**Contractors’ initiatives for improving construction productivity in Singapore: Bases, actions and results**

**ABSTRACT**

With a lack of recent systematic studies on the strategies to improve construction productivity in Singapore although the country has had a productivity development programme since the 1980s, this study aims to examine the strategies implemented by construction companies in Singapore to improve the level of construction productivity. The specific objectives are to: determine the motives of Singapore construction firms behind the actions they take to improve productivity; identify the strategies that companies have adopted to improve productivity and the relative importance of these strategies; and propose possible ways forward in the effort to enhance the productivity performance of the construction companies. A two-pronged research method was employed: questionnaire survey and in-depth interviews with subject matter experts. The results show that the top three most important motives for achieving high productivity are: increase profitability; deliver projects on time; and enhance corporate competitiveness. The top three strategies to achieve productivity improvement are: training of workers; investment in mechanisation; and more complete and firmed-up design. The findings suggest that productivity improvement is likely to be sustainable because the motives are linked to the performance of the firms, and are internally driven. They provide project managers with a clear sense on what can be done to improve productivity to benefit their own firms, and that these strategies are under the project managers’ control (these include worker training and mechanisation).

*Keywords*: Construction productivity; strategies; motives; initiatives.

**Introduction**

The level of construction productivity in Singapore and the rate of growth of this parameter have been low in most of the years during the past four decades although the country has had a long-standing programme for developing the construction industry (Ofori, 1993, Centre for Liveable Cities, 2015). The programme has been administered by a dedicated statutory agency which was established in 1984 to spearhead the continuous improvement of the construction industry (initially known as the Construction Industry Development Board (CIDB) which became the Building and Construction Authority (BCA) in 1999).

In Singapore, it is recognised that there is a need to increase productivity in the construction industry in order for construction to play its part in increasing overall productivity in the economy and enhancing national competitiveness (Ministry of Manpower, 2014), as well as to address the acute shortage of Singaporeans willing to take up careers in the industry (The Business Times, 2016).

It is recognized that the construction sector can also boost other sectors of the economy such as manufacturing, trading, transportation, finance, insurance and business services (Economic Strategies Committee, 2010; De Valence, 2019). The link between the performance of construction and economic growth is strong (Ali *et al.*, 2019). Thus, many governments such as those of Australia, Ireland, New Zealand and the UK have formulated policies and implemented initiatives to enhance the level of construction productivity (HM Government, 2013, Government of Ireland, 2014, National Infrastructure Unit, 2015).

Studies have been undertaken in many other countries to identify factors that affect the level of construction productivity and strategies that can help improve the industry’s performance along this parameter (Huang *et al.*, 2009, Economic Strategies Committee, 2010, Singh, 2010, El-Gohary and Aziz, 2014).

The aim of this study is to examine the strategies implemented by construction companies in Singapore to improve the level of construction productivity. The specific objectives are to: determine the reasons or motives of Singapore construction firms behind the actions they take to improve productivity; identify the strategies that companies have adopted to improve productivity and the relative importance of these strategies; and compare differences in strategies used/perceived by different types of contractors. Based on the findings, possible ways forward in the effort to enhance the productivity performance of the construction companies is proposed.

**Literature review**

In order to identify knowledge gaps, literature review was conducted. Extant literature of the following was reviewed: productivity concept, factors affecting construction productivity, improvement measures, factors influencing construction productivity in Singapore and efforts to improve productivity levels.

*Productivity*

Productivity measures output produced based on the inputs used in the production process (Organisation for Economic Co-operation and Development, 2001). The US Department of Commerce defined productivity as output (in dollars) divided by labour-hour input (in person-hour) (Adrian, 1987). Finke (1998) identified productivity as work produced divided by man-hour or equipment hour. Sezer and Bröchner (2014) argued that low growth rates for construction productivity in official statistics may be explained partly by difficulties in measuring changes in heterogeneous input and output qualities.

Many types of metrics on productivity are produced. Total factor productivity (TFP) and partial factor productivity (PFP) are often used for the construction industry (El-Gohary and Aziz, 2014). TFP refers to the ratio of outputs divided by all inputs and a common monetary value unit is used for both outputs and inputs (Thomas *et al.*, 1990, El-Gohary and Aziz, 2014). Azman et al. (2019) measured TFP of 37 public-listed Malaysian construction firms over 14 years (2003-2016), and using meta-frontier framework, they found that TFP improvement generally occurs due to technical efficiency and scale-mix efficiency relating to scope economies. PFP uses the ratio of outputs divided by a single or selected inputs, and accurate data can be obtained from it (Jarkas and Bitar, 2011).

In the construction industry, labour productivity is most frequently used. It is pertinent to note that, in construction, productivity can be considered at the task, process (stage), project, company or industry levels. This paper considers the concept at the macro, industry level. Forsythe (2018) argued that productivity measurement should separately measure homogenous and heterogeneous parts of work processes as this enables delineated measurement between work involving mass economies of scale (homogenous work), versus customized work (heterogeneous work).

It should also be noted that the general view that the level of construction productivity and of its rate of growth are low [as can be discerned from the national accounts data (Department of Statistics, 2018; Office of National Statistics, 2019) and governments’ reports (HM Government, 2013; HM Government, 2015) as well as several major works (see, for example, Teicholz, 2001; Vogl and Abdel-Wahab, 2015) is disputed There is also lack of agreement on the method of measurement of construction productivity at the macro level (Haugbølle *et al.*, 2019).

This debate on whether construction productivity has grown and whether the methods for measuring it are appropriate has been going on in Singapore. On the measurement approach, the BCA reports productivity in m2 per man-day and according to its estimates, it increased by an average of 1.3% per year between 2009 and 2016 (a 10% cumulative improvement). In the same period, the economic measure of construction productivity in terms of value added per worker employed in hardly grew. The aim of the government is to improve construction productivity by up to 3% annually until 2020, based on the economic measure (Pillai, 2017).

*Factors affecting construction productivity*

Extensive studies have been undertaken to identify and explore the factors which affect construction productivity. The studies that focused on factors hindering construction productivity growth are summarized in Table 1. Jarkas and Bitar (2011) classified the factors influencing productivity in Kuwait into four groups: management, technological, human/labour and external.

