Key barriers to increase construction productivity: the Singapore case

George Ofori\textsuperscript{a}, Zhe Zhang\textsuperscript{b} and Florence Y. Y. Ling\textsuperscript{c}

\textsuperscript{a}School of the Built Environment and Architecture, London South Bank University, London, UK; \textsuperscript{b}Department of Building, National University of Singapore, Singapore, Singapore; \textsuperscript{c}Department of Building, National University of Singapore, Singapore, Singapore

\begin{abstract}
This study investigated the barriers to achieving high construction productivity in Singapore with the view to providing further input into policy formulation and action to enhance the industry's productivity performance. Data were collected using a structured questionnaire, which was sent to all the 3032 members of the Singapore Contractors Association and the Singapore Chinese Chamber of Commerce and Industry. Statistical t-tests and factor analysis were conducted on the 109 valid responses using the SPSS software. The findings were validated via in-depth interviews with subject matter experts. The top three barriers are “delays in providing information to contractors”, “poor skills of workers” and “inadequate pre-project planning and pre-work planning”. The sources of these barriers are consultants and contractors, suggesting that these stakeholders should cooperate to improve productivity. The research findings for Singapore construction industry is unique in that most of the labourers on site are migrant workers from overseas. Nonetheless, the findings may be useful to countries that employ labourers mainly from overseas such as those in the Middle East and certain parts of Europe. This study adds to knowledge by identifying the most significant barriers to productivity improvement and providing suggestions to address them. To improve productivity, all participants should change their mind-set, attitudes and behaviours. Clients should support productivity initiatives and be more proactive concerning productivity through tender evaluation criteria, setting productivity targets and paying for productivity premium. Contractors should develop corporate productivity policies, monitor productivity closely and purposefully adopt measures to increase productivity of their projects.
\end{abstract}

\begin{keywords}
Construction productivity; barriers; contractors; migrant workers
\end{keywords}

\section*{Introduction}

The construction industry is important to a country because it takes up a sizeable segment of the economy (De Valence 2019). In Singapore (1° 17' N, 103° 51' E), an island city-state located in South East Asia with an area of 725.1 km\textsuperscript{2}, the construction industry contributed 3.98% to 6.12% of the gross domestic product (GDP) in the period of 2011 to 2017 (Department of Statistics 2018). Construction also generates activities in other sectors such as manufacturing, trading, transportation, finance, insurance and business services (De Valence 2019). It has strong backward and forward linkage effects with the rest of the economy (Ali et al. 2019).

Studies show that low construction productivity can have a negative impact on economic growth (Tasman Economics 2002; Productivity Commission 2014, 2015). However, the level of construction productivity and the annual rate of growth in Singapore has been low (Ministry of Trade and Industry 2017). For example, the rate of growth in value added per person employed in construction was between −6.1% and 4.0% during the period of 2011 to 2017 (Department of Statistics 2018). In 2 of the 7 years, the annual growth in construction productivity was negative; and in 4 of the 7 years, it was below that for the whole economy.

The low level of productivity growth in construction has long been a major concern in Singapore, and more so recently because the government set a target of productivity growth of 2.0 to 3.0% per annum in the economy between 2015 and 2020 (Economic Strategies Committee 2010). All industries are expected to attain this benchmark figure as the economic strategy is now based on productivity growth rather than increases in labour utilisation (Economic Strategies Committee 2010).

The low level of productivity has various consequences. For example, low labour productivity has been found to be a contributory factor to the cost and time overruns which have been observed in the construction industry in many countries (Thomas and Sudhakumar 2014; Hawkins 2018). In the particular context of Singapore, the country relies on cheaper foreign workers in the construction industry and the government has been trying to limit their numbers in order to provide continuous impetus for technological and process upgrading in the industry (Chang 2014). OECD (2013) considers Singapore’s top medium-term policy challenge to be: “Manage foreign worker dependence by increasing the productivity of local workforce”. Therefore, increasing construction productivity is important to Singapore.

Singapore has had a construction productivity development programme since the late 1980s. The government helps construction firms to improve productivity in various ways such as providing support for the training of workers; guiding firms and providing incentives to them to acquire relevant advanced technologies (BCA 2010); and introducing regulations such as that which makes buildable design mandatory (BCA 2014). However, construction productivity in Singapore and its annual rate of growth have still remained low (Tan 2013). Therefore, it is pertinent to address the impediments to the efforts to enhance...
productivity in the construction industry, but no recent systematic studies were done in Singapore.

The aim of this study is to investigate the impediments to efforts to increase construction productivity in Singapore. The specific objectives are to: identify the barriers to achieving high construction productivity; determine main stakeholders who impact project productivity; and recommend actions and policies to deal with intractable barriers.

**Literature review**

**Productivity**

Productivity is used to measure output produced based on the inputs used in a production process (OECD 2001). The US Department of Commerce defined productivity as output (in dollars) divided by labour-hour input (in person-hour) (Adrian 1987). Finke (1998) defined productivity as work produced divided by man-hour or equipment hour. Horner and Duff (2001) defined productivity as quantity produced divided by unit input. Low construction productivity causes delays in projects (El-Gohary and Aziz 2014).

Productivity is measured in various ways. Total Factor Productivity (TFP) and Partial Factor Productivity (PFP) are usually used in the construction industry (Jarkas 2005). TFP is the ratio of outputs divided by all inputs and a common monetary unit is used for both outputs and inputs (Tan 2000). PFP is the ratio of outputs divided by a single input or a number of selected inputs, and accurate data can be obtained. Because TFP requires comprehensive sets of data which are difficult to obtain (Mao et al. 2003), PFP is usually used to measure productivity (Jarkas and Bitar 2012). In the construction industry, labour productivity is more frequently used to measure productivity (Yi and Chan 2014).

