# The effect of awareness, knowledge and cost on intention to adopt green building practices

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**Abstract:** Addressing the threats of climate change has become one of the world's major challenges. More than 36 billion tonnes of carbon dioxide emissions have been recorded recently and the construction industry has been identified as one of the culprits in the worsening of climate change phenomena. Previous studies have revealed that conventional construction procedures are having a major impact on the environment. In light of these circumstances, this study examines the relationship among some influential and environmental factors – including awareness of environmental issues, knowledge of green practices, cost of green materials, subjective norms, attitudes, perceived behavioural control and intention to adopt green building practices in Qatar. The data were collected from 378 engineers using a survey method and were analysed using PLS-SEM. The findings confirmed that significant relationships exist among all variables except for the effect of perceived behaviour control

on intention to adopt green building practices. This study provides valuable insight that may help decision makers to plan for strategies to increase the adoption of green building practices among construction companies.

**Keywords:** awareness of environmental issues; AEI; knowledge of green practices; KGP; cost of green materials; CGM; intention to adopt; green building practices; theory of planned behaviour; TPB.

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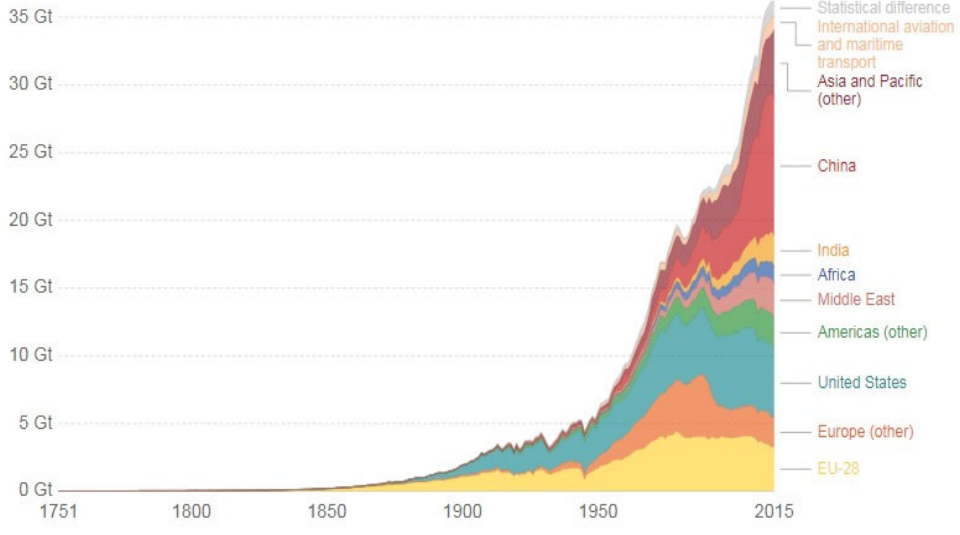
## 1 Introduction

The construction industry, and the activities associated with it such as demolition (Lemay and Lobo, 2015; Ofori, 2007) and excavation (Kibert, 2013), is normally acknowledged as hostile to the environment. Previous studies have revealed that conventional construction procedures are having a major impact on the environment such as pollution (Gray, 2018; Abidin et al., 2015; Petkar, 2014) and global warming (Sagheb et al., 2011; Landman, 1999). In addition, it is also claimed that climate change is a very serious matter because global anthropogenic carbon dioxide emissions ($CO_2e$) are continuously increasing (Pollitt, 2016). As illustrated in Figure 1, there was an exponential growth in global $CO_2$ emissions from 1900 to 2015, from two billion tonnes to more than 36 billion tonnes (Ritchie and Roser, 2019). Although $CO_2e$ became relatively stable from 2014 until 2017, it has been reported that they grew by 2.7% in 2018 (Le Quéré et al., 2018).

**Figure 1** Annual $CO_2$ emissions by world region (see online version for colours)




Notes: Annual carbon dioxide ($CO_2$) emissions measured in billion tonnes (GT) per year. Emissions data have been converted from units of carbon to carbon dioxide ($CO_2$) using a conversion factor of 3.67. Regions denoted as 'other' are given as regional totals minus emissions from the EU-28, USA, China and India (CDIAC, 2017).

This data clearly shows that the increase in $CO_2e$ is not trivial. Although this issue is not going to be solved overnight, understanding the intention to adopt green building practices (GBP) (IB) among engineers could help countries such as Qatar prevent the unwanted effects of increased $CO_2e$.

Qatar, being a relatively small nation, has been making swift progress to modernise in order to meet the government's long-term development plan, the Qatar National Vision 2030, and to prepare for hosting the World Cup 2022. In all, the country's efforts to progress in several areas reflect its ambition to give a good impression about its way of life and the developed nature of its civilisation (Sedky, 2016). However, these initiatives, especially the massive infrastructure development projects, threaten to further worsen air pollution (boosting the emissions of chemicals, total suspended particulates and other biological materials), which may inflict harm on humans, wildlife and the natural environment. As the environmental hazards brought about by the construction boom have now been recognised, Qatar is facing several new challenges. One of these, as highlighted by Al Mamoon (2014), is the need to invest heavily in easing the impacts of climate change and adopt climate-resilient structures. In addition, Qi et al. (2010) stated that contractors are not doing enough to reduce the negative environmental impacts brought about by construction processes, thus compounding the increasing the levels of harmful $CO_2e$ in Qatar, which, in turn, is threatening the well-being of future generations. Moreover, the country has already been identified as having air that is among the most polluted in the world (Walker, 2014).

As a result of the different harmful effects of construction projects, several researchers around the globe have taken the initiative to investigate various areas in the sector to further understand the situation. Several studies have attested that GBP could ease the negative environmental impact of the sector. Nduka and Ogunsanmi (2015), for example, found that GBP minimises a building's energy consumption. Kozlowski (2003) stated that such practices also help in water conservation, as well as in the promotion of recycling and reusing supplies already in the area to minimise disturbances on construction sites. Also, Kats et al. (2003) pointed out the effectiveness of GBP in reducing waste, where they lead to higher waste diversion from landfill and lower costs for waste disposal management systems, among other spillover benefits. Furthermore, overall, Lacroix and Stamatiou (2007) and Chatterjee (2009) agreed that GBP lessens the pollution caused by construction that would otherwise be detrimental to humans and the environment.

