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REVOLUTIONS OF CONSTRUCTION ORGANIZATIONS TOWARDS GREEN BUILDING PRJECTS

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ABSTRACT: In recent years, the demand for green buildings is growing fast due to legislative and social pressures. Construction organizations, which play an important role in promoting building industry growth, are facing with challenges on how to adapt themselves to enhance sustainability of the buildings. In this paper, the green value chain and system frameworks, an extend application of Porter's value chain and system models, are introduced. Based on deep analysis of the green value chain and system frameworks, a revolution model for construction organizations towards green building is created. Management factors critical for a successful green building project, at the firm and project organization level, are extracted. Furthermore, external critical relationships are also identified. Fully understanding of these management factors and the model can help and enable practitioner to know what new capabilities should be deployed and developed in the long run for maximizing sustainability.

Keywords: Green Value Chain and System, Green Building, Construction Organizations, Critical management factors

1. INTRODUCTION

The construction industry is a sizeable contributor to the national and global economy. However, due to great negative environmental impact of traditional buildings, more public and government pain more attention to green building, which can help reduce the environmental impacts. Due to regulations and growing environmental awareness, the demand for green building services is growing fast, which predicts a rapidly growing market share of green buildings in the building industry in the near future. Green building even becomes a compulsory requirement in some countries. Construction organizations, responsible for the design and construction of buildings, have substantial impacts on the implementation of green building. However, the current construction management approach does not align with the sustainability goal [1]. Therefore, how to incorporate sustainable practice into typical design and construction stages and translate "green building" into more conventional management issues should be reconsidered.

The revolution of construction organizations towards green building can be well understood by exploring the critical success factors (CSFs). The CSFs approach has been established and popularized over the last 20 years. CSFs for the project success have been widely investigated. However, the majority of the studies focus on the cost, quality and schedule of the project, there is a noticeable dearth of research that focuses on sustainability of buildings. In order to extract the CSFs for green building comprehensively and systematically, the green value chain and system theoretical frameworks, which is an extend application of Porter's value chain and system models, are introduced.

Porter's value chain and system models are very popular among academics, consultants and managers [2]. The original purpose of value chain and system analysis is to identify competitive advantages and increase profit for manufactory industry, which is product-oriented. However, they pay little attention to green value generation and improvement in construction industry, which is project-oriented. In order to bridge the gap between traditional value-added activities and green building development, this paper attempts to introduce two new concepts: "green value chain framework" and "green value system framework". They can provide powerful frameworks for extracting the major management factors critical to improve environmental performance for building projects. Based on these critical management factors, the organization will know how to bring about internal changes and how to modify resources to achieve green building.

2. THEORETICAL FOUNDATIONS

2.1 Value Chain

The concept of value chain was developed by Porter [2]. A value chain "disaggregates a firm into its strategically relevant activities in order to understand the behavior of costs and the existing and potential sources of differentiation", where the main idea is to use it as an analysis tool for strategic planning. In order to conduct the value chain analysis, the company is split into two types of activities: primary (Inbound logistic, Operations, Outbound Logistics, Marketing and Sales, Customer Service) and

support activities (Procurement, Technologic Development, Human Resources, Firm Infrastructure) (Figure 1). Primary activities are those that are directly concerned with the physical creation, sale and delivery of a product or service. The goal of the primary activities is to produce value that exceeds the cost, thereby resulting in a profit margin. While support activities are those that provide the background necessary for the effectiveness and efficiency of the firm. Every value activity employs purchased inputs, human resources and some form of technology to perform its function. Another important component is Margin, which is the difference between total value and the collective cost of performing the value activities. All the primary and support activities aim for more margin.

The value chain is not only a collection of independent activities but rather a collection of interdependent activities. Linkage can exist between primary activities, as well as, between primary and support activities. Competitive advantages can be also derived from the linkages between activities.

The value chain model represents the corporate internal environment [3]. It has been used as a powerful analysis tool for organizational strategic planning for nearly two decades now, which indicates that the value chain of a company is a useful tool in understanding and identifying crucial aspects to achieve competitive strengths and core competencies in the marketplace.

