International Journal of Construction Management

ISSN: 1562-3599 (Print) 2331-2327 (Online) Journal homepage: https://www.tandfonline.com/loi/tjcm20

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The International Journal of Construction Management (2012) Vol. 12 No.3, 1-23

A SURVEY OF FACTORS INFLUENCING THE PRODUCTIVITY OF CONSTRUCTION OPERATIVES IN THE STATE OF QATAR

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Abstract
Despite the significant developments in construction technologies, operatives remain the key drivers in the industry. In most countries, construction labour cost comprises 30 to 50% of the overall project's cost, and thus it is regarded as a true reflection of the efficiency and success of the operation. Following the announcement of awarding the FIFA 2022 World Cup hosting rights to the State of Qatar on December 02, 2010, the State will be spending tens of billions of dollars on hundreds of new construction projects. The objective of this research, therefore, is to identify, explore and rank the relative importance of the primary factors influencing the productivity of construction operatives in Qatar. To this end, a statistically representative sample of contractors was invited to participate in a structured questionnaire survey comprising 35 productivity factors, which were shortlisted based on previous relevant research studies and the input of local industry experts and professionals. Using the "Relative Importance Index" (RII) technique, the following 10 factors are perceived to be most significant to the productivity of operatives: (1) skill of labour; (2) shortage of materials; (3) labour supervision; (4) shortage of experienced labour; (5) communication between site management and labour force; (6) lack of construction managers' leadership; (7) high temperature weather; (8) delays in responding to "Requests For Information" (RFI); (9) lack of providing labour with transportation; and (10) proportion of work subcontracted. The results obtained fill a gap in knowledge of factors impacting construction labour productivity in Qatar, which can be used to provide industry practitioners and policy makers with guidance for focusing on, acting upon and controlling the most significant factors perceived to affect the efficiency of operatives.

Keywords
Productivity, Operatives, Labour, Efficiency, Construction, State of Qatar.

INTRODUCTION

Notwithstanding the significant developments in construction technologies, operatives remain the key drivers in the industry. Due to the current economic condition and its negative influence on the construction sector across the globe, improving the productivity of operatives has become even more crucial than ever. In most countries, labour cost comprises 30 to 50% of the overall project's cost (Yates and Guhathakurta, 1993; McTague and Jergeas, 2002; Kazaz *et al.*, 2008), and thus it is regarded as a true reflection of the efficiency and success of the construction operation. Horner *et al*. (1989) indicated that a 10% increase in labour productivity would yield annual savings of about £1 billion to the British economy; this conclusion was further echoed by Stoekel and Quirke (1992). Since construction is a labour-intensive industry, the significance of this impact, obviously justifies the concern over its labour productivity.

The State of Qatar, a peninsula projecting north into the Arabian Gulf, owns the world's third-largest natural gas supply, and 15 billion barrels of proved oil reserves, and hence has benefited from a four-fold increase in energy prices over the last five years (CIA, 2011). Bolstered by the rising production of Liquefied Natural Gas (LNG), the economy of the State has been able to ride out the global economic crisis and is set to record the highest economic growth in the "Middle East and North Africa" (MENA) region in 2011, with a real GDP growth of 20% (Samba, 2009; The Peninsula, 2011).

Over the past few years, the construction sector has been among the major contributors to the State's economic thriving, and is expected to continue to be a major contributor to the GDP and labour force employment. This sector witnessed a growth of 3.6% in 2003, contributing Qatari Riyal (QR) 2,850 million (USD $ 750 million) to the overall GDP (QER, 2004). Nonetheless, following the announcement of awarding the FIFA 2022 World Cup hosting rights to Qatar on December 02, 2010, the State will be further spending tens of billions of dollars on hundreds of new construction projects such as, stadiums, hotels, residences, hospitals, airports, seaports, railways, among other infrastructure facilities (Construction Week, 2010).

As a result, such an unprecedented prospective event to the State, will lead to a major boom in its construction sector. In addition, the magnitude of projects planned, will inevitably require the participation of major international consultants and construction firms. It is most probably, furthermore, that many of these international firms possess no prior practical experience or knowledge of the local industry, which may: (a) lead to inefficient or unrealistic labour utilization and expectation; and/or (b) result in inflated bids to obviate, mitigate or manage any risk associated with venturing into an unknown, culturally different, environment.

The objective of this investigation, therefore, is to identify, explore and rank the relative importance of the primary factors influencing construction labour productivity in Qatar, so that the outcomes can be used by both, local and international industry practitioners, to develop a deeper and wider perspective of the factors affecting the efficiency of operatives, on the one hand, and provide guidance to construction managers for effective planning and efficient utilization of the labour force, on the other, hence assist in achieving a reasonable level of competitiveness and cost effective operation.

The paper starts with a literature review of studies relevant to this investigation, presents the research method and data analysis, provides a discussion of the results obtained, and consummates with recommendations geared toward enhancing the labour productivity level, and ultimately the productivity of the construction industry in the State.

LITERATURE REVIEW

The US Department of Commerce defines productivity as “Dollars of output per person-hour of labour input” (Adrian, 1987). Peles (1987) interpreted productivity as “the performance accomplished by operatives”, whereas Finke (1998) defined productivity as “the quantity of work produced per man-hour, equipment-hour, or crew-hour”.
The American Association of Cost Engineers, on the other hand, defines productivity as a “relative measure of labour efficiency, either good or bad, when compared to an established base or norm” (Allmon *et al.*, 2000). Arditi and Mochtar (2000) referred to productivity as “the ratio between total outputs expressed in dollars and total inputs expressed in dollars as well”, whereas Horner and Duff (2001) expressed productivity as “how much is produced per unit input”.

In view of the previous discussion, it is obvious that the general consensus among the various researchers is to define productivity as the ratio of output to input, and therefore construction productivity can be regarded as a measure of outputs which are obtained by a combination of inputs. Consequently, two measures of construction productivity emerge: (1) total factor productivity, where all outputs and inputs are considered; and (2) partial factor productivity, often referred to as single factor productivity, where outputs and single or selected inputs are considered (Talhouni, 1990; Rakhra, 1991; Jarkas, 2005).