It is pertinent to note that there is an ongoing debate about whether the level of productivity is low, and why it has not increased for some years (Garcia 2014; Fulford 2019). Doubts have also been expressed about the appropriateness of the common methods of measuring productivity to the construction industry (Haugbolle et al. 2019). The discussion of the suitable measure for construction productivity persists in Singapore (Low 2015). The economic measure of value added per person employed is used in the national accounts statistics, whereas a physical measure, m² of completed gross floor area per man-day is favoured by the national construction industry development agency, the Building and Construction Authority (BCA). The two measures give different results. The aim of the BCA is to attain a consistent 3% annual increase in the physical measure by 2020. There is a consensus in Singapore that efforts should be made to enhance productivity performance in the industry, no matter how it is measured.

**Barriers to achieving high productivity**

The causes of low construction productivity which have been identified in the US include (Haas 2009): diverse and fragmented stakeholders; segmented processes; image of the industry which makes it difficult to attract and retain skilled workers; unique nature of most projects; variations in standards, processes, materials, skills and technologies required by different types of projects; variation in building codes and regulations in states and localities; lack of an industry-wide strategy to improve construction efficiency; and ineffective performance measures for construction projects and the industry; and lack of an industry-wide research agenda.

Meta-analysis of studies in Australia found these major causes of “lost productivity” (Productivity Commission 2014): variability in subcontractor capability and performance; interruptions and poor co-ordination (waiting for the next trade, for information or instructions, for materials, or for plant); frequent overtime work (exhaustion or burn-out); unplanned increases in labour force (flooding the project with workers to make up time); poor site management and supervision; lack of up-front integration in project teams; lack of commitment to, and focus on, productivity and continuous improvement; workers’ skills and competencies; contractual conflict and poor subcontractor relationships; design (constructability, complexity, uniqueness, prefabrication); productivity is not rewarded; and productivity is not measured and monitored. A McKinsey Global Institute Report (Barbosa et al. 2017) found the following reasons for the poor productivity performance of the construction industry: construction is extensively regulated and highly dependent on public-sector demand; the industry is fragmented, and most firms cannot offer more standardised products; the contracts have mismatches in risk allocations and rewards; and the many inexperienced owners and buyers are risk averse.

The following are some important factors that were found to affect productivity. As construction is labour-intensive, the level of productivity attainable depends on the workers. Thus, workers’ low skills level is considered one big barrier to achieving high productivity (Enshassi et al. 2007). The low pay and lack of incentive programs for workers is among the top barriers to high productivity (El-Gohary and Aziz 2014). Enshassi et al. (2007) found that the lack of financial incentive is one of the important factors causing lack of motivation for workers to increase productivity. Shortage of materials and the lack of leadership competency in construction management are also barriers to high productivity (El-Gohary and Aziz 2014). Close supervision of workers has been found to be important to reduce the occurrence of unproductive activities, and unscheduled breaks (El-Gohary and Aziz 2014). Many other barriers have also been uncovered in previous studies. Together with the factors identified above, these are summarized in Table 1.

**Knowledge gap**

Several studies have sought to identify the barriers to the attainment of high construction productivity in developed countries such as Australia (Wong and Vimosatit 2012), New Zealand (Lessing et al. 2017) and the United States (Chapman et al. 2010). Studies in developing countries include Cambodia (Durdyev and Mbachu 2018), Egypt (El-Gohary and Aziz 2014), Gaza Strip (Enshassi et al. 2007), Iran (Ghoddousi and Hosseini 2012), Kuwait (Jarkas and Bitar 2012), Malaysia (Jaafar et al. 2005; Durdyev and Ismail 2016), Qatar (Jarkas et al. 2012), Thailand (Makulsawatudom et al. 2004), Uganda (Alinaitwe et al. 2007), and United Arab Emirates (Singh 2010). Although several studies have been undertaken on the factors affecting productivity, the relationships among the factors are seldom studied.

Singapore deserves a study by itself presently because of its unique features in the productivity development efforts. It has had a comprehensive government-led construction productivity development programme since the late 1980s, but the level of productivity has remained low. Good productivity performance on some projects is evident but this has only been observed in
| Barrier                      | Australia | New Zealand | United States | Egypt | Iran | Kuwait | Malaysia | Nigeria | Qatar | Thailand | Uganda | United Arab Emirates |
|-----------------------------|-----------|-------------|---------------|-------|------|--------|----------|---------|-------|----------|--------|----------------------|
| Low skills of workers       | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Low pay and lack of incentive programs | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Shortage of materials       | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Lack of leadership competency | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Bad supervision of workers  | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Financial difficulties      | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Shortage of labours         | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Bad planning and bad work flow | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Poor organizations of contractor | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Excessive overtime          | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Inadequate use of construction technologies | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Low constructability or buildability | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Delays in issuing design documents | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Poor method of working       | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Site layout and conditions  | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Rework                      | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Delay in payment            | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Conflict between clients     | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Lack of communication and coordination | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |
| Issues related to authorities and regulations | v         | v           | v             | v     | v    | v      | v        | v       | v     | v        | v      | v                    |

Notes: "v" indicates that the factor is found to be significant in the respective country.
isolated exemplary cases (Sweet 2014; BCA 2015). Thus, general improvement in productivity performance has been elusive despite the strong government leadership, a systematic approach at national and corporate levels, and massive investment of resources. Although Lim and Alum (1995) identified several factors influencing construction productivity in Singapore, the result is outdated. Construction 21 Steering Committee (1999), BCA (2010) and Ministry of Manpower (2014) identified low productivity and negative productivity growth problems in Singapore’s construction industry, but the influencing factors were not assessed systematically and academically. Although Teo et al. (2015) identified some factors, the study did not focus on barriers to productivity improvement. The gap in knowledge is that barriers to the enhancement of productivity performance which the construction industry faces in Singapore’s context are not known. This study aims to fill this gap.

