From Economical Evolution to Industrial Revolution: Developing an IoT Based Co-creation Ecosystem

Yuan-Hsiang Liang¹*, Tzu-Chuan Chou²

¹ Graduate Institute of Management, National Taiwan University of Science and Technology, 43, Sec.4, Keelung Rd., Taipei, Taiwan.
² Department of Information Management, National Taiwan University of Science and Technology, 43, Sec.4, Keelung Rd., Taipei, Taiwan.

* Corresponding author. Tel.: 886-955531458; email: liangjack730@gmail.com
Manuscript submitted May 12, 2020; accepted December 9, 2020.

Abstract: Recently, the concept of the Internet of things (IoT) has flourished and attracted many start-ups to invest in related industries. However, start-ups and new businesses often face challenges in initial development. The subject of this study, NewGreen (NewGreen Tech Co., Ltd), is an air quality sensor start-up that has operated for 3 years. NewGreen has connected air quality operators and experts from various fields, established databases, and combined air quality detection with equipment improvement to create a sensor, product, system, and platform chain, to promote the formation of an industrial ecosystem that co-creates value eventually. The company now works with the international brand "Acer" and obtained investment from the data network product manufacturer “Edimax”. This study analyzed NewGreen’s business development history, including sensor, product, system, platform, and Industrial Ecosystem, to observe how the company react rapidly to adapt itself to the resource and environment in the aspects of its strategic agility, enterprise resource bricolage, exploration toward new opportunity and exploitation on enterprise itself. The study results can serve as a reference for start-ups engaged in IoT technology development.

Key words: Exploration and exploitation, resource bricolage, strategic agility.

1. Introduction

The term Internet of things (IoT) was first proposed during a 1998 Procter & Gamble seminar on a radio frequency identification paper published by Ashton from the Massachusetts Institute of Technology. IoT is the use of a globalized network infrastructure to mine for data and communications; link physical objects with virtual data; and conduct various control, detection, and identification services [1]. This concept has gradually being applied to daily life via various types of technologies. Based on the predictions of studies and reports, the scale and quantity of IoT will continue to grow [2].

The rapid development of IoT was predicted in the 2017 International Data Corporation (IDC) report. New ventures actively invest in the IoT industry. The concept of IoT is using the Internet to link objects and combine traditional technology with the Internet to create new companies. Atzori et al. reported that integrating current technology to create new technology makes IoT potentially valuable [3]. Technologies from new enterprises will continue to be created by combining the Internet with “things.” Products and services from many start-ups, such as Ring and Actility, significantly affect people’s daily lives [4].
However, resources are given mostly to a few organizations with unique backgrounds or those with a market advantage in reality. Katila and Shane reported that new venture capital and ventures must face a lack of resources and maintain consistency between internally obtained resources and external conditions during initial development [5]. Thus, reform and innovation are often conducted with new venture capital and ventures.

Academic research on resources remains in an early stage regarding to IoT startup. This study used strategic agility, bricolage theory, and exploration and exploitation architecture to analyze individual cases to fill in research gaps and enrich research materials.

2. Literature Review

2.1. Strategic Agility

Markets and business environments frequently change. Drivers for changes include the dominance of the Internet and related emerging phenomena, such as IoT, Industry 4.0, rapid technology improvement, and changing customer tastes, and internal changes in organizational environments, such as increasing in knowledge transfer rates and complex employee management. Companies must regularly reinspect their strategic decisions.

In recent years, studies on sustainable competitive advantages, resource-based perspectives, and strategic planning concepts have appeared in academic research. However, managers do not have a sufficiently clear understanding of these concepts, making their implementation difficult [6]. Thus the strategic agility concept has been developed. Strategic agility can be a competitive advantage as it involves continuously and rapidly discovering, perceiving, and responding to environmental changes.

