



**Thank you for downloading this document from the RMIT Research Repository.**

The RMIT Research Repository is an open access database showcasing the research outputs of RMIT University researchers.

RMIT Research Repository: <http://researchbank.rmit.edu.au/>

**Citation:**

Wong, P and Zapantis, J 2013, 'Driving carbon reduction strategies adoption in the Australian construction sector - the moderating role of organizational culture', *Building and Environment*, vol. 66, pp. 120-130.

See this record in the RMIT Research Repository at:

<http://researchbank.rmit.edu.au/view/rmit:21169>

Version: Accepted Manuscript

Copyright Statement: © 2013 Elsevier Ltd. All rights reserved

Link to Published Version:

<http://dx.doi.org/10.1016/j.buildenv.2013.04.022>

**PLEASE DO NOT REMOVE THIS PAGE**

# Accepted Manuscript

Driving carbon reduction strategies adoption in built environment – the moderating role of organizational culture

Peter S.P. Wong, Jason Zapantis



PII: S0360-1323(13)00133-9

DOI: [10.1016/j.buildenv.2013.04.022](https://doi.org/10.1016/j.buildenv.2013.04.022)

Reference: BAE 3408

To appear in: *Building and Environment*

Received Date: 11 January 2013

Revised Date: 22 April 2013

Accepted Date: 23 April 2013

Please cite this article as: Wong PSP, Zapantis J, Driving carbon reduction strategies adoption in built environment – the moderating role of organizational culture, *Building and Environment* (2013), doi: 10.1016/j.buildenv.2013.04.022.

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

**Highlights/Managerial Statement**

1. Numbers of strategies were advocated but failed to foster carbon reduction in built environment
2. The relationships among carbon reduction drivers, strategies adoption and organizational culture (OC) are investigated
3. Stringent regulations may not necessarily induce adoption of carbon reduction strategies
4. Relationship between the carbon tax and the adoption of carbon reduction strategies can be further enhanced by OC
5. Assisting organizations to reduce carbon is vital for fostering sustainable development of built environment

A Paper submitted

to

**Building and Environment**

**‘Driving carbon reduction strategies adoption in the Australian construction sector –  
the moderating role of organizational culture’**

(Ref: BAE3408)

by

**Peter S.P. Wong<sup>1</sup> and Jason Zapantis<sup>2</sup>**

<sup>1</sup> *Senior Lecturer, School of Property, Construction and Project Management, Royal Melbourne Institute of Technology University, Australia. Tel: +61 3-99253978 ; Fax: +61 3-99251939; email: peterspwong@rmit.edu.au*

<sup>2</sup> *Graduate in Bachelor of Construction Management, School of Property, Construction and Project Management, Royal Melbourne Institute of Technology University, Australia. Tel: +61 3-99253978 ; Fax: +61 3-99251939; e-mail: jason.zapantis26@gmail.com*

**\*Corresponding Author**

**Peter S.P. Wong**

**School of Property Construction & Project Management**

**RMIT University, City Campus**

**360 Swanston Street (Bldg 8. Lvl 8)**

**PO Box 2476, Melbourne, 3001 VIC, AUSTRALIA**

**Tel: +61 3-99253978**

**Fax: +61 3-99251939**

**Email: peterspwong@rmit.edu.au**

**April 2013**

## **Driving carbon reduction strategies adoption in built environment – the moderating role of organizational culture**

### **ABSTRACT**

In recent years, numbers of strategies were advocated to foster carbon reduction in built environment. However, few studies have acknowledged that strategies adoption is a matter of organizational culture (OC). In this study, a conceptual model that depicts the hypothesized relationship among carbon reduction drivers, strategies adoption and OC is developed. The model is then tested with data collected via a survey conducted in Australia. The results suggest that the significant relationship between the carbon tax and the adoption of carbon reduction strategies can be further enhanced by OC in terms of goal clarity, rewards, and innovation. Surprisingly, stringent regulations may not necessarily induce adoption of carbon reduction strategies in built environment even if OC exists.

**Keywords:** carbon reduction, strategies adoption, organizational culture, built environment

### **INTRODUCTION**

Formulating appropriate policies to combat global climate change has been an imminent but challenging task for many countries (HMGovernment, 2009; UNEPSBCI, 2009). In Australia, the government committed to reduce the national carbon emissions to a maximum of 25% below the 2000 level by 2020 (DCCEE, 2011). Achieving this target is no easy task. This requires a pivotal contribution from the major carbon emitting sectors of the country. In this regard, the government has been urging the construction sector to eradicate their carbon-intensive ways of operations (CIE, 2011; RAE, 2010).

The liability that the construction sector has on carbon emissions has already been justified by statistical records. The sector is a major contributor to carbon emissions in the country

according to the latest figures published by the Australian Bureau of Statistics (ABS) (2011), in which the sector produced 40.1 million metric tonnes of carbon dioxide equivalent (mtCO<sub>2</sub>e), sourcing 20.1% of the total emitted carbon throughout all sectors (ABS, 2008).

Carbon released through construction activities must be properly controlled and reduced (Iyer-Raniga and Wong, 2012; Lam, et al., 2010). In this regard, researchers have put forward a number of strategies to reduce carbon emissions in built environment in recent years. This includes: adopting less carbon-intensive materials in buildings (González and García Navarro, 2006), advancing technologies to optimize energy efficiency (Li and Colombier, 2009; Skopek, 1999), developing mechanisms for evaluating the environmental impact driven by the construction activities (Fieldson, 2009; Li and Colombier, 2009; Osmani, et al., 2008), and reducing energy consumption and pollution in construction processes (Osmani, et al., 2008). Furthermore, governments also joined hands with the local professional bodies to establish benchmarks of carbon emission levels suitable for the construction sector. In Australia, Green Star and National Australian Built Environmental Ratings Scheme (NABERS) were developed for the sake of benchmarking construction design and reducing carbon at the planning stage (GBCA, 2012; NABERS, 2012).

Some new government policies were introduced with an intention to drive carbon reduction in construction operations. For examples, some State Governments in Australia like Victoria have passed new regulations to disapprove new construction or alteration works that fall below the tightened energy efficient and site operations standards. Furthermore, the Australian Federal Government introduced the Clean Energy Bill in October 2011 (DCCEE, 2011). The Bill encompasses a carbon pricing mechanism that has been criticized by the public as no different from a consumption tax (Singer 2009). Indeed, when compared to carbon price, the phrase 'carbon tax' is more frequently employed by the Australian populace (Deane, 2011). Advocates of the Clean Energy Bill believe that the introduction of carbon

price will drive companies' behavioural change, ensuring that environmental initiatives are a more cost effective option, rather than paying a tax on emissions (Deane, 2011). In this sense, being taxed supposedly would motivate construction organizations to adopt carbon reduction strategies (Parag and Darby, 2009).

However, the perception about the positive effects of tightening regulations and the carbon tax in adjusting an organizations behaviour has aroused much debate in recent years (Deane, 2011; Singer, 2009). Based on a literature review, (Wong, et al., 2012b) identified that despite strategies for reducing carbon emissions being available; construction organizations are generally slow to adopt them in practice. Construction organizations in this paper refer to the organizations collaborating in a construction project. This includes the developers and their consultants, the main contractors and the sub-contractors. Acquaye & Duffy (2010) argued that it would be difficult for construction organizations to change their behavior if the responding actions are in conflict with their core values. Boiral (2006) emphasized that organization's attitudes towards environmental issues may not necessarily drive behavioral change of which benefits are not justifiable.

The above suggested that policies change does not necessarily lead to the adoption of carbon reduction strategies. However, until now, a deeper understanding of whether low carbon initiatives like new policies or more stringent regulations would be conducive to a change in construction organizations' behavior towards emission reduction is still lacking. In this aspect, Hartmann (2006) described that organizational culture (OC) can be an instrumental vehicle to drive behavioral changes. OC is a developing and emerging research topic in construction. Previous research mainly aimed to import the definitions of OC obtained from other fields to construction (Ankrah and Langford, 2005). These studies largely adopted Schein (1985) organizational theory to explain culture (Liu, 1999, Coffey 2002, Ankrah and Langford 2005, Cheung et al. 2011). Schein (1985) conceptualized OC as a pattern of shared

basic assumptions about the reality that the employees learned as they addressed and resolved problems. Since then, his efforts have further been advanced by a number of researchers (Barney 1986, McNamara 1999, Peter and Waterman 2004). Barney (1986) described OC as an ‘expression of values that members of an organization share with each other’. McNamara (1999) extended Schein’s (1985) concept by defining OC as a set of values and norms that hold members in an organization together. When time goes by, new employees would consciously or unconsciously follow such norms. A similar definition was used by Peters and Waterman (2004) who defined OC as a set of beliefs and assumptions which define the way a firm would adopt to cope with its problems in terms of internal integration and external adaptation. The notions of OC in construction were also expounded from these classical definitions (Maloney and Federle 1991, Liu, 1999, Ankrah and Langford 2005, Ozorhon et al. 2006, Zhang and Liu 2006, Cheung et al. 2011, 2013). In these studies, construction researchers often emphasized on the significant impact of OC on the attainment of the project goals (Ankrah and Langford 2005, Cheung et al. 2011, 2013). Ankrah and Langford (2005) described that OC has powerful consequences in shaping behaviour, especially when the organization’s values are being challenged by the deteriorating project performance. Zhang and Liu (2006) defined OC as the approaches that embody the shared values of an organization. This study benefited from this wealth of studies and defines OC as a set of shared values that determine the approaches taken by an organization to complete a construction project. In order to break out the entrenched carbon emission intensive operating modes, construction organizations may require a set of common values that can motivate and foster strategies adoption (Hartmann, 2006). In this study, OC is perceived as a moderating variable of the relationship between the carbon reduction drivers and the construction organization's adoption of carbon reduction strategies. Further details about the concept of



OC and how this can be identified in a construction project are provided in the next section (in particular Table 3) of this paper.

