VALUE CREATION, VALUE SENSING, VALUE DELIVERY, AND VALUE CAPTURING MECHANISM OF GREEN BUILDING: A VALUE NETWORK PERSPECTIVE

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ABSTRACT

The development and expansion of cities has led to increased public awareness of the influence of building sustainability on the environment, society, and economy. Green building eases the pressure of urbanization by saving energy, reducing waste, protecting the environment, improving the living standard, and encouraging industry. Consequently, green building has developed rapidly for 20 years. This study reviews the literature on green building, recognizes the stakeholders' motivations for and barriers to green building development, uses value network analysis, cost–benefit analysis, and case study method for understanding value creation, value sensing, value delivery, and value capturing mechanism of green building to augment the knowledge of green building development for both academics and practitioners. This study proposes an applicable analysis tool.

Keywords: Green building, Stakeholders, Value creation, Value sensing, Value delivery, Value capturing, Value network, Cost–benefit analysis

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CHAPTER 1

INTRODUCTION

The development and expansion of cities has led to increased public awareness of the influence of building sustainability on the environment, society, and economy. Green building eases the pressure of urbanization by saving energy, reducing waste, protecting the environment, improving the living standard, and encouraging industry. Consequently, green building has developed rapidly for 20 years. Green buildings in China are developing in terms of both "velocity and volume," according to "the 13th five-year plan of building energy saving and green building development." In perspective, by 2020, green buildings must cover 50% of newly developed buildings; 80% of green building projects should acquire a 2-star label; and 30% should acquire an operation label. In this context, this study reviews literature on green building, analyzes and models the stakeholders of green building development, and presents case studies of green building projects.

This study discusses the following research questions:

(1) Who are the stakeholders that influence green building development? What positive and negative influences would green building deliver to these stakeholders?

(2) Are green buildings economically, environmentally, and socially more feasibly than traditional buildings? If yes, can the value be recognized financially?

(3) What are the stakeholders' value propositions? How could green building create value for them? How are the values delivered and captured?

(4) Can value network analysis be used to describe and express value creation, sensing, delivery, and capturing of green building? How can this description and expression be developed into a reusable analysis tool?

This study combines the case study method, cost–benefit analysis, and value network analysis (Allee, 2008) to evaluate the feasibility of green buildings and understand value creation, delivery, and capturing mechanism across different stakeholders. Based on this understanding, value network analysis is used to model, analyze, and evaluate tangible and intangible values. Value network analysis includes (1) network as a basic mechanism of value delivery, (2) creating value from intangible assets, (3) medium of value delivery, and (4) value delivery.

This study is presented as follows. Chapter 2 reviews the literature on green buildings, construction, value network, business ecosystem, and cost–benefit analysis. Chapter 3 describes the research design. Chapter 4 presents two cases: one using cost–benefit analysis to assess the value creation of green buildings and the other using the value network tool developed in chapter 3 in mapping value creation, delivery, and capturing mechanism in the green building ecosystem. Chapter 5 concludes the study with key contributions for academicians and practitioners; it also mentions the limitations and highlights future research directions.

CHAPTER 2

LITERATURE REVIEW

Studies on green building mainly focus on three aspects: (1) definitions of green building; (2) cost–benefit analysis of green building; and (3) planning and implementation of green building. This chapter reviews the literature from these three aspects, development of green buildings in China, and the barriers to implementing green building.

An Overview of Construction Projects

The physical existence of a building is a combination of different materials from various sources. These materials are processed in different places and thus the materials require the services of several people and various organizations. This characteristic was discussed in detail more than 60 years ago (Cox and Goodman, 1956:36) and the discussion concluded that there are several transactions and interactions, organizations and locations involved in a single project. It requires strong problem-solving capabilities to solve the complexities of a construction project (e.g., Winch, 1987; Gidado, 1996).

Complexities should be considered when the construction industry is analyzed. The industry is often criticized for limited process efficiency (Cox & Thompson, 1997) and little progress toward innovation and technology (Dubois & Gadde, 2000). Studies have shown that the construction industry does not adapt to new technologies or methods that are successful in other industries, for example, Just In Time (Pheng & Hui, 1999), Total Quality Management (Shammas-Thoma, Seymour, & Clark, 1998), and supply chain (Gann, 1996).

Participants in a Construction Project

Gann and Salter (1998) noted the participants and their network relationships in a construction project (Figure 1). Marceau et al. (1999) highlighted that architecture and construction as a system include manufacturing (raw material, components, and devices) and service (engineering, design, surveying, consultation, and management). A construction project also requires various products, services, and logistics.

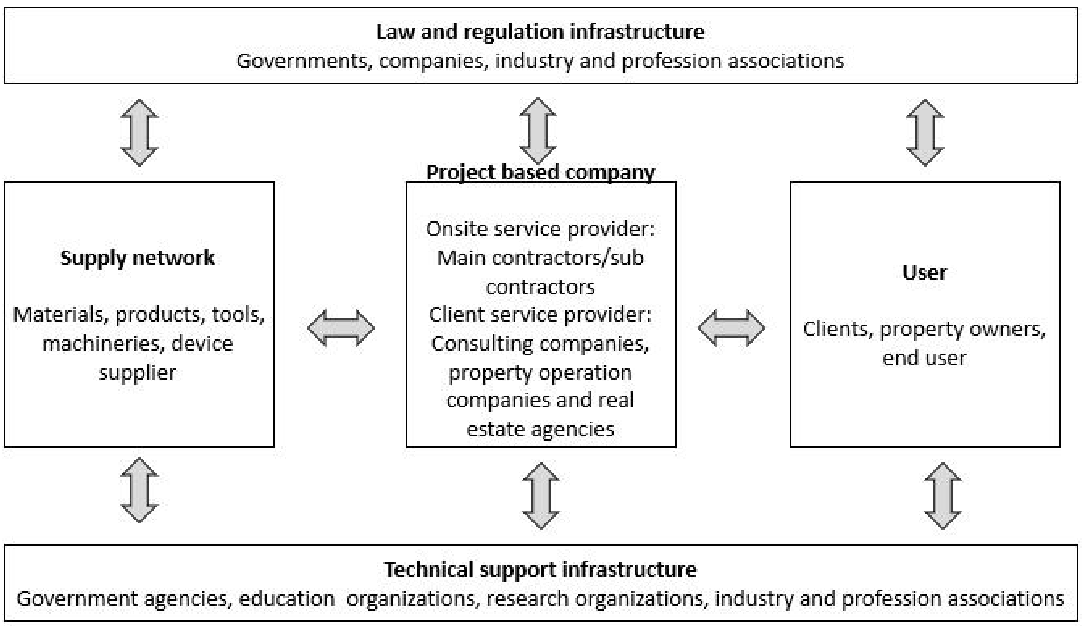

Figure 1. Participants and their Network Relationships in a Construction Project

Complexity of a Construction Project

Gidado (1996) suggested that several factors should be considered for understanding the complexity of a construction project, which is twofold: one is uncertainty, which is determined by the materials or contexts of a particular project, and the other is interdependence, which means integrating different components sourced from various locations into one workflow. Four factors determine the uncertainties in a construction project: (1) the management personnel's lack of familiarity about the site resource and environment; (2) the lack of a detailed description of onsite construction activities; (3) the lack of unity of materials, works, and teams in terms of location and time; and (4) unpredictable factors within the environment.

In construction projects, interdependencies are a result of (Gidado, 1996): (1) the interdependencies between different construction technologies; (2) the strict requirement for a sequence of main processes; and (3) the periods of overlap in different construction stages. Subcontracting is a usual practice in construction projects, which also causes the interdependencies in construction projects (Eccles, 1981).

Key Characteristics of Construction Projects

Construction projects require significant local coordination efforts (Cox & Thompson, 1997; Shirazi, Langford, & Rowlinson,, 1996), which highlights the characteristics of localized decision making and financial control and the interdependencies. Thus, construction material suppliers find it difficult to provide customized products for a certain contractor or construction site. Therefore, the construction industry depends more on "standard" products and the economy of scale created using standard products rather than following a "standard procedure" (Stinchcombe, 1959). Construction projects usually undergo a competitive bidding process, which is based on high efficiency and low cost. The bidding system also leads to a "short-term, market-oriented relationship between independent business entities" (Gann, 1996).

Loose Coupling Relationship in Construction Projects

A "tight" or "loose" relationship exists between activities at a construction site (Orton & Weick, 1990). Glassman (1973) suggested that the degree of coupling depends on the frequency and intensity of shared activities. Weick (1976) concluded that the characteristic of loose coupling is the mutual responsiveness between separately operated activities. This loose coupling can exist between individuals, organizations, environments, ideas, or activities and can help complex systems such as construction projects as follows (Dubois & Gadde, 2000):

- Localized adaptation: In a loose coupling system, a fraction, instead of the whole system, can be adapted to the uncertainties in the local context.
- Buffering: A loose coupling system provides a buffering mechanism for an organization to adapt to the changing context. Therefore, an organization does not need to respond to a minor change within the context.
- Context-sensing mechanism: Localization and decentralization features of a loose coupling system provide a sensitive responsive mechanism, which can sense changes within the context and respond accordingly.
- Self-determination: A loose coupling system provides more decision space for individuals within an organization. These autonomy units make the organization more efficient.

Table 1 summarizes the complex factors and loose coupling systems.

Table 1

Complex Factors and Loose Coupling Systems

Complexities bought by uncertainties	Complexities brought by interdependencies	Functions of a loose coupling system
• Lack of complete understanding of the context • Unfamiliar with local resources and contexts • Lack of consistency in managing materials, workflows, and teams • Unpredictability of the context	• Technologies and the correlations between them • Strict requirements in the sequence between key processes • The overlapping between stages or elements in construction projects	• Localized adaptation • Buffering • Context-sensing mechanism • Self-determination

Construction projects also comprise “tight coupling” systems. Figure 2 shows the network relationship of a construction project. A construction project can be considered a “temporary” network within a “permanent” network (Dubois & Gadde, 2000). Companies A, B, and C participate in the same project. Their outputs in the project are various resources (A1, B1, and C1). Simultaneously, these companies participate in other projects and hence should coordinate activities and resources with other companies.

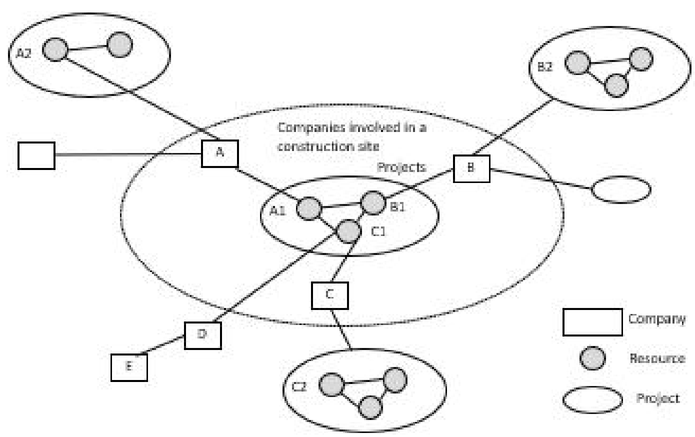

Figure 2. Network Relationship in Construction Projects

For example, company C in Figure 2 should coordinate four relationships:

1. Coordinating resources within the project (C1, A1, and B1)

In a construction project, there are time pressure, requirements in the following working procedure, and professional participation. Therefore, “tight coupled” onsite activities exist. Gidado (1996) suggested that in a strictly designed working procedure, any delay in one link could hamper the process of the entire project. Besides sequential work, a project’s process can be parallel, which also leads to uncertainty, and therefore, complexity.

2. Coordinating with companies in its supply chain (D and E)

The main “input” resource in a construction project is standardized. Activities including transportation and storage and material manufacturing follow a set of standard procedures. Construction materials are transported directly from manufacturers or distributors, depending on the required quantities. Distributors act as slack resources as they are faster than manufacturers.

3. Coordinating with other projects in company C (C2)

A company should coordinate resources between projects. As activities are closely connected, delay in one project would possibly affect other projects. The company should coordinate resources internally. Projects compete with each other if there is a lack of resources (Crichton, 1966; Dubois & Gadde, 2000).

4. Coordinating with companies in other projects (companies A and B)

Collaboration between companies across projects is rare. Therefore, the linkages of activities across projects are slack.

Construction Innovation

There is a high level of technical and business model innovation in green buildings. A construction project should provide new products and improve efficiency through innovation. Besides, a construction company should use new processes and methods to increase its competitiveness. Blayse and Manley (2004) suggested that (1) clients and manufacturers, (2) characteristics of construction projects, (3) relationship between individuals and companies, (4) purchasing, (5) regulations and standards; (6) characteristics and quality of organization resources should be considered in construction innovation.