<table>
<thead>
<tr>
<th>Strategic Agility</th>
<th>Strategic sensitivity</th>
<th>Leadership unity</th>
<th>Resource Fluidity</th>
<th>Decoupling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic sensitivity</td>
<td>Distancing</td>
<td>Gaining perspective</td>
<td>Abstracting</td>
<td>Decoupling</td>
</tr>
<tr>
<td>- Gaining insight by probing and discovering “lead locations” and innovation hotspots</td>
<td>- Nurture an “outside-in” perspective through a rich network of personal contacts</td>
<td>- Restate business models in conceptual terms</td>
<td>- Use transparency and motive clarity to attract mutual respect, trust, and positional understanding</td>
<td>- Organize by customer/segmentation-based value domains</td>
</tr>
<tr>
<td>- Conduct local experiments and in-market tests</td>
<td>- Use corporate venturing strategically and reflexively</td>
<td>- Give common meanings deeper than incentives</td>
<td>- Develop “plug and play” functionality for business systems and processes</td>
<td>- Assembling and disassembling business systems</td>
</tr>
<tr>
<td>- Use corporate venturing strategically and reflexively</td>
<td>- Gaining generality</td>
<td>- Give common meanings deeper than incentives</td>
<td>- Interdependencies</td>
<td>- Gaining flexibility</td>
</tr>
<tr>
<td>Strategic sensitivity</td>
<td>Reoring</td>
<td>Sharing common interests</td>
<td>Integrating</td>
<td>Gaining flexibility</td>
</tr>
<tr>
<td>- Strategic sensitivity</td>
<td>- Restate business models in conceptual terms</td>
<td>- Give common meanings deeper than incentives</td>
<td>- Define valuable common agendas that condition success</td>
<td>- Organize by customer/segmentation-based value domains</td>
</tr>
<tr>
<td>- Gain perspective</td>
<td>- Define valuable common agendas that condition success</td>
<td>- Give common meanings deeper than incentives</td>
<td>- Define valuable common agendas that condition success</td>
<td>- Assembling and disassembling business systems</td>
</tr>
<tr>
<td>- Share perspectives through a rich network of personal contacts</td>
<td>- Define valuable common agendas that condition success</td>
<td>- Give common meanings deeper than incentives</td>
<td>- Develop “plug and play” functionality for business systems and processes</td>
<td>- Develop “plug and play” functionality for business systems and processes</td>
</tr>
</tbody>
</table>

Alpkan and Gemici noted that maintaining agility in business environments requires becoming a market
driver of innovation [7]. Companies must adapt to unpredictable business environmental changes to achieve strategic agility. Păunescu and Badea stated that consideration of decisions must be prioritized because every choice can positively or negatively affect companies [8]. Thus, strategic agility must be able to establish value. Alpkan and Gemici remarked that companies only need to use strategic agility when reflecting value-added results [7].

Summarize from Doz and Kosonen proposed that strategic agility has three elements: strategic sensitivity, leadership unity, and resource fluidity (Table 1). Strategic sensitivity signifies that companies can predict future opportunities and possess strong awareness that balances current and changing abilities. Leadership unity refers to executives using daring and risky methods to change companies' strategic abilities. Resource fluidity is related to companies' abilities to reallocate current company resources into new roles [9].

2.2. Entrepreneurial Bricolage

The creation and delivery of enterprise value have dramatically changed in the 21st century [10]. Consequently, industries and academia have begun to focus on business models [11]. In a competitive market environment, organizations must continuously pursue innovation and breakthroughs. Examples include considerable research and development (R&D) resources being invested to build core competence [12] and products being differentiated to create niche markets [13]. However, these innovative investments are being conducted only when organizations have sufficient resources. Therefore, scholars have begun to use the “bricolage” perspective to analyze and understand how organizations survive at an operational disadvantage [14]. “Bricolage” refers to the use of any available resources on hand by carpenters or skilled workers to solve problems. Unexpected results often occur during DIY repair work. Later, management academics expanded this concept to the understanding of entrepreneurship. Studies have discovered that entrepreneurs who initially lack resources are often required to demonstrate bricolage capabilities to adequately use resources at hand and occupy market niches [14]. These methods mostly involve improvisation, resourcefulness, and resource construction to solve resource shortages. The core combination and added-value of resources can generate more resources, facilitate innovation, and transform disadvantages into advantages. Resource bricolage can be divided into five methods: combining items together, combining roles together, combining rules together, combining work together, and combining techniques together [14], [15]. In addition, “resource construction” is another type of bricolage strategy. When resources are scarce, companies can act first and construct different values for limited resources to produce “something from nothing” as bricolage results. Baker and Nelson proposed an entrepreneur bricolage theory by noting that creative use of existing but often overlooked and forgotten resources, social resources, and organizational resources can bring unprecedented new value [14]. Baker and Nelson also stated that bricolage can begin from five fields: physical inputs, labor, skills, customers, and institutional environments (Table 2) [14].

