Evaluation of Factors Affecting Productivity in the UAE Construction Industry: Regression Models

Nabil Ailabouni¹ and Kassim Gidado²

Productivity rates of construction trades is the basis for accurately estimating time and costs required to complete a project. This research aims at developing regression models for predicting changes in productivity, when the underlying factors affecting productivity are varied. These factors were broadly categorized as general work environment, organizational work policies, group dynamics and interpersonal relationships and personal competence of the employees as applicable to the construction industry in the United Arab Emirates (UAE). The most significant factors amongst these were determined through three surveys using the Severity Index and Chi Square computations for significance. The factors were regrouped into factors that afforded practical variation at site and productivity data was collected using different combination of the most significant factors of Timings, Supervision, Group Dynamics, Control by Procedures, Climate and Material Availability. Construction activities such as Excavation, Formwork, Reinforcement, Concreting, Block work, Plaster and Tiling were studied and the increase or decrease in productivity obtained was compared to the actual site average productivity; then analyzed statistically using the MINITAB 15 software, and linear regression models established. Validation was undertaken at four sites and it was observed that the regression models arrived at were capable of predicting productivity changes within ±15%.

Keywords: construction, factors, performance, productivity, regression.

Introduction

Productivity could be defined as “the ratio of output of required quality to the inputs for a specific production situation; in the construction industry, it is generally accepted as “work output per man-hours worked”. For example, excavation is measured in cubic metres per man hour and plastering is measured in square metres per man hour. Improved productivity helps contractors not only to be more efficient and profitable; knowing actual productivity levels also helps them to estimate accurately and be more competitive during bidding for projects.

This study focuses primarily on the construction industry in the United Arab Emirates (UAE). The construction industry in the UAE is a multibillion dollar industry, contributing approximately 8% to the nation’s GDP (UAE Yearbook, 2009). The UAE labour market is made up of a mix of 110 nationalities, common to the entire Gulf region and has unique characteristics, which affects the

¹ CEO, Target Engineering Construction Co., P. O. Box 960, Abu Dhabi, UAE, (PhD, University of Brighton), Tel.: +971 2 6714 700, Fax : +971 2 6714 800, Email: nabil@target.ae
² Professor, School of the Environment & Technology, University of Brighton, Brighton, BN2 GJ, UK Tel.: +44 1273 64 2394, Fax : +44 1273 64 2285, Email: k.i.gidado@brighton.ac.uk
construction personnel and their productivity. UAE does not allow organized unions for workmen and official statistics on standard productivity rates are nonexistent. The UAE has a hot humid climate with temperatures reaching up to 48 °C during summer and relative humidity up to 80%. Most of the workmen are housed in labour camps with minimal messing facilities and allowed to go on leave once every two years. Workmen are subject to a sponsorship system and cannot change their jobs; cancellation of workmen category visa invites a six month ban from employment in the UAE. Employers and expatriate employees have all to comply with the Federal Labour Law No. 8 of 1980, which has set several comprehensive regulations that protect the rights of employers and employees including employee welfare.

Further the workforce is subjected to a combination of other influences such as different management styles (supervision staff is mostly Arabic), language barriers, cultures, customs, long separation from families, late payment of salaries and so on. Such influences have a direct impact on their productivity.

Despite technological innovations in building materials, mechanized shuttering, offsite precast fabrication, the industry is still very much labour intensive. Compared to the liquidity in the region; and the value of the contracts / construction projects, the cost of labour is relatively cheap. This stifles productivity initiatives as contractors would rather push in more people and get the job completed; rather than go into the hassles of increasing productivity. Therefore the study of productivity and ways and means to increase the productivity is important for the UAE construction industry.

This paper is a précis of the doctoral research aimed at establishing regression model/s which can predict changes in productivity of selected construction activities, when the underlying factors are purposefully varied.

It is structured as under:

- Introduction
- Literature review
- Factors affecting construction productivity
- Field data collection
- Regression models for productivity
- Validation of models
- Conclusion
- Areas of future research
- References

**Literature Review**

The literature review consisted of the review of the management theories – classical and human relations / motivational approaches to management together with the review of research on productivity by contemporary authors. The review of contemporary work culminated into three matrices depicting factors affecting productivity, motivating factors affecting productivity and factors compared over several countries. This literature review together with the experience of the researcher formed the basis of establishing the comprehensive listing of the factors affecting construction productivity (Table 1).
Management Theories

The scientific management advocated by Fredrick Taylor (1947), is the first of the ‘classical management’ approach and emphasized increasing productivity of individual workers through the technical restructuring of work organization and the provision of monetary incentives as the motivator for higher levels of output. Henri Fayol’s 14 principles of management together with the bureaucratic approach to organization somehow incorporated a mechanistic - negative view of human nature and led to the contrasting human relations approach.