Table 1. Factors Affecting Construction Productivity

| Factor | References |
| --- | --- |
| Planning & scheduling | El-Gohary and Aziz (2014); Naoum (2016); Yi and Chan (2013) |
| Coordination and communication | Haas (2009); HM Government (2013); El-Gohary and Aziz (2014); Naoum (2016); Yi and Chan (2013) |
| Management control | El-Gohary and Aziz (2014); Naoum (2016); Yi and Chan (2013); Productivity Commission (2014); Vogl and Abdel-Wahab (2015) |
| Labour union agreements | Yi and Chan (2013) |
| Restrictive work practices | Yi and Chan (2013) |
| Absenteeism | Yi and Chan (2013) |
| Turnover/ Sales volume | Yi and Chan (2013) |
| Delay | Yi and Chan (2013) |
| Availability of skilled workers | Haas (2009); El-Gohary and Aziz (2014); Yi and Chan (2013) |
| Workers’ education and level of skill | El-Gohary and Aziz (2014); Yi and Chan (2013) |
| Workers’ age | El-Gohary and Aziz (2014) |
| Experience and training of workers | Naoum (2016) |
| Incentive programmes | El-Gohary and Aziz (2014); Productivity Commission (2014) |
| Insurance and medical care for workers | El-Gohary and Aziz (2014) |
| Supervision of workers | Durdyev and Mbachu (2011); El-Gohary and Aziz (2014) |
| Regulations, permitting, codes and standards | Haas (2009); Yi and Chan (2013); Sverikauskas et al. (2014); Vogl and Abdel-Wahab (2015); Barbosa et al. (2017 |
| Climate and weather | El-Gohary and Aziz (2014); Yi and Chan (2013); Vogl and Abdel-Wahab (2015) |
| Contracts | Haas (2009); Yi and Chan (2013); Barbosa et al. (2017) |
| Owner characteristics | Yi and Chan (2013); Vogl and Abdel-Wahab (2015) |
| Financing | Haas (2009); Yi and Chan (2013) |
| Automation, use of equipment, technology, tools & machinery | El-Gohary and Aziz (2014); Yi and Chan (2013) Vogl and Abdel-Wahab (2015); Dai *et al.* (2009); |
| Information system | Yi and Chan (2013) |
| Design and production information | Dai *et al.* (2009); El-Gohary and Aziz (2014); Naoum (2016); Yi and Chan (2013); Productivity Commission (2014); Barbosa et al. (2017) |
| Project scale | El-Gohary and Aziz (2014) |
| Materials | Dai *et al.* (2009); Haas (2009); El-Gohary and Aziz (2014); Yi and Chan (2013); Vogl and Abdel-Wahab (2015) |
| Changes/ Variation | El-Gohary and Aziz (2014); Liu *et al.* (2010); Naoum (2016); Yi and Chan (2013) |
| Buildability and constructability | El-Gohary and Aziz (2014); Naoum (2016); Yi and Chan (2013); Vogl and Abdel-Wahab (2015) |
| Subcontractors | Haas (2009); El-Gohary and Aziz (2014) |
| Work environment | Naoum (2016); El-Gohary and Aziz (2014) |
| Procurement method | Productivity Commission (2014); Vogl and Abdel-Wahab (2015); Naoum (2016) |
| Team integration | Haas (2009); HM Government (2013); Naoum (2016); Barbosa et al. (2017) |
| Standardisation, prefabrication and off-site production | Vogl and Abdel-Wahab (2015); HM Government 2015; Barbosa et al. (2017) |
| Rework | Durdyev and Mbachu (2011); Productivity Commission (2014) |

*Improvement measures*

A McKinsey report (Barbosa *et al.*, 2017) suggests that governments and companies acting in seven areas simultaneously could boost productivity by 50-60 percent. Making real progress in the industry will require contributions from all players. Improvement measures have also been studied in many countries such as New Zealand (Durdyev and Mbachu, 2011), United Arab Emirates (Singh, 2010), Australia and the United States (Huang *et al.*, 2009, Economic Strategies Committee, 2010). The findings are summarized in Table 2.

**Table 2. Improvement Measures**

|  |  |
| --- | --- |
| Improvement Measure | References |
| Reshape regulation | Barbosa *et al.* (2017); Singh (2010) |
| Restructure the contractual framework to reshape the industry’s dynamics | Barbosa *et al.* (2017) |
| Rethink design and engineering processes | Barbosa *et al.* (2017); Singh (2010) |
| Improve procurement and supply-chain management | Barbosa *et al.* (2017) |
| Improve on-site execution | Barbosa *et al.* (2017) |
| Apply digital technology including automation | Barbosa *et al.* (2017) |
| Apply new materials | Barbosa *et al.* (2017) |
| Reskill the workforce | Barbosa *et al.* (2017); Durdyev and Mbachu (2011); Singh (2010) |
| Adopt prefabrication based on off-site production of components | Barbosa *et al.* (2017) |
| Reduce rework | Durdyev and Mbachu (2011) |
| Adopt appropriate methods of construction | Durdyev and Mbachu (2011) |
| Ensure buildability | Durdyev and Mbachu (2011) |
| Improve on co-ordination | Durdyev and Mbachu (2011); Singh (2010) |
| Improve supervision | Durdyev and Mbachu (2011); Singh (2010) |
| Performance monitoring and control | Durdyev and Mbachu (2011) |
| Financial management | Singh (2010) |
| Predicting of demand | Singh (2010) |
| Improve work scheduling | Singh (2010) |
| Ensure right crew mix | Singh (2010) |
| Training | Economic Strategies Committee (2010); Huang *et al.* (2009); Singh (2010) |
| Improve quality of materials | Singh (2010) |
| Provide right equipment | Singh (2010) |
| Industry reform | Economic Strategies Committee (2010); Huang *et al.* (2009) |
| Use localized and experienced workers | Economic Strategies Committee (2010); Huang *et al.* (2009) |
| Apply industry best practices | Economic Strategies Committee (2010); Huang *et al.* (2009) |

Some proposals which are usually made are now outlined. Project management is considered as a major influencing factor on construction productivity. The aspects highlighted include: good planning, realistic scheduling, appropriate co-ordination, reduction of work flow changes from the plan and appropriate control (Yi and Chan, 2013). It is suggested that to improve on project management, focus should be put on planning and co-ordination; appropriate systems should be introduced to engage with specialist, outsourced workers and subcontractors, and to provide for the interfacing of people, materials and information; effective performance measurement tools should be developed and applied; logistics and materials management should be modernised; subcontractors’ work progress should be monitored; and efforts should be made to reduce indirect costs (Huang *et al.*, 2009).

Better planning strategies based on principles and tools designed to improve work flow stability such as Last Planner System (LPS) are suggested (González *et al.*, 2008). Fulford and Standing (2014) proposed collaborative project management which can help improve productivity on projects. At the project planning stage, it requires stakeholder-led design, conducting life cycle costing, strong relationships and IT sophistication. At the project execution stage, it requires trust and shared values, a collaborative culture, standardized practices and application of IT.

