The Challenges of On-site Waste Management Innovation in Building Construction Projects: Lebanese Construction Industry

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ABSTRACT

Construction and demolition (C&D) waste generation is considered to be one of the real problems in the construction industry (CI) today. This is because of its direct negative impacts on the efficiency of the CI in addition to the environment. Because the CI is depending on environmental resources, it can’t keep on practicing if these sources are being depleted, therefore the significance of waste management innovation on-site such as separation, processing and re-use of C&D waste is vital to bring forth significant social, economic and environmental benefits over traditional methods. The CI takes an important part in the economy of developing countries, such as Lebanon.

The aim of this thesis is to investigate the behavioral determinants effecting on-site C&D waste management innovation (OC&DWMI) decisions. For this purpose, a questionnaire survey was distributed between different contractors within the Lebanese CI. A preliminary theoretical model that integrates two key behavioral decision-making theories was developed based on the theory of planned behavior and innovation diffusion theory with additional significant constructs. Structural Equation Modelling was used for data analysis, model modification, and hypothesis testing. A conceptual framework was developed showing the most significant factors. Whereas the results of the final model show that behavioral intention concerning OC&DWMI and governmental supervision are the most significant factors affecting the adoption decisions of OC&DWMI. So governments should impose specific regulations and guidelines regarding OC&DWMI with comprehensive supervision and strict punishment system, in addition to the help of

R&D institutions and professional associations in increasing the behavioral intention regarding OC&DWMI to achieve its adoption.

Keywords: Construction and demolition waste management; Intention; Theory of planned behavior; Behavioral determinant

ÖZ

İnşaat ve yıkımdaki (İY) atık üretiminin günümüz inşaat sektörünün (İS) gerçekl sorunlardan biri olduğu düşünülmektedir. Bunun nedeni çevreye ilaveten İS'nün etkinliği üzerinde doğrudan olumsuz etkileri olmasıdır. İS, çevresel kaynaklara bağlı olduğu için, bu kaynaklar tükenirse uygulamaya devam edilemez, bu nedenle, İY’daki atıkların ayrılması, işlenmesi ve tekrar kullanımı gibi sahadaki atık yönetimi inovasyonunun önemi, geleneksel yöntemlere kıyasla önemli sosyal, ekonomik ve çevresel yararlar sağlamak için hayati öneme sahiptir. İS, Lübnan gibi gelişmekte olan ülkelerin ekonomisinde önemli bir yere sahiptir.

Bu tezin amacı, sahadaki İY atık yönetimi inovasyonu (SİYAYİ) kararlarını etkileyen davranışsal etkenlerin araştırılmasıdır. Bu amaçla, Lübnan İS’ndeki farklı yükleniciler arasında bir anket formu dağıtıldı. İki önemli davranışsal karar verme kuramını bütünleştiren ön teorik model, planlanmış davranış teorisi ve inovasyon yayılım teorisine dayanılarak ilave önemli düzenlerle geliştirilmiştir. Yapısal Eşitlik Modellemesi, veri analizi, model modifikasyonu ve hipotez testi için kullanılmıştır. En önemli faktörleri gösteren bir kavramsal çerçeve geliştirilmiştir. Son modelin sonuçları, SİYAYİ ve hükümet denetimine ilişkin davranışsal niyetin SİYAYİ 'nin benimsenmesiyle ilgili kararlarını etkileyen en önemli faktörler olduğunu göstermektedir. Bu nedenle, hükümetler, SİYAYİ 'nin benimsenmesini sağlamak için davranış niyetini artırmada Ar-Ge kurumları ve meslek kuruluşlarının yardımına ek olarak, kapsamlı kontrol ve sıkı ceza sistemi ile SİYAYİ ile ilgili özel düzenlemeler ve yönergeler koymalıdır.

Anahtar Kelimeler: İnşaat ve yıkım atık yönetimi, Niyet, Planlı davranış teorisi, Davranışsal etken

DEDICATION

TO MY FAMILY, MY SUSTAINABLE AND RENEWABLE SOURCE OF ENCOURAGEMENT AND LOVE.

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LIST OF ABBREVIATIONS

ACD	Attitude towards on-site C&D waste management
BI	Behavioral intention
C&D	Construction and demolition
C&DWMI	Construction and demolition waste management innovation
CFA	Confirmatory factor analysis
CI	Construction industry
DOWT	Design out waste tools
EV	Economic viability
GDP	Gross domestic product
GS	Governmental supervision
IDT	Innovation diffusion theory
PA	Previous activity
PAYT	Pay as You Throw
PBC	Perceived behavioral control
PC	Project constraints
SEM	Structural equation modelling
SN	Subjective norm
SPSS	Statistical Package for Social Science
SWMP	Site waste management planning
TPB	Theory of Planned Behavior
UK	United kingdom

Chapter 1

INTRODUCTION

1.1 Background

Construction and demolition (C&D) waste generation is considered to be one of the major issues in the construction industry (CI) today. This due to its direct negative impacts it has on the efficiency of the industry in addition to the environment. Because the CI is depending on environmental resources, it can't keep on practicing if these sources are being depleted, therefore the significance of waste management innovation on-site such as separation, processing and re-use of C&D waste is vital to bring forth significant social, economic and environmental benefits over traditional methods (Hyder, 2011). The dominance of mixed C&D waste disposed to landfills hence highlights the need to improve on-site separation or reprocessing and minimization waste contamination (DSEWC, 2012). In response to the challenges of environmental sustainability, global experts have called for greater investment in effective process and product innovation implemented in CI, which as a result is also able to enhance program overall performance, reduce cost and potential enhancements in the value of project results (Rose et al., 2016).

C&D waste may be reduced by the use of appropriate waste management innovation on-site, since it has big opportunity in making new recycled resources after suitable treatment. Dahlén and Lagerkvist (2010) said that wastes may be considered as resources in the wrong place. Whereas current researches have concluded that C&D

waste management could lead to huge economic benefits to the project stakeholders if employed effectively (Zhao et al., 2010; Coelho and de Brito, 2013). In order to show a complete image Lu and Yuan (2011) grouped the practices in C&D waste management into two measures that should be used. The first measure are the hard technical measures which considers the environmentally friendly construction technologies like recycled aggregates, prefabrication and steel framework. The second measure are the soft managerial measures which includes local economic mechanisms like on-site sorting and management measures and waste disposal charging scheme.

The main components involved in construction projects which are known as the four M's; machines, materials, money and manpower. It is either manpower or the individuals who have participated in the construction activities in any direct way that is considered to be the most significant element (Wu et al., 2011). This is due to the fact that only manpower have the ability to link all the other resources with each other to reach the goal of the final project. However, Even though many countries have set C&D waste management rules and advanced technologies have been developed, yet the practice of OC&DWMI in real projects is still considered as insufficient. As a result investigating the behavioral determinants that promotes the behavior adoption of OC&DWMI measures (Ajayi et al., 2015; Wu et al., 2015).

1.2 Problem Statement

The CI plays a significant role in the economy of developing countries, where Lebanon is one of. Regardless of the CI in Lebanon facing economic and political pressures, CI in Lebanon continue to be one of the most invested and promising sectors of the country's tough economy.

- Investments in the CI sums up to 21% of the GDP.
- $8.71 billion was the real estate sales overall volume in 2013 in Lebanon.
- The overall amount of construction in Lebanon made more than $9 billion in 2013.

However, Lebanese CI and its related operations and procedures seems to be causing many environmental problems (Azar et al., 2016).It was estimated that the construction waste generation daily varies between 717 and 6353 tons, with regard to demolition waste, 810 tons is totally generated every day in Lebanon (Ghanimeh et al., 2016).There are tremendous challenges associated with resource depletion that demand greater attention to reclaim the embodied energy of existing building stock, and to decrease the energy required to construct new buildings through innovative waste management strategies. To address these challenges, an innovative approach to on-site waste capture and segregation practices is required. This can involve the uptake of on-site processing technology to reduce transport requirements and associated environmental impacts (Rose, T. M., & Manley, K. 2016).

1.3 Research Questions and Objectives

The specific questions raised by conducting this research are:

1. What is the current situation of C&D waste management practice in the developing countries and the situation in Lebanon?
2. What are the existing C&D waste management strategies?
3. What are the factors influencing the contractors to make innovation decisions in C&D waste management?

The objective of the research is to investigate the determinants of behavioral intentions influencing relevant innovation decisions in C&D waste management in Lebanon and to develop theoretical model to study the innovative on-site waste management practice in Lebanese CI. This thesis also highlights the Lean construction approach towards construction waste management.

1.4 Research Methodology

This research includes an early review of literature concerning OC&DWMI. Also a questionnaire surveys was distributed between contractors to collect data as identified by the literature review, since the contractor is the direct C&D waste producer and waste management implementer on real projects. Structural equation modelling was used for analyzing the collected data by examining the specified constructs. The Theory of Planned Behavior (TPB) and innovation diffusion theory (IDT) were selected as the basis of the theoretical model. In addition, three contextual constructs which are economic viability, governmental supervision, and project constraints were introduced, formulating the preliminary theoretical model. Based on the preliminary theoretical model, eight constructs were identified and seven hypotheses were proposed. Statistical Package of Social Sciences (IBM SPSS) and AMOS software version 23.0.0 in addition to MS Excel sheets are used to analyze the data then confirmatory factor analysis is performed to confirm or reject the measurement theory.

1.5 Research Outline

The thesis report consists of six chapters. The first chapter begins with an introduction to the topic of the thesis and identify the research questions and objectives, chapter two gives background about C&D waste management and compared previous studies. Chapter three presents the methodology of the thesis work and developed hypotheses and preliminary theoretical model to study it. Chapter four presents data analysis and results. Whereas chapter five open a discussion and addresses the research questions. In the end chapter six summarize the conclusion and recommendations for future study.

Chapter 2

THEORETICAL BACKGROUND

2.1 Sustainability and Waste Management in the Lebanese Construction Industry

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" is the sustainability development as defined by the UN World Commission on Environment and Development Report (WCED, 1987). Sustainable construction, which also is a subset of sustainable development, has recently been supporting the application of knowledge and new technologies in improving the sustainability of building and designing civil structures. The question of determining the optimum balance between environmental sustainability and business profitability is at the core of sustainability (Chong et al., 2009).

Sustainable construction question is highly linked to Lebanon and to other developing nations. In spite of the recent worldwide economic decline the Lebanese CI is highly active which causes a large tension to the limited resources found naturally in the country. Lebanon has about 1,200 quarries which only seventy five of them had licenses to work in 2004. About 3 million cubic meters is the annual production from the 1,200 quarries distributed between aggregates and sand (Yager, 2004). Though annual demand for resources is different every year because of the growth of economy and its impact on the investment in construction projects.

Strangely security disturbance and war also increased the use of these resources since the rebuilding that happened after war period in July 2006 caused a demand of 3.77 million cubic meters of sand and aggregates. Other types of natural resources has been also affected by the reconstruction of 60,000 residence units which were extremely damaged or completely destroyed. This reconstruction demanded more than 1.2 million tons of Portland cement (Nasr et al., 2009).

Table 1: C&D waste generation in Lebanon (Tons/ year) and its cost according to (Ghanimeh et al., 2016).

Year	C&D Waste Generated (Tons)	Disposal Cost including transportation ($)
2000	77,380	1,160,700
2001	123,370	18,505,500
2002	74,460	1,119,000
2003	107,310	16,096,500
2004	91,250	1,3687,500
2005	73,730	1,1059,500
2006	81,030	12,154,500
2007	97,090	14,563,500
2008	51,100	7,665,000
2009	81,760	12,264,000
2010	62,050	9,307,500
2011	59,860	8,979,000
2012	43,800	6,570,000
2013	110,960	16,644,000
2014	116,800	17,520,000
2015	127,750	19,162,500
2016	138,700	20,805,000

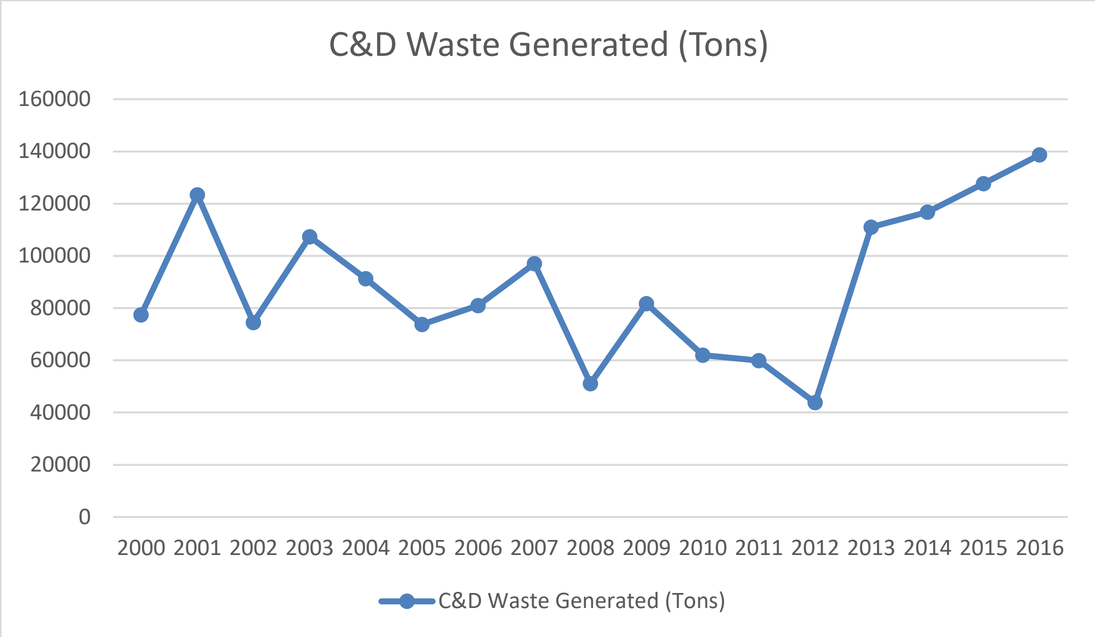

Figure 1: C&D waste generation in Lebanon graph (Tons/year) according to (Ghanimeh et al., 2016).

According to Lennon, M. (2005) the estimated cost of disposal of C&D waste including transportation is 150 $/Ton. Table 1 shows the C&D waste generation in Lebanon in different years according to Ghanimeh et al., (2016) after that the disposal cost every year was calculated based on Lennon, M. (2005) study. Figure 1 shows graph of variation of C&D waste generation in Lebanon in the recent 17 years and it clearly shows an increase due to an increase in the construction industry.

The construction demolition sector is also active in Lebanon. Even though Lebanon has small area but appropriate construction demolition waste management is highly needed. As well as the waste and remains of the regular C&D work which was estimated that the construction waste generation daily differs between 717 and 6353 tons. Regarding demolition waste about 810 tons is totally generated daily in Lebanon (Ghanimeh et al., 2016). Lebanon is under what is known as C&D waste emergency. Since the July 2006 war resulted in more than five million meter cube of wreckage from thousands of buildings which were destroyed. The removal of these wreckage was careless since there was no efforts to recycle this material through an innovative way and the most of the wreckage ended up being dumped improperly in valleys, offshore, and at temporary landfills (Srour et al., 2012).

2.2 What is Waste?

Waste in definition is any physical by product of industrial or human activity that has no value. Generally waste is a material which is not used and thrown away or is likely transferred and require special treatment by the procurements of laws (Begum et al., 2010). Furthermore by different view waste also is defined as unused or unwanted material produced by homes, institutions, or factories and industrial activities (Rahim et al., 2017).

2.3 Construction and Demolition Waste

Construction and demolition waste has many definitions. As the term shows C&D waste is referred to the discarded substances produced during the construction of buildings and infrastructure projects, demolition, and renovation (HKEPD, 2013).

According to Poon et al. (2001) and Fatta et al. (2003) the C&D waste refers to a wide variety of materials resulting from different construction works and sources:

- Roadworks and all associated materials such as asphalt, metals, sand, and gravel as result of road maintenance works.
- Rocks, vegetation, and soil as a result of excavation, civil works, site clearance, and land leveling.
- Worksite waste materials like wood, plastic, wires, metal, plastic, and glass as a result of repairing, renovation and construction activities.
- Demolition waste or wreckage such as concrete, soil, bricks, gravel, gypsum, and porcelain as result of the partial or complete demolition of buildings (Chehab 2012).

The main source of waste in the CI is the materials used in construction such as concrete, bricks, wood, steel, and, plastic which are mainly generated throughout the construction phase. In addition to the tools used in construction such as wires, nails, insulation materials and discarded wreckage and materials are also known as construction waste. Earlier studies done by Li et al. (2010) also showed that concrete, wood formwork, and steel bars are the most generated materials from construction waste.

2.3.1 Classification of Construction and Demolition Waste

There are different classifications of the types of waste, but mainly construction wastes are divided into two main groups which are physical and non-physical waste. Whereas physical waste according to the chemical characteristics of the materials involved in C&D waste can be divided into 3 categories: inert materials, non-inert materials, and hazardous chemical material (Malia et al., 2013).

