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

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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 1. Strategic Agility Elements

Strategic sensitivity				
Anticipating Sharpening foresight - Explore future usage concepts - Do not over-rely on foresight tools (e.g., scenario planning)	Experimenting Gaining insight by probing and discovering "lead locations" and innovation hotspots - Conduct local experiments and in-market tests - Use corporate venturing strategically and reflexively	Distancing Gaining perspective - Nurture an "outside-in" perspective through a rich network of personal contacts - Hear peripheral voices	Abstracting Gaining generality - Restate business models in conceptual terms	Reframing Understanding the need for business model renewal - Engage in honest, open, and rich dialogue on strategic matters
Leadership unity				
Engaging in dialogue Surfacing and sharing assumptions and understanding contexts - Explore underlying assumptions and hypotheses, not just conclusions, to develop common ground	Revealing Making explicit personal motives and aspirations - Use transparency and motive clarity to attract mutual respect, trust, and positional understanding	Integrating Building interdependencies - Define valuable common agendas that condition success	Aligning Sharing common interests - Give common meanings deeper than incentives	Caring Providing empathy and compassion - Provide the personal safety needed to be playful
Resource Fluidity				
Decoupling Gaining flexibility - Organize by customer/segmentation-based value domains	Modularizing Assembling and disassembling business systems - Develop "plug and play" functionality for business systems and processes	Dissociating Separating resource use from resource ownership and negotiating resource access and allocation	Switching Using multiple business models - Have parallel business model infrastructures and align and switch products between them	Grafting Transforming oneself - Import business models from acquired companies

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 2. Environmental Fields in Bricolage Exploitation

Environmental Domains Where Bricolage Is Used to Create Something from Nothing	
Domain	Description
Physical inputs	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.
Labor	By involving customers, suppliers, and hangers-on in providing work on projects, bricolage may create labor inputs.
Skills	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.
Customer/markets	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.
Institutional and regulatory environment	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.

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 exploitation 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.

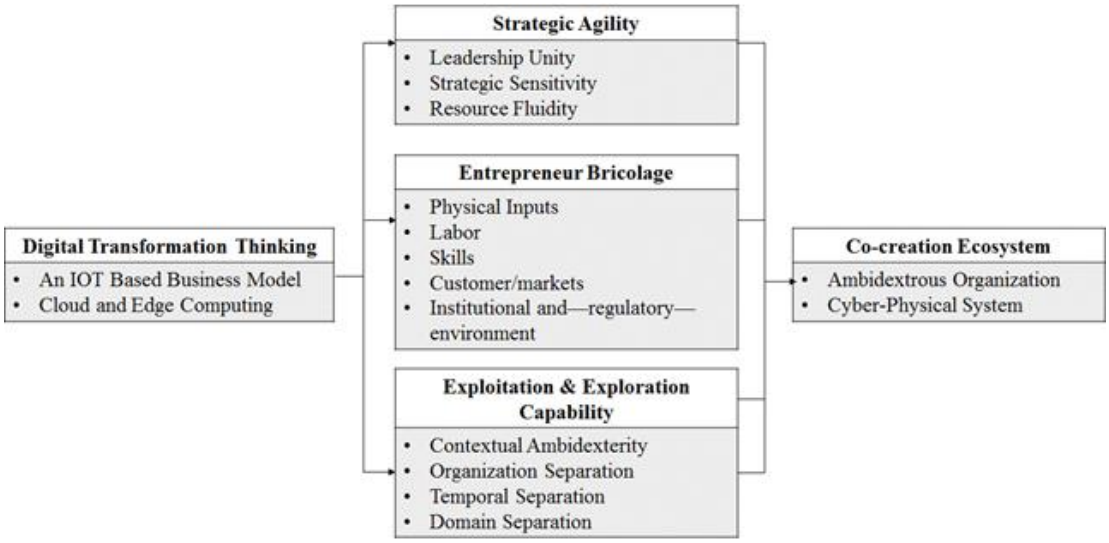

Fig. 1. Innovation process of case company.