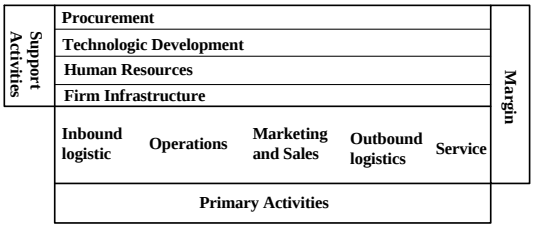

Figure 1. Value Chain (Porter, 1985)

2.2 Value System

The traditional value chain analysis strongly focuses on the internal resource of the organization and it tends to isolate the organization's activities from its environment [4]. According to McPhee and Wheeler [5], focusing on the internal core activities of a firm is not enough to derive value in today's firms. Porter [2] extends the concept of the value chain to the whole industry. A firm's value chain is part of a larger system that includes the value chains of upstream suppliers and downstream channels and customers. Porter calls this series of value chains the value system, shown in Figure 2. The total margin available is spread across suppliers, distributors and customers. A firm can enhance its profitability and competitive advantage not only by understanding its own value chain – from design to distribution – but also by understanding how the firm's value activities fit into the supplier's and customer's value chains [6].

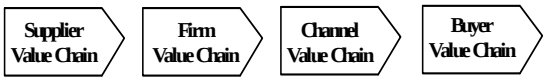

Figure 2. Value System (Porter, 1985)

2.3 Critical Success Factors (CSFs)

The concept of "Critical Success Factors" (CSFs) was developed by Rockart and the Sloan School of Management with the phrase first used in the context of information systems and project management. Rockart defines CSF as: those few key areas of activity in which favourable results are absolutely necessary for a particular manager to reach his or her own goals...those limited number of areas where 'things must go right'[7]. Rowlinson [8] states that CSFs are those fundamental issues inherent in the project, which must be maintained in order for team working to take place in an efficient and effective manner. This is particularly important with a large complex program and a large multilevel, geographically dispersed program team. Understanding the CSFs would give some guidelines on what factors that should be given more attention in order to bring the implementation process into success [9].

3. GREEN VALUE CHAIN FRAMEWORK

3.1 Green Value

Identification and analysis of primary and support activities in traditional value chain are based on the value. However, there are difficulties in providing a definition of value on which many people may agree. The value is defined by Porter as the amount buyers are willing to pay for what the firm provides. For construction, value means the satisfaction of clients [10]. In order to gain a better understanding you need to be able to explicitly identify what your customers (end users) value. Traditionally, the customers' requirements about the building are just cost, quality and schedule. However, in recent years, the sustainable performance of building becomes an important criterion for the satisfaction of clients. "Sustainability is definitely part of values, and from a marketing standpoint it has been important to us" [11]. In this sense, sustainability can be treated as a source of values itself. Therefore, in the green value chain, instead of using margin as base for activities analysis, green performance of buildings will be employed as the objective of primary and support activities. Green building rating systems can be used as a good indicator of green building performance. These systems have established various criteria for assessing environmental performance of buildings, which provide valuable references to this study.

3.2 Primary Activities

Primary activities are directly concerned with the physical creation, sale and delivery of a product or service in the traditional value chain analysis. In green value chain analysis, primary activities, involved in the physical creation of the product (green building), are actually green building measures. In an effort to address the environmental impacts of buildings, green building measures have attracted the attention of researchers and practitioners in different fields in recent years. Lots of sustainable materials and technologies have been applied in real practice. In considering the sustainability of buildings, the physical boundaries of green building measures are quite extensive and include the extraction of materials, the manufacturing of products, the assembly of products into buildings, the maintenance and replacement of systems, and the ultimate disposition of waste, building systems, and ultimately the building structure in all the life cycle stages of building (plan, design, construction, Operation & Maintenance, demolition) [12]. Usually, the responsibilities of construction organizations are in the design and construction stages. Therefore, within the control of construction organizations, only the activities, which can lead to significant improvement of green building performance in the design and construction stages, will be considered in the green value chain analysis.

