# 3

## THE ADOPTION OF GREEN INNOVATION IN THE SCOTTISH CONSTRUCTION INDUSTRY CONTEXT

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## INTRODUCTION

The growing interest in environmental innovation has led to an increase in the number of research studies around that area in different industries (Dutz & Sharma, 2012). The construction industry is a critical industry for the study of environmental- or sustainability-related issues, considering that, it is responsible for some of the most serious impacts on the environment. Indeed, there is a growing concern regarding environmental impacts resulting from construction activities. By comparison with other industries, its activities are considered as making a major contribution to environmental problems (Ball, 2002; Tam, Tam & Tsui, 2004; Tam & Tam, 2008). In the United Kingdom (UK), specifically, the construction sector contributed 11.2% of the total of UK greenhouse gas emissions in 2013 (Office for National Statistics, 2015) while around 420 million tonnes of construction material is consumed by the construction industry each year, whereby approximately 120 million tonnes is wasted (EISC, 2012). It shows that, by its nature, construction is not an environmentally-friendly activity.

Conversely, the construction industry plays a vital role in meeting the needs of society and enhancing the quality of life. Its activities directly affect the nature, function and appearance of the place in which people live. In addition, it contributes to a better standard of living by offering employment to people all over the world. Specifically, the UK construction industry employs 2.1 million people (Rhodes, 2015), accounting for 6.3% of total UK employment in 2014. The industry's output was increased to £92 billion (6.4% of the total economy) in 2014 (Office for National Statistics, 2015), which makes a valuable contribution to the UK economy. Hence, the economic significance of the construction industry cannot be underestimated.

In line with these conflicting issues, it is essentials for the industry to intensify its effort and move towards sustainable construction. In the UK, the government has set a target to achieve 60 per cent energy reduction by 2050 (SCTG, 2003). For that reason, it is necessary to identify the role that the construction industry plays in protecting the environment by looking at its involvement in environmental-related innovation activities or practices. Hence, the primary objective of this paper is to examine the extent of green innovation adoption by Scottish construction firms.

## THE CONSTRUCTION INDUSTRY

Much of the literature has often classified construction as "low-tech" and "traditional" industry (Miozzo & Derwick, 2004; OECD, 2000; Reichstein, Salter & Gann., 2008). These studies have recognized the common attributes of construction firms which are considered as conservative, risk averse, engaging in low investment of R&D, have few operating routine and the development of new technology or product is mostly dominated by suppliers. The industry has many small firms with few professional staff and is dominated by price-based competition among contractors to win a particular project (Gann, 2000). As highlighted by Gann (2000), construction has shown lower productivity growth and has continued with more labor intensive approaches compared to other industries. This dominant perspective implies the modest importance of innovation sources in construction, given the reflection of a slow pace of change in the industry. Looking at its distinctive features, construction is a project-based sector, the products is durable, it uses temporary coalitions of organizations to complete a unique project, most of its productions and assemblies are "in-situ[1]" (Allen & Iano, 2013), and it has a high level of client involvement especially during the design and production phase (Pinto, 2016). These factors have shaped its activities and significantly influence its innovative effort.

In addition, the construction industry and its activities are considered to be one of the major sources of development and economic growth. The industry plays an important role in the development of a country by improving economic and social areas in many ways. For instance, it offers job opportunities to millions of workers, generates income within and outside of the sector, and supplements the foreign exchange earnings from trade in construction materials and engineering services. The condition of the construction industry affects, to some extent, most common economic measures of a country, like Gross Domestic Product (GDP)[2] . It would also affect the availability of capital, government's decisions, and even the social health of a country. Besides, the construction industry has significant interaction with other economic sectors through its linkages.

The main aim of the construction industry is to serve and maintain the built environment. The built environment encompasses all buildings, spaces and products that are built by people within the construction industry. Examples of the built environment are houses,

[1] 'In-situ' in construction context means 'on construction site'.