However, due to the low interest in green construction (Alsanad, 2015; Horvath, 1999) claimed that the industry's efforts to reduce its environmental footprint are still low in terms of their impact. Although there has been great progress in terms of identifying the drivers of and barriers to GBP, there are still some areas in GBP that are not yet fully effective in establishing a sustainable environment in Qatar (Rybkowski et al., 2017). Thus, this research aims:

- to examine the effects of awareness of environmental issues (AEI) and knowledge of green practices (KGP) on attitudes
- to examine the effects of KGP and cost of green materials (CGM) on perceived behavioural control (PBC)
- to examine the effect of subjective norms (SN), attitudes (A) and PBC on intention to adopt GBP (IB).

By exploring the relationships among AEI, KGP, CGM, SN, A, PBC, and IB in Qatar, this research hopes to provide valuable insights for a better understanding of the above-mentioned factors. This research also makes several theoretical and practical contributions; this study not only contributes to the growing literature in this field by

providing a framework that examines the relationships among the important variables, it also suggests implementation drivers that could accelerate IB in Qatar. In addition, it highlights how the developed framework may have the capacity to influence decision makers, which could help to improve both environmental and human health in Qatar.

## 2 Literature review and hypotheses development

### *2.1 Awareness of environmental issues (AEI)*

Awareness of environmental issues can be described as being conscious of the problems that impact the world's finite natural resources. Pachamama (2017) stated that environmental awareness refers to the understanding of the environment's fragility in the face of the damaging threats of man-made activities and the importance of its protection. Indeed, Abidin (2010) noted that awareness is one of the essential elements in prompting a person to exercise environment-friendly practices. This applies in the context of the construction industry, as well; if contractors are aware of the importance and benefits of green building, they are more likely to make an effort to ensure that their construction activities do not compromise the welfare of the environment. Serpell et al. (2013) echoed this observation, stating that a company's awareness is one of the main drivers that promote the implementation of GBP. For Serpell et al. (2013) however, awareness could influence a company's actual inclusion of GBP in its overall business model. On the other hand, du Plessis (2005) emphasised that a genuine change, and the actual adoption of GBP, will come about only if there is a personal commitment to GBP.

Furthermore, the research findings of Manaktola and Jauhari (2007) showed that environmental awareness influences the way people perform and respond to everyday tasks; those with high levels of awareness are more likely to conserve water and energy, purchase local and environment-friendly products, and minimise waste. Thus, the above shows that there is a strong relationship between awareness and positive attitudes that leads to the adoption of green practices. Therefore, the following was hypothesised:

$H_1$ Awareness of environmental issues has a positive effect on attitudes.

### *2.2 Knowledge of green practices (KGP)*

Knowledge, as proposed by Badrulhisham and Othman (2016), is the basis of the conduct or behaviour of an individual. Without knowledge, one cannot respond to any information or issues that arise. It is also considered as one of the key drivers that motivate the implementation of green practices. For instance, the study of Nduka and Ogunsanmi (2015) in Nigeria confirmed that the more knowledgeable the built environment professionals and clients are, the more green practices in construction projects are adopted. In addition, Robichaud and Anantatmula (2011) stated that if leadership in energy and environmental design (LEED) professionals have knowledge on GBP, then they can manage green projects more efficiently. In general, knowledge can positively impact behaviours (Blocker and Eckberg, 1997; Singh and Bansal, 2012) and yield pro-environmental attitudes (Fisher et al., 2012; Moisander, 2007). Miller (2005) proposed that either the nature or personality of an individual and the external factors in his/her surroundings influence his/her behavioural intention and attitudes. Meanwhile,

attitudes towards knowledge sharing positively affect knowledge-sharing intentions (Lin, 2007). Thus, the development of a person's knowledge can serve as an impetus to change his/her attitude (Schwartz, 2012; Valente et al., 1998).

Based on the theory of planned behaviour (TPB), behavioural intention can be determined by attitudes as well as by PBC (Ajzen, 1991). As such, it can be articulated that there is a relationship among knowledge, attitudes, and PBC. For instance, the study of Bamberg and Möser (2007) showed that knowledge directly influences PBC in the context of pro-environmental behaviour. In addition, Mainieri et al. (1997) stated that there is always an assumption in environmental studies that increased levels of knowledge about the environment can boost people's concern for their surroundings, thereby, also increasing their green consumption activities. A later study confirmed this theory in the case of the expansion of green hotels; Suki and Suki (2015) found that customers equipped with a grasp of the impacts of human activities on the environment were willing to pay more for environment-friendly products and services notwithstanding the cost. Therefore, the following hypotheses were formulated:

$H_2$ Knowledge of green practices has a positive effect on attitudes.

$H_3$ Knowledge of green practices has a positive effect on perceived behavioural control.

### *2.3 Cost of green materials (CGM)*

Green materials, in the context of the construction industry, contain substances that reduce the negative impacts of the sector on the environment and human health (Yudelson, 2008). The development of these materials stemmed from the increased demand for green buildings (Nobe and Dunbar, 2004; Tinker and Burt, 2004); it was found that eco-friendliness is one of the important purchase criteria of some consumers (Kumar and Ghodeswar, 2015).

In spite of the significant increase in sustainable development efforts from the private sector, green building is not without challenges and barriers. Cost, for instance, is one of the most common factors that weigh on a company's decision to go green (Ghaffarian Hoseini et al., 2013). In fact, for Alzubaidi (2013), cost is one of the significant challenges that constrain businesses from fully adopting sustainable building practices. According to Testa et al. (2011), because the market for these high-cost environment-friendly products is narrow, the companies producing them escape the pressures of a highly competitive market wherein players compete to attract clients with the cheapest offer for a quality service or product.

These problems are not exclusive to Qatar. For instance, Balaban and Puppim de Oliveira (2016) found that cost also hinders the higher adoption of GBP in Japan where the decision makers of contractor companies tend to select materials that are lower cost. Also, Dulaimi and Shan (2002), who studied the factors influencing the bid mark-up decisions of large and medium-sized contractors in Singapore, confirmed that large contractors tend to be more concerned about the nature of the construction work of the tendered project when they make their decision on the size of the mark-up. Thus, the contractors' perception of the importance of such factors as CGM varies with contractor size. Therefore, it was hypothesised that:

$H_4$ Cost of green materials has a negative effect on perceived behavioural control.