Elton Mayo’s ‘human relations approach’ following the ‘Hawthorne experiments’ concluded that people are motivated by other conditions than pay; these being the need for recognition and a sense of belonging (Roethlisberger and Dickson, 1939). Mayo’s understanding of the workplace as ‘people in a social environment’ has relevant applications within the construction industry.

Motivational Theories

Most authors agree that motivation symbolizes the drive behind human behaviour. Mitchell (1982) defines motivation as the ‘degree to which an individual wants and chooses to engage in certain specified behaviours’.

Abraham Maslow (1943) proposed the theoretical framework of individual personality development and motivation based on a hierarchy of human needs; knowing the employee and determining their most urgent needs and meeting his wants and desires, managers would be able to increase the efficiency of his employees.

McGregor (1960) concluded that a manager’s view of the nature of human beings is based on a certain grouping of assumptions (Theory X: people are generally lazy and Theory Y: people do want to work and are creative), leading to either an ‘authoritative’ or a ‘participative’ type of management respectively.

Fredrick Herzberg’s (1959) concluded that people have basic needs, which he called as hygiene factors - (company policy and administration, supervision, salary, interpersonal relationships, working conditions and security). According to Herzberg, hygiene factors do not motivate; if present, they prevent employees from becoming dissatisfied. On the other hand, absence of hygiene factors results in dissatisfaction and de-motivation. The second set of needs includes motivators (achievement, recognition, work, responsibility, and advancement). If resolved, motivators cause satisfaction of employees. Thus to effectively motivate employees, a manager must not only balance hygiene environment of a company, but ensure some motivators are available, thus finding relevant application in the construction industry.

The Equity theory of Adams (1963) is based on strong social norms about fairness and accepts that people compare efforts and rewards. A state of equity exists whenever the ratio of one person’s outcomes to inputs equals the ratio of another person’s outcome to inputs. Inequity creates tensions within individuals; thus a prudent management strategy would be to keep feelings of equity in balance in order to keep the workforces motivated.
Vroom’s (1964) **Expectancy theory** suggested that employees constantly predict likely future rewards for successfully completing tasks, and if the rewards seem attractive, people become motivated to do the job to get expected rewards and suggested that the opposite is true as well. This theory finds extensive application in designing incentive schemes.

**Works of Contemporary Authors on Construction Productivity**

Olomolaiye et al (1998) stated that factors affecting construction productivity are rarely constant, and may vary from country to country – project to project, and even within a project based on circumstances. Olomolaiye (1990) found that good supervision was the most significant variable influencing percentage productive time and that fluctuations in productivity are primarily the responsibility of on-site management.

Herbsman and Ellis (1990) classified the critical factors affecting construction productivity as - technological factors such as specifications, design, location and materials; and organizational factors such as production, labour wages and relations and social factors.

Alinaitwe et al (2007) ranked factors affecting productivity in Uganda: - these were – incompetent supervision, lack of skills, rework, lack / breakdown of tools, poor construction methods, poor communications, inaccurate drawings, stoppages due to rejected work, political insecurity and harsh weather conditions.

Horner (1982) identified ten factors which affect construction productivity – quality, number and balance of workforce, motivation of labour force, degree of mechanization, continuity of work, complexity of work, required quality of finished work, quality and number of managers, and weather.

Kazaz and Ulubeyli (2006) ranked ten organizational factors based on a survey of construction companies in Turkey, which are – the site management, material management, work planning, supervision, site layout, technical education and training, crew size and efficiency, firm’s reputation, camps and relaxation allowances.

Abdel-Wahab et al (2008) concurs with other researchers that skills development and training improves productivity and that effective utilization of skills rather than mere increase in the supply of skills is a key to productivity improvements.

Research undertaken by Ruthankoon and Ogunlana (2003), Ogunlana and Chang (1998), Price (1992) and Hague (1985) used the motivation theories of Maslow and Herzberg as a framework for their research.