Clients and Manufacturers

Clients can significantly influence innovation in individuals and companies in the construction industry (Seaden & Manseau, 2001): They can demand more from developers, product suppliers, and contractors and pressurize project participants to improve the performance and flexibility of the buildings across their life spans; more demanding clients stimulate product innovation (Barlow, 2000); similarly, clients with higher technical capabilities demand more from innovation (Nam & Tatum, 1997).

Manufacturers are another source of construction innovation as they can provide innovative components and materials (Anderson & Manseau, 1999). Manufacturers serve a more stable and standardized market. Therefore, they can initiate and maintain R&D projects simultaneously as they have more learning activities and build their knowledge base.

Characteristics of Construction Projects

The transfer of knowledge within and between organizations is difficult because of the temporary and one-off characteristics of construction projects (Dubois & Gadde, 2002). These characteristics impede innovation activities. Studies have shown that there are many repetitive development works in the construction industry because of similar client requirements, which hampers organizational learning (Barlow, 2000).

Moreover, the features of construction materials are not innovation friendly. The industry prefers proven, stable materials. High inventory level (Pries & Janszen, 1995) and complexity of the project (Barlow, 2000) also hamper innovation. The industry comprises several small-size participants that do not have the resources required for innovation (McFallan, 2002).

Relationship between Individuals and Companies

The relationship between individuals and companies directly affect knowledge transfer during interactions and transactions (Anderson & Manseau, 1999), which can be about products, project management process, technology and practice, and knowledge delivery (Anderson & Manseau, 1999). A construction site can be considered a "Mini lab" (Dubois & Gadde, 2002). The knowledge created is usually tacit and difficult to deliver.

Purchasing

Purchasing practice in the construction industry does not encourage the innovation process and products. The existing system emphasizes efficiency, responsiveness, and price (Kumaraswamy & Dulaimi, 2001). The turn-key contracts in the construction industry are not innovation friendly (Walker, Hampson, & Ashton, 2003). Design-construct, construction management, and engineering management contracts promote communication and study activities between participants. Therefore, it is easier to capture values created by innovation (Walker et al., 2003).

Regulations and Standards

Government regulations and standards promote or demote innovation, largely depending on the policymaker's capability (Gann & Salter, 1998). If the policymaker lacks industrial knowledge, the regulations or standards might be based on old technology. When regulations and standards are made from a strategy perspective, they promote technology development.

Characteristics and Quality of Organization Resources

Accordingly, organizational resources include the organization's innovation culture, technology application capability, internal innovation champions, knowledge absorption and application capability, and innovation strategy (Blayse and Manley, 2004).

Definitions of Green Building

Concepts of Green Building

In literature, the concept of green building is discussed interchangeable with sustainable building and high-performance building. The definitions of green building include the following components: life cycle, environmental sustainability, health issues, and impacts on community. For example, Kibert (2008) defined green building as "*healthy facilities designed and built in a resource-efficient manner, using ecologically based principles*" (p. 8). Robichaud and Anantatmula (2010) proposed the four components of green building: (1) minimize the impact on the environment, (2) enhance the occupants' health conditions, (3) return on investment to developers, and (4) consideration of life cycle during planning and development. Green buildings in China should offer "four savings and one environment protection" as "*green building is the maximization of resource saving (energy saving, space saving, water saving and material saving), environment protection, and waste reduction. As a result, it provides healthy,* *comfortable and efficient space and building for people* (Zhang & Gu, 2012, p. 19). This study follows Zhang and Gu (2012) as the basic definition of green building.

Assessment Standard of Green Building

There are several tools to assess green building, including: Leadership in Energy and Environmental Design (LEED, USA), BRE Environmental Assessment Method (BREEAM, UK), Green Building Council of Australia Green Star (GBCA, Australia), Green Mark Scheme (Singapore), DGNB (Germany), Comprehensive Assessment System for Built Environment Efficiency (CASBEE, Japan), and Hong Kong Building Environmental Assessment Method (HK BEAM). These assessment tools are developed by national or regional green building management agencies and are not mandatory. They are usually assessed by certified professionals. China has introduced a standard system for green building assessment, for example, "Green Building Evaluation Standard" (GB/T50378-2006), "Green Industrial Building Assessment Guidelines" (2010), "Construction Projects Green Implementation Evaluation Standard" (GB / T50640-2010), and "Industry Standard – Civil Building Green Design Standard" (JGJ / T229-2010).

Assessment tools across several countries are similar. Sustainability is categorized into several dimensions and assessment methods are applied to different types of buildings. For instance, GBCA of Australia developed rating tools for 10 categories in buildings for education, office, healthcare, retail, public, residential, and commercial, and office interior and interiors. Different categories have different points allocated to management, indoor environment quality, energy, traffic, water system, material, land usage and ecology, air pollution, and innovation. The Chinese government has allocated "Green Building Design Evaluation Label" and "Green

Building Evaluation Label" and society participation for labeling is voluntary. The "Green Building Evaluation Standard" realized by the Ministry of Housing and Urban–Rural Development evaluates residential and public buildings (office, shopping, and hotel) by six categories. The categories are land saving and outdoor environment, energy saving and utilization, water saving and utilization, material saving and utilization, indoor environment quality and operational management. Green buildings are awarded one-star, two-star, and three-star rating from bottom to top. Although different assessment tools have similar design principles and methods, differences in relative environment conditions (e.g., raining volume) *may cause a significant weighting difference in similar dimensions.*

Costs and Benefits Analysis of Green Building

Several studies exist on the costs and benefits analysis of green building. These studies are consistent with normal intuition, that is, the decision-makers should consider the pros and cons of green and conventional buildings. This study compares the difference between green and conventional buildings through the lens of energy and water resource efficiency, indoor environmental quality, thermal comfort, health, and productivity.

Environmental Benefits

Green buildings can protect a city's ecosystem and biological diversity (Henry & Frascaria-Lacoste, 2012; Bianchini & Hewage, 2012) and reduce building demolition and building waste (Yeheyis et al., 2013). Buildings that pass the LEED standard perform better than conventional buildings in terms of carbon dioxide emission (Jo, Golden, & Shin, 2009) and energy saving (Turner & Frankel, 2008).

Economic Benefits

From a life cycle perspective, green buildings consume 30% less energy than conventional buildings (The Economist, 2004). Thus, the upfront cost of green buildings is higher than that of conventional buildings. For example, to achieve GBCA five-star and six-star ratings, the construction cost would increase 4% and 10%, respectively (Langdon, 2007), and LEED standard would cost extra 10% (Ross, Lopez-Alcala, & Small, 2007). From an economic perspective, cost savings earned by complying with green building standard could compensate or even exceed the extra construction costs.

Health Benefits

Occupants need to work or live in buildings for a long time. Therefore, in addition to measurable benefits, human comforts and health should be assessed direction when analyzing green buildings. The temperature and humidity control (Sicurella, Evola, & Wurtz, 2012), Indoor Environmental Quality (Yu & Kim, 2010) are better than in conventional buildings, so green building occupants are more satisfied (Lee & Guerin, 2009) and productive (Ries et al., 2006). Maintaining a comfortable environment increases energy consumption; therefore, a balance between comfort and energy saving should be achieved (Omer, 2006).

Design, Assessment, and Implementation of Green Buildings

The design, assessment, and implementation of green buildings are mainly composed of four components: technology, life cycle assessment, management, and behavior.

Technology

The use of renewable energy is an important criterion in green building assessment tools. Typical renewable energy sources in buildings include solar water heater, solar panel, small wind turbine, and geo-thermal pump (Li, Yang, & Lam, 2013). Use or mixed use of renewable energy could significantly reduce energy consumption and protect the environment. It is challenging in terms of costs, maintenance, and operation to use renewable energy in green buildings (GhaffarianHoseini et al., 2013).

Waste control in construction and demolition (C&D) process, including control of energy consumption, emissions, material recyclability, and reusability, is important in green building construction. Related indicators are directly reflected in green building assessment tools and accounts for a significant portion (Kibert, 2008).

Life Cycle Assessment

Life Cycle Assessment (LCA) considers buildings as a system. It quantifies the material flow and energy consumption using different construction stages, and therefore provides analysis based on data (Zuo & Zhao, 2014).

Management

In a green building construction process, organization and process introduce greater barriers than technology or assessment tools (Hakkinen & Belloni, 2011). At the project level, management capability and organizational support are needed for expert participation in green building, compliance with the assessment tools, continuous green building training, coordination with outside stakeholders (Robichaud & Anantatmula, 2010), human resource, technological innovation, support from designers and executives, and coordination between design and construction teams (Li, Chen, Chew, Teo, & Ding, 2011). At the company level, implementation of Environment Management System (Liu & Lau, 2012), executive support (Beheiry, Chong, & Haas, 2006), and the practice of corporate social report (Zuo, Zillante, Wilson, Davidson, & Pullen, 2012) influence green building development and operational performance. At the market and public policy level, government promotes green building using incentives or compulsory methods (Baek & Park, 2012).

Behaviors and Culture

All stakeholders should understand green building (Cole & Brown, 2009). Similar to management issues, barriers caused by social or psychological recognition are believed to be higher than that by technology or finance (Hoffman & Henn, 2008). Kato, Too, and Rask (2009) suggested that psychological satisfaction (e.g., feeling good about the working environment) of obtaining a green building certificate is more than tangible benefits (e.g., improvement in productivity). The use of green building also helps improve the corporate image (Rashid, Spreckelmeyer, & Angrisano, 2012).

Green Building Development in China

The concept of green building was introduced to China in the 1990s, and explorative research and application began in 2001 (Zhang & Gu, 2012). By September 2016, 5200 million square meters of buildings had acquired domestic green building label and more than 6 million square meters of LEED[2] certificate were added (CBRE, 2017). According to “the 13th five-year plan of building energy saving and green building development” released by the Ministry of Housing and Urban–Rural Development, green buildings should include 50% of newly developed buildings; 80% of green building projects should acquire 2-star label; and 30% should acquire a green label. The country's newly developed green buildings should reach 2 billion square meters (Figure 3).

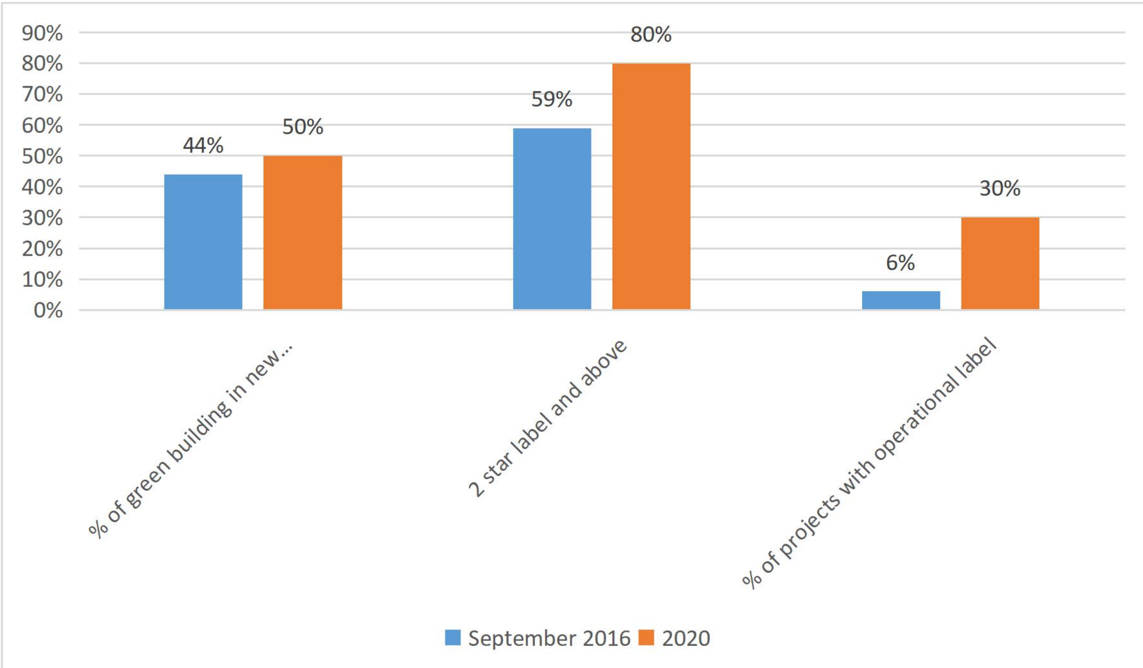

Figure 3. Green Building Target in China

Barriers to Green Building Development

Barriers to green building development can be categorized into economic, cognition, market, regulation, organization, and education barriers.

Economic Barriers

Investment in green building's design, construction, and equipment is higher than that in conventional buildings. The economics of green buildings over conventional buildings even in the long term is debated. For example, Yin and Bai (2014) reported that green buildings are more economical than conventional buildings in their full life cycle, while Forbes (2014) reported that LEEDS-certified buildings might save less energy than non-LEEDS–certified buildings.

