characteristic also comes from the large availability of official information, periodically published by financial institutions to increase public trust in them. This characteristic is fundamental to the sector.

The topic selected is relevant for scholars because of a gap in management and organizational studies about bionic enterprises. In particular,

B. Nicoletti, *Beyond Fintech*, Palgrave Studies in Financial Services Technology, https://doi.org/10.1007/978-3-030-96217-3_1

the academic literature focuses on applying "bionics" to an economic organization's life cycle. This book fills this gap by presenting the critical pillars of the bionic enterprise theory and developing a business model peculiar to this innovative organizational reality for financial institutions. The business model developed is considered in this book for real applications in several countries. In this way, it is possible to get an experimental confirmation of the soundness of the approach.

This analysis contributes to a big step forward to the existing knowledge on the bionic enterprises published by Boston Consulting Group in 2018 by raising criticisms, generating improvements, and demonstrating the existence of such a typology of organizations with the illustration of real-world case studies (Aré et al., 2019).

Book Objectives

This book explores the organizational reality of bionic banking. The main question that the author has answered is *what is bionic banking, and how it should be structured?*

For a more detailed description of the objective of this book, it is possible to divide this main question into sub-questions:

Q1: Which are the main characteristic elements of bionic banking?
Q2: What are the outcomes that bionic banking delivers into the market?
Q3. Which are the main components of the business model of bionic banking?
Q4. Is there evidence of the existence of bionic banking?
Q5. How will bionic transformation evolve in this turbulent time?

Research Method

The approach used to execute this research is a mix of qualitative and descriptive methods. The qualitative approach collects and extends available models on the topic, develops different research questions, and acquires evidence to answer the research questions. The descriptive method selected for the book allows to describe the existing theory and to discover new facts and models about it.

For combining these two methodologies, the approach used is a constructivist learning approach (Savery et al., 1995). Constructivism helps to increase the existing knowledge about a phenomenon or a specific research field. According to the constructivist theory, the initial knowledge is local, not universal, and consequently, from this, it is possible to extract a general conceptualization globally applicable.

The completion of the book required collecting several related information and data. The information analyzed has been extracted from academic publications and online papers, mainly from the personal research and case studies. In particular, case studies reporting real-work examples are helpful to determine how bionic banking operates and determine which are the main components of a bionic transformation. With this objective, it has been necessary to collect official documentation from the organizations involved and execute "covert" observations of how they operate. These case studies are the basis for building theoretical models applicable to the specific business model canvas. This approach has generated a series of practical rules that under particular circumstances can be applied as a method to support the bionic transformation.

Book's Structure

This section briefly illustrates the book's structure and gives information about the main contents discussed in each chapter.

Chapter 2 reports the fundamentals of the bionic theory. It defines the bionic research field by highlighting the multidisciplinary nature of the subject and the difference with other related disciplines. This chapter lists some of the significant bionics' applications in management science, especially enterprise management. To this extent, the chapter analyzes some relevant Japanese theories and the relative Chinese scholars' criticisms. The chapter also describes the New Normal emerging after the pandemic for organizations to reshape their operating and business model to survive and, in best cases, thrive.

Chapter 3 supports how bionic banking can evolve and be at the base of a bionic transformation. At the start, digital transformation is examined and defined. This chapter proposes a definition for the bionic transformation extracted from the literature available for digital transformation. It reports the main drivers of bionic transformation and examines this phenomenon by dividing it into three main phases. For each of the phases

of the digital transformation, the chapter identifies the impact on the business model. The last section of Chapter 3 analyzes the advancements in bionics research with the advent of bionic transformation.

Chapter 4 presents the bionic life cycle. It first defines the paradigm of bionics based on the interdependence of persons and automation. Secondly, it focuses on identifying the main factors that make a financial institution bionic. Thirdly, it describes the outcomes delivered by this hybrid organization for what concerns its operations, the main value propositions, and especially the relationship with customers.

Chapter 5 answers the main research question of the book about the structure of bionic banking. Using the analytic tool Business Model Canvas (BMC), this chapter identifies the nine fundamental components of a business model (Osterwalder et al., 2010), to which the author adds three additional ones (Nicoletti 2021a). These twelve building blocks create the bionic business model as denominated in this book.

