AN EVALUATION OF CONSTRUCTION SPEED PERFORMANCE FOR BUILDING PROJECTS IN UK AND GERMANY

ONUR DURSUN
University of Stuttgart, Institute of Construction Economics
Keplerstraße 11, 70174, Stuttgart, Germany
onur.dursun@bauoekonomie.uni-stuttgart.de

CHRISTIAN STOY
University of Stuttgart, Institute of Construction Economics
Keplerstraße 11, 70174, Stuttgart, Germany
christian.stoy@bauoekonomie.uni-stuttgart.de

Abstract

It is aimed to design a study that facilitates a fair comparison of construction speed performance for residential and office developments in UK and Germany. The definitions of the populations are restricted hence there is a necessity to construct a common basis for two different data sets. Subsequent to data base filtering, random sampling was performed via computer algorithm and 200 observations from each location were retained in the samples. Available quantitative variables were utilized to create factors and the response variable. 2 sample t-test was designed to test the group differences between two samples resulted in no substantial variation exists between population means. Limitations applied to 2 sample t-test forms a motivation for further investigation and in this context a factorial study is designed. This enables to observe the effect of not only the location factor but also the hypothesized factors that may influence the mean response. The analysis yielded that project location causes a significant variation in the mean response when factors regarding facility, standard and height are taken into account. Consistent with the complexities involve in construction projects, it is concluded that neglecting the effect of construction speed related factors and only taking project location into account would not be an appropriate approach for a post ex facto research where observations can not be controlled.

Keywords: Construction speed performance; 2 sample t-test; factorial design; international benchmark.

INTRODUCTION

As of January 1993, the Single European Market, which enables the end of trade barriers, a relaxation of customs regulations and free movement within the European Union (EU), was introduced (Proverbs *et al.*, 1998). Consequently, competition of the counterpart sectors in EU roses. In a time of globalisation and an increasingly competitive environment, measuring performance has become critical to business success, spread to many industries including construction (Bassioni *et al*., 2004). Current statistics presents EU construction investments has reached to 1,173 billion C which corresponds to 9.9% of GDP in EU (FIEC, 2009). The figure demonstrates that the industry is too important to be allowed to stagnate (Egan, 1998).
The construction industry is project oriented where each project is referred to be as unique (Ofori, 1990). Although similar production methods and sequences are employed in every project, each project is considered as a prototype (Wegelius-Lehtonen, 2001). Therefore, performance measurements mostly focus on factors associated with project levels rather than organisational ones (Love & Holt, 2000; Kagioglou *et al*., 2001). In today’s fast paced construction environment, the clients stipulate for fast track construction in order to enhance

their competitive positions by entering the market first and capitalise high profitability until other rivals penetrate the market (Kog *et al.*, 1999). To contractors increased construction speed enhances the profitability and provides competitive advantage, too (Walker, 1995). In addition, ability of constructing faster and completing projects on time objectively reflects the capacity to organise and control site operations, to optimally allocate resources and to manage the information flow between design team and among subcontractors (Murray, 2003).

In this context, it would be a valuable contribution to evaluate and benchmark one of the key performance indicators, construction speed, between Germany and UK based on projects executed during the last three decades. Although international alterations involve in construction industry such as economical, cultural, and environmental as well as industry specific ambiguities make comparisons arduous, conducting a comparison is not impossible (Xiao & Proverbs, 2002). An intervention study was designed aims at determining group differences between two locations. In addition, it is aimed to assess the variations in construction speed influenced by not only the location but also the other factors that were established by theory and intuition.