Cognition Barriers

Understanding a building's life cycle and sustainable development concept is a key barrier to promoting and accepting green building. In practice, no effective methods and tools exist for evaluating tangible and intangible benefits during a building's full life cycle and policy makers and contractors have little confidence in developing green buildings (Issa, Rankin, & Christian, 2010).

Market Barriers

Market barriers include gaining market recognition, introducing green building requirement into building contract bidding (Gundogan, 2012), not recognizing the value of green building, and having not enough market demand (Leadman, 1999).

Regulation Barriers

Government policy support, such as green building compensation or tax reduction (Xu & Shen, 2008; Chan, Qian, & Lam, 2009; Zhang, Shen, & Wu, 2011) or green finance (Ma & Shi, 2014), is essential for green building development. Green building has strong externalities, and it requires huge investment; therefore, policy support is needed to ensure that the society the benefits from green buildings.

Organizational Barriers

Construction schedule and investment are negatively affected by the lack of necessary process of green building design or construction management for design companies and construction contractors. Organizations also should summarize and transfer knowledge related to green buildings (Schaltegger & Synnestvedt, 2002).

Education Barriers

Stakeholders have different perceptions of green building, and the current education does not meet the demand of green building development (Wood, 2007). Moreover, education should address the gap in the implementation of knowledge (Leadman, 1999).

Technical Barriers

The supply of green building technologies and materials in markets is insufficient (Eisenberg et al., 2002). Practitioners do not have enough knowledge and skills on green building (Williams & Dair, 2006). Inconsistent green building assessment tools or systems have also hindered their promotion (Pitt, Tucker, Riley, & Longden, 2007). Table 2 provides a summary of barriers to green building development in the literature.

Table 2

Barriers to Green Building Development

Research	**Barriers**	**Type**
Moore (1994)	Lack of understanding of green building	cognition
	Lack of financial support	economic
	Competition	market

Table 2 , continued

	No management agency to match with	regulation
	Differences in cognition	cognition
	Lack of communication between government decision makers and government construction management agencies	regulation
	Lack of communication between government and congress	regulation
Xu and Shen (2008)	Lack of regulation support	regulation
	Higher construction cost	economic
	Higher operation cost	economic
	Higher green material and equipment cost	economic
	Higher requirement in design and construction	technical
Leadman (1999)	Lack of demand	market
	Lack of training and education	education
	Lack of long-term revenue payback mechanism	economic
	Higher development cost	economic
Wilson and Tagaza (2006)	Higher upfront development cost	economic
	Fee-model based on short-term financial return	economic
	Lack of support from occupants	cognition
	Longer design cycle	technical
	Introduction of recyclable materials	technical
	Change of old construction practice	technical
	Longer planning permission time	regulation
Williams and Dair (2006)	Lack of quantification of the impact toward environment	market

Table 2 , continued

	Understanding of costs	cognition
	Lack of expertise and authorization	technical
Wood (2007)	Lack of understanding of green building costs and benefits	cognition
	Risks in adopting new technology and process	technical
	Inconsistent definition of green building	regulation
	Lack of training and education for construction practitioners	education
	Lack of policy incentives	regulation
Richardson and Lynes (2007)	Decision power confusion within stakeholders	organization
	Lack of quantifiable sustainable development target	organization
	No incentive for operating low energy cost building	regulation
	Lack of communication between designers, property management companies and property owners	organization
Pitt et al. (2009)	Affordability	economic
	Construction regulation	regulation
	Customer awareness	cognition
	Lack of successful cases	cognition
	Lack of reliable technology	technical
	Inconsistency between assessment tools	technical
	Planning regulation	regulation

Table 2 , continued

Turner Construction (2008)	Costs in implementing LEED	economic
	Higher construction cost	economic
	Long ROI time	economic
	Lack of understanding in investment return	cognition
	Lack of quantifiable evaluation methods on investment return	technical
	Short sighted construction budget	economic
Chan, Qian, and Lam (2009)	High one-off investment	economic
	Lack of education	education
	Lack of public awareness	cognition
	Lack of government financial support	regulation
Zhang, Shen, and Wu (2011)	Costs of green design and energy-saving materials	economic
	Customers' intention of choosing green building	cognition
	Lack of policy support	regulation
Winston (2010)	Lack of visions toward sustainable buildings	market
	Lack of construction regulation	regulation
	Lack of expertise in green building	technical
	Lack of good design	technical
	Negative impression toward green building	cognition
	Unrecognized positive impact of green building on society	market
	Lack of resource	market

Table 2 , continued

Belloni and Hakkinen (2011)	Financial return	economic
	Decision making mechanism	organization
	Lack of customer understanding	cognition
	Purchasing, bidding, coordination process	Organization
	Availability of knowledge, common language, methods and tools	technical barriers
Azizi, Fassman, and Wilkinson (2011)	Financial risk	economic
	Regulation risk	regulation
	Lack of experience of designers and contactors	education
	Availability of green material	organization
	Performance of green building	technical

The Definition, Creation, and Capture of Value

Resource-based view suggests that a company's competitive advantages are sourced from valuable resources or capabilities, and it is valuable only when the resources or capabilities "exploit opportunities and/or neutralizes threats in a firm's environment (Barney, 1991, p. 105). Bowman and Ambrosini (2000) divided value into two components: (1) perceived value, which depends on a customer's perception on a product's usefulness, and the monetary value is the amount that a customer is ready to pay for the product; and (2) exchange value, which is the actual fee a customer pays to a producer. The aforementioned authors also summarized the value creating and value capturing process (Figure 4).

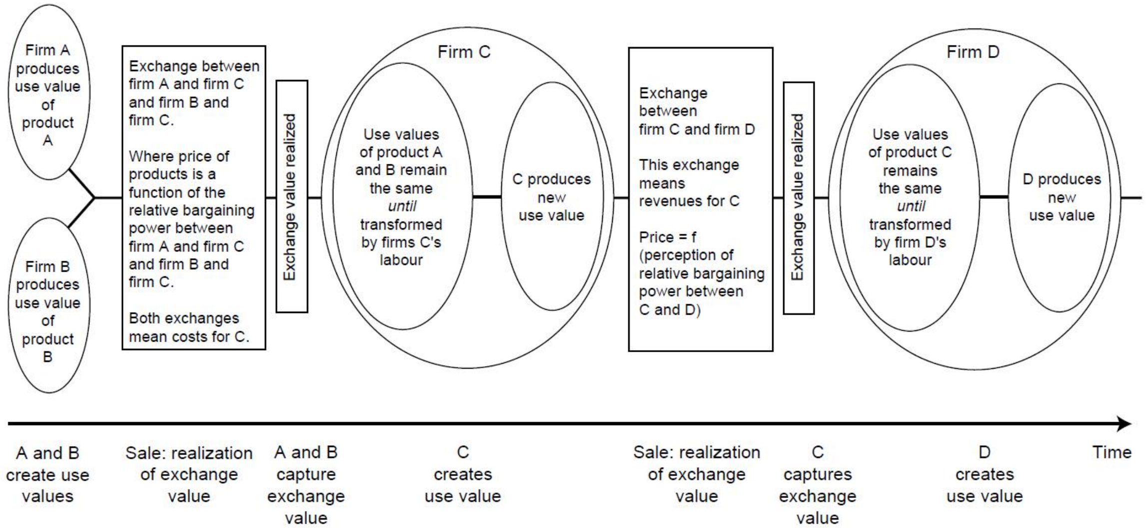

Figure 4. Value Creation and Capturing Process (Bowman & Ambrosini, 2000, p. 12)

The discussion of value is not limited to the literature of resource-based view. For example, Christensen and Rosenbloom (1995) suggested that among the factors that determine a company's achievement of technological advantages from technology progress, value network (the context in which a company interacts with customers and competitors) is a key factor, besides technology and management. While Teece (2010) emphasized the importance of value creation and delivery in business model design.

Business Ecosystem

Moore (1996) suggested that a business ecosystem is an economic aggregation that includes a focal company and its business environment (other organizations such as governments, semi-government agents, industrial associations, standard organizations, competitors, and business opportunities). At the organizational level, an ecosystem is composed of four types of organizations (Iansiti & Levien, 2004). It includes core participants, niche participants, handlers, and platform owners. Rong (2011) categorized the participants of an ecosystem as initiators (organizations willing to build ecosystems with their own platforms and products), professional organizations (adding value to the platforms), and users (build final products with the platforms). Adner and Kapoor (2001) proposed the concept of a business ecosystem configuration that connects focal firms, clients, and complementors.

The composition and configuration of a business ecosystem are dynamic. The evolution of a business ecosystem can be divided into four stages: birth, expansion, leadership, and self-renewal (Moore, 1993). A business ecosystem is also believed to be a complicated evolving system (Milton-Kelly, 2003) with 10 basic characteristics: self-organizing, emerging, connectivity, interdependency, feedback, instability, possibility space, co-evolving, history and time, and path dependency. Studies have suggested that the life cycle of a business ecosystem has five stages (Rong, 2011): (1) emerging, (2) divergence, (3) interaction, (4) solidifying, and (5) renewal.

Cost–Benefit Analysis of Green Buildings

Cost–benefit analysis (CBA) is a systematic method to examine a project’s economic costs and benefits (Cellini & Kee, 2010). CBA’s basic premise is to transform estimations of benefits over costs into current monetary value. A stream of current and future benefits and costs can be easily examined using net present value (NPV). Figure 5 illustrates the steps of a typical CBA process.

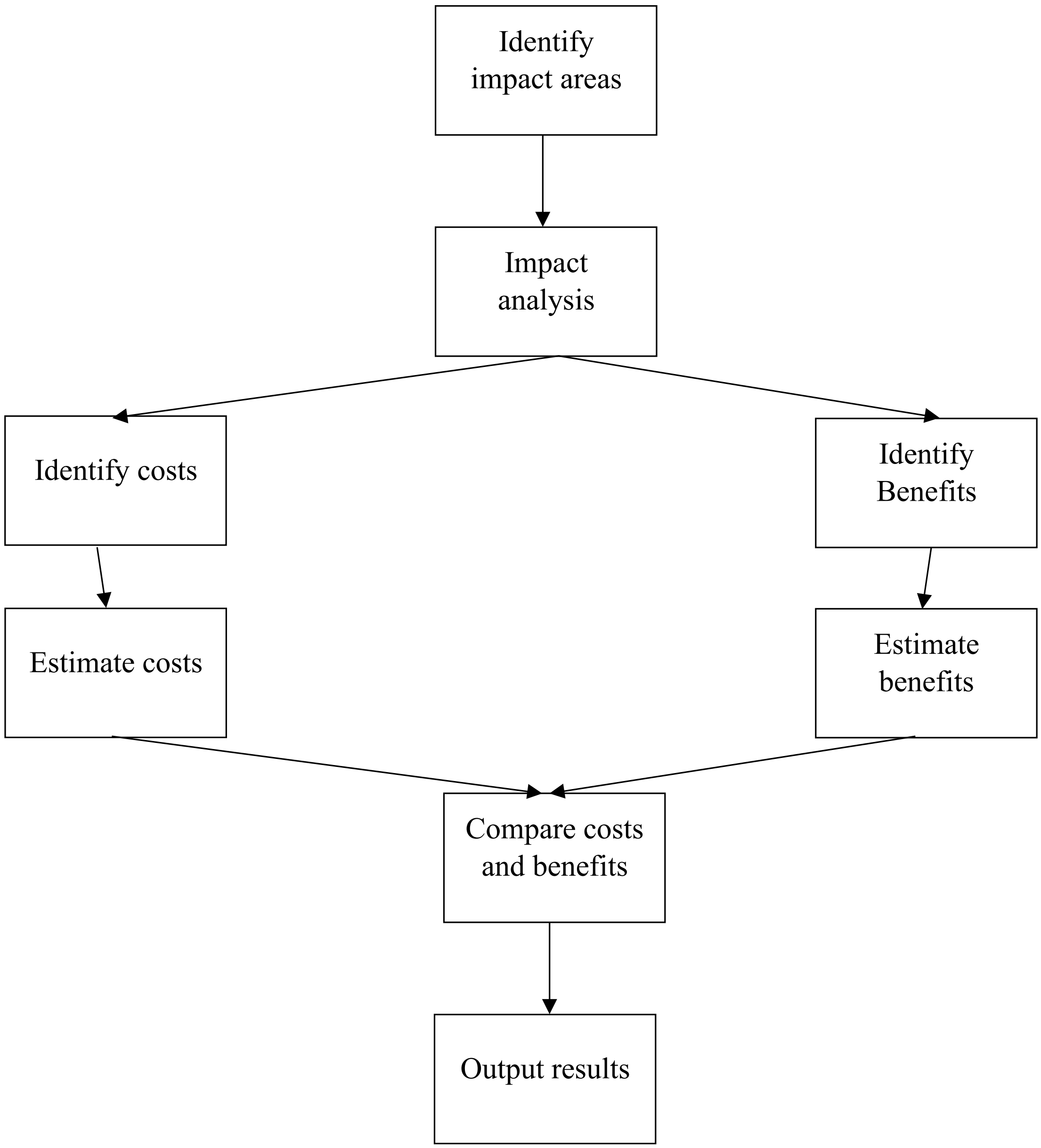

Figure 5. CBA process

The following methods are used to evaluate the added economic value of green buildings over traditional buildings using CBA method:

- Net Present Value (NPV)

A project's NPV is the difference between total investments and total benefits, denoted by B_t. It can be calculated at a certain point during a project's life span.

$$\text{NPV} = B_t - C_t$$

where B_t , C_t are the project benefits and costs, respectively, converted to a base calculating point.