In comparison with partial factor productivity, where the definition is best exemplified by the term labour productivity, i.e. units of work accomplished per man-hour (Halligan *et al.*, 1994), the disadvantages of total factor productivity measure are twofold. On the one hand, it is difficult to reasonably determine and measure all input recourses utilized to achieve the output, and on the other, it is impractical, especially for researchers, to monitor, observe or assess the effects of selected individual factors on the output. The complex nature of the construction process and the interaction of its activities, moreover, make the partial factor productivity measure the popular option since effective control systems monitor each input separately.

Labour productivity has been the subject of several research studies. Olomolaiye *et al*. (1987) investigated factors affecting labour productivity in Nigeria, and concluded that output quantities need to be established through “time study” techniques, and that the results obtained should be disseminated to a wide range of construction firms to optimize the working methods without resorting to additional physical efforts and strenuous activities.

Horner *et al.* (1989), in a questionnaire survey to a wide section of British contractors, have identified the 13 significant factors shown in Table 1.

Table 1: Perceived Importance of Factors Influencing Labour Productivity in the UK (Horner *et al.*, 1989)

Factor	**Rank**
Skill of Labour	1
Buildability/Constructability	2
Quality of supervision	3
Method of working	4
Incentive scheme	5
Site layout	6
Complexity of construction information	7
Gang size and composition	8
Length of working day	9
Availability of power tools	10
Absenteeism	11
Total number of operatives on site	12
Proportion of work subcontracted	13

Upon examining the factors affecting the construction productivity in Singapore, Lim and Alum (1995) isolated the followings as most significant: (a) lack of qualified supervisors; (b) shortage of skilled labour; (c) high rate of labour turnover; (d) labour absenteeism; and (e) communications with foreign operatives.

Zakeri *et al.* (1996), in a survey geared toward establishing the constraints on Iranian construction productivity, have recognized the following 5 factors as major determinants of operatives' efficiency: (1) materials shortage; (2) weather and site conditions; (3) equipment breakdown; (4) drawing deficiencies/change orders; and (5) lack of proper tools and equipment. Kaming *et al.* (1997), in addition, explored the factors affecting the productivity of craftsmen in Indonesia and concluded that: lack of materials; rework; absenteeism of operatives; and lack of suitable tools, are among the most influential.

The effects of 23 factors on the productivity of the construction operation in Thailand were studied by Makulsawatudom *et al*. (2004), whose research regarded: (i) lack of material; (ii) incomplete drawings; (iii) incompetent supervisors; (iv) lack of tools and equipment; (v) labour absenteeism; (vi) poor communication; (vii) instruction time; (viii) poor site layout; (ix) inspection delay; and (x) rework, as most critical.

Abdul Kadir *et al.* (2005), furthermore, assessed the influence of 50 productivity factors on Malaysian residential projects, and discerned the following 5 factors as most important to the efficiency of labour: (a) shortage of material; (b) non-payment to suppliers causing stoppage of materials delivery to sites; (c) change orders issued by consultants; (d) late issuance of construction drawings by consultants; and (e) the incapability of site management. Based upon their recognized impacts on the efficiency of craftsmen in Uganda, Alinaitwe *et al.* (2007) further ranked the following 5 factors as being most significant: (1) incompetent supervisors; (2) lack of skills; (3) rework; (4) lack of tools/equipment; and (5) poor construction methods.

In order to categorize the factors affecting construction labour productivity into global main groups, which can best relate to the various corresponding factors, several approaches have been previously used, nevertheless, a consensus among researchers on such categorization schemes, is yet to be attained.

Herbsman and Ellis (1990) reported 2-group main divisions of influencing factors: (i) technological; and (ii) administrative, whereas Talhouni (1990) classified 4 categories responsible for affecting productivity on construction sites: (1) management; (2) site; (3) design; and (4) weather. Heizer and Render (1996) partitioned productivity factors into 3 major groups: (i) labour characteristics; (ii) project conditions; and (iii) non-productive activities, whereas Sugiharto (2003) assigned the key factors impinging upon construction productivity in Indonesia to the following categories: (a) characteristics of contractors; (b) inadequate management strategy; and (c) organization's focus. Enshassi *et al*. (2007), moreover, surveyed 45 factors influencing labour productivity of building projects in the Gaza Strip, and allocated such factors under the following 10 major groups: (1) materials/tools; (2) supervision; (3) leadership; (4) quality; (5) time; (6) manpower; (7) project; (8) external; (9) motivation; and (10) safety.

It is noteworthy that, even though productivity and safety are compatible (Hinze and Parker, 1978), and that the safety record of the construction industry is in need of major improvement, among the numerous studies reviewed, the issue of construction health and safety, continues to be treated as "lip service", which thus far, few have seriously explored its effect on the performance of operatives (Paulson, 1992).

Although several group designations have been proposed by different researchers, a careful consideration of the different terminologies presented, the authors controvert, reveals a considerable level of redundancy and sub-groupings among the various classifications reviewed. For instance, the "non-productive activities" group suggested by Heizer and Render (1996) can be reasonably included under the "labour characteristics", while the "organization's focus" proposed by Sugiharto (2003) may be lumped under the "management strategy" group. The expanded 10 groups provided by Enshassi *et al.* (2007), furthermore, can be rationally presented by the following 4 major group categories: (i) management; (ii) technical; (iii) labour; and (iv) external.

Notwithstanding that factors affecting labour productivity are different in different countries, across sites, and possibly within the same construction site, depending on circumstances (Olomolaiye *et al.*, 1998), a universal agreement on a categorization scheme should be possible. A scheme under which all such factors can be allocated, the authors argue, is attainable since the terms of such classifications can hold tenable regardless of the geographical regions, environment or jobsites, on which the specific factors partitioned under vary in their effects, either among or within.

The authors, therefore, propound the following 4 major groups, which shall form the basis for categorizing the corresponding factors explored in this investigation under: (1) management; (2) technological; (3) labour; and (4) exogenous.