The main research question is “What are the significant barriers to productivity growth in Singapore and how can these be overcome?”

Research method

A large-scale research was carried out to investigate various aspects of construction productivity in Singapore such as barriers, enablers and future state of productivity (SCAL 2016). This paper reports on one part of this larger research programme, focusing on barriers to improving productivity.

The research design is based on a survey. A two-pronged research method was employed: questionnaire and in-depth interviews. The questionnaire survey was conducted to gather information from a large group of respondents. Thereafter, the responses were aggregated, and statistical analysis was conducted. The in-depth interviews were undertaken to validate and explain the statistical results.

The data collection instrument was a structured questionnaire. It was developed based on literature review of 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. One section sought information on the state of construction productivity in Singapore; another sought to find out barriers to the efforts to achieve high construction productivity. A third section sought respondents’ opinions on the actions which can be taken to address the barriers. The final section requested for respondents’ personal and company particulars.

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. The respondents were asked to rate on a 5-point scale the level of importance of each factor in causing low construction productivity that are categorized into those relating to policies and practices of the construction firm and matters outside the control of respondents’ firms. Another set of questions requested respondents to rate the importance of the factors in hindering their firms’ efforts to improve productivity.

A pilot test of the questionnaire was conducted with 5 leaders of the Singapore Contractors Association Ltd (SCAL). The purposes were to examine the appropriateness and effectiveness of the questions asked, and whether the instructions are clear to the respondents. After the pilot test, minor tweaks were made to fine-tune the questions and reduce the length of the questionnaire, so that participants could answer more easily and not be put off by the length of the questionnaire.

The population comprised contractors operating in the construction industry in Singapore. The sampling frame comprised contractors who are registered with trade associations. 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. Another 305 sets of questionnaires were sent to all Ordinary, Associate and Trade (OAT) members of SCAL. With a registered population of 3337 (being 3032 + 305), the sample size should be a minimum 94 to achieve 95% confidence level and a 10% margin of error. In this study, a total of 109 valid responses were collected, indicating that an adequate sample size was achieved.

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

$$\bar{X} = \frac{1(n_1) + 2(n_2) + 3(n_3) + 4(n_4) + 5(n_5)}{(n_1 + n_2 + n_3 + n_4 + n_5)} \quad (1)$$

where: \( \bar{X} \) is the mean rating of a specific variable, and \( n_1, n_2, n_3, n_4, \) and \( n_5 \) 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 the SPSS statistics software to analyse whether the barriers to achieving high productivity are significant. The hypothesised population mean (\( \mu_0 \)) was set at 3, which is the neutral point of the 5-point Likert scale. For each question, the null and alternative hypotheses were set out below, where \( \mu \) is the population mean.

- Null Hypothesis \( H_0: \mu \leq 3 \). The decision rule was to accept \( H_0 \) when \( p \geq 0.05 \).
- Alternative Hypothesis \( H_1: \mu > 3 \). The decision rule was to reject \( H_0 \) and accept \( H_1 \) 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 significant barriers, factor analysis was conducted using the SPSS software to detect the barriers that may be inter-dependent and to group them into a smaller number of categories/factors. Kaiser-Meyer-Olkin (KMO) and Bartlett’s Test were conducted to examine the suitability of the data for factor analysis. The KMO Measure of Sampling Adequacy was 0.819, indicating that the data was suited for factor analysis. High values (close to 1.0) generally indicate that a factor analysis may be useful, while value that is less than 0.50 indicates that the factor analysis may not be useful (IBM 2014). Bartlett’s Test of Sphericity shows that the approximate Chi-square is 1786.9, with the significance of 0.000, which is far less than 0.05, indicating that a factor analysis may be useful (IBM 2014).

For the factor analysis, principal axis factoring (PAF) was used because it is suitable for this research that is exploratory in nature. Eigenvalues, percentage of variance explained by the factors, communalities and rotated factors were calculated using the SPSS software. For the missing values, “exclude cases list-wise” treatment was adopted. Cronbach’s alpha was found to be 0.952, indicating the high reliability of the factor analysis as it is above the generally accepted threshold of 0.70 (Bruin 2006).

The second-pronged research method was in-depth face-to-face interviews with subject matter experts who were not involved in filling up the questionnaires to validate and explain
the results collected from the questionnaire. The 12 subject-matter experts were carefully selected through convenience sampling. They were senior practitioners in their construction companies. The data collection instrument comprised a list of 10 open-ended questions, which covered topics such as interviewees’ views on construction productivity measurement, drivers for productivity improvement, and strategies to improve productivity.

Characteristics of the sample

Table 2 shows the characteristics of the 109 samples. About half of respondents’ companies were graded as A1 contractors by BCA, which is the highest level of contractor type (by size) that can bid for construction projects of any value. There was a good mix of companies in terms of turnover, ranging from less than S$10 million to more than S$100 million, with about half above S$50 million. The majority of the respondents (80%) were from local construction companies. Half (50%) of the respondents held top level management positions.

Table 3 shows that the 12 subject-matter experts interviewed were from both local and foreign companies. They were from the top management of their firms. This indicates that they were experienced and well suited to inform the research.