THEORETICAL BACKGROUND

Construction speed was utilized as a response variable by Love *et al.* (2005); Stoy *et al.* (2007). While Stoy *et al.* (2007) defines the term as executed gross floor area per month, Love *et al.* (2005) describes it as the time necessary to execute a unit gross floor area. This study adopts the definition provided by Stoy *et al.* (2007). The review of the literature reported many studies intended to determine the factors affecting construction time performance and/or to provide predictive models (e.g.(Bromilow, 1974; Ireland, 1985; Walker, 1995; Kumaraswamy & Chan, 1995; Love *et al.*, 2005; Stoy *et al.*, 2007)). The findings of relevant studies indicated numerous factors including project level macro factors such as construction cost and gross floor area (Chan & Kumaraswamy, 1995), number of storeys (Ireland, 1985; Love *et al.*, 2005), project location (Nkado, 1995; Dursun & Stoy, 2011), building height (Chan & Kumaraswamy, 1999), type of facility (Ng *et al.*, 2001); and organisational level factors like managerial control (Sidwell, 1982), client objectives and communication (Walker, 1995). Moreover, Chan & Kumaraswamy (1999) analyzed the influence of special factors within the construction process (micro factors), such as construction site productivity, external wall surface, and frame type. Limited number of studies (Proverbs *et al.*, 1998; Xiao & Proverbs, 2002) made an attempt to compare construction time performance in international context. Proverbs *et al.* (1998) perform a comparison between UK, French and German building construction sectors on the basis of a hypothetical project. The respondents from 3 locations were asked to estimate the construction duration of the property designed by research team and the results were compared via ANOVA test. The results demonstrate that substantial variations occur in average construction duration. It was concluded that French companies are superior to German counterparts while UK companies remains the slowest (Proverbs *et al.*, 1998). Proverbs *et al.* (1998) also investigated the factors reported in early studies that may influence the duration such as labour utilisation, reinforcement fabrication, formwork solutions and scaffolding systems. Another relevant study was conducted by Xiao & Proverbs (2002) and it utilized a hypothetical project (a six-storey concrete frame speculative office building) to collect data from USA, UK and Japan contractors. The results revealed that average anticipated duration to execute the project is the shortest for Japanese firms followed by UK and USA, respectively.

THE SAMPLE

The *ex post facto* research which is designed to perform an international benchmark incorporates several problems when two historical data sets from the distinct locations are employed. The problem arises hence the standardisation in data collection, the structure of the data sets and definitions of available variables do not present a perfect match. Particularly for cost information, UK data base employs definitions in accordance with British Cost Information Service (BCIS) standards, while German data set classifies them according to DIN norms. Consequently, descriptions of the cost related variables must be examined attentively to figure those that correspond to each other. European Council of Construction Economists (CEEC) published Code of Measurement for Cost Planning (Wright *et al*., 2008) that emerges to determine cost group descriptions and presents a comparison basis between Germany and UK, exhaustively (table 1). Accordingly, the term "construction cost" or "cost" corresponds to the equation given below in this study.

UK (substructure + superstructure + internal finishes + fittings) = DE (300 – 327 – 390)

Another aspect of cost information involves in time value of money. Hence sampled projects executed in a wide span of time, all cost information are rebased to 2005 market prices via construction price index provided by BKI in Germany, and BCIS in UK. Last issue regarding cost related variables is the problem of different currencies. Subsequent to index the cost information to 2005, all German cost information was converted to British Pounds with the average exchange rate in 2005.

This study enjoys working with large number of observations when compared to relative studies in the literature cited in the previous section. UK data set comprises more than 15,000 observations where German one consists of approximately 2000 objects. The intervention study is designed to assess the affect of an explanatory categorical variable - in this case: location of the project. To form a common base between two data sets filtering shall be performed. Filtering observations to determine those that will retain in the sample involves in several steps. First, it is crucial to set the boundary years. In this regard, the sample is limited to the projects which were commenced after 1980 and completed before 2004. Also, it is expected to have large variations between different type of construction works. Therefore, the second limitation is applied for the type of construction works and only new construction jobs are included in the sample. There exists no common foundation for the descriptions of type of facilities in two distinct data sets. In addition, while one data set consists of some type of facilities the other does not. Thus, a decision regarding the type of facility to be included in the sample was made and only residential and office building projects were retained. The last

Table 1: CEEC cost planning cost codes and their corresponding definitions in UK and German standards

CEEC code	UK cost group (BCIS)	German cost group (DIN 276)
Substructure	Substructure	311, 312, 313, 319, 321, 322, 323, 324, 326, 329
External superstructure	Roof, external walls, windows and external doors	331, 332, 333, 334, 335, 337, 338, 339, 361, 362, 363, 369
Internal superstructure	Frame, upper floors, stairs, internal walls and partitions, internal doors	341, 342, 343, 344, 346, 349, 351, 359
Internal finishings	Wall finishes, floor finishes, ceiling finishes	325, 336, 345, 352, 353, 364

Table 2: Quantitative variables retained and derived

Variable description	Abbreviation	Unit
Number of storeys	NoS	nominal numbers
constrution duration	Dur	months
gross floor area	GFA	m^2
construction cost	cost	£
construction speed	speed	m^2/month
standard of the building	standard	£/ m^2

restriction applies to the scope of a project. According to Bromilow (1974) construction cost does not only indicate the project size but also reflected the work's complexity and quality. Therefore, the projects that has construction costs below 200k £ and above 20 million £ are excluded from the data set. Subsequent to filtering process the numbers of observations that were retained in the German and UK data set are 347 and 901, respectively. The last step is the random selection of properties to be included in the sample. 200 random observations from each country were selected via a computer algorithm that generates the list of projects to be included from given data sets. This avoids any judgemental selection that may manipulate the results of the analysis in favour of the hypotheses.