RESEARCH METHOD

The related data to this research study were collected by a structured questionnaire survey. Based upon relevant previous investigations on labour productivity, and the input of local industry experts and practitioners, 35 factors were identified and shortlisted as being influential on the productivity of construction operatives in Qatar.

The target population included construction firms which are classified by the "Central Tenders Committee" (CTC) of the State. The classification criteria for construction firms are based on: (a) the credentials of the technical and administrative staff employed; (b) equipment and tools available; (c) the financial position and strength; and (d) previous experience. As a result, the numbers of firms classified under the 1st, 2nd, and 3rd categories, are 65, 28, and 33, respectively, for a total of 126 (CTC, 2011). In an effort to obtain a statistically representative sample of the population, the formula shown in Equation 1 was used (Hogg and Tannis, 2009).

$$n = \frac{m}{1+\left(\frac{m-1}{N}\right)} \qquad (1)$$

Where: *n*, *m* and *N* represent the sample size of the limited, unlimited, and available population, respectively. On the other hand, *m* is estimated by Equation 2.

$$m = \frac{z^2 \times p \times (1-p)}{\varepsilon^2} \qquad (2)$$

Where: *z* is the statistic value for the confidence level used, i.e. 2.575, 1.96, and 1.645, for 99%, 95% and 90% confidence levels, respectively; *p* is the value of the population proportion which is being estimated; and *ε* is the sampling error of the point estimate.

Since the value of *p* is unknown, Sincich *et al.* (2002) suggest a conservative value of 0.50 be used so that a sample size that is at least as large as required be obtained. Using a 95% confidence level, that is 5% significance level, the unlimited sample size of the population, *m*, is determined by Equation 2 as follows:

$$m = \frac{(1.96)^2 \times 0.50 \times (1-0.50)}{(0.05)^2} = 385$$

Therefore, for the total number of 126 classified contractors under the 1st, 2nd, and 3rd categories, i.e. *N*, the representative sample size of the population required is quantified by Equation 1 as shown below:

$$n = \frac{385}{1+\left(\frac{385-1}{126}\right)} = 95$$

The questionnaire survey comprised an ordinal measurement scale ranking the influence level perceived of each factor in an ascending order from 1 to 5. It is worth noting, however, that the numbers assigned to the scale neither indicate equal intervals nor absolute quantities, but the influence degree of each factor, from the respondents' perception, on the productivity of operatives.

In an effort to establish a reasonable validity of the findings, that is to ensure that the questions do measure what they are supposed to measure, and assess the reliability of the questionnaire, a pilot test was conducted on samples of the prospective respondents, where the questionnaire was distributed to 20 contractors for assessment and feedback. The aim of this test was threefold: (i) to assess the clarity, comprehensibility, interpretation, and appropriateness of the questions provided in capturing the factors impinging upon the productivity of construction operatives in Qatar; (ii) to test the range adequacy of response choices; and (iii) to determine the efficiency, with which the respondents complete the questionnaires.

Except for minor comments, which were mainly related to some contextual interpretations of a few questions, almost all of the respondents' feedback was positive. Therefore, the authors rearticulated such questions using simpler expressions and incontrovertible background to avoid any future confounding of the framework, within which the response of the participants is sought.

Consequently, a total of 120 chosen firms from the CTC list of classified contractors were invited to participate in the survey and followed up by direct contacts, phone calls and frequent reminders. However, feedback from: 48 first grade category; 17 second grade category; and 19 third grade category contractors, was obtained, for a total of 84 completed questionnaires, representing approximately 88% of the required sample size, nonetheless, warranting reasonable robustness and reliability of the results obtained. The respondents are considered senior ranking officials within their organizations, ranging from managing directors to project managers, with a minimum of 10 years of experience in the local construction industry.

The 35 factors surveyed, as previously indicated, were classified into the 4 following primary groups: (1) management; (2) technological; (3) labour; and (4) exogenous. In order to determine the rank of each factor surveyed relative to all factors explored, the data collected were analyzed using the "Relative Importance Index" (RII) technique (Kometa *et al.*, 1994; Kumaraswamy and Chan, 1995; Fugar and Agyakwah-Baah, 2010). The RII for each factor explored was calculated by the formula shown in Equation 3.

$$RII\,(\%) = \frac{5(n5)+4(n4)+3(n3)+2(n2)+n1}{5(n1+n2+n3+n4+n5)} \times 100 \qquad (3)$$

Where: $n1$; $n2$; $n3$; $n4$; and $n5$, are the number of respondents who selected: 1, for no effect; 2, for little effect; 3, for moderate effect; 4, for strong effect; and 5, for very strong effect, respectively.

The rank of each group was further established by quantifying the average value of the relative importance indices for all factors classified within; the higher the average value, the stronger the effect of the group (Enshassi *et al.*, 2007).

RESULTS, DISCUSSION AND RECOMMENDATIONS

The perceived effects of the 35 factors surveyed on the productivity of construction operatives in Qatar are determined. The overall factors are classified under 4 major groups as follows: 16, under the “management group”; 10, under the “technological group”; 4, under the “labour group”; and 5, under the “exogenous group”. The relative importance indices, ranks within the corresponding group, and overall ranks of the factors explored are presented, discussed and compared to previous related findings. In addition, the “group” average relative importance indices are quantified, and therefore a comparison among their influence levels is carried out. Since the management group, in comparison with other group categories, contains the largest number of factors, the discussion of the factors classified there under shall be limited to those ranked among the top 10.

Management Group

The descriptive statistics, i.e. means, standard deviations (σ) and coefficients of variation (CV), relative importance indices (RII), and ranks of the 16 factors classified under the management group are presented in Table 2. It is important to point out at this stage, however, that during the consultation phase with local industry experts and practitioners to identify, screen and short-list the various potential factors impacting the productivity of operatives in the State, the “health and safety” factor was deemed non-influential, indicating an overall satisfactory level of management safety practices on construction sites, and thus was ruled out from any further exploration.