Results

State of construction productivity

Table 4 presents the state of construction productivity based on different types of construction, as perceived by respondents. Respondents were asked to rate the productivity of different project types as “high”, “average” or “low”. The general finding is that the productivity level is considered average for most project types. The productivity for public housing was rated high by the majority of the respondents, while the productivity for landed residential construction was rated between average and low.

Objective 1 of this study was to identify the barriers to achieving high construction productivity. Based on the ratings, mean scores were calculated and the barriers, in rank order, are presented in Table 5. The t-test conducted showed that all the barriers are significant in hindering productivity (mean > 3.0, t value positive, p < 0.05), and factor analysis revealed several distinct categories of barriers (see Table 6). The factor analysis showed internal reliability and internal consistency with Cronbach’s alpha of 0.952.

Highest ranked barriers

Table 5 presents the ranking of barriers to achieving high construction productivity in Singapore determined from the mean scores. Equation 1 was used to calculate the mean scores, and these were ranked in descending order. The top 2 barriers are: delays in providing information to contractors (highest); and poor skills of workers (second highest) (see Table 5).

Delays in providing information to contractors suggest a deeper issue to a lack of cooperation and communication between construction parties, which may lead to rework, which are harbingers of low productivity (Mahamid 2013). As the majority of the construction workers are imported, they lack proper training, and therefore poor skills is a major barrier. The finding is in concordance with previous studies that lack of skills (Karimi et al. 2017) and lack of labour experience (Mahamid 2013) have negative impact on construction project productivity. Besides Singapore, studies in other countries also find poor skills as one of the top barriers of productivity, e.g., Cambodia (Durdyev and Mbachu 2018), Egypt (El-Gohary and Aziz 2014), Malaysia (Durdyev and Ismail 2016) and Qatar (Jarkas et al. 2012).

Lowest ranked barriers

The bottom ranked barriers include inadequate application of information technology (lowest) and the lack of adoption of prefabricated construction (second lowest). In Singapore, these barriers are not the most serious because of the mandatory requirements for building plans to be submitted for approval in BIM format, and that new buildings need to achieve minimum buildability scores before they received building plan approvals from the authorities. This practice increases process efficiency and would lead to productivity improvement (Seadon and Tookey 2019).

Discussion on barriers to achieving high construction productivity

Factor analysis was conducted to group the barriers into several large categories, and five factors emerged (see Table 6).
Table 4. State of construction productivity.

| Sector of industry | Productivity of the segment is HIGH | Productivity of the segment is AVERAGE | Productivity of the segment is LOW |
|--------------------|------------------------------------|----------------------------------------|-----------------------------------|
| Public Housing     | 49.5%                              | 37.4%                                  | 13.1%                             |
| Residential (Landed) | 9.6%                               | 44.2%                                  | 46.2%                             |
| Residential (Non-landed) | 19.8%                             | 65.1%                                  | 15.1%                             |
| Commercial Buildings | 28.6%                               | 61.9%                                  | 9.5%                              |
| Industrial Buildings | 43.3%                               | 52.9%                                  | 3.8%                              |
| Institutional Buildings | 15.0%                              | 69.0%                                  | 16.0%                             |
| Small to Medium Sized Civil Engineering | 12.1%                             | 68.7%                                  | 19.2%                             |
| High-end Civil Engineering | 25.3%                             | 62.6%                                  | 12.1%                             |

Table 5. Ranking of barriers to improve productivity.

| Rank | Variable                                                                 | Mean |
|------|--------------------------------------------------------------------------|------|
| 1    | Delays in providing information to contractors                           | 4.38 |
| 2    | Poor skills of workers                                                    | 4.35 |
| 3    | Inadequate pre-project planning and pre-work planning                     | 4.33 |
| 4    | Delays caused by compliance with regulations                              | 4.22 |
| 5    | Changes in design                                                         | 4.19 |
| 6    | Inappropriate working methods                                              | 4.12 |
| 7    | Priority given to other project parameters such as cost, quality and safety | 4.09 |
| 8    | Excessive regulation of construction activity                             | 4.07 |
| 9    | Complexity of project                                                     | 4.04 |
| 10   | Poor motivation of workers                                                 | 4.02 |
| 11   | Communication difficulties between workers and supervisors, and among workers | 4.02 |
| 12   | Reworks to rectify defects                                                 | 4.02 |
| 13   | Lack of monitoring of project plans (programmes)                          | 3.93 |
| 14   | Type of procurement approach adopted                                       | 3.91 |
| 15   | Clients’ request for buildability                                          | 3.9  |
| 16   | Insufficient time to plan and execute work properly                       | 3.89 |
| 17   | Lack of support from clients                                               | 3.87 |
| 18   | Delays in payment by clients                                               | 3.87 |
| 19   | Restrictions on employment of foreign workers                             | 3.87 |
| 20   | Poor attitude of contractors to productivity                               | 3.87 |
| 21   | Lack of competent professional, management, executive and technical (PMET) personnel | 3.84 |
| 22   | Lack of support from consulting teams                                      | 3.82 |
| 23   | Poor quality of subcontractors                                             | 3.75 |
| 24   | Contractual disputes                                                       | 3.73 |
| 25   | Lack of incentives from government                                         | 3.71 |
| 26   | Over-reliance on labour subcontractors                                     | 3.69 |
| 27   | Poor materials management                                                  | 3.65 |
| 28   | Lack of guidelines for measuring productivity                             | 3.59 |
| 29   | Lack of support from suppliers                                             | 3.46 |
| 30   | High proportion of subcontracting                                          | 3.42 |
| 31   | Lack of adoption of prefabricated construction                             | 3.41 |
| 32   | Inadequate application of information technology                           | 3.4  |