This paper reports on a study that aims to examine the effects of tightening regulations and the carbon tax on the construction organizations' adoption of carbon reduction strategies in an OC perspective. Boiral (2006) stressed that our understandings about the organizational behavior associated with carbon reduction are difficult to be consolidated as they are embedded to social and sectoral contexts. In this regard, the construction sector engages a substantial portion of the work force and Gross Domestic Product (GDP) of many countries (ABS, 2008). In view of the construction developments required to sustain the economy, it is of paramount importance that future infrastructures and construction facilities can be developed with due consideration of carbon emissions. Furthermore, construction design affects household carbon emissions following occupancy. To a great extent, the construction sector determines the carbon footprints of all future construction facilities in Australia. Providing appropriate assistance to foster carbon reduction by the construction organizations is thus a pressing issue to foster sustainable development of built environments.

To accomplish the research objective, the following hypotheses are tested in this study:

**H1:** The adoption of carbon reduction strategies is contingent on two drivers - tightening building regulations and the carbon tax

**H2:** The interactions between the carbon reduction drivers and OC have a moderating effect on construction contractor's adoption of carbon reduction strategies.

This paper is organized into three sections. Firstly, a conceptual model depicting the hypothesized relationships among drivers of carbon reduction, adoption of carbon reduction strategies and OC is presented. Then, the research methodologies used for examining the

hypothesized relationships are introduced. Finally, the findings and the implications thereof are discussed.

## **CONCEPTUAL MODEL DEVELOPMENT**

Having summarized the literature, a conceptual model which depicts the energizing effect of OC on the drivers of carbon reduction and the adoption of carbon reduction strategies is developed and presented in this paper. The conceptual model is underpinned by three streams of studies, namely: carbon reduction drivers, carbon reduction strategies and OC

### ***Carbon reduction drivers***

The first stream of literature is related to the drivers of carbon reduction. There have been policies like the carbon tax or emission trading schemes proposed or even enforced in some countries aiming to reduce carbon emissions (DCCEE, 2011; Sathre and Gustavsson, 2007). While they may seem different on the outskirts, the rationale behind these policies is no different to a penalty mechanism. Emission trading scheme policies operate by means of issuing a limited amount of tradable permits capping the total national emission volumes within a targeted level. By reducing the quantities of those permits over time, should the volume of carbon emissions remain unchanged, there will be a rise in the carbon price. On the flip side, revenue generated from the carbon tax or trading schemes can be used to subsidize other low carbon technologies such as green electricity (DCCEE, 2011; Schleich, et al., 2009). It is anticipated that construction organizations will persevere with their efforts to reduce emissions from their construction operations, in face of the mounted pressure of additional cost.

Another carbon reduction driver that has been highlighted in previous research studies is 'Tightening Regulations' (Horne and Hayles, 2008; Iyer-Raniga and Wong, 2012). It has

been advocated that tightening of regulation would prompt the organizations rethink their ways of operation and develop plans that endorse new practices (Jiang and Tovey, 2010). In the construction context, imposing more rigorous building regulations may help to reduce the use of high carbon embodied building materials (HMGovernment, 2009). In Australia, some state governments such as Victoria have tightened their regulations to disapprove new construction or alteration works that fall below a set of stringent energy efficiency standards (Iyer-Raniga and Wong, 2012). Tightening regulations have been seen as the first step toward forcing behavioral changes into the construction sector (Horne and Hayles, 2008). The operational statements of the above carbon reduction drivers are listed in Table 1.

<Table 1 here>

### ***Carbon reduction strategies***

The second stream of literature is related to the carbon reduction strategies. A number of industry reports and research studies in relation to benchmarking carbon reduction activities have been published in recent years. Baumgartner *et al.* (Baumgartner and Zielowski, 2007) conducted a review on carbon emission reduction strategies and highlighted improvement of total material productivity and separation of output products and waste as the effective strategies of carbon reduction in construction projects. Zuo *et al.* (2012) stated that there is a large amount of carbon emissions from existing buildings. They emphasized the importance of design change to reduce the operational energy and embodied energy consumption of future buildings. However, practical solutions for operational changes on construction sites were not provided. Cuéllar-Franca *et al.* (2012) developed a life cycle assessment (LCA) framework to evaluate carbon emissions from the proposed construction developments. Chen *et al.*, (2012) applied a similar approach to investigate the direct and indirect energy use and carbon emissions in the design and construct stage of the building life cycle. The results

generated from an input-output analysis showed that construction activities induce a considerable amount of CO<sub>2</sub> emissions as fossil fuels are used to a large extent. Chan *et al.* (2012) called for immediate action in reducing the construction industry's consumptions of fossil fuels.

From the above review, it is not difficult to observe that researchers have been calling for pragmatic carbon reduction strategies applicable to construction operations. In this regard, the United Nations Environment Programme (UNEP) suggested seven strategies: working to introduce a carbon trade mechanism for buildings, working with governments to develop policies that make a difference in emissions behavior, dedicating research and development to zero net buildings, renovating buildings to maximize the reduction of emissions, demonstrating technology on buildings and rented office, moving to holistic and systematic solutions to sustainable buildings, and educating the supply chain. However, UNEP have not proposed any objective measures to evaluate the proposed strategies.

Global Reporting Initiatives (GRI) (2011) specifically developed guidelines for construction organizations to report their sustainability performances whereby their performance is assessed under three key aspects: management approach, strategy and profile, and performance indicators. As with the work of UNEP, the guidelines developed by GRI are not project-specific, implying that they may not be effective in a construction project to evaluate a contractor's carbon reduction behavior. In this respect, the inventory developed by the European Network of Construction Companies for Research and Development (ENCORD) may be deemed more suitable. It is because the proposed inventory evaluates the carbon emitted by contractors in a construction project specifically. The inventory proposes evaluating the carbon emitted under twelve aspects as shown in Table 3 with methods for measuring the emission amounts. This study adopts the work of ENCORD (2010) and proposes that the up taking of carbon reduction strategies by construction organizations can

be evaluated under these twelve aspects. The related operational statements are outlined in Table 2.

<Table 2 here>

### ***Organizational culture (OC)***

The third stream of literature is related to OC. In this study, OC is defined as a set of shared values that determines the approaches taken by an organization to complete a construction project. Depending on the focus of the studies, construction researchers adopted different approaches to evaluate OC (Liu, 1999; Coffey, 2002; Ankrah and Langford , 2005; Zhang and Liu, 2006, Cheung et al. 2012). Liu (1999) used nine cultural dimensions to investigate the OC of the real estate sector in Hong Kong: team orientation, power orientation, rule and procedure orientation, communication orientation, result orientation, innovation orientation, people orientation, external vs. internal focus, and result orientation. In contrast, Coffey (2002) based on the Corporate OC framework proposed by Denison (1990) and proposed to evaluate OC of contractors by twelve identifiers: agreement, vision, empowerment, capability development, team orientation, core values, goals and objectives, strategic direction and intent, creating change, coordination and integration, customer force, and organizational learning. Employing an Organizational Culture Assessment Instrument (OCAI) that was developed by Cameron & Quinn (1999), Zhang and Liu (2006) evaluated the OC of the Chinese construction enterprises through six dimensions: [1] the criteria of success that determine how victory is defined; [2] dominant characteristics of the organization; [3] how employees are managed under different working environments; [4] the leadership style that permeates the organization; [5] the criteria of success that determine how victory is defined; and [6] the organizational bonding mechanisms that hold the organization together. A recent study conducted by Cheung et al. (2011) deployed an extensive review of literature about OC

in construction. They found out that the OC models adopted in previous studies were not construction specific. In this regard, they developed an organizational culture inventory specifically for the construction industry.

Notwithstanding the difference in terminology, researchers of the above studies evaluated OC through the organizations' behaviours in a project. In this aspect, Ankrah and Langford (2005) argued that despite OC is an intangible concept, the organization's behaviour that reflects culture is tangible. Based on such argument, they agreed with an approach to evaluate OC through assessing the organizations' behaviours. However, as time passed multitudes of attributes were proposed to evaluate OC in construction (Liu, 1999; Coffey, 2002; Ankrah and Langford, 2005; Zhang and Liu; 2006). In this regard, Cheung et al. (2011) described these multitudes of attributes as the OC identifiers that 'include all the phenomena that one sees, hears and feels about his/her organization. As such, OC identifiers can be observed but are not easy to apprehend the deeper assumptions per se. Nonetheless, when some OC identifiers were considered collectively they reflect the beliefs and values shared by members of an organization. To this end, Cheung et al. (2011) suggested that those OC identifiers with similar nature can be grouped into a smaller number of behavioural dimensions to reflect the values being assessed. Extended the work of Ankrah and Langford (2005), Cheung et al. (2011) deployed an extensive review of literature about OC in construction. They found out that many OC identifiers proposed in previous studies were not construction specific. In this regard, they developed an organizational culture inventory specifically for the construction industry. This was an exploratory study that no underlying construct of OC was presumed. However, 26 OC identifiers were found by reference to a number of previous reported studies on OC. These factors were factorized to eight underlying behavioural dimensions by the use of Exploratory Factor Analysis: goal settings and accomplishment (GC), coordination and integration (CI), conflict resolution (CR), employee participation (EP), innovation orientation

(IO), performance emphasis (PE), reward orientation (RO), and team orientation (TO). This organizational culture inventory was then successfully adopted in their further study investigating the effect of OC on the performance of the construction organizations (Cheung et al. 2012).

In this study, the OC inventory developed by Cheung et al. (2011) is solely featured as one of the references used to develop the OC identifiers and behavioural dimensions. However, while devising the relevant operational statements to characterize OC, other relevant references to content were also taken into account. The operational statements of OC are listed in Table 3.