A project is economically viable when NPV > 0.

Summary

Several studies on green buildings focus on the impact on environment, sustainable development (energy consumption, water saving, and emissions), and the technical details for earning green building certificate. Only a few studies discuss about the impact of green building on society and economy, fewer if the issue is discussed through the lens of innovation management or technology acceptance. As an emerging construction form, the technology and standard also keep evolving; therefore, society, occupants, and other stakeholders' perception and acceptance of green building play a definite role in adopting green buildings.

The barriers to implementing green building include economic, cognition, market, regulation, organization, and education barriers. Stakeholders influenced by these barriers include governments, designers, contractors, owners, property management companies, material suppliers, research institutes, and the public. These stakeholders are interrelated. Their value creation, sensing, delivery, and capturing mechanism, and their understanding of tangible and intangible values of green building, have a significant impact on the popularity of green buildings. However, no studies integrate stakeholders and their value systems into one analysis framework.

CHAPTER 3

RESEARCH DESIGN

Research Tools

This study proposes the use of value network analysis (Allee, 2008) method to model value creation, sensing, delivery, and capturing mechanism of different stakeholders in green building's development process. Value network analysis provides a tool to model, analyze, and evaluate tangible and intangible values. There are four key elements in a value network analysis: (1) network as a basic value delivery mechanism; (2) value can be created through intangible assets; (3) the medium of value delivery; and (4) delivering value.

Participants in a value network can deliver their tangible and intangible assets to other participants in some form of value through transactions. Figure 6 shows a basic model of value delivery.

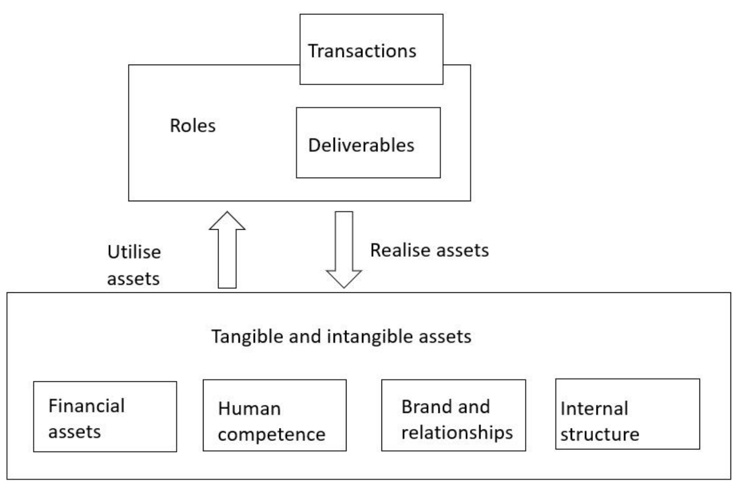

Figure 6. A Basic Model of Value Delivery

Figure 6 shows a node in the value delivery process. There are multiple nodes in a value network. In the context of green building development, these nodes can be government agents, developers, property management companies, owners, and material suppliers. The nodes connect and become a network (Figure 7). This study uses value network analysis to analyze the value creation, sensing, delivery, and capturing mechanism that affect stakeholders' impact on green buildings. The value network analysis is mainly used for analyzing organization and business relationships; therefore, the analysis should be adapted to the green building context.

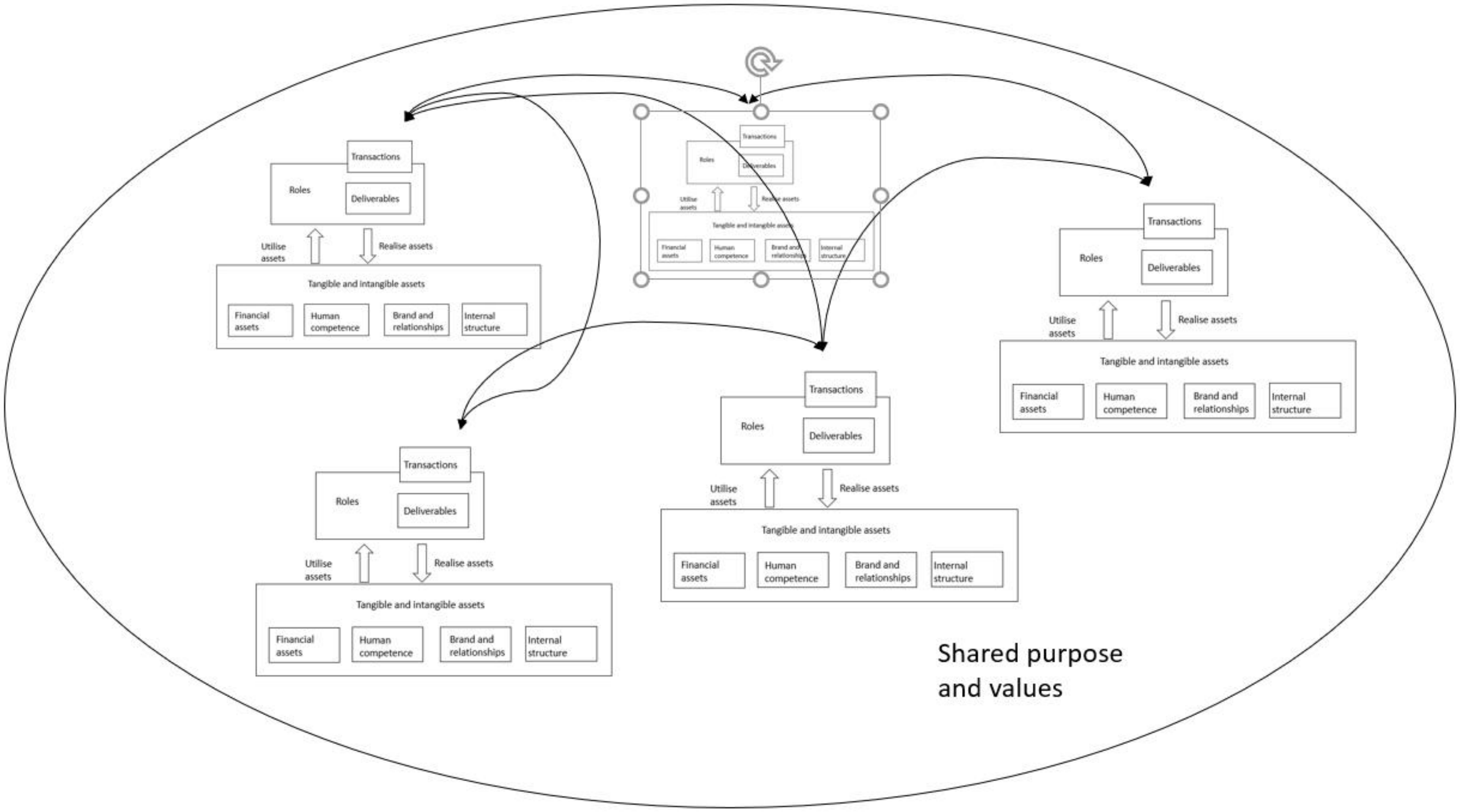

Figure 7. Value Network

Research Method

This study adopts a qualitative research method. First, the concept model and propositions are modified through an inductive process (Glaser & Strauss, 1967). A multi-case design (Eisendhart, 1989) is applied. Classic qualitative research methods, including interviews, court procedures, snowball sampling, and data triangulation, are used to ensure reliability and validity (Yin, 2003).

This explorative study uses green building projects contracted by NTSJ as case studies. The cases include developers, owners, project locations, and proper management companies to ensure differences. Project completion time is also considered. In-depth interviews (unstructured and semi-structured) with different stakeholders (including NTSJ) and observation (nonparticipative) and documents reviewing are considered. The value creation, sensing, delivery, and capturing mechanism are explored, modeled, and mapped to a value network. Based on the author's current job, data availability with NTSJ and other companies is secured.

The second phase of this study focuses on validating the value creation, sensing, delivery, and capturing mechanism. The sample is extended to non-NTSJ–contracted green building projects. Project number and selection criterion are similar to the previous phase. Data sources are mainly interviews and documents. The author has a wide network within the industry and data availability is secured.

After two phases, the green building ecosystem can be described using value network analysis. The value creation, sensing, delivery, and capturing mechanism, together with value network analysis, can be further developed into a standard value analysis tool.

Data Collection Method

To answer these research questions, two case studies at different levels were conducted. Snowball sampling and data triangulation were used to ensure the validity and reliability of the study (Yin, 2003). The main source of the data is project-related documents such as contracts, project plans, purchasing orders, and meeting memos. The use of case study method helps understand the value creation, delivery, and capturing process and the important but neglected aspects of green building and value network research. Case data collection and analysis help people rethink and challenge traditional thinking (Alvesoon & Karreman, 2007).

Data Collection

Data collection in this study consists of two stages. The first stage is to identify key activities, policies, and possible relationships between stakeholders. These data were accessed through public database, published materials, and websites. Documents related to green building, such as "*Healthy Building Evaluation Standards*" by China Architecture Association, "*the Thirteenth Five Year Plan of Architecture Energy Saving and Green Building Development*" by the Ministry of China Housing and Urban–Rural Development, were also collected. Following the guidelines by Eisenhardt and Graebner (2007), these data were cross-referenced and complementary data were collected in the following stage.

The second stage included field visit of two cases. In the first case, property developers, constructors, contractors, clients, government agents, design companies, and consulting companies were visited. In the second case, property developers, suppliers, design companies, and contractors were visited. Related documents such as project design, feasibility reports, and purchasing orders were collected. The author has worked in the construction industry for decades and maintained a good relationship with the stakeholders. Hence, the information could be validated and complementary materials collected.

Rigors in Research Method

To ensure the rigors of the research method, four data collection and analysis standards are used to ensure internal and external validity, construct validity, and reliability of the study (Campbell, 1963, 1975). Eisenhardt (1989) and Yin (1994) have also used these standards in their case study. Table 3 shows the standards used in this study.

Table 3

Methods Used to Ensure Rigor in the Research

Standards	**Methods Used to Ensure Rigors**
Internal validity Causality between variables and outcomes	• A research framework developed though value network theories, construction innovation, and business ecosystems • Triangulation by multiple theories
Construct validity The quality of conceptualization and operationalization of related concepts	• Data obtained from multiple sources

Table 3 , continued

External validity Validity, besides research settings	• Data obtained from multiple sources
reliability Reduce random errors through transparency and replicability	• Multiple case studies • Actual project documents

CHAPTER 4

CASE STUDY

Case Company Description

NTSJ, a comprehensive modern construction corporate group, was founded in 1958. NTSJ is involved in construction-based finance, investment, real estate, operation service, overseas operation, and science and technology incubation. Its business area covers construction, electromechanics, decoration, municipal projects, roads, landscape projects, and historic buildings. The total income of the group exceeded 80 billion RMB in 2017. NTSJ's project data, which include project documents such as contracts, design documents, collaboration agreements, and feasibility analysis, were readily available. The company has agreed to share data for this study.

Case 1 Project Alpha: A Hospital Expansion Project in Suzhou

Case Overview

Project Alpha started in March 2011 and commenced operation from August 2013. It has a two-star green building certification. The project includes a four-story inpatient building with a basement and the total construction measurement is 11288.32 square meters. The investment on this expansion project is 36.77 million RMB.

Project Cost Analysis

Cost analysis in Design Phase

Costs in the design phase mainly include preproject decision and preparation costs. Decision cost is composed of consultation and investigation costs, while preparation cost is composed of design, simulation, and certification costs.