Table 2: Descriptive Statistics, Relative Importance Indices and Ranks of Management Group Productivity Factors

Factor	Mean	σ	CV	RII	Rank
Shortage of materials	4.31	22.39	0.192	86.19%	1
Labour supervision	4.29	22.87	0.187	85.71%	2
Communication problems between site management and labour	4.18	19.97	0.209	83.57%	3
Construction manager’s lack of leadership	4.11	21.90	0.188	82.14%	4
Lack of providing labour with transportation	4.01	16.21	0.248	80.24%	5
Proportion of work subcontracted	3.98	19.64	0.202	79.52%	6
Unsuitability of storage locations	3.85	19.10	0.201	76.90%	7
Lack of training offered to labour	3.58	21.25	0.169	71.67%	8
Lack of incentive scheme	3.54	16.05	0.220	70.71%	9
Working overtime	3.45	18.69	0.184	68.94%	10
Payment delay	3.44	17.08	0.201	68.81%	11
Labour interference and congestion	3.30	20.97	0.157	65.95%	12
Construction method	3.12	23.27	0.134	62.38%	13
Sequencing problems	2.95	21.73	0.136	59.04%	14
Unavailability of tools	2.89	16.66	0.174	57.86%	15
Late arrival and early quit	2.23	19.54	0.114	44.52%	16

With an RII of 86.19%, the surveyed contractors ranked “shortage of materials” as the most significant factor influencing labour productivity in this group. This factor is further ranked 2nd in its impact among the 35 factors surveyed, which asserts its strong impact on the efficiency of operatives. This result is in agreement with the findings of Zakeri *et al.* (1996), Kaming *et al.* (1997), Makulsawatudom *et al*. (2004), Abdul Kadir *et al.* (2005) and Enshassi *et al.* (2007), whose research studies determined this factor as most important to labour productivity in Iran, Indonesia, Thailand, Malaysia and the Gaza strip, respectively.

This finding is most probably related to the current "supply/demand" curve of construction materials, where, due to the rapid pace of developments in the State, the demand for such materials, in relation to its local availability, is much higher, thus creating a shortage of supply to projects underway. The outcome is comprehensible as materials are essential to the construction process, and therefore work cannot be accomplished without. Consequently, shortage or interrupted supply of materials to jobsites leads to disruption of the work force momentum and progress of activities, hence negatively affects the performance of operatives.

"Lack of labour supervision", with an RII of 85.71%, ranks 2nd in this group, and 3rd among all factors explored, further corroborating the outcomes of Alinaitwe *et al.* (2007) and Enshassi *et al.* (2007), whose investigations showed that this factor is among the most influential on labour productivity in Uganda and the Gaza Strip, respectively. Such a perceived effect indicates that continuous supervision of labour is necessary to optimize the productive input. Lack of supervision encourages operatives, especially those who are under the direct employment method, to take frequent unscheduled breaks, wait idle, engage in unproductive activities or even leave the job sites during working hours to attend to personal matters. In addition, direct supervision of labour is required to avoid faulty and non-conforming work to contractual specifications, and therefore minimize the expensive incidents of "rework" and the associated delays to activities at hand.

Confirming the importance of "communication between site management and labour force" to the productivity of the construction process, this factor, with an RII of 83.57%, ranks 3rd in its influence within the management group, and 5th among all factors investigated. This outcome agrees with the findings of Lim and Alum (1995) and Makulsawatudom *et al*. (2004), whose works identified this factor among the most important to the construction productivity in Singapore and Thailand, respectively.

This result is attributed to the labour force characteristics of the local construction sector. The majority of operatives come from rural villages of Nepal and Sri-Lanka, where training of construction operatives is not common, and when available, is not adequate, and thus operatives are mainly ignorant of any language, tradition, culture and working methods other than their own. Therefore, it becomes necessary for construction managers to communicate with the labour force through gang/crew leaders, whose skills in English are also weak, and provide extensive training and orientation to labourers in international standards and local construction practices/methods. As a result, technical specifications, contracts' requirements and site management instructions are poorly interpreted – most often misinterpreted – but worst, outputs produced are largely rejected.

"Lack of construction managers' leadership", with an RII of 82.14%, is ranked 4th in this group, and 6th overall. This effect corroborates the findings of Makulsawatudom *et al*. (2004) and Abdul Kadir *et al.* (2005), whose research placed the "incompetency of supervisors" and "incapability of site management" in the 3rd and 5th ranks among 23 and 50 productivity factors recognized to impact the efficiency of operatives in Thailand and Malaysia, respectively. At the first instance, such an established effect may indicate that the local construction sector lacks construction managers possessing leadership characteristics. However, upon further inspection of the top 10 "management" factors shown in Table 2, it can be realized that the majority of decisions, which bear direct effects on such factors, are largely beyond the control of the construction manager, in particular those ranked 1st, 3rd, 5th, 7th and 8th, hence the result obtained.

With an RII of 80.24%, "lack of providing labour with transportation" is ranked 5th in the management group, and 9th among all factors surveyed. This finding may be ascribed to the official regulations of the State, which govern the labour force residencies and accommodations. The State of Qatar, as the case with all Gulf Cooperation Council (GCC) Countries, i.e. Bahrain, Kuwait, Oman, Saudi Arabia and United Arab Emirates, mandates the sponsorship of any foreigner taking up employment by a local sponsor, i.e. either individual or company, depending on the nature of employment. As for the labour force, the State, moreover, requires sponsors to provide adequate accommodations for operatives in accordance with the conservative traditions of the local community, that is bachelors – which is the case of almost all the labour force employed by the construction sector – should be accommodated reasonably away from residential facilities occupied by families.

In view of this, to avoid late start, early quit and absenteeism of operatives, it becomes cardinal for employers, i.e. construction firms, to provide labourers with transportation, especially that labour residences, as previously indicated, are located fairly remotely from urban cities, in which most construction projects are being developed.