Physical construction waste

Nagapan (2012) has defined physical construction waste as the process of construction and renovation in which it generates wreckage that is mainly produced from construction and repairing of buildings, clearing of construction sites, mining, roadworks etc... These activities mostly produce concrete, brick, plastic, glass, wood, paper, vegetation and so many other natural materials which are considered physical construction waste (Yuan et al., 2013):

1. **Inert waste:** Are the inert materials such as concrete, bricks, and sub-soil, which means that they hardly undergo any chemical reactions hardly under common circumstances these are also known as public fill because of their suitability for land recovery and site fill and also may be used in order to produce recycled construction materials.

2. **Non-inert waste:** The non-inert materials which are chemically active, non-hazardous materials, which in other words means that they are not considered dangerous to the environment and human health. This includes materials such as steel, wood, paper, metal, glass, and plastic. As result of construction activities, C&D waste is greatly produced and inappropriate treatment may lead to many harmful environmental impacts.

3. **Hazardous chemical waste:** The hazardous chemical materials are harmful or possibly harmful to the environment and human health, either alone or when interacting with other materials. Both non-inert and hazardous waste shouldn't be used for land recovery and must be recycled and later properly disposed of at landfills (EPD, 2013)

Non-physical construction waste

The waste that is generated during the construction process and procedures is called non-physical waste which is mostly considered the price of project and time needed for completion. According to Nagapan (2012), non-physical waste is wasting in time and/or money not just wasting materials during the project.

2.3.2 Causes of Construction and Demolition Waste

According to different scholars a lot of factors lead to C&D waste generation. These factors have been grouped and summarized in Table 2 under six categories: (1) Design; (2) Procurement; (3) Construction Operation/ Project Management; (4) Handling; (5) Culture; and (6) External.

- Design errors and changes that result in disassembling the installed work. (Eramela 2009)
- Lack of standards and guidance for implanting appropriate waste management measures on site.

- Lack of initiatives from contractors to engage proper waste management measures.
- Due to the fact that concrete is the main material used in construction so more use of formwork is required. But wood formwork regularly may be used for one to two times only. Wood formwork forms 30% of all the waste generated during the construction phase.
- About five percent of the used material is being wasted because of the excess material ordering throughout the construction stage.
- Some works should be repeated due to poor concrete placement quality or unexperienced workmanship.
- The loss during the inappropriate loading and unloading of bricks leads to high damage due to overstocking in the storage area (Poon et al. 2003).

Table 2: Causes of construction waste

Group	Causes of Construction waste	References
Design	•Detailing Errors •Design Changes •Complexities in Design •Lack of dimensional coordination •Poor project coordination •Unclear specification •Non-standardization of spaces	Ekanayake & Ofori, 2004; Bossink & Brouwers, 1996; Gamage et al., 2009.
Procurement	• Ordering Errors • Left Over Due to Over Estimation • Packaging Materials • Incorrect quantity estimation • Use of low-quality material	Greenwood, 2003; Lu et al., 2011; Wang et al., 2008; Gamage et al., 2009; Esin and Cosgun, 2007.
Construction Operation/ Project Management	• Reworks Due to Errors • Improper project planning • Poor workmanship • Left over from cutting and shaping • Poor site conditions • Poor supervision • Materials off-cuts • Inadequate knowledge	Tam et al., 2007a; Poon et al., 2004; Bossink &Brouwers, 1996; Wahab&Lawal, 2011; Kofoworola &Gheewala, 2009.

Handling	• Poor Materials Storage • Poor Materials Handling	Kofoworola&Gheewala, 2009; Lu et al., 2011.
Culture	•Lack of awareness •Lack of incentives •Lack of support from senior management •Lack of training	Lingard et al. (2000) ; Chinda, T. (2016) ; Poon (2007)
External	• Damages Due to Weather • Accident • Theft and Vandalism	Senaratne& Wijesiri, 2011; Bossink &Brouwers, 1996.

2.3.3 Cost of Waste

Construction contractors can save a lot of money and increase the company profits if they properly manage and minimize the construction waste generating from different activities on-site. This since different types of wastes are generated from different activities on-site and causing millions of dollars losses every year.

Between one to ten percent of each purchase of construction materials ends up as solid waste and almost 9% of the total purchased materials are wasted in the Dutch CI (Bossink & Brouwers 1996). That means that in the end of every project a minimum of 20% of purchased materials are not being used and in most cases ends up as waste keeping in mind that construction materials cost more than half of the overall construction cost. A report by the Hong Kong’s Environmental Protection Department in 2007 shows that about 2900 tons of C&D waste was dumped at landfills every day (Yuan, H. 2012). A reduce of ordering errors and excess of ordering would lead to a significant decrease of the number of waste and accordingly reduces the need of landfills. About two hundred million pounds are paid each year by construction companies as landfill taxes in the United Kingdom.

Besides its impact on the economy, C&D waste also has a vital impact on the environment. Forty percent of the natural recourses globally are consumed annually by the CI. With the growth of the CI the amount of generated waste in increasing too were more than 50% of this waste is not undergoing the basic treatment and disposed in landfills directly (Dajadian & Koch 2014).

2.4 Waste Management

Long ago, the amount of waste generated by people had less importance. This because of a smaller population combined with limited usage of natural resources compared to today. In the past waste had less environmental impact since the common wastes generated then were generally ashes and human biodegradable wastes which can be easily decomposed in the ground. After the Industrial Revolution and the significant increase in the population especially around the industrial cities, the waste generated also increased which further on led to waste management as an important topic.

Therefore, a consequential increase in industrial and household wastes led to threating human health and the environment. Waste management industry includes the gathering, storing, and dumping of all waste ranging from typical house waste to the waste generated from a plants and factories. So the need for appropriate waste management strategy became important for all countries, since special type of waste may react and change to cause severe problem if not managed appropriately. Governments and many firms work together to supply different types of waste management services. The common used way for the waste disposal was to bury it under the ground or in specific landfills which lead to more problems because of the limited space, soil pollution and many other problems rather than using recycling processes for treatment. Whereas this waste may be used to generate gas, electricity and may be recycled to be reused again. Overall, the appropriate waste management avoids many problems and promotes a sustainability development of the future societies.

2.4.1 Waste Management in Construction Industry

Today, environmental sustainability plays an important role in the CI. Therefor the need of innovative construction waste management is very important in this era of limited natural resources and scarcity, combined with the growing barriers against setting new landfills especially in and around the increasingly developing metropolitan urban areas with limited spaces. The increase in the amounts of C&D waste in such areas has led to huge negative environmental and socio-economic impacts and also a significant land sources loss because of the enlargement of current landfills or the construction of new ones (Poon et al., 2003). Consequently the CI is being under extra pressure to encourage innovation in C&D waste management practices guided by the three Rs principles of Reducing, Reusing, and Recycling (Calvo et al., 2014; Tam and Tam, 2006 ;Esin and Cosgun, 2007; Lu and Yuan, 2010).

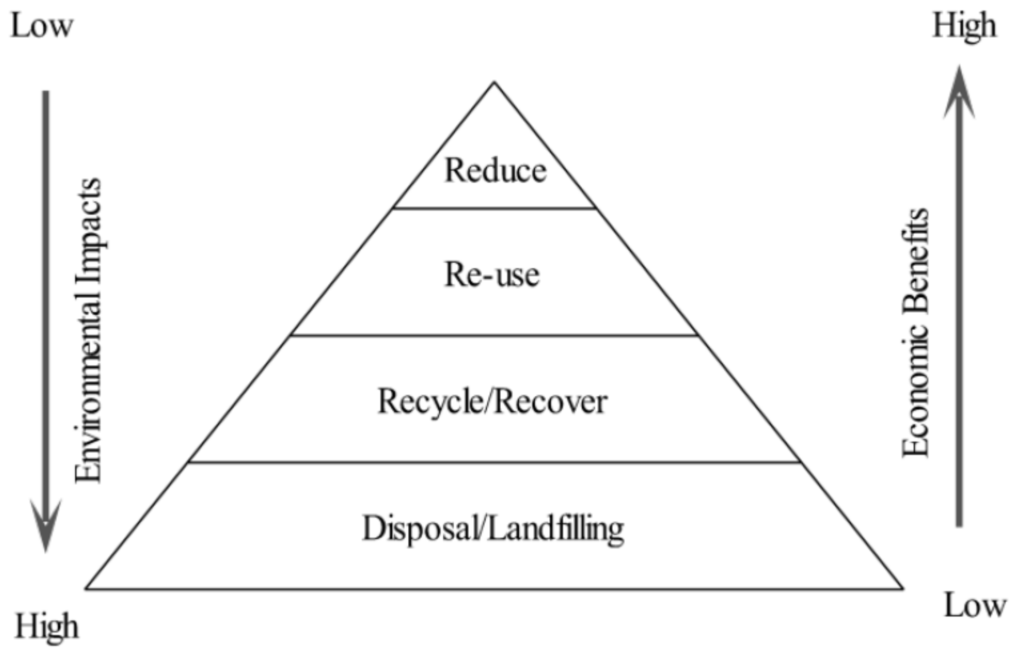

Figure 2: The C&D waste management method hierarchy (Calvo et al., 2014)

Perfectly, the three Rs principle bring to forth many economic benefits such as:

1) Reduction in construction material purchasing costs (Bossink and Brouwers, 1996)
2) Saving in tax costs at landfills
3) Saving in the costs of transportation from construction site to landfills
4) Profits from selling waste recycled materials.

The CI is naturally steered to adopt the 3 Rs principle. But the actual application seems to be extremely affected by the awareness level of different stakeholders who have different corresponding benefits from the project. These may have false preconception that C&D waste management affects highly to the project expenses or the perception of C&D waste management as less importance objective with respect to other project objectives for meeting deadline and maximizing profit (Manowong, 2012). In contrast due to the non-considering of innovative C&D waste management measures is causing negative environmental impacts and also time and budget overruns (Lu and Yuan, 2010). So raising the project stakeholders' awareness about the economic and environmental consequences of C&D waste management has appeared as an important driver for culture and innovation diffusion within organizations to encourage the adoption of sustainable practices (Osmani et al., 2008).

2.4.2 Construction and Demolition Waste Management in Developing Countries

C&D wastes are directly segregated on-site in order to reuse and/or recycle them later in developed countries because of the strict C&D waste management policies are applied (Malia et al., 2013). But, in other countries however there is a lack of clear governmental legislation ruling C&D waste management. Several types of

C&D waste being mixed and dumped carelessly. This is mostly common in the Czech Republic, Cyprus, India, and Malaysia which are all considered developing countries (Duan et al,. 2015) because there is no specific regulations concerning C&D waste management as the case in Lebanon (Bakshan et al., 2015), or not following these regulation due to lack of governmental supervision as the case of Turkey (Esin and Cosgun, 2007).

2.4.3 Previous Studies Regarding C&D Waste Management

Based on an extensive literature review about the studies investigating construction stakeholders' attitudes and behavior effecting adoption of OC&DWMI are summarized and listed in the following Table 3 according to reference , country , used methodology and, main study measures or outcomes.

Table 3: Previous studies regarding C&D waste management

Reference	Country	Methodology	Main study measures/outcome
Lingard et al. (2000)	Australia	combination of interview and self-administered questions survey questionnaire	-Managerial staff had less positive perception of the waste management climate than the site workers. -The managerial staff regarded cost, time and quality objectives are more important than potential environmental issues
Kulatunga et al. (2006)	Sri Lanka	structured questionnaire survey	- Findings indicate the positive perceptions and attitudes of the construction workforce towards minimising waste and conserving natural resources. -Lack of effort in practicing these positive attitudes and perceptions towards waste minimization -Lack of training to reinforce the importance of waste minimization practices
Tam (2008)	Hong Kong	A questionnaire survey and structured interviews	-Use of prefabricated materials -Purchase management -Education and training -Proper site layout planning -On-site waste recycling operation

Begum et al. (2009)	Malaysia	questionnaire survey	-investigated the factors affecting contractor's attitude and behavior regarding waste management -found that a positive attitude towards waste management can lead to satisfactory behavior
Wang et al. (2010)	China	Survey questionnaire and face-to-face interviews	-Workforce -Market for recycled material -Sorting out waste -Better management -Site space -Equipment for sorting waste
Al-Sari et al. (2012)	occupied Palestinian territory	Survey questionnaire and direct interviews	-examined how the local contractor waste management attitude and behavior is influenced -absence of a regulatory framework, the C&D waste management behavior of the local contractors was mostly driven by direct economic considerations.
Calvo et al. (2014)	Spain	simulation model—using the Systems Dynamic methodology	-influencing factors of C&D waste management behavior -influence of governmental policies (i.e., economic incentives and penalties) in recycling of C&D waste aggregates
Udawatta et al. (2015)	Australia	Interviews and a questionnaire survey	-Five factors of solution for C&D waste management were found and highlighted the importance of innovation in waste management decisions
Sun et al. (2015)	UK	on-line questionnaire survey	-investigated the waste management practices and opinions of small builders

From the previous literature review, it is clearly seen that a lot of researches have studied the contractor's attitude and behavior concerning C&D waste management. In the current studies, the contractor's attitude towards C&D waste management was commonly assumed to be equal to the real behavior of contractor's towards C&D waste management. But, according to the TPB, it is wrong to consider that attitude towards behavior equal to the actual behavior since the final behavior is affected by many factors.

2.4.4 Construction Waste Management Strategies

Other than waste landfill which is the traditional method commonly used but generally discouraged to be used as a waste management strategy, various strategies have been working on changing the path of waste from landfill. These strategies are summarized in Figure 3 and explained briefly bellow.

1. Sorting and recycling Waste: Many industries including the CI have adopted recycling, which is considered as the second action in to stop the landfilling of waste, the non-environmental friendly and traditional way of treatment for waste. After sorting C&D wastes on-site throughout construction process or off-site at designated recycling sites into recyclable and non-recyclable materials the recycling process starts (Barros et al., 1998). Recently in UK, on-site sorting was encouraged widely seeing that it makes the recycling process easier and guarantees a proper separation of inert and non-inert wastes (Poon et al., 2001). This strategy does not certainly reduce the waste generated from CI, but it is an effective way to divert C&D waste from landfilling. Additionally, recycling strategies guarantees the reuse of recycled materials, in which it decreases the requisite of more natural resources. Consequently this protects the environment from the negative impact of materials processing, transportation, and excavation.

2. Materials reuse: Materials reuse is an important method to divert C&D waste from landfilling. Different from recycling, material reuse is using waste with slightly change or no change of its physical and chemical state (Guthrie and Mallet, 1995). C&D waste is commonly reused for landfill, road surfacing, and as a replacement of concrete aggregates. Furthermore, some industrial

waste material may be used as a replacement of cement material in the concrete mix like coal fly ash and slag (Halliday, 2008).In addition to that leftover of materials, excavated soil, etc., produced in the construction site may also be reused again in the project or in different projects.

3. Use of waste prediction tools: With the aim of effectively managing C&D waste, various types of predicting and measuring tools have been developed in the CI. By using different tools generally during the early design stages in order to predict the possible waste generated from construction activities. Net Waste is a widely speeded waste prediction tool in the UK Developed by the UK WRAP, and helps designers during design stages to estimate the cost and quantity of the project generated waste, it also assists them in choosing the appropriate strategy in order to improve the effectiveness of the project (WRAP, 2008).Key project info containing structure volume and materials used types are collected by Net Waste in order to make a complete waste evaluation function. DOWT-B or DOWT-CE are design out waste tools for building- and civil engineers developed by the same group for identifying the potentials for designing out waste, calculating the impacts of such solution, recording design solution for waste mitigation, and comparing the impact of various design options for civil engineering projects. Different tools and approaches are used outside UK in order to predict the C&D waste, Solís-Guzmán et al. (2009) built upon data from hundred construction sites a Spanish waste prediction model. Jalali (2007) proposed a components and global index measuring waste per square meter and material types respectively. Another Singaporean model BWAS developed by Ekanayake and Ofori (2004) for waste score determination by comparing different design

situations and checking each one and its waste effectiveness so the proper reducing strategies may be used. These tools are used at the first and throughout the design phases of the project.

4. Site waste management planning (SWMP): which is a governmental obligation for construction projects in several countries. SWMP regulation (2008) in the UK obligates each project that costs more than £300,000 to prepare a SWMP in advanced of starting any construction works. In addition to a regulation that required every demolition, alteration, maintenance, excavation, civil engineering works and decoration more than the specified expanse to give a SWMP but in December 2013 this regulation was revoked. But up till now engineers involved in the CI are voluntarily preparing SWMP with the purpose of reducing the harmful impact of wastes or in order to follow the green certifications and sustainable homes codes. Likewise, in 2003 SWMP was introduced to the Hong Kong CI, Even though it was not preferred by the contractors due to the belief that it reduces the project productivity (Tam, 2008). In Australia SWMP is also a prerequisite for the approval of planning big projects (Hardie et al., 2007). The SWMP aims to, divert waste from landfilling, make sure of the proper waste separation and sorting, increase profitability and efficiency, and to make sure that the proper strategy is used for waste reduction, reuse and recycling. SWMP usually involves details of the planned strategies used during and after the construction works for waste management in addition to statement of pre-construction strategies taken before the work starts to reduce waste. Site waste managers usually prepare and manage the SWMP, the plan often suggest the amount of waste to be recycled and reused, assign the on-site

waste storage area, the strategy of waste reduction and sorting in addition to specifying the responsible stakeholders for the removal of wastes from the site (Tam, 2008).