3.3 Support Activities

The support activities only affect the implementation of green building to the extent that they affect the performance of primary activities. They can maximize sustainability of buildings based on present technological conditions. In order to enable and improve the performance of the primary activities, support activities should be identified and analysis in detail.

3.3.1 Support activities at firm's level

The relevant level of support activities is a firm's management strategies (the business unit) in manufactory industry. This indicates that the management activities at the firm's level can affect value addition for the product-oriented company. For construction industry, which is project-oriented, construction firms may support many projects simultaneously. In this sense, the project performance is somewhat influenced by management activities of the central company organization. In the green value chain, the support activities at firm's level which affect environmental performance of building should be explored. However, the classification of support activities at firm's level in traditional value chain is too broad, and may obscure important sources of influence factors. Consequently, more in-depth investigations of support activities at the construction firm's level should be conducted.

In order to have a clear and detail understanding of the support activities, current organization management strategies should be uncovered firstly. These management activities provide insight to the fundamental components of an organization, which are sources of support activities for green building. Resource-Based View (RBV) and Cheah's Conceptual Model are two well known theories, which can help investigate competitive advantages of firms based on exploring the firm's resources. Although they are usually used for strategy analysis for the firm, they can help investigate internal resources at firm's level. Therefore, in this paper, the strategic theory of RBV and Cheah's Conceptual Model are used, which can lay the groundwork for identifying the support activities at the firm's level.

(1) Resource-Based View

The RBV looks at internal assets (resources) as a foundation for value strategy [13]. Most researchers agreed that internal assets can be classified into tangible and intangible resources. Tangible resources include financial resources, physical resources, human resources and organizational resources. Intangible resources include technological resources, resources for innovation and reputation [14]. The RBV is a conceptual framework for understanding firm-level growth using resources as building blocks.

(2) Cheah's Conceptual Model

Cheah (2002) classified the internal resources of large global engineering and construction firms into seven strategic fields: Business strategy, operational strategy, IT strategy, Marketing strategy, Technology strategy, Human resource, and Financial strategy. Two internal mechanisms of organization (organizational structure and culture) are also identified. Any discussions of corporate strategy should always parallel the internal mechanisms of an organization. These issues exist at the corporate level and are embedded in the very lifeblood of the organization, and hence reflect the corresponding firm-specific resources and capabilities [15]

In the language of traditional strategic analysis, the support activities at the firm's level can be classified into: Financial resources, Technical competency, Experience and Knowledge, Human resource management, Company image, R&D capability, Innovation capability, Organizational structure and Organizational culture. All these management strategies, which can be controlled by the firm, have potential effects to help improve environmental performance of building projects.

3.3.2 Support activities at project organization's level

The traditional value chain analysis is established based on the manufactory industry, which is product-oriented. Thus, the support activities are mainly at firm's level. However, construction industry is a project-oriented industry. Construction firms sometimes may have many simultaneously ongoing construction projects. Different roles of players, mainly including an architect, structural and mechanical engineers, a construction contractor, are assembled to carry out the project. Usually the team is

gathered provisionally just for this project. Therefore, besides management strategies at firm's level, effective project management is also very critical for the successful accomplishment of sophisticated projects [16]. In essence, until now, a large body of research has been conducted to investigate project management factors which are behind project success in terms of cost, time and quality. These project management activities should be explored firstly, for the purpose of exploring current components of project organization. These components represent some features inherent in projects organization, which may have potential impacts on the environmental performance of building project.

Review of previous literature suggests that there are a large number of variables influencing the success of project implementation. In this paper, only the project management factors within the control of construction organizations are considered. A careful study of these factors proposed by previous literatures indicates that critical management factors can be grouped under four main categories: Support from senior management, Human source-oriented factors, Management-oriented factors, Technical factors. These issues exist and are embedded in very project organization, and reflect the corresponding factors at project organization level for improving building projects.

Based on exploration of the three important components, the green value chain framework can be presented in the Figure 3.