### *2.4 Subjective norms (SN)*

Subjective norms, as originally conceptualised in the TPB, relate to the social pressure of complying with a certain behaviour (Ajzen, 1991). Social norms supposedly form the foundation of appropriate behaviour. Under the concept of SN, people use these norms to decide not only what is morally right or wrong, but also whether it is beneficial to act a certain way (Bamberg and Möser, 2007). Several environmental studies have shown that SN is the main predictor of the intention to practise certain behaviours (Han and Kim, 2010; Harland et al., 1999; Sparks and Shepherd, 1992), which implies that SN is essential in having a positive intention towards to practise environmental behaviours. In addition, it has been argued by Dezdar (2017) that SN can significantly affect the intention to use green IT. Therefore, based on previous studies, the following hypothesis is proposed:

$H_5$ Subjective norms have a positive effect on the intention to adopt GBP (IB).

### *2.5 Attitudes (A)*

Attitudes have been defined in several ways in different research studies. Based on the study of Allport (1935), attitude is a mental and neural state of readiness which exerts a direct influence on how an individual responds to situations. The study by Ko and Jin (2017) showed that consumers in the USA highly lean towards purchasing environment-friendly apparel due to their high level of awareness about the problems facing the environment. In addition, the attitudes of people towards sustainable living are the ultimate critical factor in achieving a low-carbon, green built environment (Wu, 2016). Therefore, the following hypothesis was developed:

$H_6$ Attitudes have a positive effect on the intention to adopt GBP (IB).

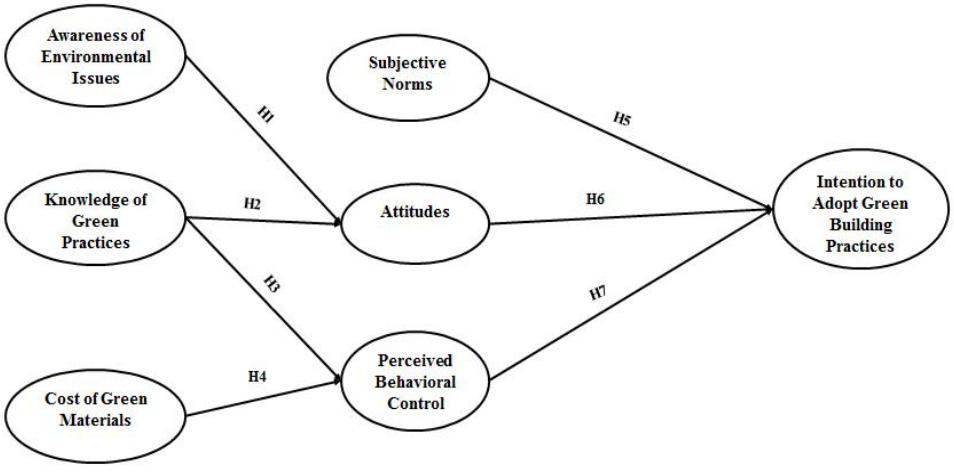
### *2.6 Perceived behavioural control (PBC)*

Perceived behavioural control is a crucial factor in predicting behavioural intention and behaviours. It is determined by an individual's beliefs about the power of both situational and internal factors to facilitate the performance of a behaviour (Francis et al., 2004). Also, it measures how the person perceives the ease with which a certain behaviour can be conducted. As explicated by Ajzen (1991), PBC refers to people's perception of the ease or difficulty of performing the behaviour of interest. According to the results of analysis conducted by Kai and Haokai (2016) in Beijing and Shanghai, green commuting behaviour is directly influenced by PBC. In addition, the research of Botetzagias et al. (2015) showed that the most important predictor of the intention to recycle, which is considered to be one of the main green practices, is PBC. Therefore, in light of the aforementioned research, it is hypothesised that:

$H_6$ Perceived behavioural control has a positive effect on the intention to adopt GBP (IB).

## 3 Research framework

**Figure 2** Research framework




## 4 Methodology and measurement

### *4.1 Data collection and sample*

The research design for this study focused on examining the causal relationships among AEI, KGP, CGM, SN, A, PBC on the intention to adopt GBP (IB) in order to propose a solution to the issues being faced by construction projects in Qatar. In view of the aims of this research, consultant and contractor engineers were considered the unit of analysis as they are some of the main decision makers in green construction projects (Jarkas et al., 2013; Ramesh et al., 2010). Hence, an understanding of their opinions concerning the intention to adopt GBP will benefit and help the government authorities and high-ranking officials to develop and accelerate the implementation of GBP in the construction industry in Qatar.

In order to gather the required data from the identified sample population within the research time frame and to provide convenience to the respondents, this study chose to employ a web-based survey (Schultz, 2014) as the data collection method. In addition, the quantitative approach (Burns and Grove, 2005) was judged to be the most suitable approach for this study because it can cover a huge number of respondents/samples (Wiid and Diggines, 2009). It can also enable the summarisation of the results of analyses in the form of numeric statistical values with a high level of confidence.

The data used for this study was collected from eight municipalities in Qatar and was sorted into three clusters through cluster random sampling (Cochran, 1963). As the documented response rate of engineers in previous studies on GBP and the adoption of GBP ranges from 40% to 61% (e.g., Khaemba and Mutsune, 2014; Nduka and Ogunsanmi, 2015), it was determined that 877 questionnaires should be distributed. Out of these, 378 were completed and returned, resulting in a response rate of 43.10%.

As shown in Table 1, the bulk of the respondents were male (91.5%); most were aged between 33 and 43 years (29.6%); the majority were engineers (70.1%); and more than half rendered consultancy services (52.4%).