<table>
<thead>
<tr>
<th>Domain</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical inputs</td>
<td>By imbuing forgotten, discarded, worn, or presumed “single-application” materials with new-use value, bricolage transforms valueless or even negatively valued resources into valuable materials.</td>
</tr>
<tr>
<td>Labor</td>
<td>By involving customers, suppliers, and hangers-on in providing work on projects, bricolage may create labor inputs.</td>
</tr>
<tr>
<td>Skills</td>
<td>By permitting and encouraging the use of amateur and self-taught skills (such as electronics repair, soldering, and road work) that would otherwise be unapplied, bricolage creates useful services.</td>
</tr>
<tr>
<td>Customer/markets</td>
<td>By providing otherwise unavailable products or services (such as housing, cars, and billing systems) to customers because of poverty, thriftiness, or lack of availability, bricolage creates new products and markets.</td>
</tr>
<tr>
<td>Institutional and regulatory environment</td>
<td>By refusing to limit many “standards” and regulations and actively exploring various areas with unclear or nonconstraining rules, bricolage creates space to “get away with” solutions that otherwise deemed impermissible.</td>
</tr>
</tbody>
</table>
2.3. Exploitation and Exploration

New ventures lack experience and face two types of challenges: external opportunity exploration and continuously increasing internal company efficiency. March proposed exploration and exploitation-based analytical architecture for organizational learning [16]. Exploration must seek answers among the unknown, and related risks are high. Conversely, exploitation does not present considerable short-term risk but can possibly reduce long-term benefits. Under the premise of limited resources, exploration and exploitation are perceived as two ends of the same linear spectrum, and a trade-off relationship must be considered [16]. Lavie et al. attempted to understand the long-term workings of exploration and exploitation and the cycle concept [17]. Exploitation activities initially invested in by organizations produce income. During the next stage, organizations invest some income in exploration to discover new opportunities. These activities invested in by organizations generate new opportunities, which result in organizations investing in exploration activities in the following stage to create income. In the long-term, exploration and exploitation are interdependent. Therefore, some scholars have begun focusing on dynamic balance and not static balance, such as how organizations implement exploration and exploitation activities rather than the actual ratio of nonspecific time period exploration and exploitation [18]. Lavie et al. compiled four types of models to balance exploration and exploitation [17]:

1) Contextual ambidexterity
   Enterprises give employees clear tasks and implementation autonomy based on core strategic objectives.

2) Organizational separation
   Enterprises can use functional separation or units based on business situations to restructure organizations.

3) Temporal separation
   Organizations can set staged objectives according to current situations and use the time to divide and decide on current strategic exploitation activities.

4) Domain separation
   An organization can implement strategies internally and seek cooperation with other organizations to balance required exploration and exploitation activities.

3. Research Method

This research uses the grounded theory as the research method, which emphasizes the systematic and flexible collection and analysis of qualitative data, including field memos, interviews, information in records and reports, and other data, to build “grounded” on the data Concepts and theories.

NewGreen dedicated itself many years in the air purification field. The core business of the company is indoor air quality detection and purification solutions, air quality data integration and analysis, and cooperation and exploitation in related industries. Their patented indoor air detector can detect 12 types of air purity factors. The product visualizes data, which allows users to understand indoor air quality status. The company also uses cloud technology to create big data services to link related products, achieving smart IoT environment at home.

This study uncovered how NewGreen creatively used strategic agility, resource bricolage, and exploitation and exploration to find a new path, use limited resources to realize corporate growth and development, and build business ecology (see Fig. 1).

4. Case Description and Analysis

NewGreen uses healthy indoor environment as a starting point when investing in air quality detection and diagnostic systems and applied indoor air quality detection and technology standards set by the
International Well Building Institute to develop the GiA air quality smart controller (GiA), which can detect 12 air pollution sources critically affecting human health. GiA combines building design, big data, and IoT technology and uses cloud air quality big data, detection, analysis, and diagnosis to keep indoor air the most comfortable and healthiest possible through detection, diagnosis, improvement, and maintenance.

This process uses the following strategic agility, bricolage methods, and exploration and exploitation architecture (Table 3).

The strategic agility "Sharpening foresight" could be the driving force for NewGreen. First, air quality is converted into data and the allergy index designed by the Taiwan Association of Sick-Building Consultants and academia is integrated. GiA converts air quality data for visualization, which allows for follow-up products and services. During this period, NewGreen began to cooperate with green decoration certification systems to become a green decoration equipment with formaldehyde-free certification.

By using IoT technology, GiA can detect indoor air quality, provide data, and use the Internet to activate corresponding air improvement devices. Initially, NewGreen had insufficient influence and limited resources. Thus, for the single-machine interlinking portion, NewGreen began to cooperate with small manufacturers. The company therefore entered the product sales stage.