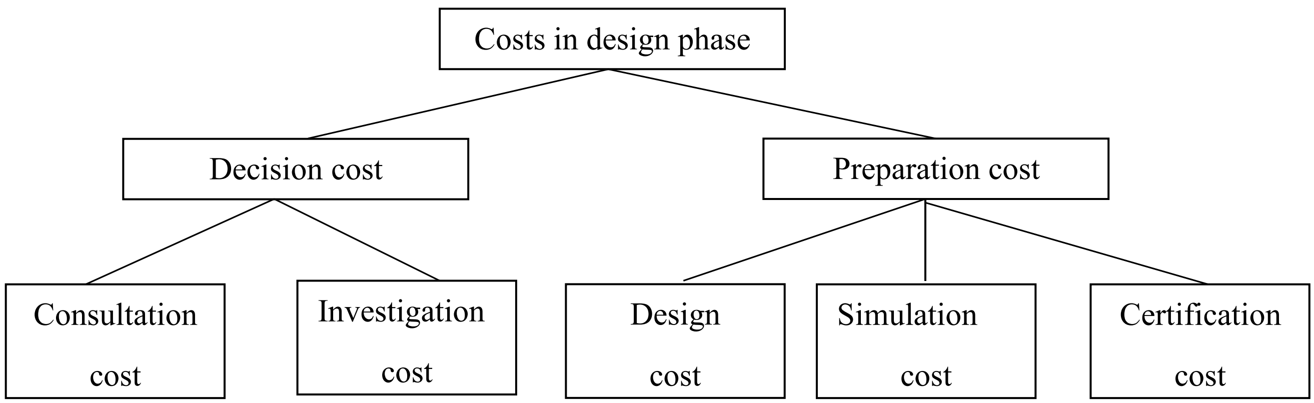

Figure 8. Costs in Design Phase

Project Alpha outsourced preproject consultation, investigation, simulation, and certification to a local construction energy-saving tech company for 300,000 RMB. The architecture and construction design were contracted to a local design company for 1,200,000 RMB. No additional cost was charged for green building design. Therefore, the additional economic cost of this green building compared with traditional buildings in the design phase was 300,000 RMB.

Cost analysis in Construction Phase

Costs in the construction phase include additional costs for land saving and outdoor environment, additional costs for energy saving, additional costs for water saving and recycling, and additional costs for construction materials.

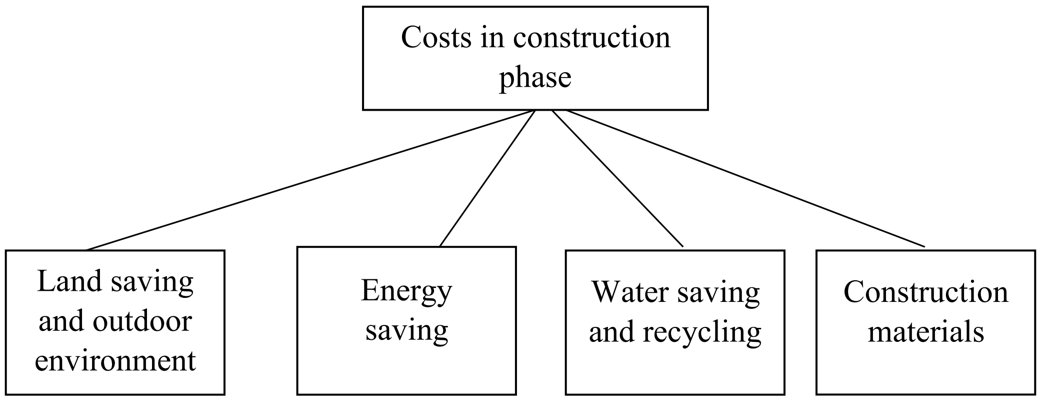

Figure 9. Costs in the Construction Phase

1. Additional cost for land saving and outdoor environment

Project Alpha had a rooftop green area measuring 700 square meters designed to increase green space and save on construction land at the cost of 130 RMB per square meters, Therefore, the additional cost for land saving and outdoor environment was 91,000 RMB.

2. Additional cost for energy saving

Energy saving in the enclosed structure includes the insulation of external walls, rooftop, and external glass. The additional costs for external wall insulation (thermal insulation bricks and mortar), rooftop insulation (thermal plate), and external glass insulation were 200,000 RMB, 80,000 RMB, and 100,000 RMB, respectively. Thus, the total additional cost for enclosure structure was 380,000 RMB.

This project used a ground-source heat pump AC system for heating, cooling, and providing hot water. Compared with the traditional system, the additional cost was 90

RMB per square meters and the cost of energy saving in air-conditioned system was 720,000 RMB.

Project Alpha used LED as light source and an intelligent lighting management system. The additional cost for lighting was 45,000 RMB. The investment on heating system included a solar energy system and air-source heating pump. The total additional cost was 60,000 RMB and the total additional cost for energy saving was 1,205,000 RMB.

3. Additional cost for water saving and recycling

Project Alpha used water-saving sanitary ware and the additional cost was 6,000 RMB. The cost of the water recycling system was 10,000 RMB and that of the rain recycling system was 90,000 RMB. The total additional cost for water saving and recycling was 106,000 RMB.

4. Additional cost for construction materials

The additional cost for lightweight steel was 15,000 RMB and for concrete was 150,000 RMB. The total additional cost for construction materials was 165,000 RMB and that for the construction phase was 1,567,000 RMB.

Cost Analysis in the Operation Phase

The operation cost for LED lighting, water saving system, AC system, heating system is similar that for a traditional building (in this case, an old hospital building); therefore, there is no additional cost. The additional cost for the water and rain recycling system is 2,500 RMB per year. It is also worth mentioning that the equipment cost and labor cost for replacement are covered in the estate management fee (Wang and Wang, 2015), and the additional cost for the estate management fee is 3,000 RMB per year. The total additional cost for operation is 5,500 RMB per year.

Table 4 lists the total additional cost for Project Alpha.

Table 4

Total Additional Cost for Project Alpha

Phase	**Area**	**Additional cost (RMB)**	**Additional cost per square meters (RMB/m²)**
Design phase	Consultation	300,000	26.58
Construction phase	Land saving	1,000	8.06
	Energy saving	1,205,000	106.75
	Water saving	106,000	9.39
	Material saving	165,000	14.62
Operation phase	Operation	5,500 per year	

Project Benefit Analysis

Benefit generated by Project Alpha includes economic, social, and environmental (Figure 10).

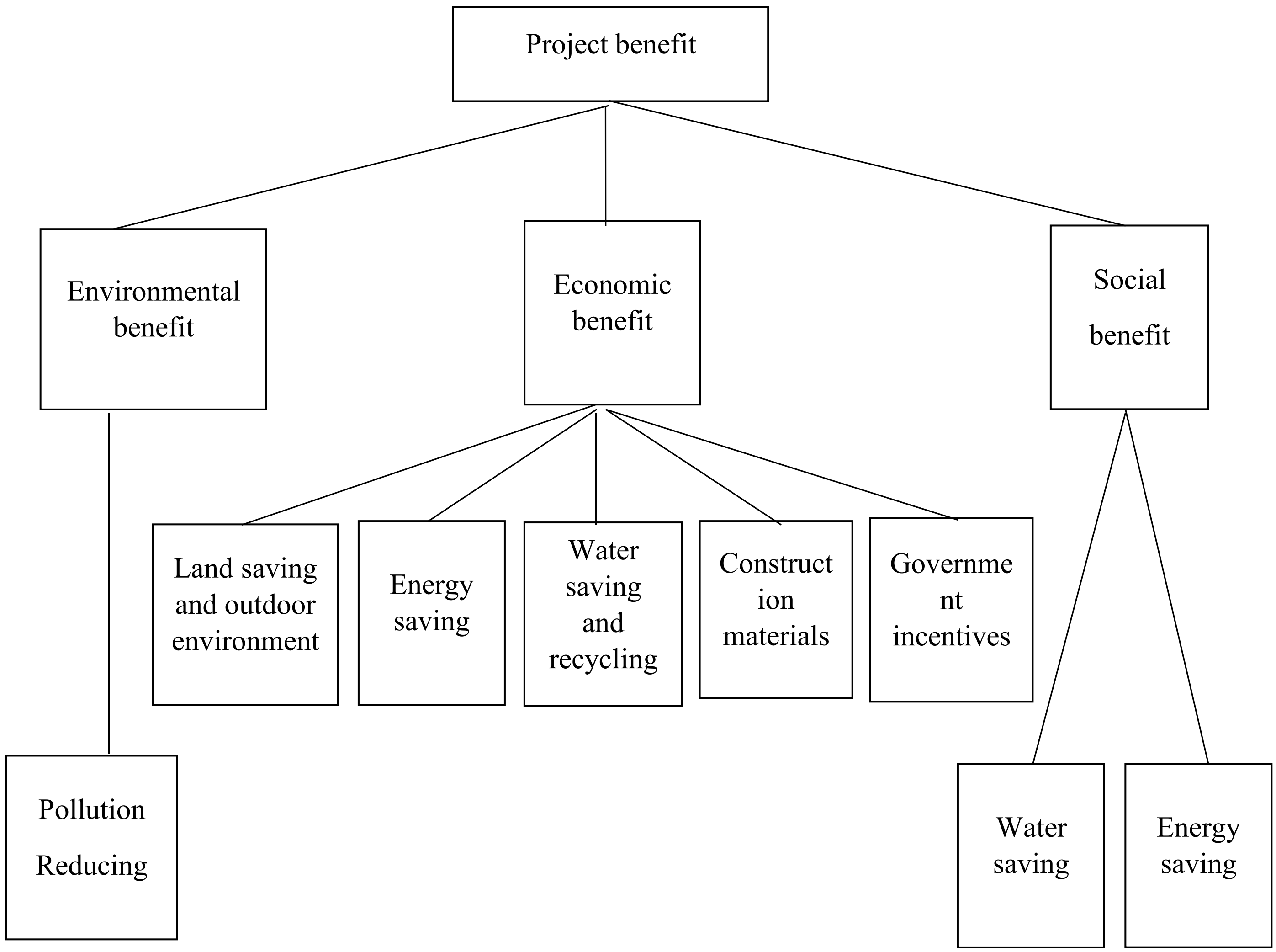

Figure 10. Project benefit

Economic Benefit

1) Economic benefit analysis for land saving and outdoor environment

Total energy saving from the rooftop green area was 0.14 Kwh per square meters per day during summer (90 days). The total additional economic benefit of the rooftop green area was 0.14 × 700 × 0.54 (local electricity cost) × 90 = 4763 RMB.

2) Economic benefit analysis for energy saving

Electricity worth 20000 Kwh per year was saved, according to the "*civil building energy saving assessment report.*" The total additional economic benefit generated by energy saving was 20000 × 0.538 = 10760 RMB per year.

3) Economic benefit analysis for AC energy saving

The energy saving by a ground-source heating pump compared with a traditional central AC system was 170000 Kwh per year. The total additional economic benefit generated by AC energy saving was 170000 × 0.538 = 91460 RMB per year.

4) Economic benefit analysis for lighting system

The energy saved by using LED lighting and smart system was 40000 Kwh per year; therefore, the total additional economic benefit generated by the lighting system was 40000 × 0.538 = 21520 RMB per year.

5) Economic benefit analysis for recyclable energy

Solar energy was the main source of hot water, and air-source heat pump was auxiliary source. The total energy saved by the solar system was 100000 Kwh per year and 200000 Kwh per year for air-source heat pump. Therefore, the total additional economic benefit generated by the recyclable energy was 300000 × 0.538 = 161400 RMB per year.

The total additional economic benefit generated by energy saving was 10760 + 91460 + 21520 + 161400 = 285140 RMB per year.

6) Economic benefit analysis for water saving

Water usage was reduced from 200 liter to 150 liter per day per patient by advanced water-saving sanitary ware. The building accommodates 200 patients and the water cost was 3.4 RMB per cubic meter. Therefore, the total additional economic benefit generated by water saving was 0.05 × 365 × 200 × 3.4 = 12410 RMB per year.

The capacity of water recycling system was 12 cubic meters per day; therefore, the total additional economic benefit generated by water recycling system was 12×365×3.4=14892 RMB per year.

The annual rainwater collection was 2111 cubic meters per year (based on Suzhou's weather condition and the size of the rooftop). Therefore, the total additional economic benefit generated by rainwater recycling system was 3.4 × 2111 = 7177 per year.

The total additional economic benefit generated by water saving was 12410 + 14892 + 7177 = 34479 RMB per year.

7) Economic benefit analysis for material saving

Compared with traditional projects, the project used less steel and concrete. The total additional economic benefit derived from high-strength steels was 120000 RMB and from high-strength concrete was 200000 RMB. Therefore, the total additional economic benefit generated by material saving was 120000 + 200000 = 320000 RMB.

8) Economic benefit analysis for government incentives

The project successfully applied for two-star green building certificate in the second year of operation. The government allowed 45 RMB per square meter. Therefore, the total additional economic benefit generated by government incentives was 11288.32 × 45 = 507974 RMB.

Social Benefit

1) Social benefit analysis for energy saving

The social benefit from energy saving was 0.42 RMB per Kwh (Ye, 2013). The total energy saved in this project was 20000 + 170000 + 40000 + 300000 = 530000 Kwh per year. Therefore, the additional social benefit generated by energy saving was 530000 × 0.42 = 222600 RMB per year.

2) Social benefit analysis for water saving

The social benefit from water saving was 2.3 RMB per cubic meter (Xu, 2008). The total water saved in this project was 3650 + 4380 + 2111 = 10141 cubic meters per year. Therefore, the additional social benefit generated by water saving was 10141 × 2.3 = 23324 RMB per year.