<Table 3 here>

### ***The conceptual model***

Based on the hypotheses and the attributes identified in Tables 1 to 3, a conceptual model as shown in Figure 1 is developed. The arrows represent the direction of the hypothesized influence. The conceptual model is partly underpinned by the work of Cheung et al. (2012) which identified OC according to the eight dimensions (i.e. GC, TO, CI, PE, IO, EP, RO and CR), as summarized in Table 3. The drivers of carbon emission reduction are evaluated by carbon tax (D1) and more stringent standard (D2). Construction organization's adoption of carbon reduction strategies are evaluated according to the twelve aspects proposed by ENCORD (2010) (i.e. S<sub>1</sub> to S<sub>12</sub> as summarised in Table 2).

<Figure 1 here>

## **DATA COLLECTION**

### ***Measurement of construct and questionnaire***

To test the conceptual model, a questionnaire survey was performed for data collection. The questionnaire and the data collection method adopted for this study received approval from

the local university research ethics committee whose clearance standards are outlined in the Australia National Ethics Application Form (NEAF). The questionnaire contains four parts. Part 1 deals with demographic information about the respondents. Respondents were asked to specify a project they had been involved in for at least one year, and the questionnaires of those not having taken part in a specified project for more than one year were discarded. The respondents were requested to answer the questions in Parts 2 to 4 of the questionnaire by referring to their experience gained in the specified project. In Part 2, questions engage the extent of the drivers that enable adoption of carbon reduction strategies (refer to Table 1). Part 3 seeks to solicit the degree of respondents' agreement on the strategies being adopted in their projects (refer to Table 2). In Part 4, respondents were asked to express their degree of agreement on the use of the operational statements to reflect the OC of their companies (refer to Table 3).

A pilot study that involved twelve industry experts was conducted before undertaking the main survey. Equal numbers of experts were invited from three major groups: developers, consultants and contractors to avoid domination of input by more powerful and vocal stakeholders. Apart from some minor revisions regarding the format, the experts generally endorsed the content of the questionnaire as relevant to the construction project scenario. A sample of the questionnaire is presented in Figure 2.

<Figure 2 here>

### ***Sampling***

The targeted respondents for this study were assembled from two major sources. Firstly, the registered contractors list maintained by the Masters Builders Association of Victoria and New South Wales, was adopted. Master Builders is a major building and construction industry association in Australia, and its members represent 95% of all sectors of the



Australian building industry (MBA, 2011). Secondly, targeted respondents in the developers and consultant sample group were searched from the yellow pages, using the keywords developer, architect, engineer, surveying consultant, and also from general browsing on the official webpages of professional institutes including the Australian Institute of Builders, Australian Institute of Architects, Engineers Australia and Australian Institute of Quantity Surveyors. 600 target respondents were randomly selected from the above sources. Questionnaires were dispatched with an even distribution ratio to the target respondents from the developers/consultants and the contractors (refer to Table 4). The target respondents were invited to participate in the survey via either an online platform supported by Qualtrics or hardcopies delivered by our research team. To avoid disruption to selected hardcopies recipients, the research team initially sought permission via telephone before visiting the respective companies in person.

<Table 4 here>

## **DATA ANALYSIS METHODS**

Two data analysis methods were employed in this study, which included the Pearson correlation analysis and the multiple moderated regression (MMR) analysis. To test Hypothesis H1, Pearson correlation analysis was applied. Pearson correlation analysis is a statistical method with a primary purpose of evaluating whether a significant relationship exists between two sets of ratings. The significance of relationship can be expressed by the  $\rho$ -value. If the  $\rho$ -value is greater 0.01, it denotes a significant relationship between two sets of ratings. Furthermore, the extent of correlation between two sets of ratings can be signified by the correlation coefficient value (the  $r$ -value), which ranges from  $-1.0$  to  $1.0$ , where  $0$

represents no correlation and 1.0 and  $-1.0$  represent perfectly positive and negative correlations respectively.

The MMR analysis was used for testing H2 (i.e. the interactions between the carbon reduction drivers and OC having a moderating effect on the adoption of carbon reduction strategies). MMR is a commonly used technique in management, social and behavioural science research to test the existence of any moderating effect of an independent variable (Choe, 2004). MMR has also been applied in construction research. For instance, Yiu et al. (2007) used MMR to investigate the moderating effect of construction dispute sources on the mediator tactics and the respective mediation outcomes, while Wong et al. (2012a) employed MMR to investigate whether the effect of intra-organizational learning on performance is contingent on the practice of unlearning.

This study employed the MMR analysis to examine the effect of OC (i.e. GC, TO, CI, PE, IO, EP and RO as summarised in Table 3) on the relationship between the carbon reduction drivers ( $D_1$  and  $D_2$ ) and the adoption of carbon reduction strategies ( $S_1$  to  $S_{12}$ ). The equations for the MMR analysis are as following:

$$S_x = a_1 + b_1 D_y + b_2 OC_z + \varepsilon_1 \quad (\text{Eq. 1})$$

$$S_x = a_2 + b_1 D_y + b_2 OC_z + b_3 D_y OC_z + \varepsilon_2 \quad (\text{Eq. 2})$$

where

$S_x$  is the  $x^{\text{th}}$  attribute for evaluating the adoption of carbon reduction strategies and  $x = 1, 2, 3, \dots, 12$

$D_y$  is the  $y^{\text{th}}$  attribute for identifying the drivers of carbon reduction and  $y=1, 2$

$OC_z$  is the  $z^{\text{th}}$  attribute for evaluating the organizational culture and  $OC_z = GC_1$  to  $GC_7$ ,  $TO_1$  to  $TO_4$ ,  $CI_1$  to  $CI_3$ ,  $PE_1$  to  $PE_3$ ,  $IO_1$  to  $IO_3$ ,  $EP_1$  to  $EP_3$ ,  $RO_1$  to  $RO_3$ .

Where  $S_x$  is the dependent variable,  $D_y$  and  $OC_z$  are the independent variables,  $a_1$  and  $a_2$  are the least square estimate values of the intercepts of Eq. 1 and Eq.2 respectively,  $b_1$  and  $b_2$  are the unknown constants,  $\varepsilon_1$  and  $\varepsilon_2$  represent the prediction errors of the equations. Eq. 1 assumes that  $D_y$  and  $OC_z$  have independent effects on predicting the dependent variable  $S_x$ , whereas Eq. 2 also takes the moderator variable (i.e.  $D_y OC_z$ ) into account. The insertion of  $D_y OC_z$  as the third independent variable in Eq.2 signifies that the hypothesized interaction between the driver of carbon reduction (i.e.  $D_y$ ) and organizational culture (i.e.  $OC_z$ ) is taken into account to predict  $S_x$ . Two indicators can be used to determine whether the inclusion of  $D_y OC_z$  in Eq.2 has a moderating effect:

- (1) The coefficient of determination ( $R^2$ ): This represents the proportion of variations in the dependent variable explained by the independent variables in an equation. The possible value of  $R^2$  falls between 0 and 1. When  $R^2=1$ , the specified independent variables perfectly predict the dependent variable. If  $R^2=0$ , the specified independent

variables do not account for any variation of the dependent variable (Choe, 2004). If the  $R^2$  value of Eq.2 is significantly higher than that of Eq.1, the null hypothesis (H2) can be accepted.

- (2) the significance of the moderator variable ( $D_yOC_z$ ) in explaining the dependent variable ( $S_x$ ). If the standardised coefficient of the moderator variable (i.e.  $b_3$ ) is significant at  $p < 0.05$ , the null hypothesis (H2) can be accepted.

Fisher test ( $F$ -test hereafter) was used to determine significance of  $\Delta R^2$  (Jaccard and Turrisi, 2003; Wong, et al., 2008). The  $R^2$  value of Eq.2 is considered significantly higher than that of Eq.1 if the calculated  $F$ -value for  $\Delta R^2$  is significant at  $p < 0.05$ . The  $F$ -value can be calculated by the following equation:

$$F\text{-value} = [(R_2^2 - R_1^2) / (k_2 - k_1)] / [(1 - R_2^2) / (P - k_2 - 1)] \quad (\text{Eq. 3})$$

where

$k_1$  is the number of predictors in Eq. 1;

$k_2$  is the number of predictors in Eq. 2;

$P$  is the total sample size;

$(P - n_2 - 1)$  is the degree of freedom;

$R_1^2$  is the  $R^2$  value for Eq. 1; and

$R_2^2$  is  $R^2$  value for Eq. 2.

A  $t$ -test for the regression coefficient was used to examine the significance of the moderator variable ( $D_yOC_z$ ) in explaining the dependent variable ( $S_x$ ). The moderating effect of  $D_yOC_z$  is considered significant when the probability of error ( $\rho$ -value) of the standardised coefficient of the moderator variable (i.e.  $b_3$ ) is lower than 0.05 (Jaccard and Turrisi, 2003). In this study, a total of 624 MMR analyses devising from different combinations of the  $S_x$ ,  $D_y$  and  $OC_z$  were conducted. The significance of moderating effects was examined by the  $F$ -test and  $t$ -test. Both the Pearson correlation analysis and the MMR analysis were performed using Statistical Package for Social Sciences (SPSS) – Version 17.0.

## **RESULTS AND DISCUSSIONS**

### ***Response rate and sample profiles***

218 valid responses were used representing a 36.3% response rate (refer to Table 4). This outcome is comparable with questionnaire surveys of this kind (Lam, et al., 2010). The study has attracted a reasonable response rate in comparison to other questionnaire surveys in the construction field normally ranging from 25% to 30% (Wong, et al., 2012a). Likewise, the response rate of the current research is similar to that of study related to carbon emissions conducted by Lam et al. (2010) (i.e. 100 responses out of 652 questionnaires being sent out or 15% of the response rate). Osmani et al. (2008) yielded a 40% response rate for similar studies given 40 out of 100 questionnaires were received. Both sample size and return rate of this survey study are considered acceptable.