As sales were promoted, NewGreen’s visibility began to increase. In addition to increasing the number of interlinkable air improvement equipment, NewGreen start to work with Acer to co-design an interlinkable detection instrument and used this to expand the detection range of indoor air quality. Because the number of interlinkable equipment pieces increased, NewGreen worked with the Taiwan Association of Sick-Building Consultants to provide training for interior designers. NewGreen also provided a designer survey module, simplified designer introduction system procedures, and began to cooperate with designers in improvement projects. The company built a smart indoor air management ecosystem, introduced the IoT and cloud service architecture, and established cooperation with logistical, cash flow, information flow, and service flow stakeholders. Thus, NewGreen served as the foundation for building an indoor air management platform promoted overseas. An international software/hardware integrated symbiotic ecosystem was established by actively cooperating with Indonesian and Japanese building design system integrators and indoor air quality improvement vendors. This promotion and work attracted the interest of the dominant sensory instrument vendor Edimax Technology, who considered investing in NewGreen. NewGreen is being considered as a cooperation partner because it has become a platform business model and not a competitor.
in the same field.

<table>
<thead>
<tr>
<th>Development stage</th>
<th>Strategic sensitivity</th>
<th>Sensor</th>
<th>Product</th>
<th>System</th>
<th>Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic Agility</td>
<td>Leadership unity</td>
<td>⬤ Expectation: forging ahead</td>
<td>⬤ Share mutual benefit</td>
<td>⬤ Designer system</td>
<td>⬤ Multiple sales promotion methods and simultaneous implementation</td>
</tr>
<tr>
<td></td>
<td>Resource fluidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical inputs</td>
<td>Introduction of public IoT data and use of outdoor air quality as key reference for work methods to improve indoor air quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>Cooperation of designers possessing English ability who can provide explanations when exhibiting overseas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneur</td>
<td>Skills</td>
<td>Introduction of ecology system, cloud service, and IoT architecture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bricolage</td>
<td>Customers/markets</td>
<td>Regular indoor air quality improvement mainly using air purification and introducing in new air. Successfully development of air quality improvement projects in veterinary hospitals, clinics, gyms, and Yunlin area elementary school classrooms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Institutional and regulatory environment</td>
<td>Government establishment of Indoor Air Quality Management Act and green decoration introduced to air quality testing procedures</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3. NewGreen’s Development Architecture**

<table>
<thead>
<tr>
<th>Exploration and exploitation</th>
<th>Contextual ambidexterity</th>
<th>Secretary acting as project contact and working with consultation companies. Taking actions according to current situations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Organizational separation</td>
<td>Formation of project teams and implementation of activities according to needs</td>
</tr>
<tr>
<td></td>
<td>Temporal separation</td>
<td>Time used as unit. Individuals or organizations implementing exploration or exploitation work according to current critical items</td>
</tr>
<tr>
<td></td>
<td>Domain separation</td>
<td>Ecosystem members performing respective duties. Ecosystem having units responsible for exploration and exploitation</td>
</tr>
</tbody>
</table>

Observing the development history of NewGreen’s core competence, we can find that the trade-off between exploration and development is an accumulation and iteration model. The earliest core product sensor was further developed in the second phase to improve efficiency and accuracy, and the exploration of equipment linkage began at this stage. The device linkage is further developed in the next stage, and new applications are explored, and so on.

Start-up members must often adopt multiple roles. In this case, NewGreen’s secretary acted as the contact window for cross-regional planning. Although the secretary’s original work was simply to arrange schedules and organize documents, this process required the secretary to become involved with management and strategic planning. Besides, R&D engineering personnel originally responsible for improving internal operation efficiency conducted strategic planning, which was exploratory and embodies organizational separation. In the year when team members worked with consultants, the members received process re-engineering under the guidance of consultants while sometimes participating in sales expansion and technology blueprint planning. In this situation, exploration and exploitation also had to change according to the latest assignments. After constructing the smart air ecosystem, technology companies now can focus on investing in system exploitation work while they may need to develop their own sales previously. In addition, designer units involved in promotion activities no longer need to be distracted from air management technology and knowledge development because they have technical support. In this study,
contextual ambidexterity, organizational separation, temporal separation, and domain separation exploitation could be observed in various stages.