To enhance human resource management, comprehensive training and knowledge transfer programmes need to be developed; appropriate salary, compensation and incentive systems should be developed and applied; a culture of excellence in both quality and quantity of work should be fostered; organizational expertise and best practices should be used; and frequent feedback should be provided to the workers (Pipeline and Gas Journal, 2015).

Technology related to tools, machinery, material and information technology has also played an important role on productivity (Yi and Chan, 2013). It is suggested that, to improve technology adoption, measures should be taken to mechanize where appropriate including seeking to automate where possible; consider the utilization of prefabrication, pre-assembly and modularization; and utilize new technologies such as ICT, BIM and Radio-frequency identification (RFID) (Huang *et al.*, 2009).

To improve management at the company level, it is suggested that the leadership should communicate productivity improvement ideas; and emphasize the importance of productivity for everyone (Huang *et al.*, 2009). Government policies that affect productivity include regulations such as environmental requirements (Yi and Chan, 2013). Thus, appropriate changes in relevant regulations can be enabling factors.

*State of Singapore’s construction productivity*

The factors which have been found to influence construction productivity and its growth in the literature have also been evident in Singapore. A special feature of the industry is its reliance on foreign workers (constituting 70 - 80% of the workforce) which is often the top cause, as it gives rise to issues such as poor skill levels, difficulties in communications, and differences in work ethic and attitudes (Ministry of Manpower 2019). Lim (1996) found that factors hindering construction productivity in Singapore included: shortage of trained, skilled supervisors and workers; a weakening local construction workforce; and a large, mostly unskilled and transient pool of foreign workers. Lim’s (1998) recommendations for improving construction productivity included: recruitment and training of a new generation of local workers; continuous upgrading of management and technical skills of supervisors; a study of long-term viability of construction automation processes; promotion of buildable designs; and application of prefabrication.

The Construction 21 Steering Committee (1999) highlighted these challenges: the predominance of multi-level subcontracting; fragmentation of the construction process with separation of design from construction and a multitude of participants; predominance of labour-intensive production methods and lack of attention at the design stage for ease of construction; and multiplicity of small firms resulting in lack of investment in mechanisation and investment in R&D. Teo et al. (2015) undertook a factor analysis of 27 contributors to low construction site productivity in Singapore and grouped them as follows: (i) site conditions, quality and attitudes of personnel, and management of projects; (ii) design and procurement; (iii) subcontracting, and corporate productivity practice; (iv) communication, and complexity of project; and (v) resources and construction method.

Singapore has been improving the productivity of its construction industry to reduce reliance on foreign workers, enable faster and better quality construction, and improve the image of the construction industry (Building and Construction Authority, 2014). Some of the initiatives which have been applied are: workforce development, technology adoption, and capability development (Building and Construction Authority, 2010). The aim of the government’s first Construction Productivity Roadmap was to attain: higher quality workforce (through the requirement of minimum percentage of highly skilled workers; and by providing incentives to train workers); higher capital investment (such as for adoption of Design for Manufacturing and Assembly (DfMA); procurement requirements; incentives for productive technologies; and encouraging continual innovation) (Building and Construction Authority, 2015).

*Knowledge gap*

The Singapore government has formulated policies and strategies, introduced regulatory requirements, set up incentive schemes to support training and investment in technology, produced guides (Building and Construction Authority, 2019a), and launched national awards to improve construction productivity. Construction companies have adopted strategies across the spectrum of suggested actions. However, there has been no systematic study on the corporate strategies that construction firms in Singapore have adopted, nor a systematic examination of these strategies. Although there were studies focusing on strategies adopted in other countries, these are not always applicable to Singapore. Singapore requires a separate study because it is a small country, where its construction industry is heavily reliant on migrant workers from Asia for its workforce. This study aims to fill this gap.

There is a large volume of literature on the factors which hinder efforts to increase construction productivity. These studies usually offer generally plausible recommendations. There have not yet been any studies which have analysed and examined the usual recommendations in the form of the operating strategies adopted by contractors. Singapore has had what could be described as a state-led construction productivity programme (Sweet, 2014) for several decades. The current study seeks to find out what motivates contractors in Singapore to take measures to improve the levels of productivity on their projects. It then examines the particular strategies and actions adopted by the construction firms to improve productivity. The findings will help to identify the segments of the government’s programme which work, and guide the formulation of policies and the adoption of corporate initiatives to enhance productivity. The results of the study will provide lessons for other countries on how to solve the construction productivity conundrum.

**Research methods**

This paper reports on one part of a larger research programme on construction productivity in Singapore (SCAL, 2016). A two-pronged research method was employed: survey and in-depth interviews. The survey was conducted to gather information, using a structured questionnaire, from a large group of respondents, and thereafter, aggregate the responses and conduct statistical analysis. The in-depth interviews were undertaken to validate and explain the statistical results.

A questionnaire was developed based on the following: published research papers, reports and other publications of the relevant agencies such as BCA, relevant publications in the media, and public speeches on the subject of construction productivity. In the questionnaire, one section asked for information on corporate practices on productivity improvement adopted by the contractor. The questions related to technology, labour, management and planning. Another section sought respondents’ opinions on possible future improvement measures. The questions included the following: support from stakeholders, government efforts, labour management, technology, planning and corporate management. The final section asked respondents to indicate some basic personal particulars and those of their companies. There was a mix of answers required from respondents such as: “yes” or “no” answers; several options for selection; and 5-point Likert Scale. The Likert scale was anchored as follows: 1 = of least use/importance; 2 = not useful/important; 3 = neutral; 4 = useful/important; 5 = very useful/important. A pilot test of the questionnaire was conducted in three meetings with the members of the Productivity and Innovation Committee of the Singapore Contractors Association (SCAL), who are subject matter experts, to validate the appropriateness of the questions. Their suggestions, which included the trimming of the length of the questionnaire, delineation of the period of the productivity programme the study should cover (to begin in 2000) and inclusion of particular questions, were adopted to improve the questionnaire.

The population comprised contractors operating in the construction industry in Singapore. 3032 E-mails were sent to all relevant members of the Singapore Contractors Association Ltd (SCAL) and Singapore Chinese Chamber of Commerce and Industry members who are operating in the construction industry. 305 sets of questionnaire were sent to Ordinary, Associate and Trade (OAT) members of SCAL. With a population of 3337 (being 3032 + 305), the sample size should be minimum 94 to achieve 95% confidence level and a 10% margin of error. In this study, a total of 109 valid responses were collected, giving an adequate sample size.