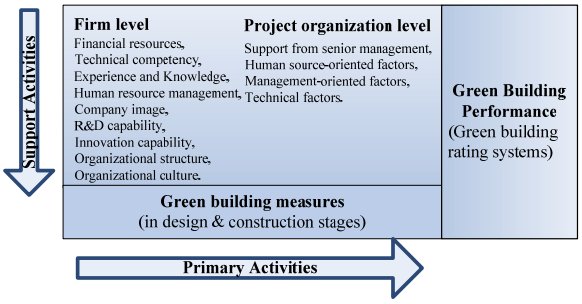

Figure 3. Green Value Chain Framework

4. GREEN VALUE SYSTEM FRAMEWORK

The green value chain framework only focuses on internal sources of construction firms, which can help improve the environmental performance of building projects. Although improvements within construction organization are prerequisite to reduce environmental impacts of buildings, by itself it is not enough. This is the greatest challenge facing the construction industry as a whole. Therefore, the concept of green value chain should be extended beyond the construction firm and applied to all the life cycle stages of building industry, which can be defined as green value system framework. Recently, researchers pay more attention on life cycle analysis method, which is considered as the most comprehensive and appropriate method to analyze the activities contributing to the sustainability of building. The life cycle of green building include from planning and design, to construction, use, refurbishment and reuse, demolition, reuse and recycling. In order to bring improvements within the built environments, the construction industry has to pay attentions to all the activities carried out in each of the above mentioned phases [17]. The different stages of a building's life cycle are handled by different players. Based on the life cycle analysis of decision-makers for green building, the green value system framework, describing the full range of activities required to improve the sustainability of buildings, has been created (see Figure 4). This framework can help understand the whole process of green value activities and identify the external factors critical for green building projects.

5. REVOLUTION MODEL FOR CONSTRUCTION ORGANIZAITONS

Based on the introduction and detail analysis of "green value chain and system frameworks", a revolution model for the construction organizations towards green building is created, as shown in Figure 5.

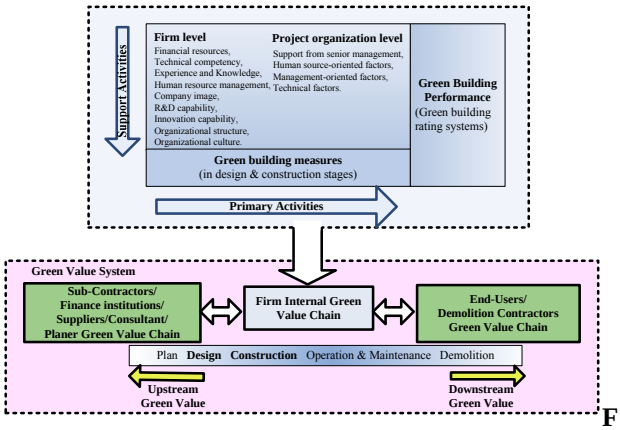

Figure 4. Green Value System Framework

At present, most of the researches for green building strongly focus on the primary activities (green building measures), which can help improve environmental performance of buildings technologically. Little works have been done to investigate support activities (management activities at the firm and project organization level within the construction organization) and external factors for green buildings, which also play an important role for the successful implementation of green building. A more detail analysis that focuses on these areas is fully discussed in the following research work. Management factors and external factors critical for green building are extracted from the analysis of environmental performance and green building measures for construction organizations.