Environmental Benefit

The environmental benefit was measured by the weight of coal converted from electricity saving. The total coal saved was 0.0004 × 530000 = 212 ton. Therefore, the additional environmental benefit generated by reducing pollution was 225944 RMB per year.

Table 5

Total Additional Benefit for Project Alpha

Category	**Area**	**Additional benefit (RMB per year)**
Economic benefit	Land saving	4,763
	Energy saving	285,140
	Water saving	34,479
	Material saving	320,000
	Government incentive	507,974
Social benefit	Energy saving	222,600
	Water saving	23,324
Environmental benefit	Pollution reducing	225,944

Project Benefit Analysis

The additional cost of 1,987,000 RMB of the project is a one-off investment and the additional benefit of 320,000 RMB in material is a one-off saving. The additional savings of 324,382 RMB in land, energy, and water flow are annual savings for the whole life span of the project. The life span is 48 years, calculated based on the structure life (50 years) and construction period (2 years). Table 6 shows the net cash flow of the project.

Table 6

Net Cash Flow of the Project

	Net Cash Flow (RMB)					
Time(year)	0	1	2	3	......	48

Table 6 , continued

Additional cost	-1,975,000	5,500	5,500	5,500	5,500	5,500
Additional benefit	320,000	324,382	324,382	324,382	324,382	324,382
Additional net cash flow	-1,655,000	318,882	318,882	318,882	318,882	318,882

The additional benefit and cost are calculated to time zero, assuming the discount rate is 8%, and the inflation rate is considered in the discount rate.

$$ENPV= \sum_{t=1}^{n} (B-C)_t \times (1+\mathrm{i})^{-t}$$

$$= -1655000 + 318882\ (P/A, 8\%, 48)$$

$$= -1655000 + 3886896$$

$$= 2231896 \text{ RMB}$$

ENPV > 0, which implies that this project is more economically viable than traditional projects.

The social and environmental benefits are 222600 (energy saving) + 233324 (water saving) + 225944 (pollution reducing) = 681868 RMB per year.

Case Discussion

As a green building project, Project Alpha is more economically viable and environmentally friendly than traditional buildings. In this case, values in different stakeholders are listed in Table 7.

Table 7

Values for Different Stakeholders in Project Alpha

Stakeholders	Tangible value	Remarks	Intangible value	Remarks
Focal firm	Positive	ENPV>0	Positive	Positive social benefit
Government	Negative		Positive	Positive social benefit
Design company	Negative	No extra income from green building design but more knowledge needed	Positive	Showcase project
Suppliers	Neutral		Positive	Showcase project
Construction company	Not disclosed		Not disclosed	
Consultation company	Negative	No extra income from green building design but more knowledge needed	Positive	Showcase project

Green building needs a relatively higher initial investment (in this case, 1,667,000 RMB additional costs). However, it has significant externality from both construction and operation. The benefits include making inhabitants comfortable, saving on energy and water and reducing pollution. It can ease the government's anxiety of sustainability against economic development. Therefore, the government is willing to promote green building by enforcing laws or providing incentives. The society and community also enjoys certain environmental and social benefits derived from green building.

Project Beta: Green Building Demonstration Project

NTSJ's low-energy-consumption green building demonstration project is in the green building industrial park. It is the first demonstrative green building project that combines prefabricated and low-energy-consumption intelligent technology in the area that bears both hot summers and cold winters. The project covers 545.98 m² land and the size of the four-story building is 2311.94 m². It combines R&D, design, BIM technology, building industrialization, and full decoration in one project. It significantly reduced operation energy consumption and increase comfort. Simultaneously, it solved problems such as environment contamination and waste control. Therefore, it improved construction quality and reduced construction duration.

Stakeholders in the Case Project

Investing Company

An investing company owns the project. It is the main body in project management and responsible for proposing a construction plan and providing land and capital.

The Investing company of this project is Bokangda Energy Saving Technology Ltd. (an NTSJ subsidiary).

Design Company

A design company is responsible for design, documentation, and design quality of a construction project. This project's design company is Nanjing Changjiang Dushi Architecture, which is the biggest residential design company in Jiangsu province. It has a class A certificate in construction project, building intelligent design, project design, and supervision.

Construction Company

Haojiahengye construction development company is the project's construction company. It was founded in 2009 as a total contractor.

Consulting Company

A consulting company provides the feasibility report, project proposal, project application report, financial application report, project plan report, and valuation consulting. S&T and Industrialization Center, Ministry of Housing and Urban Rural Development is this project's consulting company.

Supervision Company

A supervision company is entrusted by the owner company as a third party to oversee the project. This project's supervision company is Taicang Zhenxin Project Management Company.

Key Material Providers

This project's key product material providers are shown in Table 8.

Table 8

Key Material Providers

Material	**Provider**
Graphite polystyrene board	Bokangda Energy Saving Technology Ltd
External window system	Bokangda Energy Saving Technology Ltd

Table 8 , continued

External window section bar	Wengerun Energy Saving Window Technology Company
External window	Qingdao Hengda Window Technology Company
Flexible external shading	Swiss Sengke Shading Company
Heating and AC device	Wanfude Electronic Heat Control Technology Company

Value Creation, Delivery, and Capturing of the Demonstration Project

A framework of value creation, delivery, and capturing analysis is presented later. This framework is used to develop a table, centered on values created, delivered, and captured between a focal company and related parties. The value network mapping is then followed to visualize the value flow between two parties.

Value Creation, Delivery, and Capturing: Focal Company and Construction Company

Table 9 shows the value transferred between a focal company and a construction company. Figure 11 shows the value delivery between two parties.

Table 9

Value Creation and Capture: Focal Company and Construction Company

	Recognition	Economic	Market	Policy and regulation	Technology	Organization	Education
Product and service	*understand necessity of innovation in organization and management	*high development and construction cost *financial resources *innovative profit model	*a small number of qualified construction company	*green building regulation and requirement	*high requirement of green building technology *transfer of conventional construction practice	*new process needs to be built	
Knowledge	*value of knowledge			*lack of knowledge by both focus company and construction company	*import of external knowledge *retaining successful knowledge *need to be led by design company		*external training for both parties

Table 9 , continued

Intangible value	*build common vision and improve reputation			*positive image for government			

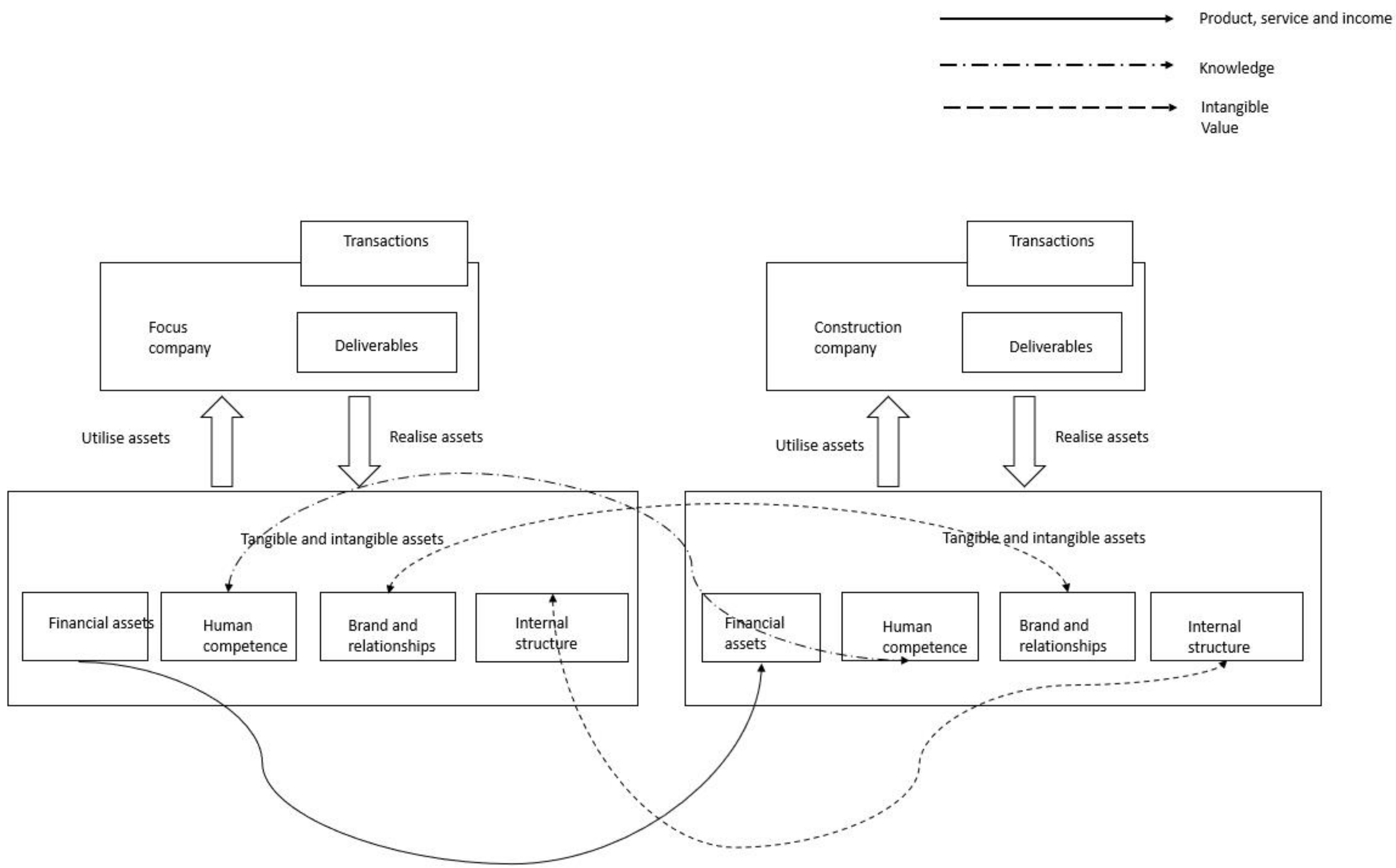

Figure 11. Value Delivery between a Focal and a Construction Company

Value Creation, Delivery, and Capturing: A Focal and a Design Company

Table 10 shows the value transferred between a focal and a design company. Figure 12 shows the value delivery between two parties.

Table 10

Value Creation and Capture: A Focus and a Design Company

	Recognition	Economic	Market	Policy and regulation	Technology	Organization	Education
Product and service	*understand necessity of innovation in organization and management *collaboration of design company in innovation management	*high design cost of green building	*a small number of qualified design company	*green building regulation and requirement post significant challenges to design companies	*high requirement of green building design capability	*New process needs to be built	

Table 10 , continued

Knowledge	*value of knowledge			*lack of knowledge of focus company	*retaining successful knowledge *need to be led by a design company		*provide training to owner companies
Intangible value	*build common vision and improve reputation			*Positive image for government			

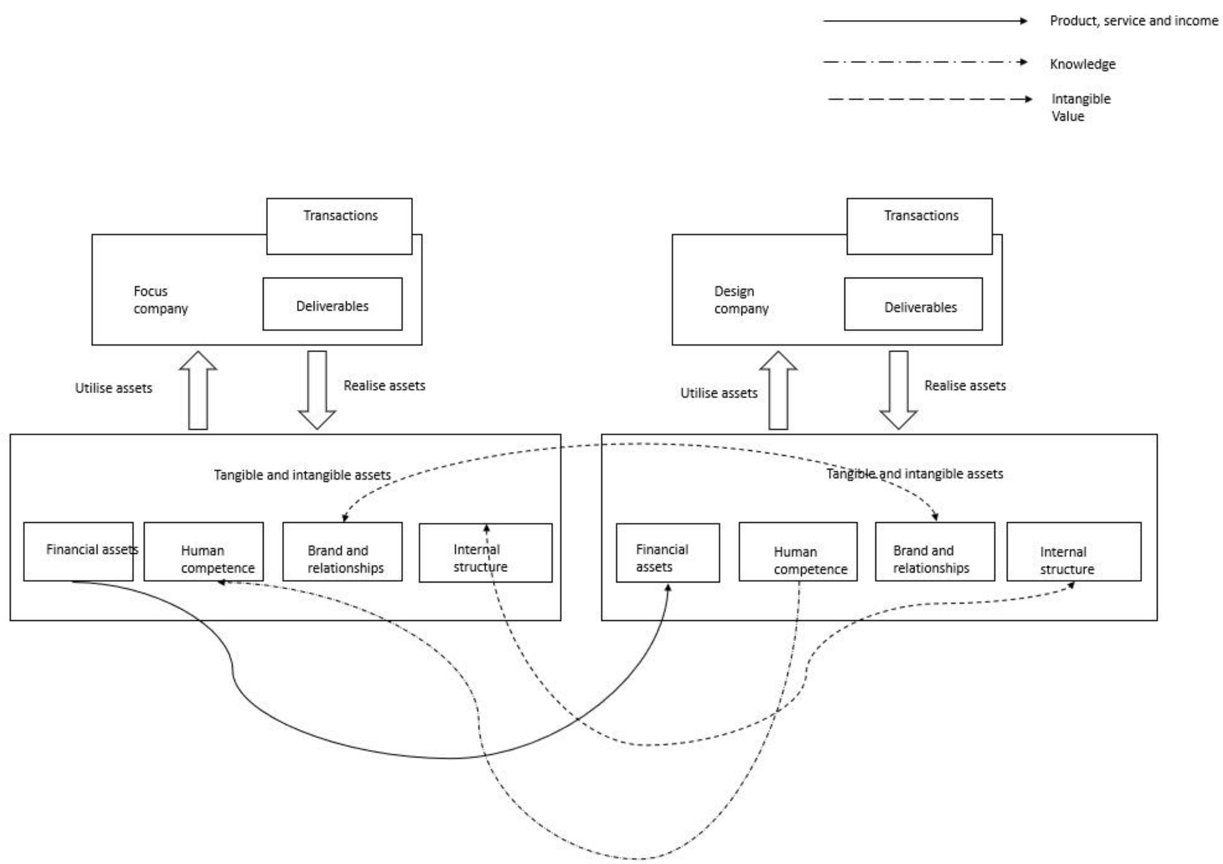

Figure 12. Value Delivery between a Focal and a Design Company

Value Creation, Delivery, and Capturing: A Focal and a Consulting Company

Table 11 shows the value transferred between a focal and a consulting company. Figure 13 shows the value delivery between two parties.