In-depth interviews were conducted to validate and explain the results collected from the questionnaire. The 12 subject-matter experts were carefully selected senior practitioners in construction companies. The data collection instrument comprised a list of 10 open-ended questions, which covered topics relating to interviewees’ views on construction productivity.

After the responses were processed, the mean importance ratings were calculated for variables measured on the 5-point Likert scale. The formula for calculating the mean importance rating is given in Eq. 1.

|  |  |  |
| --- | --- | --- |
|  | 1(n1) + 2(n2) + 3(n3) + 4(n4) + 5(n5) |  |
| x̄ = |  | ………Eq. 1 |
|  | (n1 + n2 + n3 + n4 + n5 ) |  |

where:

x̄ is the mean importance rating of a specific variable, and

n1 , n2 , n3 , n4 , and n5 are the number of respondents who indicated on the 5-point Likert scale, the level of importance as 1 , 2, 3, 4, and 5 respectively.

One sample t-test was conducted using SPSS statistics software to analyse the following: reasons/motives for achieving high construction productivity, and strategies to improve productivity. The hypothesized population mean (μ0) was set at 3, which is the neutral point of the 5-point Likert scale. For each question, the null and alternative hypotheses were as set out below, where μ is the population mean.

* Null Hypothesis H0: μ ≤ 3. The decision rule was to accept H0 when p ≥ 0.05.
* Alternative Hypothesis H1: μ > 3. The decision rule was to reject H0 and accept H1 when the t-value is positive at significance level p < 0.05. It is then concluded that the population mean is significantly higher than 3.

As there are many significantly effective strategies, factor analysis was conducted using SPSS software to detect the strategies that may be inter-dependent and to group them into a smaller number of categories or factors. Cronbach’s alpha, eigenvalues, communalities and rotated factors were calculated using SPSS software. For the missing values, “exclude cases list-wise” treatment was adopted. A conceptual framework is presented in Figure 1.

Figure 1 Conceptual framework

Reasons for Improving Productivity

(Objective 1) [T-test]

Seniority of respondents

(Objective 3) [Anova]

Strategies to Improve Productivity

(Objective 2)

[T-test & Factor Analysis; In-depth interviews]

Size of contractor

(Objective 3) [Anova]

One-way analysis of variance (ANOVA) was conducted to determine whether there are any significant differences between the means of different groups of respondents: firms with high turnover versus low turnover; and respondents who are in top management versus middle management. ANOVA compares the means between these groups and determines whether any of those means are statistically significantly different from each other.

**Characteristics of the sample**

Table 3 shows the characteristics of the 109 respondents. About half of the respondents are working in very large construction firms (graded as A1 contractors by the BCA, and may bid for public projects of any value). There is a good mix of companies in terms of turnover in 2014, spreading from less than S$10 million (exchange rate is S$1 ≈ US$0.72) to more than S$100 million, with the majority having revenue more than S$10 million in 2014. The majority of the respondents (80%) are working in local construction firms. Half (50%) of the respondents hold top level management roles.

Table 3. Profile of respondents

|  |  |  |
| --- | --- | --- |
| Description | Frequency | % (out of the respondents who provided relevant information) |
| Company’s Current BCA Registration (Total 57 responded) | | |
| A1 | 29 | 50.9% |
| Others | 28 | 49.1% |
| Company’s Turnover in 2014 (T million S$) (Total 52 responded) | | |
| T ≤ 10 | 13 | 23.2% |
| 10 < T ≤ 50 | 14 | 25% |
| 50 < T ≤ 100 | 7 | 12.5% |
| T > 100 | 22 | 39.3% |
| Origin of the Company (Total 66 responded) |  |  |
| Local | 53 | 80.3% |
| Local/Foreign Joint Venture | 0 | 0% |
| Foreign | 13 | 19.7% |
| Seniority (Total 66 responded) | | |
| Top Management | 33 | 50% |
| Mid Management | 33 | 50% |
| Meaning of productivity (Total 110 responded, multiple responses allowed) |  |  |
| Output per person employed | 76 | 69.1% |
| Proportion of time saved compared to the project’s plan | 32 | 29.1% |
| Unit cost of the amount of work done | 26 | 23.6% |
|  |  |  |
|  |  |  |

Twelve subject matter experts were interviewed (see Table 4). The majority work in local construction companies, and are from top management. This indicates that the interviewees are experienced and well suited to inform the research.

Table 4. Profile of interviewees

|  |  |  |
| --- | --- | --- |
| Interviewee Code | Company Country of Origin | Designation |
| C1 | Local | Director (Safety) |
| C2 | Local | Deputy Managing Director (Operations) |
| C3 | Local | Operations Manager |
| C4 | Local | Director |
| C5 | Foreign | Managing Director |
| C6 | Foreign | Planning Manager |
| C7 | Foreign | Human Resource and Administration Manager |
| C8 | Local | CEO |
| C9 | Local | CEO |
| C10 | Local | CEO |
| C11 | Local | Director |
| C12 | Local | Director |

**Results**

This section presents respondents’ views on the following: concept of productivity, reasons for achieving high productivity, and important strategies to improve productivity. Except for the profile of respondents (Table 3), all 109 respondents answered all the questions in the questionnaire.

*Meaning of productivity to respondents*

The first question of the survey asked respondents what productivity means to them. More than two-thirds of respondents selected “output per person employed”, followed by one-third stating “proportion of time saved compared to the project’s plan” (see Table 3). This indicates that the majority of the respondents have similar notion of productivity when responding to the survey.

*Reasons for achieving high productivity*

T-test was conducted to determine motives contractors have in seeking to achieve high construction productivity. Table 5 shows the top 3 reasons are to increase profitability, deliver projects on time and enhance corporate competitiveness. These factors are related: by having high construction productivity, the firms can reduce time and man-hour required, which can help save cost and increase productivity (Ballard *et al.*, 2003) since many of the major cost items on a construction project are time sensitive. Moreover, delays may lead to the imposition of liquidated damages on contractors (Yi and Chan, 2013). High productivity to reduce time and cost required to finish projects would enable firms to be more attractive when bidding for projects, thereby increasing company competitiveness. Meanwhile, winning national construction productivity awards is not a significant reason to achieve high construction productivity.