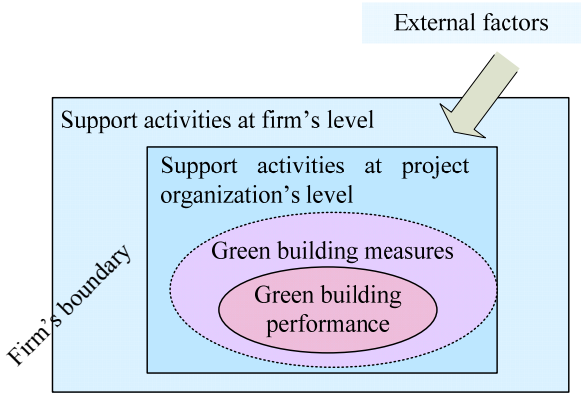

Figure 5. Critical management factors model

6. ENVIRONMENTAL PERFORMANCE AND IMPROVING FACTORS FOR CONSTRUCTION ORGANIZATIONS

6.1 Environmental impacts for construction organizations

Until now, lots of performance assessment tools have been developed. Examples include Building Research Establishment Environmental Assessment Method (BREEAM) (U.K.), Leadership in Energy & Environmental Design (LEED) (U.S.), Green Mark (Singapore). There are an unwieldy number of criteria and indicators that introduce various ways of measuring various aspects of building performance [18]. Base on the analysis of criteria of different assessment methods, building performance criteria can typically fall into six basic categories: Energy, Water, Materials, Indoor environment and Outside environment (Soil erosion, Dust, Harmful gases, Noise, Liquid effluents), site development. Since the site development is decided by planner, which is beyond the control of construction organizations, we will not consider this criterion in the paper. Based on the five environmental performance criteria of buildings, the green building measures and support management factors can be identified.

6.2 Green building measures for construction organizations

Construction organizations are only in charge of decisions in the design and construction stages. In broad term, design stage includes all the processes before the commencement of constructing a building on site [19]. Thus it includes architectural and structural design, the development of contract documents, and in some cases, includes bidding or negotiation, and award of the construction contract, which marks the transition into construction [20]. The researchers for sustainable construction highlight the importance of design in order to achieve greater sustainability, because buildings or any other facility are the end product of all the design decisions taken at the outset of a project [21]. The decisions making in this stage can influence the environmental performance of building in the areas of energy efficiency, water efficiency, material usage, indoor environment, and atmospheric considerations. There are many opportunities for improving project sustainability before any actions begin on site. Specific elements that should be considered include integrated building design (which take into account of building form, building orientation, construction details, ventilation strategies, insulation, passive solar design), the selection of heating and lighting systems and appliances within a building, and the choice of building materials [19-20]. Usually, the levels of building performance have been fixed at this point. In the construction stage, the contractor only needs to follow detailed specifications to meet sustainable requirements set at the design stage. Therefore, green building measures in construction stage are often ignored. However, at present, more and more researchers realize substantial environmental impacts caused at the construction stage and more green building measures have been developed.

The construction stage is the bridge between concept and reality, which includes construction planning, execution, start-up and commissioning [20]. Various of environmental problems are related to the construction operations, such as substantial dust, noise, site disturbance, and indoor environmental quality which may have significant, although generally short-term, local effects [22]. The recommendations, offering opportunities for increasing sustainability of projects, include erosion and sediment control, the choice of green building materials, sequencing work to minimize exposure of materials to potential contamination, waste minimization and recycling, commissioning, etc.. These problems present the need for proper management measures during construction [19].

Detail green building measures in the design and construction stages are listed in the table 1.

Table 1. Green building measures in design and construction stages [1, 19, 24]

Green building criteria	Green building measures	Stages of building life-cycle influenced (design/construction)
Energy efficiency	An integrated design (building orientation, building form, internal design, increased insulation and shading) with computer simulation tools	design
	Green roofing/Light colored roofing	design
	Efficient heating and cooling equipments and appropriate sizing	design
	Efficient lighting fittings	design
	Solar water heating	design
	Sub-metering systems	design
	Solar photovoltaics	design
	Advanced on-site construction equipments	construction
	Energy management systems	construction
	Commissioning	construction
Water efficiency	On-site gray water/rainwater/excess groundwater reuse	design
	Low-water-use fixtures and water-free urinals	design
	Sub-meters	design
Materials	Innovative design and construction techniques, i.e., design for demolition, prefabricate building components.	design/construction
	Use local products and materials	design/construction
	Use waste and highly-recycled-content materials	design/construction
	Use reusable components and recyclable materials	design/construction
	Use certified sustainable materials	design/construction
Indoor air quality	Design/construction integration measures	design/construction
	Control pollutant sources (i.e. avoid materials that will off gas pollutants)	design/construction
	Install carbon-dioxide monitors	design
	Protect building materials from the elements during construction	construction
	Implement construction IAQ management plan	construction
	Computer-aid simulation of indoor environment	design
Outdoor environment (Soil erosion, Dust, Harmful gases, Noise, Liquid wastes)	Silt Fence	construction
	Diversion Ditches	construction
	Construction Entrances	construction
	Temporary matting	construction
	Site restoration with native plants	construction
	Permeable paving (i.e. riprap dissipation pads)	construction
	Static crushing/chemical breaking	construction
	Wet excavation/drilling	construction
	Having vehicles stay on established routes, and keep these routes moist/Washing transporting equipment/Reducing vehicle speed and do not overload haul vehicle	construction
	Careful planning to keep the disturbed area to a minimum	construction
	Hydraulic piling equipment	construction
	Electric machine	construction
	Bolt/pressure connection	construction
	Poison-free solvent	construction
	Laser cutting	construction
	Soundproof room and wall	construction
	biological waste treatment systems	construction
	Night shift	construction