A comparatively low response rate of 32.7% was obtained from the developers. The result is not atypical as with similar scholarly studies conducted by Dulaimi et al. (2003). However, this data characteristic should be considered when interpreting the findings. Furthermore, it also points to further research using a larger sample size to validate the current results.

It should be noted that more than 73% of the respondents have more than 10 years of project management experience. The creditability of the respondents is indicative of their service to the industry thus their responses are considered to be reflective to the industry's views.

<Table 5 here>

#### ***Correlations between drivers and adoption of strategies***

The results of Pearson correlation analysis indicate that the carbon tax (D1) has positive and significant correlation (at  $p < 0.05$  level) with the adoption of all the carbon reduction strategies (refer to Table 6). The results seem contrary to some forewarning from the construction professional institutes that they would merely pass the additional costs incurred by the carbon tax onto the real estate buyers without changing their operational practices (CIE, 2011). Boiral (2006) stressed that whether an organization would accept or resist new strategies adoption is dependent on the timing. When the policy was not clearly understood, most organizations 'tend to maintain the status quo and not react as long as they are not obliged to do so' (Boiral, 2006). This study was conducted after three months of the carbon tax becoming effective. It is generally believed that the carbon tax will bring a knock on

effect on the cost of construction materials and transportation. Moreover, reducing carbon in construction designs and operations may incur additional project costs that may subsequently erode profits (Spiegel and Meadows, 2010). However, to protect the corporate image and to respond to the market demands of greener products, construction organizations may still need to devise and adopt carbon reduction strategies (Spiegel and Meadows, 2010). The correlation results indicate that the effect of the carbon tax may have driven the construction organizations to work closely together to reduce carbon in construction operations.

Surprisingly, tightening regulations (D2) has a positive and significant correlation (at  $p < 0.01$  level) with the adoption of only two carbon reduction strategies, i.e. 'Reducing waste' [S10] ( $r$ -value=0.38), and 'Reducing emissions from the facility' [S12] ( $r$ -value=0.38). It has comparatively weak correlation with the adoption of the rest of the carbon reduction strategies (refer to Table 6). This may reflect that the respondents do not have a high regard for the effect of stringent building regulations on driving carbon reduction strategies adoption. The result seem to be incompatible with the government's presumption that tightening building regulations would prompt carbon reductions in construction operations (CIE, 2011; Wong, et al., 2012b). It is also contradictory to a similar study conducted by Reid *et al.* (2009) who found that tightening regulations would increase the likelihood that organizations will engage in new strategies adoption. However, the result coheres with some critics mentioning that the construction industry perceived green star ratings as a marketing tool under an assumption of

reduced utilities and better design (Lam, et al., 2010; Ren, et al., 2011; Wong, et al., 2012b).

In fact, the construction organizations may not be genuine in seeking low-carbon solutions to comply with the tightened regulations.

As such, the above results partly confirm Hypothesis H1 in which carbon tax (D1) was found as the driver that significantly correlated to the adoption of all the identified carbon reduction strategies.

<Table 6 here>

#### ***Moderating effect of carbon reduction drivers and OC***

Moderated regression analyses (MMR) were performed to validate hypotheses H2. This examination was conducted to investigate whether the interactions between the carbon reduction drivers and OC have a significant contribution to the adoption of carbon reduction strategies. If such an interaction effect is statistically significant, this would lead to a conclusion that the relationship between the carbon reduction drivers and strategies adoption might be energised by the culture of the construction organizations.

The F-test and t-test results suggest that 45 out of these 624 sets of MMR results have significant moderating effect. To save space and preserve clarity, only the results that showed the significant moderating effects are presented in Table 6. As an illustration, the effect of the 'carbon tax' (D1) on 'reducing the use of fuel in projects' (Strategy1) is perceived as contingent on 'How well the employees know what they need to do to succeed in the long



run' (GC1). The  $\Delta R^2$  value of 0.10 (Column A) and the F-value for  $\Delta R^2$  of 7.01 (Column B) are significant at  $p < 0.01$  level. The standardised coefficient value of the Predictor–Moderator product D1GC1 is 0.77 (Column C) at  $p < 0.01$ . The other 44 combinations with significant MMR results are also summarized in Table 7. As such, the hypothesis H2 is only partially supported.

<Table 7 here>

The results of Pearson correlation suggest that 'D2: Tightening regulations' alone may not induce the adoption of carbon reduction strategies. The MMR results further suggest that tightening regulations may not necessarily affect the adoption of carbon reduction strategies even if OC exists. These findings can be served as a cautionary note to the advocator of tightening regulations to engender behavioural change. Policies and stringent regulations implemented by governments are indispensable, as most building industry professionals will only adopt new practices if they are required by the regulations (Li and Colombier, 2009). However, behavioural change should be aligned with professional judgement. Indeed, many of the construction practitioners observed that complying with the tightening standards may result in greater carbon emissions because the local market does not adequately supply those required low-carbon products and materials (Wong et al. 2012). Importing these products to Australia consume carbon too. Interestingly, carbon emissions generated from imports are rarely carefully accounted in Australia. Notwithstanding, it is not suggested to coin such

findings as evidence for diminishing the effectiveness of tightening regulations in fostering carbon reduction strategies adoption. Government policies and instruments play a stimulating role in mitigating carbon emission (Li and Colombier, 2009). The MMR results indicate that out of the twelve strategies, ‘reducing wastes (S10)’ and ‘reducing emissions from the facility (S12)’ can be motivated by OC in some extent. The results befittingly indicates that, with a recognized set of guidelines, together with appropriate OC, organizations may be more aware of taking actions in response to the stringent building regulations. However, as the correlations between ‘Tightening regulations’ and the adoptions of the carbon reduction strategies are generally weak. Taking these correlation results into consideration it becomes less assertive to say that OC can effectively energize the driver –strategy adoption relationships.

It is worth noting that out of the 45 results that were detected to have significant moderating effects, 44 of them were reported to have significant correlations. The results indicate that with appropriate OC, the effect of carbon reduction drivers on the adoption of carbon reduction strategies can be further strengthened.

‘Carbon tax’ (D1) interacted effectively with OC in terms of GC, IO and RO to facilitate stronger correlations with the adoption of a wide range of carbon reduction strategies. It has been advocated that the carbon tax can be a driving force of carbon reduction in construction projects. However, a number of studies have already pointed out that construction

organizations may simply pass the additional cost driven from the carbon tax onto the end-users (CIE, 2011; Gustavsson and Sathre, 2006). Findings from this study indicate that despite the carbon tax possibly appearing as an unfavourable policy, this can be regarded as one of the effective means that motivate real carbon reduction actions. In particular, the results of the MMR analysis indicate that the effect of the carbon tax on carbon reduction strategies adoption can be energized by a Goal Clarity (GC), RO (Reward orientation) and IO (Innovation Orientation). The results echo the findings of Coffey (2002) that 'goal settings and accomplishment' is an important cultural factor that directs organizations moving towards behavioural change. With common goals to achieve, communication among employees becomes quicker and more effective, and resources would not be wasted to resolve internal conflicts.

Among the eight OC dimensions, RO and IO can be considered as positive cultural factors as suggested by Barney (1986). Construction has been prompted by the governments of different countries to transform into a low-carbon and environmentally responsible sector (HMGovernment, 2009; RAE, 2010; UNEPSBCI, 2009). To achieve this, organizations should develop a culture of rewarding employees for their contributions to reduce carbon in the construction operations. Based on a case study conducted in Switzerland, Hartmann (2006) identified three managerial actions that construction organizations can take to maintain staff involvement in and dedication to the change of operational practices: (1) establishing

reward and incentive schemes to recognize innovative staff ideas, (2) allowing staff to take reasonable risks for implementing innovative ideas in operations and (3) providing prompt and positive feedback on the staff proposals for innovative activities. Item (1) neatly brings our discussion to ‘Reward orientation’ as a critical cultural factor that motivates carbon reduction strategies adoption. Furthermore, construction organizations should also develop a culture of accepting innovative ideas in order to sustain their performance and competitive advantages. The findings of this study suggest that a shared value of treasuring innovation within an organization can significantly moderate the effect of carbon reduction drivers on the related strategies adoption. However, pragmatic solutions of carbon reduction usually come from the front line project team members. It should be aware that the top-down management structure in a typical construction project may easily drain away innovative ideas on carbon reduction (Cheung et al. 2012). In this regard, rewards from the developers may embody empowerment and acceptance of innovative ideas.

Based on the above findings, it is recommended that the construction organizations should:

- 1) unite in a common set of targets for reducing carbon emissions in construction operations. The results indicate that the carbon tax may induce adoption of carbon reduction strategies. However, carbon tax is a policy that does not entail any method that integrates carbon reduction strategies into operations. The MMR results of this study reveal that the construction organizations should firstly set carbon reduction as a

common project goal. Subsequently, pragmatic solutions should be devised for achieving the common goal.

- 2) rewarding innovative ideas that are conducive to carbon reduction. From the construction organizations' perspective, rewarding ideas in carbon reduction may incur additional project costs. However, such conventional mindsets may undermine innovative ideas that can strengthen the competitive edge of the organizations under a new market environment that demands sustainable solutions. Proper reward for carbon reduction ideas should be an integral part of the business.

### **LIMITATIONS AND THEIR IMPLICATIONS FOR FURTHER RESEARCH**

The findings of this study offered an avenue to interpret the impact of carbon reduction drivers on the adoption of strategies in behavioural perspectives. However, they should be taken within the context of several limitations. Firstly, the questionnaire survey reported in this study was conducted in the States of New South Wales and Victoria of Australia. Therefore, the results should be taken into context considering the geographical confines of this study.