Table 5. Reasons/motives for achieving high construction productivity

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S/N | Reasons/motives | Mean | T-value | 1-tail Sig |
| 22a | Increase profitability | 4.45 | 17.124 | 0.000 |
| 22b | Deliver projects on time | 4.44 | 16.622 | 0.000 |
| 22c | Enhance corporate competitiveness | 4.26 | 13.485 | 0.000 |
| 22d | Reduce number of foreign workers | 3.61 | 5.346 | 0.000 |
| 22e | Keep within Man-Year Entitlement (MYE) quotas | 3.77 | 7.585 | 0.000 |
| 22f | Enhance corporate image | 3.99 | 9.496 | 0.000 |
| 22g | Win national construction productivity awards | 3.08 | 0.629 | 0.265 |

*Most important strategies to improve productivity*

The most effective strategies that can help construction firms to improve productivity, based on the mean scores of the strategies, are shown in Table 6. The top 3 most important strategies are: training of workers; investment in mechanization; and more complete and firmed-up design (see Table 6).

Table 6. Top 10 strategies to improve productivity

|  |  |  |
| --- | --- | --- |
| Rank | Variable | Mean |
| 1 | Training of workers (current) | 4.24 |
| 2 | Investment in mechanisation | 4.14 |
| 3 | More complete and firmed-up design | 4.11 |
| 4 | Standardisation of components | 4.07 |
| 5 | Training of workers (future) | 4.06 |
| 6 | More prompt payment from clients | 4.04 |
| 7 | More attention to productivity by firm’s leaders | 4.00 |
| 8 | Involvement of contractor in design | 3.98 |
| 9 | Re-engineering of designs | 3.97 |
| 10 | Support of clients | 3.97 |

The most important strategy is consistent with Singapore’s effort to improve the quality of its workforce across the board, as discussed above. This agrees with other studies which stressed the importance of workers’ skills (Hasan, 2018) and providing them with a high level of training to improve productivity (Sherekar and Tatikonda (2016). Nasir et al. (2014) discovered that one of the main reasons that the rate of growth of construction productivity of Canada has been greater than the US is due to its worker training systems.

The second most important strategy to invest in mechanisation is directly linked to the Singapore government’s efforts to provide incentives to help construction firms to mechanise their operations (BCA 2019b). The third most important strategy about having complete and firmed-up design confirms Hasan’s (2018) finding that one of the most frequently highlighted reasons for poor productivity is incomplete drawings. The continuous requests for design information interrupts work progress (Rivas *et al.*, 2011) and leads to productivity loss at construction sites (Hughes and Thorpe, 2014). The schemes contractors have used are further discussed and evaluated in the discussion section below.

**Discussion**

One sample t-test as described above, was conducted to identity significantly effective strategies (p < 0.05) to improve construction productivity. Those that were significantly effective were then subject to factor analysis, to group them into several categories. The results in Table 7 show that five categories/factors were extracted.

Cronbach's alpha, which is an internal reliability test, showed that each factor had internal consistency. Some strategies were manually reclassified for better fit. The eigenvalues (which represent the variance that can be explained by the variables included in the category) for every category are more than 1, indicating a good quality score for each factor. Communalities represent how much the variance of the specific variable can be explained by the common factor. Table 7 shows that the communalities for all variables are high (more than the threshold of 0.4), indicating that each variable loads significantly on the factor it is categorized under. Rotated factors represent how the variables are weighted for each factor and also the correlation between the variables and the factor. All the rotated factors are larger than |0.4|, indicating that the variable is important to the factor. The results of the factor analysis as shown in Table 7 are discussed below. The strategies are also differentiated by levels of impact: external, company and project.

Table 7. Factor analysis of strategies to improve productivity

| Factor | Initial Total Eigenvalues | S/N | Variable | Application | Mean | T-value | 1-tail Sig | Initial Communalities | Rotated Factor |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| F1: Government initiatives  Cronbach’s alpha: 0.871 | 18.300 | 23d | guidance from government programmes | External | 3.63 | 6.154 | 0.000 | 0.979 | 0.738 |
| 20c | increasing the number of direct workers | Project | 3.57 | 5.649 | 0.000 | 0.882 | 0.708 |
| 23c | government’s incentive schemes for firms | External | 3.94 | 8.855 | 0.000 | 0.964 | 0.667 |
| 29i | increase of man-year entitlement | External | 3.63 | 5.358 | 0.000 | 0.913 | 0.632 |
| 20g | introduction of incentive schemes for workers | Company | 3.78 | 7.617 | 0.000 | 0.923 | 0.574 |
| 23e | role models in the industry | External | 3.56 | 5.231 | 0.000 | 0.919 | 0.563 |
| 29c (F3) | review of relevant government regulations | External | 3.94 | 8.855 | 0.000 | 0.964 | 0.567 |
| F2: Design factors  Cronbach’s alpha: 0.902 | 2.692 | 20i | re-engineering of designs | External | 3.97 | 10.338 | 0.000 | 0.940 | 0.734 |
| 20h | adoption of prefabrication | Project | 3.71 | 7.978 | 0.000 | 0.977 | 0.726 |
| 29d (F5) | more extensive use of prefabrication | Project | 3.58 | 5.537 | 0.000 | 0.958 | 0.461 |
| 20l | use of design-and-build | External | 3.72 | 6.738 | 0.000 | 0.925 | 0.707 |
| 29m | greater extent of design-and-build | External | 3.80 | 7.651 | 0.000 | 0.991 | 0.609 |
| 29v | input by contractors of accurate data to Electronic Productivity Submission System (ePSS) | Project | 3.25 | 2.182 | 0.016 | 0.922 | 0.577 |
| 20m | monitoring Buildability and Constructability Scores | Project | 3.23 | 1.974 | 0.026 | 0.974 | 0.551 |
| 20k (F4) | applying information technology (including BIM) | Project | 3.52 | 4.921 | 0.000 | 0.964 | 0.430 |
| 29t (F6) | more complete and firmed-up design | External | 4.11 | 10.690 | 0.000 | 0.953 | 0.598 |
| 29f (F6) | standardisation of components | Project | 4.07 | 11.659 | 0.000 | 0.942 | 0.575 |
| 29n | involvement of contractor in design | External | 3.98 | 10.398 | 0.000 | 0.971 | 0.524 |
| F3: Site operations  Cronbach’s alpha: 0.841 | 2.339 | 20b | training of workers (current) | Company | 4.24 | 16.582 | 0.000 | 0.953 | 0.693 |
| 29b (F1) | training of workers (future) | Company | 4.06 | 12.284 | 0.000 | 0.956 | 0.465 |
| 20f | more effective project planning and monitoring | Project | 3.96 | 12.166 | 0.000 | 0.954 | 0.658 |
| 29j | more attention to productivity by firm’s leaders | Company | 4.00 | 9.723 | 0.000 | 0.959 | 0.590 |
| 20a | investment in mechanisation | Company | 4.14 | 12.720 | 0.000 | 0.918 | 0.575 |
| 29k (F6) | more mechanisation of construction work | Company | 3.94 | 10.119 | 0.000 | 0.950 | 0.531 |
| 20j | engagement of more supervisors | Company | 3.21 | 2.279 | 0.013 | 0.838 | 0.509 |
| 29u | applying techniques to reduce amount of work | Company | 3.94 | 9.791 | 0.000 | 0.890 | 0.457 |
| 29p (F5) | increase in extent of subcontracting | Project | 3.29 | 3.158 | 0.001 | 0.833 | 0.626 |
| F4: Support of stakeholders  Cronbach’s alpha: 0.821 | 1.887 | 23f | support of clients | External | 3.97 | 9.063 | 0.000 | 0.966 | 0.749 |
| 23h | support of consulting teams | External | 3.76 | 6.341 | 0.000 | 0.942 | 0.721 |
| 23g | support of subcontractors | External | 3.76 | 7.142 | 0.000 | 0.954 | 0.662 |
| 29q (F6) | better service from subcontractors | External | 3.74 | 7.601 | 0.000 | 0.960 | 0.554 |
| 29a (F7) | clients’ insistence on productivity | External | 3.73 | 6.385 | 0.000 | 0.884 | 0.759 |
| 29r (F1) | more prompt payment from clients | External | 4.04 | 10.452 | 0.000 | 0.932 | 0.526 |
| 29e (F5) | better service from suppliers | External | 3.61 | 6.455 | 0.000 | 0.898 | 0.491 |
| 29s | longer construction period | External | 3.80 | 7.386 | 0.000 | 0.968 | 0.419 |
| F5: Industry pressure  Cronbach’s alpha: 0.744 | 1.780 | 23a | pressure from the presence of foreign contractors | External | 3.20 | 1.827 | 0.036 | 0.939 | 0.445 |
| 29g | mandatory requirement for contractors to pay attention to productivity | External | 3.54 | 5.110 | 0.000 | 0.949 | 0.538 |
| 23b (F3) | competition within the industry | External | 3.94 | 9.317 | 0.000 | 0.921 | 0.434 |