Table 11

Value Creation and Capture: A Focal and A Consulting Company

	Recognition	Economic	Market	Policy and regulation	Technology	Organization	Education
Product and service		*focal company need to obtain government subsidies	*focal company needs to obtain certification from consulting companies	*Green building regulation and requirement			
Knowledge				*lack of knowledge of focal company		*focal company needs to fit to consulting companies' process	*learn green building application process

Table 11 , continued

Intangible value	*focal company needs to use consulting company for brand image			*positive relationship building with consulting company (semi-government background)			

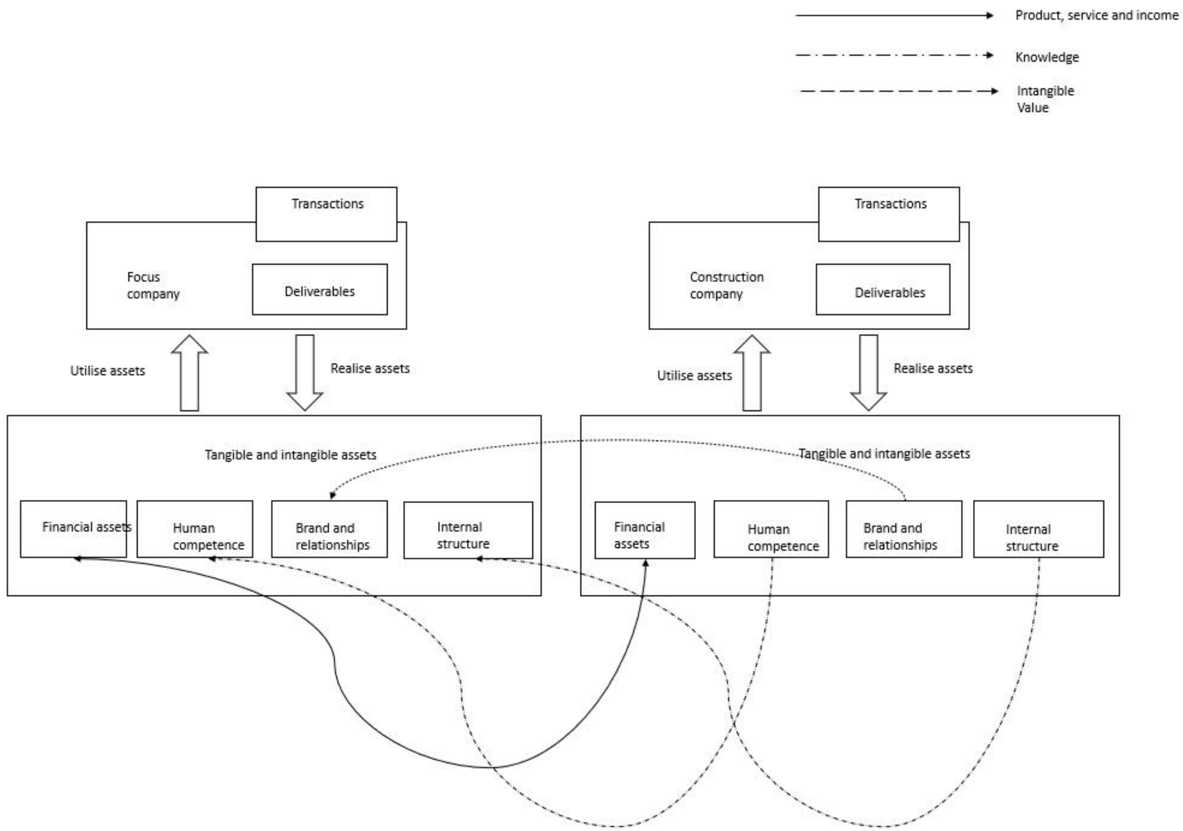

Figure 13. Value Delivery between a Focal and a Consulting Company

Value Creation, Delivery, and Capturing: A Focal and a Supervision Company

Table 12 shows the value transferred between a focal and a supervision company. Figure 14 shows the value delivery between two parties.

Table 12

Value Creation and Capture: A Focus and a Supervision Company

	Recognition	Economic		Policy and regulation	Technology	Organization	Education
Product and service	*understand necessity of innovation in organization and management	*high supervision cost for green buildings		*Green building regulation and requirement	*high requirement of green building supervision capabilities	*New process needs to be built	

Table 12 , continued

Knowledge	*value of knowledge			*lack of knowledge by both focal company and supervision company	*Retainment of successful knowledge		*external training for both parties
Intangible value	*build common vision and improve reputation			*Positive image for government			

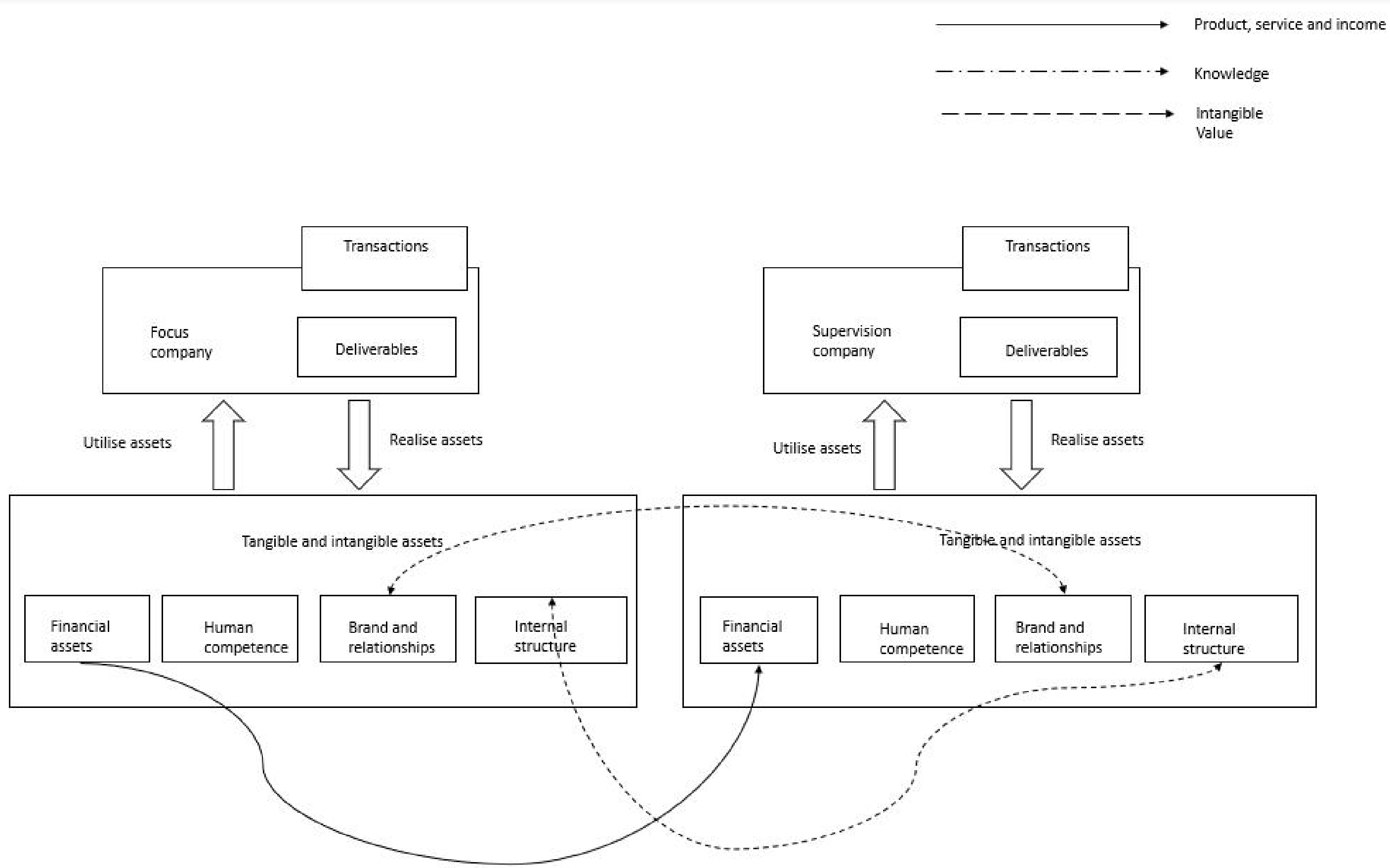

Figure 14. Value Creation and Capture: Focus Company and Supervision Company

Value Creation, Delivery, and Capturing: Focal Company and Suppliers

Table 13 shows the value transferred between a focal company and construction. Figure 15 shows the value delivery between two parties.

Table 13

Value Creation and Capture: Focal Company and Suppliers

	Recognition	Economic	Market	Policy and regulation	Technology	Organization	Education
Product and service	*understand necessity of innovation in organization and management	*difficult to achieve economics of scale at this stage	*need to locate new suppliers for green buildings	*lack of green building material regulation and requirement	*high requirement of green building products and services	*new process needs to be built *need to build dedicated support teams for green buildings	*suppliers need to educate focal company new features of green building materials

Table 13 , continued

Knowledge	*value of knowledge				*Retainment of successful knowledge		*external training for both parties
Intangible value	*build common vision and improve reputation		* a strategic opportunity for suppliers to enter green building market	*Positive image for government			

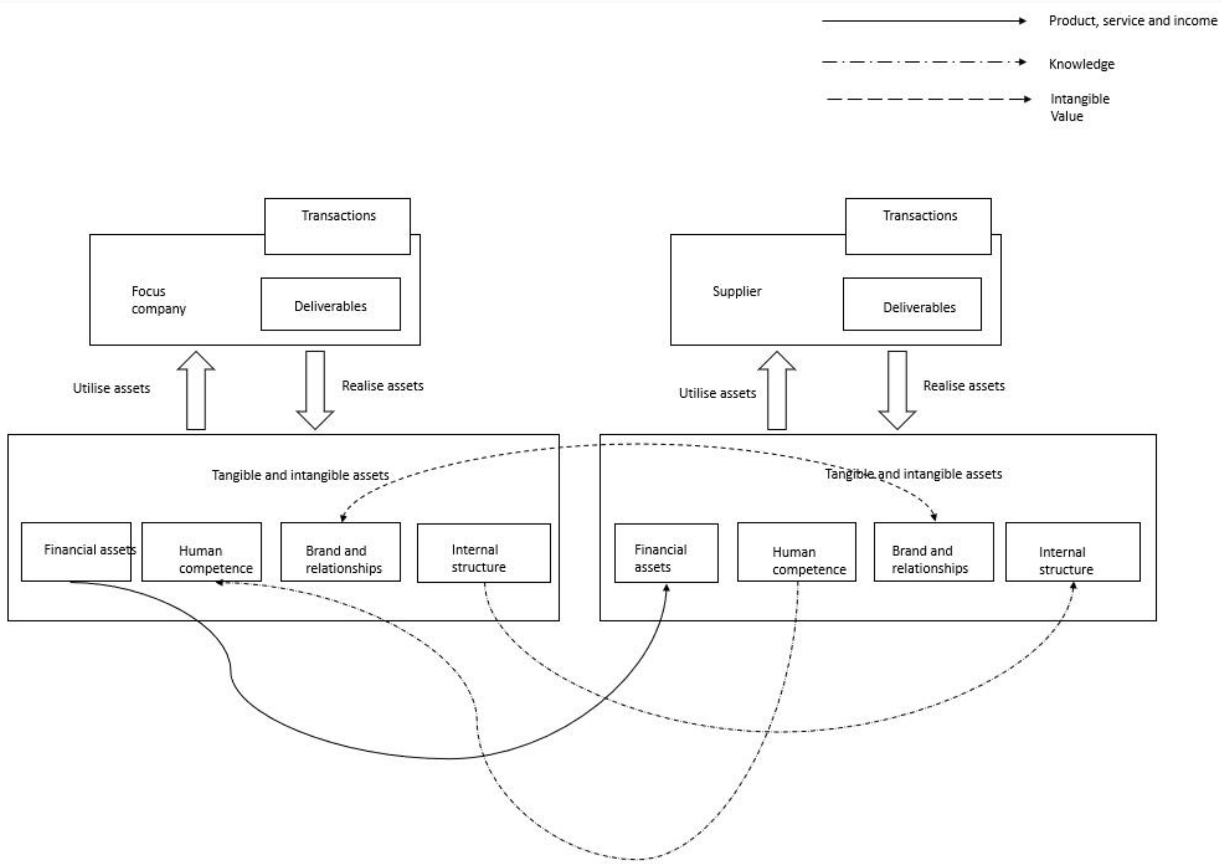

Figure 15. Value Creation and Capture: Focal Company and Suppliers

Value Delivery between a Construction and a Supervision Company

Figure 16 shows the value delivery between a construction and a supervision company.