**Table 1** Frequency of respondents by demographic variable

| *Demographic variable* | *Category* | *Frequency* | *Percentage* |
|---|---|---|---|
| | | *N = 378* | *%* |
| Gender | Male | 346 | 91.5 |
| | Female | 32 | 8.5 |
| Total | | 378 | 100.0 |
| Age | 22–32 | 111 | 29.4 |
| | 33–43 | 112 | 29.6 |
| | 44–54 | 73 | 19.3 |
| | 55–65 | 70 | 18.5 |
| | ≥ 66 | 12 | 3.2 |
| Total | | 378 | 100.0 |
| Current occupation | Engineer | 265 | 70.1 |
| | Supervisor | 7 | 1.9 |
| | Manager | 100 | 26.5 |
| | Others | 6 | 1.6 |
| Total | | 378 | 100.0 |
| Current role | Consultant | 198 | 52.4 |
| | Contractor | 180 | 47.6 |
| Total | | 378 | 100.0 |

## *4.2 Measurement of the variables*

Using a five-point Likert scale, the survey measured seven variables: AEI, KGP, CGM, SN, A, PBC, and IB. All the measures were adapted from the literature to strengthen the validity of the content of the survey.

- *Awareness of environmental issues (AEI):* Three items were adapted from the studies by Lee (2008, 2009) to measure AEI:
  1 I think the environmental issues in Qatar are a serious matter.
  2 I think Qatar's environmental issues that are caused by non-green practices need to be dealt with urgently.
  3 I think Qatar's environmental problems are threatening our health.
- *Knowledge of green practices (KGP):* Four statements were adapted from the research of Haron et al. (2005) to measure KGP:
  1 I am knowledgeable about green practices in construction projects.
  2 I know green practices that help to conserve natural resources for future generations.

3 I am knowledgeable about the green materials that can help in reducing the negative impacts of construction on the environment and health.

4 I am knowledgeable about the non-green construction work practices that can cause air pollution in Qatar.

- *Cost of green materials (CGM):* To measure whether cost is one of the barriers that prevent consultant and contractor engineers from using green materials or switching from non-green to green materials, three items were adapted from the study by Brown and Venkatesh (2005):
  1 I think the green materials that are available today are relatively expensive.
  2 I think green materials are quite pricey.
  3 I consider green materials to be high-value items.
- *Subjective norms (SN):* To measure whether consultant and contractor engineers are influenced by others, four items were adapted from the research of Al-Swidi et al. (2014), the four items to measure SN are:
  1 The trend of using GBP among the people around me is increasing.
  2 The people around me generally believe that it is better for health to use GBP.
  3 The people around me would appreciate it if I use GBP.
  4 I would get all the required support (money, time, information) I need from friends and family if I used GBP.
- *Attitudes (A):* Five items were also adapted from Al-Swidi et al. (2014) to measure the respondents' attitudes to GBP:
  1 I prefer GBP because they reduce the impact of climate change.
  2 I prefer GBP because it reduces the impact on the environment and human health.
  3 I prefer GBP because it conserves natural resources more than non-GBP.
  4 I prefer GBP because they are environment friendly.
  5 It is exciting for me to use GBP.
- *Perceived behavioural control (PBC):* PBC refers to the decision-making ability of the consultant and contractor engineers to adopt GBP, measurements for PBC were adapted from Al-Swidi et al. (2014):
  1 I can take the decision independently to adopt GBP.
  2 I have the financial capability to buy green materials.
  3 I believe green materials are readily available in Qatar.
  4 I have control over the resources required to support my decision to adopt GBP.
- *Intention to adopt GBP (IB):* Four items were used to measure IB, the measurements were adapted from Al-Swidi et al. (2014):
  1 I am motivated to adopt and implement GBP.
  2 I have a full consideration in adopting the usage of green materials in construction projects.

3 I am willing to encourage others to adopt green practices.

4 I am determined to adopt green practices in construction projects.

## 5 Results

### *5.1 Descriptive statistics*

A descriptive analysis was executed in this study for three reasons:

1 to present a summary of the data

2 to get an insight on how the respondents answered the questionnaire items (Sekaran and Bougie, 2010)

3 to describe the respondents' perceptions of the constructs of interest to this study.

The calculated mean and standard deviation of the constructs are presented in Table 2. The results show that the mean ranged from 2.937 to 4.157, while the standard deviation ranged from 0.742 to 0.947.

**Table 2** Descriptive statistics for the constructs

| *Construct* | *N* | *Minimum* | *Maximum* | *Mean* | *Std. deviation* |
|---|---|---|---|---|---|
| Awareness of environmental issues (AEI) | 378 | 1 | 5 | 3.351 | 0.901 |
| Knowledge of green practices (KGP) | 378 | 1 | 5 | 3.618 | 0.947 |
| Cost of green materials (CGM) | 378 | 1 | 5 | 3.620 | 0.742 |
| Subjective norms (SN) | 378 | 1 | 5 | 3.375 | 0.804 |
| Attitudes (A) | 378 | 1 | 5 | 4.157 | 0.904 |
| Perceived behavioural control (PBC) | 378 | 1 | 5 | 2.937 | 0.805 |
| Intention to adopt green building practices (GBP) | 378 | 1 | 5 | 4.091 | 0.904 |

### *5.2 Reliability and validity assessment*

The reliability and validity of the developed model were measured by determining the convergent validity and discriminant validity. The latter was achieved by checking that the factor loadings and cross-loadings were greater than 0.70 (Hair et al., 2011). The results presented in Table 3 and Table 4 show that the factor loadings for the items of each construct were all above 0.70, except for AE1– AE3 and CGM1, CGM2 and CGM3. However, Hair et al. (1995) stated that a loading greater than 0.45 can still be considered significant as long as it leads to an average variance extracted (AVE) that is larger than 0.5. In this case, the loadings for AEI were considered significant as the AVE was 0.618 (refer to Table 5).