5. Conclusions

In the era of changing and complicated economic patterns, how to use crisis awareness to build future-oriented capabilities and enable enterprises to face the future is a proposition that they have to face. By cross-verifying case experiences, strategic agility, and resource bricolage theory this study discovered that NewGreen had limited initial resources in the beginning. The company continuously collected, pieced together resources and displayed a bricolage spirit, and changed its business model from selling detection instruments to matching and selling improvement equipment. The company moved from selling single products and services to eventually establishing an industrial Ecosystem.

In recent years, scholars have begun to apply ecosystem perspective to the research of organizational marketing and business management, to explore the dependencies between all partners in the business market, or the adaptation and evolution capabilities of partners, and to discuss "How a group of interdependent, economically and socially responsible partners create value; a self-sufficient and self-regulating system composed of a group of resource integration partners; and these partners are connected through shared institutional logic and the mutual creation of value during the service exchange process." There are three main roles in the ecosystem: 1) to attract or invite stakeholders in the entire service ecosystem to participate in value creation with partners and use shared resources; 2) to shape and induce stakeholders to provide available resources and relationships, to commit to co-creation of value; 3) to regulate the system's resource sharing and derives a value proposition with a future vision and greater benefits.

In summary from this case study, there are three key factors for maintaining agility in the business environment and becoming an innovation driver in the market:

1) Commit to promoting industrial progress, training and developing teams to build organizational capabilities:

How to make organizational ability and efficiency and organizational development can really promote enterprise progress is very important. The building of organizational capabilities, the organization's continuous change, and the promotion of sustainable growth capabilities must be done.

2) Return to customer value, system synergy and value creation:

Enterprises should strive to establish a market and customer information search mechanism, with the application of digital, mobile and Internet technologies to better understand customers.

3) Put itself on a longer-term value contribution and stick to long-termism

When a company is guided by long-termism, it can guarantee that the enterprise truly creates value and can prevent or surpass the fluctuations and changes brought by the environment. Furthermore, it maintains the mindset of constantly seeking improvement and finding new ideas, continuously reviews the effectiveness of strategy execution from performance, and maintains its vitality and motivation at any time.

This study used strategic agility, resource bricolage, and exploration and exploitation theory framework to describe a commercial case and cited recommendations as references for companies for long-term development. This study can serve as a reference for start-ups to sustain continuous operations and for future studies on strategic agility, resource bricolage, and exploration and exploitation theory.

Conflict of Interest

We declare that we do not have any associative financial and personal relationships interest that represents a conflict of interest in connection with the work submitted.
Author Contributions

1) First author make substantial contributions to research framework conception and conduct stakeholders interviews design, case description and theory analysis, interpretation.

2) Co-Author give final approval of the version to be submitted and participate in drafting the article, and revising it critically for important intellectual content.

Acknowledgment

Firstly, I would like to express my very great appreciation to Public & Livelihood IoT Data Application Subsidy of Industrial Development Bureau, Ministry of Economic Affairs, ROC, which provide valuable support to the Small and Medium Enterprises. Besides, assistance provided by Acer, Edimax and Taiwan Association of Sick-Building Consultants for data collecting was greatly appreciated. Finally, I would like to offer my special thanks to Mr. Wen-Cheng Shao, the Associate Professor and Chairman of the Department of Architecture, National Taipei University of Technology, who provides his profession and support to the indoor air quality issue.

References


Copyright © 2021 by the authors. This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited (CC BY 4.0).

**Yuan-Hsiang Liang** was born in 1973 in Taiwan. He currently is studying at the College of Management doctoral program, National Taiwan University of Science and Technology. In 2002, he earned the MBA from the Department of Business Administration, National Taipei University, and the topic of his master's thesis is “the empirical study of macroeconomic indicators constructing the trading strategy of Taiwan stock index futures.”

He was assumed the director and senior management consultant of the Integrated Business Group at China Productivity Center which is “the most reliable and valuable business management consulting institute among Chinese corporations” since 2002. Under his leadership, two consultancy guidebooks “Corporate Customer-Oriented Operation Success Formula-Service Capital Chain Management” and “Profit Design” were compiled.

He is taking charge of Incubation & Entrepreneurship Services, Enterprise Growth, Industrial internationalization & Innovation Consultancy Departments at China Productivity Center. He is leading the team to play the role of an advisor to accompany the organization’s business strategy for high-quality growth, to connect with overseas economies and facilitate trade expansion, to be a pioneer in international management law, and to be partners in business innovation. The goal of his research is to provide social innovation and digital enabling strategy to accompany entrepreneurs leading the industrial transformation.