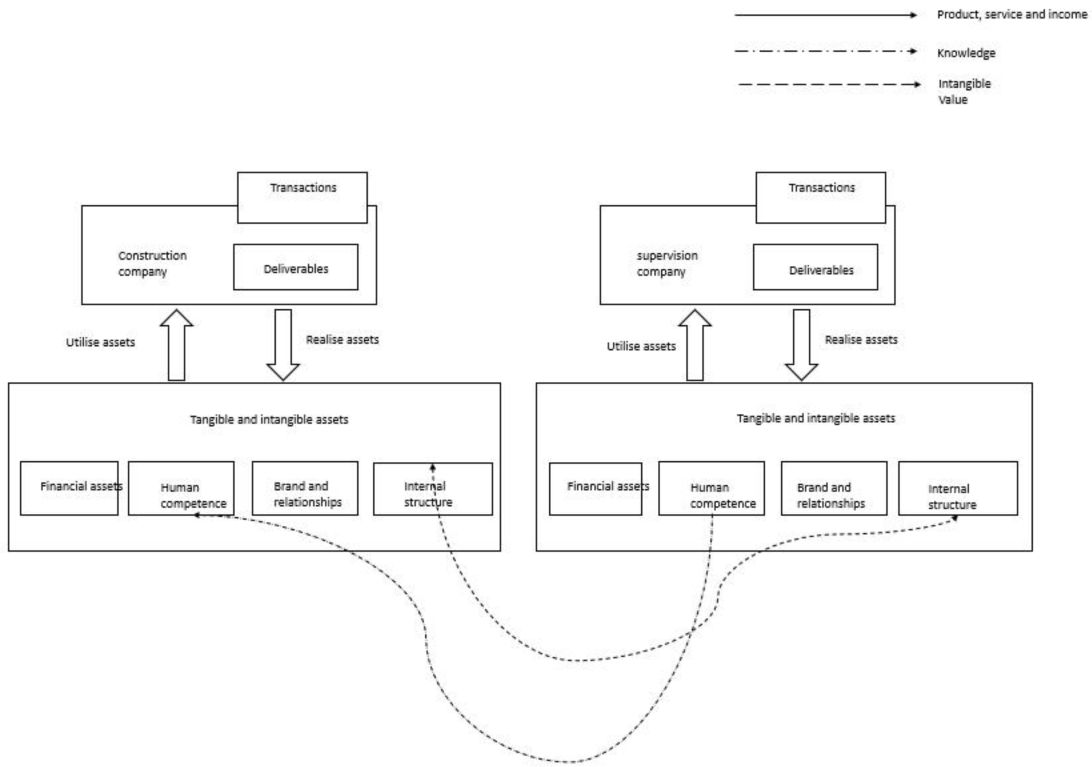

Figure 16. Value Delivery between a Construction and a Supervision Company

Value Delivery between a Construction and a Consulting Company

Figure 17 shows the value delivery between a construction and a consulting company.

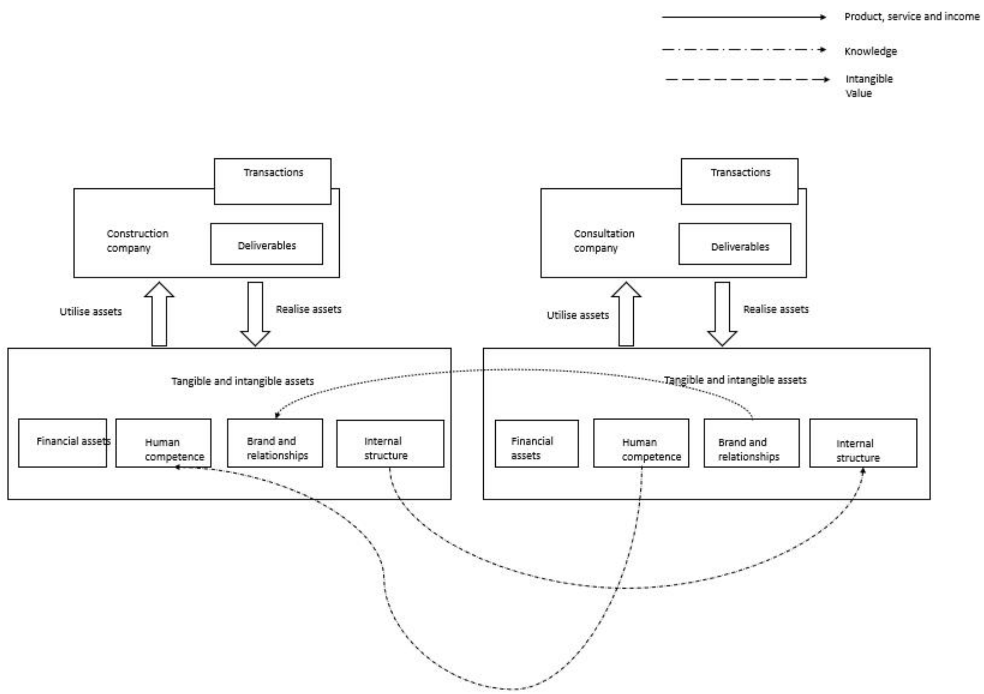

Figure 17. Value Delivery between a Construction and a Supervision

Value Delivery between a Construction Company and Supplier

Figure 18 shows the value delivery between a construction company and supplier.

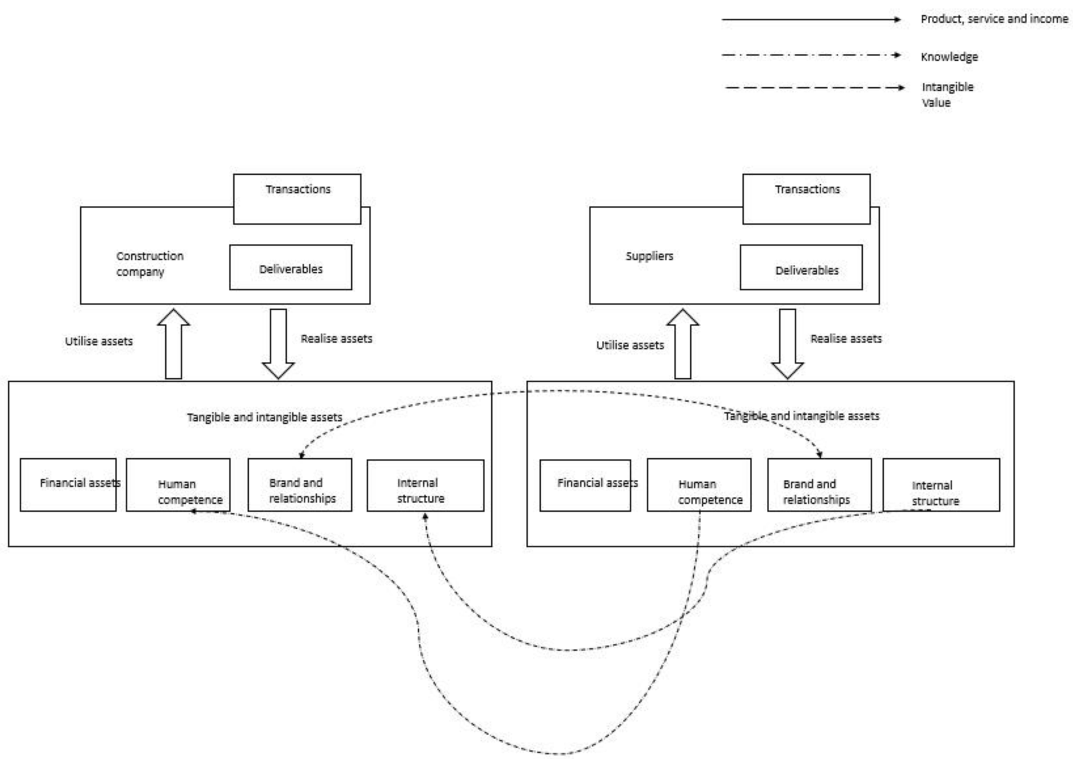

Figure 18. Value Delivery between Construction Company and Supplier

Value Network Mapping of Project Beta

Figure 19 illustrates the relationship among a focal, construction, design, consulting, and supervision companies and a supplier within a green building value network.

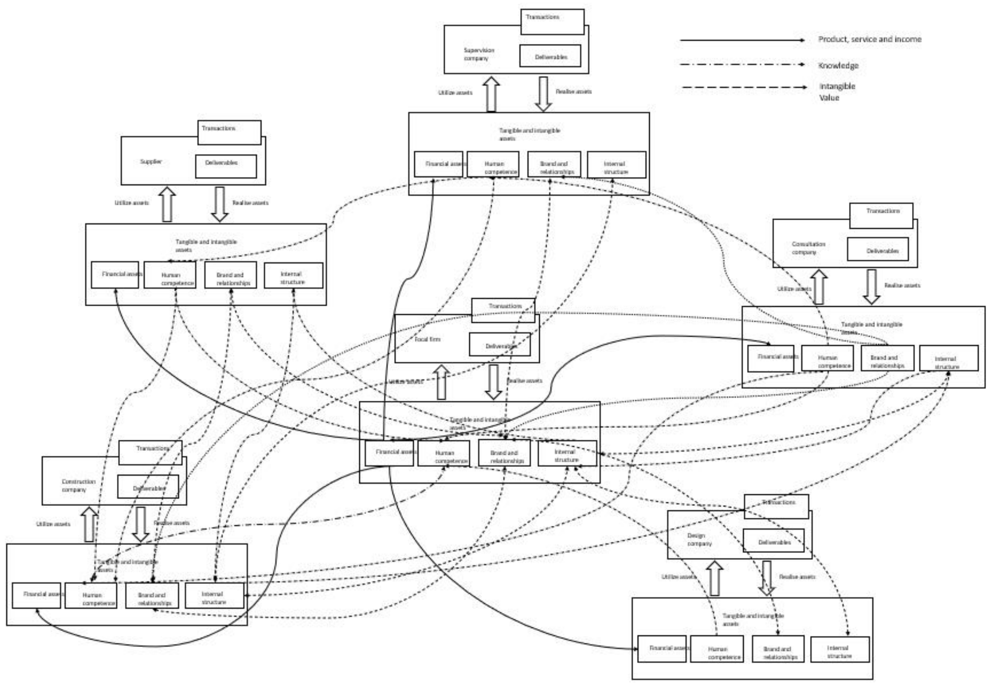

Figure 19. Value Network Mapping of Project Beta

CHAPTER 5

DISCUSSSION

This study adopts a value creation, delivery, and capturing aspects to examine the mechanism that influences the application of green buildings. First, the concept and characteristics of construction projects and green buildings are discussed and clarified. Current theories and tools in value, value network, and cost–benefit analysis are conducted. Second, based on a literature review and discussion, the value creation, delivery, and capturing mechanism are discussed in the context of China. Third, two cases are presented and analyzed to illustrate the value mechanism among stakeholders. The value (product and service, knowledge, intangible value; economic value, environmental value, and social value) flow among stakeholders is also discussed. Building on the case study, an integrated value network map is presented.

This study contributes to the literature as follows:

1) It considers green building with a value management perspective, which extends the boundary of green building research from construction engineering to the field of management and innovation. The "value" dimension of current green building is deconstructed and integrated into a value network framework, which leads to a new understanding of green buildings.

2) The resource-based view and business ecosystem theory are expanded to a new context of green building management.

3) The economic, environmental, and social values of green building over traditional building are quantified using a cost–benefit analysis. It shows that green buildings are more feasible than traditional buildings in the short and long term.

4) This study develops a tool for analyzing an operational green building. It supports practitioners’ decision-making in the field of green building.

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