**Table 3** Cross-loading factors

| *Item* | *Attitudes* | *Awareness of environmental issues* | *Cost of green materials* | *Intention to adopt green building practices* | *Knowledge of green practices* | *Perceived behavioural control* | *Subjective norms* |
|---|---|---|---|---|---|---|---|
| A1 | *0.929* | 0.451 | 0.411 | 0.691 | 0.562 | 0.219 | 0.482 |
| A2 | *0.949* | 0.423 | 0.447 | 0.674 | 0.574 | 0.209 | 0.414 |
| A3 | *0.924* | 0.458 | 0.411 | 0.637 | 0.526 | 0.197 | 0.406 |
| A4 | *0.927* | 0.445 | 0.457 | 0.661 | 0.521 | 0.210 | 0.443 |
| A5 | *0.872* | 0.393 | 0.401 | 0.670 | 0.548 | 0.310 | 0.487 |
| AEI1 | 0.438 | *0.859* | 0.288 | 0.449 | 0.434 | 0.284 | 0.401 |
| AEI2 | 0.421 | *0.873* | 0.305 | 0.460 | 0.449 | 0.159 | 0.321 |
| AEI3 | 0.170 | *0.597* | 0.225 | 0.230 | 0.241 | 0.036 | 0.181 |
| CGM1 | 0.258 | 0.234 | *0.558* | 0.217 | 0.146 | –0.103 | 0.014 |
| CGM2 | 0.261 | 0.214 | *0.497* | 0.200 | 0.141 | –0.078 | 0.040 |
| CGM3 | 0.470 | 0.320 | *–0.561* | 0.437 | 0.305 | 0.167 | 0.245 |
| IB1 | 0.712 | 0.464 | 0.424 | *0.931* | 0.511 | 0.229 | 0.466 |
| IB2 | 0.643 | 0.449 | 0.362 | *0.911* | 0.535 | 0.322 | 0.454 |
| IB3 | 0.690 | 0.496 | 0.372 | *0.928* | 0.530 | 0.289 | 0.480 |
| IB4 | 0.619 | 0.460 | 0.341 | *0.913* | 0.546 | 0.326 | 0.492 |
| KGP1 | 0.421 | 0.387 | 0.182 | 0.434 | *0.820* | 0.336 | 0.345 |
| KGP2 | 0.553 | 0.454 | 0.275 | 0.536 | *0.871* | 0.298 | 0.353 |
| KGP3 | 0.517 | 0.442 | 0.233 | 0.515 | *0.903* | 0.392 | 0.401 |
| KGP4 | 0.541 | 0.423 | 0.278 | 0.486 | *0.841* | 0.272 | 0.389 |
| PBC1 | 0.305 | 0.224 | 0.105 | 0.324 | 0.347 | *0.778* | 0.396 |
| PBC2 | 0.109 | 0.183 | –0.043 | 0.187 | 0.274 | *0.768* | 0.378 |
| PBC3 | 0.155 | 0.082 | 0.003 | 0.168 | 0.143 | *0.661* | 0.345 |
| PBC4 | 0.155 | 0.186 | 0.025 | 0.245 | 0.331 | *0.854* | 0.435 |
| SN1 | 0.396 | 0.384 | 0.113 | 0.455 | 0.445 | 0.452 | *0.799* |
| SN2 | 0.434 | 0.304 | 0.176 | 0.428 | 0.296 | 0.374 | *0.849* |
| SN3 | 0.416 | 0.331 | 0.179 | 0.406 | 0.331 | 0.331 | *0.817* |
| SN4 | 0.286 | 0.256 | 0.055 | 0.334 | 0.298 | 0.472 | *0.718* |

## *5.3 Convergent validity analysis*

To examine the convergent validity, three measures (factor loadings, composite reliability, and AVE) were utilised, as recommended by Hair et al. (2010). The results, which are presented in Table 5, show that the factor loadings were all above 0.60, except for CGM. The composite reliability (excluding CGM) ranged between 0.826 and 0.965, while the adequate convergent validity ranged from 0.591 to 0.848. This indicated that A, AEI, IB, KGP, PBC, and SN were significant ($p < 0.001$).

**Table 4** Factor loading significance

| *Construct* | *Item* | *Factor loading* | *Standard error* | *T value* | *P value* |
|---|---|---|---|---|---|
| Attitudes | A1 | 0.929 | 0.010 | 94.424 | 0.000 |
| | A2 | 0.949 | 0.009 | 106.768 | 0.000 |
| | A3 | 0.924 | 0.018 | 52.478 | 0.000 |
| | A4 | 0.927 | 0.012 | 79.128 | 0.000 |
| | A5 | 0.872 | 0.022 | 39.646 | 0.000 |
| Awareness of environmental issues | AEI1 | 0.859 | 0.023 | 37.058 | 0.000 |
| | AEI2 | 0.873 | 0.020 | 42.763 | 0.000 |
| | AEI3 | 0.597 | 0.063 | 9.411 | 0.000 |
| Cost of green materials | CGM1 | 0.558 | 0.404 | 1.379 | 0.168 |
| | CGM2 | 0.497 | 0.363 | 1.368 | 0.171 |
| | CGM3 | –0.561 | 0.635 | 0.884 | 0.377 |
| Intention to adopt green building practices | IB1 | 0.931 | 0.010 | 95.670 | 0.000 |
| | IB2 | 0.911 | 0.016 | 57.773 | 0.000 |
| | IB3 | 0.928 | 0.011 | 87.954 | 0.000 |
| | IB4 | 0.913 | 0.017 | 55.172 | 0.000 |
| Knowledge of green practices | KGP1 | 0.820 | 0.022 | 37.615 | 0.000 |
| | KGP2 | 0.871 | 0.019 | 46.241 | 0.000 |
| | KGP3 | 0.903 | 0.012 | 72.353 | 0.000 |
| | KGP4 | 0.841 | 0.023 | 36.671 | 0.000 |
| Perceived behavioural control | PBC1 | 0.778 | 0.031 | 24.991 | 0.000 |
| | PBC2 | 0.768 | 0.034 | 22.625 | 0.000 |
| | PBC3 | 0.661 | 0.059 | 11.114 | 0.000 |
| | PBC4 | 0.854 | 0.021 | 40.824 | 0.000 |
| Subjective norms | SN1 | 0.799 | 0.023 | 35.091 | 0.000 |
| | SN2 | 0.849 | 0.020 | 43.235 | 0.000 |
| | SN3 | 0.817 | 0.026 | 31.770 | 0.000 |
| | SN4 | 0.718 | 0.035 | 20.319 | 0.000 |

### *5.4 Discriminant validity analysis*

An analysis of discriminant validity was performed to compare the shared variances between the AVE of each construct and the other factors (Fornell and Larcker, 1981). The results, which are presented in Table 6, showed that the square root of the AVE of each of the constructs was greater than that of the other factors. This indicated that the discriminant validity of the outer model was satisfactory and that all the constructs in this study were different from one another, both conceptually and empirically.