Notes: Factor Analysis Method: Principal axis factoring. List Value: Exclude cases listwise.

Rotation: Varimax

Re-categorization of variables was done to ensure better logic.

*Government’s initiatives to improve productivity*

Factor 1 comprises strategies relating to the government’s initiatives to improve construction productivity, and has eigenvalue of 18.3, which is much larger than other factors (see Table 7), suggesting that this factor represents a principal component of strategies to improve productivity. The effective strategies include: “guidance from government programs”, “government’s incentive schemes” and “increase of man-year entitlement”. Some of the initiatives include the Buildable Design Appraisal System (Building and Construction Authority, 2018) which indicates minimum levels of buildability to be attained in designs, guidance on technology adoption and support for capability development (Building and Construction Authority, 2010), providing incentives for the adoption of productive technologies (Building and Construction Authority, 2015), and the range of support schemes under the Construction Productivity and Capability Fund (CPCF) (Building and Construction Authority, 2019b). The statistical findings are validated by several interviewees. Interviewees C4, C5, C6 and C8 mentioned many initiatives launched by the government have helped them to improve productivity. They highlighted these actions: the government’s push for the adoption of precast and prefabricated construction, the prescription of minimum buildability and constructability scores for proposed projects to be granted Building Plan Approval and awarded government tenders, and funds provided by the government to improve productivity. They considered government involvement and leadership as having been key in productivity improvement; to them, such a process needs to be government-led. Incentives for contractors to use technology and reduce the volume of labour they utilise is also one of the factors that help Australia (Economic Strategies Committee, 2010) and the US (Huang *et al.*, 2009) improve construction productivity.

The survey showed that two strategies: “increase the number of direct workers” and “increase man-year entitlement” are effective in improving productivity. The latter strategy may give rise to more workers being on construction sites, and this is inconsistent with improving productivity by reducing inputs and increasing outputs, as well as with the Singapore government’s policy priority of reducing the reliance on foreign workers (Building and Construction Authority, 2014). One possible explanation of this result is that the respondents are manifesting the fact that not all construction activities can be mechanized. It is also consistent with Karimi et al.’s (2017) finding that craft labour availability has a significant impact on project productivity.

Interviewees C5 and C9 suggested that the government should try to influence and developers and incentivize consultants so that they will consider productivity when doing their part of the job. While government initiatives were welcomed, it was also considered necessary to “review relevant government regulations”. Interviewees C6 and C11 suggested the streamlining and reduction of the numerous and complex reporting procedures of the government agencies, especially the BCA. Some suggested that the government should have flexible regulations on the setting of the level of man-year entitlement reduction and prefabricating requirements. Some proposed that higher weightage be given to productivity and safety, as compared to price and quality, for tender evaluation of public projects. These findings are in agreement with those of Durdyev and Ismail (2016) who found that bureaucratic processes are bottlenecks to construction industry.

*Design considerations to improve productivity*

Factor 2 relates to design considerations to improve productivity (see Table 7). As suggested by the Building and Construction Authority (2014), when contractors are involved in the design, either through the design-and-build procurement route, or being invited by consultants to provide inputs during the design stage, productivity would improve. Interviewee C3 confirmed this by observing that design-and-build helps to improve productivity and suggesting that this procurement mode be promoted. The suggested superior efficiency of design-and-build confirms Ling and Kerh’s (2004) finding that design-and-build projects have significantly higher delivery speed than traditional projects. Interviewees C5 and C9 also confirmed that involving contractors early in the design would improve productivity. Interviewees C3 and C8 shared that simplifying design helps to improve productivity, in line with the findings of Productivity Commission (2014) and Naoum (2016).

“Standardisation of components” and “Adoption of prefabrication” need to be considered during the design stage. Interviewees C6 and C8 agreed that prefabrication improves productivity significantly, and this can be monitored through the buildability and constructability scores. When necessary, designs should be re-engineered so that the projects are more buildable or cost effective. Several interviewees (C2, C6, C8 and C9) shared that productivity is improved when BIM is used from the design stage, and the design is more complete and firmed up. This confirms the results of previous studies which found that there is significant productivity improvement when prefabrication (Tam *et al.*, 2007; Jeong *et al.*, 2017) and value engineering (Abd *et al.*, 2008, Chhabra and Tripathi, 2014) are adopted. Designs that are firmed up early would help to reduce changes and rework during construction, thereby increasing productivity (El-Gohary and Aziz, 2014). Interviewee C8 suggested that, for this to happen, the technical and professional capabilities of design personnel should be improved.