[2] Gross domestic product (GDP) is a measure of the total expenditure of a country on goods and services within a certain time (normally a year).

schools, workplaces, parks, business areas, farms, and roads. Furthermore, construction activities generally consist of design, planning, construction, and maintenance of a building. These activities could enhance the built environment while contributing to the economy and society as a whole. In addition, these project-based construction works that are delivered to the built environment involve numerous participants whose responsibilities are defined according to contracts. The major participants in typical construction projects are architects, engineers, consultants, contractors, subcontractors, construction workers and owners or customers who have spent their money on the constructed facilities (Isa, Jimoh, & Achuenu, 2013). These participants deliver a variety of outputs including visible facilities which contribute to the economy of a country in several ways.

**Environmental Issues in the UK Construction Industry**

Construction of any types of building, whether residential, commercial or other infrastructure has significant impact on the environment. Every aspect of building and infrastructure development could affect the environment, in which many activities can result in negative environmental consequences. The construction industry plays a substantial role in increasing the quality of life by providing housing, utilities, workspaces and transport infrastructure. It also makes significant contribution to the economy, despite its serious consequences on the environment (Burgan & Sansom, 2006). Both the processes of building new facilities and renovating existing built environment have various environmental impacts. Construction is directly and indirectly responsible for the emission of greenhouse gases as a result of the energy used for its activities, such as raw material extraction, construction, transportation and demolition (Sorrell, 2003).

Around the globe, there has been growing concern regarding the environmental impacts created by the construction industry. In the UK, around 420 million tonnes of construction materials are consumed by the construction industry each year, which is equivalent to 7 tonnes per person. However, approximately 120 million tonnes were wasted out of the total consumption of all materials (EISC, 2012). Construction waste accounted for 32 % of total landfill waste, and this shows how it contributes significantly to landfill (Environment Agency, 2010). In addition, Construction Excellence (2008) reported that up to 13% of the 'waste' was not delivered nor used.

In 2013, total UK greenhouse gas emissions were equivalent to 566 million tonnes of carbon dioxide (DECC, 2015), of which the construction sector contributed 11.2% of these emissions (Office of National Statistics, 2015). In addition to direct environmental impacts caused by its activities, the industry is responsible for significant amounts of soil, air and water pollution. BIS (2010) reported that almost a third of all industry-related pollution incidents occurred in the construction industry. This situation needs to be addressed if the industry is to reduce its negative impact on the environment.

The industry's economic significance creates opportunities as well as responsibilities for the construction sector to innovate and advance beyond its existing practices. This requires the industry to adopt different thinking and new ways to perform its operations. Thus, it is necessary for construction firms to get engaged in environmental-related innovation activities or practices.

## GREEN INNOVATION PRACTICES IN THE CONSTRUCTION INDUSTRY

It has been proven that by 'being environmentally-friendly', organizations have found value (Porter & Kramer, 2006). In fact, there is a positive relationship between a firm's adoption of green innovation strategies and its overall performance (Eiadat, Kelly, Roche & Eyadat, 2008). In general, green innovation is a type of innovation that has a reduced negative impact on the environment. The other notions that used in the literature to describe this type of innovation is 'green', 'eco' and 'sustainable', which are used interchangeably (Schiederig, Tietze & Herstatt, 2012).

In the context of this study, green innovation are categorized into three types: green technical innovation, green process innovation and green administrative innovation (Chiou, Chan, Lettice & Chung, 2011; Chen, Lai & Wen, 2006 ; Chen, 2008 ; Huang, Ding & Kao, 2009; Tseng, Wang, Chiu, Geng & Lin, 2013). Green technical innovation involves application of environmentally-friendly equipment and technologies that reduce the negative impacts on the environment (Huang et al., 2009), which also reflects the transition towards adoption of clean technologies. Green process innovation is any adaptation of construction process including the addition of new processes or improvement of existing processes to reduce environmental impact (Cheng & Shiu, 2012), while green administrative innovation is the introduction of a new administrative process, management systems or staff development program (Subramanian & Nilakanta, 1996).