**Table 5** Analysis of convergent validity

| *Construct* | *Item* | *Cronbach's alpha* | *Convergent validity* | | |
|---|---|---|---|---|---|
| | | | *Factor loadings* | *Composite reliability* | *Average variance extracted* |
| Attitudes | A1 | 0.955 | 0.929 | 0.965 | 0.847 |
| | A2 | | 0.949 | | |
| | A3 | | 0.924 | | |
| | A4 | | 0.927 | | |
| | A5 | | 0.872 | | |
| Awareness of environmental issues | AEI1 | 0.705 | 0.859 | 0.826 | 0.618 |
| | AEI2 | | 0.873 | | |
| | AEI3 | | 0.597 | | |
| Cost of green materials | CGM1 | 0.683 | 0.558 | 0.103 | 0.291 |
| | CGM2 | | 0.497 | | |
| | CGM3 | | –0.561 | | |
| Intention to adopt green building practices | IB1 | 0.940 | 0.931 | 0.957 | 0.848 |
| | IB2 | | 0.911 | | |
| | IB3 | | 0.928 | | |
| | IB4 | | 0.913 | | |
| Knowledge of green practices | KGP1 | 0.881 | 0.820 | 0.918 | 0.738 |
| | KGP2 | | 0.871 | | |
| | KGP3 | | 0.903 | | |
| | KGP4 | | 0.841 | | |
| Perceived behavioural control | PBC1 | 0.770 | 0.778 | 0.851 | 0.591 |
| | PBC2 | | 0.768 | | |
| | PBC3 | | 0.661 | | |
| | PBC4 | | 0.854 | | |
| Subjective norms | SN1 | 0.809 | 0.799 | 0.874 | 0.636 |
| | SN2 | | 0.849 | | |
| | SN3 | | 0.817 | | |
| | SN4 | | 0.718 | | |

**Table 6** Analysis of discriminant validity

| *Constructs* | *A* | *AEI* | *CGM* | *IB* | *KGP* | *PBC* | *SN* |
|---|---|---|---|---|---|---|---|
| Attitudes | *0.921* | | | | | | |
| Awareness of environmental issues | 0.471 | *0.786* | | | | | |
| Cost of green materials | –0.153 | –0.057 | *0.539* | | | | |
| Intention to adopt green building practices | 0.725 | 0.508 | –0.173 | *0.921* | | | |
| Knowledge of green practices | 0.594 | 0.498 | –0.123 | 0.576 | *0.859* | | |
| Perceived behavioural control | 0.246 | 0.230 | –0.238 | 0.312 | 0.372 | *0.769* | |
| Subjective norms | 0.485 | 0.404 | –0.187 | 0.513 | 0.433 | 0.507 | *0.797* |

**Figure 3** Items loadings, path coefficients and $R^2$ values

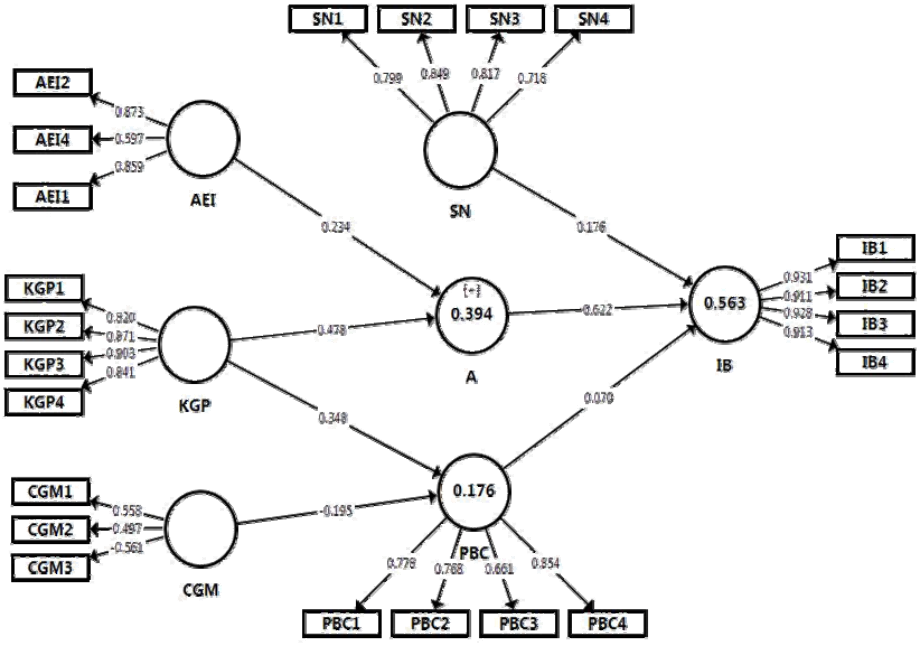
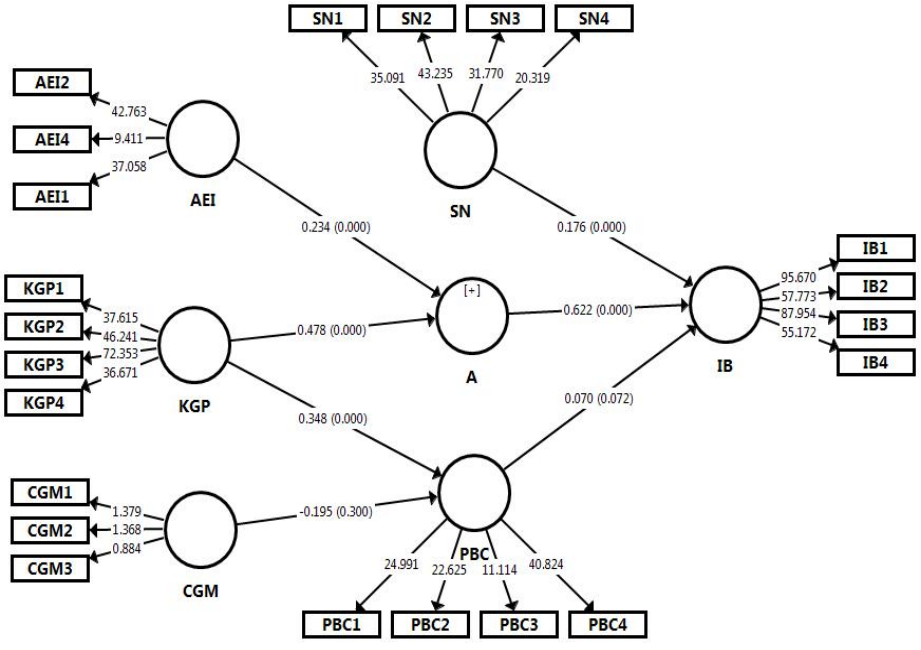



**Figure 4** PLS bootstrapping (t values and p values)




Notes: Awareness of environmental issues (AEI), cost of green materials (CGM), knowledge of green practices (KGP), subjective norms (SN), attitudes (A), perceived behavioural control (PBC), intention to adopt GBP (IB)

### 5.5 Hypotheses testing

Using SMARTPLS 3, this study tested the developed model through the partial least squares (PLS) algorithm, after which the path coefficients were generated, as illustrated in Figures 3 and 4.