Laufer and Borcherding (1981) indicated that financial incentives for the construction labour force are practical; they could raise productivity, lower production costs, shorten the construction time and increase the earnings of the workers.

Aiyetan and Olotouah (2006) established a relationship between motivation and performance of workers in the Nigerian construction industry. He listed the motivating factors as – overtime, health care, provision of transport, promotion, increase in salary, recognition, company policy, working conditions, relations with


co-workers, work itself, responsibility, holiday abroad with pay, achievement, telephone services and sharing of profit.


Factors Affecting Construction Productivity

The literature review indicated in previous section, coupled with the experience of the author was used to establish a comprehensive listing of the factors affecting productivity in the UAE Construction Industry (Table 1) in four major interrelated categories factors; these are: Environmental, Organizational, Group and Individual Factors. Figure 1 depicts the four major factor categories affecting productivity, as established for this research.

![Figure 1: Major Categories of factors affecting productivity](image)

Further the factors from Table 1 were transposed into a sixty-one survey questions and circulated to the purposefully selected key industry players — engineers, foremen and workmen from the construction industry. Sampling was aimed to have a comprehensive coverage of client, contractors, consultants and subcontractors. A snapshot of the survey questionnaire is presented in Figure 2. This survey result served as the first set of primary data for the research. The responses were treated with respect to both their significance as identified by the respondents together with how frequently the experience the factor on site. This was achieved by applying the ‘Importance Index’, ‘Frequency Index’ and ranked using the ‘Severity Index’ (see Table 2) used as described in Kadir et al (2005). These factors were considered as significant for further study and are presented in Table 2: Significant Factors affecting productivity.

For the convenience of field study, the significant factors were regrouped into factor variables and two perception surveys were conducted to establish the effect of each of these factor variables. Regrouping into factor variables helped purposeful variation of these and recording resultant effect on the productivity of construction operations on site.

Table 3 gives the seven factor variables with their weighted averages. The survey responses were subjected to chi-square tests of significance, which indicated that the factors groups identified in Table 3 – namely Timings, Competence of supervisors, Salaries, Procedures, Group dynamics, Individual
factors, Availability of material and Climate conditions were indeed statistically significant.

The related computations on weightages and the chi-square statistic have been kept out of this paper for space restrictions.

Table 1: Comprehensive List of Factors affecting productivity

<table>
<thead>
<tr>
<th>Environmental Factors</th>
<th>Group Factors</th>
<th>Individual Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• labour market characteristics</td>
<td>• group structure or composition</td>
<td>• level of academic / technical education / past</td>
</tr>
<tr>
<td>• economic situation</td>
<td>• individual skills within the group</td>
<td>training</td>
</tr>
<tr>
<td>• safety and job security</td>
<td>• overall skills of the group</td>
<td>• past experience / age</td>
</tr>
<tr>
<td>• minimum wages, salary payments</td>
<td>• nature of work / assignment</td>
<td>• overall competence and skills</td>
</tr>
<tr>
<td>• use of technology / level of mechanization</td>
<td>• demography of team / nationalities</td>
<td>• motivation and morale</td>
</tr>
<tr>
<td>• climate and weather conditions</td>
<td>• cultural differences</td>
<td>• individual culture / attitude</td>
</tr>
<tr>
<td>• client requirements / project specific requirements</td>
<td>• language barriers</td>
<td>• individuals creativity</td>
</tr>
<tr>
<td>• site layout</td>
<td>• frequency of changes</td>
<td>• absenteeism</td>
</tr>
<tr>
<td>• political situation</td>
<td></td>
<td>• overall job satisfaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• overall communal feeling / belongingness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• overall appreciation</td>
</tr>
</tbody>
</table>

Organizational Factors

| work timings / working hours                           | reward schemes                                 |
| discipline / hierarchy order                          | • attainable goals and targets                 |
| policies and procedures, method statements            | • overtime                                    |
| management involvement, accountability, transparency   | • instant cash award schemes                  |
| availability of materials / tools and equipment        | • contract system of work                      |
| construction work complexity                           | • fair treatment of employees                 |
| interruptions of work                                  | • fulfillment of promises                     |
| competencies of supervisors                            | • appraisal / feedback schemes                |
| • leadership skills                                    | • freedom of expression and grievances        |
| • systematic delegation                               | • experience is valued                         |
| • level of communication                               | • welfare schemes                             |
| • brand name of company                                | • camp conditions                             |
|                                                           | • lunch breaks / packets                       |
|                                                           | • recreation                                  |