The final sample consists of 4 quantitative variables which are number of storeys (nominal scale), construction duration in months (nominal scale), gross floor area (ratio scale) in square meters, construction cost in £ (ratio scale) (table 2); and 2 factors each with 2 levels that are associated with the location of the project and the type of the facility (table 3). Via employing those variables 2 more quantitative variables are derived: construction speed (ratio scale) defined as the average amount of constructed gross floor area per construction duration unit and standard of the building (ratio scale) that is measured by construction cost per gross floor area unit (table 2). Finally this leads obtaining 2 more factors identified as height and standard of the building. Creation of factors associated with height and standard was performed based on investigation of descriptive statistics for the corresponding quantitative variables. Principally, the threshold values of levels were obtained from minimum, first quartile, median, third quartile and maximum values of the variables associated. Please see table 3 for exhaustive information of factors retained and derived.

METHODOLOGY

Bi variate and multivariate statistical analysis are employed to draw and verify conclusions. Two sample t-test is a bi variate statistical procedure suggested to compare means of two distinct population sample. It determines if the difference in two sample means (if any) is

Table 3: Factors retained and/or derived

Factor name	Levels	Abbreviation	Description
building location	2	f_loc	1=Germany, 2=UK
building height	4	f_hei	Based on number of storeys: 1=low (0-2), 2=medium (3-5), 3=med-tall (6-8), 4=tall (9-12)
building standard	4	f_std	Based on standard: 1=low (250-451), 2=medium (451.01-649.86), 3=med-high (649.87-997.26), 4=high (997.27-3500)
type of facility	2	f_tf	1=office, 2=residential

caused by the random chance or not, under given circumstances (Tabachnick *et al.*, 2001). Certain assumptions must be fulfilled prior to conducting the test. The first one involves in sampling procedure that the analysis shall be based on data from two independent, random samples. The sampling procedure was presented in detail at previous section and therefore the assumption related to randomisation of sampling was considered to be fulfilled. Hence, the observations located in different countries there is no reason that why dependencies between observations would occur. Since t-test is a parametric one, the second restriction of the test assumes that both samples are normally distributed. Parametric tests assume that the distribution is known, or that the sample is large, so that a normal distribution may be assumed (Fellows and Liu, 2008). The test statistics is given as follows

$$t = \frac{\overline{x_1} - \overline{x_2}}{standard\ error\ of\ the\ difference\ in\ means}$$

where $\overline{x_1}$ is the mean of sample from Germany and $\overline{x_2}$ is the mean of sample from UK. The significance of the results will be evaluated according to *p* value of the test that is derived from *t* distribution. The null hypothesis will be rejected in case *p* value is less than 5% ($p(t) \leq 0.05$). This indicates the level of risk one is willing to accept of making the opposite of above conclusions (null hypotheses) when it is not true.

It is crucial to report a shortcoming of the test that also stands for the main motivation to construct a factorial design for further investigations. 2 sample t-test assumes that utilized samples are identical to each other and only receive different treatments (in this case: project location). Then it is powerful instrument to draw a conclusion regarding the effect of treatment under given circumstances, where control and treatment group only differs in intervention. Observational studies of single groups are rarely useful for evaluation because the characteristics of the populations to be compared may differ in ways that affect the outcomes being measured-characteristics other than the interventions being compared (Grimshaw *et al.*, 2000). Every construction project (each observation in the sample) is referred to be as unique and therefore, construction related researches can not be evaluated such as controlled experiments performed in laboratory conditions.

Commonly the term “factorial design” is utilized to describe situations where two or more factors are assumed to have effect on dependent variable. A factor is a categorical variable with two or more nominal values referred to as levels (recall table 3). Factorial design is a powerful multivariate instrument to field scientists as a preliminary study, allowing them to judge whether there is a link between variables, whilst reducing the possibility of experimental error and confounding variables. For instance, intuitively one can argue that the standard of a building may vary within different locations also effects the construction speed alongside. In this context, the study constructs 2×2×4×4 factorial design that addresses two aims. The first one is to verify the result obtained by two sample t-test and the second one is to monitor the main effects and interactions of hypothesized factors on the construction speed. Each multiplier element of the study design is derived from the number of levels by the factors created. The method can be assumed as an extended version of ANOVA (analysis of variance); evaluating the effect and interactions of more than one factor simultaneously on mean response from various samples. The underlying principle applies to many cases in construction related researches hence various factors are interdependent to each other. For instance, intuitively one can argue that the standard of a building may vary within different locations for a given type of facility, also affects the construction speed alongside. The test routine incorporates calculation of *F* statistics which corresponds to the ratio of estimated