You should keep in mind that some green building measures can not be applied in buildings without the cooperation of designers and contractors.

6.3 Critical management factors for construction organizations

In line with green building measures to maximize reducing environmental impacts of building projects, construction organizations should reconsidered the current management practice. Critical management factors for green building projects, both at the firm level and project organization level, are summarized in the following:

Factors at firm's level

1. Financial strength;
2. Technical competency;
3. Experience and knowledge in green building;
4. Training and Education;
5. Incentives and compensation policies and systems;
6. Company image;
7. R&D capability;
8. Innovation capability;
9. Organizational structure;
10. Organizational culture that encourages cooperation;
11. Organizational culture that cultivate environmental responsibility.

Factors at project organization's level

Support from senior management

1. Financial support;
2. Technology support.

Human source-oriented factors

3. Skilled designer;
4. Skilled project manager;
5. Trouble-shooting;
6. Project team motivation;
7. Commitment of all project participants.

Cooperation between project internal participants

8.Cooperation between architects and engineers;
9.Designers involved in construction stages;
10.Contractors involved in design stages.

Management-oriented factors

11. Strong/detailed plan effort in design and construction;
12. Adequate communication channels;
13. Effective control, such as monitoring and updating plans;
14. Effective environmental compliance and auditing programs;
15. Effective feedback;
16. An appropriate project organization structure;
17. Effective change management;

Technical and innovation-oriented factors

18. Advanced machinery and equipments;
19. Effective and efficient software development and application;
20. Innovative management approaches;
21. Innovative technological approaches;
22. Innovative financing methods.

Procurement-related factors

23. Procurement methods;
24. Tendering method.

Financial factors

25. Adequate financial budget.

The identification of critical management factors for green building can help construction organizations arrange internal resource effectively and efficiently.

7. EXTERNAL CRITICAL FACTORS FOR CONSTRUCTION ORGANIZATIONS

The construction firms are only one part in the green value system. Adjacent players and external linkages can lead to significant reduction of environmental impacts. This indicates that the successful implementation of green building requires the communication and collaboration between construction organizations and other players. Therefore, construction organizations should established good relationships with other players in the green value system, which include: Local qualified/certified materials and products suppliers; Advanced equipment suppliers; Qualified/certified sub-contractors; Green consultants; Planers; Clients; Demolition contractors; Finance institutions; Government. These relationships are also within the realm of control of construction organizations and have been regarded as external resources of construction organizations, which are critical for the success of organizations.

8. CONCLUSIONS

From the basic theories of value chain and value system, the green value chain and system frameworks are introduced. A revolution model for construction organizations towards green building is established through the analysis of green value chain and system frameworks. In this model, environmental performance of buildings was used as a source of values itself. The primary and support activities (both at the firm and project organization level), as well as some external factors all contribute to the improvements environmental performance of buildings. In the following section, the detail green building measures, critical management factors and external relationships, within the control of construction organizations, were extracted. These critical factors and activities can serve as a checklist and help managers to allocate the limited resource and time effectively and efficiently. The theoretical framework can also be used as the bridge between corporate strategy and green building practices for future works. However, the identification of the critical management factors in this paper is considered from a theoretical point of view. Further quantitative and empirical studies on these factors in order to identify their relative importance should be done in the future research works.

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