5. Legislative and tax measures: Governments imposed different legislative and tax measures in order to divert waste from landfills. “Pay as You Throw” (PAYT) is one of these measures in which the person causing pollution pays the government amount of money equivalent to the cost of diverting the volume of waste from landfill. PAYT aims to discourage waste landfilling and encourage waste reduction, reuse and recycling. PAYT is based on unit pricing in which it charges per unit weight of the complete wastes disposed on landfill site. Previously the use of PAYT which is a variable landfill tax different landfill taxes were used but failed to reduce the waste generated. Like in the US the use of a fixed price tax that doesn’t change according to the volume of waste generated didn’t result in a major waste reduction in comparison with PAYT system (Skumatz, 2008). Numbers from many countries like UK, Canada, Greece, The Netherland, Sweden, and Switzerland proves that PAYT system eventually decreases the wastes loaded into landfill areas (Ajayi et al,. 2015 ; Browna and Johnstone, 2014).

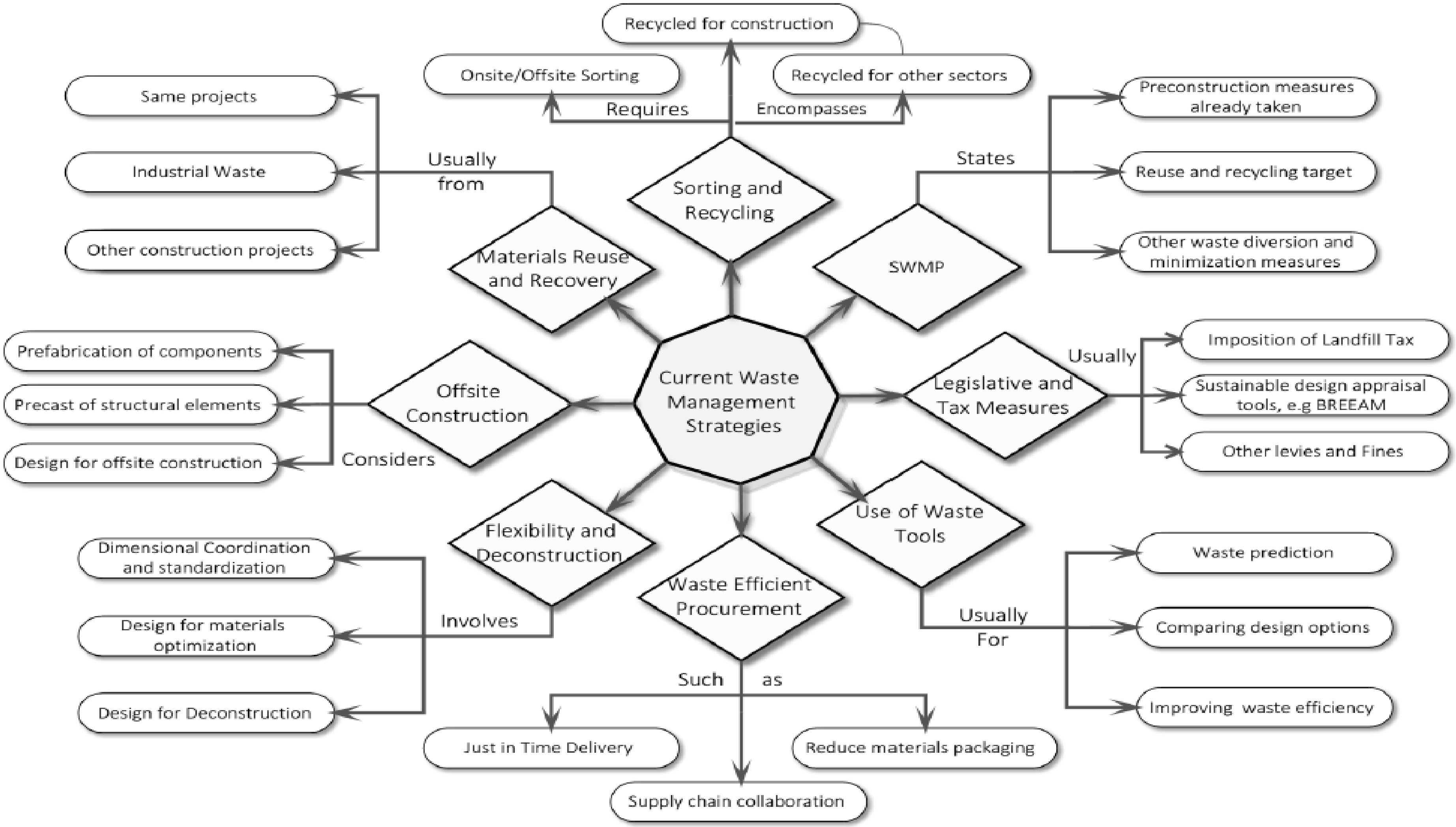

Figure 3: Summary of existing waste management strategies (Ajayi et al. 2015)

2.5 Lean Thinking in Managing the Construction Waste

The use of lean thinking at the design phases of the construction project is called lean construction, it is used to enhance the delivery of the project to fulfill the clients' needs and increase the profit by eliminating waste. It works on "optimizing the total value" rather than "minimizing the cost" as the fundamental target. Non value added activities are eliminated within lean in order to cut costs (Womack and Jones, 2003). Eriksson (2010) studied which way is the best to increase the understanding of how different characteristics of lean thinking can be adopted in construction sites and in which way does they affect the supply chain performers and their performance. Examining the basic characteristics of lean construction led to the classification of the different characteristics of lean construction into six main elements: systems perspective, continuous improvements, process focus in production planning and control, cooperative relationships, end customer focus and waste reduction.

2.6 Innovation in C&D Waste Management

OC&DWMI such as separation, processing and re-use of C&D waste is vital to bring forth significant economic, social and environmental benefits over traditional methods, and also decrease transportation costs (Hyder, 2011). Improvements in on-site sorting and separation of waste materials decreases the pollution of C&D waste through suitable treatment, while on-site reuse of these wastes in the same project saves a lot of natural resources (Chini & Bruening, 2005), thus accordingly decreasing the energy to construct or demolish a building. OC&DWMI can be characterized as:

- on-site collecting and sorting of C&D waste treatments and technological innovations

- innovative fixed or transportable on-site recycling technology for C&D waste material recycling
- Advanced technology treatments in the reuse of C&D waste materials on-site.

Regardless of the studies care about developing new strategies to apply the 3R principle of reduce, re-use and recycle C&D waste the application of such strategies on-site practically was limited (Yuan & Shen, 2011; Tam, 2008). In Lebanon, the C&D waste is the most percentage of waste generated compared with other wastes. From these materials mixed C&D waste is the biggest amount disposed at landfills highlighting the urge to develop on-site sorting and reusing in order to decrease waste contamination (Ghanimeh et al., 2016). New federal government study in Australia (DOE, 2013) identified 4 main actions needed to improve the recovery of natural resources ending up as C&D wastes:

1. Encourage the use of steel structures and designing buildings taking into consideration the deconstruction stage in order to support recovery of resources and reduce the embodied energy.
2. Decrease the pollution and mixing of C&D waste on-site while collecting and sorting wastes at the source.
3. Promote the application of recycled materials with developed specifications regarding these materials and its application in the product.
4. Overcome market and technical challenges that limit the use of innovative applications by conducting research and development (Rose & Manley 2016).

Significant adjustments in the way C&D waste is recycled and reused on-site is needed to reach these main goals with special attention to the takeoff of the innovative technology and practices by changing the behavior toward C&D waste. The diffusion of OC&DWMI must be considered and improved in the traditional practices in the industry since that is the main barrier (Damptey et al., 2010).

Clear understanding of the main barriers resulting in bad perception concerning the importance of innovation is required to promote for construction innovation. Regulations and policy responses should be made together aiming to encourage and increase the optimistic attitudes toward innovation as stated by global innovation studies (OSTP, 2008).

On the contrary, new research in sustainability management stressed on the importance of developing the processes that support the application of technologies in sustainability and not to be just leaded by the market demand and economic situation but also by the interests of the stakeholders (Schweber & Leiringer, 2012). Improvements in the performance of construction supply chain could be accomplished by encouraging the positive attitudes to innovation and solving the problems of traditionalism.

2.7 Theory of Planned Behavior (TPB) and Innovation Diffusion Theory (IDT)

Ajzen (1985) developed the famous behavioral theory which is known as Theory of Planned Behavior (TPB) that considers the real behavior as a direct function of the behavioral intentions towards behavior, in addition to the proportional sum of subjective norm (SN), attitudes, and perceived behavioral control (PBC) (Ajzen, I. 1985). TPB is considered as one of the most effective and commonly used theories when it comes to explaining the intentions toward using new technology (Mathieson,

K. 1991). Regardless of the effectiveness of TPB as the base theory that describe the behavioral intentions of construction practitioners.

There are 3 main determinants of a particular behavior in the TPB as shown in TPB framework Figure 4:

(1) Attitude towards behavior (favorable or unfavorable evaluation of the behavior)
(2) SN (the perception of the expectations of relevant others)
(3) PBC (perceived individual ability to effectively express the behavior).

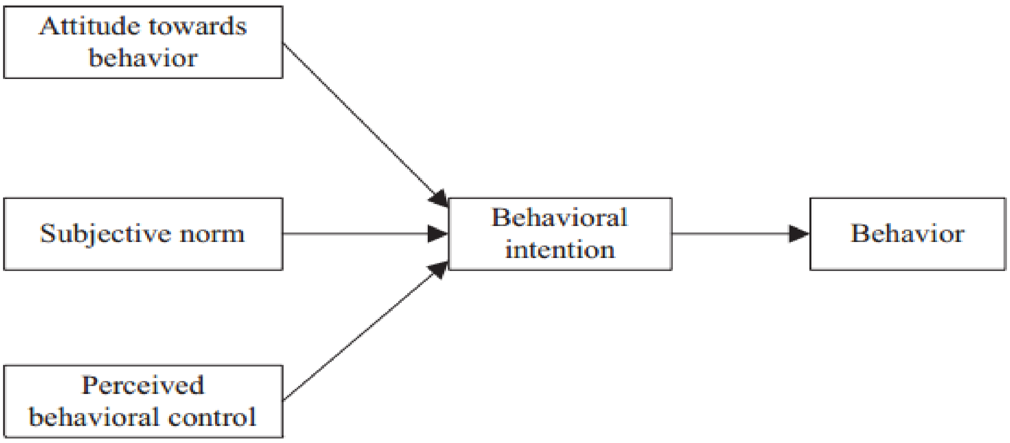

Figure 4: Theory of Planned Behavior (Ajzen, 1985)

TPB framework presented shows how the behavior of an individual is directly affected by the individual behavioral intention (BI). While the BI is affected in a direct way by the individual attitude, SN, and PBC. So an increase in the individual positive attitude towards behavior with an increase the support of the individual, and an increase in the PBC, increases the possibility of individual positive BI which in a direct way affect the actual behavior. The TPB proves effective application in different fields of research, such as doing physical exercise (Carmen Neipp et al., 2015), internet purchasing (George, 2004), green hotel choice (Han et al., 2010).

Since the actual control contains the possibility of resources and opportunities which is considered the precondition of performing behavior. Ajzen (1991) conformed that the actual behavioral control have more importance than the PBC.

The PBC is not quite the same as the actual control in light of the fact that perceived behavior of an individual can’t be precise. For instance a student has a big level of self-control to go to a class, but many unexpected coincidences might affect his actual behavior like a traffic jam or snowstorm. In such circumstance the specific behavior can’t be performed despite the fact that this person has strong PBC. So in order to find solution for this issue, additional constructs recommended to be included in the basic TPB model based on previous studies (Chu and Chiu, 2003; Guagnano et al., 1995).

Innovation Diffusion Theory (IDT) is considered “The process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers, 1995). At the point when an individual or an organization thinks of a novel idea they need this new idea to get employed by all the possible users at the earliest opportunity. Thus the idea or new product should be used by the largest number of people quickly. This process spreading this new idea or what is called innovation is known as diffusion. Hence, the main innovation characteristics that affect the final behavior and attitude taken from IDT (Rogers, E. 2003), are combined and included with TPB model to develop its illustrative power in the innovation process.

2.8 Factors Affecting On-site C&D Waste Management Innovation

According to TPB in addition to the additional constructs added the factors affecting OC&DWMI are identified and listed in Table 4 by different researchers with description of each factor.

Table 4: Factors affecting on-site C&D waste management innovation

Factor	Description	Assessment	Sub Factor	Abbreviation	Reference
Attitude towards on-site waste management innovation	Attitude of construction workforce can influence the generation and implementation of waste management strategies	Asking contractors about their feelings toward behavior and if it is useful and beneficial	OC&DWMI can promote the sustainability development of the society	ACD1	(Kulatunga et al., 2006) , (Begum et al., 2009), (Ramayah et al., 2012) , (Wu et al., 2015), (Rose & Manley, 2016)
			OC&DWMI can improve the company's brand benefit	ACD2	
			OC&DWMI can improve the social image of the project	ACD3	
			OC&DWMI should be advocated	ACD4	
			OC&DWMI relative advantage	ACD5	
			OC&DWMI compatibility	ACD6	
			OC&DWMI complexity	ACD7	
			Personal feeling towards OC&DWMI	ACD8	
Subjective Norm	Social pressure or norm may have great impact where an individual exhibits a certain behavior positively when he/she	Asking about the approval and influence of stakeholders weighted by how much their opinion is valued	Project manager	SN1	Ajzen, 1993; Chan, 1998; Ramayah et al., 2012; Shaw, 2008 ;
			Colleagues	SN2	
			Family and friends	SN3	
			Project owner	SN4	
			Potential customers	SN5	

	perceives that it is important what others think he/she should be doing		Local government	SN6	(Wu et al., 2015), (Rose & Manley, 2016)
perceived behavioral control	Duration of professional past experience in on-site waste management practices shapes workers' attitude positively through awareness towards the consequences of waste management and is the best direct predictor of conservation behavior	Asking about degree of influence of contextual factors and years of experience	Enough opportunity	PBC1	Ajzen, 1993; Begum et al., 2009; Wang and Yuan, 2011). (Wu et al., 2015), (Rose & Manley, 2016)
			Enough support	PBC2	
			Enough time	PBC3	
			Enough space	PBC4	
			Enough experience	PBC5	
behavioral intention	intention and willingness are key outcome measure for the TPB including the willingness to commit to behavior if opportunity is provided	Asking about intention and willingness to use a higher level of on-site construction waste management innovation, if conditions were supportive	Intention to take actions to avoid C&D waste generation	BI1	Ajzen, 1993; Shih, Y., & Fang, K. 2004 (Wu et al., 2015), (Rose & Manley, 2016) Rose et al. (2016)
			Intention to reuse or recycle the generated C&D waste	BI2	
			Intention to see the inappropriate dumping of C&D waste	BI3	
			Intention to attend the training concerning on-site waste management innovation	BI4	
			Intention to use a higher level of on-site waste management innovation, if conditions were supportive.	BI5	

Governmental supervision	Governmental regulations and corresponding supervision can significantly affect the behavior of contractors and improving their behavior regarding on-site waste management innovation.	Asking about the degree of influence of governmental regulation and supervision impacting on-site waste management innovation	Specific regulations	GS1	(Kulatunga et al., 2006), Al-Sari et al. (2012), Calvo et al. (2014), Udawatta et al., 2015), Lu et al., 2015, (Wu et al., 2015), (Ding et al., 2016)
			Specific department	GS2	
			Comprehensive supervision system	GS3	
			Strict punishment to illegal C&D waste dumping	GS4	
			Attractive policies to encourage C&D waste recycling	GS5	
Economic viability	Nature of the contractor is earning profits so on-site C&D waste management measures are usually adopted incompletely in order to cut the construction cost, regardless of the potential environmental problems	Asking about how landfilling fee , recycling market and construction cost affects on-site C&D waste management	OC&DWMI can reduce construction cost	EV1	Lingard et al. (2000) (Hao et al., 2008) (Zhao et al., 2010). Al-Sari et al. (2012)
			Reducing C&D waste generation can decrease the construction cost	EV2	
			Benefits to the company	EV3	
			Landfilling fee	EV4	
			Recycling market	EV5	
Project constraints	Project constraints (time , money etc.) also directly affect the adoption of on-site C&D waste management innovation measures	Asking about level of availability of resources in the project such as manpower, equipment ,time , money and space for implementing on-site C&D waste management	Workers number	PC1	Lingard et al. (2000) Kulatunga et al., 2006) Tam (2008) Wang et al. (2010) Al-Sari et al. (2012)
			Money	PC2	
			Time	PC3	
			Space	PC4	

			Equipment	PC5	(Wu et al., 2015), (Rose & Manley, 2016)
Activity	Previous on-site C&D waste management innovation activity as predictor of future behavior	Asking about previous on-site C&D waste management activity used	Appropriate OC&DWMI	PA1	Kulatunga et al. (2006) Begum et al. (2009) (Wu et al., 2015), (Rose & Manley, 2016) Rose et al. (2016)
			Appropriate material procurement	PA2	
			Advanced construction technologies	PA3	
			On-site sorting	PA4	
			Directly reuse C&D waste in same project	PA5	
			Recycle C&D waste in project other measures	PA6	

2.9 Innovation in this Study and the Research Gap

In reference to the above theoretical background it is obviously seen that there is a research gap since the adoption of OC&DWMI behavior has not been studied based on behavior and attitude theories. The objective of this study is to investigate the determinants of OC&DWMI behavior based on the integration of TPB and IDT. The innovation in this research is that IDT in addition to additional relative constructs like Project constraints, governmental supervision and economic viability are added and integrated with the basic TPB model. This integrated model is considered for the first time in order to analyze adoption behavior of C&D waste management innovation.