In addition, in order to evaluate the statistical significance of the path coefficients, bootstrapping in SMARTPLS 3 was performed. Table 7 shows that out of the seven hypotheses, Hypotheses H1–H6 were supported whereas H7 was not supported.

**Table 7** Path coefficients of the research hypotheses

| *Hypothesis no.* | *Hypothesis statement* | *Std. beta* | *Standard error* | *T value* | *P value* | *Decision* |
|---|---|---|---|---|---|---|
| H1 | AEI → A | 0.234 | 0.049 | 4.761 | 0.000*** | Supported |
| H2 | KGP → A | 0.478 | 0.050 | 9.497 | 0.000*** | Supported |
| H3 | KGP → PBC | 0.348 | 0.049 | 7.141 | 0.000*** | Supported |
| H4 | CGM → PBC | -0.195 | 0.188 | 1.036 | 0.300 | Supported |
| H5 | SN → IB | 0.176 | 0.049 | 3.578 | 0.000*** | Supported |
| H6 | A → IB | 0.622 | 0.054 | 11.482 | 0.000*** | Supported |
| H7 | PBC → IB | 0.070 | 0.039 | 1.797 | 0.072 | Not supported |

Notes: *p < 0.05; **p < 0.01; ***p < 0.001.

#### 5.5.1 Model fit

Following the recommendation of Wetzels et al. (2009), the following guidelines were considered in order to accurately determine the validity of the PLS model was: if the goodness of fit (GoF) is 0.10, it is low; if it is 0.25, it is medium, and if it is 0.36, it is high. Table 8 shows that the GoF index was 0.497, indicating that the PLS model had a high GoF. Thus, the model had a satisfactory fit.

**Table 8** GoF of the model

| *Construct* | *R square* | *AVE* |
|---|---|---|
| Attitudes | 0.394 | 0.847 |
| Awareness of environmental issues | | 0.618 |
| Cost of green materials | | 0.291 |
| Intention to adopt green building practices | 0.563 | 0.848 |
| Knowledge of green practices | | 0.738 |
| Perceived behavioural control | 0.176 | 0.591 |
| Subjective norms | | 0.636 |
| *Average* | *0.378* | *0.653* |
| *GoF* | | *0.497* |

## 6 Discussion

This research aimed to measure and investigate the relationships among AEI, KGP, CGM, SN, A and PBC on the intention to adopt GBP (IB) in Qatar. A number of thought-provoking findings were generated.

First, in examining the hypotheses, this study found that AEI has a significant impact on attitudes. This supports Hypothesis H1, which was developed in line with previous studies (Alcorn, 2014; Kim and Chung, 2011; Liu, 2011; Serpell et al., 2013). The results showed that Qatar's engineering consultants and contractors in Qatar have a high level of awareness about environmental issues. The results also affirmed that as AEI increases, the inclination to adopt GBP heightens proportionately. Thus, all players, particularly decision makers in Qatar, should promote greater AEI, especially among construction engineers, so that they can incorporate their AEI and environmental knowledge into projects, thereby reducing the risks to the environment and human health. In addition, the government may wish to reform relevant policies and/or increase environmental legislation to protect the environment.

Second, KGP has a significant impact on attitudes and PBC, a finding that supports Hypotheses H2 and H3, which were formulated on the basis of parallel findings in previous studies (Bamberg and Möser, 2007; Fisher et al., 2012; Moisander, 2007; Suki and Suki, 2015). This indicates that engineering consultants and contractors in Qatar are knowledgeable about the negative consequences of the use of non-green materials on the environment and human health. Moreover, the finding highlights the significance of the effect of KGP on attitudes and PBC. As such, it can be articulated that knowledge will serve an impetus to change attitudes (Schwartz, 2012; Valente et al., 1998) as well as boost PBC, which, in turn, will lead to higher GBP adoption. According to the empirical study by Levin (1990), individuals with a higher level of knowledge are more sensitive towards the environment which, in turn, gives them the ability to mitigate and manage the negative consequences on their actions on the environment and to enhance quality of life (Thøgersen and Crompton, 2009). Moreover, the finding of this research is beneficial in terms of future planning as it may encourage decision makers to advance the awareness and knowledge of contractors and consultants through delivering technical training to increase their knowledge and skills in GBP.

Third, the relationship between CGM and PBC is significant, which supports Hypothesis H4. This result is consistent with previous research studies (e.g., Alzubaidi, 2013; Zhang et al., 2004) which showed that engineering consultants and contractors in Qatar do not consider using green materials due to their high cost. This reflects a broader problem, where cost prevents countries from implementing GBP, as shown by a study conducted in Ghana (Chan et al., 2017). It is therefore recommended that the government consider this factor in their development plans. One way of motivating GBP adoption would be to, for instance, grant financial incentives such as reduced import taxes, among others, to businesses that use green materials for construction projects. In addition, the government has the power to influence the industry in terms of managing the CGM by providing cheaper or locally available green materials. Moreover, it is essential to establish regular training sessions/courses to disseminate the principles of sustainable construction which could enlighten and convince engineers to adopt GBP.

Fourth, the relationship between SN and IB was found to be significant. This supports Hypothesis H5, and also corresponds with the results of previous studies (Bamberg,

2003; Finlay et al., 1997; Kalafatis et al., 1999; Kim et al., 2011; Tarkiainen and Sundqvist, 2005). The results indicate that Qatar's engineering consultants and contractors are influenced by green building authorities and the government since they might have been actively involved in seminars and training offered by the government on GBP.