The impact of "proportion of work subcontracted", which is ranked 6th in this group with an RII of 79.52%, and 10th among the 35 factors explored, augments the previous discussion of the "lack of labour supervision" influence on labour efficiency. Subcontracting work packages or certain trades is locally based on the "lump sum" procurement method to subcontractors, on the condition to accomplish and hand-over works, in accordance with contracts' specifications and within specified durations. Hence, any additional costs required to "making good" on faulty or nonconforming work, along with any associated liquidated damages incurred, would be borne directly by the related subcontractors. Consequently, such a practice encourages subcontractors to be more organized, committed and focused; pay more attention to technical details and contracts' specifications; work harder; and take less frequent breaks, all of which help boosting the efficiency level of operatives, and therefore result in higher productivity. This outcome is in agreement with the findings of Horner *et al.* (1989), reporting this factor among the most important to labour productivity in the British construction industry.

The "unsuitability of storage location" factor comes in 7th in rank within this group, and 11th overall, with an RII of 76.90%. This finding supports the results obtained by Thomas and Sanders (1991), Kaming *et al.* (1997), and Enshassi *et al.* (2007), who reported a significant impact of materials storage location on labour productivity. The perceived effect of this factor can be attributed to the following two reasons: (a) the continuous fetching can waste labour energy and may cause physical fatigue to operatives, especially on large sites, which could otherwise be productively used in the task required for the activity under progress; and (b) increased transportation time of operatives between direct work and storage locations increases the unproductive input of labourers, and thus results in lower productivity rates.

With an RII of 71.67%, "lack of training offered to Labour", ranks 8th in the management group, and 16th among all the factors investigated. The perceived effect of this factor on labour productivity suggests a shortfall on the management side to provide operatives with orientation and follow up training sessions to coach and familiarize them with international and local standard practices, such as, modern construction methods, techniques and specifications, equipment and tools available, inspection procedures and weather conditions.

Such a management shortcoming leads to poor practices, misinterpretation of contracts' conditions and faulty outputs, therefore, rejection of completed activities, expensive reworks, de-motivation of the work force, working overtime, and thus physical fatigue and exhaustion, which may contribute to accidents on sites. On the other hand, this finding may be further ascribed to the fact that contractors, whether local or international, usually take a short-term view of labour training, and this may mainly be due to: (i) the current work-load and its fluctuation, depending on the economic conditions and demand for construction; and (ii) the provisional objectives of foreign operatives themselves of an interim and transient employment.

"Lack of incentive scheme", with an RII of 70.71%, factor ranks 9th in this group, and 17th, in comparison with all factors surveyed. This influence is most probably related to the structure and socioeconomic background of the construction labour force, which, in its entirety, comprises foreign operatives, who basically, as the case with the other GCC countries, share the goal of "making and saving as much as possible, then go back home". Thus, a monetary incentive scheme is likely to further promote the transient, purely financial, common employment objective of operatives, and hence can create a high level of motivation and satisfaction among them; as a result, higher productivity may be achieved on sites. The established effect of this factor corroborates the findings reported by Horner *et al.* (1989) and Enshassi *et al.* (2007). The results obtained by the former, ranked this factor 5th among the 13 factors indentified, whereas the outcomes of the latter, of what they termed "lack of financial motivation system", ranked it 2nd after "payment delay", compared to 6 other factors classified under a "motivation group".

"Working overtime", a factor that can be reasonably connected to the previously discussed "lack of supervision and training offered to labour", which may result in faulty and contractual nonconforming outputs, is ranked 10th in its influence within this group, with an RII of 68.94%, and 19th overall. This outcome further supports the results obtained by Horner *et al.* (1989), Makulsawatudom *et al.* (2004), Alinaitwe *et* *al.* (2007), and Enshassi *et al.* (2007), who classified this factor among the important factors affecting labour productivity in the UK, Thailand, Uganda, and the Gaza Strip, respectively. The impact of this factor is expected since working overtime, as previously highlighted, causes physical fatigue to operatives, decreases their agility, stamina and motor skills, hence leading not only to low productivity, but also to a high probability of poor workmanship, and thus rework, frustration, de-motivation, and possibly accidents.

Technological Group

Table 3 presents the descriptive statistics, findings of the perceived importance and ranks of factors classified under the technological group. Upon inspecting the relative importance indices determined, and ranks established, it can be noticed that out of the 10 factors, which are classified under this group, the following 5 can be termed "Constructability" factors: (a) ranking 1st in this group, and 8th overall, with an RII of 80.95%, "delay in responding to Requests For Information (RFI)"; (b) ranking 3rd in this group, and 21st overall, with an RII of 67.86%, "clarity of technical specifications"; (c) ranking 4th in this group, and 22nd overall, with an RII of 67.14%, "coordination level among various design disciplines"; (d) ranking 5th in this group, and 24th overall, with an RII of 64.05%, "design complexity level"; and (e) ranking 8th in this group, and 31st overall, with an RII of 54.76%, "the extent of change/variation orders during execution".

Table 3: Descriptive Statistics, Relative Importance Indices and Ranks of Technological Group Productivity Factors

Factor	Mean	σ	CV	RII	Rank
Delays in Responding to "Requests For Information" (RFI)	4.05	18.25	0.222	80.95%	1
Rework	3.80	18.70	0.203	75.95%	2
Clarity of technical specifications	3.39	22.86	0.148	67.86%	3
Coordination level among design disciplines	3.36	23.06	0.146	67.14%	4
Design complexity level	3.20	25.33	0.126	64.05%	5
Confinement of working space	3.09	25.04	0.124	61.90%	6
Stringent inspection	2.77	22.69	0.122	55.48%	7
The extent of variation orders during execution	2.74	19.33	0.142	54.76%	8
Inspection delay	2.67	21.98	0.121	53.33%	9
Site restricted access	2.64	23.00	0.115	52.86%	10

Constructability, as defined by the Construction Industry Institute (CII), is "the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives" (CII, 1986). Nevertheless, an early attempt to address this concept can be credited to Sir Harold Emmerson (1962), when he suggested a new form of relationship between designers and contractors. The point of concern was the lack of cohesion between the two parties and their inability to see the whole construction process through each other's eyes.