Red tape and lack of support

Group 1 is labelled “Red Tape and Lack of Support”. The factors include barriers from government and other stakeholders. The Government’s actions that hinder productivity improvement include: “excessive regulation of construction activity”, “lack of incentives from government”, “delays caused by compliance with regulations” and “restrictions on employment of foreign workers”. Some interviewees took buildability scores as an example. According to an interviewee, “to achieve high scores, we adopted some practices which reduce productivity instead”. Some interviewees shared that restrictions on the recruitment of foreign workers reduced productivity, as this “caused current workers to work overtime, thereby reducing their productivity and sometimes safety issues arise”. One interviewee noted that “consultants and project managers on both public- and private-sector projects are reluctant to accept proposals of alternatives to the design, specifications and procedures”. Similar factors were also observed by Durdyev and Ismail (2016) in Malaysia.

Other stakeholders may be the sources of the causes of low productivity. The barriers indicated included: “Lack of support from clients”, “delays in payment by clients”, “lack of support from consulting teams”, “lack of support from suppliers”, “poor quality of subcontractors” and “contractual disputes”. Several interviewees expressed opinions on their relationships with clients and consultants. They felt that their hands were tied when working with some clients. They had to go through the clients’ consultants if they proposed any productivity improvement measures. One interviewee noted that “consultants are not willing to consider changes to the design or specified method even if this results in faster completion of work”. Another observed that “some resident engineers and clerk of works are obstructive in that they reject work that had been completed, and asked for it to be re-done, and this required more time”. The lack of collaboration among the project participants hinders the effort to improve productivity. An interviewee noted issues relating to contract administration, citing “unfair contracts and not being paid for work done under variation orders”. Issues with subcontractors were also observed by El-Gohary and Aziz (2014). Delay in payment was observed in Kuwait (Jarkas and Bitar 2012) and Malaysia (Jaafar et al. 2005).

“Insufficient time to plan and execute work properly” points to the initial allocation of time even before bidding for projects.
Lack of leadership competency working hours and level of compensation in order to improve its industry itself needs to review its work environment, length of its poor image and low levels of remuneration. The construction industry is not a preferred industry to work in due to management skills. Several interviewees mentioned that the construction industry needs to improve its work environment, length of working hours and level of compensation in order to improve its image and to attract more talent. Lack of leadership competency and poor labour supervision were also observed by Enshassi et al. (2007) and Jarkas and Bitar (2012).

### Table 6. Barriers to achieving high construction productivity.

| Factor S/N | Initial Total Eigenvalues | % of variance | S/N | Factor Variable | Mean | 1-tail Sig | Initial Communalities | Rotated Factor |
|------------|---------------------------|---------------|-----|-----------------|------|------------|-----------------------|----------------|
| 1          | 13.248                    | 41.4          | 24f | Excessive regulation of construction activity | 4.07 | 0.000      | 0.839                 | 0.763          |
|            |                           |               | 24e | Lack of support from clients | 3.87 | 0.000      | 0.840                 | 0.755          |
|            |                           |               | 24h | Delays in payment by clients | 3.87 | 0.000      | 0.678                 | 0.711          |
|            |                           |               | 24g | Lack of support from consulting teams | 3.82 | 0.000      | 0.850                 | 0.709          |
|            |                           |               | 24c | Lack of support from suppliers | 3.46 | 0.000      | 0.790                 | 0.694          |
|            |                           |               | 24b | Lack of incentives from government | 3.71 | 0.000      | 0.806                 | 0.678          |
|            |                           |               | 24d | Poor quality of subcontractors | 3.75 | 0.000      | 0.785                 | 0.661          |
|            |                           |               | 12f | Delays caused by compliance with regulations | 4.22 | 0.000      | 0.752                 | 0.552          |
|            |                           |               | 24a | Restrictions on employment of foreign workers | 3.87 | 0.000      | 0.776                 | 0.550          |
|            |                           |               | 24j | Insufficient time to plan and execute work properly | 3.89 | 0.000      | 0.822                 | 0.519          |
|            |                           |               | 24i | Lack of competent professional, management, executive and technical (PMET) personnel | 3.84 | 0.000      | 0.774                 | 0.488          |
|            |                           |               | 12i | Contractual disputes | 3.73 | 0.000      | 0.650                 | 0.483          |
|            |                           |               | 9b  | Communication difficulties between workers and supervisors, and among workers | 4.00 | 0.000      | 0.865                 | 0.765          |
|            |                           |               | 9c  | Poor motivation of workers | 4.02 | 0.000      | 0.748                 | 0.666          |
|            |                           |               | 9a  | Poor skills of workers | 4.35 | 0.000      | 0.799                 | 0.655          |
|            |                           |               | 9f  | Inadequate pre-project planning and pre-work planning | 4.33 | 0.000      | 0.791                 | 0.620          |
|            |                           |               | 12d | Changes in design | 4.19 | 0.000      | 0.734                 | 0.491          |
|            |                           |               | 12a | Type of procurement approach adopted | 3.91 | 0.000      | 0.633                 | 0.491          |
|            |                           |               | 9e  | Inappropriate working methods | 4.12 | 0.000      | 0.715                 | 0.465          |
|            |                           |               | 9g  | Lack of monitoring of project | 3.93 | 0.000      | 0.782                 | 0.551          |
|            |                           |               | 9k  | Inadequate application of information technology | 3.40 | 0.000      | 0.676                 | 0.757          |
|            |                           |               | 9j  | Poor materials management | 3.65 | 0.000      | 0.730                 | 0.694          |
|            |                           |               | 9m  | Poor attitude of contractors to productivity | 3.87 | 0.000      | 0.683                 | 0.532          |
|            |                           |               | 9d  | Reworks to rectify defects | 4.00 | 0.000      | 0.723                 | 0.479          |
|            |                           |               | 12g | Lack of guidelines for measuring productivity | 3.59 | 0.000      | 0.635                 | 0.670          |
|            |                           |               | 12b | Complexity of project | 4.04 | 0.000      | 0.793                 | 0.781          |
|            |                           |               | 12c | Clients’ request for buildability | 3.90 | 0.000      | 0.744                 | 0.598          |
|            |                           |               | 12e | Delays in providing information to contractors | 4.38 | 0.000      | 0.792                 | 0.558          |
|            |                           |               | 12h | Priority given to other project parameters such as cost, quality and safety | 4.09 | 0.000      | 0.720                 | 0.415          |
|            |                           |               | 9i  | Lack of adoption of prefabricated construction | 3.41 | 0.000      | 0.682                 | 0.483          |
|            |                           |               | 9h  | Over-reliance on labour subcontractors | 3.69 | 0.000      | 0.885                 | 0.831          |
|            |                           |               | 9l  | High proportion of subcontracting | 3.42 | 0.000      | 0.785                 | 0.622          |