*Site operations to improve productivity*

Factor 3 comprises strategies relating to site operations (see Table 7). Productivity may be improved by the training of workers and employment of more supervisors to oversee their work. The Singapore government also implemented initiatives to develop the workforce of the construction industry (Building and Construction Authority, 2010, 2015, 2016, 2019b). Interviewee C8 acknowledged that government programs are effective in encouraging and enabling contractors to train their workers. The finding is consistent with those in previous studies which found that skill of labour is one of the major factors influencing productivity (Singh, 2010, Durdyev and Mbachu, 2011, El-Gohary and Aziz, 2014, Naoum, 2016). Effective site supervision is also important to ensure that high levels of productivity are attained on construction projects (Singh, 2010).

Another strategy is to have effective project planning and monitoring. This is confirmed by interviewee C5 who emphasized the importance of planning and management of resources, assigning experienced personnel to manage scheduling and actual site progress, and having management skills to manage resource utilization and scheduling. Interviewees C8 and C9 identified a particular software, P6 Primavera, which helped them to improve planning. This finding is consistent with those of Naoum (2016) who found that detailed and accurate planning can translate productivity improvement objectives to executable plans in reality. Project planning needs to be done at an early stage (Eizakshiri *et al.* 2011). When time and effort are invested in planning, many benefits can be derived (Mawdesley 2010).

“More attention to productivity by firm’s leaders” is found to be an effective productivity improvement strategy. When senior management pays attention to improvement of site productivity, team members can credit their leaders for establishing value for productivity and promoting a productive environment (Chen *et al.*, 2006).

At construction sites, other effective strategies to improve productivity are: “Investment in mechanization”; “more mechanization of construction work” and “applying techniques to reduce amount of work”. Interviewees C5 and C6 mentioned that while mechanization and advanced technologies, which are encouraged by the government, have a large impact on productivity improvement, they use them only when it is cost effective to do so. Interviewee C5 stated that when the labour cost for a particular job is high, it is better to mechanize. Technology is one of the keys for productivity improvement because it can reduce the requirement for manpower on the construction site (Yi and Chan, 2013).

“Increase in extent of subcontracting” is found to be effective in improving productivity. This confirms the conclusions of El-Gohary and Aziz (2014) that subcontracting parts of the project to efficient companies and ensuring their effective management may help to increase productivity. In this way, the firm applies the theory of smart specialization (Capello and Kroll, 2016).

*Stakeholders’ support to improve productivity*

Factor 4 is a collection of strategies relating to support from stakeholders. Clients are important stakeholders in the efforts to improve productivity. They can influence the way things are done on projects by way of: “insisting on productivity”, “supporting productivity initiatives” and “making prompt payments”. Interviewees C3 and C8 confirmed the importance of clients as one of the driving forces for productivity improvement. Interviewee C3 suggested that clients need to understand and embrace new or advanced construction methods in order to improve productivity. Interviewee C8 suggested that clients should commit themselves to the adoption of prefabricated prefinished volumetric construction (PPVC), BIM and higher buildability scores on their projects.

Interviewee C9 suggested that consultants should be given incentives to do their part in the efforts to enhance productivity performance. Interviewees C9 and C11 suggested that consultants should provide information to contractors on time in order to avoid the wastage of time on projects in waiting for vital information. Timely provision of information is important to contractors as it facilitates planning and decision making (Shan *et al.*, 2016).

The strong support of subcontractors for main contractors, and better service from suppliers are also important to improve productivity. Subcontractors should ensure that the part of the work assigned to them is finished on time so that the total productivity will not be affected negatively (El-Gohary and Aziz, 2014). Suppliers can also influence efficiency on the project by adhering to the delivery schedules and ensuring the quality of the inputs provided is in line with the specifications.

*Industry pressure to improve productivity*

Factor 5 relates to external pressures on contractors that may bring about productivity improvement. “Mandatory requirement for contractors to pay attention to productivity” may be from clients or the government. The competitive forces from “pressure from the presence of foreign contractors” and “competition within the industry” also drive contractors to seek to undertake and complete their projects in a cost-effective and productive manner. Interviewees C2, C5 and C6 mentioned that they have experienced the direct linkage between productivity and cost – improvement in productivity helped them to finish their projects on time and there was cost savings.

*Comparing strategies used by different types of contractors*

All strategies rated by different categories of respondents were compared using ANOVA, and significantly differences in ratings are shown in Table 8.

Table 8. Comparing strategies used/perceived by different types of contractors

| Variable | Category | N | Mean | F-value | Significance |
| --- | --- | --- | --- | --- | --- |
| Companies with High Turnover (Above S$ 50 million) vs Lower Turnover (No more than S$ 50 million) | | | | | |
| 20d. increasing the extent of subcontracting | Lower Turnover | 22 | 2.91 | 5.608 | 0.022 |
| High Turnover | 28 | 3.50 |
| 29f. standardisation of components | Lower Turnover | 27 | 4.04 | 6.342 | 0.015 |
| High Turnover | 29 | 4.45 |
| 29q. better service from subcontractors | Lower Turnover | 27 | 3.48 | 8.334 | 0.006 |
| High Turnover | 29 | 4.03 |
| 29r. more prompt payment from clients | Lower Turnover | 27 | 4.37 | 5.848 | 0.019 |
| High Turnover | 29 | 3.90 |
| 29t. more complete and firmed-up design | Lower Turnover | 26 | 4.00 | 4.173 | 0.046 |
| High Turnover | 28 | 4.43 |
| Top Management vs Mid Management | | | | | |
| 20a. investment in mechanisation | Top | 33 | 3.94 | 8.001 | 0.006 |
| Mid | 32 | 4.47 |
| 20c. increasing the number of direct workers | Top | 31 | 3.35 | 4.129 | 0.047 |
| Mid | 31 | 3.81 |
| 23c. government’s incentive schemes | Top | 33 | 3.91 | 4.994 | 0.029 |
| Mid | 33 | 4.33 |
| 23d. guidance from government programmes | Top | 33 | 3.42 | 10.707 | 0.002 |
| Mid | 33 | 4.06 |
| 29p. increase in extent of subcontracting | Top | 33 | 3.12 | 6.133 | 0.016 |
| Mid | 33 | 3.58 |

Respondents were first divided into 2 groups: firms with higher turnover (above S$50 million) and firms with lower turnover (≤S$50 million). ANOVA results show that respondents with higher turnover value rated “increasing the extent of subcontracting” and “better service from subcontractors” significantly higher than companies with lower turnover. Increasing the extent of subcontracting suggests that larger firms prefer to outsource than to do the work in-house, which may lead to hiring more staff, leading to higher overheads. With many projects involving a wide range of activities (which may not be the same from one project to the next), these larger firms tend to engage subcontractors instead of attempting to build capacity and capability across the range of works. Thus, they also need subcontractors to offer an efficient service.