The results obtained, on the one hand, further confirm the importance of the constructability concept to labour productivity, which are in agreement with previous findings of Horner *et al.*, (1989), Zakeri *et al.*, (1996), Kaming *et al.*, (1997), Makulsawatudom *et al.*, (2004), Abdul Kadir *et al.*, (2005), Jarkas (2005), Pulaski and Horman, (2005), Alinaitwe *et al.*, (2007), and Saghatforoush *et al.*, (2009), but on the other, indicate a concern of designs and contract documents output quality, as discerned by contractors surveyed.

Incomplete, unclear or outdated technical specifications require continuous requests for information and clarifications, thus consecutive interruptions and/or disruptions to the work progress. Furthermore, possible revisions or substantial alterations may be required to design documents, which can lead to variation/change orders and/or rework on sites, therefore, low productivity is incurred. Complex design schemes, moreover, increases the task level difficulty, requires elaborate information, and extensive contributory activities, as a result, in comparison with rationalized alternatives, such schemes are typically associated with higher labour inputs, longer durations, and hence lower labour productivity.

This impact is probably related to the insufficient time available to designers between the design start up and the call for tender to develop and review design alternatives, related details, specifications, and tender documents. Consequently, tender documents are often incomplete, unclear or contain serious conflicts among the various disciplines involved. Additionally, the perceived effects of the “stringent” and “inspection delay by the Architect/Engineer”, factors, which rank 7th and 9th within this group; 30th and 32nd overall, respectively, can be ascribed to unwarranted inspection strictness, inflexibility with allowable tolerances and possible shortfall of several architectural/engineering (A/E) firms’ staff in providing efficient professional services, further making a bad situation of designs characterized with low constructability, worse.

With relative importance indices of 75.95%, 61.90% and 52.86 %, “rework”, “confinement of working space”, and “site restricted access”, are ranked 2nd, 6th and 10th within this group; 12th, 26th and 33rd overall, respectively. The findings support the results reported by Kaming *et al.* (1997) Makulsawatudom *et al.* (2004); Alinaitwe *et al.* (2007); and Enshassi *et al.* (2007), whose research studies recognized the significance of these factors to labour productivity.

Rework, which may further cause collateral delays and disruption to surrounding work, as previously discussed, is a direct result of lack of labour supervision and training, unclear drawings and specifications, design complexity and overtime work. “Site restricted access”, and “confinement of working space”, on the other hand, negatively affect the efficiency of labour, mainly due to lost flexibility in the mobility of operatives, materials, equipment and plant movement “in and out” and within sites, in addition to overcrowding and interference resulting from the space confinement. The results obtained further reinforce the importance of the design stage, role of the supervisor and the characteristics of the jobsite to the productivity of the construction operation.

Labour Group

Table 4 presents the descriptive statistics, relative importance indices and ranks of the labour group factors identified and perceived to affect the efficiency of operatives on construction sites. Substantiating the results obtained by Horner *et al.* (1989), whose research ranked the “skill of labour” factor 1st in its importance to labour productivity in the UK, with an RII of 87.38%, this factor ranks not only 1st within this group, but also among the 35 factors surveyed, and thus perceived to be the “most significant factor” influencing construction labour productivity in Qatar.

Table 4: Descriptive Statistics, Relative Importance Indices and Ranks of Labour Group Productivity Factors

Factor	Mean	σ	CV	RII	Rank
Skill of labour	4.37	21.53	0.203	87.38%	1
Shortage of experienced labour	4.23	19.10	0.221	84.52%	2
Motivation of labour	3.73	18.62	0.200	74.52%	3
Physical fatigue	3.63	20.02	0.181	72.62%	4

Moreover, with an RII of 84.52%, “shortage of experienced labour”, is ranked 2nd in the labour group, and 4th overall. This outcome agrees with the findings of Lim and Alum (1995), whose study identified the effect of this factor among the most significant to labour productivity in Singapore. “Lack of skill” and “shortage of experienced operatives” are detrimental to the productivity of the construction process. Unskilled and poorly trained labourers are commonly characterized with low and faulty outputs coupled with unjustifiably high inputs. Their outputs, in addition, are almost always rejected, either in whole or in part, by the inspection architect/engineer, resulting in extensive and expensive rework, rectifications or repairs. Contrastingly, experienced operatives possess sound intellectual abilities, practical solutions to encountered obstacles, and high technical skills. All of which lead to higher productivity, lower cost of labour, and better quality of finished activities.

The “motivation of labour”, with an RII of 74.52%, is ranked 3rd in this group, and 13th overall. Motivated labourers are usually more enthusiastic and show more initiative. They work harder, and respond faster to instructions. Their pace is, furthermore, associated with a greater sense of satisfaction, pride and responsibility, hence they typically achieve more, compared to de-motivated or discouraged operatives. This outcome corroborates the findings of Hazeltine (1976), Borcherding *et al.* (1980), and Whitehead (1990), whose research asserted the importance of motivation to the efficiency of labour.

Ranks 4th in this group, and 15th among all factors explored, with an RII of 72.62%, are assigned to “physical fatigue” of operatives. This finding may be largely attributed to working long hours, that is, overtime. As previously discussed, working overtime leads to labour exhaustion, and hence adversely impacts their performance and production rate.

Exogenous Group

Although several factors can be further classified under this group, e.g. economic conditions, industry related laws and regulations, security level, all the exogenous factors identified and perceived to influence labour productivity in Qatar, are "weather" related. Therefore, to develop a wider and deeper understanding of the results obtained, an overview of the prevailing weather conditions is first provided.

The weather in the State is classified as subtropical dry, hot desert with little rainfall and abundant sunshine (Qatar Weather, 2011). During the long summer season, which spans from May to October, the weather is hot and humid, with temperatures reaching 45 °C. However, between the months of June and September, conditions become much worse, where the temperature peaks above 50 °C, and humidity is at its utmost highest, reaching above 90%, making working conditions, especially externally, rather unbearable. Consequently, the government imposes a midday work ban on construction sites and open spaces between 11:30 am and 3:00 pm, in the period from June 15 to August 31. The summer season is further typified by the occurrence of the "Chamal", a violent heavy wind, which often changes into severe sandstorms.