Once defined what bionic banking is and its main structural components, Chapter 6 presents the characteristics of a bionic transformation project. The case studies proposed in this chapter belong to the financial industry. Their selection is for the presence of many of the characteristics and models analyzed in the previous chapters.

Chapter 7 presents the conclusions summarizing the answers to the research questions. It also specifies the type of future research on the subject.

Conclusions

Just after the crisis in which emergency measures are no longer necessary, bionic banking must reorganize its operations, processes, and management strategies based on the changes experienced. If necessary, the organization must adapt to the post-pandemic market, social, and environmental disruptions (Nicoletti 2021b). Eventually, it is desirable to perform an ex-post analysis and assessment of the approach taken during the emergency and, notably, the crisis management plan to establish whether it has adequately worked.

This book identifies the main consequences of the crisis, which have become fundamental in the core operations of organizations for the post-pandemic phase. From the considerations above, it is possible to derive the lessons learned by organizations which can translate into objectives to implement in the shortest possible time for bionic banking. Firstly, to

prepare for future critical events, bionic businesses need to implement crisis management practices. These initiatives aim to grant business continuity of core operations, save lives and assets, and learn how to recover after being hit by disruptive events.

In addition to crisis management plans, bionic organizations need to include in their operative strategy the remote work modality. Remote work has spread during the lockdown period in which the recurring imperative was to "stay at home." However, remote does not refer only to the way work is carried out. It should be a new modality for offering different services, remote banking, and products such as wealth management.

The continuous increase in technology, the internet, and innovative tools expose organizations to information security risks. During the pandemic crisis, cyber-attacks damaged many organizations, and consequently, it is necessary to consider cyber security as one of the main concerns for the "New Normal."

In conclusion, it is possible to say that bionic organizations need to include in their business and operating model the three factors previously discussed—crisis management practices, remote modality, and cybersecurity strategies—that have been fundamental during the pandemic for organizations to remain sustainable.

The book provides an overall description of bionic transformation. Since there is no unanimous definition of bionic transformation, the first section identifies an appropriate theorization of this phenomenon. This conceptualization determines Bionic Transformation (BT) drivers, introducing advanced solutions to cope with the global shift of competition and customer preferences changes. The analysis underlines that digitization is not the only impact of bionic transformation. BT affects the organization's core business model, the Customer Experience (CX) and engagement in the value creation process, and the overall business model. In summary, the outcome of BT is a disruptive modification of the original business model.

The implication for practice is that it is necessary to consider the micro-, meso-, and macro-levels for coping with the disruptive changes brought about by the bionic transformation (Oosthuizen 2021). On the micro-level, instead of individuals wasting time worrying about technological unemployment, they should instead develop a resilience-based coping strategy and reskill themselves to be ready for their new role (Hillmann et al., 2021). They need to choose a new role to take advantage of the

fourth industrial revolution (Noble 2020). On the meso-level, organizations should adopt a strategic transformational approach to empower operators in the context of the bionic transformation. On the macro-level, governments should direct bionic change initiatives (Steyn 2020). Governments should mobilize organizations to arrange skills training courses and assist citizens in adapting modern innovations.

References

Aré, L., Bailey, A., Hutchinson, R., & Rose, J. (2019). The bionic company. *Boston Consulting Group-BCG. Featured Insights*.

Hillmann, J., & Guenther, E. (2021). Organizational resilience: A valuable construct for management research? *International Journal of Management Reviews, 23*(1), 7–44.

Nicoletti, B. (2021a). *Banking 5.0*. Springer.

Nicoletti, B. (2021b). Introduction. In E. Lechman, & A. Marszk (Eds.), *The digital disruption of financial services: International perspectives*. Routledge.

Noble, E. (2020). The stages of industrial revolution and its impact on jobs. *The South African Institute of Chartered Accountants*.

Oosthuizen, R. M. (2021). The fourth industrial revolution: A resilience-based coping strategy for disruptive change. *Agile coping in the digital workplace* (pp. 11–34). Springer.

Osterwalder, A., Pigneur, Y., & Clark, T. (2010). *Business model generation*. John Wiley & Sons.

Savery, J. R., & Duffy, T. M. (1995). Problem based learning: An instructional model and its constructivist framework. *Educational Technology, 35*(5), 31–38.