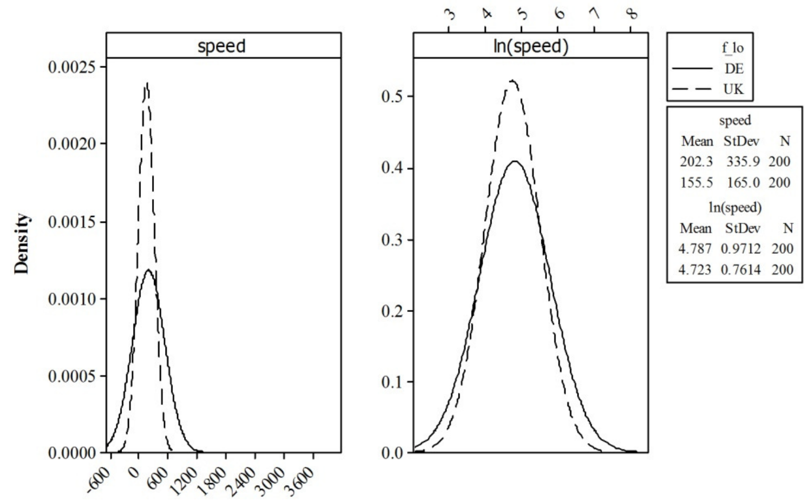

Figure 1: Distribution function of the response variable with respect to project location

variance between groups to estimated variance within groups. Accordingly, the null hypothesis is rejected if probability of the statistic computed is less than 5%.

ANALYSIS AND DISCUSSION

Exploratory Data Analysis

Prior to the commencement of analysis careful investigation of the data shall be performed due to verification of the assumptions outlined in the last section. In addition, to demonstrate the properties of the data shall ease the readers' ability to interpret the results. Hence the analysis involves in parametric tests the distribution function of the response variable plays a vital role. The histogram of the response variable presents that the distribution function is positively skewed (figure 1). Natural logarithm transformation is applied to the response which results in inducing symmetry and reducing skewness (figure 1). Subsequent to variable transformation, one outlier in each sample was detected visually by investigating the box plot of the *ln(speed)* with respect to project location (figure 2). Those observations were excluded from samples and therefore will not be retained for the analysis.

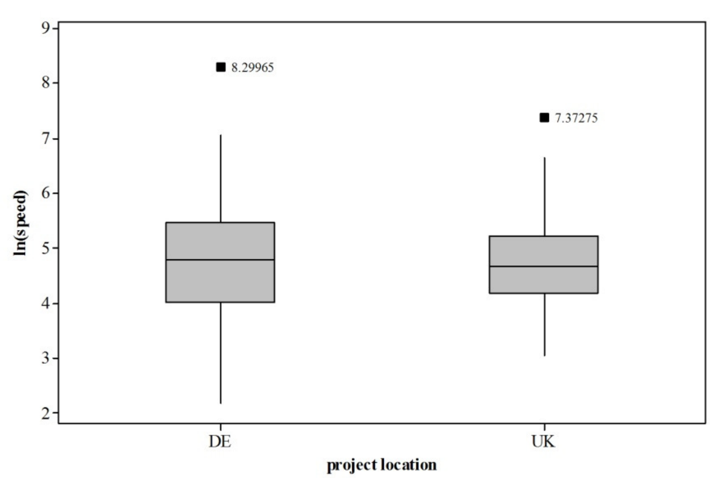

Figure 2: Box plot of *ln(speed)* with respect to project location

Table 4: Descriptive statistics of quantitative variables by means of project location

Variable	Location	N	Mean	SE Mean	St Dev	Median
NoS	DE	199	4.005	0.111	1.565	4
	UK	199	2.899	0.105	1.477	3
dur	DE	199	14.729	0.541	7.633	13
	UK	199	12.417	0.286	4.034	12
GFA	DE	199	2551	206	2912	1564
	UK	199	1915	136	1913	1282
cost	DE	199	1264951	121892	1719495	672240
	UK	199	2056515	190600	2688738	1154075

Table 4 presents descriptive statistics of the quantitative variables: number of storeys, construction duration, gross floor area and construction cost. One can see that, average height of German buildings - function of number of storeys - is greater than UK ones. It is also observed that mean duration to complete construction works of residential and office properties in Germany is slightly greater than those in UK. While average gross floor area of the sample is greater in Germany, construction cost shows a strong opposite trend. The figure might be caused by different factors such as national standards; cost of labour, material and machine; market conditions; site conditions; and so on. It should also be noted that, the argument is also supported by Construction Statistics Annual Report published by Department of Trade and Industry (DTI) in 2006. According to DTI (2006), although the average labour cost is more expensive in Germany, to construct a square meter of residential and office buildings in UK is significantly more expensive than in Germany.