Secondly, although 218 valid responses are considered reasonable for research of this kind, a larger number of replies are preferred. Using greater sample size for analyses and collecting

data from other countries would, therefore, be desirable in further studies. These should help identify whether cultural differences would have a significant impact on the research findings.

Thirdly, throughout the study, a seven point Likert scale was employed in the questionnaire survey to collect the perceptive views of respondents. Certain biases may exist in this survey, given that the responses were collected from persons holding key positions, like project managers, engineers, surveyors, etc., in construction organizations. However, as many of them have over 10 years of industry experience, the respondents should have sufficient knowledge about their company's practices to answer the questionnaire, which should increase the reliability of this study.

Fourthly, this survey study was conducted at a time when carbon tax had just been introduced in Australia. It can be understood that further studies may be needed to identify the full extent of the carbon tax and how carbon reduction is being approached. However considering the careful sampling process and experience of the respondents, the results can only be acknowledged as an intermediate snapshot as the influence of the carbon tax has yet to be realized.

Further research into this topic and perhaps a more comprehensive response rate in the years to come should further identify the full extent of the effectiveness of inputted measures as the buffering effect of the carbon tax fades and prices will begin to reflect the impact if at all, significant.

## CONCLUDING REMARKS

This study aims to examine the effect of the carbon tax and stringent building regulations for fostering carbon reduction strategies adoption in an OC perspective. The results of the Pearson correlation analysis partially support hypothesis H1. Carbon reduction strategies adoption is contingent on the carbon tax, however, not on the stringent building regulations. Furthermore, hypothesis H2 is partially supported as suggested by the results of the MMR analysis. Many studies perceived strategies adoption as an indubitable response to the carbon reduction policies. The results of this study indicate that such perceptions may hold especially when the carbon tax is viewed as a driver of carbon reduction. The perceptions may be valid on the assumption that OC in terms of GC, RO and IO are conducive to behavioural change.

Nevertheless, it is found that should OC exist, the effect of ‘tightening regulations’ on the adoption of carbon reduction strategies may not be motivated. Previous studies often urged construction organizations to adopt carbon reduction strategies in operations, disregarding the fact that the efforts made in behavioural change may not be adequately recognized and rewarded. Although our results do not explain how OC can direct construction organizations to make different decisions in face of different carbon reduction drivers, the results provide a potential avenue for further research on such a question. The findings aptly remind us that an introduction of a policy may not necessarily lead to the anticipated responses.

More research is needed, particularly relating to addressing the needs of the construction organizations to improve the practicality of policies implemented to induce carbon reduction in construction operations. As such, a mission drift of carbon reduction can be avoided if the policy makers can be more receptive of the difficulties being faced by construction organizations. On the other hand, the construction sector should also explain to the public the difficulties they may encounter during the transformation process. A best practice of strategies adoption cannot be established without establishing equilibrium among the diversified interest groups.

#### ACKNOWLEDGMENT

The authors are grateful for the reviewers' constructive comments that have made improvements of the manuscript.

#### REFERENCES

- Australian Bureau of Statistics (ABS). 2008. Australian systems of national account. ABS
- Acquaye AA, Duffy AP. 2010. Input-output analysis of Irish construction sector greenhouse gas emissions. *Building and Environment* 45(3): 784-791
- Ankrah NA, Langford DA. 2005. Architects and contractors: A comparative study of organizational cultures. *Construction Management and Economics* 23(6): 595-607
- Barney JB. 1986. Strategic Factor Markets: Expectations, Luck, and Business Strategy. *Management Science* 32(10): 1231-1241
- Baumgartner RJ, Zielowski C. 2007. Analyzing zero emission strategies regarding impact on organizational culture and contribution to sustainable development. *Journal of Cleaner Production* 15(13-14): 1321-1327



- Bettinger, C. 1989. Use corporate culture to trigger high performance, *Journal of Business Strategy*, 38-42.
- Boiral O. 2006. Global Warming: Should Companies Adopt a Proactive Strategy? *Long Range Planning* 39(3): 315-330
- Cameron KS, Quinn RE. 1999. *Diagnosing and changing organizational culture : based on the competing values framework* (1st ed.). Jossey-Bass: San Francisco, CA
- Chen J, Taylor JE, Wei H-H. 2012. Modeling building occupant network energy consumption decision-making: The interplay between network structure and conservation. *Energy and Buildings* 47(0): 515-524
- Cheng CWM, Liu AMM. 2007. The relationship of organizational culture and the implementation of total quality management in construction firms. *Surveying and Build Environment* 18(1): 7-16
- Cheung SO, Wong PSP, Lam LA. 2012. An investigation of the relationship between Organizational Culture and the Performance of Construction Organizations. *Journal of Business, Economics and Management* In press
- Cheung SO, Wong PSP, Wu AWY. 2011. Towards an organizational culture framework in construction. *International Journal of Project Management* 29(1): 33-44
- Choe JM. 2004. Impact of management accounting information and AMT on organizational performance. *Journal of Information Technology* 19(3): 203-214
- Centre for International Economics (CIE). 2011. Effects of a carbon price on the building and construction industry – prepared for Master Builder Australia. CIE.
- Coffey V. 2002. Assessing organizational culture? value management to the rescue. *Value Manager* 8(3): 6-13
- Cuéllar-Franca RM, Azapagic A. 2012. Environmental impacts of the UK residential sector: Life cycle assessment of houses. *Building and Environment* 54(0): 86-99
- Cummings LL, Bromiley P. 1996. The Organizational Trust Inventory In R Kramer, T Tyler (Eds.), *Trust in Organization: Frontier of Theory and Research*. Sage: Thousand Oaks
- Department of Climate Change and Energy Efficiency (DCCEE). 2011. Clean Energy Act 2011. In A Department of Climate Change and Energy Efficiency (DCCEE) (Ed.):
- Deane F. 2011. A new legal avenue for pricing GHG emissions? To trade or to tax? 28(2): 111-133
- Denison D. 1990. *Corporate Culture and Organizational Effectiveness*. Wiley: New York
- Dulaimi MF, Ling FYY, Bajracharya A. 2003. Organizational motivation and inter-organizational interaction in construction innovation in Singapore. *Construction Management and Economics* 21(3): 307-318
- European Network of Construction Companies for Research and Development (ENCORD). 2010. Construction CO2 Measurement Protocol (First Issue Rev K). ENCORD

- Fieldson RaR, Deepak and Sodagar, Behzad. 2009. Towards a framework for early estimation of lifecycle carbon footprinting of buildings in the UK. *Construction Information Quarterly* 11(2): 66-75
- Green Building Council Australia (GBCA). 2012. Green Star Rating Tools. Green Building Council Australia (GBCA): Sydney
- González MJ, García Navarro J. 2006. Assessment of the decrease of CO<sub>2</sub> emissions in the construction field through the selection of materials: Practical case study of three houses of low environmental impact. *Building and Environment* 41(7): 902-909
- Global Reporting Initiative (GRI). 2011. Sustainability reporting guidelines and construction and real estate sector supplement:
- Gustavsson L, Sathre R. 2006. Variability in energy and carbon dioxide balances of wood and concrete building materials. *Building and Environment* 41(7): 940-951
- Harkink E, Tjihuis, Wilco. 2006. Innovation strategy: choosing a central and decentral approach in construction business. In M Dulaimi (Ed.), *The Joint International Conference on Construction Culture, Innovation and Management (CCIM)*: 10-12. The British University in Dubai: Dubai, UAE
- Hartmann A. 2006. The role of organizational culture in motivating innovative behaviour in construction firms. *Construction Innovation* 6(3): 159-172
- HM Government. 2009. The UK low carbon industrial strategy. In IAS Department of Business, Department of Energy and Climate Change (Ed.). HM Government, United Kingdom
- Hofstede G. 1983 The Cultural Relativity of Organizational Practices and Theories. *Journal of International Business Studies* 14(2): 75-89
- Horne R, Hayles C. 2008. Towards global benchmarking for sustainable homes: An international comparison of the energy performance of housing. *Journal of Housing and the Built Environment* 23(2): 119-130
- Iyer-Raniga U, Wong JPC. 2012. Evaluation of whole life cycle assessment for heritage buildings in Australia. *Building and Environment* 47(1): 138-149
- Jaccard J, Turrisi R. 2003. *Interaction effects in multiple regression*. Sage Publications: Thousand Oaks, Calif
- Jiang MP, Tovey K. 2010. Overcoming barriers to implementation of carbon reduction strategies in large commercial buildings in China. *Building and Environment* 45(4): 856-864
- Lam PTI, Chan EHW, Poon CS, Chau CK, Chun KP. 2010. Factors affecting the implementation of green specifications in construction. *Journal of Environmental Management* 91(3): 654-661
- Li J, Colombier M. 2009. Managing carbon emissions in China through building energy efficiency. *Journal of Environmental Management* 90(8): 2436-2447