Chapter 3

METHODOLOGY

3.1 Introduction

This section introduces the research methodology used in this study. The development of the preliminary theoretical model is firstly presented; this is followed by the data collection, screening and descriptive statistical procedures. The data analysis procedures are also explained at the end of this section.

3.2 Theoretical Model

The integration of TPB and IDT was selected as the base to formulate the initial theoretical model. Information technology innovation research have experimentally used such integration between the two theories previously. This integrated model is used for the first time in order to analyze adoption behavior of C&D waste management innovation. Different changes have been applied to TPB and IDT model in order to study the consumer intentions toward adopting technology in information technology sector (Shih, Y., & Fang, K. 2004) and marketing (Taylor, S., & Todd, P. 1995). Due to the fact that the application of OC&DWMI is a behavior within the perspective of construction sector, so specific factors linked to the CI could have direct affect OC&DWMI behavior, such as project constraints (PC) governmental supervision (GS), and economic viability (EV). Thus, the initial theoretical model was established, as shown in Figure 5.

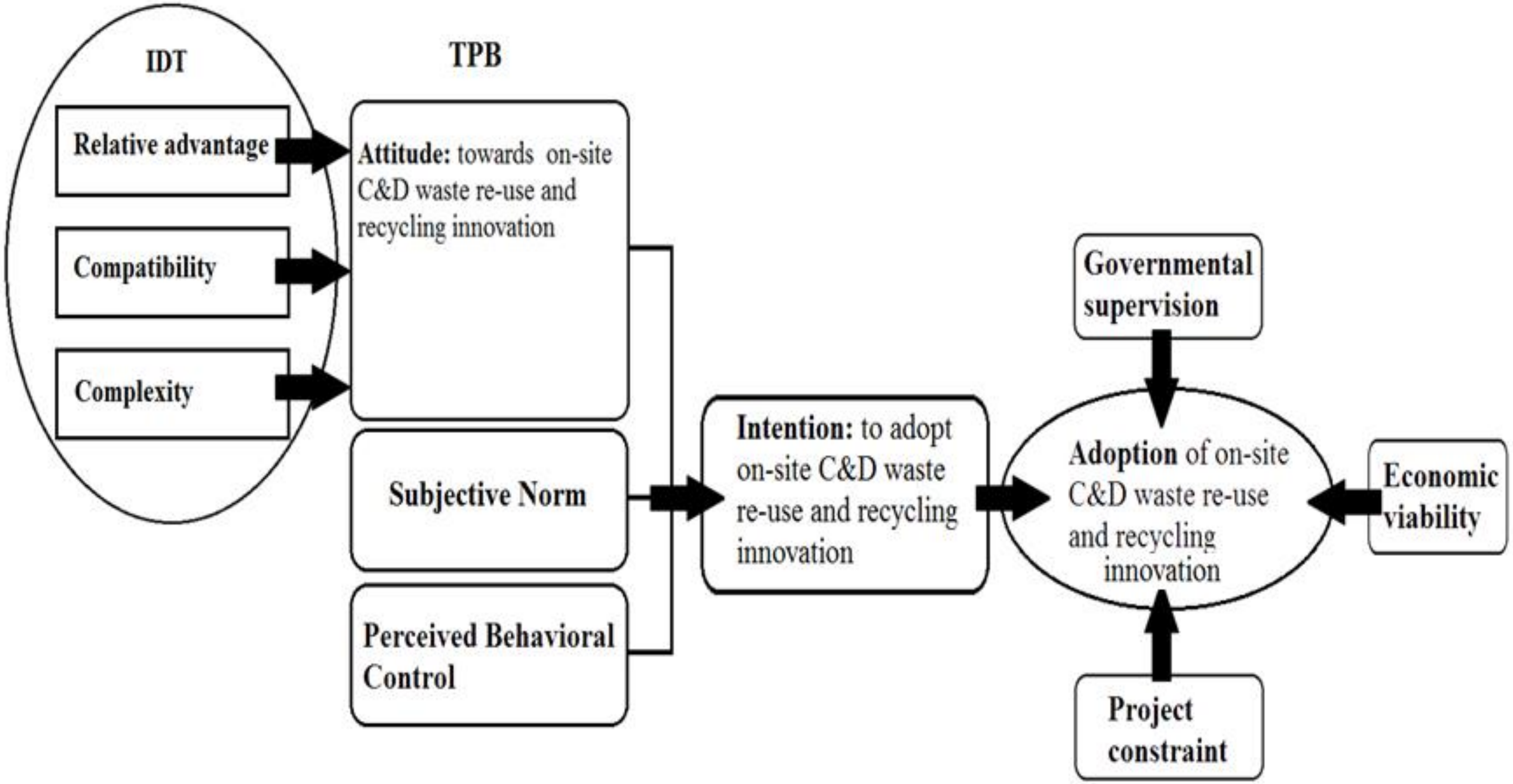

Figure 5: The preliminary theoretical model of Innovation Diffusion Theory (IDT) and Theory of Planned Behavior (TPB), based on (Rose & Manley 2016).

As shown in Figure 5, IDT could be integrated conveniently to notify the predecessors about the potential adopter attitude since IDT constructs supports the TPB attitude construct. BI is considered as a weighted sum of attitude, SN and PBC according to this model, therefore the actual behavior of the stakeholders participated in the project in order to adopt innovation is directly related to the BI.

As a breakdown of the traditional TPB model the factors affecting attitude are measured by 3 relevant IDT factors which are:

- *Relative advantage*: the grade of how innovation is perceived to have major advantage over other alternatives.
- *Compatibility*: the grade of how innovation is perceived as being consistent with current needs, existing values and past experiences.
- *Complexity*: the grade of how innovation could be easily understood and applied.

Perceived behavioral control is also considered as a predictor of intention toward behavior since it concentrates on internal and external factors influencing the perception of control over behavioral results. In addition to subjective norms which are predictors of behavioral intentions by referring to the affect and influence of social pressure and particular pressure exerted from close people or groups which play an important role and motivation to obey the pressure.

Three construct related to CI which act as facilitating conditions for innovation adoption were considered uniquely since the adoption behavior of OC&DWMI can’t be reached without considering these factors which are explained as follows.

Governmental rules and consistent supervision could affect the behavior of contractor in a significant way that’s why GS was added to the established model (Ding et al., 2016). The affecting way is frequently immediate since the contractor should obey the rules and follow any new regulations if something is considered illegal by the government. Concerning C&D waste management if a condition is set so the contractor is required by rule from the government to dump all the project waste at a specific landfill in addition to penalty for illegal dumping this would absolutely decrease the spread behavior of illegal dumping (Lu et al., 2015).

Due to the fact that contractors’ nature is to earn profits so economic viability was included in the model. Hence the main goal of the contractor working in a particular project is reduce cost and increase profit (Hao et al., 2008). In a case where conflict among profit and environment occurs, usually the project managers choose their profit instead of the environment. Notwithstanding of the potential environmental harm the on-site C&D waste management procedures in practice are generally adopted but to reduce the construction cost and increase the profit, these measures are incompletely applied on-site (Zhao et al., 2010).

In the daily life construction projects there is a lot of unpredictable and practical constraints that can also affect the adoption decision of OC&DWMI in a direct way. Labors, material, money, time and machine are the main constraints to be considered in a construction project. Therefore the contractor should choose the most applicable process according to the project constraints. For example the contractor might use fewer on-site C&D waste management measures if the time is limited in a construction project in order to save time. In the same way less attention might be given to effective OC&DWMI if there is lack in number of workers on-site (Wu et al ,. 2015).

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3.3 Data Source

The source of the data survey taken is this research Lebanon is struggling from chaotic dumping of C&D waste due to absence of regulations concerning the appropriate disposal of C&D waste in addition to lack of selected landfills. However the most of the waste generated about half million tons from constructing new buildings and more than one million tons from demolition works, is transported and thrown out in abandoned quarries and valleys (Bakshan et al., 2015).

3.4 Reason for the Questionnaire

The aim of the survey is to explore the validity of the preliminary theoretical model by distributing it among the engineers and contractors working in the CI.

3.5 Data Collection

"Quantitative Research" gives importance to the scopes and consideration of fundamental relationships between variables, not process (Lincoln, 1998). In this thesis, a questionnaire survey was implemented for data collection. The primary measures and scale used in the questionnaire survey is based on proposed studies published by Wu et al. (2015) and Rose et al. (2016). The online survey conducted via Google Form and the link was distributed in May, 2017 among professionals in construction companies through emails. The ‘‘snowball sampling” strategy was used in this study by telling the respondents to invite their colleagues to fill the form of the questionnaire since this method allows the researcher to get a relatively large number of filled forms faster and in an economic way (Sambasivan and Soon, 2007).

3.6 Content of the Questionnaire

The questions in the formal questionnaire are designed to be specific, direct, simple, clear and easily readable by all participants as it consists of two parts. The first investigates the background and general information regarding the respondents such as working category, experience in the firm, education level, projects participated in, etc. The second part deals with measurement of the eight constructs. The number of respondents that participated in this survey is 104, which does not fulfill the requirements for a clean structural equation modeling. The small sample size could lead to low Goodness-of-fit of the structural model.

3.7 Research Method

The proposed constructs were measured by items evaluated on 5-point Likert scales as follow:

1	2	3	4	5
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

The data obtained from the survey undergo different statistical procedures to deal with data screening including missing data of answers and coding the data for analysis. The reliability test, descriptive statistical analysis, confirmatory factor analysis and structural equation modeling are then performed in sequence to process the raw data to obtain the critical successful collaboration factors. A sample of the questionnaire can be found in Appendix.

3.8 Data Analysis

The first step to analyze the data were data screening looking for missing data. Then in the process of descriptive analysis, standard deviation of each item were measured and items with zero standard deviation were deleted from database. After that, the internal consistency of measured items in a construct “Cronbach’s Alpha” is investigated to measure how reliable the collected data are. At the end, to confirm already hypothesized structural model, confirmatory factor analysis is performed.

3.8.1 Normality Testing

Normality test is used to determine if the data set is well-modeled by a normal distribution. A non-normal distributed data could cause problems for the goodness-of-fit of proposed structural model. In this test, two elements are important to be measured which are skewness and kurtosis.

3.8.2 Factor Loadings

Factor loadings represent how much a factor explains a variable in factor analysis. Loadings can range from -1 to 1. Loadings close to -1 or 1 indicate that the factor strongly affects the variable. Loadings close to zero indicate that the factor has a weak effect on the variable. Factor loadings greater than ±0.30 are considered to meet the minimal level; loadings of ±0.40 are considered more important; and if the loadings are ±0.50 or greater, they are considered practically significant. Thus the larger the absolute size of the factor loading, the more important the loading in interpreting the factor matrix (Livesley. et al., 1998).

3.8.3 Reliability Analysis

As a measure of internal consistency, Cronbach's alpha determines how reliably items of a questionnaire that are designed to measure the same construct actually do so. Cronbach’s alpha can be written as a function of the number of test items and the average inter-correlation among the items. Below, for conceptual purposes, we show the formula for the standardized Cronbach’s alpha:

$$\alpha = \frac{N.\bar{c}}{\bar{v} + (N-1).\bar{c}}$$

Where N is equal to the number of items, $\bar{c}$ is the average inter-item covariance among the items and $\bar{v}$ equals the average variance.

Higher values of Cronbach's alpha indicate higher internal consistency. A historical benchmark value of 0.70 is commonly used to indicate that at least some of the items measure the same construct (Cronbach, 1951).

3.8.4 Confirmatory Factor Analysis

Confirmatory factor analysis (CFA) is a multivariate statistical procedure that is used to test how well the measured variables represent the number of constructs. In other words, CFA is performed to confirm or reject the measurement theory. Observed variables are used to measure latent variables in the measurement model, and the relationships between latent variables are tested in the structural model. Before testing the structural model, a structural measurement model is first developed then by using (Statistical Package for Social Science) IBM SPSS+AMOS version 23.0.0. Software empirical results are fitted to this model, using maximum likelihood method to assess the measurement model validity.

First, convergent validity of the model is measured, which means that variables (items) within each factor (construct) have to be highly correlated. For this purpose, each variable within a factor which has a loading smaller than 0.50 is deleted from structural model.

In the next step, multicollinearity is measured, which refers to a situation in multiple regression analysis, where two predictor variables (constructs) are highly correlated. Though multicollinearity does not affect the goodness of fit or the goodness of prediction, it can be a problem if the purpose is to estimate the individual effects of each variable. To resolve this problem one of the highly correlated predictor variables are deleted in the process.

After the CFA, the next step is to improve the goodness-of-fit of the structural model. Modification indices can be used to improve the structural model. Once the optimized model is derived, the significant influencing factors and the regression weights are determined.

Chapter 4

RESULTS AND ANALYSIS

4.1 Introduction

This chapter explains the results and analysis of the data collected from the questionnaires. Invitation for participation was send via Google form to firms/individuals, and 104 responses were collected.

4.2 General Information about the Respondents

It is found that one hundred four have successfully responded. The first section of the questionnaire was asking about general information about the respondents in order to determine; working category, working experience, education level, number of projects participated in, type of projects, and staff number.

4.2.1 Working Category of the Respondents

As it is shown in the Figure 6, most of the respondents were construction engineers (33.7%, 35 respondents) followed by on-site construction engineers, and project managers with equal ratio (27.9%, 29 respondents). In addition to other respondents' five company managers (4.8%), two quality controllers (1.9%), two cost controllers (1.9%), and two working in other category (1.9%) like architects. As a result this question shows that our target in this study are mostly construction engineers who are the directly related to the decisions made on-site on daily basis.

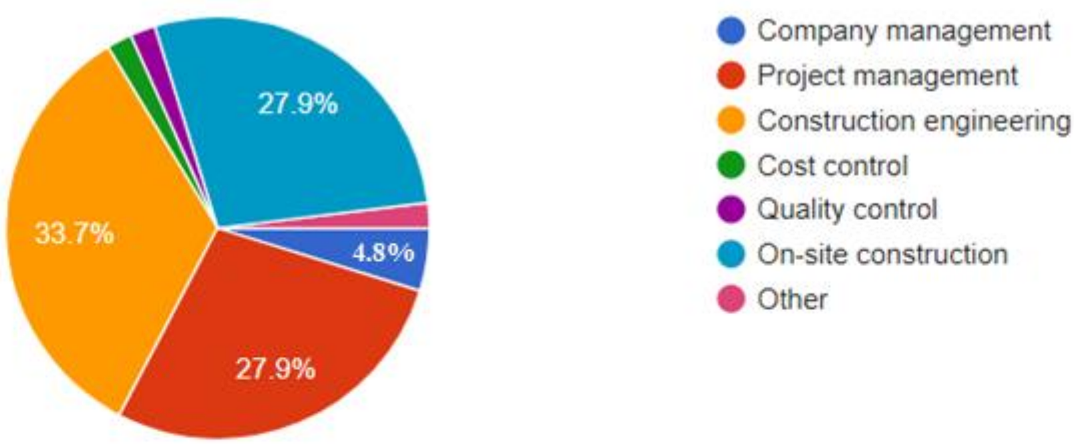

Figure 6: Working category of respondents

4.2.2 Working Experience in the Construction Industry

The working experience in the CI of the most respondents were between two to five years recording 64.4% from total responses with 67 responses followed by six to ten years (18.3% , 19 responses) , one year (13.5%, 14 responses), eleven to fifteen years (2.9%, 3 responses), and more than fifteen years (1% , 1 response). As a result this question shows that the respondents may not have enough experience about OC&DWMI since most of them have experience between two to five years.

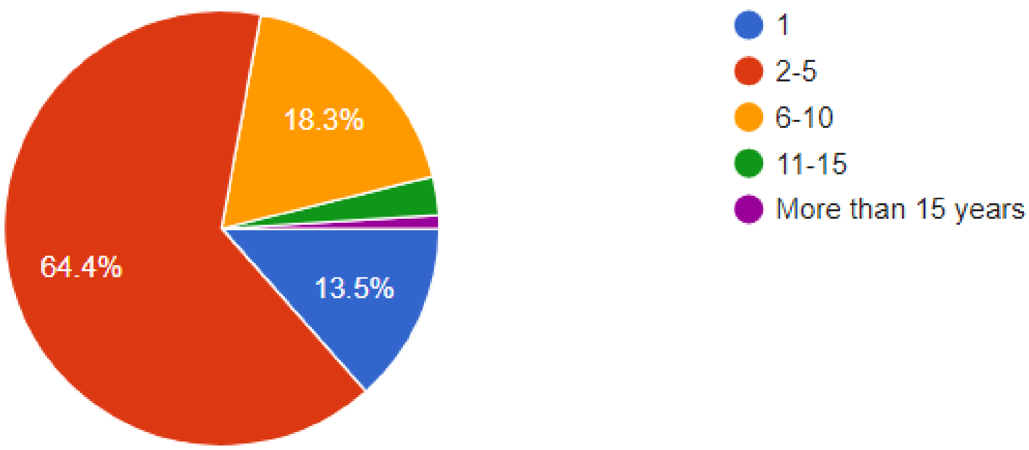

Figure 7: Working experience in construction industry (year)

4.2.3 Education Level of Respondents

The education level of respondents was distributed as following 74% (77 responses) with bachelor degree, 23.1% (24 responses) Masters, 1.9% (2 responses) High school or below, and 1% one response with PhD degree. This result shows that the respondents may not be well educated about OC&DWMI and the accompanied benefits since they didn't get any further graduate studies.