In the construction industry, green innovation requires actors who are involved in construction activities to increase their effort towards minimizing the environmental impact. In order to do so, they could (1) try to improve the efficiency of the processes used in construction activities, (2) try to minimize the amount of construction waste, and (3) try to conserve water, energy and other resources during the implementation of construction activities. In addition, it could also include other environmental strategies that may reduce costs and increase productivity, as well as do not greatly impact on the project budget or schedule (9). Previous research on construction projects in the field of sustainability has shown that firms' involvement in green innovation not only improved the quality of the construction projects, but also strengthened the company position in the marketplace (Bossink, 2004). In addition, it offers some potential advantages to construction firms such as increase opportunities to tender, fewer money lost through wasted resources, fewer money wasted on fines, fewer money lost on restoring environmental damages, and improve firm's environmental profile (Cole, 2000).

Significantly, this study sheds light on the ways in which project-based firms in the construction industry cultivate and implement innovation activities within their organizations. Moreover, green innovation adoption may explain on the conditions under which some firms are more environmental "friendly" than others.

## METHOD

Survey data was used to fulfill the objective of the study. Prior to implementing the main survey, a pilot test was performed by administering the questionnaire to a small group of respondents that were similar to the target population. A sample of 33 construction companies that were identified randomly from the internet was emailed to invite their

participation in the survey. Along with the link to the online survey, the purpose of the survey was explained to each respondent. The feedback from the pilot test revealed a few problematical questions that need to be amended. In addition, these amendments were also done based on a number of discussion sessions with two academics at the University of Edinburgh, which resulted in improvement to the questionnaire.

For the main survey, a total of 84 construction companies throughout Scotland have participated in an online survey. The developed online survey questions were using 5-point Likert scale where the green innovation constructs were derived from literature review. Three approaches have been taken to administer the online survey. First, the survey invitation has been emailed to Federation of Master Builder (FMB) members in Scotland by focusing to only members that considered as general builders. Second, invitation emails have been sent to a number of builders in Scotland that have been searched from the internet. Finally, a few visits have been done to a number of construction companies in surrounding area of Edinburgh city. The three approaches were conducted sequentially for the purpose of increasing the response rate.

The green innovation constructs and the individual items were derived from the literature review. Specifically, green technical innovation is measured based on instruments developed by Qi, Shen, Zeng and Jorge (2010) and Huang et al. (2009). The respondents were asked to specify on a Likert scale from 1 (strongly disagree) to 5 (strongly agree) with the statements related to the adoption of listed green-related technologies in the questionnaire. Green process innovation is measured using an instrument adapted from Chen et al. (2006) and Sev (2009). Based on a five-point Likert scale, the respondents were asked to state the degree of their agreement with the statements that reflect their consideration on the environment during the implementation of construction activities anchored by 'strongly disagree' (1) and 'strongly agree' (5). By referring to the instruments developed by Huang et al. (2009), Sev (2009), Jaskyte (2004), Lefebvre, Lefebvre and Talbot (2003) and Smallwood (2000), five items have been adapted to measure the adoption of green administrative innovation by the construction companies. Five-point Likert scale is used to assess the degree of agreement with the statements pertaining the implementation of administrative process, new management system and employee development program within the firm. All these questions were systematically presented in the online survey platform hosted by Bristol Online Survey (BOS).

## RESULTS

Most of the questions that were related directly to the variables investigated in this study were using scale data. In contrast, general questions regarding the respondents and their firms were mainly using nominal data. Therefore, a number of different statistical procedures were employed to analyze the different types of data. However, for the purpose of this paper, the results of basic descriptive statistics are shown below.

## General Information of the Respondents and Their Firms

Table 3.1 depicts the demographic characteristics of the 84 respondents for this research. Notably, most of the respondents were holding senior positions as almost 70 % were the Managing Director or Proprietor of the firms. In terms of familiarity with the firms, more than 75 % of the respondents had been working there for more than five years. Almost 90 % of the respondents were men, indicating men's dominance compared to women in the construction industry. This was aligned with the findings of previous studies (for example Byrne, Clarke, & Van Der Meer, 2005).