- Liu AMM. 1999. Culture in the Hong Kong real-estate profession: A trait approach. *Habitat International* 23(3): 413-425
- Maloney WF., Deferle MO. 1991. Organizational culture and management. . *Journal of Management in Engineering*, ASCE 7(1): 43-57
- Master Builders Australia (MBA). 2011. Official webpage of Master Builder Australia:
- McNamara C. 1999. Organizational Culture, available at: [http://www.mapnp.org/library/org\\_thry/culture/culture.htm](http://www.mapnp.org/library/org_thry/culture/culture.htm) (accessed 2 July 2003).
- National Australian Built Environment Rating System (NABERS). 2012. About National Australian Built Environment Rating System (NABERS). NABERS: Sydney
- Osmani M, Glass J, Price ADF. 2008. Architects' perspectives on construction waste reduction by design. *Waste Management* 28(7): 1147-1158
- Ozorhon B, Arditi D, Dikmen I, Birgonul MT. 2008. Implications of culture in the performance of international construction joint ventures. *Journal of Construction Engineering and Management* 134(5): 361-370
- Parag Y, Darby S. 2009. Consumer-supplier-government triangular relations: Rethinking the UK policy path for carbon emissions reduction from the UK residential sector. *Energy Policy* 37(10): 3984-3992
- Peters TJ, Waterman RH. 2004. *In search of excellence: lessons from America's best-run companies*. HarperBusiness Essentials: New York
- RAE TRAOE. 2010. *Engineering a low carbon built environment – the discipline of building engineering physics*. The Royal Academy of Engineering (RAE) London
- Reid EM, Toffel MW. 2009. Responding to public and private politics: corporate disclosure of climate change strategies. *Strategic Management Journal* 30(11): 1157-1178
- Ren Z, Chen Z, Wang X. 2011. Climate change adaptation pathways for Australian residential buildings. *Building and Environment* 46(11): 2398-2412
- Sathre R, Gustavsson L. 2007. Effects of energy and carbon taxes on building material competitiveness. *Energy and Buildings* 39(4): 488-494
- Schein EH. 1985. *Organizational culture and leadership: A dynamic view*. Jossey-Bass, San Francisco, USA.
- Schleich J, Rogge K, Betz R. 2009. Incentives for energy efficiency in the EU Emissions Trading Scheme. *Energy Efficiency* 2(1): 37-67
- Singer SF. 2009. A climate bill that does nothing for the climate, *inFocus: Environment*, Vol. 3: 4-6
- Skopek J. 1999. *BREEAM strategy for reducing buildings' environmental impact*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc
- Spiegel R, Meadows D (Eds.). 2010. *Green Building Materials: A Guide to Product Selection and Specification* (3rd ed.). John Wiley & Sons, Inc.: New York

- United Nations Environmental Programme Sustainable Buildings and Climate Initiative (UNEPBCI). 2009. Buildings and climate change – summary for decision-makers. UNEP SBCI
- Wong PSP, Cheung SO, Leung KY. 2008. Moderating effect of organizational learning type on performance improvement. *Journal of Management in Engineering* 24(3): 162-172
- Wong PSP, Cheung SO, Yiu RLY, Hardie M. 2012a. The unlearning dimension of organizational learning in construction projects. *International Journal of Project Management* 30(1): 94-104
- Wong PSP, Lacarruba N, Bray A. 2012b. Can carbon tax push the Australian construction sector towards self-regulation? – Lessons learned from the European Union experiences. *Journal of Legal Affairs and Dispute Resolution*, ASCE Article in press
- Yiu TW, Cheung SO, Cheung CH. 2007. Toward a typology of construction mediator tactics. *Building and Environment* 42(6): 2344-2359
- Zhang SB, Liu AMM. 2006. Organizational culture profiles of construction enterprises in China. *Construction Management and Economics* 24(8): 817-828
- Zuo J, Read B, Pullen S, Shi Q. 2012. Achieving carbon neutrality in commercial building developments – Perceptions of the construction industry. *Habitat International* 36(2): 278-286

**Re: BAE3408**

**Responses to the Data Administrator**

1. To ensure that we process your article correctly, please complete the publishing forms  
Authors' Response: The publishing form has been completed.
  
2. We have received the above-mentioned article for publication; however, the following references are uncited: Cheng and Liu, 2007; Cummings and Bromiley, 1996; Harkink and Tijhuis, 2006; Ozorhon et al., 2008.  
Authors' Response: Cheng and Liu, 2007; Cummings and Bromiley, 1996; Harkink and Tijhuis, 2006; Ozorhon et al., 2008 are deleted from the revised reference list as attached.
  
3. Please introduce appropriate citations in the article. The following references are unmatched: Ozorhon et al. 2006, Cheung et al. 2013, Peters and Waterman 1982. Please provide corresponding references.  
Authors' Response:  
Please delete Ozorhon et al. 2006 from the submitted manuscript.  
Please revise Cheung et al. 2013 to Cheung et al. 2012 from the submitted manuscript.  
Please revise Peters and Waterman 1982 to Peters and Waterman 2004 from the submitted manuscript.
  
4. The Title Page for your paper is not included. Please provide a Title Page for your manuscript that contains the following information: full title, all authors and their affiliations, complete contact information for the corresponding author.  
  
Authors' Response: The title page is attached in this reply.

**REVISED REFERENCE LIST**

- Australian Bureau of Statistics (ABS). 2008. Australian systems of national account. ABS
- Acquaye AA, Duffy AP. 2010. Input-output analysis of Irish construction sector greenhouse gas emissions. *Building and Environment* 45(3): 784-791
- Ankrah NA, Langford DA. 2005. Architects and contractors: A comparative study of organizational cultures. *Construction Management and Economics* 23(6): 595-607
- Barney JB. 1986. Strategic Factor Markets: Expectations, Luck, and Business Strategy. *Management Science* 32(10): 1231-1241
- Baumgartner RJ, Zielowski C. 2007. Analyzing zero emission strategies regarding impact on organizational culture and contribution to sustainable development. *Journal of Cleaner Production* 15(13-14): 1321-1327
- Bettinger, C. 1989. Use corporate culture to trigger high performance, *Journal of Business Strategy*, 38-42.
- Boiral O. 2006. Global Warming: Should Companies Adopt a Proactive Strategy? *Long Range Planning* 39(3): 315-330
- Cameron KS, Quinn RE. 1999. *Diagnosing and changing organizational culture : based on the competing values framework* (1st ed.). Jossey-Bass: San Francisco, CA
- Chen J, Taylor JE, Wei H-H. 2012. Modeling building occupant network energy consumption decision-making: The interplay between network structure and conservation. *Energy and Buildings* 47(0): 515-524
- Cheung SO, Wong PSP, Lam LA. 2012. An investigation of the relationship between Organizational Culture and the Performance of Construction Organizations. *Journal of Business, Economics and Management* In press
- Cheung SO, Wong PSP, Wu AWY. 2011. Towards an organizational culture framework in construction. *International Journal of Project Management* 29(1): 33-44
- Choe JM. 2004. Impact of management accounting information and AMT on organizational performance. *Journal of Information Technology* 19(3): 203-214
- Centre for International Economics (CIE). 2011. Effects of a carbon price on the building and construction industry – prepared for Master Builder Australia. CIE.
- Coffey V. 2002. Assessing organizational culture? value management to the rescue. *Value Manager* 8(3): 6-13
- Cuéllar-Franca RM, Azapagic A. 2012. Environmental impacts of the UK residential sector: Life cycle assessment of houses. *Building and Environment* 54(0): 86-99
- Department of Climate Change and Energy Efficiency (DCCEE). 2011. Clean Energy Act 2011. In A Department of Climate Change and Energy Efficiency (DCCEE) (Ed.):
- Deane F. 2011. A new legal avenue for pricing GHG emissions? To trade or to tax? 28(2): 111-133

- Denison D. 1990. *Corporate Culture and Organizational Effectiveness*. Wiley: New York
- Dulaimi MF, Ling FYY, Bajracharya A. 2003. Organizational motivation and inter-organizational interaction in construction innovation in Singapore. *Construction Management and Economics* 21(3): 307-318
- European Network of Construction Companies for Research and Development (ENCORD). 2010. Construction CO2 Measurement Protocol (First Issue Rev K). ENCORD
- Fieldson RaR, Deepak and Sodagar, Behzad. 2009. Towards a framework for early estimation of lifecycle carbon footprinting of buildings in the UK. *Construction Information Quarterly* 11(2): 66-75
- Green Building Council Australia (GBCA). 2012. Green Star Rating Tools. Green Building Council Australia (GBCA): Sydney
- González MJ, García Navarro J. 2006. Assessment of the decrease of CO2 emissions in the construction field through the selection of materials: Practical case study of three houses of low environmental impact. *Building and Environment* 41(7): 902-909
- Global Reporting Initiative (GRI). 2011. Sustainability reporting guidelines and construction and real estate sector supplement:
- Gustavsson L, Sathre R. 2006. Variability in energy and carbon dioxide balances of wood and concrete building materials. *Building and Environment* 41(7): 940-951
- Hartmann A. 2006. The role of organizational culture in motivating innovative behaviour in construction firms. *Construction Innovation* 6(3): 159-172
- HM Government. 2009. The UK low carbon industrial strategy. In IaS Department of Business, Department of Energy and Climate Change (Ed.). HM Government, United Kingdom
- Hofstede G. 1983 The Cultural Relativity of Organizational Practices and Theories. *Journal of International Business Studies* 14(2): 75-89
- Horne R, Hayles C. 2008. Towards global benchmarking for sustainable homes: An international comparison of the energy performance of housing. *Journal of Housing and the Built Environment* 23(2): 119-130
- Iyer-Raniga U, Wong JPC. 2012. Evaluation of whole life cycle assessment for heritage buildings in Australia. *Building and Environment* 47(1): 138-149
- Jaccard J, Turrisi R. 2003. *Interaction effects in multiple regression*. Sage Publications: Thousand Oaks, Calif
- Jiang MP, Tovey K. 2010. Overcoming barriers to implementation of carbon reduction strategies in large commercial buildings in China. *Building and Environment* 45(4): 856-864
- Lam PTI, Chan EHW, Poon CS, Chau CK, Chun KP. 2010. Factors affecting the implementation of green specifications in construction. *Journal of Environmental Management* 91(3): 654-661
- Li J, Colombier M. 2009. Managing carbon emissions in China through building energy efficiency. *Journal of Environmental Management* 90(8): 2436-2447