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 3. NewGreen's Development Architecture

Development stage		Sensor	Product	System	Platform
Strategic Agility	Strategic sensitivity Leadership unity Resource fluidity	● Expectation: forging ahead	● Share mutual benefit ● Joint manufacturing	● Designer system	● Multiple sales promotion methods and simultaneous implementation
	Physical inputs	Introduction of public IoT data and use of outdoor air quality as key reference for work methods to improve indoor air quality			
	Labor	Cooperation of designers possessing English ability who can provide explanations when exhibiting overseas			
Entrepreneur Bricolage	Skills	Introduction of ecology system, cloud service, and IoT architecture			
	Customers/markets	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			
	Institutional and regulatory environment	Government establishment of Indoor Air Quality Management Act and green decoration introduced to air quality testing procedures			
	Exploration	Sensor	Equipment link	Interlink system	Smart air platform
	Exploitation		Sensor	Equipment interlink	Interlink system
Exploration and exploitation	Contextual ambidexterity	Secretary acting as project contact and working with consultation companies. Taking actions according to current situations			
	Organizational separation	Formation of project teams and implementation of activities according to needs			
	Temporal separation	Time used as unit. Individuals or organizations implementing exploration or exploitation work according to current critical items			
	Domain separation	Ecosystem members performing respective duties. Ecosystem having units responsible for exploration and exploitation			

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.

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References

[1] Santucci, G. (2009). From internet of data to internet of things. Retrieved from the website: http://www.ipv6council.lu/docs/G_Santucci_paper.pdf

[2] Shin, D. (2014). A socio-technical framework for Internet-of-Things design: A human-centered design for the Internet of Things. *Telematics and Informatics*, *31*, 519–531.

[3] Atzori, L., Iera, A., & Morabito, G. (2010). The internet of things: A survey. *Computer Networks*, *54*, 2787–2805.

[4] Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, *29*, 1645–1660.

[5] Katila, R., & Shane, S. (2005). When does lack of resources make new firms innovative? *Academy of Management Journal*, *48(5)*, 814–829.

[6] Weber, Y., & Tarba, S. Y. (2014). Strategic agility: a state-of-the-art introduction to the special section on strategic agility. *California Management Review*, *56(3)*, 5–12.

[7] Alpkan, L., & Gemici, E. (2016). Disruption and ambidexterity: How innovation strategies evolve? *Procedia-Social and Behavioral Sciences*, *235*, 782–787.

[8] Păunescu, C., & Badea, M. R. (2014). Examining the social capital content and structure in the pre-start-up planning. *Procedia Economics and Finance*, *15*, 560–568.

[9] Doz, Y. L., & Kosonen, M. (2010). Embedding strategic agility: A leadership agenda for accelerating business model renewal. *Long Range Planning*, *43(2)*, 370–382.

[10] Wirtz, B. W., Schilke, O., & Ullrich, S. (2010). Strategic development of business models: Implications of the web 2.0 for creating value on the internet. *Long Range Planning*, *43(2/3)*, 272–290.

[11] DaSilva, C. M., & Trkman, P. (2014). Business model: what it is and what it is not. *Long Range Planning*, *47(6)*, 379–389.

[12] Prahalad, C. K., Hamel, G., Hahn, D., & Taylor, B. (2006). *The Core Competence of the Corporation Strategische Unternehmungsplanung Strategische Unternehmungsfhrung*, 275–292. Berlin, Heidelberg: Springer.

[13] Hull, C. E., & Rothenberg, S. 2008. Firm performance: The interactions of corporate social performance with innovation and industry differentiation. *Strategic Management Journal*, *29(7)*, 781–789.

[14] Baker, T., & Nelson, R. E. (2005). Creating something from nothing: resource construction through entrepreneurial bricolage. *Administrative Science Quarterly*, *50(3)*, 329–366.

[15] Senyard, J., Baker, T., Steffens, P., & Davidsson, P. (2014). Bricolage as a path to innovativeness for resource-constrained new firms. *Journal of Product Innovation Management*, *31(2)*, 211–230.

[16] March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, *2(1)*, 71–87.

[17] Lavie, D., & Rosenkopf, L. (2006). Balancing exploration and exploitation in alliance formation. *Academy of Management Journal*, *49(4)*, 797–818.

[18] Lavie, D., Stettner, U., & Tushman, M. L. (2010). Exploration and exploitation within and across organizations. *The Academy of Management Annals*, *4(1)*, 109–155.

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