Steyn, P. (2020). *Get educated for industry 4.0. Business Day Focus 4.0*. Cold Press Media (Pty) Ltd for Arena Holdings.

CHAPTER 2

Bionic Banking

Introduction

This chapter presents the most recent findings in bionic research based on the innovative trends introduced by bionic transformation (BT). In this sense, BT contributes to the development of bionic operating systems, bio-inspired product design practices. It leads to a significant transformation of the enterprise system defined bionic enterprise. The following chapters explore some of the critical determinants of bionic banking. This chapter presents a history of bionics and starts by describing how Japanese researchers launched this new field of research, the criticisms raised by Chinese scholars, and the main findings resulting from these initial critics.

Improving the innovation process provides a competitive advantage in banking, as required by today's challenging times. Combining humans and automation helps make organizations faster and more efficient than the competitors, thus creating the basis for competitiveness and future success. In this context, the transfer and application of bionic transformation is an appropriate approach to face these challenges.

Bionic transformation is essential to innovate processes, organizations, and business models. This extension might require modifications to make it successful.

This chapter overviews the main bionic theories following the introduction of the new concept. First and foremost, it is necessary to specify what is intended for bionics since what is commonly associated with this

B. Nicoletti, *Beyond Fintech*, Palgrave Studies in Financial Services Technology, https://doi.org/10.1007/978-3-030-96217-3_2

concept refers to robots and artificial body parts. Because of this, to avoid misconceptions, it is essential to distinguish between bionics and biomimetics.

Due to their capabilities, robots also increasingly act as collaborators of human labor (Decker et al., 2017). Robots and automation, in general, do not necessarily replace human labor but complement it and, in many areas, make it more productive. This chapter elaborates on these considerations and demonstrates how technical progress can enable a transition from industrial to services automation and a shift in the relationship between humans and automation from a formerly substitutional to a complementary one. These considerations connect with the so-called capital-skill complementarity hypothesis, which addresses the relationship between physical capital and different types of skills (Beltrán-Martín et al., 2008).

Until now, there has not been a complete presentation of a model for the New Normal. The objective of this chapter is to contribute to this direction, especially for the financial services. The human-automation collaboration addresses both challenges and opportunities for human labor resulting from technological change.

Origin of Bionics

The word "bionics" derives from the Greek word bios (life) and the ending of the word "electronic." It thus basically refers to an association between biology and electronics. Since the 1960s, scholars have started to pursue studies in the research field of bionics. Jack Steele, Colonel of the USA Aerospace Division, in 1958 defined bionics as "the science of systems whose foundation is based on living systems, or which have characteristics of living systems, or which resemble these" (Roth, 1983).

Jack Steel in 1950 promoted bionics as a social science during a seminar in Dayton, Ohio. When he first coined the term, he referred to engineering studying living organisms. This discipline is called biomimetics. It creates artificial products by synthesizing and imitating biological living entities or structures, functions, and composition. According to literature, robotics is one of biomimetics' largest areas of interest (King, 2013). While for what concerns bionics, it is generally considered a multidisciplinary subject which deals with modeling engineering systems that display a set of features coming from similar biological systems. Recently this practice has been widely used in augmented

intelligence.[1] Engineers have observed and abstracted human problem-solving processes and have implemented them on software applications.

Bionics Fundamentals

Analogies Between Organisms and Organizations

This book focuses on the application of bionic theories to business management. For the first time in 1952, Edith Tilton Penrose pointed out in her paper "*Biological analogies in the theory of the organization*" (Penrose, 1952) about the similarity between enterprises and living beings. She affirmed that the most widely agreed-upon resemblance between human beings and organizations regards their life cycle. Like humans, also organizations experience a growth process in their lives, commonly divided into phases: birth, growth, maturity, decline, and death.

Japanese and Chinese scholars in the 1960s developed some studies regarding bionics applied to enterprise management. According to them, the study of economic systems and processes from a bionic point of view had similarities between organisms and organizations.