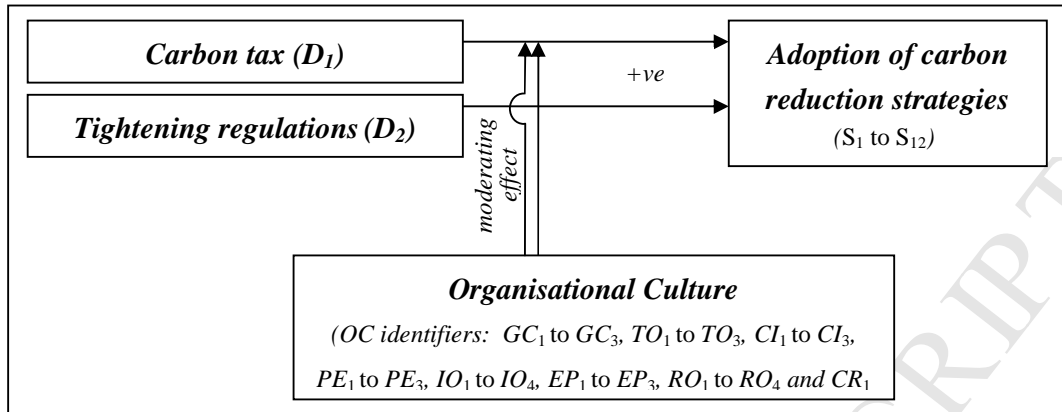


- Liu AMM. 1999. Culture in the Hong Kong real-estate profession: A trait approach. *Habitat International* 23(3): 413-425
- Maloney WF., Deferle MO. 1991. Organizational culture and management. . *Journal of Management in Engineering*, ASCE 7(1): 43-57
- Master Builders Australia (MBA). 2011. Official webpage of Master Builder Australia:
- McNamara C. 1999. Organizational Culture, available at: [http://www.mapnp.org/library/org\\_thry/culture/culture.htm](http://www.mapnp.org/library/org_thry/culture/culture.htm) (accessed 2 July 2003).
- National Australian Built Environment Rating System (NABERS). 2012. About National Australian Built Environment Rating System (NABERS). NABERS: Sydney
- Osmani M, Glass J, Price ADF. 2008. Architects' perspectives on construction waste reduction by design. *Waste Management* 28(7): 1147-1158
- Parag Y, Darby S. 2009. Consumer-supplier-government triangular relations: Rethinking the UK policy path for carbon emissions reduction from the UK residential sector. *Energy Policy* 37(10): 3984-3992
- Peters TJ, Waterman RH. 2004. *In search of excellence: lessons from America's best-run companies*. HarperBusiness Essentials: New York
- RAE TRAoE. 2010. *Engineering a low carbon built environment – the discipline of building engineering physics*. The Royal Academy of Engineering (RAE) London
- Reid EM, Toffel MW. 2009. Responding to public and private politics: corporate disclosure of climate change strategies. *Strategic Management Journal* 30(11): 1157-1178
- Ren Z, Chen Z, Wang X. 2011. Climate change adaptation pathways for Australian residential buildings. *Building and Environment* 46(11): 2398-2412
- Sathre R, Gustavsson L. 2007. Effects of energy and carbon taxes on building material competitiveness. *Energy and Buildings* 39(4): 488-494
- Schein EH. 1985. *Organizational culture and leadership: A dynamic view*. Jossey-Bass, San Francisco, USA.
- Schleich J, Rogge K, Betz R. 2009. Incentives for energy efficiency in the EU Emissions Trading Scheme. *Energy Efficiency* 2(1): 37-67
- Singer SF. 2009. A climate bill that does nothing for the climate, *inFocus: Environment*, Vol. 3: 4-6
- Skopek J. 1999. *BREEAM strategy for reducing buildings' environmental impact*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc
- Spiegel R, Meadows D (Eds.). 2010. *Green Building Materials: A Guide to Product Selection and Specification* (3rd ed.). John Wiley & Sons, Inc.: New York
- United Nations Environmental Programme Sustainable Buildings and Climate Initiative (UNEPBCI). 2009. Buildings and climate change – summary for decision-makers. UNEP SBCI



- Wong PSP, Cheung SO, Leung KY. 2008. Moderating effect of organizational learning type on performance improvement. *Journal of Management in Engineering* 24(3): 162-172
- Wong PSP, Cheung SO, Yiu RLY, Hardie M. 2012a. The unlearning dimension of organizational learning in construction projects. *International Journal of Project Management* 30(1): 94-104
- Wong PSP, Lacarruba N, Bray A. 2012b. Can carbon tax push the Australian construction sector towards self-regulation? – Lessons learned from the European Union experiences. *Journal of Legal Affairs and Dispute Resolution*, ASCE Article in press
- Yiu TW, Cheung SO, Cheung CH. 2007. Toward a typology of construction mediator tactics. *Building and Environment* 42(6): 2344-2359
- Zhang SB, Liu AMM. 2006. Organizational culture profiles of construction enterprises in China. *Construction Management and Economics* 24(8): 817-828
- Zuo J, Read B, Pullen S, Shi Q. 2012. Achieving carbon neutrality in commercial building developments – Perceptions of the construction industry. *Habitat International* 36(2): 278-286

## FIGURES



**Figure 1:** Conceptual model about the relationships among carbon reduction drivers, organizational culture and adoption of carbon reduction strategies

Q1.1	Your working experience in the construction field:	a: <5 years c: 11-15 years e: >20 years	b: 5-10 years d: 16-20 years
Q1.2	No. of employees in your company	a: <20 c: 51-100	b: 21-50 d: >100
With reference to one construction <b>project</b> that you have been (either fully or partly: involved for at least 1 year and provide the following particulars:			
Q1.3	Project nature	1) Residenti al	2) Office/Amenitie s
Q1.4	Project Sum (\$,000s) (optional)	a: <5,000 c: >20,000	b: 5,000-20,000
Q1.5	Project Name :	_____	
<b>Part 2- Carbon reduction drivers</b>			
During the <i>project</i> as stated in Q1.5, the following drive your company to reduce carbon emission:			
(1 = Disagree strongly, 7= Agree strongly)			
Q2.1	) <i>Refer to the operational statements as shown in Table 1</i>	1	2 3 4 5 6 7
Q2.2	)	1	2 3 4 5 6 7
<b>Part 3- Adoption of carbon reduction strategies</b>			
During the <i>project</i> as stated in Q1.5, your company adopted the following strategies to reduce carbon emissions			
(1 = Disagree strongly, 7= Agree strongly)			
Q3.1	)	1	2 3 4 5 6 7
Q3.2	)	1	2 3 4 5 6 7
⋮	) <i>Refer to the operational statements as shown in Table 1</i>	⋮	
Q3.12	)	1	2 3 4 5 6 7
<b>Part 4- Measure of organizational culture</b>			
During the <i>project</i> stated in Q1.5, the following statements represent the organizational culture of your company:			
(1 = Disagree strongly, 7= Agree strongly)			
Q4.1	)	1	2 3 4 5 6 7
Q4.2	)	1	2 3 4 5 6 7
⋮	) <i>Refer to the operational statements as shown in Table 1</i>	⋮	
Q4.26	)	1	2 3 4 5 6 7

**Figure 2:** The sample questionnaire

**TABLES**

<i>Carbon Reduction Drivers</i>	<i>Respective Operational Statements</i>	<i>References</i>				
		<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>
Carbon tax [D1]	The introduction of carbon tax or similar policy that induce cost for carbon emission	*				*
Tightening regulations [D2]	The more stringent building regulations disapprove works that cannot attain the energy efficiency rating / standards	*	*	*	*	*

*References: (A)(Sathre et al., 2007); (B)(Schleich et al., 2009); (C)(Acquaye et al., 2010); (D)(HMGovernment, 2009); (E) (UNEPSBCI, 2009)*

**Table 1:** Drivers of carbon reduction

<i>Carbon Reduction Strategies</i>	<i>Respective Operational Statements</i>
Reducing fuel (project) [S1]	Reduce fuel for plants and machinery in use on site
Reducing fuel (premises) [S2]	Reduce fuel for use in premises which support the company's activities (i.e. offices and godowns)
Reducing process emissions [S3]	Reduce carbon emissions from physical and chemical processing involved in the production of mineral products (such as cements) and metal products (such as steel)
Reducing electricity (project) [S4]	Reduce electricity for plants and machinery in use on site
Reducing electricity (premises) [S5]	Reduce electricity for use in premises which support the company's activities (i.e. offices and godowns)
Reducing imported heat [S6]	Reduce heat purchased by the company for use at the company's project and premises
Reducing vehicle fuel [S7]	Reduce the use of vehicles travelling on public highways
Reducing the use of public transport [S8]	Reduce the use of public transports by the employees
Monitoring sub-contractors [S9]	Coordinate with sub-contractors at project level to achieve items 1 to 8
Reducing wastes [S10]	Reduce construction wastes and the associated transportation for disposal
Reducing high embodied CO <sub>2</sub> materials [S11]	Reduce the use of materials with high embodied CO <sub>2</sub> like structural steel concrete, reinforcement, cladding, aggregates and bituminous products
Reducing emissions from the facility [S12]	Reduce carbon emissions resulting from the built object through better design