Companies with higher turnover figures rate “standardisation of components” and “more complete and firmed-up design” to improve productivity significantly higher than the firms with lower turnover value. Such companies may already have the capacity for off-site production of standardized components and therefore standardization can help them to improve productivity significantly. To facilitate off-site production, designs need to be complete and firmed-up early.

Companies with lower turnover prefer to have “more prompt payment from clients” significantly more than companies with higher turnover. Companies with high turnover have better capital resources as well as expertise in financial management. Moreover, they receive better terms of service from other members of the value chain than smaller companies. They are also able to delay payments to their subcontractors, often for some time. Thus, these contractors would be able to cope with some delays in payments by clients. On the other hand, companies with lower turnover do not have similar advantages; they need to manage their cash flow from all sources more carefully. Thus, they value prompt payment from clients.

The second ANOVA is to compare the views of respondents of different levels of seniority. They were categorised into persons in the “top management” and those in “middle management”. In all the 5 strategies that present significant differences in ratings, the respondents in top management positions rated significantly lower than mid management. This is most likely because as top-level managers, they need to consider the company’s priorities and hence its performance from a more strategic position, and not just with respect to productivity.

Respondents in the top management group rated “investment in mechanisation”, “increasing the number of direct workers” and “increasing in extent of subcontracting” significantly lower than those in middle management. Mechanization might involve significant amounts of capital. Employing more direct workers increases the employee headcount, and might lead to the firm having long-term fixed costs. Having more subcontractors can erode the main contractor’s in-house capability and reduce its competitiveness. The results show that top management seems to be balancing productivity as a performance parameter with cost competitiveness to advance the development of their companies.

Top management respondents value “government’s incentive schemes” and “guidance from government programmes” significantly lower than those in middle management. The companies’ top leaders would be more confident in making decisions which they consider to be in the best interest of the company and rely less on guidance from the government. They would also give greater importance to internal resources over which they have full control than assistance from the government. They can then plan to develop the companies’ core competencies to enhance corporate competitiveness.

**Limitations**

The limitation of this study is that the samples were only from Singapore. As most of the workers on site are migrant workers from other countries, Singapore’s construction industry is different from those of many other countries, hence the findings need to be generalized carefully. Notwithstanding this, the findings may be useful to countries that employ overseas migrant workers such as those in the Middle East and certain parts of Europe. Future studies may further examine the effectiveness of different strategies used in small countries that have labour shortage.

**Recommendations and concluding remarks**

The aim of this study is to examine the strategies implemented by construction companies in Singapore to improve the level of construction productivity. These strategies are implemented at both the corporate and project levels. Companies can encourage their personnel to take ownership of the productivity programme by adopting a campaign similar to what has worked so well with regard to safety. Considering the multi-origin composition of the industry's workforce, language and cultural relevance will be key. While the government has launched many schemes to enable the construction industry to improve upon its productivity performance, the contractors’ real initiatives determines the overall attainment. Input should be sought from the industry to ensure that the policies and initiatives are appropriate, considering the needs and aspirations of the companies and practitioners. The schemes should also be reviewed periodically.

The first objective of this study is to determine reasons or motives for contractors to achieve high construction productivity. The top 3 reasons are to increase profitability, deliver projects on time and enhance corporate competitiveness (see Table 5). The implication of the findings is that productivity improvement is likely to be sustainable because the motives to improve productivity are linked to the performance of the firms and internally driven. Construction companies should adopt a strategic approach to productivity as their performance on that parameter can influence their corporate growth and competitiveness. They should adopt corporate productivity policies, as most of the sizeable construction companies in Singapore have done for quality, safety and health, and environmental performance. They should then adopt appropriate organizational structures which incorporate the role for spearheading technology improvement initiatives within the company. The firms should also build their internal capabilities to be able to work effectively in productivity enhancing procurement arrangements such as design and build and early contractor involvement approach.

The second objective of this study is to identify strategies to improve productivity for Singapore contractors. The top strategies identified are workers’ training, mechanization and more complete and firmed-up design (see Table 6). The main categories of strategies to improve productivity are: government’s initiatives, design factors, site operations, the support of stakeholders, and industry pressure (see Table 7). This supports the well-established notion in the literature and in practice that productivity improvement is not the effort of any one party, or the result of what is done at any particular stage in the construction process. It is evident that decisions made by the client on many aspects of the project and the desired product, the choices at the design stage, the planning and building control procedures and requirements and so on, all have an impact. The stakeholders in the construction industry, no matter how remote, should be educated about the impact on their own stake of the levels of growth in productivity. Stakeholder awareness building and education should be a thrust of the next construction productivity masterplan in Singapore.

The third objective of this study is to compare differences in strategies used/perceived by different types of contractors. The significant finding is that firms with larger turnover value standardisation of components, employing more subcontractors and having firmed-up designs early more than smaller companies (see Table 8). The implication is that contractors with higher turnover need to manage their stakeholders closely. For example, persuade consultants repeatedly for standardized and firmed-up design, and demand better service from subcontractors. Contractors should strengthen the relationships between them and the other constituents of their value chain. They should seek to nurture their subcontractors (whose work can have such an impact on productivity) and monitor their performance.

The major significance of this study is that it has identified the main motives construction firms have in implementing strategies to improve productivity, as well as the most important strategies they adopt. This provides a steer for government's policies and areas where the government and industry can collaborate. It also indicates areas where further research would yield most benefits. As the top motives are found to be that firms adopt the strategies for their own benefits, and the top two most important strategies for productivity improvement (worker training and mechanisation) are under the control of the contractor, the implication is that contractors should take responsibility for improving productivity and focus on areas which are the most important. From the comparisons, large contractors with high turnover should work closely with stakeholders such as clients, consultants and subcontractors so that they can develop programmes to improve productivity together. The government may adopt a light-touch approach to improving productivity in construction.

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**Research Data**

Data will be made available on request.

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