Notes: Factor Analysis Method: Principal axis factoring. List Value: Exclude cases listwise. Rotation: Varimax. Re-categorization of variables was done to ensure better logic.
of workers was also observed in Egypt (El-Gohary and Aziz 2014), Malaysia (Durdyev and Ismail 2016) and Cambodia (Durdyev and Mbachu 2018). One interviewee mentioned that “some foreign contractors were not investing in training workers”. Supervisors who should be assigned based on their ability to understand the foreign workers’ language so as to facilitate better communication.

Work processes that impede productivity are “inadequate pre-project planning and pre-work planning” and “inappropriate working methods”. One interviewee shared that “especially on constrained sites, careful planning is needed to deal with site layout, logistics and materials delivery and storage”. Another interviewee noted that “design and working methods need to be examined to see if they are the most suitable for the project”.

“Changes in design” slow down construction and impede productivity (Jarkas et al. 2015), and they interrupt work rhythm (El-Gohary and Aziz 2014). The interviewees agreed that design changes seriously affect the productivity of construction. For example, one interviewee observed that:

When there are changes to the design, contractors would calculate the time and cost implications first and seek approval for additional payment or extension of time before executing the work resulting from the variation. On the other hand, starting the work resulting from the variation first and negotiating time and cost implications as the work progresses requires collaboration and trust among the parties.

The results also show that the “lack of monitoring of project plans (programmes)” is a barrier to achieving high productivity, supporting Durdyev and Ismail (2016) finding.

**Inadequate process control**

Group 3 is labelled as “Inadequate Process Control” (see Table 6). This group includes issues with technology application, materials management, attitudes, reworks and productivity measurement. Regarding “inadequate application of information technology”, one interviewee used the Building Information Modelling (BIM) software to illustrate the fact that technology is not always applied most efficiently. The interviewee shared that “all drawings need to be completed and input into the software; however, this is difficult for fast-track projects, and therefore, it is a challenge to adopt it”. “Poor materials management” impedes productivity and is related to the lack of competency in construction management (El-Gohary and Aziz 2014).

“Poor attitude of contractors to productivity” impedes productivity improvement. It was pointed out by the interviewees that there was a tendency to over-rely on government actions and incentives. It was felt that contractors should try to improve productivity themselves first because this is related to their own competitiveness and survival.

“Reworks to rectify defects” occur due to errors or low-quality of work leading to lower productivity level (Jarkas and Bitar 2012). Reworks can cost contractors due to longer construction period, disruptions to schedules and programmes and reputation damage (Durdyev and Ismail 2016). “Lack of guidelines for measuring productivity” hinders contractors’ effort to measure and use the result to improve on productivity. One interviewee noted that “we find it difficult to understand how productivity is actually defined”. The interviewees also had different views on the usefulness of productivity measurement at both project and industry levels. These views were expressed although BCA had provided guidance on how to measure labour productivity at trade level (BCA 2012), as well as company-level productivity in terms of value added per person employed (for example, the spreadsheet template and guide of BCA 2017a). As in Singapore, several measurement methods for construction productivity exist in other countries (Jarkas and Bitar 2012).

**Project complexity**

Group 4, labelled as “Project Complexity”, relates to barriers that cannot be controlled by contractors. “Complexity of project” has also been found by other authors to impede productivity (Durdyev and Ismail 2016). “Clients’ request for buildability” often disrupts project flow. “Lack of adoption of prefabricated construction” is a barrier to productivity improvement and it prevails because contractors do not play a role in design. Prefabricated construction is being encouraged in many countries such as the UK (House of Lords Science and Technology Select Committee 2018) to enhance productivity performance (El-Gohary and Aziz 2014). However, some interviewees noted that adopting prefabrication can introduce rigidity in the project and may hinder productivity. An interviewee shared that:

Precast elements are bulky and very heavy. Extra cost and time would be required to plan the transport route, arrange for special lifting equipment and police escort for the vehicles to transport these elements to the site.