**Table 2:** Carbon reduction strategies proposed by the ENCORD (modified from (ENCORD, 2010))

<i>Behavioural Dimensions of Organizational Culture (OC)</i>	<i>OC operational statements</i>	<i>References</i>										
		<i>A</i>	<i>C</i>	<i>D</i>	<i>E</i>	<i>F</i>	<i>G</i>	<i>H</i>	<i>J</i>	<i>K</i>		
<b>Goal Clarity (GC)</b>	How well the employees know what they need to do to succeed in the long run ( <b>GC1</b> )	*	*				*	*	*	*	*	
	The extent to which organization's goals is reasonably and clearly set with regular reviews ( <b>GC2</b> )	*	*			*	*	*	*	*	*	
	The extent to which employees' effort is directed to accomplish the organizations' goal ( <b>GC3</b> )	*	*			*	*	*	*	*	*	
<b>Coordination and Integration (CI)</b>	The effectiveness of resolving problems between departments ( <b>CI1</b> )	*	*	*	*	*	*	*	*	*	*	
	The extent to which sharing of information between departments is encouraged ( <b>CI2</b> )	*	*	*	*	*	*	*	*	*	*	
	The extent to which cooperation and assistance across department is encouraged ( <b>CI3</b> )	*	*	*	*	*	*	*	*	*	*	
<b>Conflict Resolution (CR)</b>	The extent to which the employees accept criticism or negative feedback without becoming defensive ( <b>CR1</b> )				*					*	*	
	The extent to which the employees are encouraged to share the responsibility of things that go wrong in their work group ( <b>CR2</b> )				*					*	*	
	The atmosphere of trust in this organization ( <b>CR3</b> )				*					*	*	
<b>Employee Participation (EP)</b>	The extent to which employees are encouraged to have some input on decisions that affect their work ( <b>EP1</b> )	*	*				*	*	*	*	*	
	The extent to which organizations allow employees to participate in the decision-making process ( <b>EP2</b> )	*	*				*	*	*	*	*	
	The extent to which employees are consulted in respect of decisions regarding what the organization plans to do ( <b>EP3</b> )	*	*				*	*	*	*	*	
<b>Innovation Orientation (IO)</b>	The extent to which the organization helps employees to obtain the resources necessary to implement their innovative ( <b>IO1</b> )	*	*			*				*	*	
	The extent to which the employees are encouraged to search for better ways of getting the job done ( <b>IO2</b> )	*	*			*	*			*	*	
	The extent to which the employees are encouraged to be creative and innovative ( <b>IO3</b> )	*								*	*	
	The willingness of the organization to take reasonable risk in response to changes of business environment. ( <b>IO4</b> )	*				*				*	*	
<b>Performance Emphasis (PE)</b>	The extent to which the employees are coached to improve their skills so they can achieve higher levels of performance ( <b>PE1</b> )	*	*	*			*	*	*	*	*	
	The establishment of a set of performance standards for employees ( <b>PE2</b> )	*	*	*			*	*	*	*	*	
	The extent to which the organization emphasizes on delivering products with good quality ( <b>PE3</b> )	*	*	*			*	*	*	*	*	
<b>Reward Orientation (RO)</b>	The extent to of equitable rewards ( <b>RO1</b> )	*					*	*	*	*	*	
	The level of which performance appraisals are used as the basis to reward employees ( <b>RO2</b> )	*					*	*	*	*	*	
	The level of which emphasis is placed on rewarding employees for success rather than punishing them for failure ( <b>RO3</b> )	*					*	*	*	*	*	
	The extent which the employees are adequately recognized and rewarded ( <b>RO4</b> )	*					*	*	*	*	*	
<b>Team Orientation (TO)</b>	The extent to which the organization emphasizes on team contributions rather than individual contributions ( <b>TO1</b> )		*	*			*			*	*	
	The extent to which the organizations emphasizing on building cohesive, committed teams of people ( <b>TO2</b> )		*	*			*			*	*	
	The extent to which members work as a team and exchange opinions and ideas ( <b>TO3</b> )		*	*			*			*	*	

References: (A) Peters and Waterman 1982; (B) Bettinger 1989; (C) Cameron and Quinn 1999; (D) Denison 1990; (E) Hofstede 1983; (F) Coffey 2002; (G) Ankras and Langford 2005; (H) Zhang and Liu 2006; (J) Cheung et al. 2011; (K) Cheung et al. 2012

**Table 3:** Identifiers and operational statements of OC

<i>Sample group</i>	<i>Questionnaires sent (No.)</i>	<i>Questionnaires received (No.)</i>	<i>Response rate (%)</i>
<b>Developers and Consultants</b>	300	96	32.0%
<b>Construction Contractors</b>	300	122	40.7%
<b>Total</b>	600	218	36.3%

**Table 4:** Questionnaires sent and received

<i>Working experience</i>	<i>No. of respondents</i>	<i>%</i>
Below 5 years	19	8.7
5 to 10 years	38	17.4
11-15 years	56	25.7
16-20 years	62	28.4
Over 20 years	43	19.7
Total	218	100

**Table 5:** Respondents' working experience



	Carbon tax [D1]	Tightening regulations [D2]
Reducing fuel (project) [S1]	.52*	.30
Reducing fuel (premises) [S2]	.52*	.32
Reducing process emissions [S3]	.58*	.31
Reducing electricity (project) [S4]	.56*	.21
Reducing electricity (premises) [S5]	.60*	.24
Reducing imported heat [S6]	.51*	.27
Reducing vehicle fuel [S7]	.48*	.26
Reducing the use of public transport [S8]	.50*	.21
Monitoring sub-contractors [S9]	.48*	.20
Reducing wastes [S10]	.62*	.38*
Reducing high embodied CO <sub>2</sub> materials [S11]	.60*	.30
Reducing emissions from the facility [S12]	.64*	.38*

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

**Table 6:** Correlation between the carbon reduction drivers and the organization's adoption of carbon reduction strategies

Variables of the MMR Analysis				(A)	(B)	(C)		
Dependent (S <sub>x</sub> )	Predictor (D <sub>y</sub> )	Moderator (OC <sub>z</sub> )	Predictor–Moderator product (D <sub>y</sub> OC <sub>z</sub> )	$\Delta R^2$	F-value for $\Delta R^2$	Sig.	Std. coefficient of variable D <sub>y</sub> OC <sub>z</sub>	Sig.
S1	D1	GC1	D1 x GC1	0.04	7.01	**	0.77	**
S1	D1	GC2	D1 x GC2	0.05	7.74	**	0.76	**
S1	D1	RO4	D1 x RO4	0.05	6.60	*	0.79	*
S2	D1	GC1	D1 x GC1	0.04	5.47	*	0.68	*
S2	D1	GC2	D1 x GC2	0.05	7.21	**	0.73	**
S2	D1	RO4	D1 x RO4	0.04	5.80	*	0.75	*
S3	D1	GC2	D1 x GC2	0.03	4.21	*	0.58	*
S3	D1	RO2	D1 x RO2	0.04	5.44	*	0.90	*
S3	D1	RO4	D1 x RO4	0.05	6.33	*	0.78	*
S3	D1	CR1	D1 x CR1	0.04	4.62	*	0.77	*
S4	D1	GC1	D1 x GC1	0.04	5.40	*	0.68	*
S5	D1	GC1	D1 x GC1	0.03	4.05	*	0.60	*
S5	D1	GC2	D1 x GC2	0.05	5.49	*	0.94	*
S7	D1	IO3	D1 x IO3	0.04	5.30	*	0.82	*
S7	D1	GC1	D1 x GC1	0.04	4.78	*	0.72	*
S7	D1	GC2	D1 x GC2	0.04	5.55	*	0.82	*
S7	D1	GC3	D1 x GC3	0.05	6.86	**	0.88	**
S7	D1	IO1	D1 x IO1	0.05	6.16	*	0.85	*
S7	D1	IO2	D1 x IO2	0.03	3.95	*	0.73	*
S7	D1	IO3	D1 x IO3	0.08	10.36	**	1.23	**
S7	D1	IO4	D1 x IO4	0.04	4.96	*	0.88	*
S8	D1	GC1	D1 x GC1	0.05	5.39	*	0.92	*
S8	D1	GC2	D1 x GC2	0.07	8.03	**	1.01	**
S8	D1	GC3	D1 x GC3	0.08	8.96	**	1.10	**
S8	D1	IO1	D1 x IO1	0.05	5.41	*	1.16	*
S8	D1	IO2	D1 x IO2	0.06	6.47	*	0.96	*
S8	D1	IO3	D1 x IO3	0.13	15.76	**	1.56	**
S8	D1	TO1	D1 x TO1	0.06	6.89	**	1.07	**
S8	D1	RO1	D1 x IO1	0.05	5.60	*	0.80	*
S8	D1	RO2	D1 x IO2	0.04	4.70	*	0.79	*
S8	D1	RO3	D1 x IO3	0.05	5.56	*	0.82	*
S8	D1	RO4	D1 x IO4	0.09	10.81	**	1.14	**
S9	D1	GC3	D1 x GC3	0.04	3.96	*	1.00	*
S9	D1	RO3	D1 x RO3	0.05	5.88	*	0.76	*
S10	D1	GC2	D1 x GC2	0.05	5.25	*	0.68	*
S10	D1	GC3	D1 x GC3	0.04	4.68	*	0.86	*
S11	D1	GC1	D1 x GC1	0.04	4.31	*	0.83	*
S11	D1	IO3	D1 x IO3	0.05	5.34	*	1.15	*
S12	D1	GC3	D1 x GC3	0.09	10.13	**	1.49	**
S12	D1	RO1	D1 x RO1	0.04	4.14	*	0.83	*
S10	D2	GC1	D3 x GC1	0.08	8.87	**	1.44	**
S10	D2	IO1	D3 x IO1	0.06	6.82	*	1.09	*
S10	D2	IO2	D3 x IO2	0.04	4.00	*	0.92	*
S12	D2	RO3	D3 x RO3	0.04	4.08	*	0.74	*
S12	D2	IO2	D3 x IO2	0.04	3.98	*	1.10	*

Remarks: \*  $\rho < .05$  (one-tailed), \*\*  $\rho < .01$  (two-tailed)

**Table 7:** Results of the MMR Analyses