Enterprise life cycle is just one of the main drivers of the bionic theory. Another characteristic shared by humans and enterprises is the interaction with the external environment. As a result, this interaction affects their behaviors and processes. Supporters of organizational ecology theory, such as Aldrich and Wiedenmayer, spent significant efforts sustaining that environmental social, economic, political, factors and events are similar (Aldrich & Wiedenmayer, 2019). Changes in the external ecosystem produce variations within the organization (Clegg & Hardy, 1999). This situation is because environments own the necessary resources for running an organization. In this sense, it is possible to consider the environment as a "resource controller" (Aldrich, 1979).

Starting from representing the environment as a resource controller, scholars have noticed that the organisms belonging to the same ecosystem need to share the same resources. Therefore, resources are limited. Aldrich wrote in his book "*Organizations and Environments*" that six

[1] In the spirit of bionics uses the term Augmented intelligence (AI) rather than Artificial intelligence.

dimensions of environments affect the distribution of resources and availability to resources: environmental capacity, environmental homogeneity–heterogeneity, environmental stability–instability, environmental concentration–dispersion, domain consensus–dissensus, and turbulence (Aldrich, 1979). Since the resources are limited, only the fittest organization can survive (Winter, 1964). This concept comes from Charles Darwin's environmental-driven natural selection principles (Darwin, 2004). The economic phenomenon that corresponds to the "struggle to survival" among living organisms is competition among organizations. Like in natural selection, the individuals unable to adapt to a changing environment will eventually disappear. Organizations that fail in competing with the others within a sector succumb.

Literature has discussed adaptation. There is a dispute between deterministics and voluntarists (Çera et al., 2019). Scholars have agreed that adaptation to the environment is necessary because the external ecosystem of economic agents is continuously changing. A practical example of ecosystem variations is the presence of new entrants in the market. The new entrants represent a threat for the already existing organizations (This is the case of fintech organizations in the financial services (Nicoletti, 2017)). To not exit the market, organizations require changes, thus, to react to environmental variations. Adaptive changes of the main components of an organization are fundamental to conform to the evolving external environment. Otherwise, evolution would prevail, and the organizations would not survive for a long time. These assumptions lead to identifying another similarity between humans and economic organizations: the need for adaptation and struggle to survive.

A structural aspect that characterizes both organisms and organizations is the interdependence among parts: that is, departments, business units, divisions, responsibility centers for what concerns organizations, and organs, apparatus, tissues for humans. Organizations are generally complex organizations made of "components." These logical units are self-functioning because they have independent means, such as HR, financial, and other resources or plants. The different parts of an economic organization are interdependent because they collaborate in pursuing the same object, that is, the main business goals based on the vision and mission of the organization. Cooperation is necessary to make the organization sustainable and effective. In this perspective, various organization functions share a unified strategy designed by the top management level.

A broadly discussed topic in the literature related to behavioral economics regards the "*bounded rationality,*" a theory developed by Herbert Simon in 1982 (Simon, 1997). This theory applies to the study of persons' cognitive capabilities. It deals with the conception that living beings have limited rationality regarding knowledge and information when making decisions. Although individuals try to optimize the decision-making process and make it as efficient as possible, their limits, which concern discovering and developing alternatives, persist. Simon adapted the concept of bounded rationality to economics (Cristofaro, 2017). It is possible to extend it to economic organizations since individuals are the decision-maker agents in the business. Enterprises are run, designed, controlled, and managed by humans. It is possible to state that a further analogy between humans and enterprises is that both are rationally bound beings.

Enterprise Bionic Theories

Starting from these assumptions, scholars have applied bionics to organizations. They developed theories about improving the enterprise system based on what they had observed in biological systems.

Japanese research on enterprise bionics aimed to develop a quantitative model to measure an organization's age. It reflects the speed of development, competitive capacity, operating capability, and economic benefit of an enterprise. It is a quantitative index of enterprise vitality (Jiali et al., 2009). They built this index as a synthetic measure of three variables (Liu et al., 2013):

- The operators' average age represents the level of management and innovation ability of the whole organization.
- The equipment age is an indicator of the technology level of operations.
- The average sales growth rate measures the growth of the organization and its profitability.

The main merit of this model is the nature of the data at its basis. Enterprise reports and statistics can provide this information. Chinese scholars challenged the model claiming that this study lacks qualitative evaluation. Furthermore, from a statistical point of view, the Japanese