Figure 2: Snapshot of Survey Questionnaire

1 Would Work Timings giving a proper balance between work and recreation affect
Table 2: Significant Factors affecting productivity (with ranks)

<table>
<thead>
<tr>
<th>No</th>
<th>Factors affecting productivity</th>
<th>Importance Index</th>
<th>Frequency Index</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Proper Work Timings giving a balance between work and recreation and</td>
<td>0.9025</td>
<td>0.7339</td>
<td>0.6624</td>
</tr>
<tr>
<td></td>
<td>time with family</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Leadership Skills of supervisors</td>
<td>0.8437</td>
<td>0.7619</td>
<td>0.6428</td>
</tr>
<tr>
<td>3</td>
<td>Salaries on time</td>
<td>0.8496</td>
<td>0.7507</td>
<td>0.6378</td>
</tr>
<tr>
<td>4</td>
<td>Technical qualified / educated for the trade</td>
<td>0.8437</td>
<td>0.7507</td>
<td>0.6334</td>
</tr>
<tr>
<td>5</td>
<td>Reasonably well paying job</td>
<td>0.8462</td>
<td>0.7465</td>
<td>0.6317</td>
</tr>
<tr>
<td>6</td>
<td>Safe Secured Job</td>
<td>0.8412</td>
<td>0.7479</td>
<td>0.6291</td>
</tr>
<tr>
<td>7</td>
<td>Transparency and Accountability of each level of management</td>
<td>0.8555</td>
<td>0.7283</td>
<td>0.6230</td>
</tr>
<tr>
<td>8</td>
<td>Overtime Paid for work done beyond normal Working hours</td>
<td>0.8353</td>
<td>0.7381</td>
<td>0.6165</td>
</tr>
<tr>
<td>9</td>
<td>Materials available on time</td>
<td>0.8580</td>
<td>0.7185</td>
<td>0.6165</td>
</tr>
<tr>
<td>10</td>
<td>Defined policies and procedures by management</td>
<td>0.8185</td>
<td>0.7521</td>
<td>0.6156</td>
</tr>
<tr>
<td>11</td>
<td>Individual or Personal Skills</td>
<td>0.8050</td>
<td>0.7633</td>
<td>0.6145</td>
</tr>
<tr>
<td>12</td>
<td>Competence of supervisors</td>
<td>0.8244</td>
<td>0.7451</td>
<td>0.6142</td>
</tr>
<tr>
<td>13</td>
<td>Systematic method statements / procedures in place and known</td>
<td>0.8345</td>
<td>0.7353</td>
<td>0.6136</td>
</tr>
<tr>
<td>14</td>
<td>Knowledge of Work</td>
<td>0.8261</td>
<td>0.7423</td>
<td>0.6132</td>
</tr>
</tbody>
</table>

Formulae used (Kadir et al., 2005)

Importance Index = \( \frac{5n_1 + 4n_2 + 3n_3 + 2n_4 + n_5}{5(n_1 + n_2 + n_3 + n_4 + n_5)} \)

Frequency Index = \( \frac{3m_1 + 2m_2 + m_3}{3(m_1 + m_2 + m_3)} \)

Severity Index (rank) = Importance Index x Frequency Index

Where, \( n_1, n_2, \ldots, n_5 \) = number of responses for “Very Important”, “Important”……..“Highly Not Important” degree of importance respectively. \( n_1, n_2, n_3, n_4, \) and \( n_5 \) each have a weight of 5, 4, 3, 2, and 1 respectively.

And, \( m_1, m_2 \) and \( m_3 \) = number of responses for “High”, “Medium” and “Low” frequency of occurrence, each having a weight of 3, 2 and 1 respectively.