During spring and autumn seasons, i.e. March to beginning of May, and October to beginning of December, respectively, the temperature drops considerably hovering around 17 °C. Even though warm and dry, conditions during these two seasons are rather pleasant. The State's short winter season commences in December and ends in February, where the temperature retains a significantly more comfortable disposition, with pleasant, even chilly in the evenings and nights. Winter is further the season when the State receives the bulk of its little rainfall, most of it in the form of sudden, short but heavy cloudbursts and thunderstorms. Nonetheless, Qatar receives a meagre 3 inches (75 mm) precipitation annually (Qatar Weather, 2011).

In view of the preceding discussion, the exogenous group factors perceived to impact labour productivity in the State, descriptive statistics, relative importance indices quantified and ranks established are presented in Table 5.

Table 5: Descriptive Statistics, Relative Importance Indices and Ranks of Exogenous Group Productivity Factors

Factor	Mean	σ	CV	RII	Rank
High temperature	4.10	17.80	0.230	81.90%	1
High humidity	3.67	20.17	0.182	73.33%	2
Sandstorms	3.49	22.29	0.157	69.76%	3
High wind	2.83	21.81	0.130	56.67%	4
Rain	1.82	22.31	0.0816	36.43%	5

Conceivably, the results obtained show that "high temperature" is the most influential exogenous factor on the efficiency of operatives. With an RII of 81.90%, this factor ranks 1st in this group, and 7th among all factors surveyed. This outcome is in agreement with the findings of Alinaitwe *et al.* (2007).

The 2nd, 3rd, 4th, and 5th factors in ranks, with relative importance indices of 73.33%, 69.76%, 56.67% and 36.43%, are: high humidity; sandstorms; high wind; and rain, respectively. The quantified relative importance indices indicate that, while the impacts of high humidity and sandstorms are relatively strong to moderate, since working under such harsh conditions becomes extremely hard, if not impossible, high wind and rain are associated with modicum effects on labour productivity, largely due to their transient and infrequent occurrences; in fact, the contractors surveyed, rank the rain factor 35th among the 35 factors explored, cognizing its impact as “least influential” on the productivity of operatives in Qatar.

Overall Perceived Influence of Productivity Factors Surveyed and Groups Ranking

The overall perceived impacts of the 35 factors explored are presented in Table 6. As shown, the top 10 ranked factors influencing the productivity of construction operatives in Qatar are: (1) skill of labour; (2) shortage of materials; (3) lack of labour supervision; (4) shortage of experienced labour; (5) communication problem between site management and labour; (6) lack of construction managers’ leadership; (7) high temperature; (8) delay in responding to “Requests For Information” (RFI); (9) lack of providing labour with transportation; and (10) proportion of work subcontracted.

Table 6: Overall Relative Importance Indices, related Groups and Ranks of Productivity Factors Surveyed

Factor	**RII**	**Group**	**Rank**
Skill of labour	87.38%	Labour	1
Shortage of materials	86.19%	Management	2
Labour supervision	85.71%	Management	3
Shortage of experienced labour	84.52%	Labour	4
Communication between site management and labour	83.57%	Management	5
Lack of construction manager’s leadership	82.14%	Management	6
High temperature	81.90%	Exogenous	7
Delay in responding to “Requests For Information” (RFI)	80.95%	Technological	8
Lack of providing labour with transportation	80.24%	Management	9
Proportion of work subcontracted	79.52%	Management	10
Unsuitability of storage locations	76.90%	Management	11
Rework	75.95%	Technological	12
Motivation of labour	74.52%	Labour	13
High humidity	73.33%	Exogenous	14
Physical fatigue	72.62%	Labour	15
Lack of training offered to labour	71.67%	Management	16
Lack of incentive scheme	70.71%	Management	17
Sandstorms	69.76%	Exogenous	18
Working overtime	68.94%	Management	19
Payment delay	68.81%	Management	20
Clarity of technical specifications	67.86%	Technological	21
Coordination level among design disciplines	67.14%	Technological	22
Labour interference and congestion	65.95%	Management	23
Design complexity level	64.05%	Technological	24
Construction method	62.38%	Management	25
Confinement of working space	61.90%	Technological	26
Sequencing problems	59.04%	Management	27
Unavailability of tools	57.86%	Management	28

Table 6: Overall Relative Importance Indices, related Groups and Ranks of Productivity Factors Surveyed (Cont'd)

Factor	RII	Group	Rank
High wind	56.67%	Exogenous	29
Stringent inspection	55.48%	Technological	30
The extent of variation orders during execution	54.76%	Technological	31
Inspection delay	53.33%	Technological	32
Site restricted access	52.86%	Technological	33
Late arrival and early quit	44.52%	Management	34
Rain	36.43%	Exogenous	35

Table 7, on the other hand, shows the overall ranking of the four primary groups, under which the corresponding factors influencing labour productivity are classified.

Table 7: Overall Average Relative Importance Indices and Ranks of Productivity Groups

Group	Number of Factors Surveyed	Average RII	Rank
Labour	4	79.76%	1
Management	16	71.51%	2
Exogenous	5	63.62%	3
Technological	10	63.43%	4

Substantiating the positive effects of skill, experience and motivation of labour on the productivity of the construction process, the findings demonstrate that the "labour" ranks 1st among the groups, with an overall average RII of 79.76%. The "management" group, with an average RII of 71.51%, ranks 2nd over the "exogenous' and "technological" groups, which rank, surprisingly, third and fourth, respectively. However, the quantified relative importance indices of the exogenous and technological groups, i.e. 63.62% and 63.43%, respectively, indicate, on average, tantamount effects of factors belonging to both groups on the efficiency of labour, further asserting the significant negative impact of inclement weather on operatives' performance and production rates.