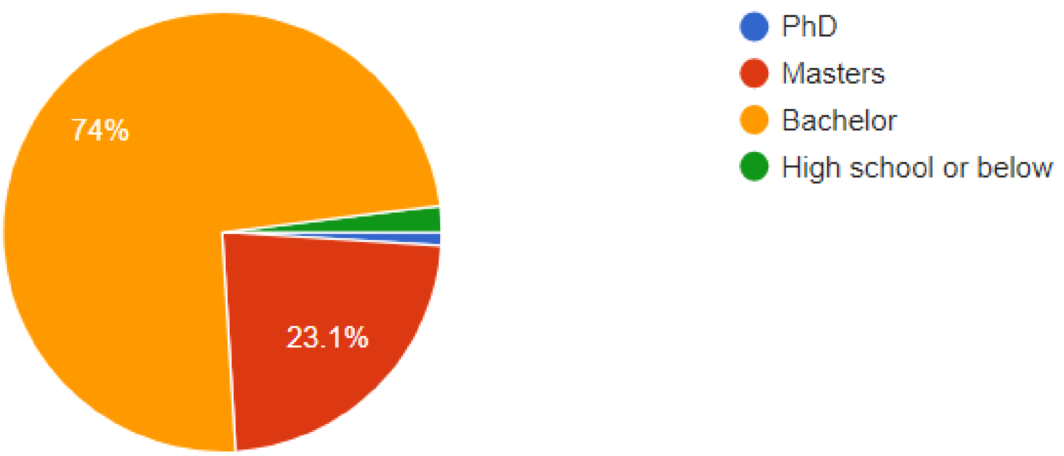

Figure 8: Education level of respondents

4.2.4 Number of Projects Participated in

Most of the respondents participated in one to five projects (70.2%, 73 responses) followed by 6-10 (22.1%, 23 responses), 11-20 (5.8%, 6 responses), and only 1.9% (2 responses) have participated in more than 20 projects as shown in Figure 9. This shows that the most of the respondents have participated in few projects so they know the amount of C&D waste generated from each project and the dangers of C&D wastes on the environment.

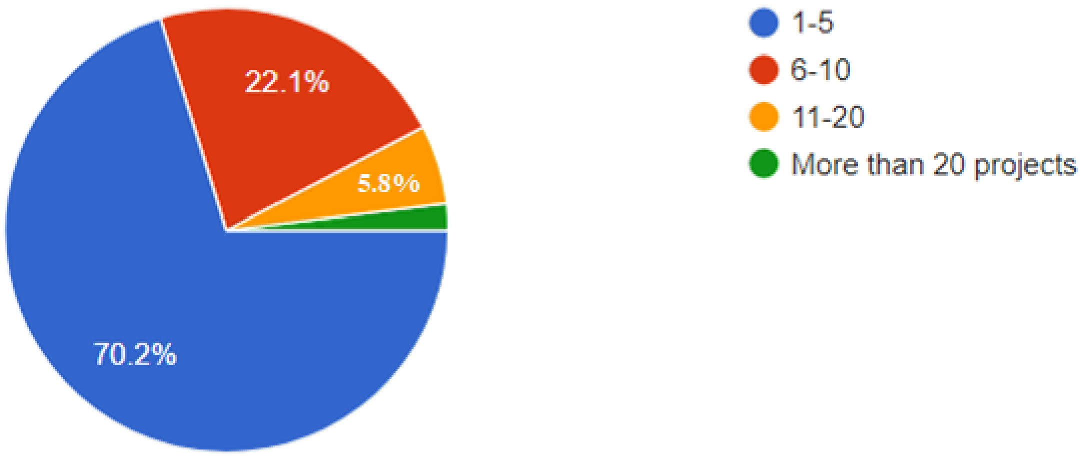

Figure 9: Number of projects participated in

4.2.5 Type of Projects Participated in

Residential projects were the most project type respondents participated in scoring 76.9% (80 responses) followed by commercial projects (14.4%, 15 responses), industrial (4.8%, 5 responses), infrastructure (2.9%, 3 responses), and 1% (1 response) other type of projects. These results shows the fact that residential projects are the most active projects in the Lebanese CI with lack of infrastructure projects and the most generated C&D wastes are from residential projects.

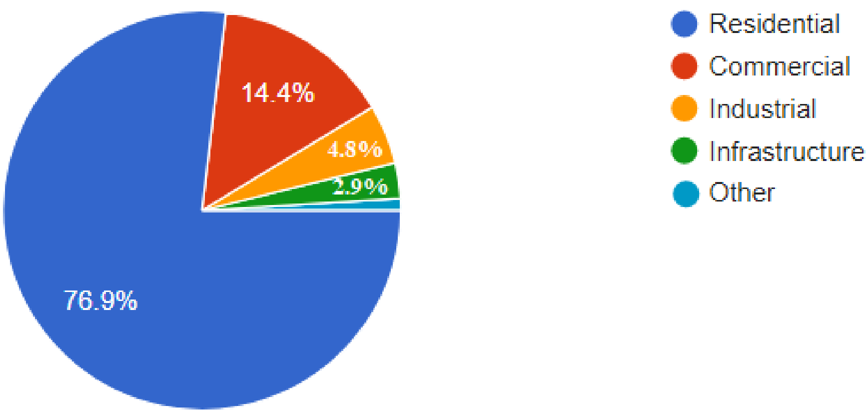

Figure 10: Type of projects

4.2.6 Staff Number

The number of employees in the company was distributed as following 80.8 %(84 responses) 1-50, 13.5 %(14 responses) 51-100, 2.9% (3 responses) 101-200, and 2.9% (3 responses) more than 200 employees as shown below in Figure 11. These results shows that most companies are relatively small companies in Lebanon which may affect the adoption of OC&DWMI due to the limited resources.

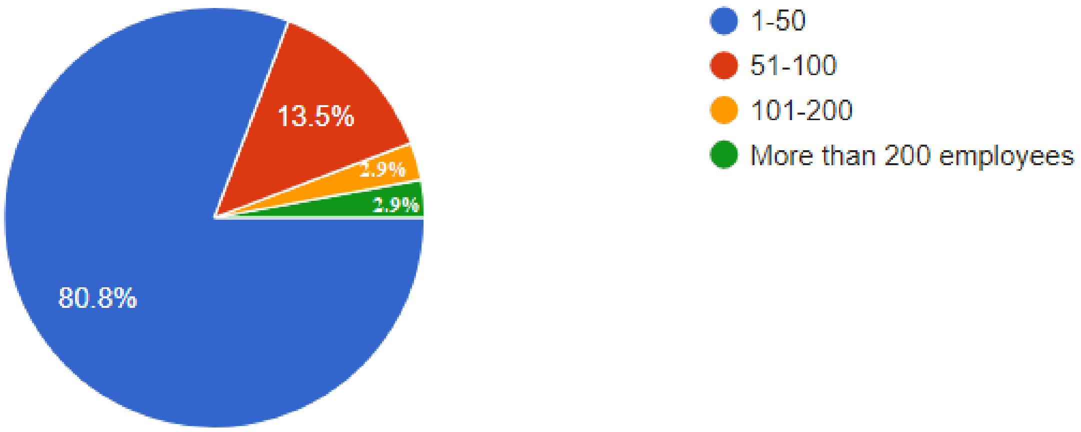

Figure 11: Staff number

4.3 Descriptive Statistics and Correlation Analysis

Summary of all the information of the 104 respondents is shown in Table 5 and the correlation analysis matrix for the studied constructs with the aim of evaluating the significance level of the relationships are shown in Table 6. Correlations higher than 0.70 indicate a high relationship among independent variables which can cause multicollinearity and problem by multiple regression.

Table 5: Descriptive Statistics

Variable	Category	Frequency	Percentage (%)	Cumulative Percentage (%)
Working Category	Company management	5	5%	5%
	Project management	29	28%	33%
	Construction engineering	35	34%	66%
	Cost control	2	2%	68%
	Quality control	2	2%	70%
	On-site construction	29	28%	98%
	Other	2	2%	100%
Working experience (year)	1	14	13%	13%
	2-5	67	64%	78%
	6-10	19	18%	96%
	11-15	3	3%	99%
	More than 15 years	1	1%	100%
Education level	Bachelors	77	74%	74%
	Masters	24	23%	97%
	PhD	1	1%	98%
	High school or below	2	2%	100%
Number of participated projects	1-5	73	70%	70%
	6-10	23	22%	92%
	11-20	6	6%	98%
	More than 20 projects	2	2%	100%
Project type	Residential	80	77%	77%
	Commercial	15	14%	91%
	Office	0	0%	91%
	Industrial	5	5%	96%
	Infrastructure	3	3%	99%
	Other	1	1%	100%
Staff number	1-50	84	81%	81%
	51-100	14	13%	94%
	101-200	3	3%	97%
	More than 200 employees	3	3%	100%

Table 6: Correlation analysis matrix

Correlations								
	ACD	SN	PBC	BI	GS	EV	PC	PA
ACD	1.000							
SN	.506**	1.000						
PBC	.455**	.806**	1.000					
BI	.376**	.504**	.400**	1.000				
GS	.240*	.677**	.647**	0.148	1.000			
EV	.393**	.745**	.759**	.303**	.751**	1.000		
PC	.279**	.787**	.851**	.299**	.801**	.809**	1.000	
PA	.246*	.760**	.744**	.383**	.748**	.655**	.816**	1.000

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

4.4 Factor loading and Confirmatory Factor Analysis

During the confirmatory factor analysis, the observed variables with factor loadings less than 0.5 were deleted for the subsequent multiple regression analysis. Through the CFA, several observed variables had to be deleted because their corresponding factor loadings were too low (<0.5).

Table 7: Factor loading

Construct	Item	Factor loading	Cronbach α
ACD	ACD2	0.844	0.807
	ACD3	0.778	
	ACD5	0.684	
	ACD8	0.544	
SN	SN1	0.928	0.922
	SN2	0.88	
	SN3	0.826	
	SN4	0.926	
	SN5	0.865	
	SN6	0.645	
PBC	PBC2	0.781	0.747
	PBC3	0.563	
	PBC4	0.937	
BI	BI1	0.992	0.824
	BI2	0.773	
	BI4	0.605	
GS	GS1	0.943	0.965
	GS2	0.952	
	GS3	0.932	
	GS4	0.858	
	GS5	0.955	
EV	EV1	0.917	0.900
	EV2	0.898	
	EV3	0.798	
	EV4	0.738	
	EV5	0.76	
PC	PC2	0.895	0.820
	PC3	0.664	
	PC4	0.931	
	PC5	0.593	
PA	PA1	0.757	0.907
	PA2	0.586	
	PA3	0.933	
	PA4	0.876	
	PA5	0.871	
	PA6	0.795	

Table 8: Deleted variables and corresponding factor loading

Item	ACD1	ACD4	ACD6	ACD7	PBC1	PBC5	BI3	BI5	PC1	PA7
Factor Loading	0.43	0.41	0.42	0.15	0.17	0.25	0.34	0.31	0.38	0.48

After deleting the observed variables with low factor loadings, the CFA for all of the constructs was employed. The estimation method used in the CFA was maximum likelihood. Correlations have been made between the errors of the observed variables as the modification indices suggested. It can be seen that there were a total of 36 observed variables in the measurement model. The number of distinct sample moments was 666 and the number of distinct parameters to be estimated was 100. The degrees of freedom of the default model, therefore, was 566, which means the model is identifiable. The goodness-of-fit indices are shown in Table 9. For a medium-sized sample (100<N<200), Chi-square/df model fit shows satisfactory result (2.304). However, this model does not satisfy most other goodness-of-fit indices.

Table 9: goodness-of-fit indices for the preliminary structural Model

Goodness-of-fit measure		Level of acceptance fit	Fit Statistics
Absolute Fit	Chi-Square/df	<5 acceptable; <3 good	2.304
	GFI	>0.8 acceptable; >0.9 good	0.544
	AGFI	>0.8 acceptable; >0.9 good	0.463
	RMSEA	<0.1 acceptable; <0.08 good	0.113
Incremental Fit	NFI	>0.9	0.716
	RFI	>0.9	0.684
	IFI	>0.9	0.817
	TLI	>0.9	0.793
	CFI	>0.9	0.814

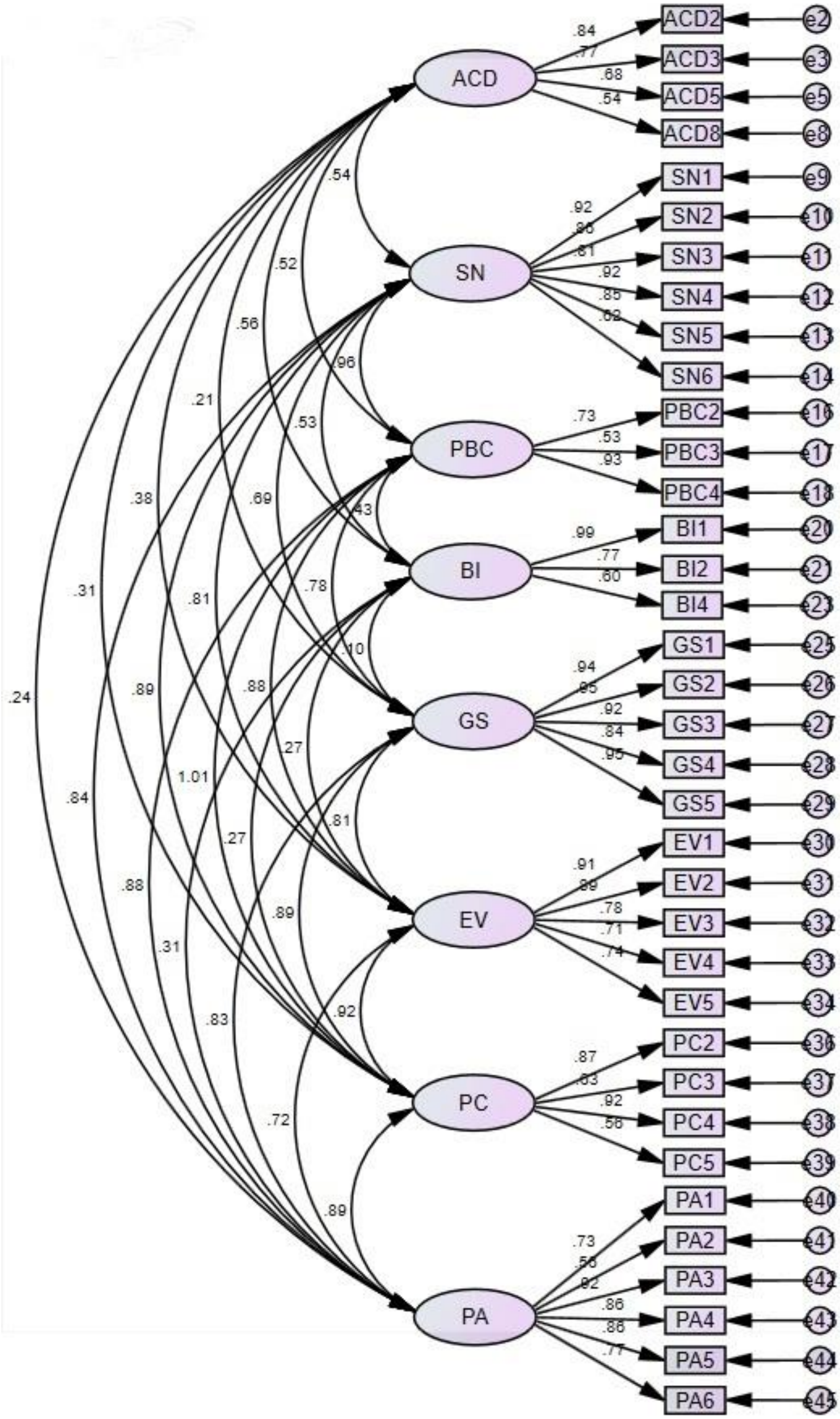

Figure 12: Preliminary structural model

4.5 Multiple Regression Analysis

The preliminary structural model is derived as shown in Figure 12. There are eight constructs in this model. Each latent variable has several observed variables to measure which are based on the proposed initial hypotheses shown in Table 10.

Table 10: Hypothesis of the theoretical model

H1	Attitude towards on-site C&D waste management innovation has a direct positive effect on the behavioral intention to adopt on-site C&D waste management innovation.
H2	Subjective norm has a direct positive effect on the behavioral intention to adopt on-site C&D waste management innovation.
H3	Perceived behavioral control has a direct positive effect on the behavioral intention to adopt on-site C&D waste management innovation.
H4	Behavioral intention has a direct positive effect on the adoption of on-site C&D waste management innovation.
H5	Economic viability has a direct positive effect on the adoption of on-site C&D waste management innovation.
H6	Project constraints have a direct negative effect on the adoption of on-site C&D waste management innovation.
H7	Governmental supervision has a direct positive effect on the adoption of on-site C&D waste management innovation.