In addition, a majority of the respondents were 40 years old and above (78.6 %). This was normal as senior position posts are normally held by persons with more experience, which can be represented by age. Most of the respondents held at least a college qualification; 40.5 % were holders of a university undergraduate degree or higher qualification.

**Table 3.1**
Demographic Characteristics of Respondents

| Characteristics | *n* | % |
|---|---|---|
| Position | | |
| Managing Director/CEO | 40 | 47.6 |
| Proprietor | 16 | 19.0 |
| General Manager | 12 | 14.3 |
| Project Manager | 2 | 2.4 |
| Technical Manager | 1 | 1.2 |
| Other | 13 | 15.5 |
| Period of working (years) | | |
| Less than 1 | 6 | 7.1 |
| 1-5 | 14 | 16.7 |
| 6-10 | 24 | 28.6 |
| 11-15 | 13 | 15.5 |
| 16-20 | 4 | 4.8 |
| 21 or longer | 23 | 27.4 |
| Gender | | |
| Male | 75 | 89.3 |
| Female | 9 | 10.7 |
| Age (years) | | |
| 20-29 | 4 | 4.8 |
| 30-39 | 14 | 16.7 |
| 40-49 | 30 | 35.7 |
| 50 and above | 36 | 42.9 |
| Education level | | |
| Vocational/Technical school | 13 | 15.5 |
| High school | 9 | 10.7 |
| College | 28 | 33.3 |
| University degree or higher | 34 | 40.5 |

*n*=84

Further, Table 3.2 shows the characteristics of the respondents' firms. The majority of the firms have either very small number of full time employees that is in the range of one to four people (36.9%) or more than 15 employees (35.7%). Most of the firms have been established for between 11 to 25 years (35.7%). The firms were mainly providing services to residential customers (35.7%) as normally served by small firms who focusing more on single sector. Majority of them are family business firms (76.2%) and only 10.7 percent of them are ISO 14000 certified firms.

**Table 3.2**
Firms' Characteristics

| Characteristics | *n* | % |
|---|---|---|
| Number of full-time employees | | |
| Fewer than 5 | 31 | 36.9 |
| 5 to 15 | 23 | 27.4 |
| More than 15 | 30 | 35.7 |
| Age of company (years) | | |
| Less than 10 | 28 | 33.3 |
| 11 to 25 | 30 | 35.7 |
| More than 25 | 26 | 31.0 |
| Industry sector | | |
| Residential | 30 | 35.7 |
| Commercial | 4 | 4.8 |
| Residential & commercial | 23 | 27.4 |
| Residential, commercial & industrial | 27 | 32.1 |
| Ownership | | |
| Non-family business | 20 | 23.8 |
| Family business | 64 | 76.2 |
| ISO 14000 certification | | |
| ISO 14000 certified | 9 | 10.7 |
| Non-certified | 71 | 84.5 |
| In the process of applying for certification | 4 | 4.8 |

*n*=84

## Level of Green Innovation Adoption

Descriptive analysis was conducted to find out the frequency of adoption of each green practice that had been listed in the survey. A 5-point Likert scale was used by the respondents, with a rating from 'strongly disagree' (1), 'disagree' (2), 'neutral' (3), 'agree' (4) to 'strongly agree' (5) to rate their agreement with the statements that indicated their adoption of particular green practices.

This scale, further, was recoded into a two category group. Firms rating the scale at 1, 2 and 3 (disagree with the statements) show no adoption or involvement in particular practices while firms rating the scale at 4 and 5 indicate their adoption of particular practices to some extent. The adoption level of green technical, green process and green administrative practices by 84 Scottish construction firms are shown in the Table 3.3.