Recommendations

It is a common objective among contractors, designers, employers and policy makers in the State of Qatar to improve the productivity level of the construction sector. The findings of this research, collectively or selectively as may be practically applicable to the relevant phase of the project and related party involved, can assist achieving this goal by controlling the most significant factors perceived to influence the efficiency of operatives.

Improving labour skills is certainly the first step in the right direction. This can be reasonably accomplished through periodic training programmes offered by construction firms to operatives. On the other hand, policy makers can contribute, in coordination with labour agencies, in obviating the recruitment of unskilled and inexperienced labour force by developing an effective screening process for labour visa applications, and imposing minimum pre-requisite conditions on the qualifications of applicants, such as, authenticated proofs of prior construction experience, field or trade expertise and communication skills in either the English or Arabic language, which must be submitted along with, and be a required part of the application process. Such a regulation can prove effective in enhancing the quality level of the workforce employed in the construction sector of the State, on the one hand, and may result in a substantial saving in time, efforts and costs associated with the training required to enhance the skills and dexterities of operatives, on the other.

Increasing the designers' awareness of the significant effect of the constructability concept on the productivity of the construction process is another subject, which can considerably help improving the efficiency of operatives. Such an approach may be augmented by encouraging contract procurement or project delivery methods, particularly in public projects, which allow the involvement of contractors during the design stage of projects, such as, the Design-Build (DB), Design-Build-Operate-Transfer (DBOT), or Turnkey/Engineering, Procurement, and Construction (EPC), and therefore facilitate incorporating the construction experience at the early stage of the projects development process so that the associated benefits can be realized during the execution phase. Perhaps, in view of the outcomes, policy makers may, in addition, consider instigating a formal constructability assessment application as a proviso for granting construction permits, where minimum requirements of constructability principles must be satisfied before a permit can be issued.

The improvement of construction productivity can be further achieved by employing high calibre construction managers to: (i) implement, at the early stage of the management plan, an efficient material procurement, in particular for "long lead" items, and site storage strategies. This would thus mitigate the risks of work interruptions, and labour fetching, due to lack or shortage of materials in the local market, and unsuitability of storage locations, respectively; (ii) employ effective labour supervision criteria; (iii) provide the required leadership on sites; (iv) organize and carry out practical working hours, especially during peak temperature and inclement weather seasons, and tolerant labour transportation plans; (v) scrutinize the contract documents and detect potential pitfalls, obscurities and missing important details, and prepare, early enough in the process, a comprehensive "Request For Information" (RFI) list to avoid excessive delays in responding to sporadic requests along the course of the construction phase. Since this procedure may reduce potential conflicts and disagreements in interpreting ambiguous specifications and contract conditions at the site level, such an approach can alleviate adversarial relationships between construction managers and inspectors, and further assist in placating the architect's/engineer's inspection stringency; and (iv) evaluate and consider the most practical "Work Breakdown Structure" (WBS), which may optimize the proportion of subcontracted work packages. However, it is recommended that such an evaluation, at the very least, be tentatively thought out and considered during the tendering stage of the project to ensure efficient implementation at the construction phase.

Based upon the previously discussed socioeconomic background of the labour force, it is further recommended that construction managers, in coordination with the executive management of the firms, establish incentive monetary scheme programmes geared toward rewarding operatives who surmount certain predetermined benchmarks, especially those associated with activities located on the critical paths of construction schedules. Such an approach may motivate and encourage the rest of labourers to improve their performance to match, and perhaps surpass such achievements, all of which can create a level of enthusiasm, competition, satisfaction and a sense of pride among the labour force; therefore, may translate into a vibrant and productive operation.

CONCLUSIONS

This investigation has indentified, explored and, based on the determined relative importance indices, established the ranks of 35 factors perceived to influence the efficiency of construction operatives in the State of Qatar. The factors surveyed were, furthermore, categorized under the following four primary groups: (1) management; (2) technological; (3) labour; and (4) exogenous.

Although the results obtained identify the “skill of labour” as the salient factor affecting the performance of operatives in the State, out of the top 10 factors explored, 6 are classified under the management group, further corroborating Whitehead’s (1990) postulate that “productivity is strongly and positively related to the degree of management control”, and substantiating the findings of Danladi and Horner (1981) and Olomolaiye (1990).

The outcomes, moreover, indicate a shortcoming of “constructability” practices among the various A/E firms operating in the State, which may further suggest a lack of awareness on their part of the importance of this concept to the productivity of the construction operation, and reinvigorates the “50-year old” concern of Emmerson (1962). The findings, in addition, demonstrate that the notion of exerting pressure on designers to cut down design fees and durations – a practice typical of private sector developers – is “false economy”. In fact, more opportunities exist to significantly lower the total project cost by directing more attention on the design than on the construction phase. Decisions made during the design phase of a project not only have a maximum influence on its construction cost, but also dictate its viability, future expenditures and durations, albeit the local designer’s fee, depending on the project’s type, typically ranges between 3 to 6% of the construction cost. It may, furthermore, justify, from the designer’s perspective, the “cutting corner” approach commonly used in such circumstances, to both, quality and design time, in order to rationalize the cost/benefit ratio of the contract.

Such a practice leads to poor concepts and details, which are, most often, associated with low constructability levels; uncoordinated disciplines and drawings; unclear and outdated technical specifications; incompatible contract documents; frequent variation/change orders; and numerous requests for information, hence low productivity rates, increased cost of projects, and prolonged durations of construction.

The findings reported in this study not only contribute to the overall body of literature related to causes impacting the efficiency of the construction labour force, but also fill a gap in knowledge of factors influencing the productivity of operatives in Qatar, which can be used to provide local and international contractors, construction and procurement managers, architects and engineers, in addition to policy makers, direction for focusing, acting upon and controlling the cardinal factors perceived to affect the efficiency of operatives, hence ameliorating the productivity of the construction industry in an environment on the verge of witnessing an unprecedented international industry practitioners influx to match the anticipated boom in demand for expeditious, yet efficient delivery and reasonable cost of constructed facilities.

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