Fifth, attitudes have a significant impact on IB which supports Hypothesis H6. This result matches those of the preceding studies (Cunningham and Kwon, 2003; Kalafatis et al., 1999; Manaktola and Jauhari, 2007; Rahman, 2013). This also establishes the argument that the more favourable the attitude, the bigger the chance of IB. In other words, consultant and contractor engineers who had high positive attitudes appeared to have greater IB than those with low attitudes.

Lastly, this study found that PBC has insignificant impact on IB. This is somewhat surprising as it does not support the Hypothesis H7 and is inconsistent with the findings of previous studies (Hsieh et al., 2008; Kai and Haokai, 2016; Kalafatis et al., 1999; Kats, 2006; Povey et al., 2000; Taylor and Todd, 1995). This could mean that the engineering consultants and contractors in Qatar choose not to adopt GBP, even though even they have control over all the resources such as time and money that would enable them to do so. This implies that the consultant and contractor engineers are still in need of some support (such as incentives and recognition) from the green building authorities and government to motivate them in their decision to fully adopt GBP.

## 7 Conclusions and contributions

### *7.1 Conclusions*

Several research studies have attested that GBP could curb the worsening consequences of climate change. However, there are still some areas of GBP that have not yet been fully investigated. To address this gap in knowledge, this research explored and investigated the relationships among AEI, KGP, CGM, SN, A, PBC, and IB in Qatar. Based on the analysis of 378 valid questionnaires completed by consultants and contractor engineers in Qatar, it was found that:

1 AEI and KGP have significant influence on attitude

2 KGP and CGM have significant influence on PBC

3 SN and attitude significantly influence on IB.

On the other note, PBC has no significant influence on IB.

This shows that the green building authorities can achieve their development goals when many more companies are willing to adopt GBP. Moreover, the findings of this study provide valuable insights for a better understanding of the relationships among AEI, KGP, CGM, SN, A, PBC and IB. The study also contributes to the expanding literature on sustainable development as it offers a framework that examines the relations among the important variables and the intention to adopt GBP. The findings of this study would help decision makers strategise on how to apply these factors in their development plans, which in turn, may accelerate the adoption of GBP in Qatar.

## *7.2 Contributions*

The findings of this study provide valuable insights for government authorities and high-ranking officials whose aim is to develop and accelerate the implementation of GBP in the construction industry in Qatar. The main theoretical and practical contributions of this study are discussed below.

### *7.2.1 Theoretical contributions*

This research has been able to make several contributions to the body of knowledge on IB in an environment where air pollution levels are high. First, it addressed the relationships among AEI, KGP, CGM, SN, A, PBC and IB. The findings showed how AEI and KGP influenced attitudes towards GBP among consultants and contractor engineers. Additionally, the results showed how KGP and CGM impact on PBC as well as the influenced of SN, A and PBC on IB. Hence, from the theoretical point of view, this study provided a clear understanding on how the factors studied influence the adoption of GBP.

Second, this study extended and tested the TPB and showed that it had the ability to predict the behaviour of consultant and contractor engineers in the context of adopting GBP. This study integrated AEI, KGP, and CGM and specified 56.3% variance exceeding the basic TPB model where previous studies such as the meta-analysis conducted by Thompson and Barton (1994) indicated a 40%–50% variance in intentions using the TPB model, while the study of Alam and Sayuti (2011) indicated a 29.1% variance in the intention to purchase halal food products. Thus, this study showed that the extended theory was reliable and more effective in predicting the intention to adopt GBP. It is therefore recommended that all interested parties and GBP authorities refer to the extended model.

Third, the developed model was considered a valuable extension of the TPB in the green construction context, it expands its usage to the context of a developing country. Most of the studies that have utilised the TPB to investigate the issue of green construction have been conducted in developed regions. Therefore, this research aimed to examine the applicability of the TPB in Qatar, which is a developing country with a high risk of air pollution. Moreover, this research verified that the TPB was effective in examining the adoption behaviour towards GBP among consultants and contractor engineers.

Fourth, the developed framework contributes to the literature on sustainable development as it examines the relations among the important variables as well as the implementation drivers, which may help decision makers to consider these factors in their development plans and, in turn, accelerate the adoption of GBP in Qatar. The model developed in this study has high GoF index that indicates a satisfactory fit for IB. Hence, the model can be adopted not only in Qatar but also in other countries worldwide.

### *7.2.2 Practical contributions*

The results of this research also offer tremendous value for government authorities and high-ranking officials who are concerned about speeding up the implementation of GBP in the construction industry in Qatar. Some of the practical contributions that may assist them in their endeavours are explained below:

First, the findings provide empirical evidence on which factors and how they influenced IB. This study showed that AEI and KGP positively influenced attitudes while KGP positively influenced PBC. Similarly, SN and attitudes positively influenced the intention to adopt GBP. Based on these findings, the GBP authorities and the Qatar government can incorporate these factors into their strategies and plans. On the other hand, the study showed that CGM negatively influenced the decision of engineering consultants and contractors to adopt GBP. It is therefore important that government authorities also consider these factors in their plans and projects. One way this could be achieved is by encouraging more local manufacturers to produce green materials in a bid to fuel competition which would make affordable and high-quality green materials available in the market. Another option would be to remove import taxes on green materials, or at least decrease them, and provide other financial incentives that could motivate engineers to consider using green materials for their projects.

Second, the results of this study may enlighten decision makers in regards to what they may wish do in the future. Decision makers could, for instance, create campaigns or advertisements to increase awareness about the need to adopt GBP, provide incentives to increase the motivation of consultant and contractor engineers to adopt GBP, and provide technical training to increase engineers' knowledge and skills in GBP. When all engineers are engaged, it is highly recommended that the government institute regulations to enhance and sustain the adoption of GBP.

## 8 Limitations and recommendations

This research has generated interesting results. However, it has some limitations. Nevertheless, these can be addressed in future research. First, the study sample was conducted in Qatar only. So it is recommended that future studies would be conducted in more than one country. By conducting the study in more than one country, perhaps the results would have more generalisation. Second, this study focused on engineering consultants and contractors in Qatar, so the intention of other significant decision makers such as owners, stockholders, and chief executive officers of construction companies were not covered. Lastly, this research concentrated on AEI, KGP, CGM, SN, A, and PBC. Therefore, incorporating other variables (e.g., regulations, green technology, green management) may enhance the understanding of the existing phenomena.

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