Prior to structural modeling, normality assessment was conducted, while skewness and kurtosis of data is calculated to see if they are normally distributed. The result showed that absolute values of skewness coefficient were lower than 2.5 and the absolute values of the kurtosis were lower than 5 as shown in Table 11. Thus maximum likelihood could be used as the estimation method.

Table 11: Descriptive statistics of variables showing Skewness and Kurtosis

	N	Min	Max	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic							Std. Error	Statistic	Std. Error
ACD2	104	2.00	5.00	3.3269	1.04688	1.096	-.072	.237	-1.330	.469
ACD3	104	2.00	5.00	3.6058	.94938	.901	-.657	.237	-.628	.469
ACD5	104	1.00	5.00	2.9327	.97805	.957	.327	.237	-1.238	.469
ACD8	104	2.00	5.00	3.7596	.83020	.689	-.456	.237	-.171	.469
SN1	104	1.00	5.00	2.1154	.97848	.957	1.286	.237	1.625	.469
SN2	104	1.00	5.00	2.3077	.89309	.798	1.517	.237	2.056	.469
SN3	104	1.00	5.00	2.2500	1.23658	1.529	.640	.237	-.421	.469
SN4	104	1.00	5.00	1.7308	1.14256	1.305	1.544	.237	1.316	.469
SN5	104	1.00	5.00	2.1346	1.20724	1.457	.715	.237	-.496	.469
SN6	104	1.00	5.00	2.0769	1.16329	1.353	1.093	.237	.404	.469
PBC2	104	1.00	5.00	1.9519	1.04630	1.095	1.031	.237	.331	.469
PBC3	104	1.00	5.00	2.6442	1.00405	1.008	.474	.237	-.198	.469
PBC4	104	1.00	5.00	1.6346	1.06176	1.127	1.723	.237	2.090	.469
BI1	104	1.00	5.00	3.3365	1.00107	1.002	-.604	.237	-1.062	.469
BI2	104	1.00	5.00	3.0288	1.14448	1.310	-.216	.237	-1.109	.469
BI4	104	1.00	5.00	3.5385	1.04206	1.086	-.445	.237	-.678	.469
GS1	104	1.00	5.00	1.7308	1.03559	1.072	1.687	.237	2.469	.469
GS2	104	1.00	5.00	1.6538	1.02179	1.044	1.633	.237	1.866	.469
GS3	104	1.00	5.00	1.7308	1.00707	1.014	1.496	.237	1.636	.469
GS4	104	1.00	5.00	1.7019	1.00368	1.007	1.513	.237	1.668	.469
GS5	104	1.00	5.00	1.5577	1.01280	1.026	1.841	.237	2.464	.469
EV1	104	1.00	5.00	2.0577	1.14762	1.317	1.143	.237	.453	.469
EV2	104	1.00	5.00	2.3173	.96808	.937	1.547	.237	1.828	.469
EV3	104	1.00	5.00	2.4327	1.17221	1.374	.866	.237	-.241	.469
EV4	104	1.00	5.00	2.2019	1.18551	1.405	.953	.237	-.048	.469
EV5	104	1.00	5.00	2.5769	1.03053	1.062	.712	.237	-.494	.469
PC2	104	1.00	5.00	1.8654	1.14957	1.322	1.324	.237	.756	.469
PC3	104	1.00	5.00	2.2596	1.19867	1.437	.724	.237	-.518	.469
PC4	104	1.00	5.00	1.5000	1.03342	1.068	2.045	.237	2.979	.469
PC5	104	1.00	5.00	2.2596	1.13202	1.281	.781	.237	-.292	.469
PA1	104	1.00	5.00	1.9808	1.13189	1.281	.939	.237	.060	.469
PA2	104	1.00	5.00	2.5288	1.09683	1.203	.398	.237	-.666	.469
PA3	104	1.00	5.00	1.4519	.95409	.910	2.260	.237	4.329	.469
PA4	104	1.00	5.00	1.6154	1.10873	1.229	1.729	.237	1.797	.469
PA5	104	1.00	5.00	1.8846	1.09107	1.190	1.331	.237	1.114	.469
PA6	104	1.00	5.00	1.8942	1.10531	1.222	1.137	.237	.414	.469

In Table 12 the analysis of initial model Figure 13 has been shown. Although all paths exist with significant p-values, but according Table 13 the initial model does not fit the data very well and the solution was not admissible, thus it is important to modify it.

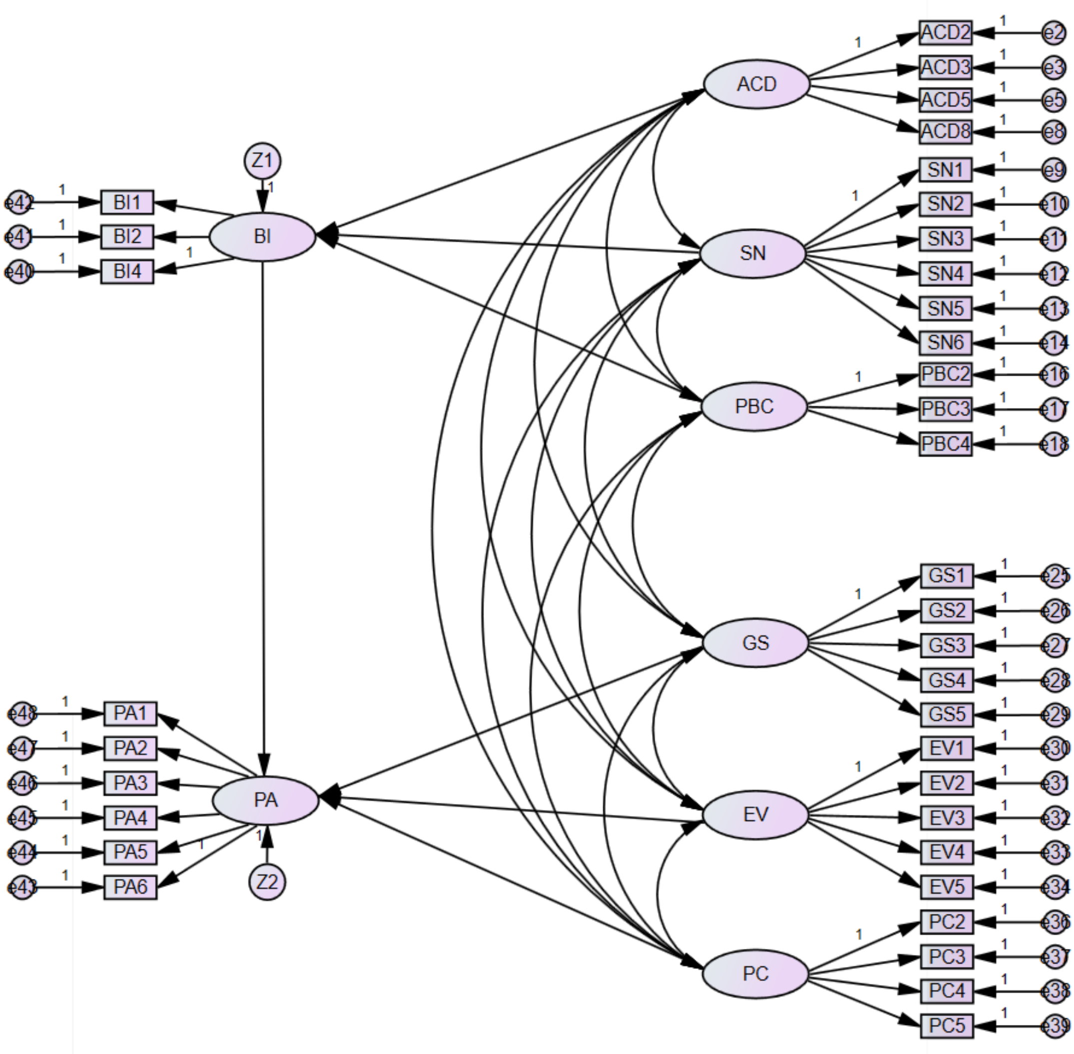

Figure 13: Initial structural model

Table 12: Regression weights in the initial model

			Estimate	Standard Error	Critical Ratio	P
BI	<---	ACD	0.25	0.097	2.568	0.01
BI	<---	SN	1.019	0.315	3.235	0.001
BI	<---	PBC	-0.93	0.339	-2.744	0.006
PA	<---	GS	0.269	0.125	2.147	0.032
PA	<---	EV	-0.514	0.154	-3.327	***
PA	<---	PC	0.959	0.194	4.942	***
PA	<---	BI	0.245	0.092	2.661	0.008
ACD2	<---	ACD	1			
ACD3	<---	ACD	0.837	0.103	8.154	***
ACD5	<---	ACD	0.76	0.107	7.073	***
ACD8	<---	ACD	0.511	0.094	5.412	***
SN1	<---	SN	1			
SN2	<---	SN	0.857	0.063	13.639	***
SN3	<---	SN	1.113	0.094	11.781	***
SN4	<---	SN	1.157	0.073	15.836	***
SN5	<---	SN	1.141	0.087	13.147	***
SN6	<---	SN	0.791	0.108	7.302	***
PBC2	<---	PBC	1			
PBC3	<---	PBC	0.683	0.126	5.436	***
PBC4	<---	PBC	1.283	0.126	10.18	***
GS1	<---	GS	1			
GS2	<---	GS	0.998	0.051	19.564	***
GS3	<---	GS	0.961	0.054	17.848	***
GS4	<---	GS	0.874	0.065	13.524	***
GS5	<---	GS	0.992	0.05	19.778	***
EV1	<---	EV	1			
EV2	<---	EV	0.824	0.06	13.654	***
EV3	<---	EV	0.875	0.084	10.39	***
EV4	<---	EV	0.815	0.09	9.019	***
EV5	<---	EV	0.731	0.077	9.487	***
PC2	<---	PC	1			
PC3	<---	PC	0.738	0.099	7.427	***
PC4	<---	PC	0.938	0.063	14.819	***
PC5	<---	PC	0.627	0.097	6.45	***
BI4	<---	BI	1			
BI2	<---	BI	1.42	0.22	6.462	***
BI1	<---	BI	1.554	0.227	6.84	***
PA6	<---	PA	1			
PA5	<---	PA	1.092	0.113	9.68	***
PA4	<---	PA	1.123	0.114	9.835	***
PA3	<---	PA	1.031	0.096	10.694	***
PA2	<---	PA	0.721	0.123	5.88	***
PA1	<---	PA	0.974	0.121	8.023	***

Table 13: Goodness-of-fit of initial model

Goodness-of-fit measure		Level of acceptance fit	Fit Statistics
Absolute Fit	Chi-Square/df	<5 acceptable; <3 good	2.366
	GFI	>0.8 acceptable; >0.9 good	0.529
	AGFI	>0.8 acceptable; >0.9 good	0.455
	RMSEA	<0.1 acceptable; <0.08 good	0.115
Incremental Fit	NFI	>0.9	0.703
	RFI	>0.9	0.676
	IFI	>0.9	0.804
	TLI	>0.9	0.783
	CFI	>0.9	0.802

As shown in the modification indices of regression weights in appendix A. There are no significant suggestions for adding a new path between latent variables. According theoretical assumptions and negative estimates, the constructs of PBC and EV were deleted to formulate a new model, which means that H3 is rejected so the Perceived behavioral control does not has a direct positive effect on the BI to adopt OC&DWMI so enough support, time and/or space does not affect significantly on the BI to adopt OC&DWMI.

Similar modeling procedure has been done and paths PC → PA, EV → PA were deleted because their path were statistically insignificant.

4.6 Final Structural Model

After the previously mentioned modifications, the final model was derived as illustrated in Figure 14. In this model (Table 14) it can be seen that two paths GS → PA and BI → PA are significant at the level of 0.001. The goodness-of-fit measures in Table 15 also indicate that the final model fits the data relatively well, despite the fact that the sample size is pretty small.

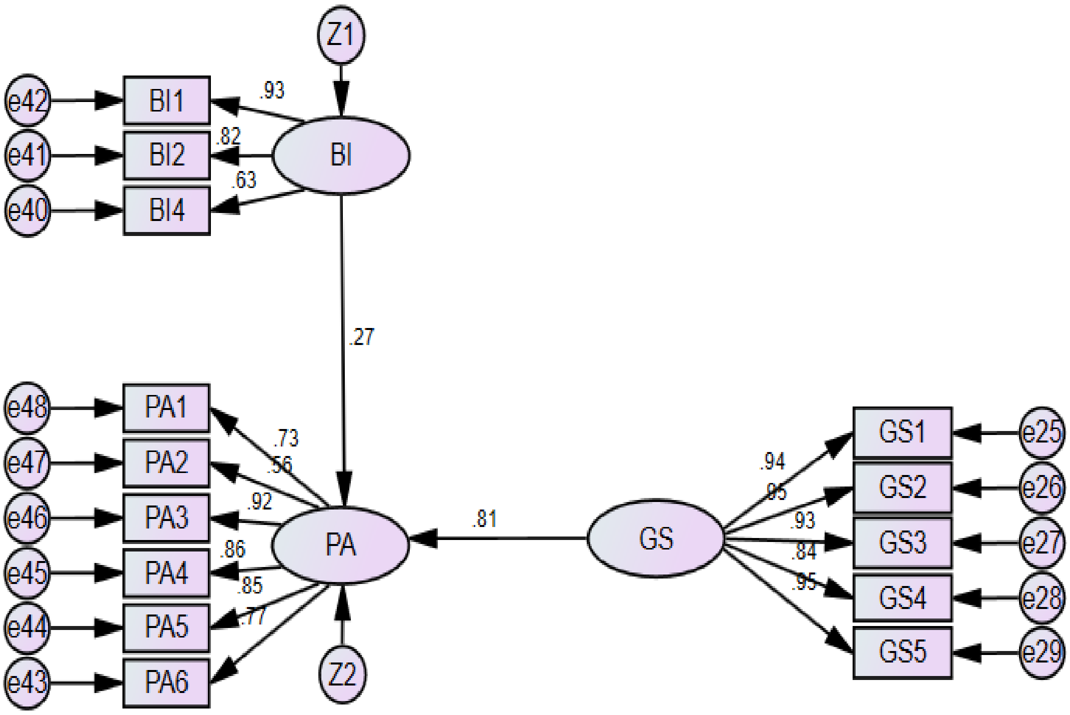

Figure 14: Determinants of the final structural Model

Table 14: Regression weights of final model

			Estimate	Standard Error	Critical Ratio	P
PA	<---	GS	0.702	0.081	8.725	***
PA	<---	BI	0.348	0.095	3.67	***
GS1	<---	GS	1			
GS2	<---	GS	1.002	0.051	19.826	***
GS3	<---	GS	0.961	0.054	17.827	***
GS4	<---	GS	0.872	0.065	13.437	***
GS5	<---	GS	0.989	0.051	19.478	***
BI4	<---	BI	1			
BI2	<---	BI	1.421	0.212	6.695	***
BI1	<---	BI	1.421	0.213	6.67	***
PA6	<---	PA	1			
PA5	<---	PA	1.082	0.116	9.344	***
PA4	<---	PA	1.116	0.117	9.525	***
PA3	<---	PA	1.025	0.099	10.365	***
PA2	<---	PA	0.73	0.126	5.805	***
PA1	<---	PA	0.968	0.125	7.764	***

Table 15: Goodness-of-fit of Final structural model

Goodness-of-fit measure		Level of acceptance fit	Fit Statistics
Absolute Fit	Chi-Square/df	<5 acceptable; <3 good	2.555
	GFI	>0.8 acceptable; >0.9 good	0.800
	AGFI	>0.8 acceptable; >0.9 good	0.720
	RMSEA	<0.1 acceptable; <0.08 good	0.123
Incremental Fit	NFI	>0.9	0.872
	RFI	>0.9	0.845
	IFI	>0.9	0.918
	TLI	>0.9	0.899
	CFI	>0.9	0.917

It can be concluded that in this study there are two main determinants affecting the degree to which the contractors will implement OC&DWMI, which are behavioral intention and governmental supervision. So hypothesis H4 and H7 clearly support this study and the path regression weight from construct BI to PA is 0.35, which means that when BI goes up by 1 standard deviation, OC&DWMI adoption behavior (PA) goes up by 0.35 standard deviations. Similarly, the estimate regression weight from construct GS to PA is 0.702.

Chapter 5

DISCUSSION

5.1 Introduction

This chapter discuss the findings of this research with respect to previous studies concerning C&D waste management and provides a conceptual framework of the adoption of OC&DWMI developed by the researcher. The most significant results are stated and explained in addition for addressing the research questions in the end of this chapter.

5.2 Behavioral Intention

As it is expected, H4 is clearly supported in this study and the behavioral intention is a statistically significant factor for the contractor to employ C&D waste management. This results comes in consistent with other studies about household waste (Pakpour et al., 2014) and food waste (Quested et al., 2013) which stated that the behavioral intentions is a significant factor on the adoption of waste management and agrees with (Loosemore et al.2002) discussion that waste could be prevented by exerting enough efforts for improving the personal influencing factors. This may be because on site C&D waste management innovation behavior has similar characteristics as waste management in other fields.