**Table 3.3**
Level of Adoption of Green Practices by Scottish Construction Firms

| Green Practices | Percentage of adoption |
|---|---|
| **Green technical innovation (GT)** | |
| (GT1) Our company adopts the technologies of energy conservation | 70.2 |
| (GT2) Our company adopts the technologies/ processes of pollution prevention | 76.2 |
| (GT3) Our company adopts the technologies of noise controlling | 60.7 |
| (GP1) Emission of hazardous substances or waste during construction activities are monitored | 79.8 |
| **Green process innovation (GP)** | |
| (GP2) Our company utilises, integrates with or recommends adoption of site waste management plans | 72.6 |
| (GP3) Energy is used efficiently during construction | 79.8 |
| (GP4) Materials that require low energy to produce where possible are specified or used during construction | 58.3 |
| (GP5) Locally sourced materials are used for construction activities to reduce energy use for transport | 76.2 |
| (GP6) Natural environment is conserved during construction activities | 83.3 |
| **Green administrative innovation (GA)** | |
| (GA1) Our company adopts environmental auditing | 20.2 |
| (GA2) Our company undertakes environmental protective education and training | 22.6 |
| (GA3) Our company offers employee remuneration and promotion based on environmental initiatives/improvements | 3.6 |
| (GA4) Our company promotes new activities or events for staff linked to environmental-related issues | 22.6 |
| (GA5) Our company provides written environmental documentation such as policies, a mission statement, rules or procedures to protect the environment | 47.6 |

*n*=84

The results indicate that most of the firms had adopted the four types of green technologies while undertaking construction work for clients. They reveal that the majority of the firms (79.8%) had monitored the emission of hazardous substances or waste during construction activities. Also, technology of pollution prevention was adopted by more than 76 per cent of the firms, followed by the other types of green technologies; technologies of energy conservation (70.2%) and technologies for controlling noise (60.7%).

In terms of green process, the percentages of adoption of five environmentally-friendly construction processes while implementing construction work for clients are considerably high. In terms of high levels of adoption, 83.3 per cent of the firms gave great attention to conserving the natural environment of the surrounding area of the construction site while implementing construction activities. In addition, 79.8 per cent of the firms had used energy efficiently during construction. In terms of low levels of adoption, low energy materials were used by only 58.3 per cent of the firms during construction.

On the other hand, the adoption of green administrative practices by the 84 construction firms in Scotland was relatively low. The results reveal that no more than half of the firms (47.6%) have their own written environmental documentation. Only 22.6 percent of the firms encouraged new environmental-related activities for staff and undertook environmental education and training, respectively. Remuneration and promotion for employees based on their environmental initiative was the practice was adopted by the lowest number of construction firms (3.6%).

## DISCUSSION

The aim of this study is to examine the extent of green innovation adoption by Scottish construction firms. The findings present, overall, more than half of the construction firms have adopted various types of green technical and green process during construction. However, they have shown a relatively slow movement towards green initiatives by adopting basic green practices. In terms of green technical, they have focused on monitoring the emission of hazardous substances or waste during construction activities, adopting the technology/ processes of pollution prevention, technology of energy conservation, and technology of noise controlling. In terms of green construction processes, they have focused on natural environmental conservation, efficient utilization of energy, and consumption of locally-sourced materials for construction. Those are the basic practices which have been suggested by Qi et al. (2010) to be promoted through managing the construction activities. Green administrative practices, however, were less adopted by the construction firms.

On the other hand, the implications of this study are discussed as well. The results could encourage construction firms to increase their effort towards becoming more environmentally-friendly in order to play their parts in protecting the environment. The construction firms should put emphasis on how to appropriately adopt green innovation. Furthermore, management should also focusing on administrative components in promoting the importance of environmental consideration. Since the administrative innovation often occurred voluntarily, strong commitment from employees as well as support from the management are very crucial. In addition, it may be possible to generalize

the findings of this study to other project-based firms such as design and engineering firms. In many project-based firms, project teams have limited contact with senior management, are based off-site and work in teams with many other firms. The performance and competitiveness of these firms depend not solely on the single firm, but on the efficient functioning of the entire network. In addition, as project processes have a tendency to be temporary and unique (Gann, 1998), they present non-routine features, in contrast to traditional manufacturing approaches, which can limit opportunities for process improvement or innovation. Thus, the results related to the extent of innovation adoption and its hindrances, particularly, could be generalized to other project-based firms.

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