Field Data Collection

Field data has been collected from six construction sites of a “case study” contracting company in Abu Dhabi. To remove any possible bias in the productivity results, the workmen involved in the productivity studies on sites, have were unaware that their work is being recorded. Further, practical difficulties of raising wages to vary the factor on Salaries led to its inclusion within the Timings factor, which included overtime and fixed output based payments. The remaining six factor variables were subjected to three levels of variation as explained in Table 4. Productivity was measured for the seven construction trades of Excavation (cubic metres/man-hour), Formwork (square metres/man-hour) Reinforcement (tons/man-hour), Concreting (cubic metres/man-hour), Block-work (square metres/man-hour), Plastering (square metres/man-hour) and Tiling Works (square metres/man-hour).
Table 3: Factor variables for field data collection

<table>
<thead>
<tr>
<th>Timings</th>
<th>Competence of Supervisors</th>
<th>Salaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning Shifts</td>
<td>Team with Classified Supervisor</td>
<td>Incentive Given for Specific</td>
</tr>
<tr>
<td>Fixed Work at Any Hours</td>
<td>Known Team Members</td>
<td>Amount of Job</td>
</tr>
<tr>
<td>8+4</td>
<td>Supervisor Change</td>
<td>Increase Rates</td>
</tr>
<tr>
<td>8+6</td>
<td>Team Member Change</td>
<td>Fixed Daily Rates</td>
</tr>
<tr>
<td>8+2 Normal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Afternoon Shifts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Night Shifts</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Systems and Procedures</th>
<th>Group Dynamics</th>
<th>Climate Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systematic Procedures</td>
<td>Groups with all Skilled Members</td>
<td>Hot / Humid Weather</td>
</tr>
<tr>
<td>Work Instruction available</td>
<td>Groups with Unskilled Members</td>
<td>Cold / Windy Weather</td>
</tr>
<tr>
<td>Specific / Stringent HSE Requirements</td>
<td>Groups with Mix of Skilled and Unskilled Members</td>
<td>Pleasant Weather</td>
</tr>
<tr>
<td>Specific / Stringent Quality Requirements</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Factor Levels used for Data Collection

<table>
<thead>
<tr>
<th>No</th>
<th>Factors affecting Productivity</th>
<th>Levels / Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Work Timings (T)</td>
<td>8+2 (Normal)</td>
</tr>
<tr>
<td>2</td>
<td>Level of Supervision (S)</td>
<td>Average</td>
</tr>
<tr>
<td>3</td>
<td>Group Dynamics (G)</td>
<td>Unskilled</td>
</tr>
<tr>
<td>4</td>
<td>Availability of Material (M)</td>
<td>Not available</td>
</tr>
<tr>
<td>5</td>
<td>Control by Procedures (P)</td>
<td>Lack of Procedures</td>
</tr>
<tr>
<td>6</td>
<td>Climate Conditions (C)</td>
<td>Extreme</td>
</tr>
</tbody>
</table>

A review of the minimum, maximum, range and the average productivity rates for all the trades under observation indicated large variation of productivity rates over sites and generally supported the fact that baseline productivity rate attached to an activity cannot be fixed, as there are several factors interacting with each other, affecting the overall productivity. The productivity figures also differed significantly with the existing database of productivity rates of the case study company, concurring with the results of Olomolaiye (1998). The reasons for this difference were attributed to technical problems associated with construction trades, based on the location of the site, soil strata, contract specifications and client involvement, besides the factor variables considered in the study.

To overcome this problem, the actual site productivity average was used as a base for comparison; further, as these trades have different units of measurement, the output variable measured and used in further statistical analysis was the “difference in actual productivity minus the average productivity” specific to the
site. This independent, unit-free output variable was termed as “percentage productivity change”. Data so obtained was subjected to homogenization within a band of ± 40%. The band of ± 40% was selected based on the variations seen in actual productivity on site, the presence of possible concurrent factors other than the six under study and the fact that around 74% of the results were within this band.

A total of 1090 data sets were collected from six construction sites, and for the seven construction trades under study. The data was scrutinized for any abnormal readings using the baseline productivity and the site average comparisons and a set of 812 homogenized readings were subjected to further review and analysis. This data were then fed into the MINITAB 15 software and a regression analysis was performed. The output variable was the “percentage productivity change” while the input variables were the six factors of Timings (T), Supervision (S), Group Dynamics (G), Procedures (P), Availability of Material (M) and Climate (C).

Regression Models For Productivity

Initial trial runs were made using ‘MINITAB 15’ software for a straight line overall model using all the trade wise productivity rates available in the data sets. However the coefficient of determination - R^2 returned were very low around 16%. Therefore a switch to trade wise productivity modelling was made, which then gave a better fit with a higher R^2.