“Delays in providing information to contractors” can affect the workflow of the construction job (El-Gohary and Aziz 2014). “Priority given to other project parameters such as cost, quality and safety” may also impede productivity. Several interviewees noted that most clients want the cheapest, most cost-effective option instead of the most productive method. Some interviewees suggested that quality and safety should be considered together with cost and tender prices; quality is important because end users expect a high standard of completed work. The result shows that contractors need to achieve an optimal balance of cost, quality, safety and productivity.

**Over-reliance on subcontractors**

The final group relates to the prevalent practice of subcontracting (Construction 21 Steering Committee 1999). “Over-reliance on labour subcontractors” suggests that the main contractor’s productivity performance and achievement on the whole project is dependent on the productivity of the subcontractors. In some cases, problems with one subcontractor may affect the workflow of the entire project (El-Gohary and Aziz 2014). Several interviewees confirmed the need to monitor the performance of subcontractors to ensure that they are productive. Proper subcontracting agreement is suggested so that subcontractors can take responsibility for higher productivity.

**Stakeholders’ influence on productivity**

Objective 2 was to determine the impact that stakeholders have on project productivity. Table 7 shows that all 9 stakeholders impact productivity to a significant extent (mean > 3, t value positive, p < 0.05). Main contractors (ranked 1st) have the most impact on productivity, followed by architects (2nd) and structural engineers (3rd). Material suppliers and labour subcontractors are ranked last and second last respectively (9th and 8th).

Unfortunately, while architects and structural engineers hold 2nd and 3rd most important impact on productivity (Table 7),
more than half of the respondents (54%) felt that consultants are not paying enough attention to productivity (Table 8). Architects play an important role in productivity improvement because their design at the upstream need to incorporate buildable features right from the start. The Code of Practice for Buildability requires building designs that facilitate ease of construction, such as standardisation and repetition of design, and design for manufacturing and assembly (BCA 2017b). Structural engineer also has an important role in productivity improvement because the structural systems that they design (e.g., Precast concrete system and structural steel system) would go a long way to improve buildability and project productivity (BCA 2017b).

Table 8 shows that the 82% of respondents agree that contractors are paying attention to productivity. In Singapore, contractors need to achieve minimum constructability score (BCA 2017b). They need to ensure that productivity concepts initiated during the upstream design phase by architects and engineers would be implemented with labour-saving construction processes during the downstream construction phase. Productivity improvement needs to be approached in an integrated way comprising increase in process efficiency which comes about from consultants’ buildable designs and execution with quality materials and workmanship (Seadon and Tookey 2019).

Table 8 further shows that 9 out of 10 respondents felt that the government is paying adequate attention to productivity. The government has introduced a slew of productivity improvement initiatives such as buildability and constructability scores (BCA 2017b), pushing design for manufacture and assembly as an industry transformation initiative (BCA 2017c) and provide funding through Construction Productivity and Capability Fund (BCA 2019). However, its role in actually influencing productivity improvement is ranked 5th, and this indicates that there is a limited influence that rules and regulations can have in improving productivity.

Table 7 shows that the client takes 4th most important place in impacting productivity, but 60% of the respondents felt that clients are not paying enough attention to it (Table 8). To persuade clients to pay more attention to productivity, it may be important to show them that this can be achieved in an affordable and sustainable manner (Seadon and Tookey 2019), that also takes into consideration safety (Baniassadi et al. 2018).

**Recommendations**

The final objective is to recommend actions and policies to deal with intractable barriers. Singapore has applied a productivity development programme for several decades, with a series of policies, relevant regulations, incentives, procurement preferences for productivity performance, and efforts to improve the quality of the workforce. It is evident that the industry has been significantly developed. Construction in Singapore had been labour intensive; it required workers to fix steel, erect formwork, cast concrete, lay bricks, fix doors and windows, plaster and paint walls, lay tiles, fix pipes and sanitary fittings, and install electrical wiring (South East Asian Iron and Steel Institute 2017). The industry has been transformed into a highly mechanised and semi-industrialised one. Why are significant barriers to productivity growth still found in Singapore? Are the barriers intractable? The top 5 barriers identified in Singapore may be used to address these questions.

The top barrier identified was “Delays in providing information to contractors”. The nature and quality of the design has an impact on several project parameters including productivity. Consultants should aim to provide complete, well-coordinated production information to the construction team to reduce the occurrence of requesting and waiting for information (Gao and Low 2014). As the design for significant-sized buildings is required by regulation to be on a BIM platform, the construction team can review the building model together to identify incomplete design segments and likely constructability issues. As the clients’ representatives, they should maintain their knowledge of novel, innovative productive technologies, practices and procedures. Consultants should also be willing to consider proposals by other stakeholders of possible alternatives. Consultants should accept and promote to clients the application of Early Contractor Involvement in design which is being advocated by BCA (2018), and collaborate with contractors to achieve more buildable designs.

The second most significant barrier is “Providing adequate training for workers”. It should be noted that the regulations require the foreign/migrant construction workers to be certified by BCA as skilled before they are granted work visas to enter the country. Thus, the training is undertaken in the source countries. BCA could work with the overseas training centres to enhance the quality and relevance of the training. Construction companies should take advantage of the government’s grant schemes to undertake the continuous development and training of their professional employees, supervisors and workers in subjects relating to productivity such as prefabrication and BIM applications. Contractors should engage adequate numbers of workers; seek to pay their workers decent wages and give them incentives to motivate them to be more productive; and demand high standards of productivity from the workers.