5.3 Governmental Supervision

Another Factor which proved to play the most significant role in this study was governmental supervision, which shows a direct positive effect on the adoption of OC&DWMI, and therefore it can be concluded that H7 is also supported in this case study. Recent studies by Calvo et al. (2014) and Al-Sari et al. (2012) stated the absence of a regulatory framework and also considered GS and policies like economic incentives and penalties to be significant factor affecting C&D waste management behavior . So the government should have specific detailed regulation for on-site C&D waste management and establish strict supervision for on-site C&D waste management behavior in order to have effective on-site C&D waste management adoption by the contractors and to encourage innovation.

5.4 Project Constrains

Concerning the project constrains (H6) it was found that project constrains do not affect the adoption of OC&DWMI in a negative way as it was stated in the hypothesis. Since OC&DWMI is not expensive compared with other project expenses also it does not need high number of workers, new technologies or advanced equipment. Lack of space may be the problem on-site for storing and recycling C&D waste but this can be solved during the development stages of the project as stated by Wang et al. (2010) and Tam (2008).

5.5 Economic Viability

From the results, it is surprising that H5 is not supported, in contrast with recent studies by Wu et al. (2016) and Al-Sari et al. (2012) indicating that due to the company's benefit earning culture the decision makers in the projects prefer to choose the economic benefit instead of the environmental measures. But this was not the case in this study since EV was found insignificant factor affecting on-site C&D waste management.

5.6 A Conceptual Framework of the Adoption of On-site C&D Waste Management Innovation

The study results shows that there are two main determinants affecting the adoption behavior of on OC&DWMI and the developed conceptual framework shown in Figure 15 shows a clearer idea about how each construct is affecting the adoption decision from different level.

Where the governmental level through government supervision regarding OC&DWMI directly has a direct effect on the adoption decision within the company and organizational level. Several activities should be applied by the government, pressure groups, local authorities and municipalities in order to insure the adoption of OC&DWMI and waste minimization. These activities are:

1. impose specific regulations and guidelines regarding OC&DWMI
2. develop specific department specialized for OC&DWMI
3. apply comprehensive supervision system for OC&DWMI
4. impose strict punishment to illegal C&D waste dumping
5. make attractive policies and incentives to encourage OC&DWMI

Consequently the organization should apply and follow these regulations so it would try to improve the individual BI towards OC&DWMI by increasing awareness in order to take actions to avoid on-site C&D waste generation, motivating the reuse and recycle of the generated C&D waste on-site, and do training concerning OC&DWMI.

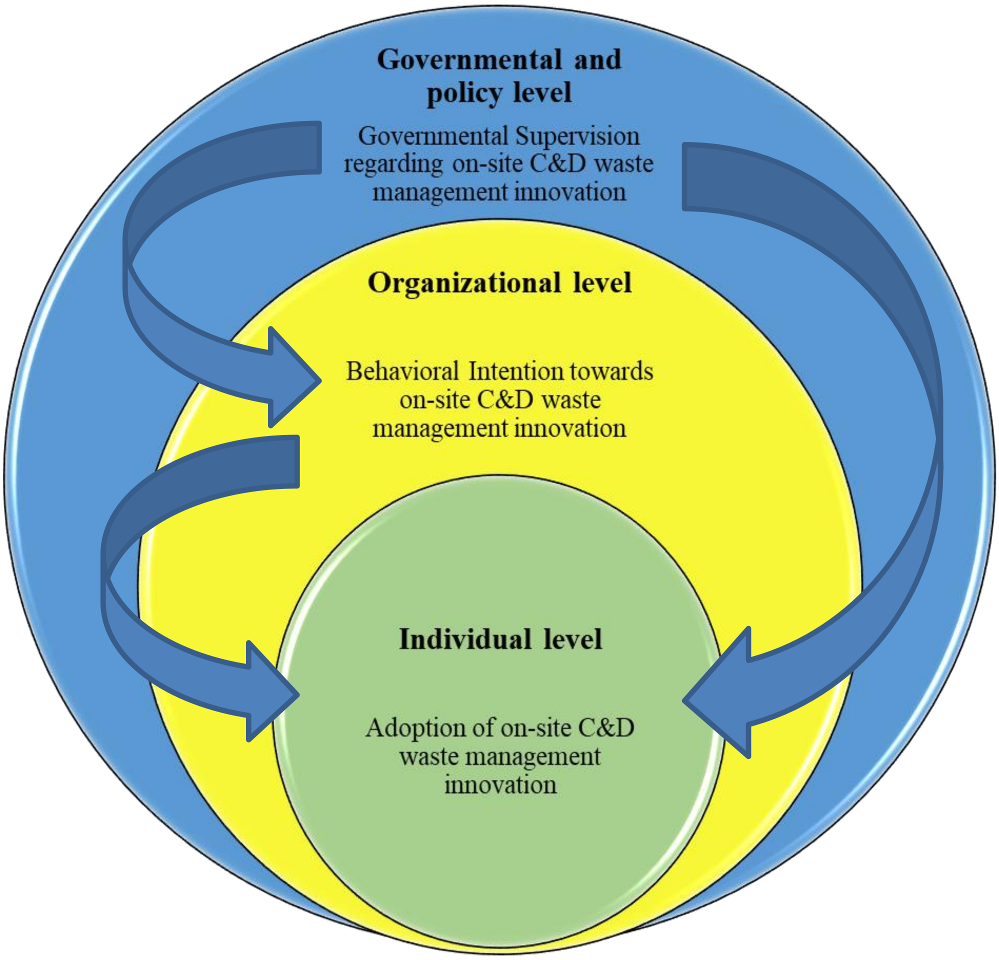

Figure 15: A conceptual framework of the adoption of on-site C&D waste management innovation

This would directly affect the individual level and the adoption of OC&DWMI so many actions would be taken to minimize the C&D waste generated on site. The adoption of OC&DWMI is illustrated in Figure 16.

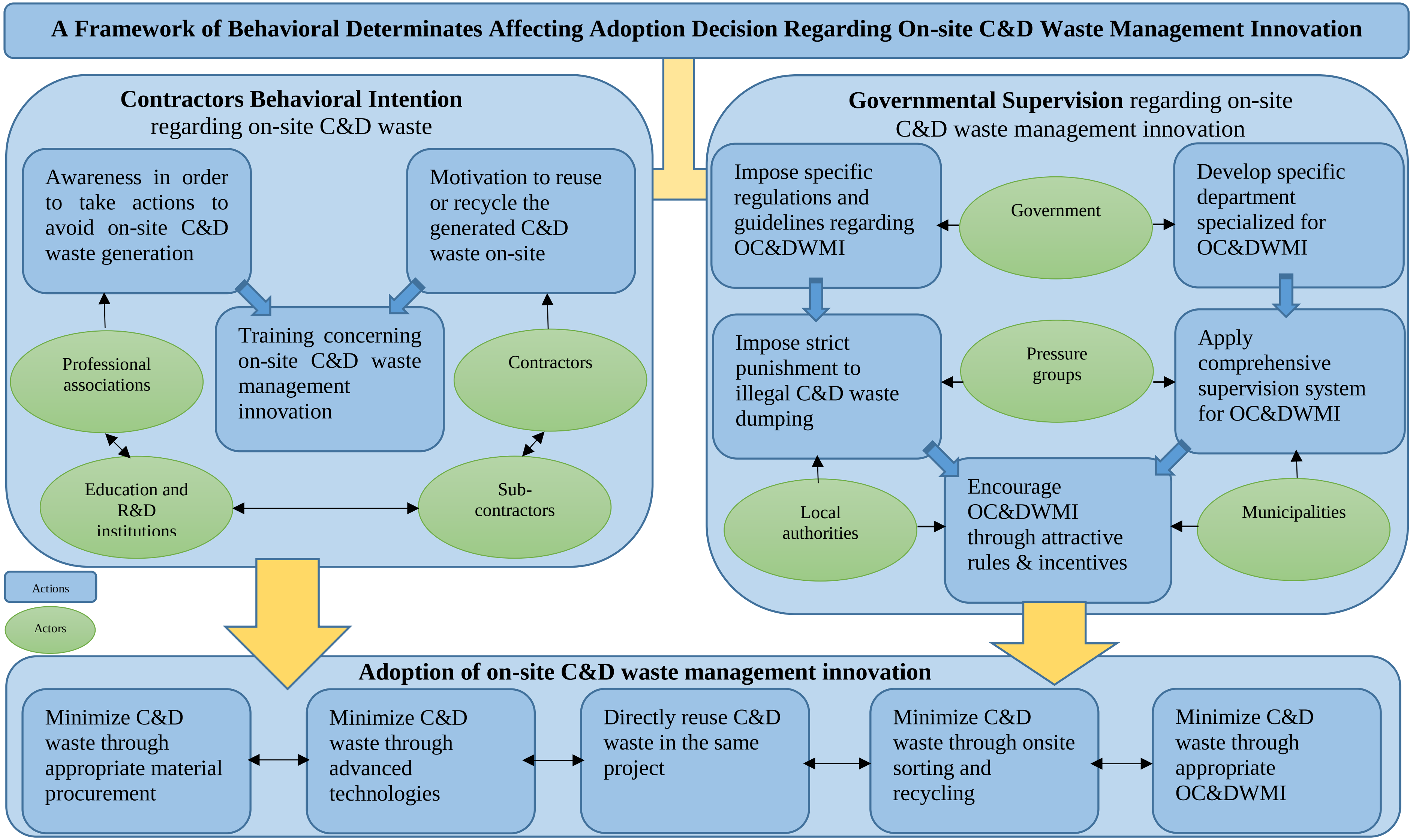

Figure 16: A Framework of Behavioral Determinates Affecting Adoption Decision Regarding On-site C&D Waste Management Innovation

5.7 Addressing the research questions

The three research questions from the first chapter will be answered individually in the following pages in this section.

Research question 1: What is the current situation of C&D waste management practice in the developing countries and the situation in Lebanon?

In developing countries different types of C&D waste being mixed and dumped carelessly. This is mostly common in the Czech Republic, Cyprus, India, and Malaysia which are all considered developing countries because there is no specific regulations concerning C&D waste management as the case in Lebanon which is still struggling from random dumping of C&D waste due to absence of regulations concerning the appropriate disposal of C&D waste in addition to lack of selected landfills, or not following these regulation due to lack of governmental supervision as the case of Turkey.

Research question 2: What are the existing C&D waste management strategies?

Other than waste landfill which is the traditional method commonly used but generally discouraged to be used as a waste management strategy, various strategies have been working on changing the path of waste from landfill.

Sorting and recycling waste: either on-site or off-site, but recently in UK, on- site sorting was encouraged widely since it makes recycling process easier and guarantees the proper separation of inert and non-inert wastes. This strategy does not certainly reduce the waste generated from CI, but it is an effective way to divert C&D waste from landfilling.

Materials reuse: Materials reuse is important method to divert C&D waste from landfilling. Different from recycling, material reuse is using waste with slightly change or no change of its physical and chemical state. C&D waste is commonly reused for landfill, road surfacing, and as a replacement of concrete aggregates. Also some industrial waste material may be used as a replacement of cement material in the concrete mix like coal fly ash and slag. In addition to that leftover of materials, excavated soil, etc., produced in the construction site may also be reused again in the project or in different projects.

Use of waste prediction tools: With the aim of effectively managing C&D waste, various types of predicting and measuring tools have been developed in the CI. By using different tools generally during the early design stages in order to predict the possible waste generated from construction activities. Net Waste is a widely speeded waste prediction tool in the UK Developed by the UK WRAP, and helps designers during design stages to estimate the cost and quantity of the project generated waste, it also assists them in choosing the appropriate strategy in order to improve the effectiveness of the project.

Site waste management planning: which is a governmental obligation for construction projects in several countries. SWMP regulation (2008) in the UK obligates each project that costs more than £300,000 to prepare a SWMP in advanced of starting any construction works. The SWMP aims to, divert waste from landfilling, make sure of the proper waste separation and sorting, increase profitability and efficiency, and to make sure that the proper strategy is used for waste reduction, reuse and recycling. SWMP usually involves details of the planned strategies used during and after the construction works for waste management in addition to statement of pre-construction strategies taken before the work starts to reduce waste. Site waste managers usually prepare and manage the SWMP, the plan often suggest the amount of waste to be recycled and reused, assign the on-site waste storage area, the strategy of waste reduction and sorting in addition to specifying the responsible stakeholders for the removal of wastes from the site.

Legislative and tax measures: Governments imposed different legislative and tax measures in order to divert waste from landfills. “Pay as You Throw” (PAYT) is one of these measures in which the person causing pollution pays the government amount of money equivalent to the cost of diverting the volume of waste from landfill. PAYT aims to discourage waste landfilling and encourage waste reduction, reuse and recycling. PAYT is based on unit pricing in which it charges per unit weight or volume of all the wastes disposed on landfill site.

Research question 3: What are the factors influencing the contractors to make innovation decisions in C&D waste management?

Behavioral intention and governmental supervision are the key drivers for OC&DWMI as the previous data analysis results shows and in consistent with previous studies which stated that the behavioral intentions is a significant factor on the adoption of waste management and shows that intention and willingness are key outcome measure for the TPB including the willingness to commit to behavior if opportunity is provided so waste could be prevented by exerting enough efforts for improving the personal influencing factors or by establishing governmental regulations and corresponding supervision that significantly affect the behavior of contractors and improving their behavior regarding OC&DWMI.

Chapter 5

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

C&D waste accounts more than 50% of the waste generated worldwide and has a lot of negative environmental impacts on all phases of the project process, as well as raw transportation, material mining, manufacturing, construction and demolition. In Lebanon the CI appear to be causing many environmental problems since the daily construction waste generation varies between 717 to 6353 tons between different cities and regarding demolition waste about 810 tons is totally generated daily in Lebanon this comes with absence of clear regulations concerning C&D waste management.

Contractors have a big role in C&D waste reducing. Although affective C&D waste management methods have been studied in previous studies, but the actual application of these measures is poor in many developing countries including Lebanon.

There are formidable challenges associated with resource depletion that require greater attention to reclaiming the embodied energy of existing building stock, and decrease the energy required to construct new buildings though innovative waste management strategies. Despite significant research attention aimed at improving C&D waste management practices in construction, implementation strategies have been far from effective resulting in the unnecessary disposal of C&D waste to landfill. This research build upon previous work in order to understand practitioner attitudes towards on-site C&D waste re-use and recycling, a theoretical model was initially established based on Theory of Planned Behavior and innovation diffusion theory in this study. Structural Equation Modeling was used in data analysis. Whereas the given results revealed that EV does not significantly affect the adoption of actual waste management by contractors on-site. Also project constraints are not considered important to the contractors' behavior concerning on-site C&D waste management innovative decisions. However, behavioral intention and GS are the two significant factors affecting innovative decisions concerning on-site C&D waste minimization by the contractors, with weights distributed as 0.35 and 0.702 respectively. Thus for guiding the project contractor to sufficiently implement C&D waste management measures on-site, increasing contractor's intention and willingness through awareness towards the environmental and economic consequences of C&D waste management through training and enhancement of GS are two effective measures.

6.2 Research Limitation

Although this research was carefully prepared, there were some of unavoidable limitations. This study is applicable to all the CI in general and it is not limited to a specific geographical location and can provide specific solutions for improving the behavior towards C&D waste management innovation and the its adoption in the CI. The research is limited to the application of this model in Lebanese CI thus the respondents of the questionnaire survey are from the local firms in Lebanon. Also the sample size in this study wasn't perfectly enough for the SEM analysis since the sample size used in this study is 104 respondents due to time limitations. Keeping in mind there is no prior research studies on the same topic for the region, causing it more difficult to lay a foundation for understanding the research problem.

6.3 Recommendations for Further Study

Future improvement recommends that the sample size should be improved in order to satisfy the measures of using equation modeling and get higher goodness-of-fit. Also future studies can be done by either applying this study in different countries with different characteristics or in specific region but studying different stakeholders (clients, consultants, sub-contractors, local government, and NGOs) engaged in the CI in order to get clearer idea about the most significant factors affecting OC&DWMI from different points of view. Finally, it is recommended to develop a specific department in all construction firms in order to encourage the innovation.

6.4 Originality

This study provides a sound basis for a large scale empirical research project of on-site waste management innovation adoption on Lebanese construction projects. By identifying the behavioral drivers to adoption, strategies can be proposed to improve on-site waste management practice in projects, and shed new light on the system supporting the adoption of innovative on-site waste management initiatives.