Table 5 acknowledges location as the main factor and presents descriptive statistics of the other factors created. In both locations mean response of construction speed in office buildings are greater than in residential buildings. One can see in table 5 that the spread in

Table 5: Descriptive statistics of *ln(speed)* with respect to factors defined

Location	Factor	Level	N	Mean	SE Mean	St Dev	Median
DE	f_tf	office	37	5.15	0.16	0.95	5.2
		residential	162	4.68	0.072	0.921	4.69
UK	f_tf	office	77	5.05	0.095	0.83	5.03
		residential	122	4.495	0.053	0.585	4.52
DE	f_std	low	93	5.12	0.076	0.733	5.11
		mid-low	62	4.57	0.126	0.992	4.45
		mid-high	37	4.232	0.164	0.996	3.92
		high	7	4.638	0.355	0.94	4.60
UK	f_std	low	7	4.907	0.159	0.421	4.93
		mid-low	38	4.703	0.105	0.646	4.62
		mid-high	62	4.69	0.0908	0.714	4.69
		high	92	4.71	0.085	0.81	4.64
DE	f_hei	low	27	4.14	0.185	0.961	4.09
		mid-low	148	4.76	0.072	0.88	4.84
		mid-tall	21	5.54	0.142	0.651	5.59
		tall	3	5.49	0.811	1.404	4.98
UK	f_hei	low	98	4.53	0.066	0.651	4.51
		mid-low	85	4.81	0.084	0.773	4.69
		mid-tall	16	5.32	0.172	0.687	5.35
		tall	0	*	*	*	*

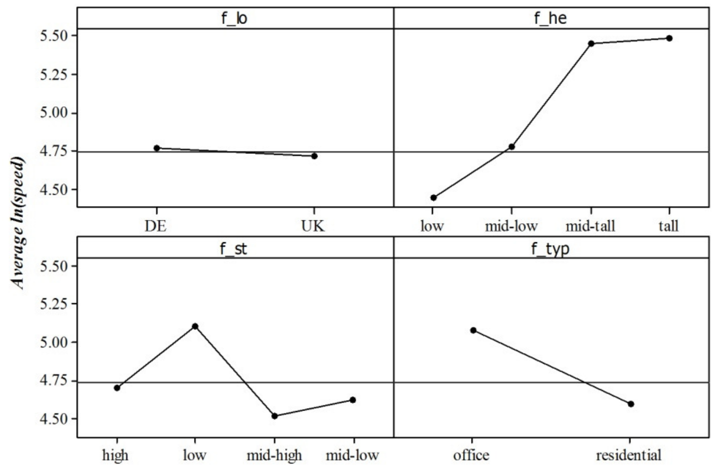

Figure 3: Main effects plot for *ln(speed)* by means of factor defined

number of observations for defined standards shows an opposite pattern. While low and mid-low levels of projects are dominating the German sample, UK sample is dominated by mostly mid-high and high levels of projects. The motivation stands for this figure is no different than the motivation for "cost" variable and has already been outlined in paragraph above. In addition, both in Germany and UK low standard buildings leads the construction speed. Lastly, one can observe in table 5 that the average speed roses as the height of the building increase. Main effects plot presents the changes in average response with respect to the factors defined (figure 3). This in turn may illustrate the behaviour of the *ln(speed)* by means of single factors.

Inferential Statistics

The first test to be conducted aims to assess the significance of group differences in mean response assuming that both samples have identical properties except the intervention: project location. Minitab 16 statistical software was employed to perform 2 sample t-test. 3 assumed conditions will be tested through the analysis (null hypotheses):

- $H_{1,N}$ = the mean response of German sample is not significantly different than UK
- $H_{2,N}$ = the mean response of German sample is not significantly less than UK
- $H_{3,N}$ = the mean response of German sample is not significantly greater than UK

The statistics of the hypotheses tests are given in table 6. CI stands for confidence intervals and it quantifies the uncertainty associated with estimating the difference from sample data. It indicates one can be confident 95% that the true difference of sample means lies between -0.10769 and 0.22594. *p* values can be observed in table 6 and consequently none of the null hypotheses can be rejected. Therefore, based on the 2 sample t test results there is not enough evidence to conclude that the means differ at 5% level of significance. Besides, it is concluded that construction speed of German residential and office buildings neither fast, nor slower when compared to UK counterparts. The test diagnostics are investigated carefully mainly focusing on determining possible outliers that may influence the results dramatically. No violations or outliers are detected.

Second stage of the inferential analysis involve in validating the results provided by 2 sample t-test as well as evaluating the influence of other factors created on the construction speed

Table 6: Two sample t-test and confidence intervals for $ln(speed)_{DE}$ and $ln(speed)_{UK}$

Hypothesis	Statistics	$ln(speed)_{DE}$	$ln(speed)_{UK}$
	Sample Size	199	199
	Mean	4.769	4.7099
	95% CI	(4.63 , 4.90)	(4.61 , 4.81)
	St Dev	0.941	0.7396
	difference between means	0.059122	
$H_{1,N}$	95% CI	(-0.10769 , 0.22594)	
	$p_{1,N}$	0.486	
$H_{2,N}$	90% CI	(-0.080768 , 0.19901)	
	$p_{2,N}$	0.757	
$H_{3,N}$	90% CI	(-0.080768 , 0.19901)	
	$p_{3,N}$	0.243	

Table 7: Analysis of variance for *ln(speed)*

Source	*d.f*	Seq SS	Adj SS	Adj MS	*F*	*p*(*F*)
f_loc	1	0.3478	7.387	7.387	13.85	≤ 0.000
f_tf	1	20.8714	22.8817	22.8817	42.91	≤ 0.000
f_std	3	31.6204	30.5766	10.1922	19.11	≤ 0.000
f_hei	3	23.6181	23.6181	7.8727	14.76	≤ 0.000
Error	389	207.479	207.479	0.5334		
Total	397	283.937				

along with project location. The task will be performed via 2×2×4×4 factorial study as indicated in the methodology section. It is aimed to test the following null hypotheses:

- $H_{4,N}$ = Project location affects no significant difference in mean *ln(speed)*
- $H_{5,N}$ = Type of facility influences no significant difference in average *ln(speed)*
- $H_{6,N}$ = Level of building standard cause no significant difference in mean *ln(speed)*
- $H_{7,N}$ = Level of building height affect no significant changes in average *ln(speed)*

The computation of the analysis is performed with the general linear model routine. The results are outlined in table 7. One can observe that all *F* values are statistically significant. Therefore, the null hypotheses, $H_{4,N}$ $H_{5,N}$ $H_{6,N}$ $H_{7,N}$ were rejected. The result of the general linear model concludes that there is a significant difference in construction speed by project location, type of facility, standard and height of the building.

Discussion

On top, the study shall address to discuss the reasons that the analyses present contradictory results. Although identical samples were employed; 2 sample t-test argued German and UK construction speed performance is not significantly differ from each other on the basis of test statistics that were shown in detail, while general linear model presented project location as a significant factor and it causes substantial variations in the mean that can not be explained by chance. The reason of this disparity lies in the design of the research and the methodologies employed to test the hypotheses. While 2 sample t test assumes that random observations in samples are identical except the intervention (project location) and therefore neglects the effect of any factor that may influence the construction speed; general linear model takes other factors (derived from theory, intuition, common sense and field experience) into account that may cause variation in the response mean. Consistently, the effect of location

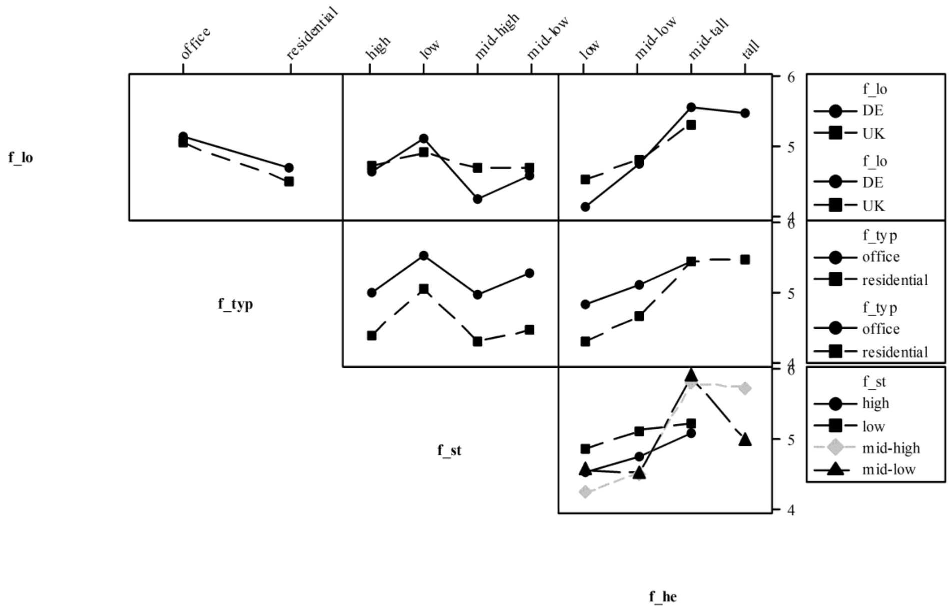

Figure 4: Interaction plot for *ln(speed)*

factor on construction speed becomes insignificant similar to 2 sample t test when general linear model applies to only one factor: project location.

On the other hand, interactions between defined factors may influence the results. The interaction plot of the factors (figure 4) illustrate the pair wise factors and corresponding mean of *ln(speed).* It is observed that in both locations for the given type of facility*, ln(speed)* shows an identical trend: speed of office buildings is superior to residential ones. This indicates there is no interaction between project location and type of facility. However, for the given location and standard ln(speed) presents different properties resulted in two lines intersecting each other (figure 4). It can also be observed that ln(speed) presents more sensitivity for a change in standard in UK when compared to Germany. This indicates a strong pattern of interaction between factor of location and standard. One can also see at the top right corner of the figure 4, given factor of height and location the mean response present two intersecting lines. Thus, it can be concluded that interaction is also present between factors of location and height. Similarly, another interaction can also be monitored between the standard and height of the building according to figure 4. However, one must bear in mind that visual inspections do not provide sufficient evidences regarding significance of interactions.

It is vital to note that perception of a researcher regarding the construction project environment plays a major role to interpret the results of the analysis and draw conclusions out of them. Therefore, consistent with the reasons outlined above, the results from general linear model are accepted and the results from 2 sample t test are declined. It is concluded that 2 sample t test is not an appropriate instrument to execute a post ex facto research because of the construction project specific complications. It is argued that multi variate design of a research that enables to take more than one factor at the same time into account is superior to bi variate design when utilized sample consists of uncontrolled observations. According to the results derived by factorial design it is concluded that factor of project location, type of facility, standard of the building and building height causes significant difference in construction speed.

The findings of this study supports the arguments postulated by Ireland (1985); Nkado (1995); Kumaraswamy and Chan (1995); Chan and Kumaraswamy (1999); Ng *et al*. (2001); Love *et al*. (2005); Dursun and Stoy (2011) and others that project location, standard as an indicator not only for project cost and size but also for the complexity involves in the project, type of facility, and building height as a function of number of stories are significant factors of construction time performance. However, it fails to evaluate the effect of organisational level factors such as communication and management, due to availability of data. Hence compared samples and methodologies employed do not match each other, the results are not sufficient to remark a discussion regarding the study conducted by Proverbs *et al*. (1998). Yet, one can observe at the left top corner of figure 4 that the average construction speed of German office developments are slightly greater than those in UK.

CONCLUSION

The study is designed to enable a fair comparison for construction speed performance of residential and office developments in UK and Germany. The definitions of the populations are restricted hence there is a necessity to construct a common basis for two different data sets. In this context, the populations are limited to projects that are executed between 1980 and 2004. Another restriction is applied to the scope of construction works measured as construction cost. In this regard, only projects between 200 k and 20 million pounds (indexed to 2005 prices) were included in the data sets. Subsequent to data base filtering, random sampling was performed via computer algorithm and 200 observations from each location were retained in the samples. Available quantitative variables were utilized to create factors and the response variable. 2 sample t-test was designed to test the group differences between two samples resulted in no substantial variation exists between population means. Limitations applied to 2 sample t-test forms a motivation for further investigation and in this context a factorial study is designed. This enables to observe the effect of not only the location factor but also the hypothesized factors that may influence the mean response. The analysis yielded that project location causes a significant variation in the mean response when factors of facility, standard and height are taken into account. Consistent with the complicated issues involve in construction projects, it is concluded that neglecting the effect of construction speed related factors and only taking project location into account would not be an appropriate approach for a post ex facto research where observations are not controlled. Therefore, the conclusions of factorial design are considered to provide superior results and accepted as the outcomes of the study. To sum up, it is concluded that project location along with type of facility, standard of a building defined as construction cost per square meters, and height of the building - a function of number of storeys - cause substantial variations in construction speed. It has to be noted that the conclusions are strictly limited to populations described.

This research also demonstrates how the design of a study may play a crucial role to reach the realistic responses to the research questions. Particularly, a research involves in an international investigation may face to various problems regarding availability of the data. Moreover, when the data is available, one has to deal with compatibility of the variables caused by different methods and definitions of storing the data. The research community shall consider developing international standards to create mass data bases. The authorities such as government representatives, parliament members, politics and etc. shall be informed regarding the benefits that can be earned in case such developments are supported by laws. Only then, the developed standards can be dictated to the industry practitioners. Further research shall focus on setting international standards for collecting the data. On the other hand, setting international construction performance indicators and determining the standard methodologies to be employed is crucial to generate objective results.

References

Bassioni, HA, Price, ADF, & Hassan, TM. 2004. Performance measurement in construction. Journal of Management in Engineering, 20(2), 42–50.
Bromilow, FJ. 1974. Measurement and scheduling of construction time and cost performance in the building industry. The Chartered Builder, 10(9), 57–65.

Chan, D.W.M., & Kumaraswamy, M.M. 1995. A study of the factors affecting construction durations in Hong Kong. Construction Management and Economics, 13(4), 319–333.

Chan, D.W.M., & Kumaraswamy, M.M. 1999. Modelling and predicting construction durations in Hong Kong public housing. Construction Management and Economics, 17(3), 351–362.

DTI. 2006. Construction statistics annual report. Tech. rept. DTI.

Dursun, O., & Stoy, C. 2011. Time–cost relationship of building projects: statistical adequacy of categorization with respect to project location. Construction Management and Economics, 29(1), 97–106.

Egan, John. 1998. Rethinking construction. Report of the Construction Task Force to the Deputy Prime Minister on the Scope for Improving the Quality and Efficiency of UK Construction, DETR, London.

Fellows, R., & Liu, A. 2008. Research methods for construction. Blackwell Pub. FIEC. 2009. Construction in Europe - key figures.

Grimshaw, J., Campbell, M., Eccles, M., & Steen, N. 2000. Experimental and quasi experimental designs for evaluating guideline implementation strategies. Family Practice, 17(suppl 1), S11.

Ireland, V. 1985. The role of managerial actions in the cost, time and quality performance of high-rise commercial building projects. Construction Management and Economics, 3(1), 59–87.

Kagioglou, M., Cooper, R., & Aouad, G. 2001. Performance management in construction: a conceptual framework. Construction Management and Economics, 19(1), 85–95.

Kog, YC, Chua, DKH, Loh, PK, & Jaselskis, EJ. 1999. Key determinants for construction schedule performance. International Journal of Project Management, 17(6), 351–359.

Kumaraswamy, M.M., & Chan, D.W.M. 1995. Determinants of construction duration. Construction Management and Economics, 13(3), 209–217.

Love, P.E.D., & Holt, G.D. 2000. Construction business performance measurement: the SPM alternative. Business process management journal, 6(5), 408–416.

Love, P.E.D., Tse, R.Y.C., & Edwards, D.J. 2005. Time–Cost Relationships in Australian

Building Construction Projects. Journal of Construction Engineering and Management, 131, 187.
Murray, M. 2003. Construction Reports 1944-98. Wiley-Blackwell.

Ng, S.T., Mak, M.M.Y., Skitmore, R.M., Lam, K.C., & Varnam, M. 2001. The predictive ability of Bromilow's time–cost model. Construction Management and Economics, 19(2), 165–173.

Nkado, R.N. 1995. Construction time-influencing factors: the contractor's perspective. Construction Management and Economics, 13(1), 81–89.

Ofori, G. 1990. The construction industry: Aspects of its Economics and Management. NUS Press.

Proverbs, DG, Holt, GD, & Olomolaiye, PO. 1998. Factors impacting construction project duration: a comparison between France, Germany and the UK. Building and Environment, 34(2), 197–204.

Sidwell, A.C. 1982. A critical study of project team organisational forms within the building process.

Stoy, C., Dreier, F., & Schalcher, H.R. 2007. Construction duration of residential building projects in Germany. Engineering, Construction and Architectural Management, 14(1), 52–64.

Tabachnick, B.G., Fidell, L.S., & Osterlind, S.J. 2001. Using multivariate statistics. Allyn and Bacon Boston.

Walker, D.H.T. 1995. An investigation into construction time performance. Construction Management and Economics, 13(3), 263–274.

Wegelius-Lehtonen, T. 2001. Performance measurement in construction logistics. International journal of production economics, 69(1), 107.

Wright, M., O'sullivan, G., Martin, J., & P., Schmid. 2008. CEEC Code of measurement for cost planning.

Xiao, H., & Proverbs, D. 2002. Construction time performance: an evaluation of contractors from Japan, the UK and the US. Engineering Construction and Architectural Management, 9(2), 81–89.