Table 5: Regression Models for Construction Activities (using MINITAB 15)

<table>
<thead>
<tr>
<th>Trade</th>
<th>R^2 %</th>
<th>Final Regression Model having best R^2 value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>93.4</td>
<td>(= -0.0024+0.0806T+0.0190S-0.233G-0.157P+0.328C)</td>
</tr>
<tr>
<td>Formwork</td>
<td>75</td>
<td>(= -0.661+0.195T+0.140S-0.0196G+0.0966P+0.0057C)</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>73.8</td>
<td>(= -0.748+0.150T+0.242S-0.0386G+0.0301P-0.0499C)</td>
</tr>
<tr>
<td>Concreting</td>
<td>78.5</td>
<td>(= -0.0283+0.0733T+0.143S+0.0514G-0.180P+0.0389C)</td>
</tr>
<tr>
<td>Block work</td>
<td>82.9</td>
<td>(= -0.480+0.138T+0.141S-0.128G+0.125P+0.0444C)</td>
</tr>
<tr>
<td>Plastering</td>
<td>92.6</td>
<td>(= -0.203+0.242T-0.0049S-0.0344G-0.0548P+0.0328C)</td>
</tr>
<tr>
<td>Tiling</td>
<td>83.1</td>
<td>(= +0.073+0.0050T+0.354S+0.0878G-0.282P-0.170C)</td>
</tr>
</tbody>
</table>

Note: Refer Table 4 for legend.

Although statistical texts indicated that an R^2 value of 80% and above is a realistic value to accept a regression model, some of the iterations resulted in one of the main factor variables being deleted out of the regression equation. In such cases, an R^2 value of less than 80% was accepted for the purposes of this research. Further a straight line regression was considered acceptable as higher non linear regression models investigated did not give appreciable change in R^2 values. The regression models acceptable with their R^2 values have been summarized in Table 5 above.
Validation of Models

Notwithstanding the selection of straight line regression, the expected real life productivity changes of ±25%; the acceptance of $R^2$ at 70%; the complex relationship between model and data, technical constraints on site and the subjectivity of the factors themselves, the validation of the model was set for acceptance at a band of ±15%.

Four construction sites were chosen for model validation ensuring field variation of the factors affecting productivity similar to the one used during data collection and model formulation.

A total of 11 data sets constituting 1963 data readings were used for validation. The data was reviewed for consistency by first comparing the average site productivity and the productivity measures obtained actual on site and those predicted by the model. The validation band of ± 15% was chosen as explained above and the models were validated for use within ± 15% accuracy which is acceptable for field use on sites.

Conclusion

This research aimed at developing a regression model which can predict changes in productivity in construction, when the underlying factors were purposefully varied. The major category factors were broadly classified as Environmental factors, Organization factors, Group factors and Individual factors. The significant factors finally chosen for the field study was a result of two field surveys one – ranking results using the severity index encompassing both the significance and frequency of occurrence of the factors on site; and the other using the weighted averages for the magnitude of the effect of the factors on productivity. The most significant factors affecting construction productivity in the UAE have been established as – Work timings, Competent supervision, Group dynamics, Control by procedures, Availability of material and Climatic conditions. A comparison of these factors with the works of the contemporary authors reveals that these factors have frequent mention in most of the works regarding construction productivity. Although limited by the simplicity of assuming nonlinear regression models, the productivity models have been established for each of the seven construction trades of excavation, formwork, concreting, blockwork, plastering and tiling. The models have been validated using data for four construction sites in UAE and it is found that the models can predict productivity changes within ± 20% accuracy. The doctoral research is now concluded and fitting of non-linear regression models for the existing data was not undertaken for want of time.

Notwithstanding the complex nature of construction activities and the presence of numerous constraints outside the control of management, the models and the underlying implications can help construction personnel to achieve improved productivity rates on sites; i.e. to ensure favourable factors for achieving optimal productivity, keeping costs within budget, completing projects on time and ultimately helping contractors to run their business profitably.

Lastly, possible areas for future research have been suggested in the next section.
Areas for future research

The areas for refinement in the models and consequent future research arise from the practical assumptions in the study, field application of productivity on construction sites, and the considerations of non linear regression model and study of interactions of the factors affecting productivity. Additionally, future research could consider higher levels of variation 1-5 instead of 1-3 in this study, other factors affecting productivity, motivation levels for individuals and the group as a whole, benchmarking productivity rates across other contractors in the region and other countries and the inter-dependability of variables in concurrent construction trades and the project specific exigencies and unique events that may affect the baseline productivities for the site.

References


***