The third most significant barrier is “Inadequate pre-project planning and pre-work planning”. Studies have shown that projects with the worst results tend to be those that are missing important planning components, and projects that take a long time in planning also have poor results (Choma and Bhat 2010). Contractors should improve planning and preparation to start on site; and undertake constant review and fine tuning of the programmes during the project. From the interviews, it is necessary for clients to give the contractors adequate time before project start to accomplish the necessary preparatory activities. Contractors should also improve their overall corporate and project management; aim to increasingly improve their operational efficiency; and undertake regular assessment of their real-time production.

**Table 7.** Entities’ influence on project productivity.

| S/N | Variable | Mean | T-value | t-tail Sig |
|-----|----------|------|---------|-----------|
| 10a | Main Contractor | 4.33 | 14.973 | 0.000*** |
| 11b | Architect | 4.29 | 14.862 | 0.000*** |
| 11c | Structural Engineer | 4.27 | 14.841 | 0.000*** |
| 11a | Client | 4.21 | 11.907 | 0.000*** |
| 11e | Approving Authority/ Government | 4.18 | 11.696 | 0.000*** |
| 10b | Specialist Subcontractor | 4.16 | 13.227 | 0.000*** |
| 11d | Mechanical and Electrical Engineer | 4.05 | 11.485 | 0.000*** |
| 10c | Labour Subcontractor | 3.86 | 8.732 | 0.000*** |
| 10d | Supplier of Materials | 3.60 | 6.336 | 0.000*** |

**Table 8.** Stakeholders’ attention to productivity (Q6).

| Stakeholder | Yes | No |
|-------------|-----|----|
| Government | 89.8% | 10.2% |
| Contractors | 82.2% | 17.8% |
| Consultants | 45.8% | 54.2% |
| Clients | 40.2% | 59.8% |
The fourth barrier identified was: “Delays caused by compliance with regulations”; and the eighth was that there was “Excessive regulation of construction activity”. The construction industry in Singapore has arguably the highest level of regulation of the construction process, product and industry; and this has helped in attaining progress in many areas. Complying with the regulations is not only expensive (such as the employment of clerks of works and resident engineers and safety managers; paying the foreign worker levy) but also involves time and effort, such as requirement of completing submission documentation. Moreover, while each of the regulations was formulated to address a particular issue, it would be useful to evaluate their operation in combination. There is a need for the regulations to be reviewed, consolidated and reduced where necessary and possible. The approval process should also be reviewed, streamlined and expedited. The authorities should aim to have a progressively more self-regulating industry as it matures, and actively work towards its attainment.

The fifth barrier was: “Changes in design”. Consultants should take productivity into consideration during design. For example, in general, they should design for easy construction and repetition using standardised components, such as consideration of prefabrication and DfMA. If productivity is a major consideration, consultants should and clients would also ensure that design changes are kept to the minimum, as they would realise their impact on productivity.

It is recommended that clients support productivity initiatives, and adopt appropriate attitudes concerning productivity because they are the fourth most important influencer of productivity (see Table 7) and some of the significant barriers such as lack of client’s support and delays in payment (see Table 5) are attributed to them. In the tender documents, targets for productivity standards to be achieved should be stated. At the tender evaluation stage, clients should give weightage to tenderers’ productivity performance in past projects, and their proposals for productivity enhancing measures. Clients should be willing to pay a premium for productive measures to be implemented as they reap the benefit of getting their facilities completed earlier.

Contractors are the most important influencer of productivity (see Tables 5 and 7). It is therefore recommended that contractors adopt a new mindset, attitudes and behaviours towards productivity. Contractors should develop corporate productivity policies and clearly assign responsibility and accountability to the appropriate persons for productivity enhancement in their projects to solve the poor attitude to productivity. They should measure productivity, set measurable targets on productivity on each project, measure and monitor productivity as the project proceeds, and adopt measures to increase productivity on projects.

The Singapore construction industry is unique in that most of the labourers on site are migrant workers from overseas. Nonetheless, the findings may be useful to countries that employ labourers mainly from overseas such as those in the Middle East and certain parts of Europe. Further studies can be conducted to explore barriers unique to their own regions.

**Limitations**

The limitation of this study is that it was conducted only in Singapore. The Singapore construction industry is unique in that most of the labourers on site are migrant workers from overseas. Nonetheless, the findings may be useful to countries that employ labourers mainly from overseas such as those in the Middle East and certain parts of Europe.

**Conclusions**

Using a questionnaire survey, the top most significant barriers to achieving high project productivity are: delays in providing information to contractors (attributed to consultants), poor skills of workers and inadequate pre-project planning and pre-work planning (attributed to contractors). The 32 barriers are categorized into 5 groups: red tapes and lack of support; inadequate management of workers and workflow; inadequate process control; uncontrollable external factors and over-reliance on sub-contractors. The implication of the finding is that contractors should plan work well, implement effective working methods, monitor project progress closely, attract suitable talents, provide adequate training for workers, facilitate better communication and provide enough supervision.

This study contributes to policy in the following ways. The Government could advocate more public projects to adopt the early contractor involvement procurement system. Public agencies may adopt a tender evaluation system that give weightage to productive measures and productive companies. Another policy consideration is to regularly review regulations and revise those that inhibit productivity improvement.

The study found that all stakeholders have a significant impact on project productivity, with main contractors and consultants taking the top spots. However, the finding is that consultants and clients are not paying enough attention to productivity. The implication of this is that all stakeholders such as clients, architects, engineers, contractors and subcontractors should work together to improve productivity. They need to commit themselves to improve productivity, provide information in a timely manner and collaborate among themselves to minimize changes to the project. While the government has impact on productivity, it should regulate in a light manner and review the rules and regulations to ensure the project team members are not tied down by red tapes and bureaucracy that hinder productivity.

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