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APPENDICES

Appendix A: Modification indices of initial model

			Modification Index	Parameter change
BI	<---	GS	8.012	-0.16
PA1	<---	ACD	4.871	0.217
PA1	<---	BI	21.322	0.599
PA1	<---	BI1	20.511	0.362
PA1	<---	BI2	25.623	0.354
PA1	<---	BI4	4.79	0.168
PA1	<---	PC5	8.339	0.204
PA1	<---	PC3	11.484	-0.226
PA1	<---	EV5	5.936	-0.189
PA1	<---	EV1	9.49	-0.217
PA1	<---	GS1	6.021	-0.19
PA1	<---	SN5	13.566	0.244
PA1	<---	SN3	15.107	0.252
PA1	<---	ACD3	16.93	0.347
PA3	<---	SN1	4.177	0.093
PA4	<---	ACD	6.191	0.18
PA4	<---	PC3	4.534	0.105
PA4	<---	PBC2	12.307	0.2
PA4	<---	ACD3	5.437	0.145
PA4	<---	ACD2	5.626	0.132
PA5	<---	ACD	9.548	-0.228
PA5	<---	PA6	4.422	0.115
PA5	<---	ACD5	4.131	-0.125
PA5	<---	ACD3	6.11	-0.157
PA5	<---	ACD2	10.65	-0.186
PA6	<---	ACD	8.941	-0.259
PA6	<---	BI1	4.041	-0.142
PA6	<---	PC5	9.86	0.196
PA6	<---	PBC3	5.087	0.159
PA6	<---	ACD5	4.431	-0.152
PA6	<---	ACD2	9.594	-0.207
BI1	<---	PC	6.774	-0.143
BI1	<---	EV	4.005	-0.115
BI1	<---	GS	10.286	-0.186
BI1	<---	ACD	5.323	0.157
BI1	<---	PA	6.75	-0.171
BI1	<---	PA3	5.6	-0.138
BI1	<---	PA5	8.515	-0.148

BI1	<---	PA6	7.412	-0.137
BI1	<---	PC2	15.799	-0.19
BI1	<---	EV1	7.974	-0.138
BI1	<---	GS5	9.869	-0.172
BI1	<---	GS4	7.577	-0.152
BI1	<---	GS3	7.392	-0.15
BI1	<---	GS2	8.105	-0.155
BI1	<---	GS1	12.41	-0.189
BI1	<---	ACD3	12.133	0.204
BI1	<---	ACD2	5.676	0.125
BI2	<---	PC	5.717	0.171
BI2	<---	GS	4.64	0.162
BI2	<---	PA	6.413	0.217
BI2	<---	PA1	12.523	0.226
BI2	<---	PA2	5.193	0.15
BI2	<---	PA3	7.305	0.204
BI2	<---	PA5	5.668	0.158
BI2	<---	PC5	6.305	0.16
BI2	<---	PC2	6.133	0.154
BI2	<---	GS5	6.09	0.176
BI2	<---	GS4	5.037	0.161
BI2	<---	PBC4	4.655	0.147
BI2	<---	SN5	7.862	0.168
BI2	<---	SN4	4.472	0.134
BI2	<---	SN3	5.149	0.132
BI4	<---	ACD8	4.121	-0.202
PC5	<---	PA1	13.675	0.298
PC5	<---	PA5	5.787	0.201
PC5	<---	PA6	13.13	0.299
PC5	<---	BI2	5.302	0.184
PC5	<---	PBC3	4.808	0.199
PC5	<---	PBC2	7.444	-0.241
PC5	<---	SN5	6.652	0.195
PC4	<---	ACD	6.896	0.126
PC4	<---	ACD5	5.427	0.093
PC4	<---	ACD3	8.699	0.122
PC3	<---	PA1	7.596	-0.224
PC3	<---	BI2	5.28	-0.185
PC3	<---	PBC2	4.797	0.195
PC2	<---	ACD	11.742	-0.235
PC2	<---	BI	18.922	-0.395
PC2	<---	BI1	20.315	-0.253
PC2	<---	BI2	8.423	-0.142
PC2	<---	BI4	4.583	-0.115

PC2	<---	SN3	4.754	-0.099
PC2	<---	SN1	6.292	-0.144
PC2	<---	ACD3	14.753	-0.227
PC2	<---	ACD2	8.097	-0.151
EV5	<---	PA1	4.38	-0.133
EV5	<---	ACD3	4.387	-0.158
EV4	<---	BI	6.589	0.337
EV4	<---	BI1	7.081	0.216
EV4	<---	BI4	7.136	0.208
EV4	<---	ACD3	6.947	0.225
EV3	<---	ACD3	5.047	0.181
EV2	<---	PA2	4.694	-0.1
EV2	<---	PBC2	4.903	-0.108
EV1	<---	BI	14.043	-0.363
EV1	<---	PA1	16.025	-0.211
EV1	<---	BI1	14.732	-0.229
EV1	<---	BI2	7.756	-0.145
EV1	<---	BI4	6.396	-0.145
EV1	<---	PC5	6.814	-0.138
EV1	<---	GS3	7.484	0.162
EV1	<---	GS1	6.378	0.146
EV1	<---	SN5	6.553	-0.127
EV1	<---	SN3	7.253	-0.13
EV1	<---	ACD3	10.158	-0.201
GS5	<---	PBC	4.599	0.103
GS5	<---	SN	5.82	0.099
GS5	<---	ACD	6.683	0.114
GS5	<---	PA1	9.136	0.096
GS5	<---	PA4	4.045	0.065
GS5	<---	BI2	5.352	0.073
GS5	<---	PBC2	4.245	0.072
GS5	<---	SN5	6.649	0.077
GS5	<---	SN3	5.114	0.066
GS5	<---	SN2	4.085	0.082
GS5	<---	SN1	10.5	0.12
GS5	<---	ACD3	8.516	0.111
GS4	<---	PBC	4.053	0.146
GS4	<---	SN	6.323	0.156
GS4	<---	ACD	4.866	0.148
GS4	<---	BI2	4.098	0.097
GS4	<---	PBC4	4.867	0.114
GS4	<---	SN5	6.331	0.114
GS4	<---	SN4	4.993	0.107
GS4	<---	SN3	9.53	0.137

GS4	<---	SN2	4.81	0.134
GS4	<---	SN1	5.188	0.128
GS3	<---	SN6	4.987	0.079
GS2	<---	EV4	5.348	-0.072
GS2	<---	EV3	4.294	-0.065
GS2	<---	PBC3	5.477	-0.086
GS1	<---	SN	6.561	-0.116
GS1	<---	ACD	11.25	-0.163
GS1	<---	BI	17.298	-0.268
GS1	<---	PA1	11.154	-0.117
GS1	<---	PA4	5.401	-0.083
GS1	<---	BI1	16.898	-0.163
GS1	<---	BI2	16.269	-0.14
GS1	<---	SN5	10.942	-0.109
GS1	<---	SN3	11.831	-0.111
GS1	<---	SN1	8.926	-0.121
GS1	<---	ACD3	17.319	-0.174
PBC3	<---	GS2	4.806	-0.181
PBC3	<---	SN6	4.026	-0.145
PBC2	<---	PA4	4.763	0.138
PBC2	<---	BI4	4.779	0.147
PBC2	<---	PC5	10.979	-0.205
PBC2	<---	PC3	6.109	0.144
PBC2	<---	SN5	4.46	-0.122
SN6	<---	GS	6.299	0.237
SN6	<---	EV1	4.212	0.164
SN6	<---	GS3	11.795	0.309
SN6	<---	GS2	6.69	0.229
SN6	<---	GS1	6.633	0.225
SN6	<---	ACD8	4.771	0.238
SN6	<---	ACD3	5.517	-0.224
SN5	<---	BI	7.584	0.305
SN5	<---	PA1	15.849	0.24
SN5	<---	BI1	7.192	0.183
SN5	<---	BI2	11.945	0.206
SN5	<---	PC5	11.44	0.204
SN5	<---	PC3	7.243	-0.153
SN5	<---	PBC2	7.024	-0.175
SN5	<---	SN6	6.308	-0.148
SN5	<---	SN3	10.526	0.179
SN5	<---	ACD8	8.353	-0.238
SN4	<---	EV	4.596	0.111
SN4	<---	GS	5.883	0.127
SN4	<---	BI	4.692	-0.175

SN4	<---	PA5	5.708	0.109
SN4	<---	BI1	5.712	-0.119
SN4	<---	PC2	6.748	0.112
SN4	<---	EV5	6.337	0.122
SN4	<---	EV1	10.495	0.143
SN4	<---	GS3	6.049	0.122
SN4	<---	GS2	5.637	0.116
SN4	<---	GS1	8.297	0.139
SN4	<---	SN6	6.978	0.113
SN4	<---	ACD3	6.827	-0.138
SN4	<---	ACD2	4.08	-0.096
SN3	<---	GS	5.759	-0.19
SN3	<---	BI	9.829	0.385
SN3	<---	PA1	8.283	0.193
SN3	<---	BI1	10.189	0.242
SN3	<---	BI2	9.99	0.209
SN3	<---	PC3	9.105	-0.191
SN3	<---	PC2	4.163	-0.133
SN3	<---	EV5	5.203	-0.168
SN3	<---	EV1	7.844	-0.187
SN3	<---	GS5	4.293	-0.155
SN3	<---	GS3	6.327	-0.189
SN3	<---	GS2	5.53	-0.175
SN3	<---	GS1	8.979	-0.219
SN3	<---	SN6	5.06	-0.147
SN3	<---	SN5	8.556	0.184
SN3	<---	ACD3	8.041	0.227
SN2	<---	BI	4.732	-0.162
SN2	<---	BI1	4.533	-0.098
SN2	<---	BI2	4.082	-0.081
SN2	<---	ACD3	7.433	-0.132
SN1	<---	ACD	6.371	0.132
SN1	<---	BI	6.68	0.178
SN1	<---	PA5	7.953	-0.11
SN1	<---	BI1	7.645	0.118
SN1	<---	PC2	6.841	-0.096
SN1	<---	GS2	4.57	-0.089
SN1	<---	GS1	4.915	-0.091
SN1	<---	ACD3	8.475	0.131
SN1	<---	ACD2	5.262	0.093
ACD8	<---	SN6	8.121	0.173
ACD8	<---	ACD5	6.625	0.186

ACD5	<---	PC	14	0.278
ACD5	<---	EV	14.453	0.296
ACD5	<---	GS	15.895	0.313
ACD5	<---	PBC	11.777	0.343
ACD5	<---	SN	7.617	0.236
ACD5	<---	PA	12.572	0.316
ACD5	<---	PA3	13.244	0.287
ACD5	<---	PA4	10.328	0.218
ACD5	<---	PA5	8.385	0.2
ACD5	<---	PA6	6.349	0.172
ACD5	<---	PC4	14.729	0.279
ACD5	<---	PC3	9.604	0.195
ACD5	<---	PC2	15.876	0.258
ACD5	<---	EV5	9.871	0.229
ACD5	<---	EV2	10.986	0.258
ACD5	<---	EV1	18.154	0.282
ACD5	<---	GS5	13.893	0.277
ACD5	<---	GS4	9.026	0.225
ACD5	<---	GS3	12.463	0.264
ACD5	<---	GS2	14.995	0.285
ACD5	<---	GS1	14.834	0.28
ACD5	<---	PBC4	9.728	0.221
ACD5	<---	PBC2	9.033	0.219
ACD5	<---	SN6	12.636	0.23
ACD5	<---	SN4	10.018	0.208
ACD5	<---	SN2	9.098	0.254
ACD5	<---	SN1	4.279	0.159
ACD5	<---	ACD8	9.364	0.277
ACD3	<---	GS	5.611	-0.164
ACD3	<---	BI	10.763	0.353
ACD3	<---	PA1	5.579	0.139
ACD3	<---	BI1	12.172	0.232
ACD3	<---	BI2	4.516	0.123
ACD3	<---	BI4	6.112	0.158
ACD3	<---	PC3	4.747	-0.121
ACD3	<---	PC2	5.843	-0.138
ACD3	<---	EV5	4.454	-0.136
ACD3	<---	EV1	9.197	-0.178
ACD3	<---	GS3	6.978	-0.174
ACD3	<---	GS2	4.899	-0.144
ACD3	<---	GS1	10.103	-0.204
ACD3	<---	SN6	7.135	-0.153

ACD2	<---	PA	6.314	-0.208
ACD2	<---	PA1	10.276	-0.198
ACD2	<---	PA3	5.21	-0.167
ACD2	<---	PA5	9.074	-0.193
ACD2	<---	PA6	8.675	-0.186
ACD2	<---	BI2	7.824	-0.171
ACD2	<---	PC5	7.791	-0.172
ACD2	<---	SN5	4.469	-0.122
ACD2	<---	SN4	4.272	-0.126

Appendix B: Survey Questionnaire

Dear Participant,

You are invited to voluntarily participate in a survey about "Contractors' Behavioral Determinants Concerning On-site Waste Management Innovation in Building Construction Projects". This questionnaire is a part of data collection process of a MSc study conducted by Riad Merhi under supervision of Assoc. Prof. Dr. İbrahim Yitmen in Department of Civil Engineering at Eastern Mediterranean University in North Cyprus.

The purpose of this study is to investigate the determinants of behavioral intentions influencing relevant innovation decisions in C&D waste management.

Your participation in this research project is completely voluntary. Your responses will remain confidential and anonymous. Collected data will be used for academic issues only. If you agree to participate in this project, please answer the questions as best you can. It should take approximately five minutes to complete.
If you have any questions about this project, feel free to contact Riad Merhi at riad.merhi717@gmail.com or on (+905338504262- KKTCELL).

Your participation and contribution is highly appreciated. Thank you for your support.

Best Regards,

Riad Merhi

General business characteristics

* Required

1. **What is your work category? ***
Mark only one oval.

   - Company management
   - Project management
   - Construction engineering
   - Cost control
   - Quality control
   - On-site construction
   - Other

2. **What is your experience in construction industry (year) ? ***
Mark only one oval.

   - 1
   - 2-5
   - 6-10
   - 11-15
   - More than 15 years

3. **What is your education level ? ***
Mark only one oval.

   - PhD
   - Masters
   - Bachelor
   - High school or below

4. **What is the number of projects you participated in ? ***
Mark only one oval.

   - 1-5
   - 6-10
   - 11-20
   - More than 20 projects

5. **What project types you participated in the most ?** *
Mark only one oval.

- Residential
- Commercial
- Industrial
- Infrastructure
- Other

6. **what is the staff number in your company?** *
Mark only one oval.

- 1-50
- 51-100
- 101-200
- More than 200 employees

Attitude towards on-site construction and demolition waste management innovation

To what extent do you agree or disagree with the following statements?

7. **Implementing on-site C&D waste management innovation can promote the sustainability development of the society** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree						Strongly agree

8. **Implementing on-site C&D waste management innovation can improve the company's brand benefit** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree						Strongly agree

9. **Implementing on-site C&D waste management innovation can improve the social image of the project** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree						Strongly agree

10. **Implementing on-site C&D waste management innovation should be advocated** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree						Strongly agree

11. **Implementing on-site C&D waste re-use and recycling innovation has significant advantage over other alternatives** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

12. **Implementing on-site C&D waste re-use and recycling innovation is consistent with existing values, past experience and current needs of the project** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

13. **Implementing on-site C&D waste re-use and recycling innovation can be complicated to apply on site** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

14. **I feel pleasant about implementing on-site waste management innovation** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

Subjective Norm

To what extent do you agree or disagree with the following statements?

15. **My project manager expects me to implement on-site waste management innovation** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

16. **My colleagues expect me to implement on-site waste management innovation** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

17. **My family and friends expect me to implement on-site waste management innovation** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

18. **My project owner expects me to implement on-site waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

19. **The potential customers expect me to implement on-site waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

20. **The local government expects me to implement on-site waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

Perceived Behavioural Control

To what extent do you agree or disagree with the following statements?

21. **I have enough opportunity to implement on-site waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

22. **I have enough support to implement on-site waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

23. **I have enough time implement on-site waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

24. **I have enough space implement on-site waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

25. **I have enough experience to implement on-site waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

Behavioural Intention

To what extent do you agree or disagree with the following statements?

26. **I intend to take actions to avoid C&D waste generation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

27. **I intend to reuse or recycle the generated C&D waste** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

28. **I intend to see the inappropriate dumping of C&D waste** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

29. **I intend to attend the training concerning on-site waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

30. **I will use a higher level of on-site waste management innovation, if conditions were supportive.** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

Governmental Supervision

To what extent do you agree or disagree with the following statements?

31. **The government has specific regulations on C&D waste management** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

32. **The government has specific department for C&D waste management** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

33. **The government has a comprehensive supervision system for C&D waste management** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

34. **The government imposes strict punishment to illegal C&D waste dumping** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

35. **The government has attractive policies to encourage C&D waste recycling** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

Economic Viability

To what extent do you agree or disagree with the following statements?

36. **On-site C&D waste management innovation can reduce construction cost** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

37. **Reducing C&D waste generation can decrease the construction cost** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

38. **Implementing on-site C&D waste management innovation can bring benefits to the company** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

39. **The current landfilling fee for C&D waste is low** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

40. **The current recycling market is mature** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

Project Constraints

To what extent do you agree or disagree with the following statements?

41. **The project has enough workers for implementing on-site C&D waste management innovation** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

42. **The project has enough money for implementing on-site C&D waste management innovation** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

43. **The project has enough time for implementing on-site C&D waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

44. **The project has enough space for implementing on-site C&D waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

45. **The project has enough equipment for implementing on-site C&D waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

Previous on-site C&D waste management innovation activity

To what extent do you agree or disagree with the following statements?

46. **I used to minimize C&D waste through appropriate on-site C&D waste management innovation** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

47. **I used to minimize C&D waste through appropriate material procurement** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

48. **I used to minimize C&D waste through advanced construction technologies** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

49. **I used to minimize C&D waste through on-site sorting** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

50. **I used to directly reuse C&D waste in my project** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

51. **I used to recycle C&D waste in my project** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

52. **I used to minimize C&D waste through other measures in my project** *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree